Climate change – present and future extremes

IPCC Update: Selected Assessments and Regional Differences

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IPCC Lead Author, AR6 (2018–2023)

IPCC Contributing Author, AR5 (2009–2013)

(Update 07.01)

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A Changing Climate System is about:

- The Global Carbon Cycle
- The Radiation and Energy Balances
- The Water Balance

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A Changing Climate System is about:

- Trends
- Variations/Oscillations
- Extremes (frequency, intensity, duration, space, and links to coupled events)

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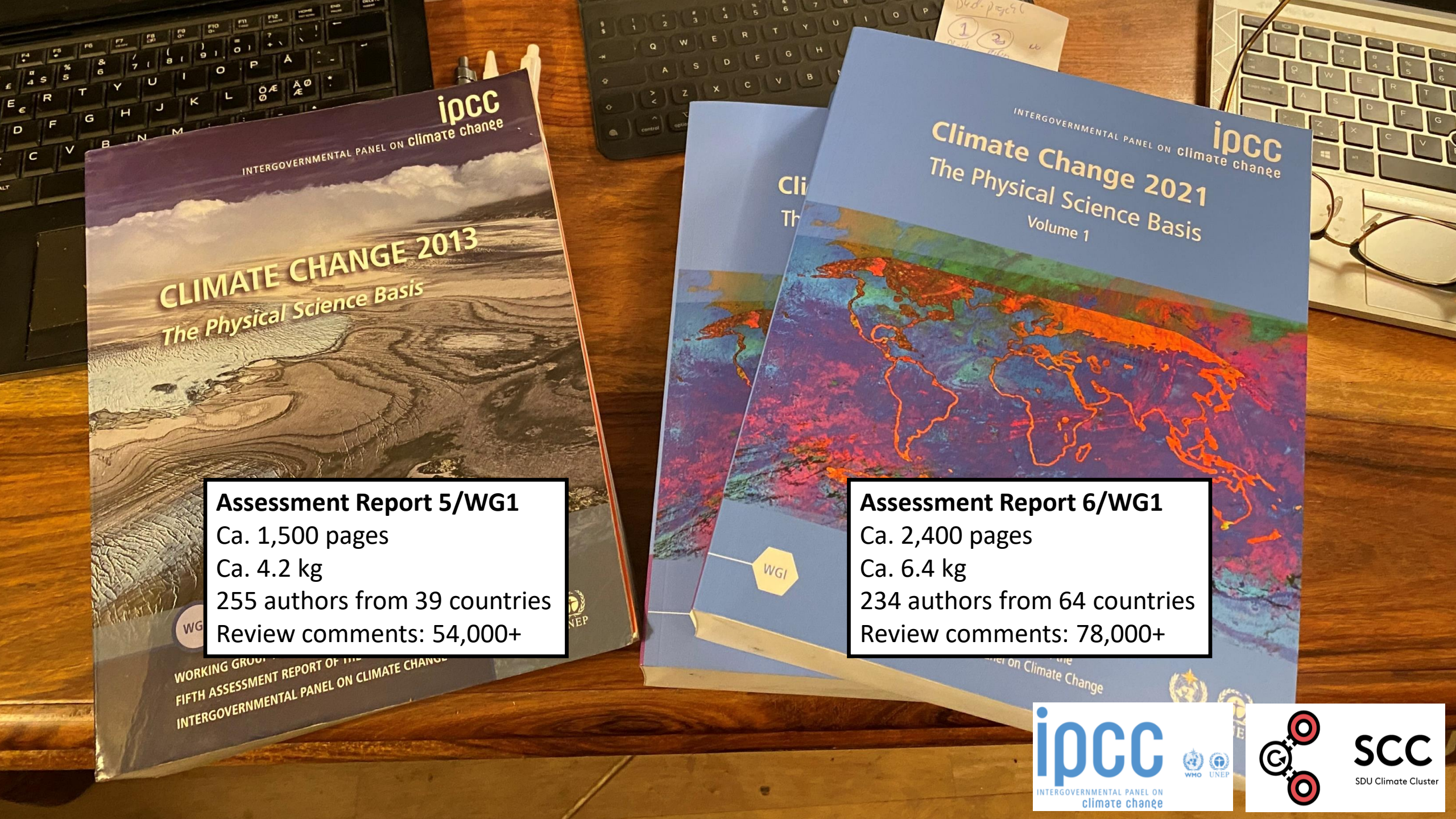
In the field

