

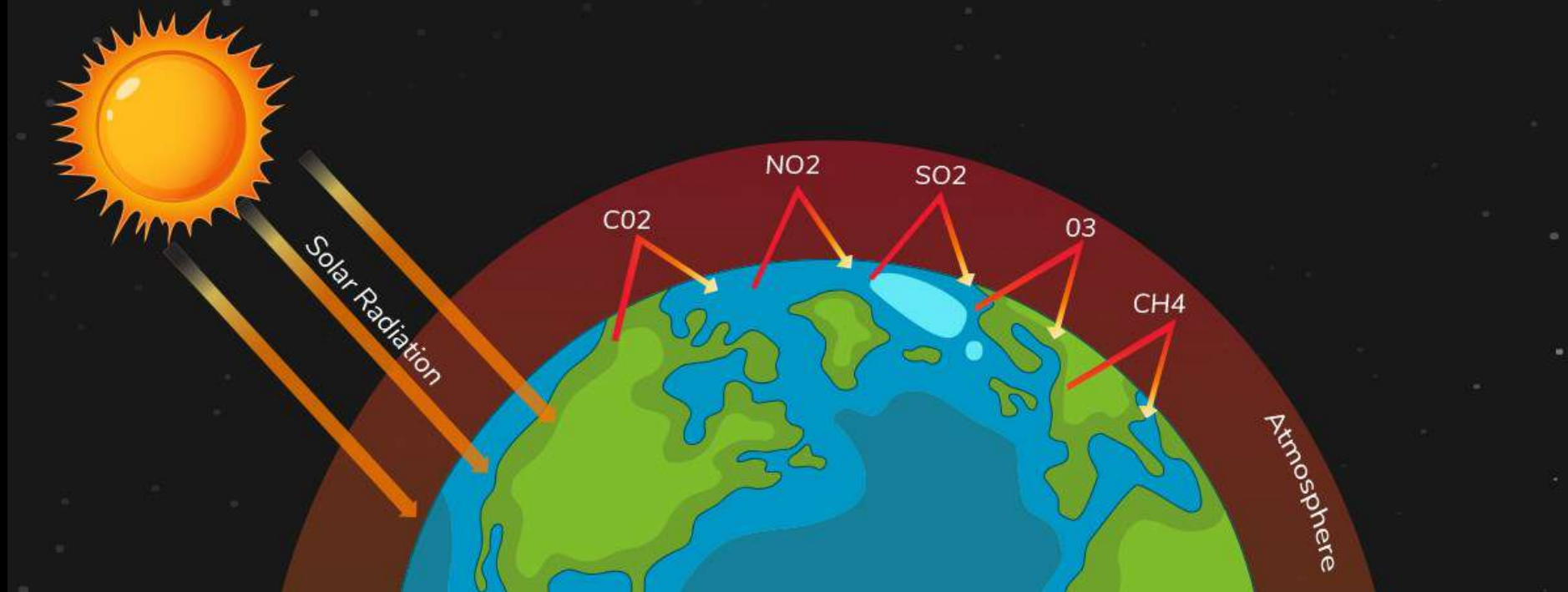


Present day and near future climate (change)

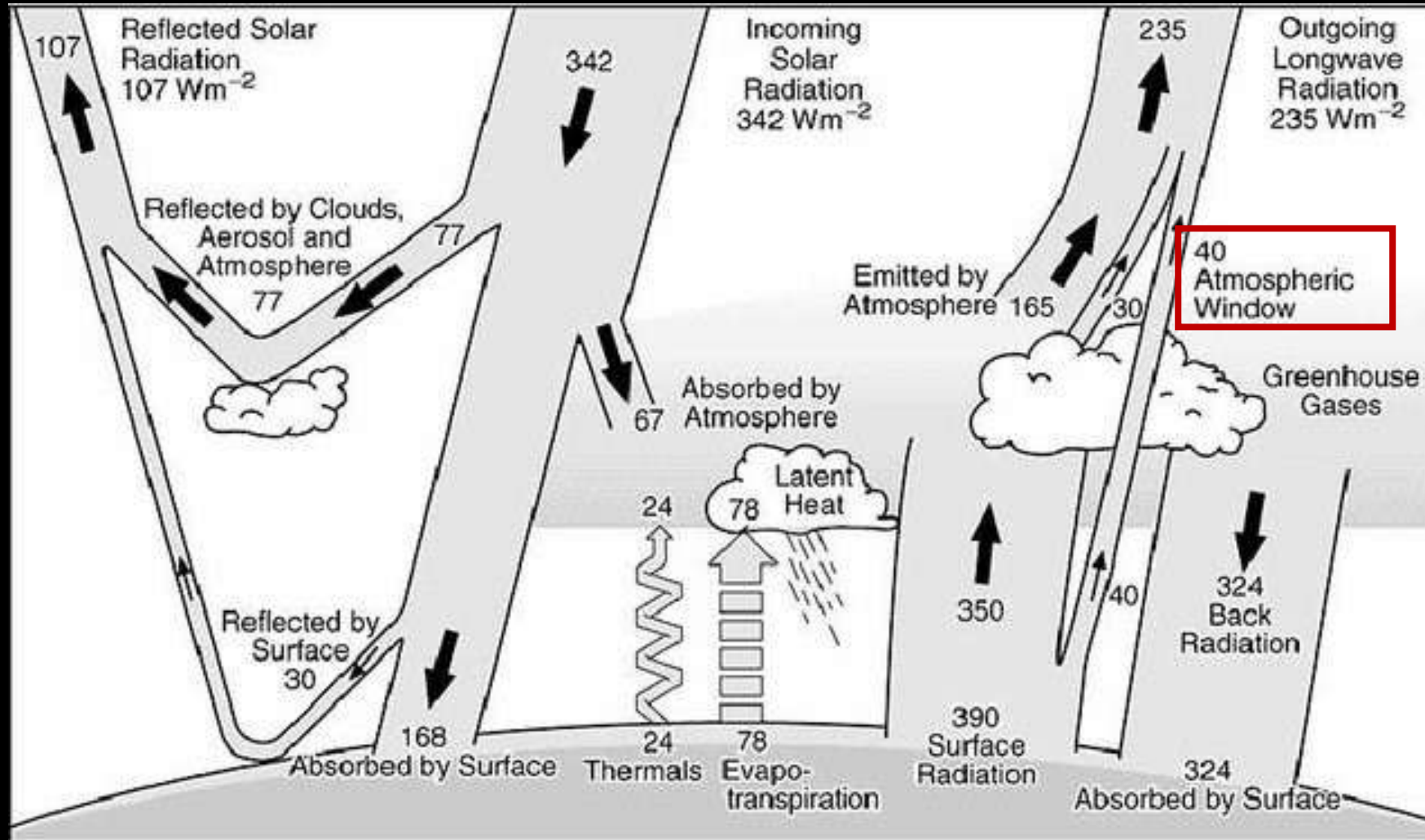
Wolfgang Gurgiser, University of Innsbruck

Greenhouse Gases: How is the world tackling them?

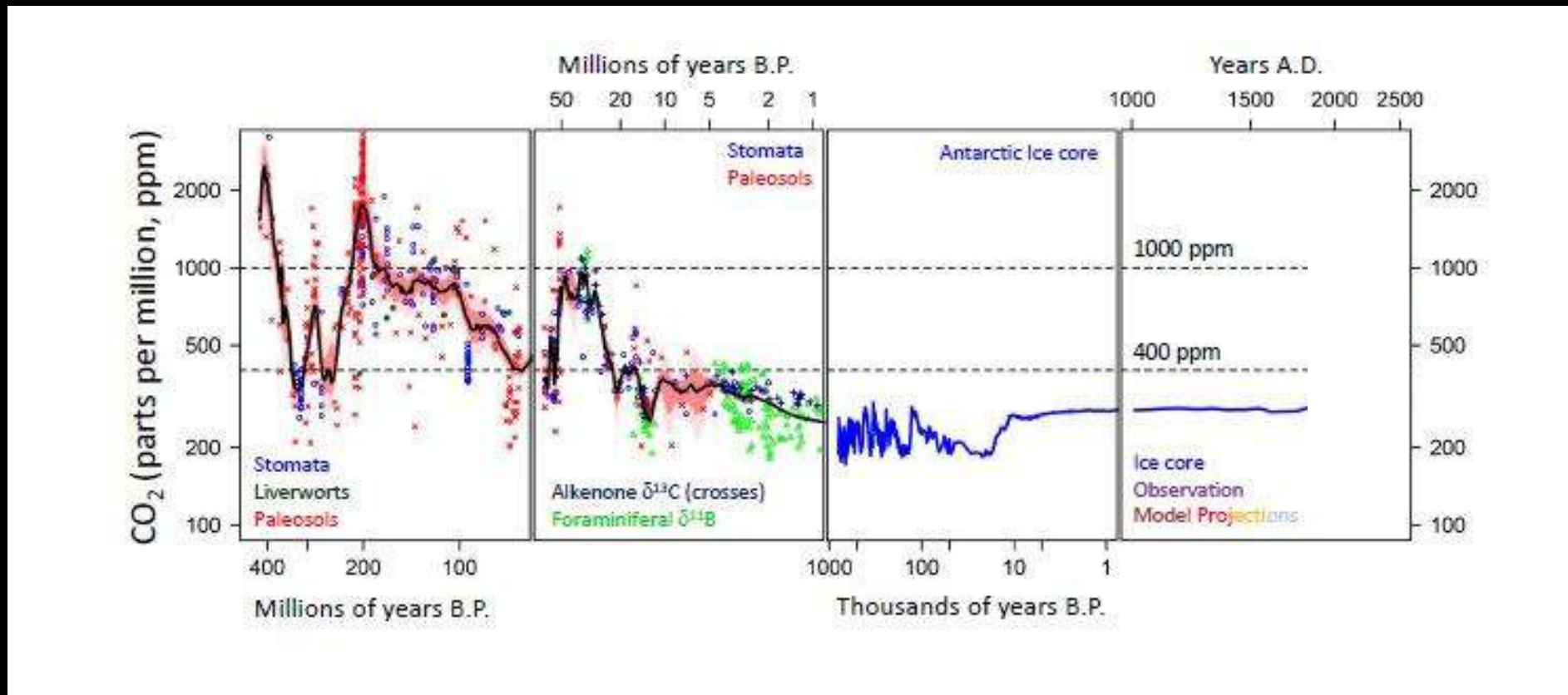
Causes | Effects | Solution



<https://www.pranaair.com/blog/what-is-greenhouse-effect-its-gases-causes-solution/>



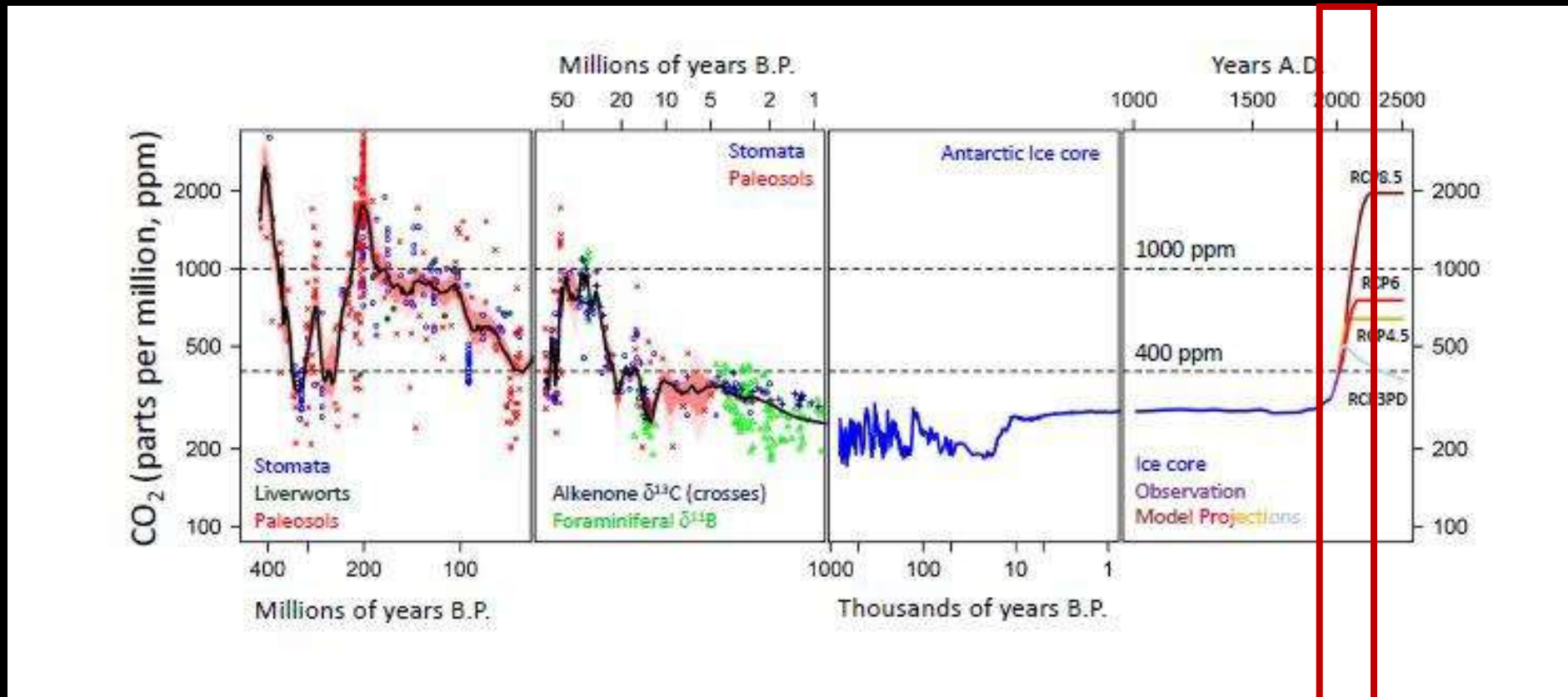
<https://www.researchgate.net/publication/2172122> Environmental Physics Physical Principles and Applications/figures?lo=1



<https://skepticalscience.com/Past-and-Future-CO2.html>

<https://climatescience.org/advanced-climate-future-temperatures>

Today's focus



<https://skepticalscience.com/Past-and-Future-CO2.html>

Today's topics

- Near past and current climatic changes
- Attribution of the changes
- Future perspectives

Near past and current climatic changes

On what variables do we focus?

- Essential climate variables

Definition:

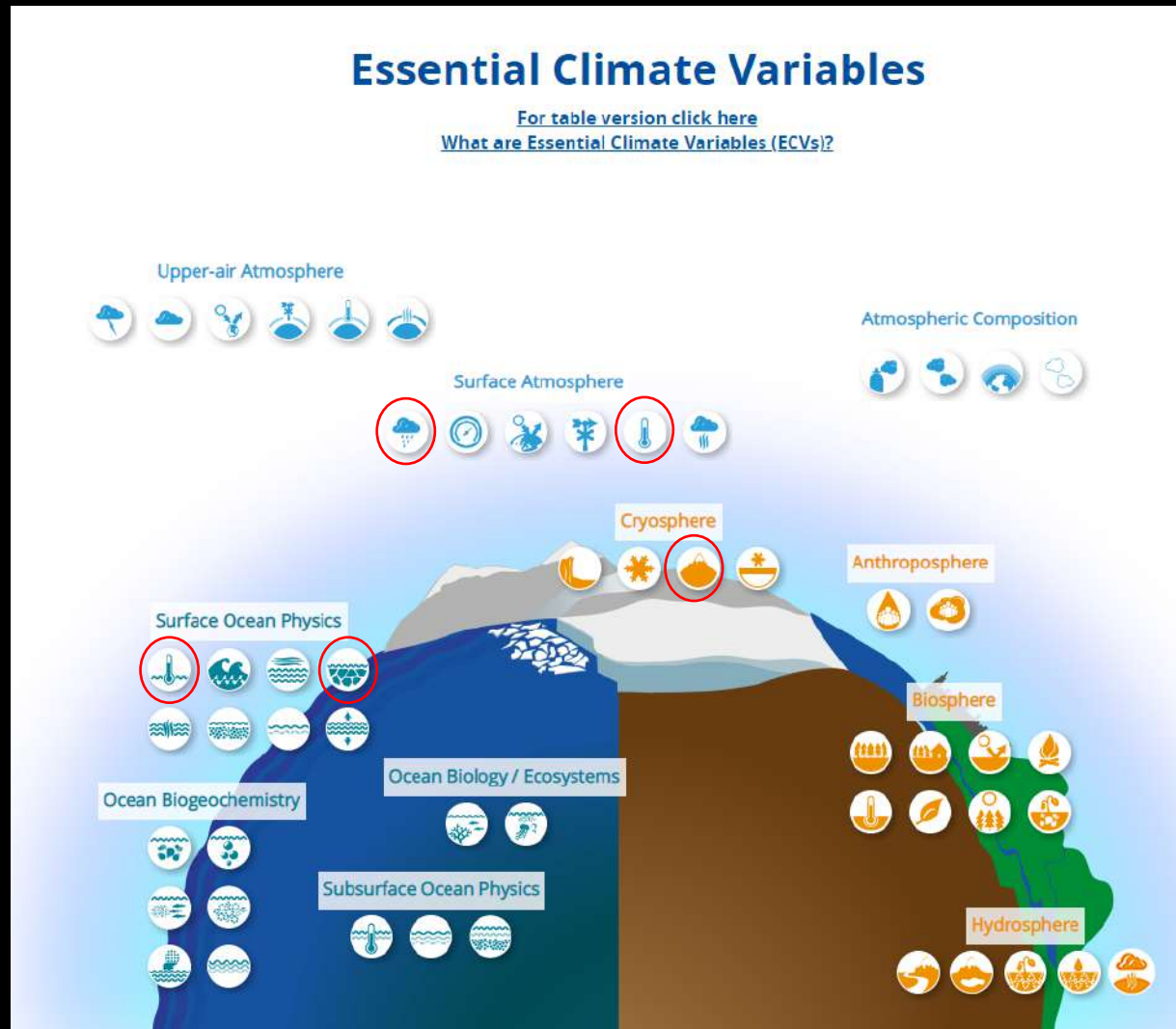
An Essential Climate Variable (ECV) is a physical, chemical or biological variable or a group of linked variables that critically contributes to the characterization of Earth's climate.

Identification:

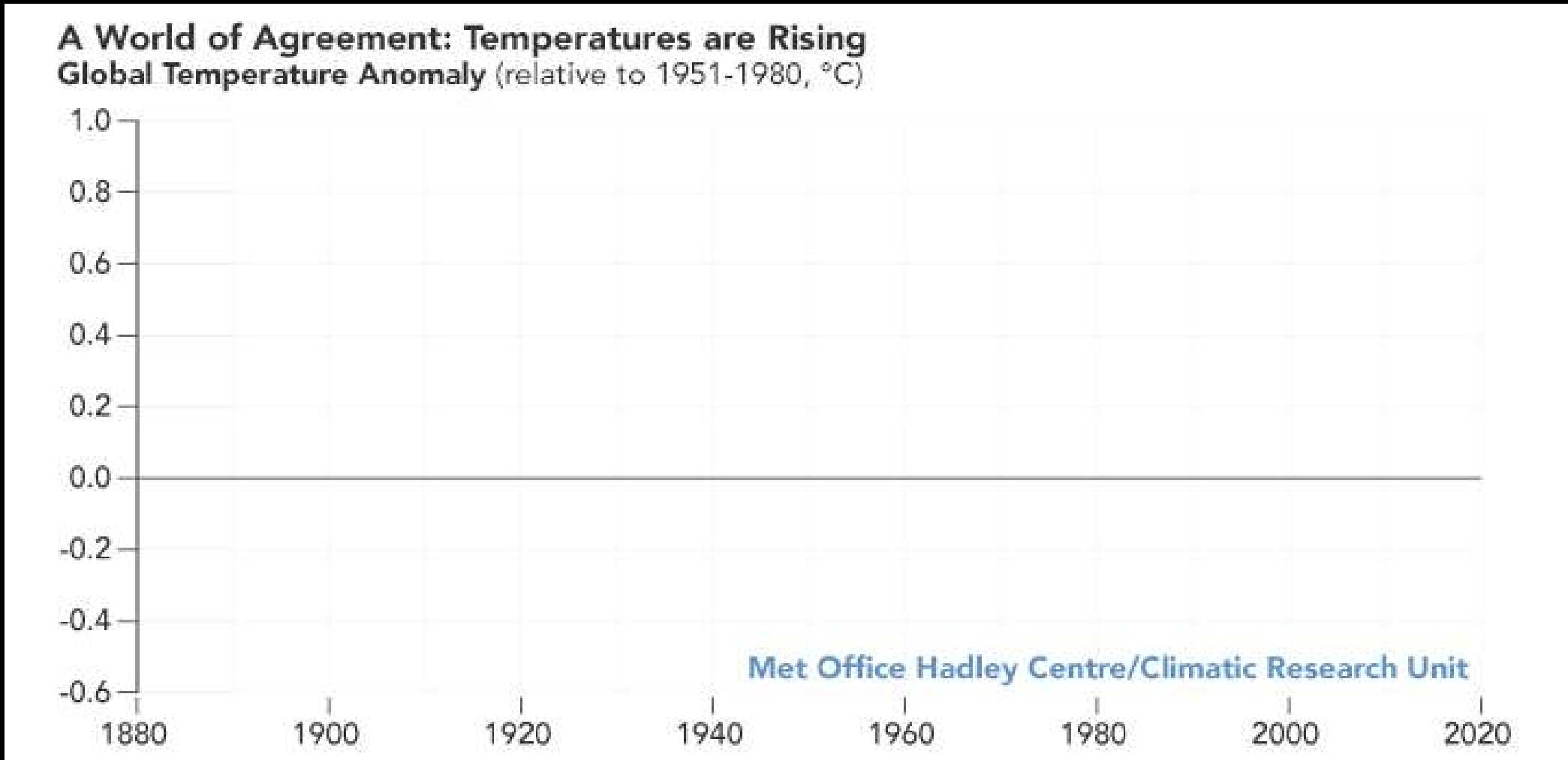
- **Relevance:** The variable is critical for characterizing the climate system and its changes.
- **Feasibility:** Observing or deriving the variable on a global scale is technically feasible using proven, scientifically understood methods.
- **Cost effectiveness:** Generating and archiving data on the variable is affordable, mainly relying on coordinated observing systems using proven technology, taking advantage where possible of historical datasets.