Automatic Weather Stations

WORKING GROUP I CONTRIBUTION TO THE IPCC SIXTH ASSESSMENT REPORT

FIRST LEAD AUTHOR MEETING

GUANGZHOU, CHINA, 25-29 JUNE 2018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CLIMATE CHANGE 2013
The Physical Science Basis
WORKING GROUP I CONTRIBUTION TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
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INTERGOVERNMENTAL PANEL ON climate change
Climate Change 2021
The Physical Science Basis
Volume 1
WGI
Assessment Report 5/WG1
Ca. 1,500 pages
Ca. 4.2 kg
255 authors from 39 countries
Review comments: 54,000+
Assessment Report 6/WG1
Ca. 2,400 pages
Ca. 6.4 kg
234 authors from 64 countries
Review comments: 78,000+
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INTERGOVERNMENTAL PANEL ON Climate Change

CLIMATE CHANGE 2023

Synthesis Report

Summary for Policymakers

A Report of the Intergovernmental Panel on Climate Change

AR6 Synthesis Report

Climate Change 2023

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CO2 concentration is today higher than at any time **in at least 2 million years**

Cumulative net CO2 emissions: **About 42%** occurred between 1990–2019

Human activities have **unequivocally caused global warming** of **1.1°C** since 1850–1900

Surface temperature has increased fast since 1970, looking back 2000 years

Evidence of **observed changes in extremes** e.g. heatwaves, heavy precipitation, droughts, and tropical cyclones

Human influence was *very likely* the main driver of **sea level rise** increases, since at least 1971

AR6 Synthesis Report

Climate Change 2023

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There are gaps between projected emissions from implemented policies and those from NDCs

If climate goals are to be achieved, both adaptation and mitigation **financing would need to increase many-fold**

Limit warming to 1.5°C (>50%) with no/limited overshoot, **global GHG emissions are reduced by 43% by 2030**, relative to 2019

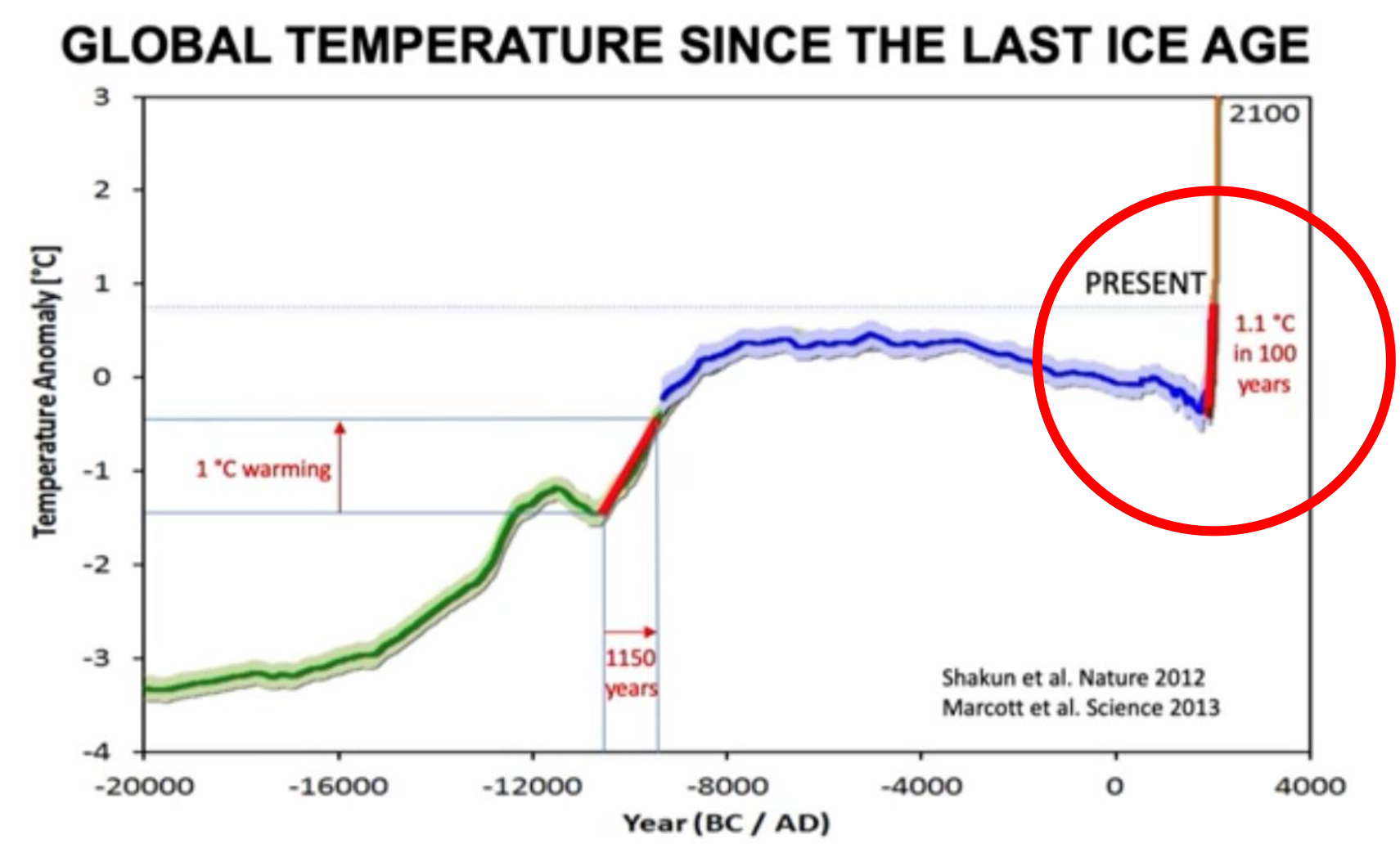
Deep, rapid, and sustained reductions in GHG emissions would lead to a **discernible slowdown in global warming** within around two decades…and