On what variables do we focus?

<https://gcos.wmo.int/en/essential-climate-variables>



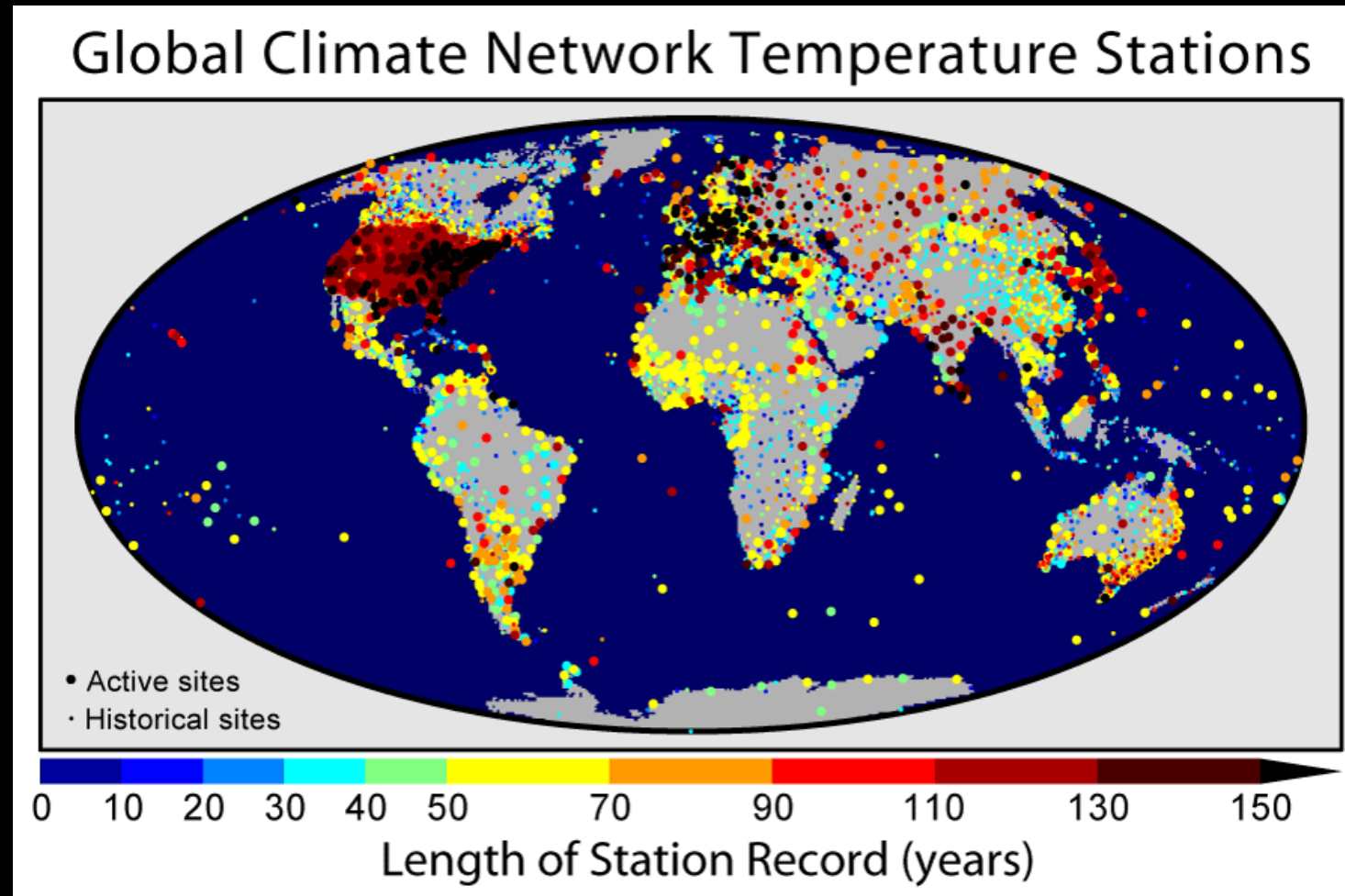
Global temperature change



Why 5 different curves?

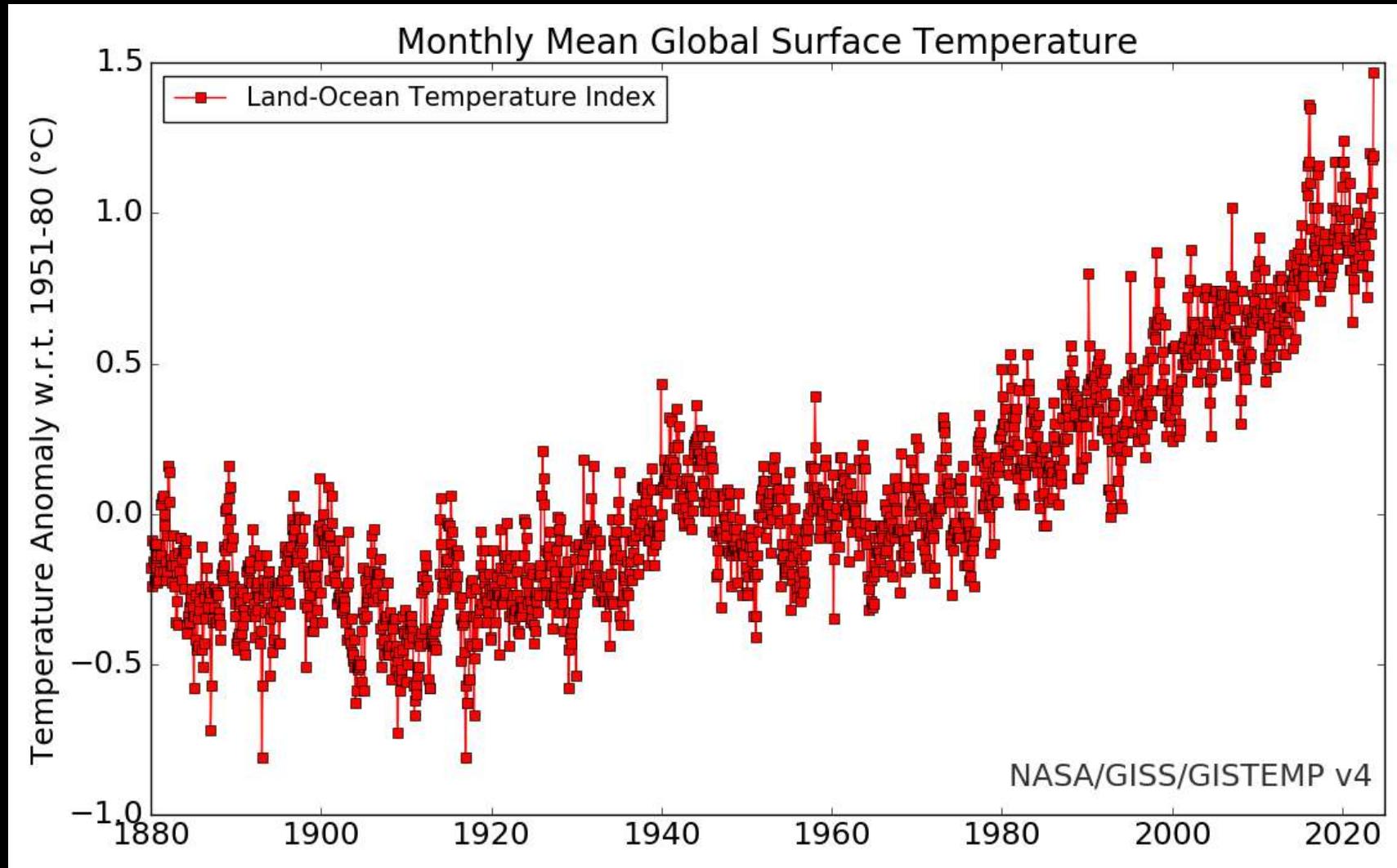
- Reconstruction based on instrumental data
- Uncertainties due to
 - Measurement quality
 - Spatial coverage
 - Moving stations
 - Changes in the surrounding of stations (e.g. urban heat effect)

Spatial coverage of T measurements



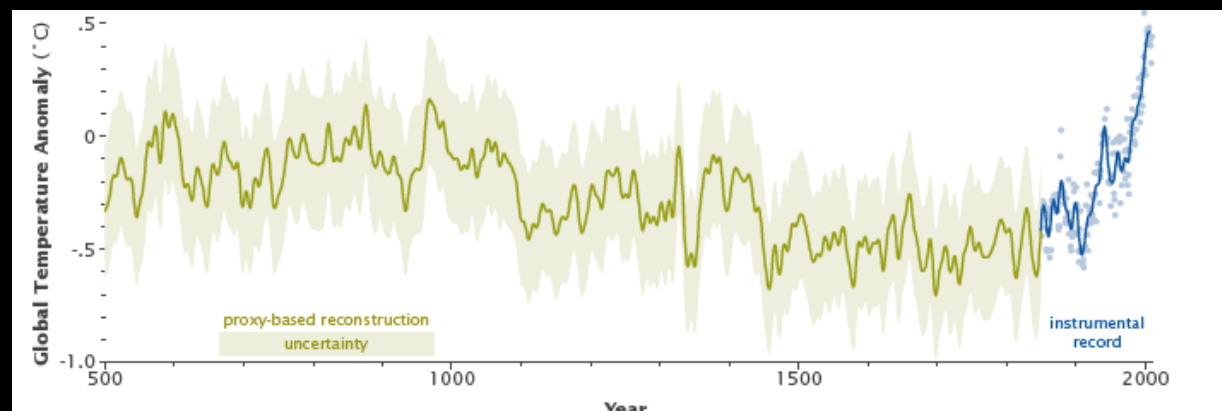
Global temperature change recent values

https://data.giss.nasa.gov/gistemp/graphs_v4/



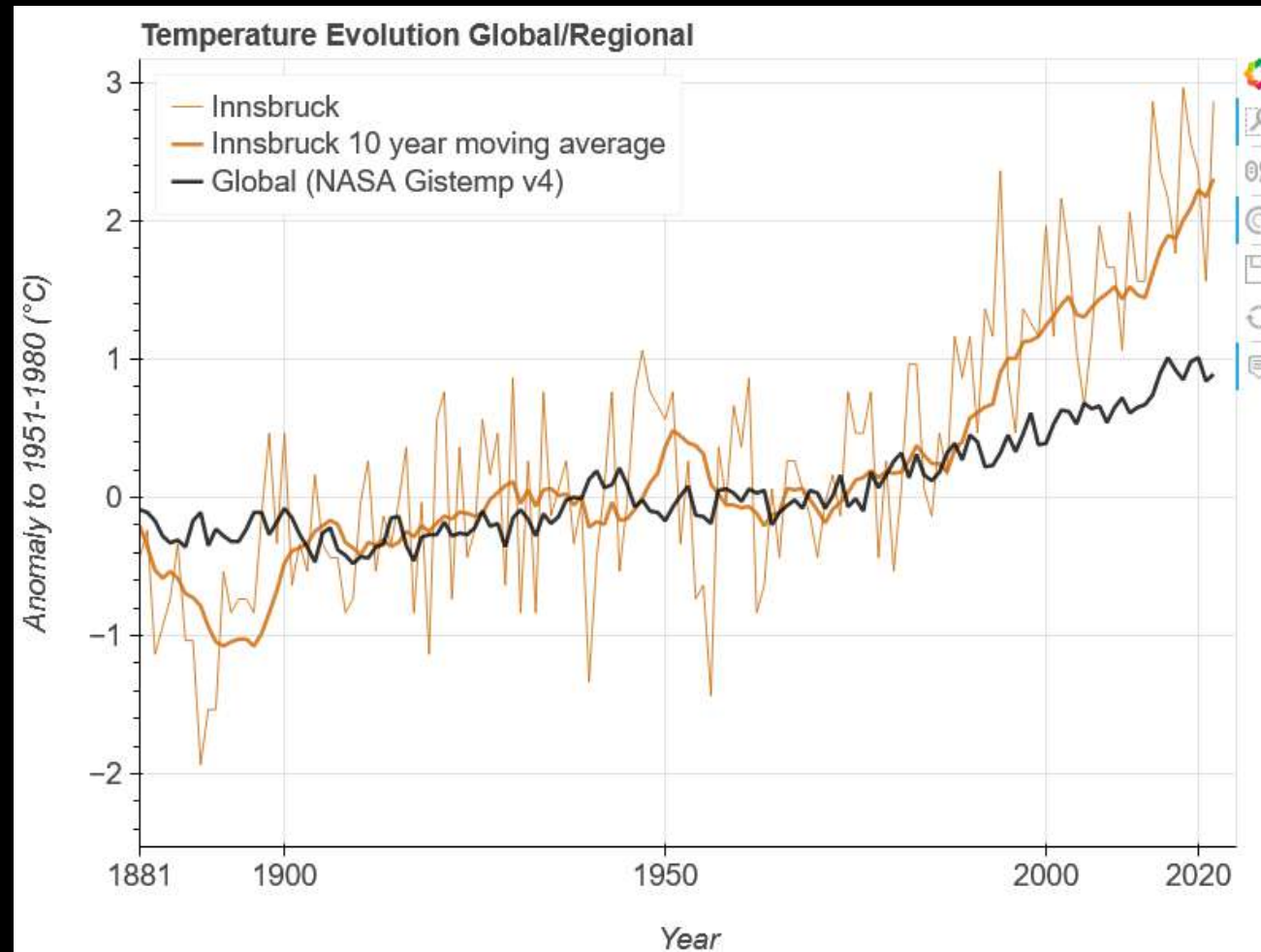
Rate of temperature change

“As the Earth moved out of ice ages over the past million years, the global temperature rose a total of 4 to 7 degrees Celsius over about 5,000 years. In the past century alone, the temperature has climbed 0.7 degrees Celsius, roughly ten times faster than the average rate of ice-age-recovery warming.”

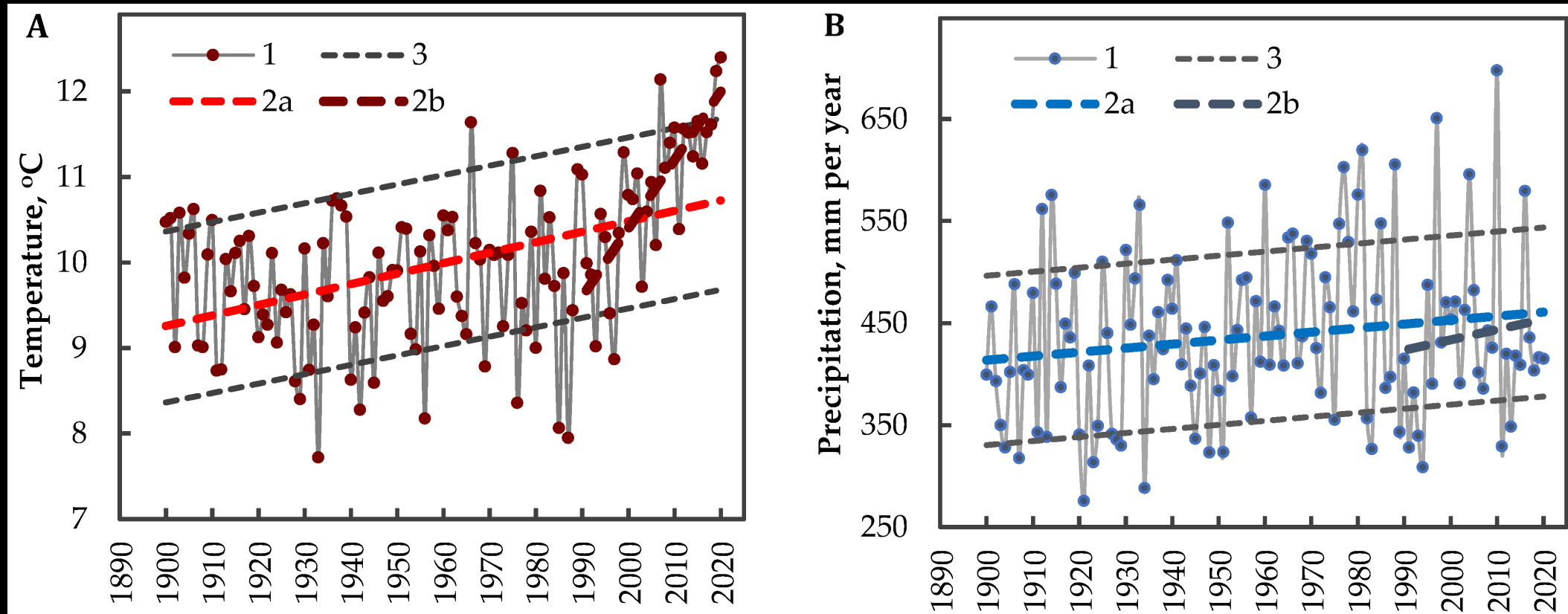


<https://earthobservatory.nasa.gov/features/GlobalWarming/page3.php>

Global change vs. regional change



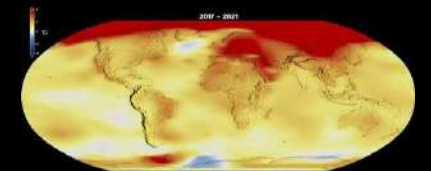
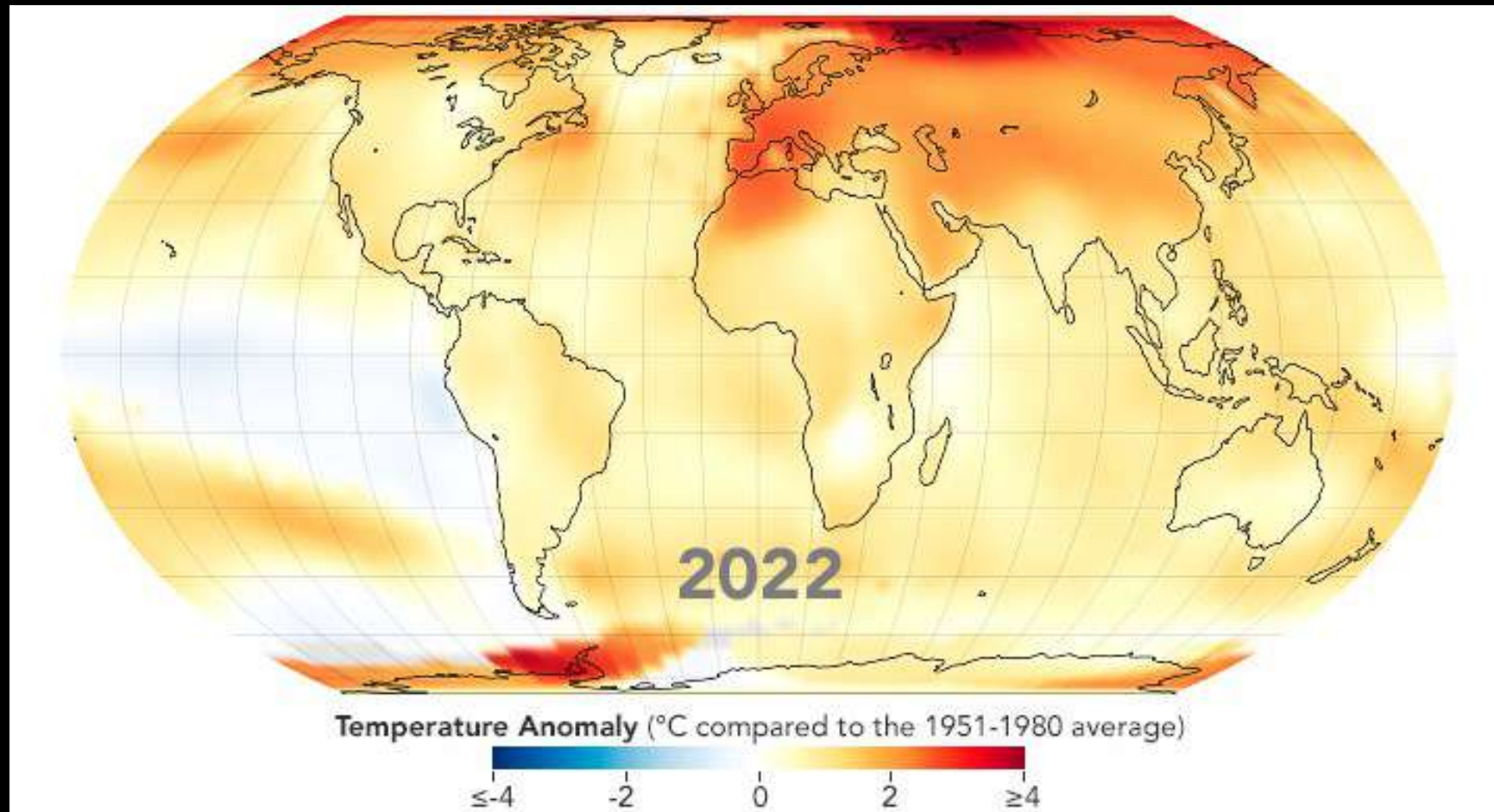
Regional temperature and P change Southern Ukraine*



Kherson, Mikolaiv, Odesa, and Zaporizhzhia

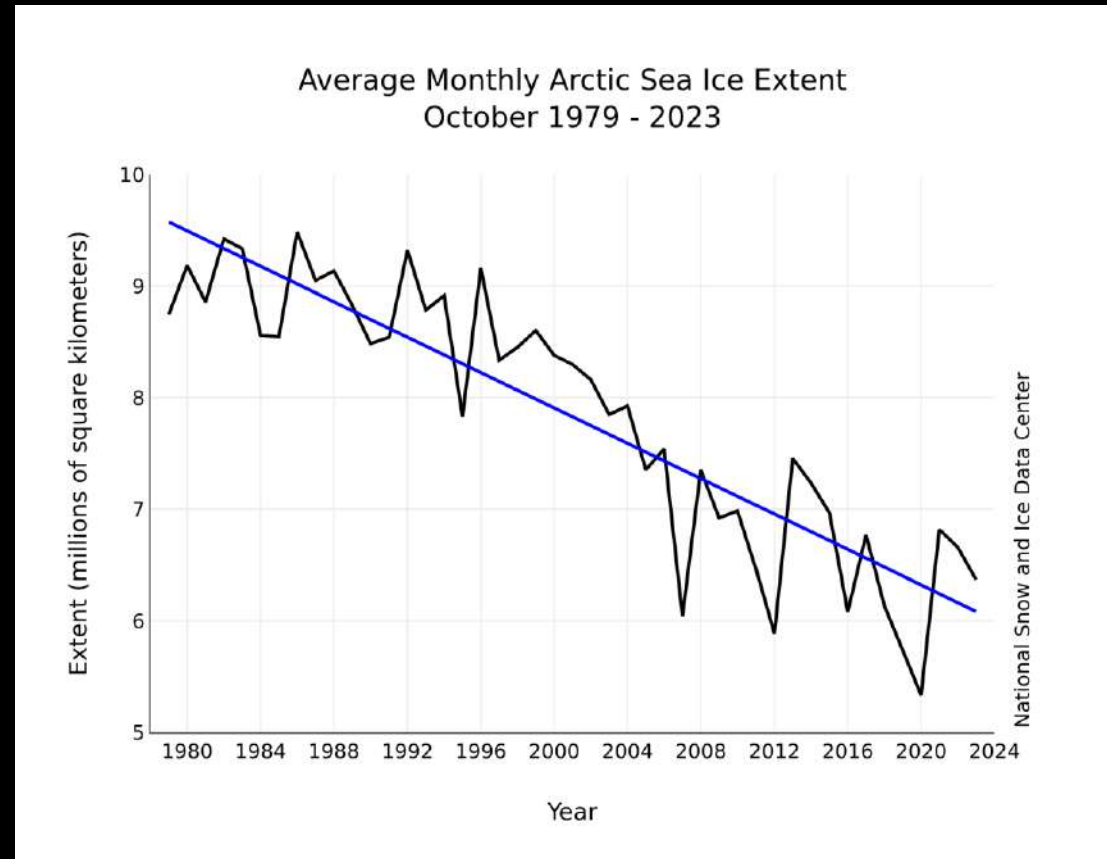
<https://doi.org/10.3390/su14095664>

Regional T change on a global scale



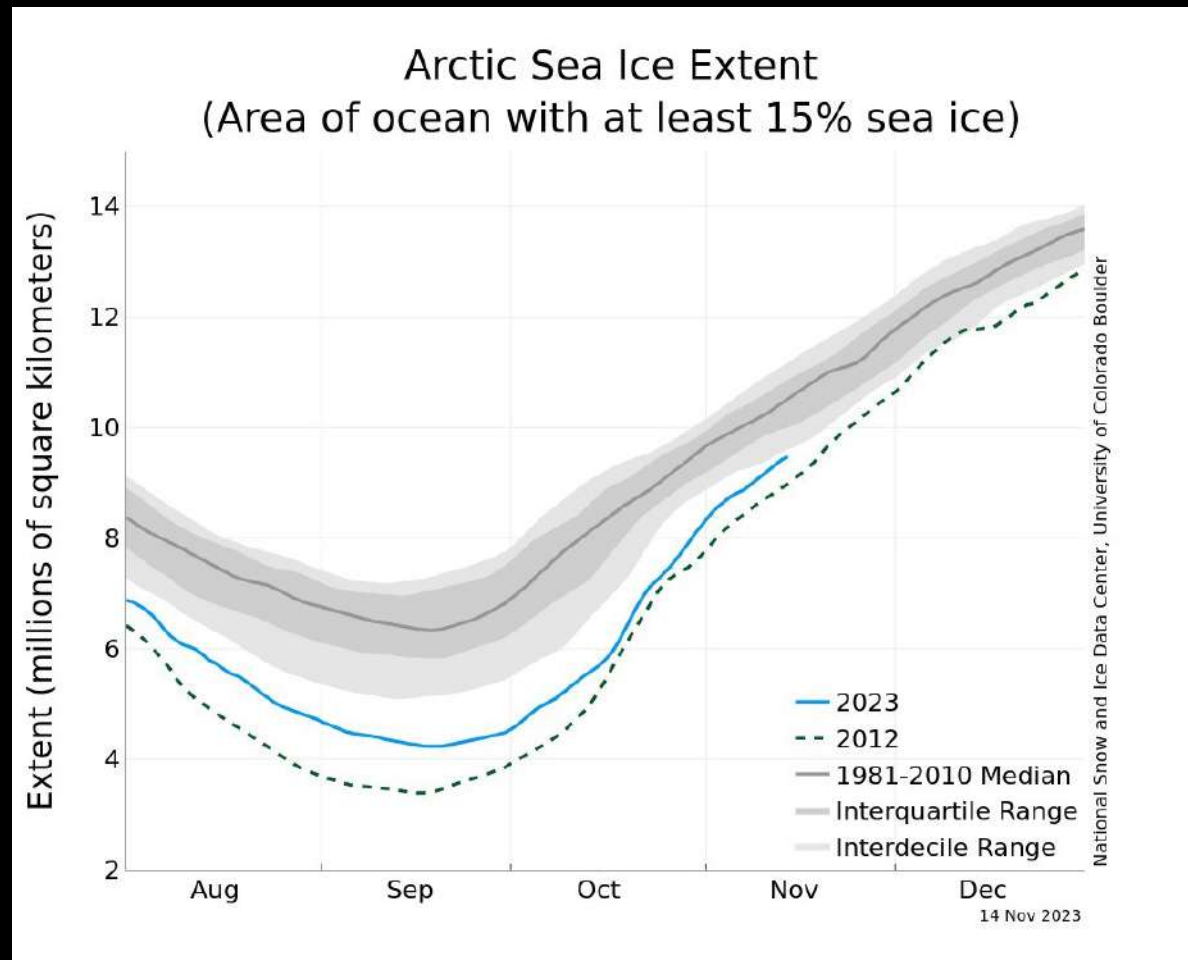
<https://youtu.be/haBG2IlbwbA>

Consequences of Regional T change



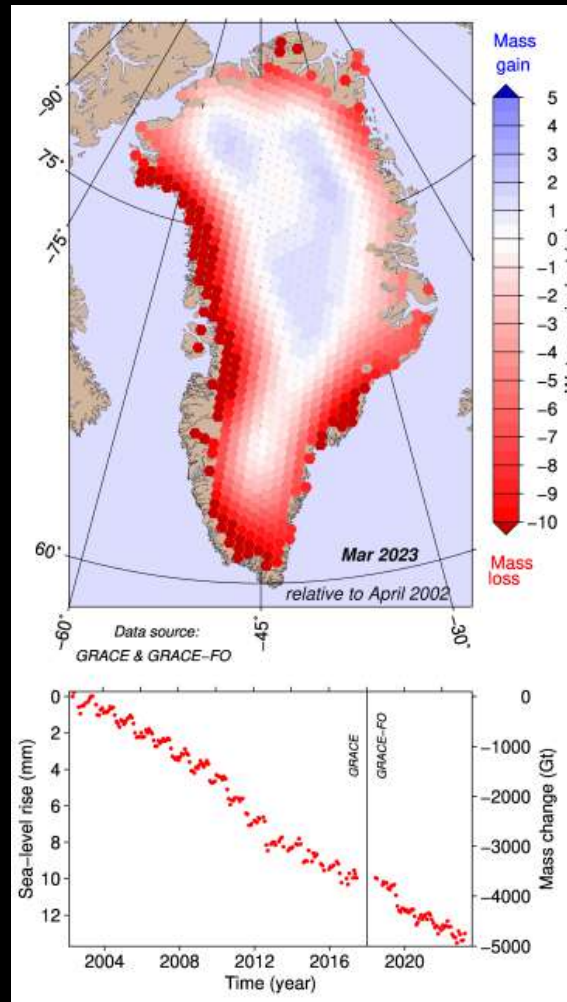
<http://nsidc.org/arcticseaicenews/>

Consequences of Regional T change

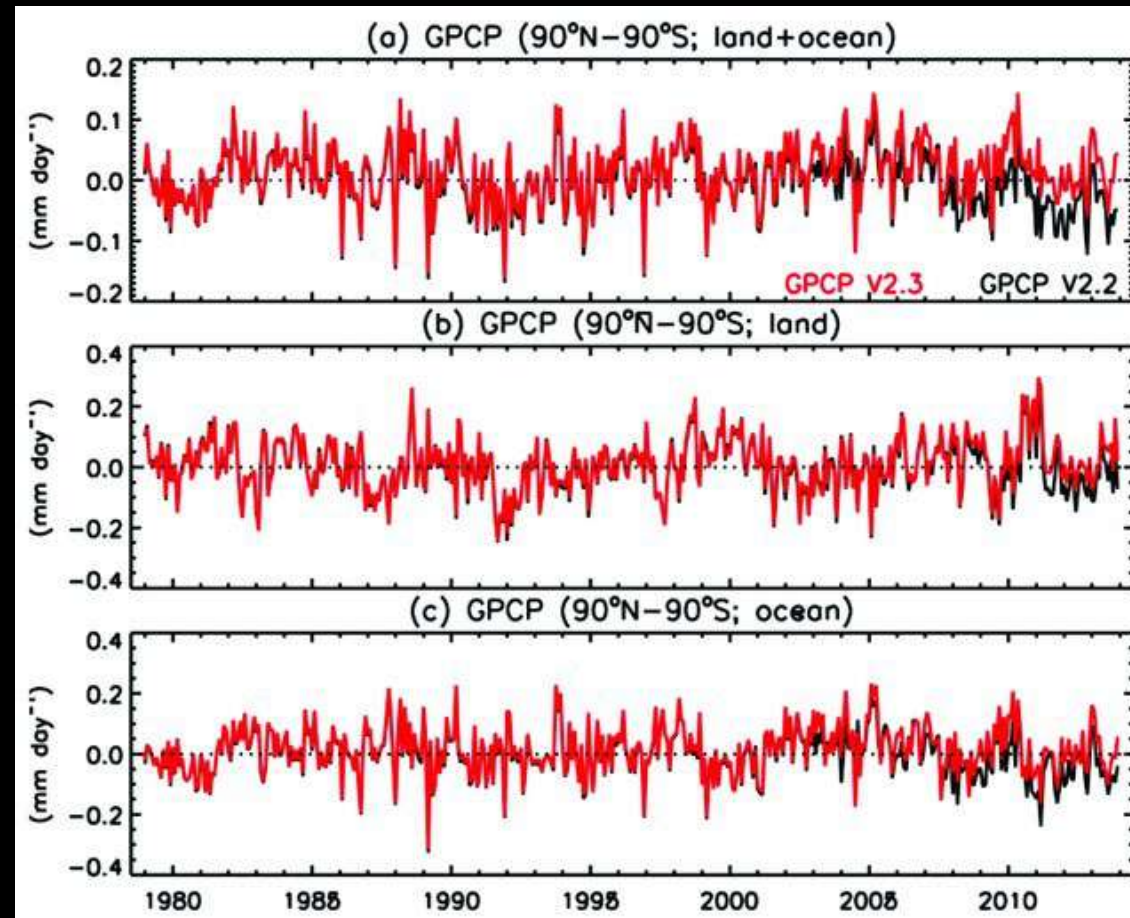


<http://nsidc.org/arcticseaicenews/>

Consequences of Regional T change



Evolution of precipitation globally



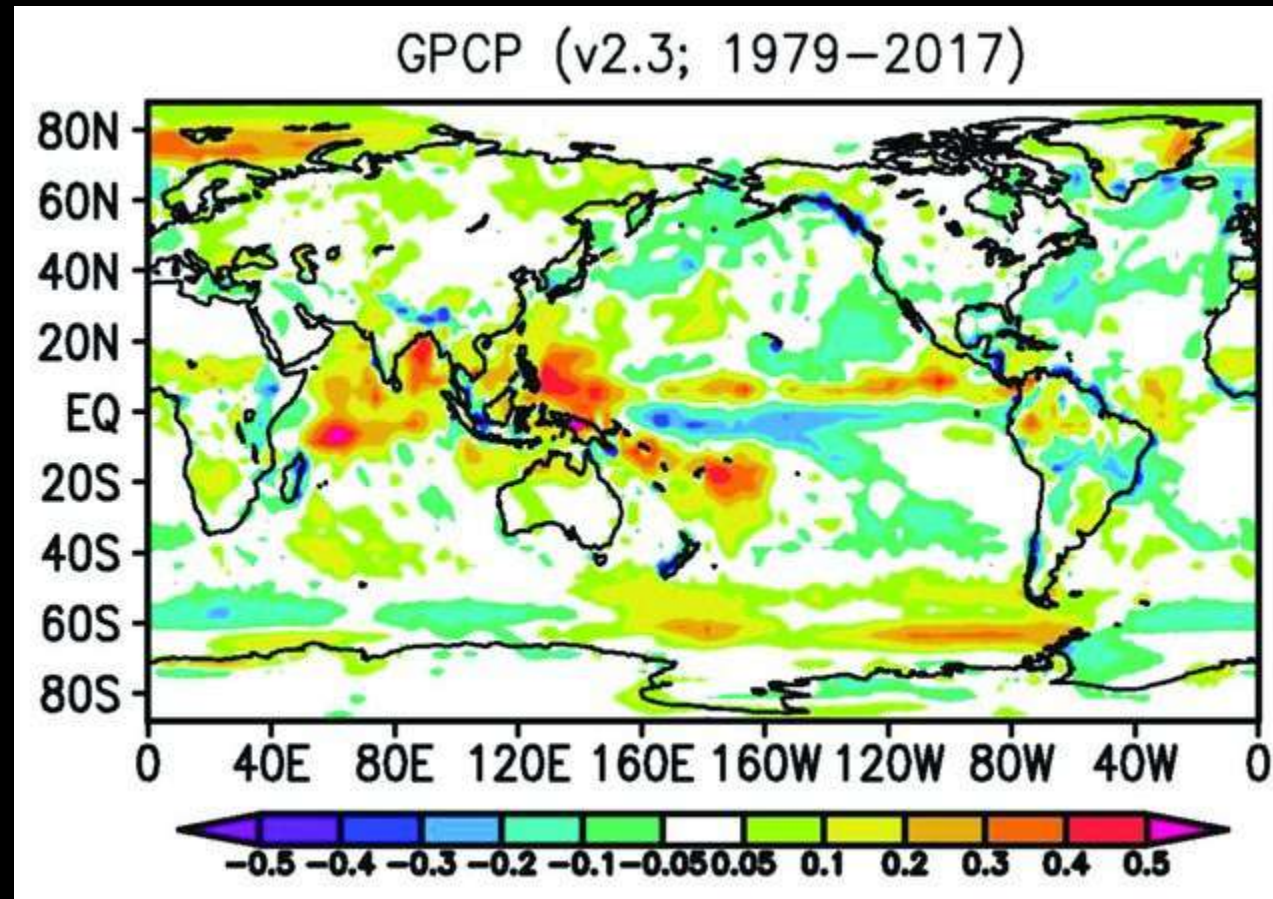
<https://www.researchgate.net/publication/324427078> The Global Precipitation Climatology Project GPCP Monthly Analysis New Version 23 and a Review of 2017 Global Precipitation

Precipitation globally:

- Much more complex to assess than temperature
- Satelites provided strong improvements although there are still substantial uncertainties