Overshooting 1.5°C will result in **irreversible adverse impacts on certain ecosystems with low resilience**

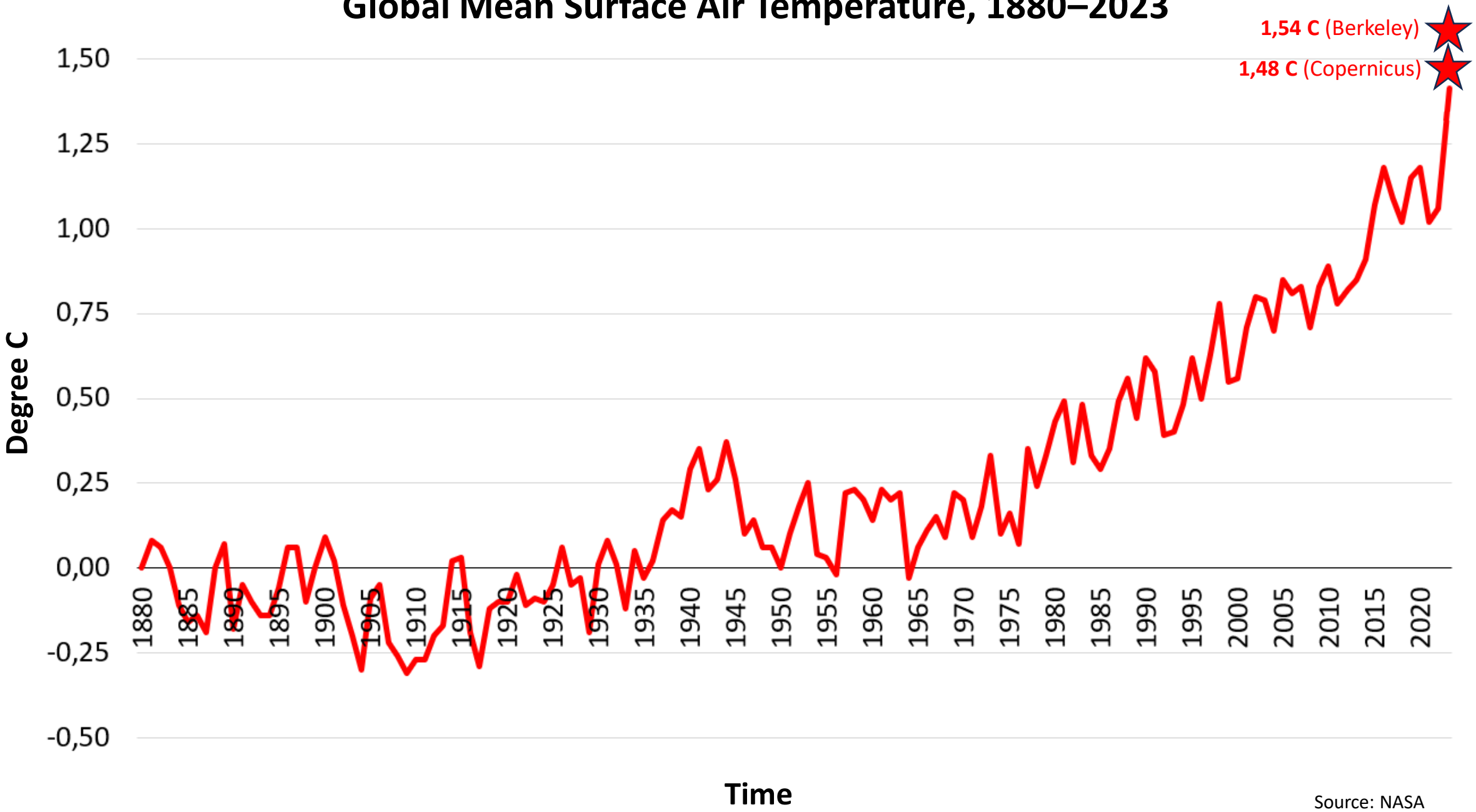
….would reduce projected losses and damages for humans and ecosystems

Our climate is changing – Temperatures!

Our climate is changing – Water!


GLOBAL TEMPERATURE SINCE THE LAST ICE AGE
Temperature Anomaly [°C]
3
2
1
0
-1
-2
-3
-4
2100
PRESENT
1.1 °C
in 100
years
1 °C warming
1150
years
Shakun et al. Nature 2012
Marcott et al. Science 2013
-20000
-16000
-12000
-8000
-4000
0
4000
Year (BC / AD)

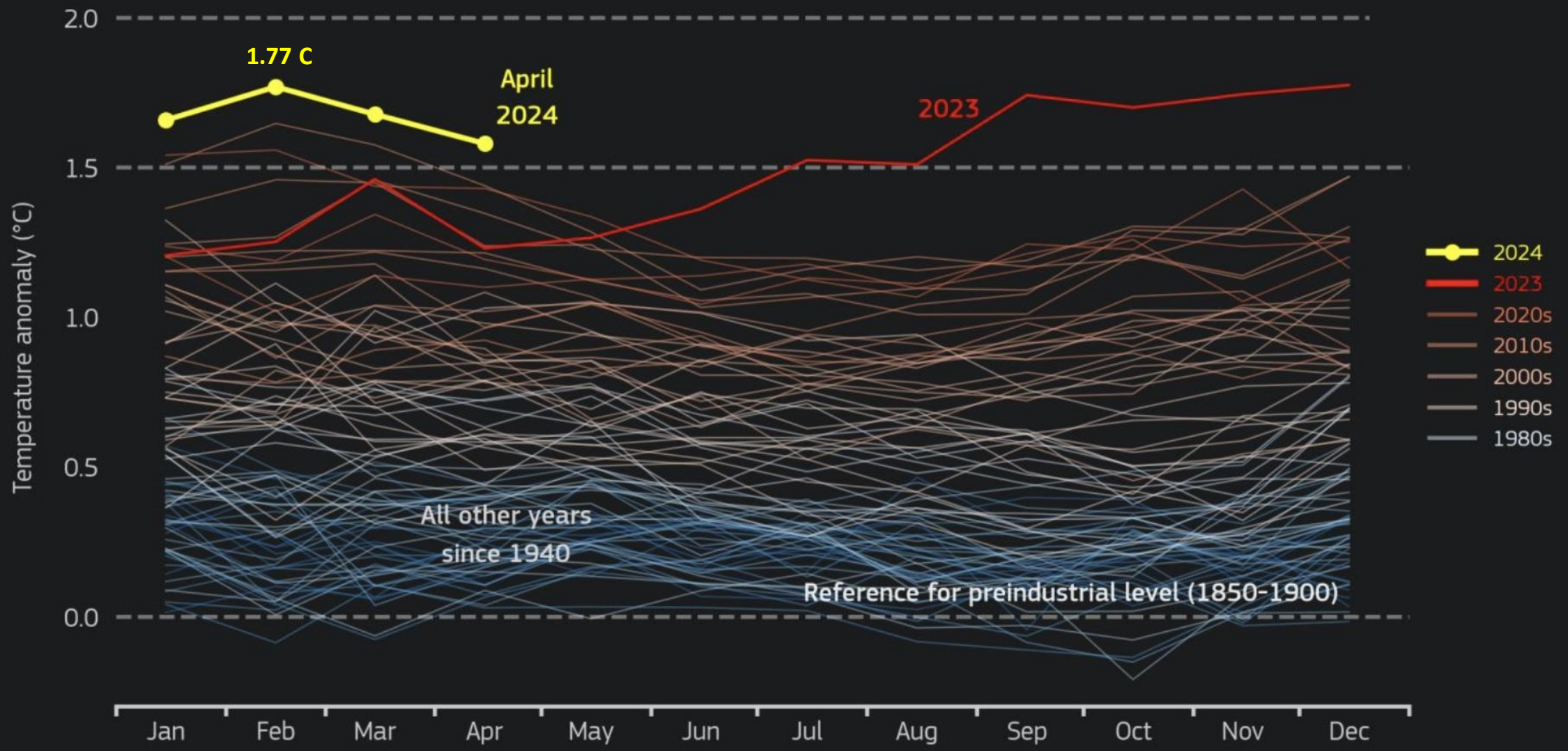
Global Mean Surface Air Temperature, 1880–2023