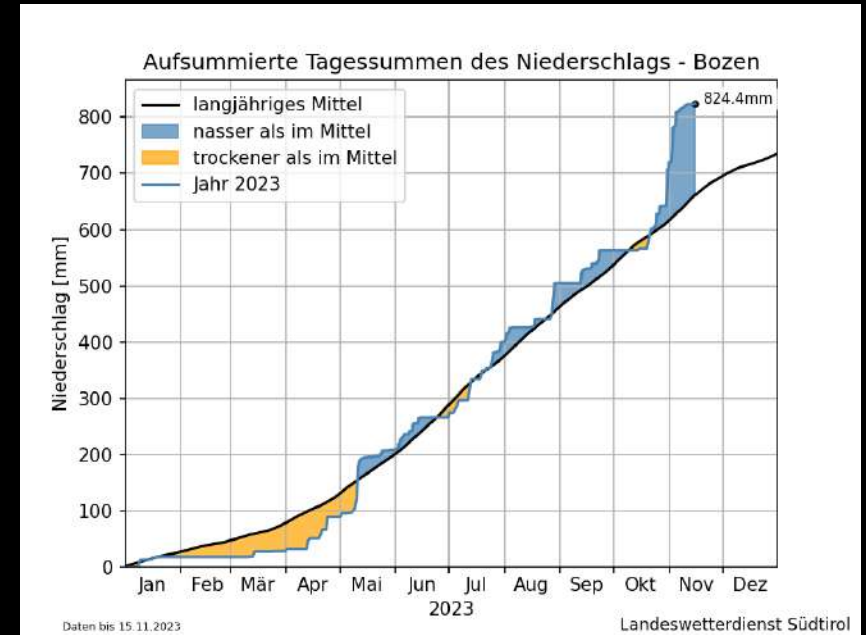
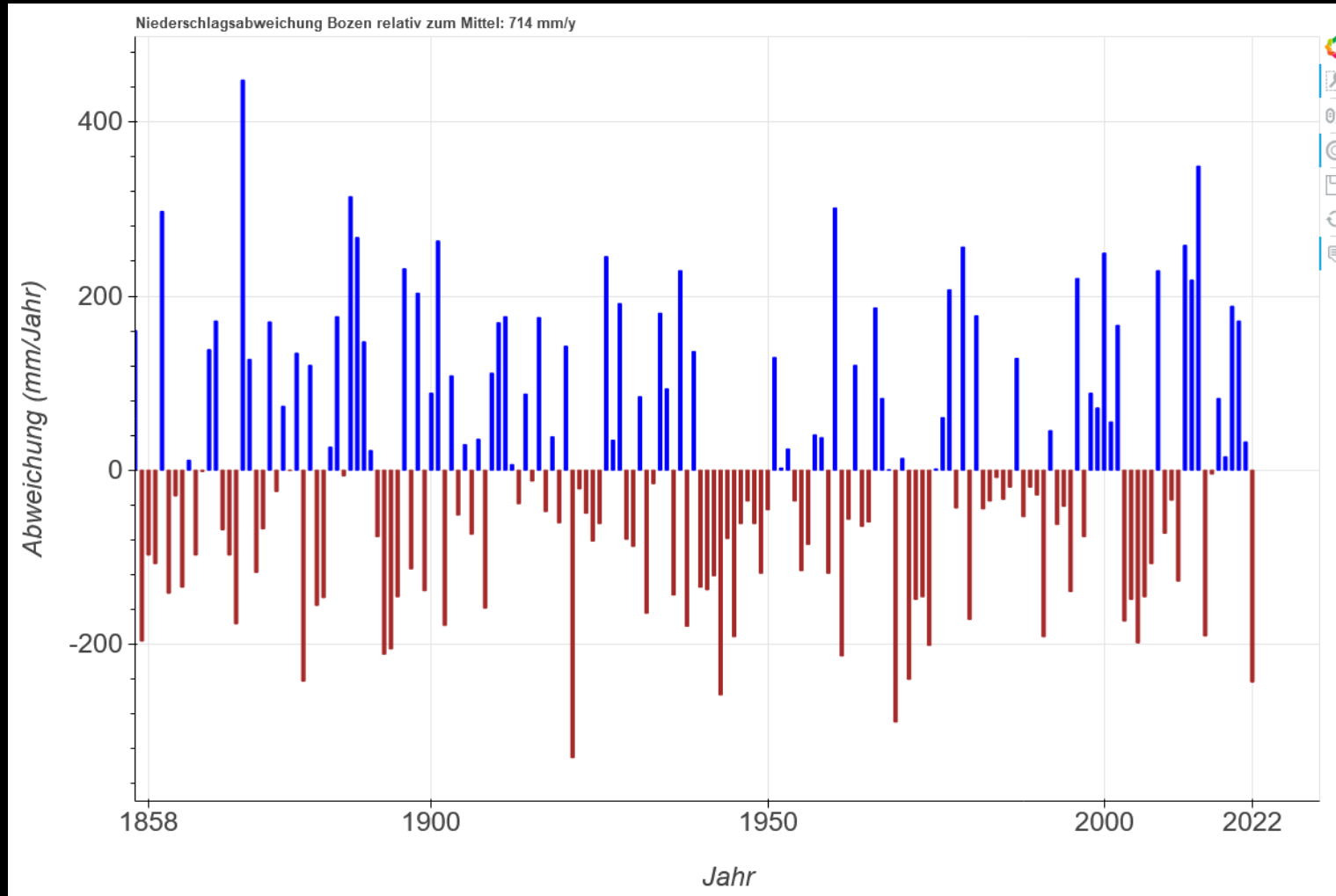
Evolution of precipitation regionally

Linear trend of GPCP precipitation
(mm day⁻¹ decade⁻¹) from 1979-
2017.



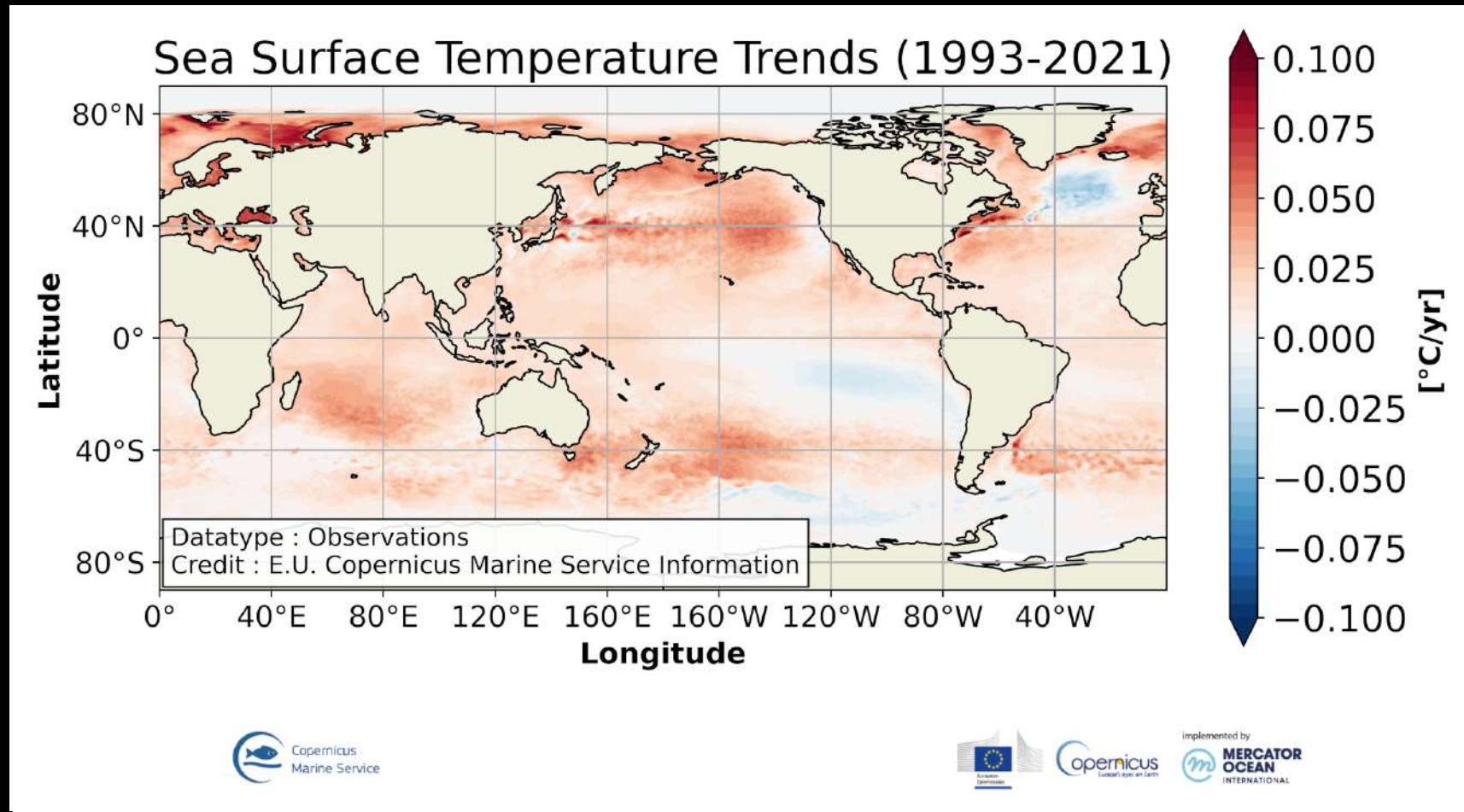
<https://www.researchgate.net/publication/324427078> The Global Precipitation Climatology Project GPCP Monthly Analysis New Version 23 and a Review of 2017 Global Precipitation

Evolution of precipitation regionally

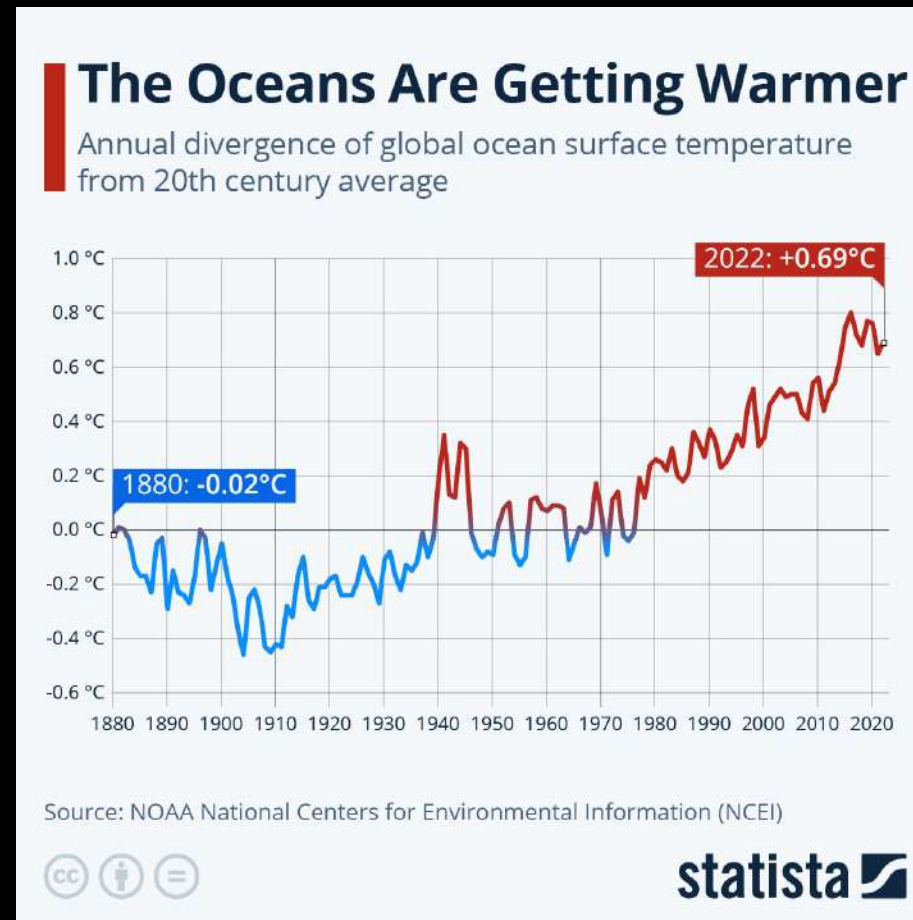


<https://wetter.provinz.bz.it/klimadiagramme.asp>

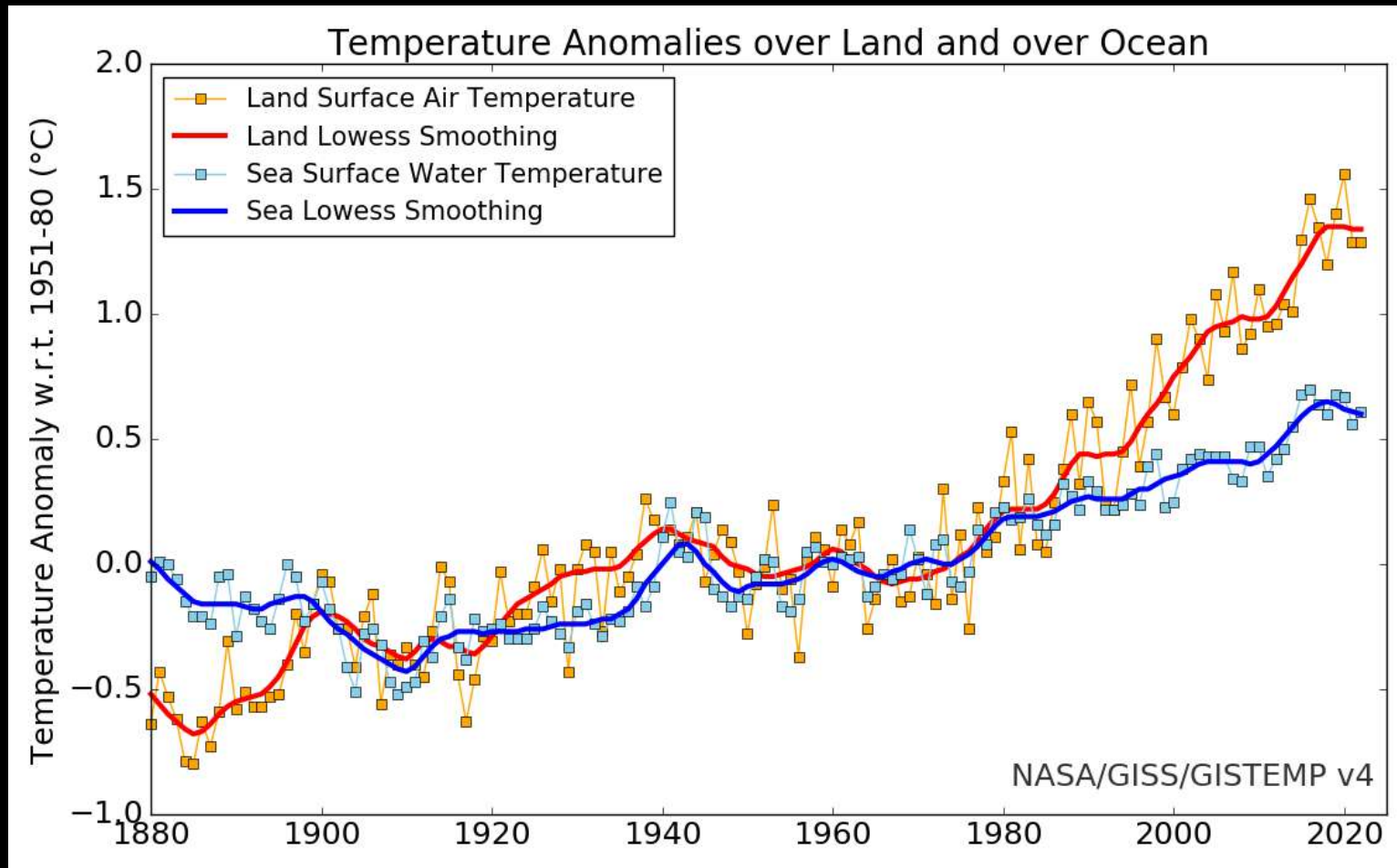
Evolution of sea surface temperature



Evolution of sea surface temperature



Evolution of ocean vs. land surface temperature



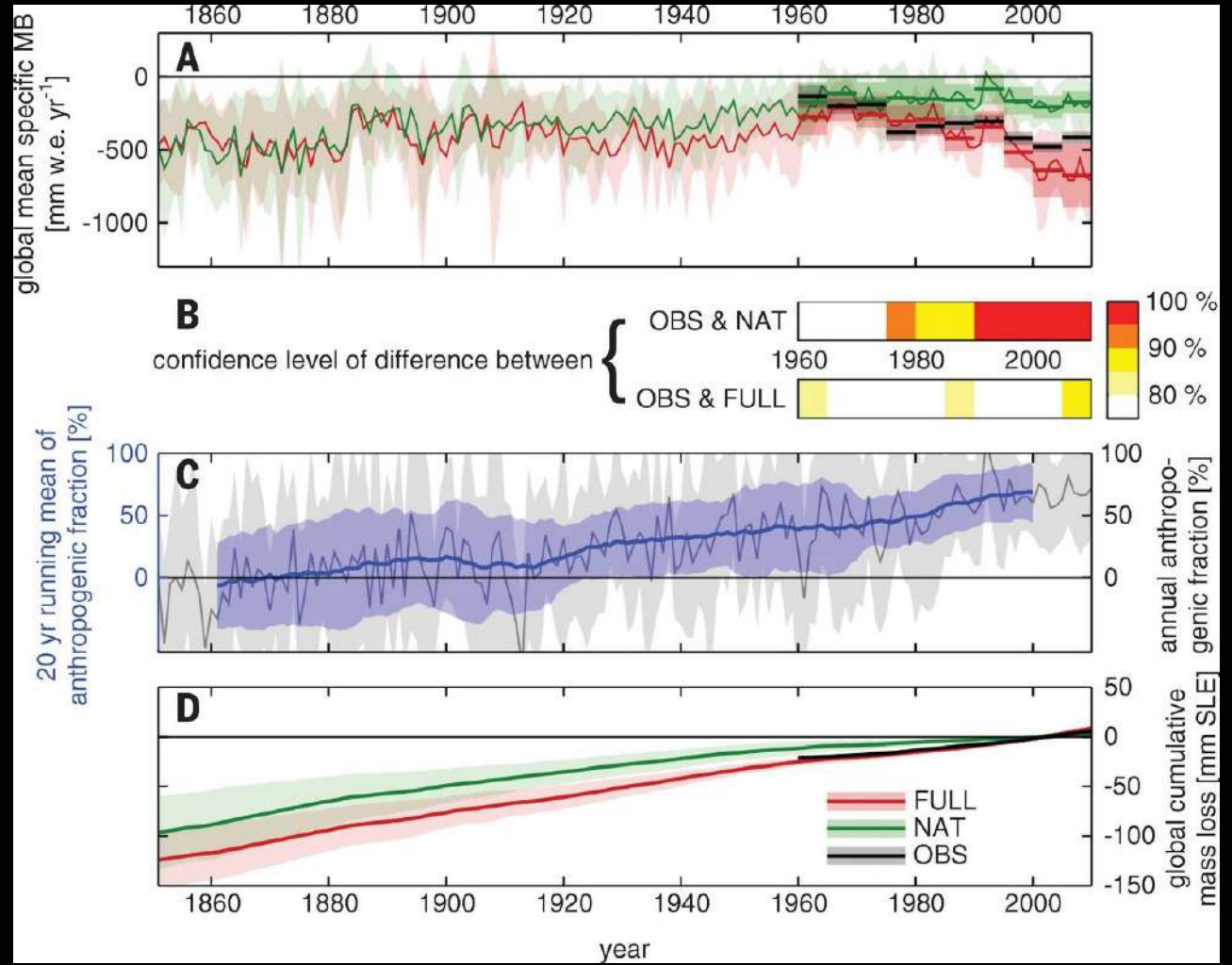
Recap Block 2:
90% of additional heat
absorbed by the ocean

https://data.giss.nasa.gov/gistemp/graphs_v4/

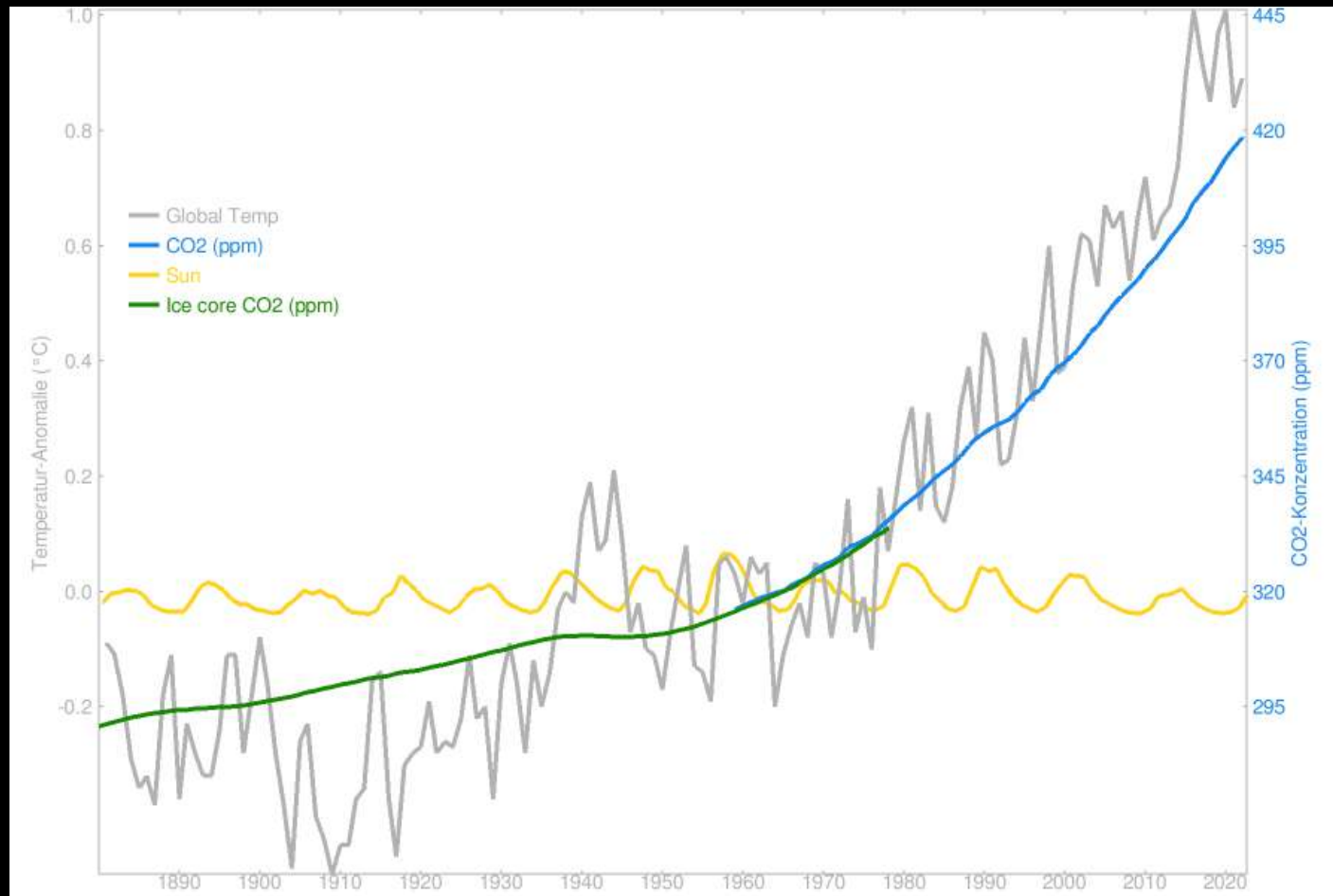
Attributions and contributions

Attributions natural/anthropogenic: Example glaciers

<https://www.science.org/doi/10.1126/science.1254702>



Contribution: CO2 from comparing curves (recap Block 2)

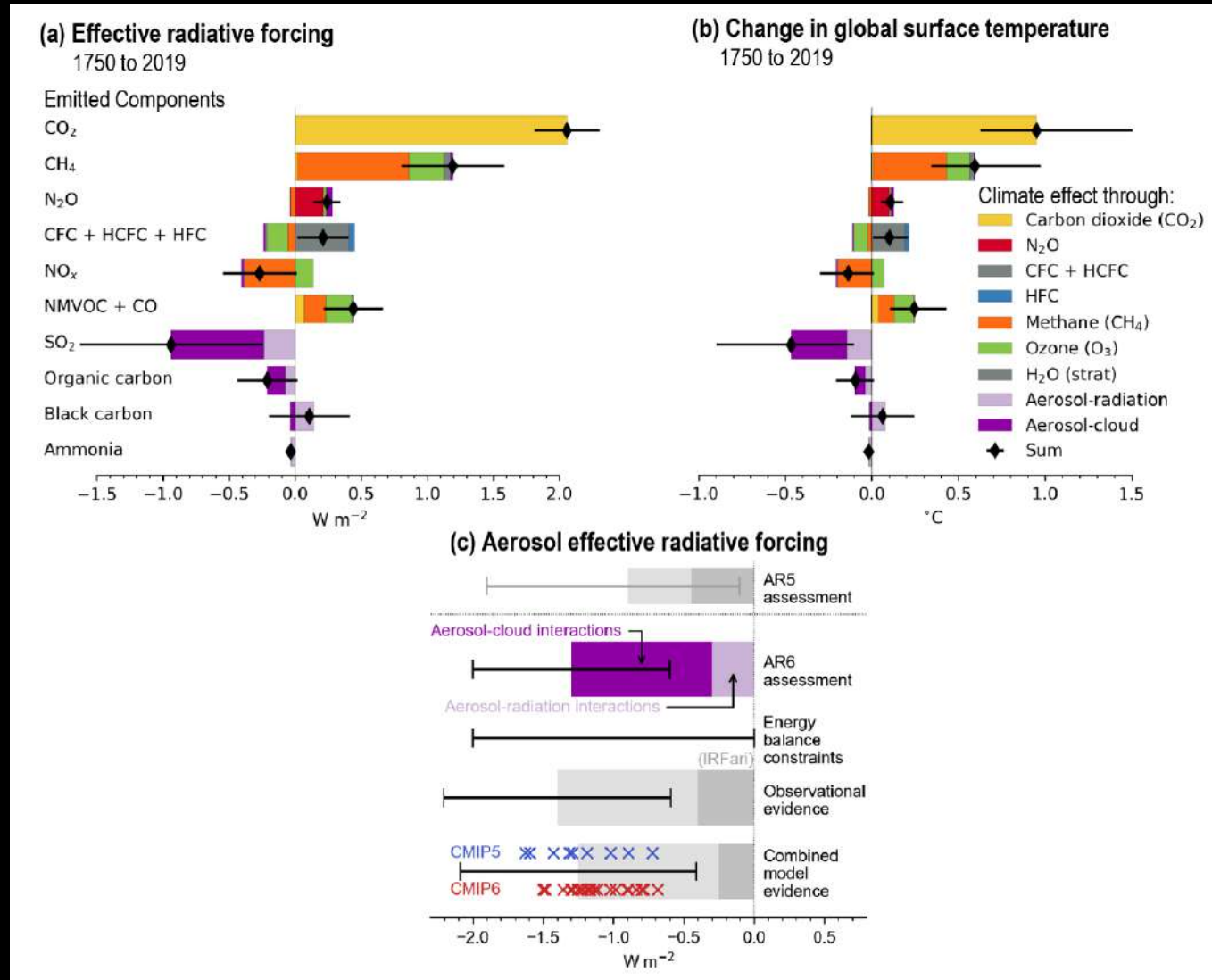


http://herdsoft.com/climate/widget/image.php?width=900&height=600&title=&temp_axis=Temperatur-Anomalie+%28%20C%29&co2_axis=CO2-Konzentration+%28ppm%29&start_year=1880

<https://www.realclimate.org/index.php/archives/2016/11/record-heat-despite-a-cold-sun/>

Contribution: Individual gases

<https://www.ipcc.ch/report/ar6/wg1/figures/chapter-6/figure-6-12>



Future scenarios

2°C scenario



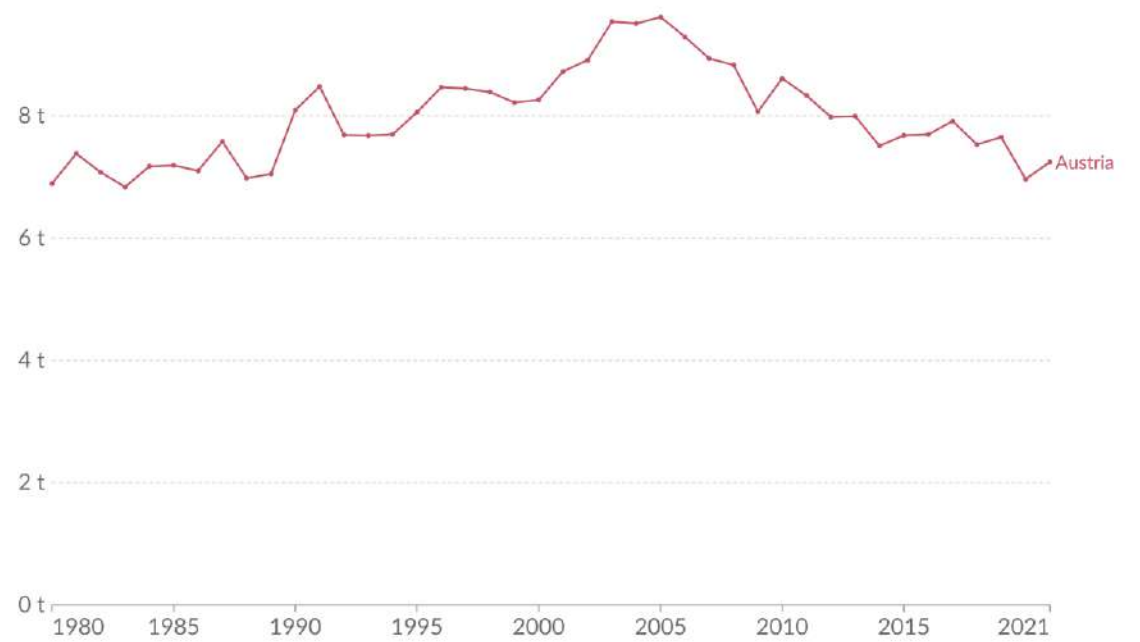
1.5°C scenario



<https://www.mcc-berlin.net/forschung/co2-budget.html>

Per capita CO₂ emissions

Carbon dioxide (CO₂) emissions from fossil fuels and industry¹. Land use change is not included.



Data source: Global Carbon Budget (2022); Population based on various sources (2023)
OurWorldInData.org/co2-and-greenhouse-gas-emissions | CC BY

¹ Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO₂) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO₂ includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

How big is a country's carbon budget, when divid

Country carbon budget for

Limit warming above pre-industrial levels to

Global Carbon Budget: **400 GtCO₂**

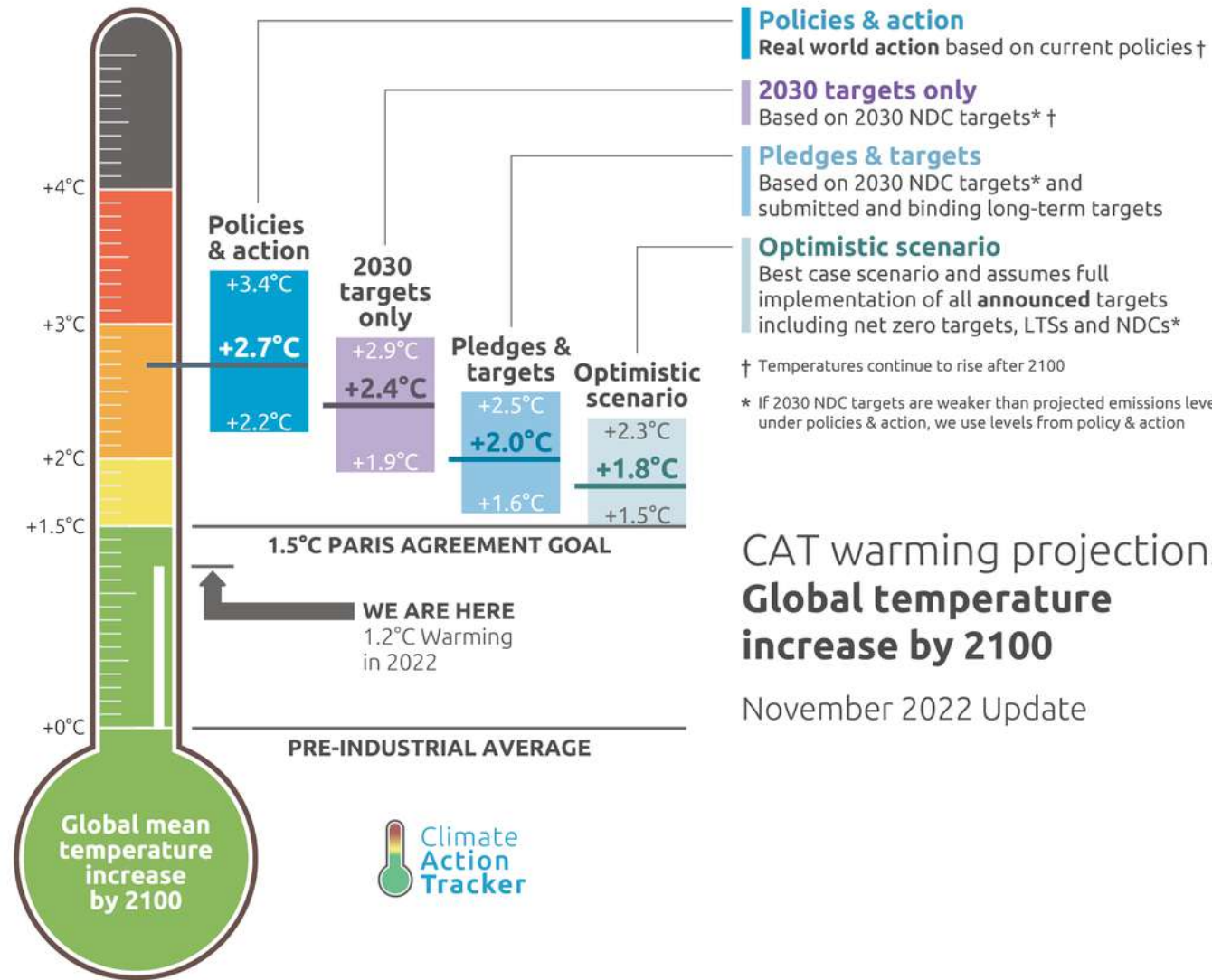
Global Fossil Carbon Budget: **360 GtCO₂**

Per Person Fossil Carbon Budget: **45.57 tCO₂**

Country population: **9,006,398**

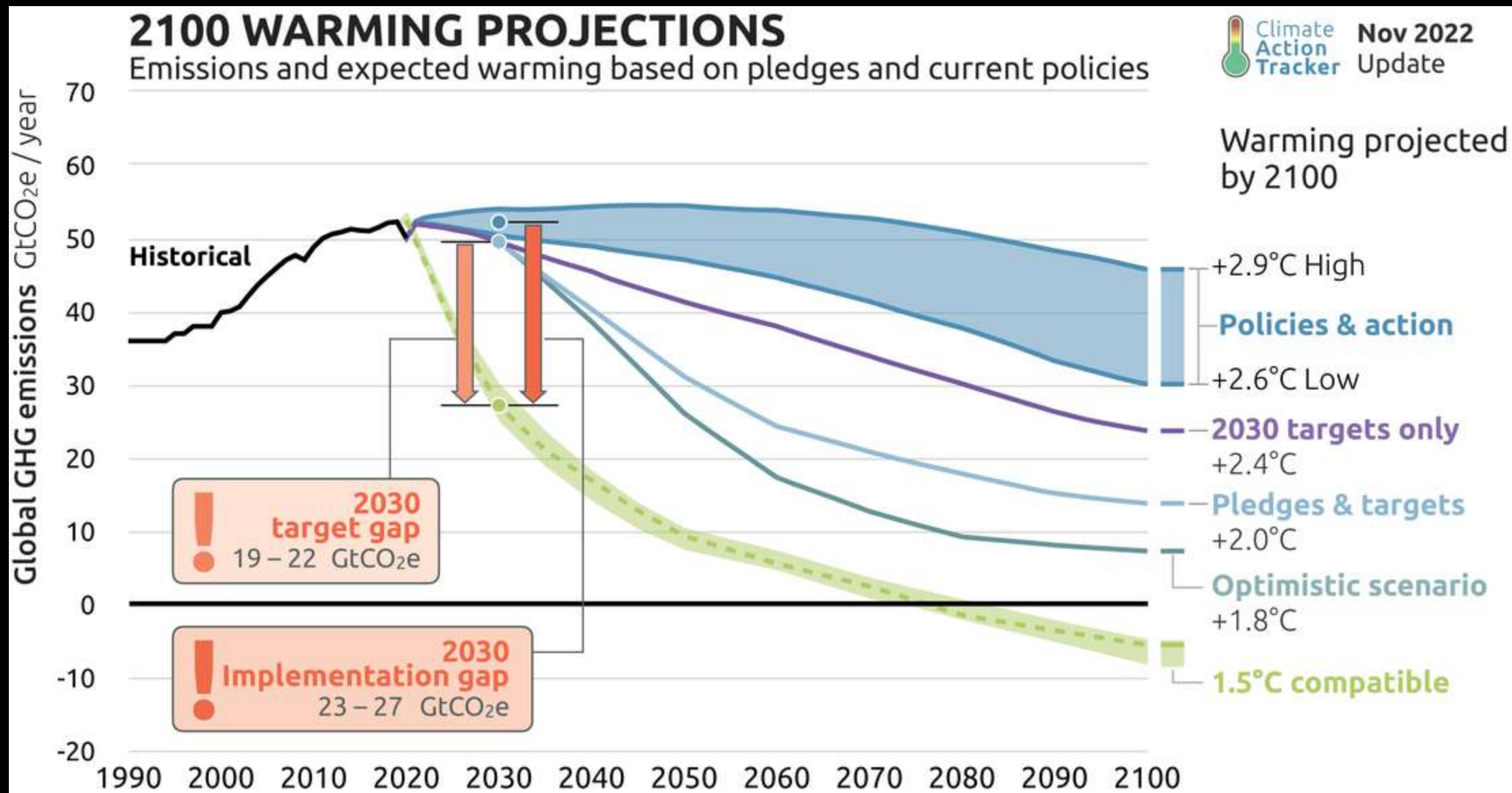
Fossil Country Carbon Budget: **410.42 MtCO₂**

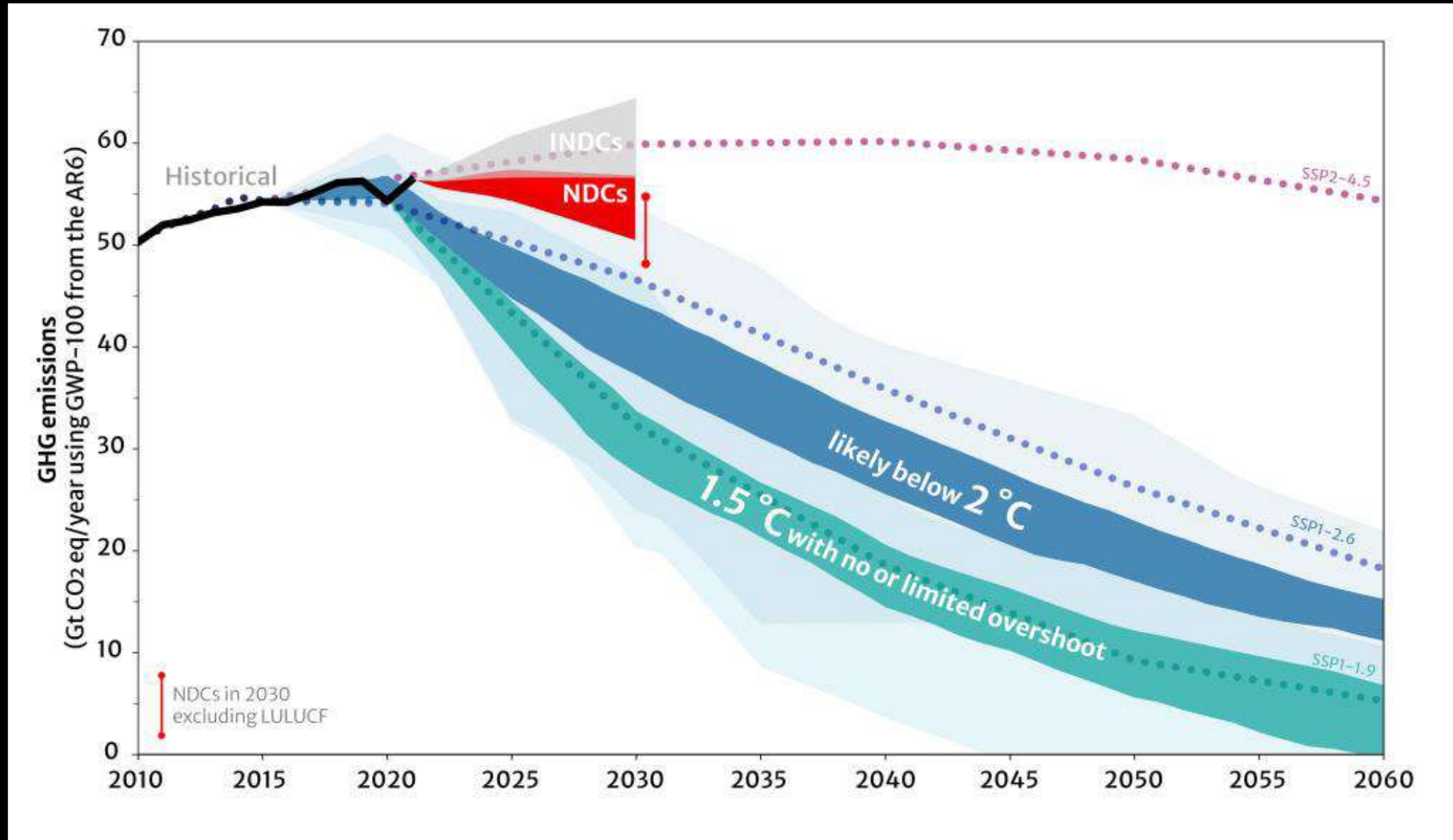
Country Carbon Emissions (fossil fuels and cement production) per year (2019): **67.96 MtCO₂**