Source: NASA

Monthly global surface air temperature anomalies

Data: ERA5 1940–2024 • Reference period: 1850-1900 • Credit: C3S/ECMWF



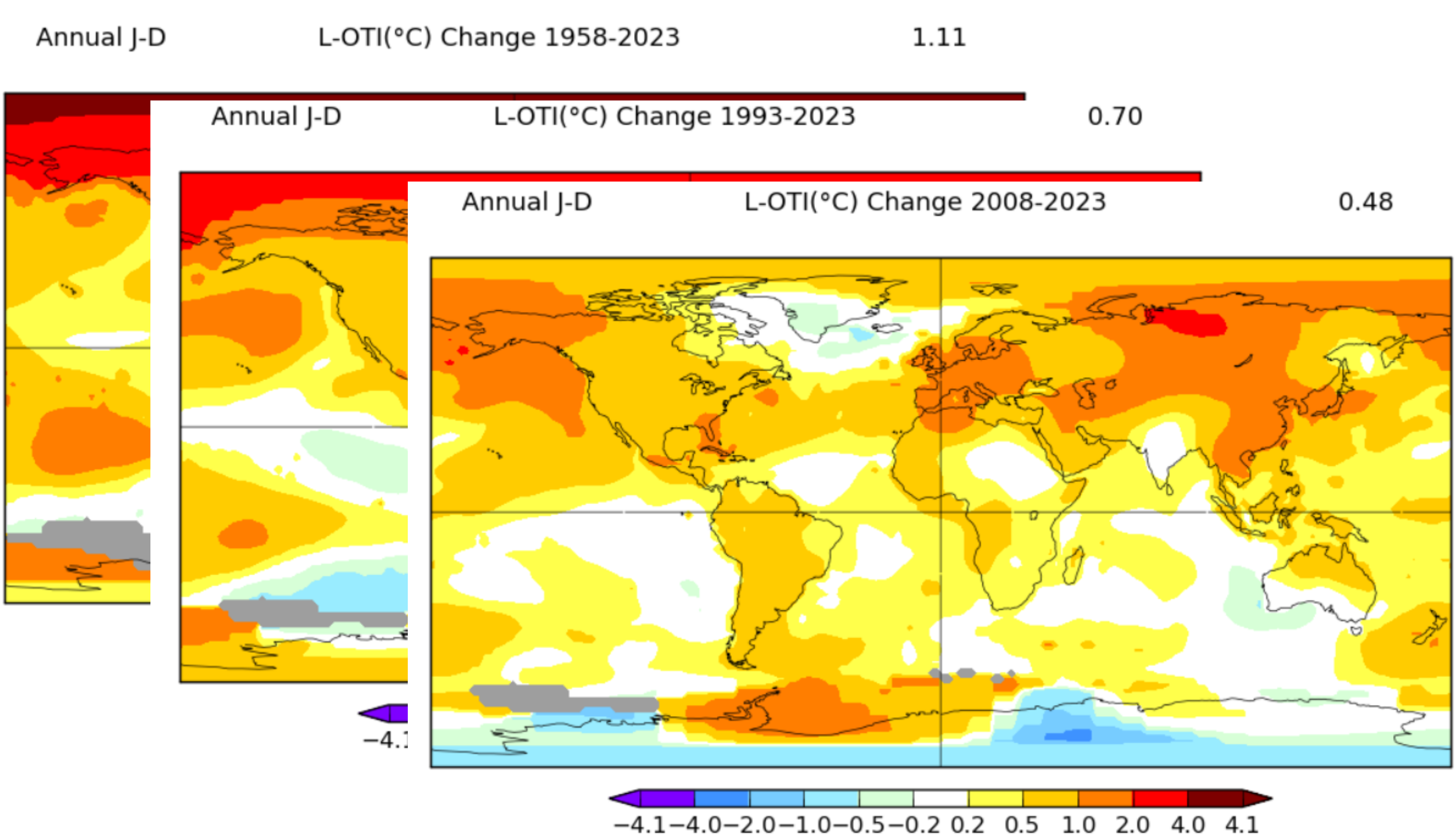
PROGRAMME OF THE EUROPEAN UNION

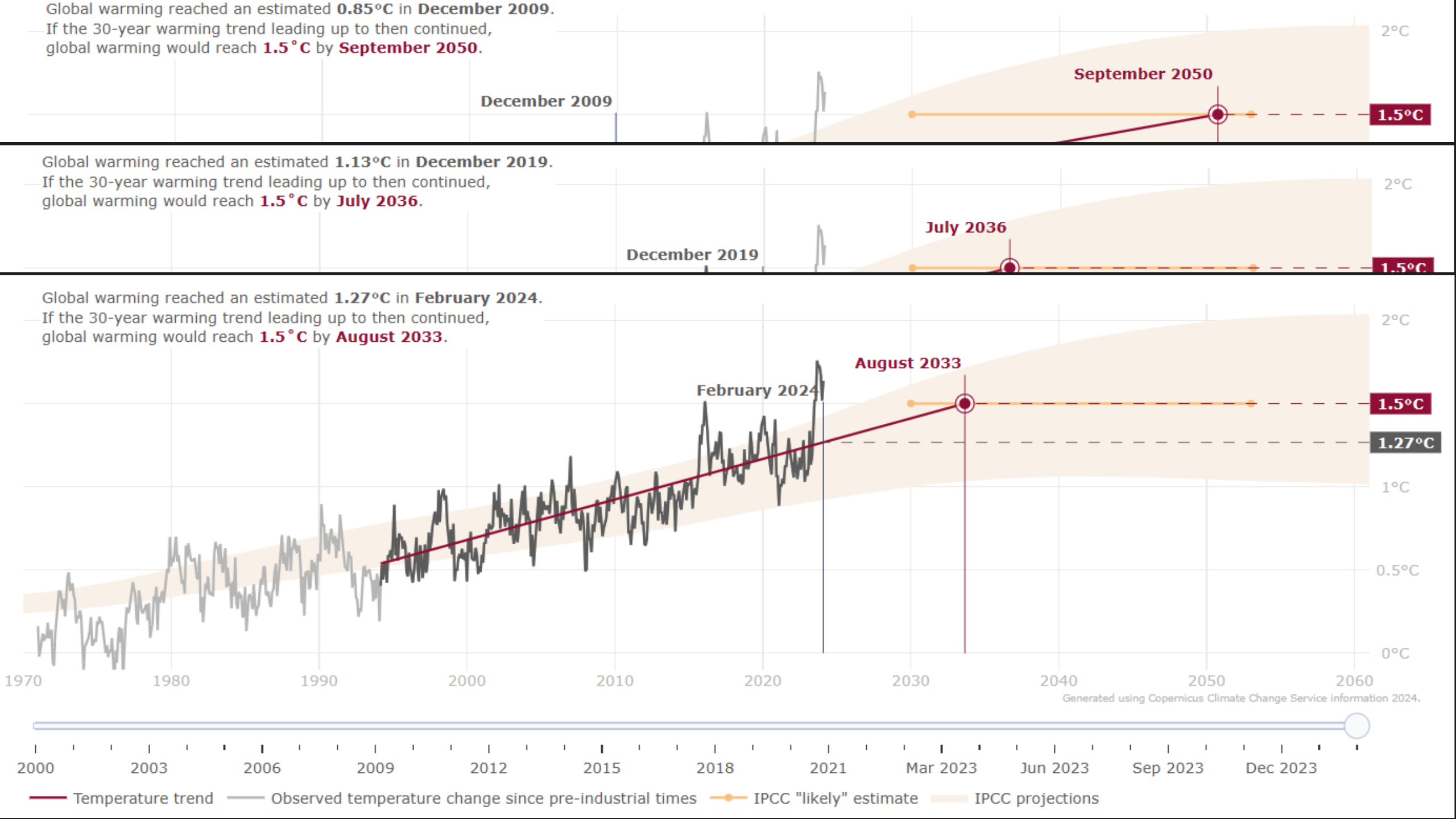
Copernicus Europe's eyes on Earth

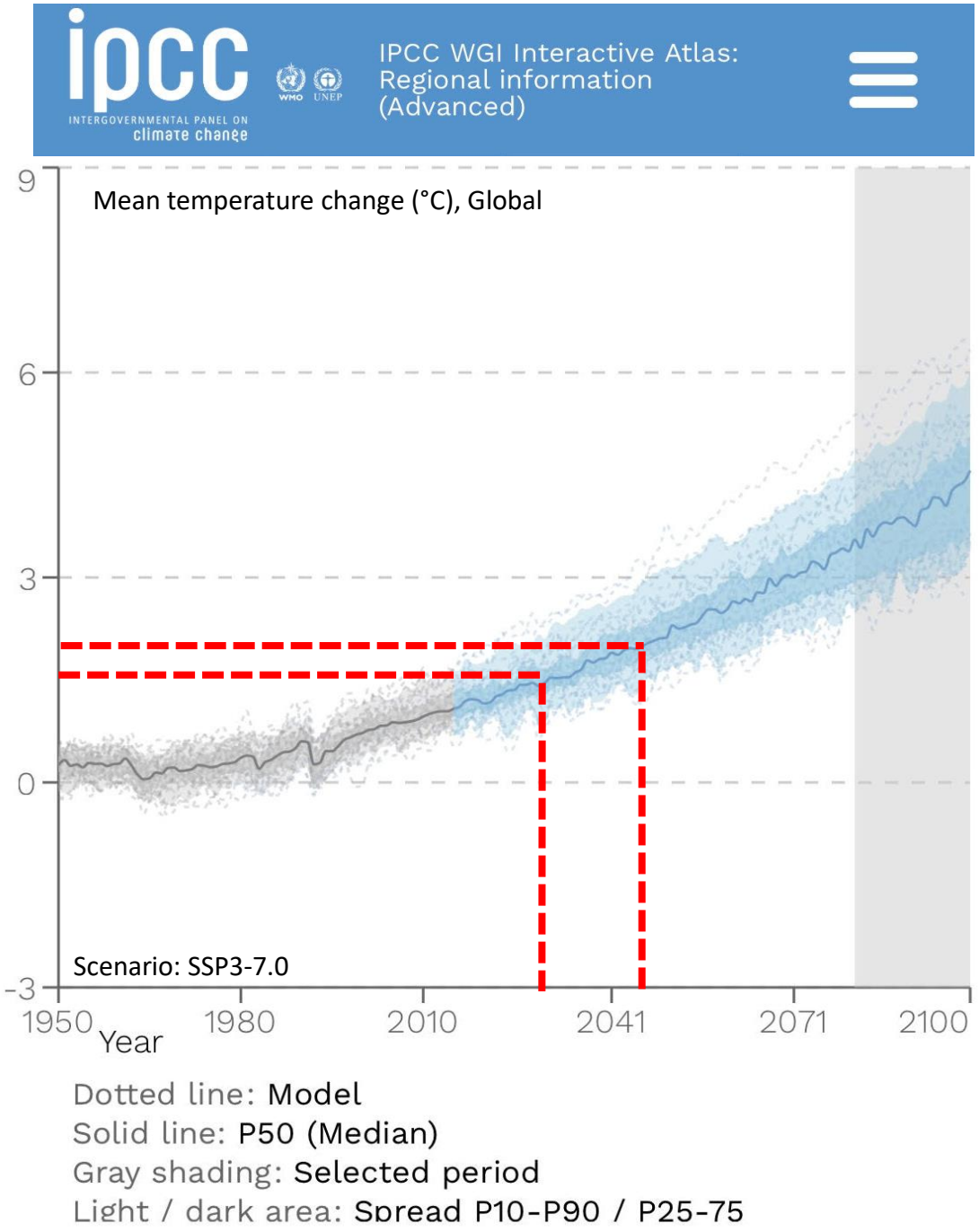
IMPLEMENTED BY ECMWF

Climate Change Service

climate.copernicus.eu

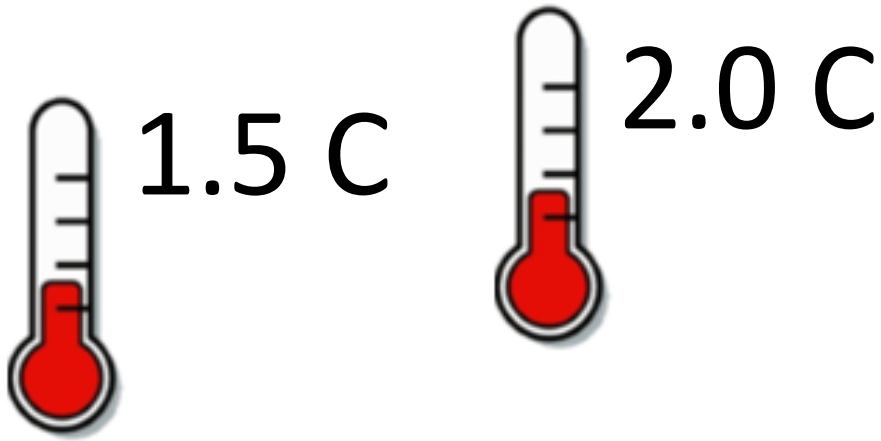

Annual J-D
L-OTI(°C) Change 1958-2023
1.11
Annual J-D
L-OTI(°C) Change 1993-2023
0.70
Annual J-D