CAT warming projections Global temperature increase by 2100

November 2022 Update

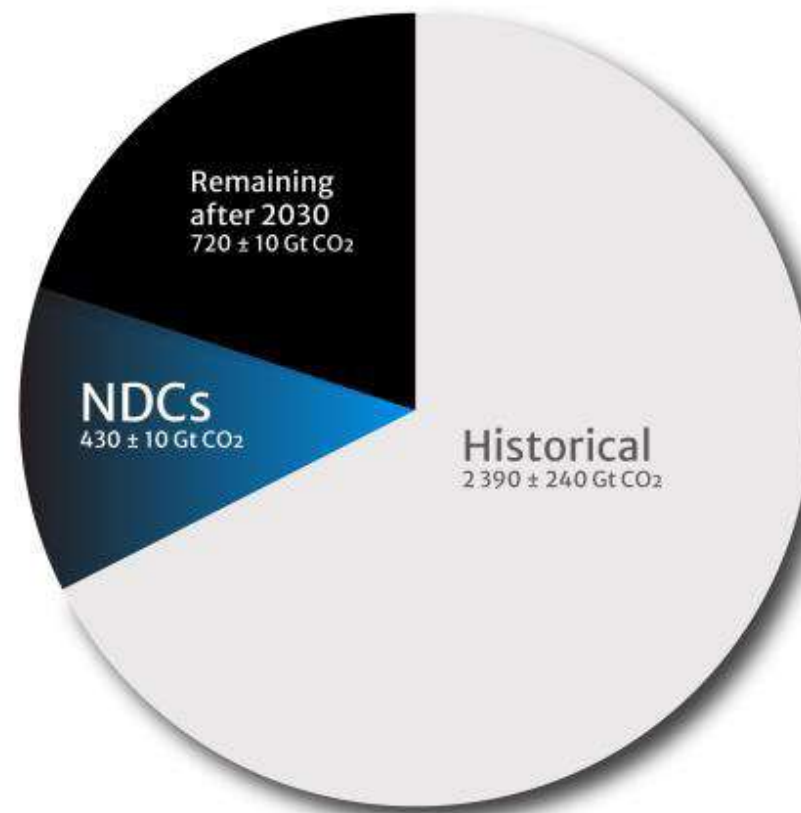


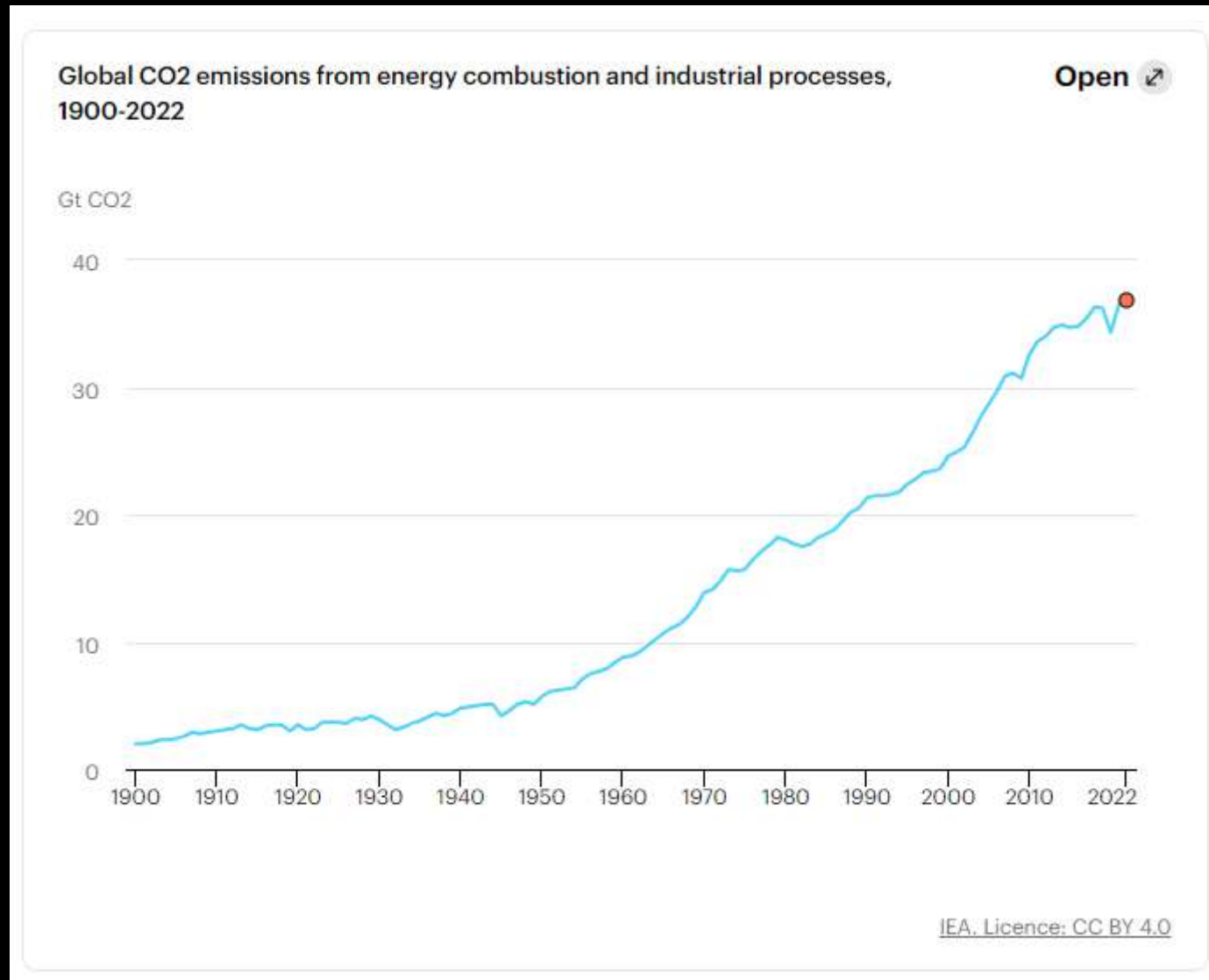


Carbon budget for a 50 per cent chance of limiting warming to 1.5 °C



Carbon budget for a 67 per cent chance of keeping warming below 2 °C

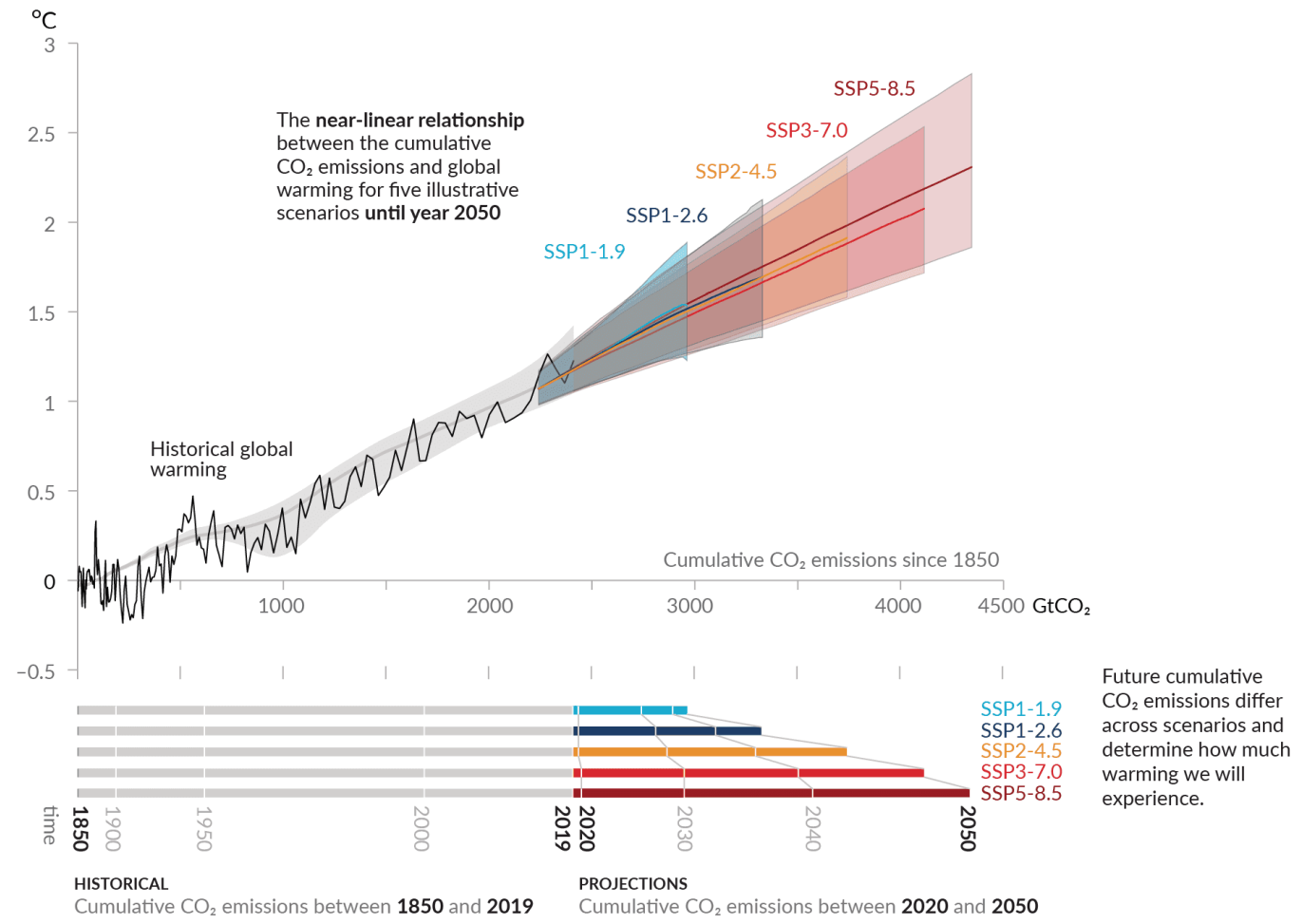




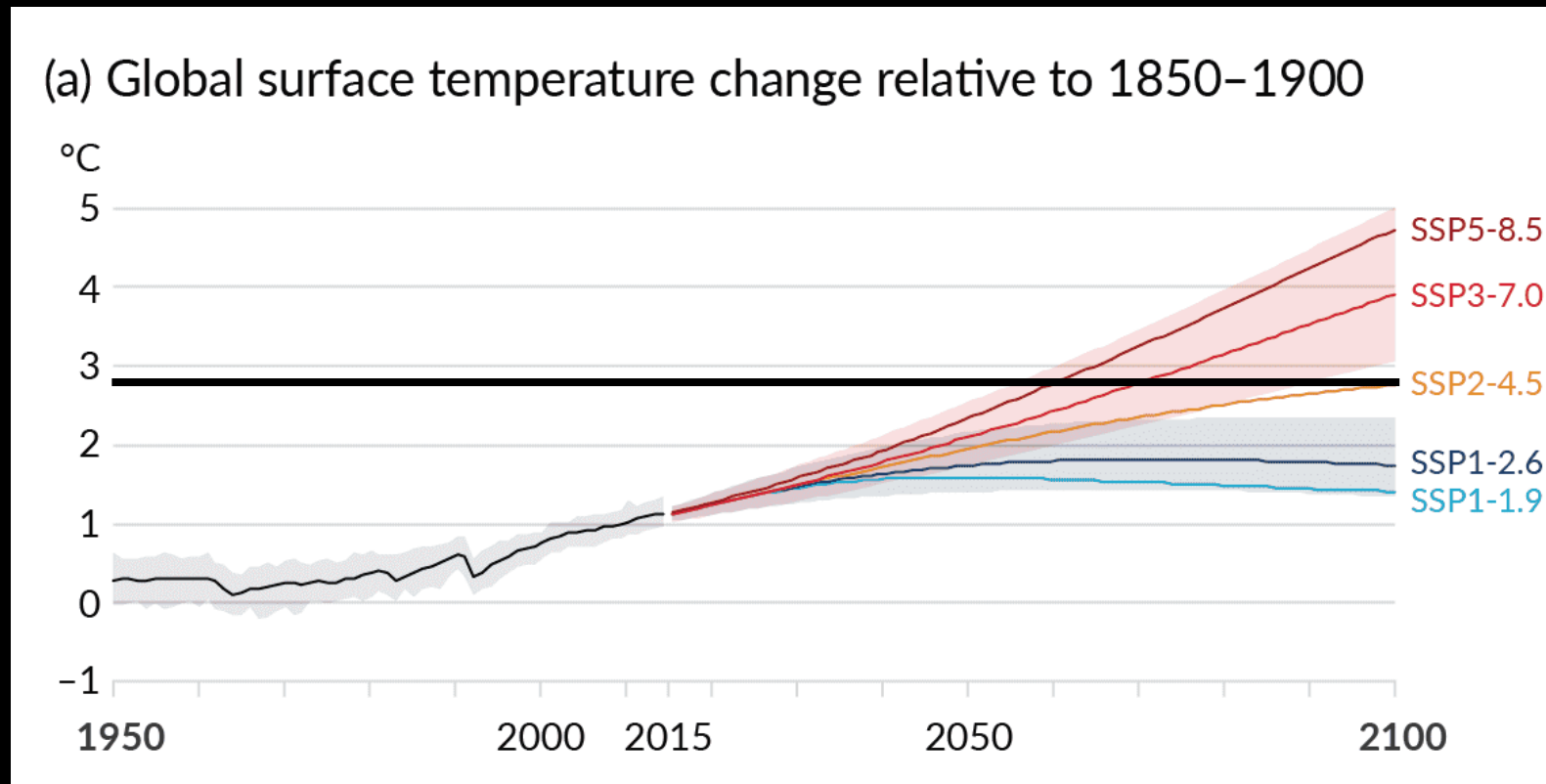
Global temperature change

Every tonne of CO₂ emissions adds to global warming

Global surface temperature increase since 1850–1900 (°C) as a function of cumulative CO₂ emissions (GtCO₂)



Global temperature scenarios

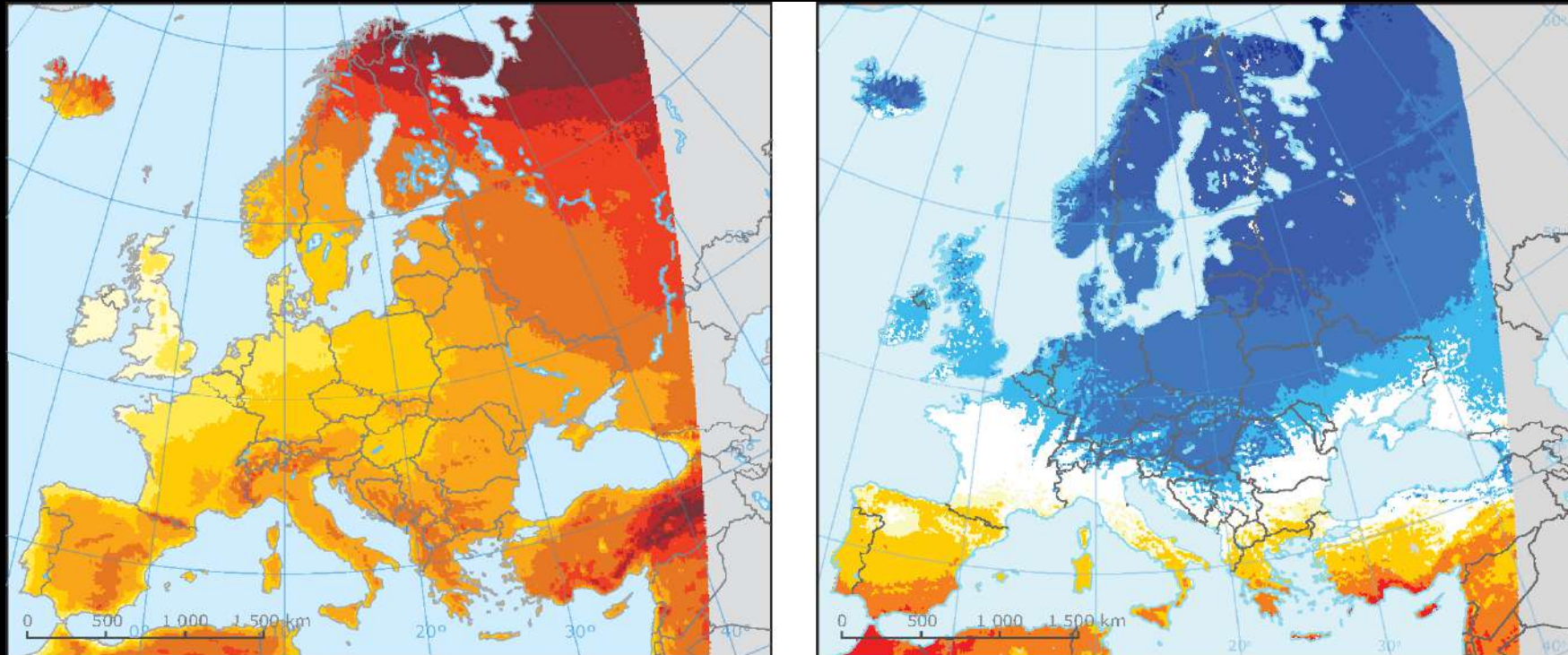


Currently realistic

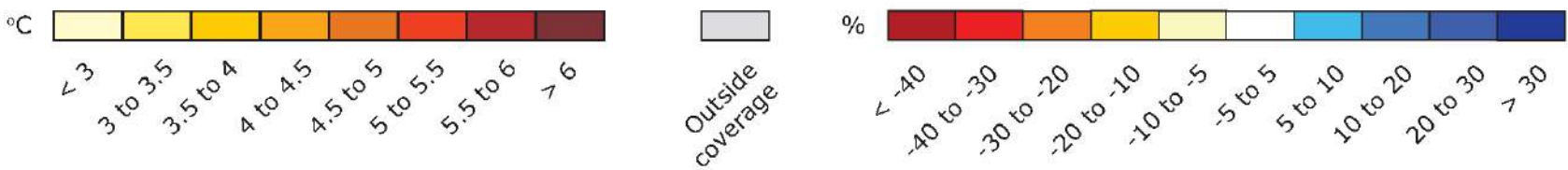
<https://www.ipcc.ch/report/ar6/wg1/figures/summary-for-policymakers/>

Regional temperature/precipitation scenarios RCP 8.5

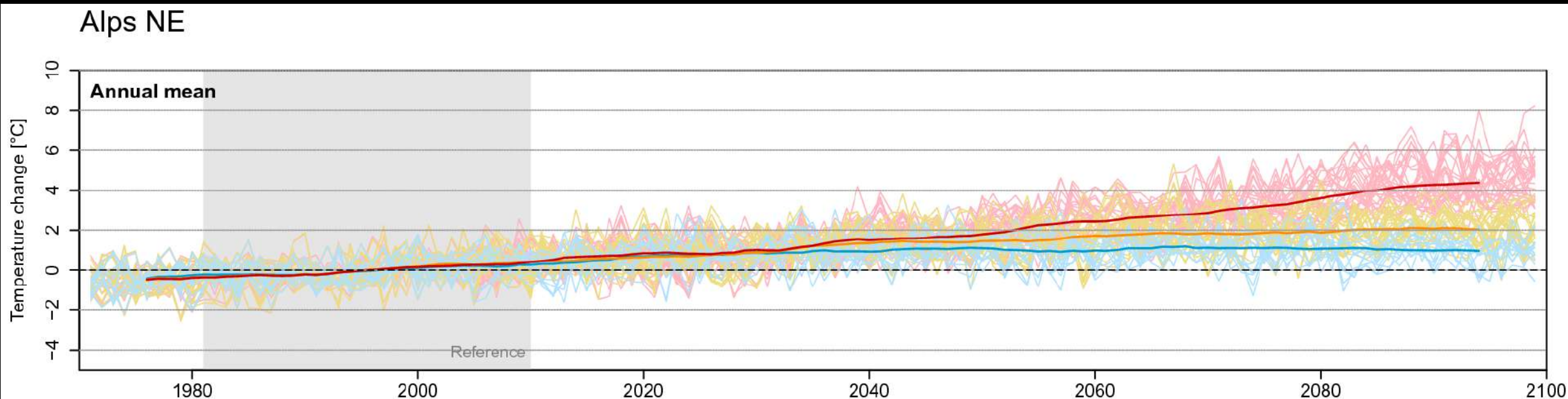
<https://www.eea.europa.eu/soer/2015/europe/climate-change-impacts-and-adaptation>



Projected changes in annual mean temperature (left) and annual precipitation (right)



Regional temperature scenarios Alps

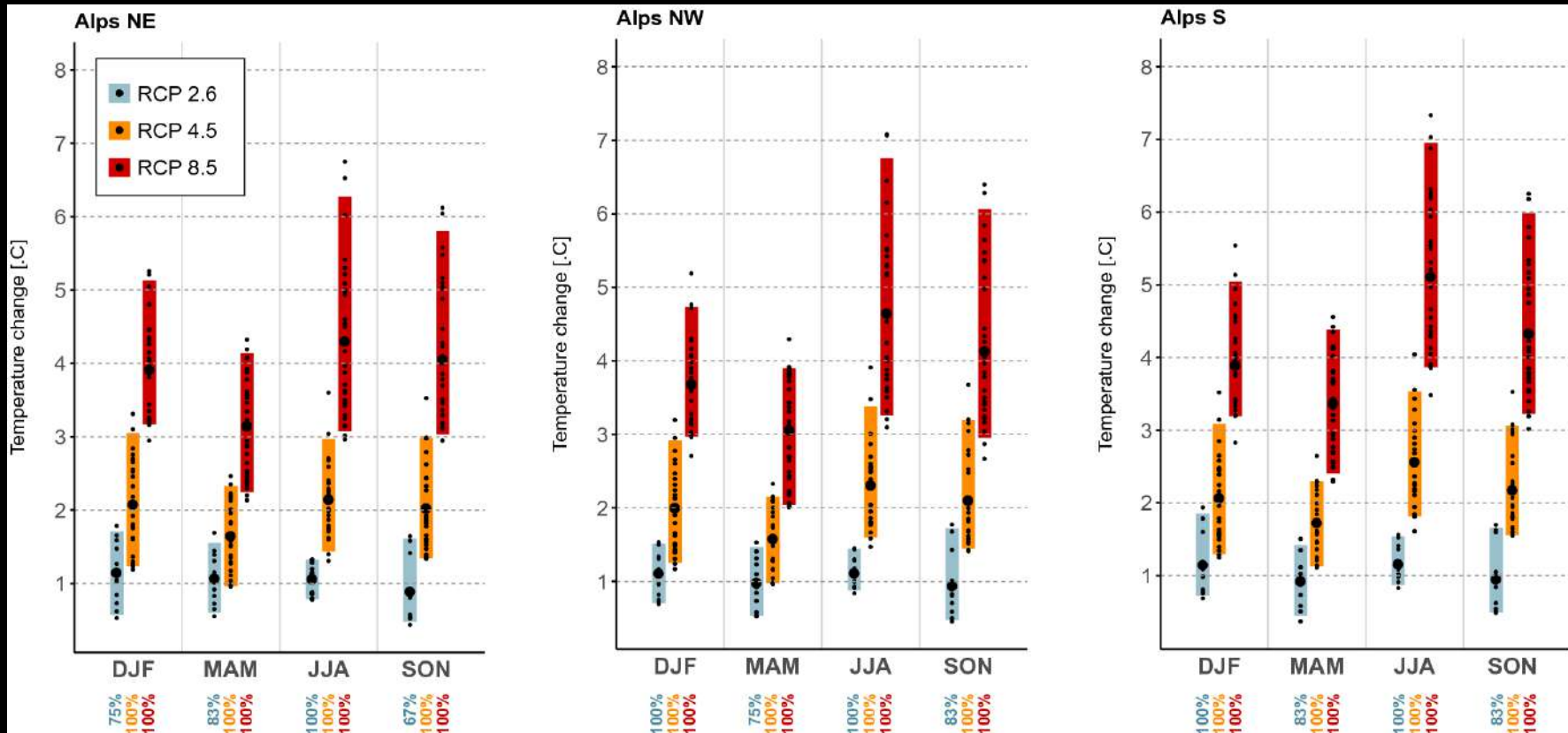


RCP 4.5:

- +1.5° compared to current conditions (approx. +4°C compared to preindustrial)

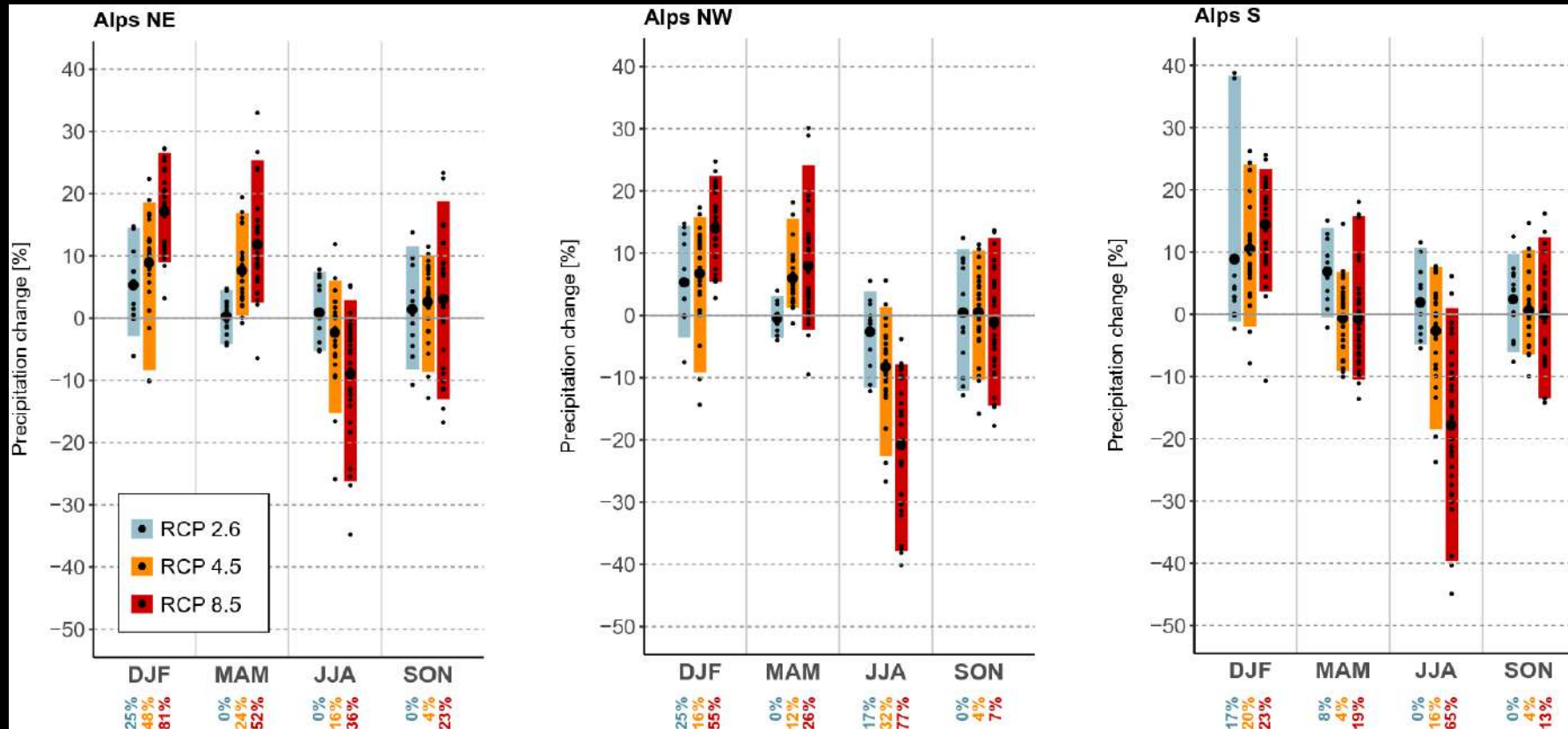
Regional temperature scenarios Alps seasons

<https://doi.org/10.1007/s00382-022-06303-3>

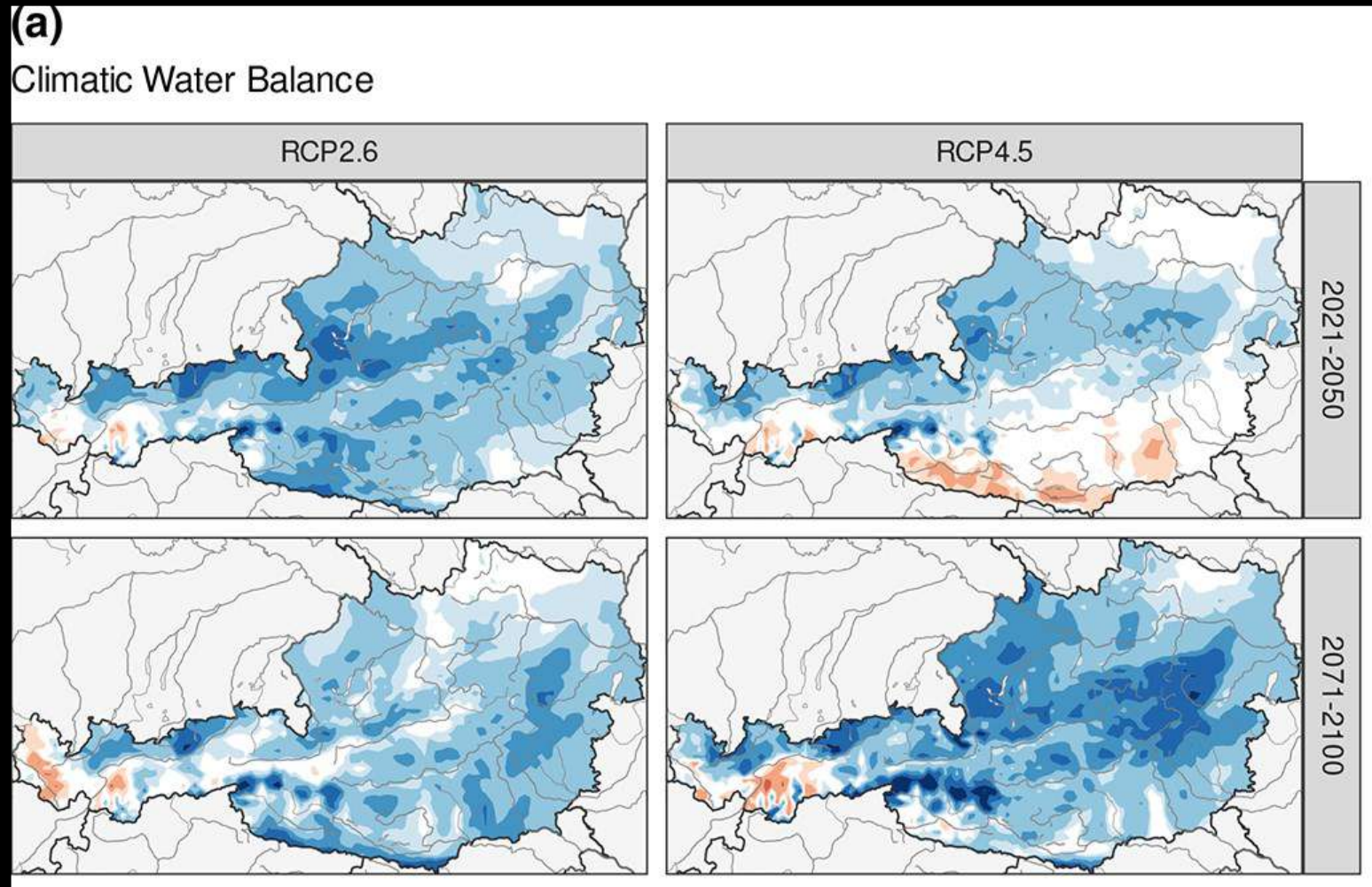


Regional precipitation scenarios Alps seasons

<https://doi.org/10.1007/s00382-022-06303-3>

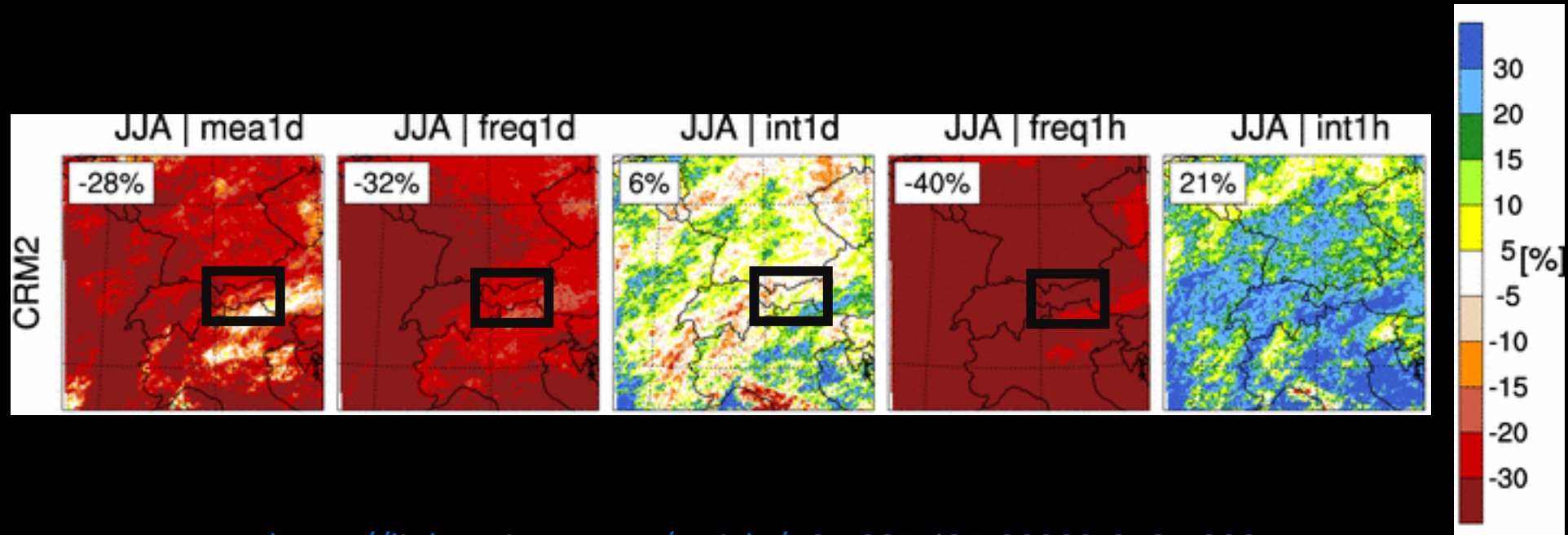


Regional water balance



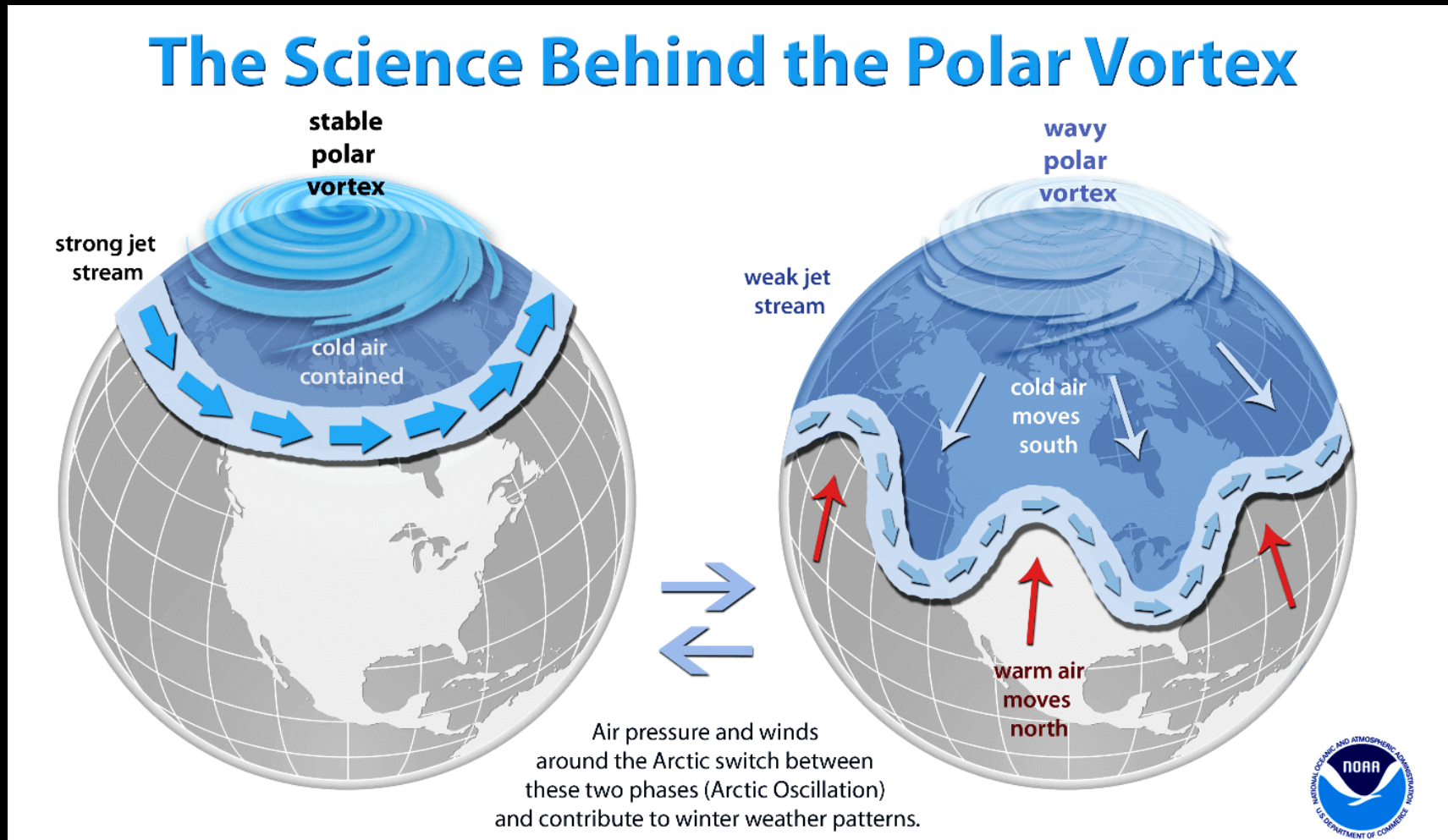
<https://nhess.copernicus.org/articles/23/2749/2023/>

Future Precipitation characteristics Alps

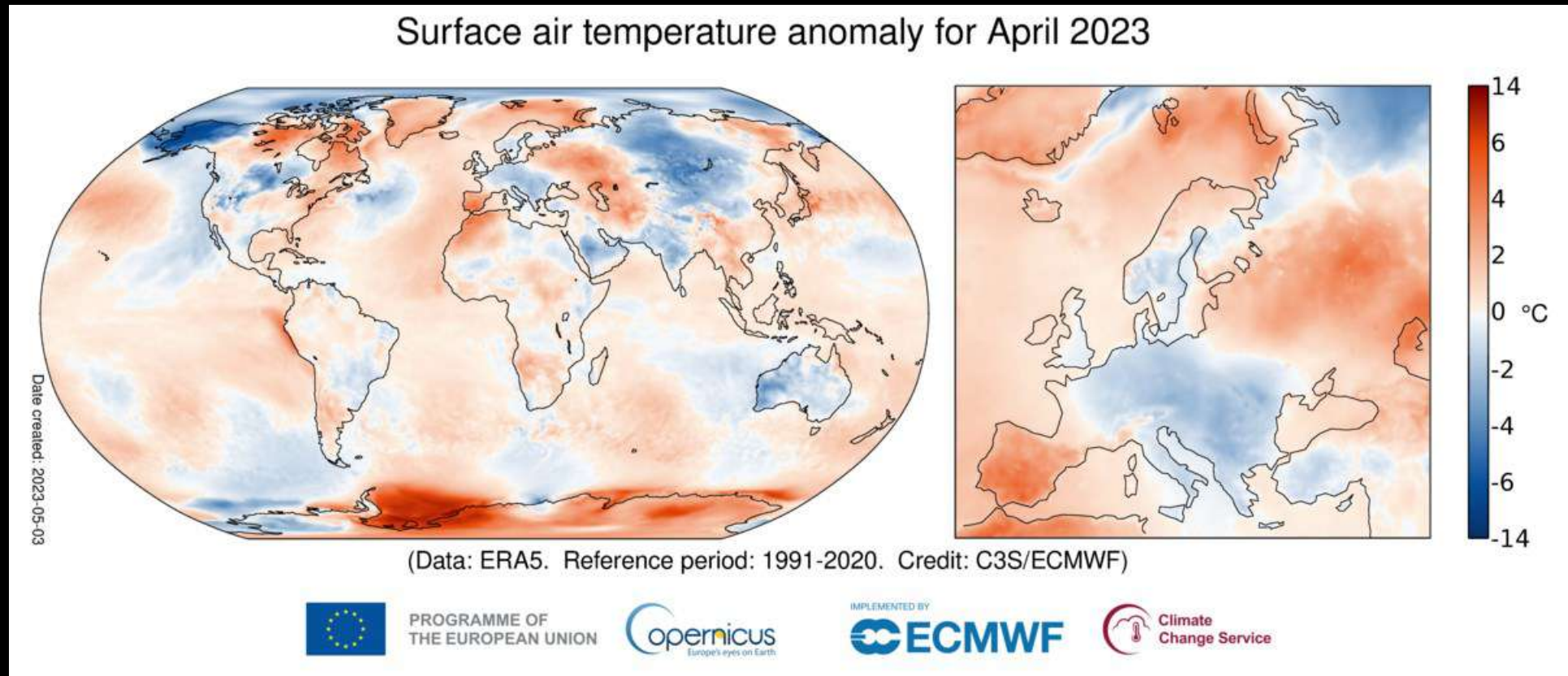


<https://link.springer.com/article/10.1007%2Fs00382-018-4339-4>

Regional Uncertainties: Frequencies of weather patterns



Regional Uncertainties: Frequencies of weather patterns



<https://climate.copernicus.eu/surface-air-temperature-april-2021>

Regional Uncertainties: Frequencies of weather patterns

Editorial Type: [Article](#)
Article Type: [Research Article](#)