L-OTI(°C) Change 2008-2023
0.48
−4.1
−4.1 −4.0 −2.0 −1.0 −0.5 −0.2 0.2 0.5 1.0 2.0 4.0 4.1

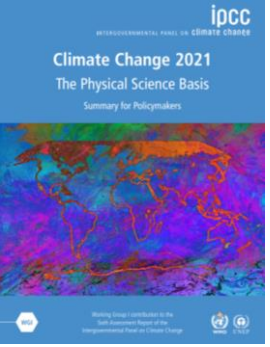

Global warming reached an estimated 0.85°C in December 2009.
If the 30-year warming trend leading up to then continued,
global warming would reach 1.5°C by September 2050.
December 2009
September 2050
2°C
1.5°C
Global warming reached an estimated 1.13°C in December 2019.
If the 30-year warming trend leading up to then continued,
global warming would reach 1.5°C by July 2036.
December 2019
July 2036
2°C
1.5°C
Global warming reached an estimated 1.27°C in February 2024.
If the 30-year warming trend leading up to then continued,
global warming would reach 1.5°C by August 2033.
February 2024
August 2033
2°C
1.5°C
1.27°C
1°C
0.5°C
0°C
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
Generated using Copernicus Climate Change Service information 2024.
2000
2003
2006
2009
2012
2015
2018
2021
Mar 2023
Jun 2023
Sep 2023
Dec 2023
Temperature trend
Observed temperature change since pre-industrial times
IPCC "likely" estimate
IPCC projections