More-Persistent Weak Stratospheric Polar Vortex States Linked to Cold Extremes

[Marlene Kretschmer](#), [Dim Coumou](#), [Laurie Agel](#), [Mathew Barlow](#), [Eli Tziperman](#), and [Judah Cohen](#)

Print Publication: 01 Jan 2018
DOI: <https://doi.org/10.1175/BAMS-D-16-0259.1>
Page(s): 49–60

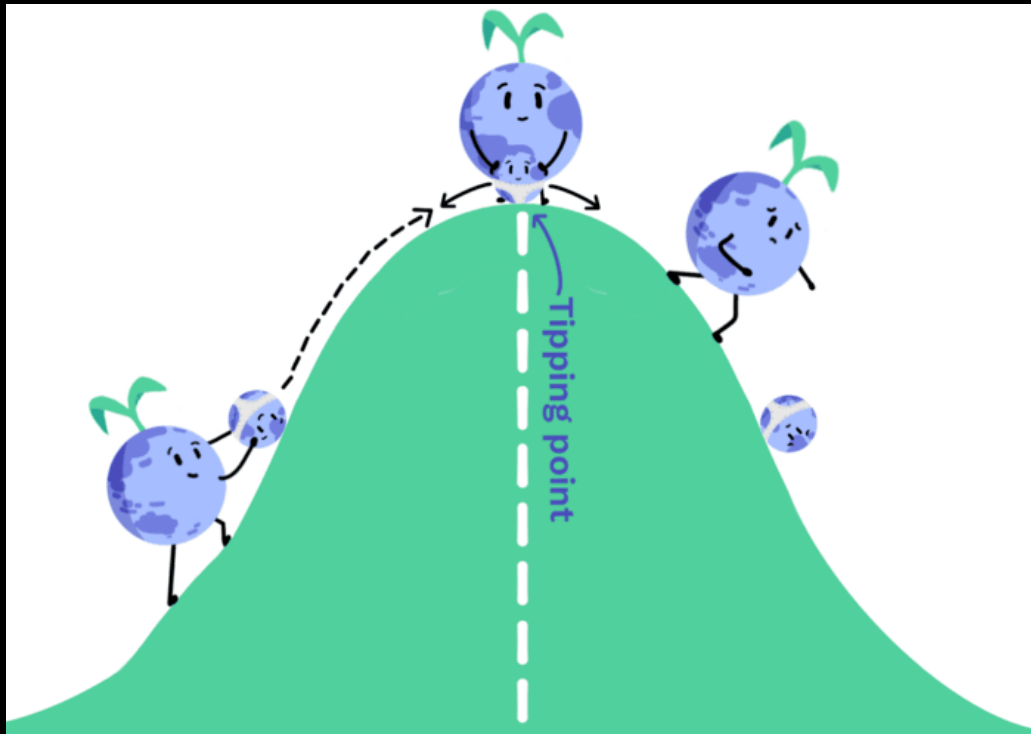
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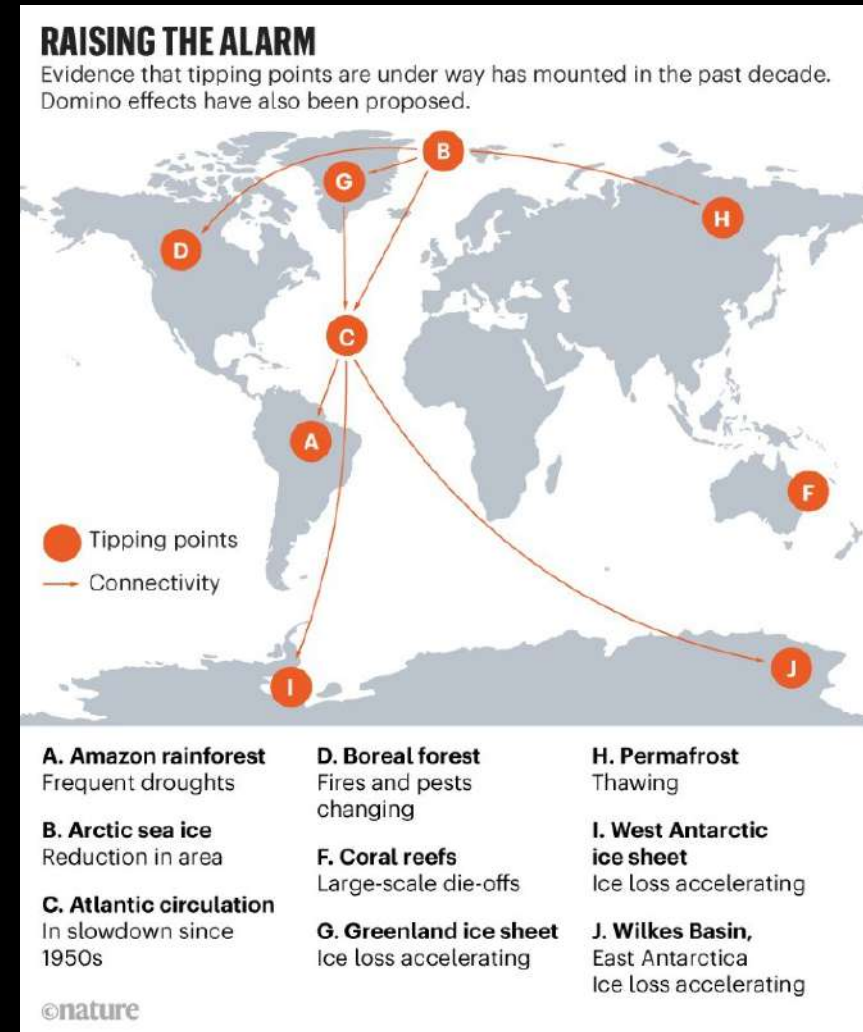
Interaction between polar vortex and arctic sea ice (decrease)
not well understood yet

<https://journals.ametsoc.org/view/journals/bams/99/1/bams-d-16-0259.1.xml>

Uncertainties /Risks for evolution 2100+: Tipping points

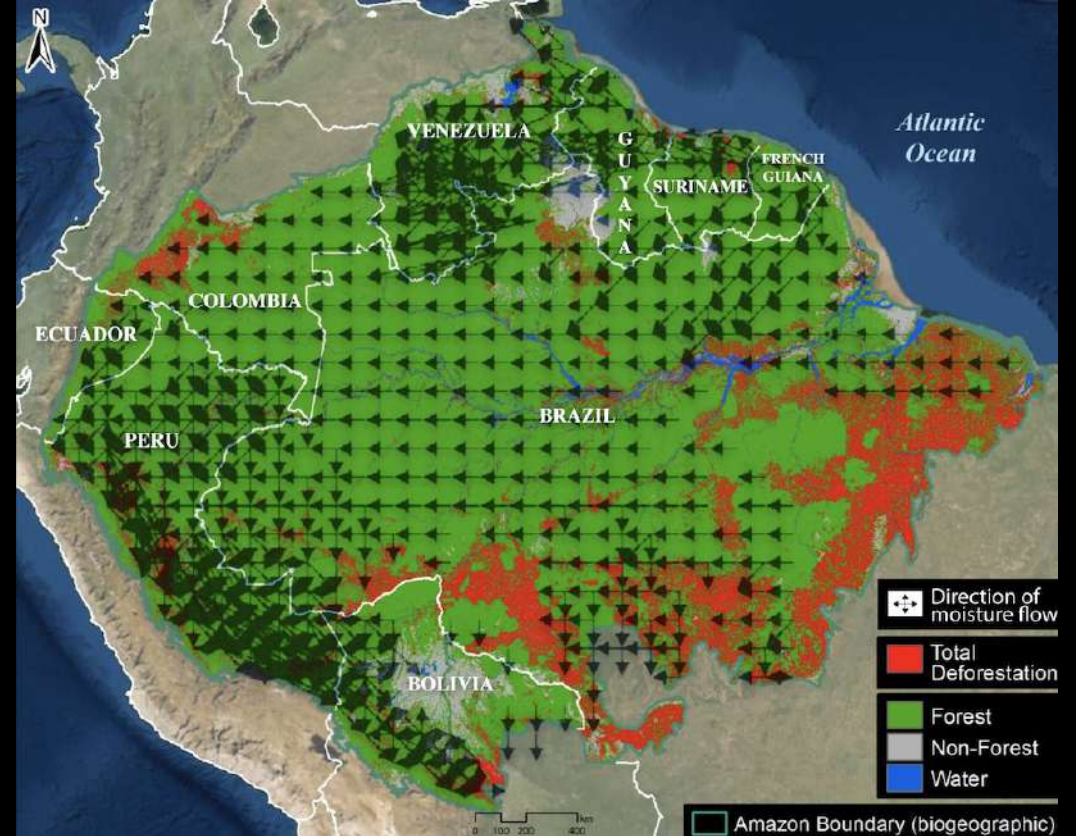


<https://climatescience.org/advanced-climate-climate-tipping-points>



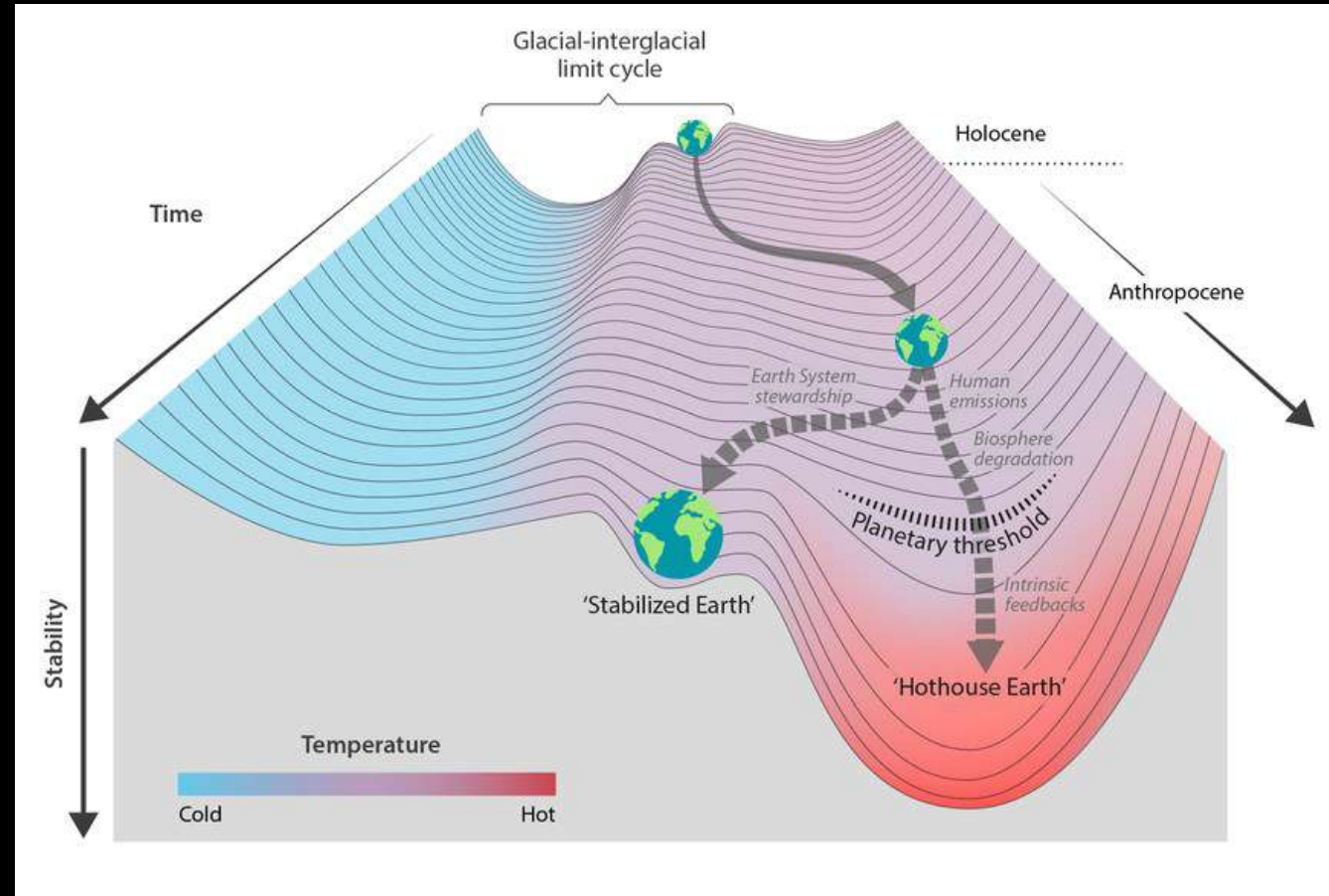
Uncertainties /Risks for evolution 2100+: Tipping points

<https://www.eurekalert.org/news-releases/691405>



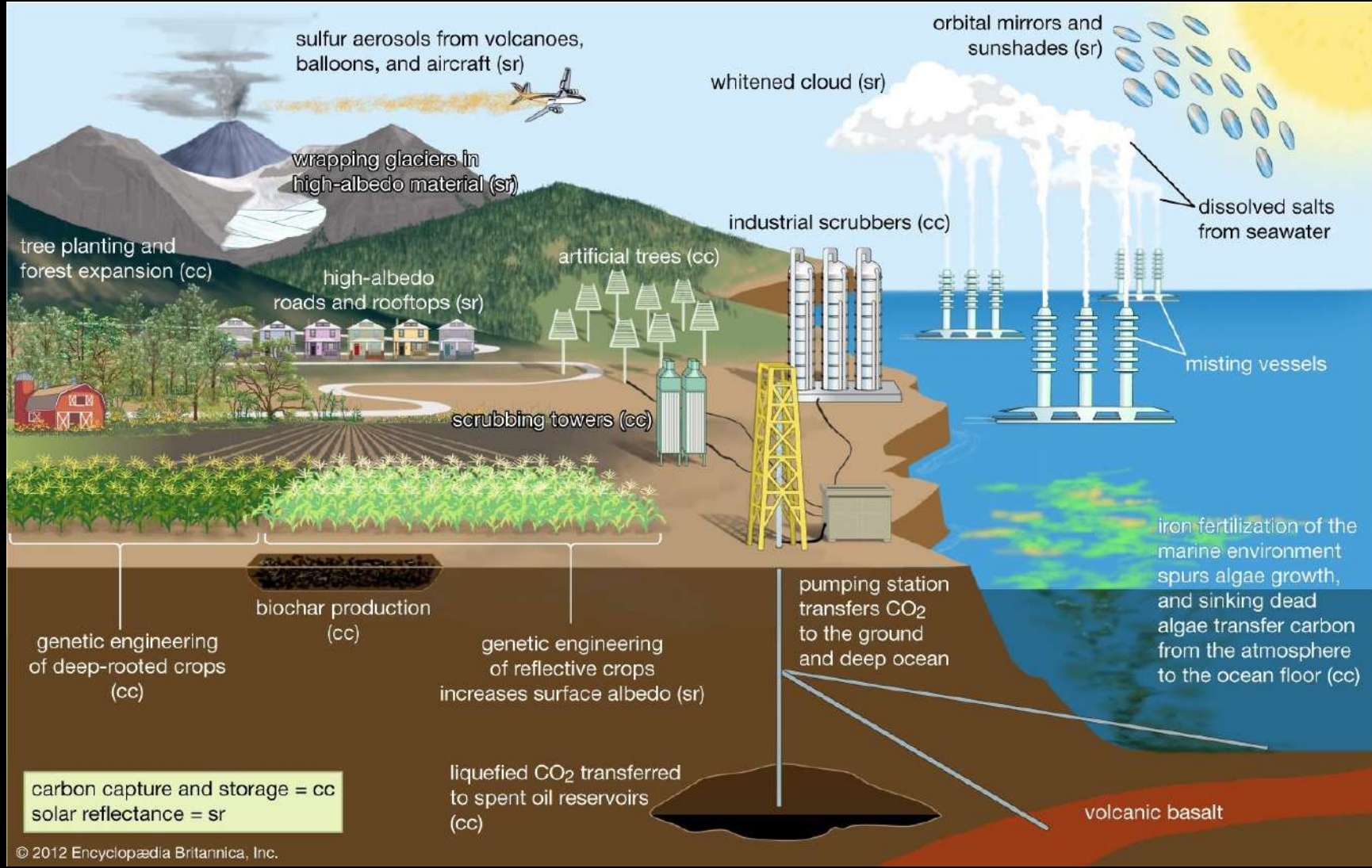
<https://news.mongabay.com/2022/09/how-close-is-the-amazon-tipping-point-forest-loss-in-the-east-changes-the-equation/#:~:text=Scientists%20warn%20that%20the%20Amazon,of%20the%20forest%20is%20lost>

Uncertainties /Risks for evolution 2100+



„Hothouse Earth“ – will Geoengineering safe us?

<https://www.britannica.com/science/geoengineering>



„Hothouse Earth“ – will Geoengineering safe us?

OPEN LETTER

We Call for an International Non-Use Agreement on Solar Geoengineering

We call for immediate political action from governments, the United Nations, and other actors to prevent the normalization of solar geoengineering as a climate policy option. Governments and the United Nations must assert effective political control and restrict the development of solar geoengineering technologies at planetary scale. Specifically, we call for an International Non-Use Agreement on Solar Geoengineering.

<https://www.solargeoeng.org/non-use-agreement/open-letter/>

<https://www.klimareporter.de/technik/soll-geoengineering-verboten-werden>

Initiative von 50 Wissenschaftlern

18.01.2022

Sollte Geoengineering verboten werden?

Ob die Klimaerwärmung bei 1,5 Grad gestoppt werden kann, ist zweifelhaft. Doch was dann? Einige Wissenschaftler schlagen vor, das Klima mit Aerosolen zu kühlen. Andere fordert jetzt ein Abkommen, um das Dimmen der Sonne zu verbieten. Ein Konsens ist nicht in Sicht.

von Christoph Müller, Jörg Staude



Summary

- Globally, temperature has increase around 1.3°C compared to pre-industrial values
- Regionally and/or over land, the temperature increases are stronger (e.g. currently $\sim 2.5^{\circ}\text{C}$ in Innsbruck compared to pre-industrial)
- It's human greenhouse gas emissions that are causing the exceptional fast temperature increase
- Future scenarios strongly depend on future emissions – current politics might yield almost $+3^{\circ}\text{C}$ (compared to pre-industrial) warming until 2100
- Regionally, changes in temperature are expected to still be amplified – e.g. $+4^{\circ}\text{C}$ (compared to pre-industrial) in the Alps expected (similar for parts of Ukraine)
- Multiple feedbacks between the components of the climate system – risk of crossing tipping points!