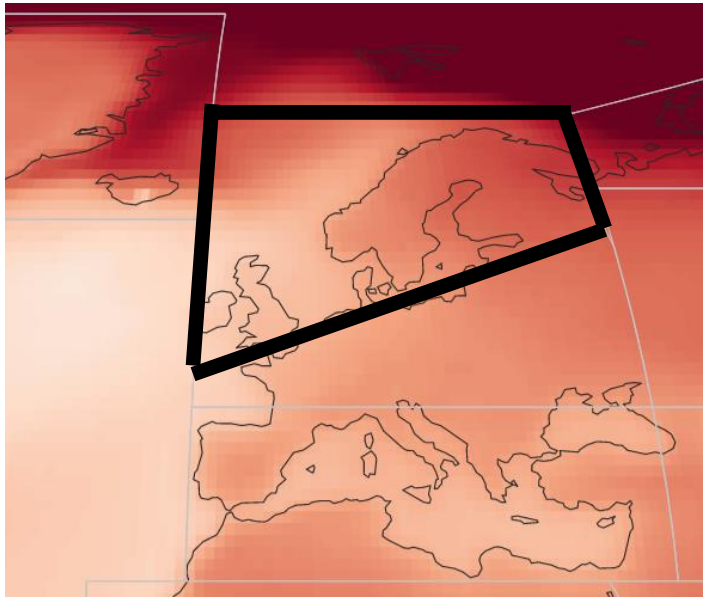
Without a strengthening of policies, global warming of 3.2°C is projected by 2100: **Overshoot will occur**

The best estimate of reaching 1.5°C of global warming lies in the **first half of the 2030s**

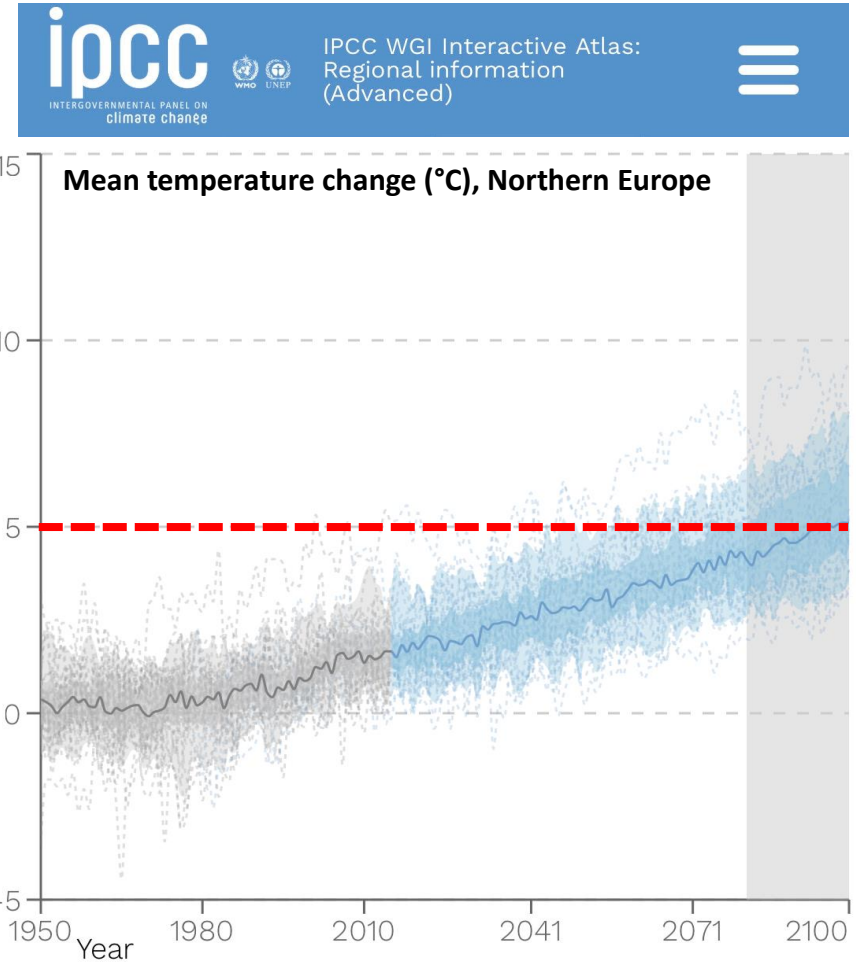




Region: Northern Europe



Scenario: SSP3-7.0



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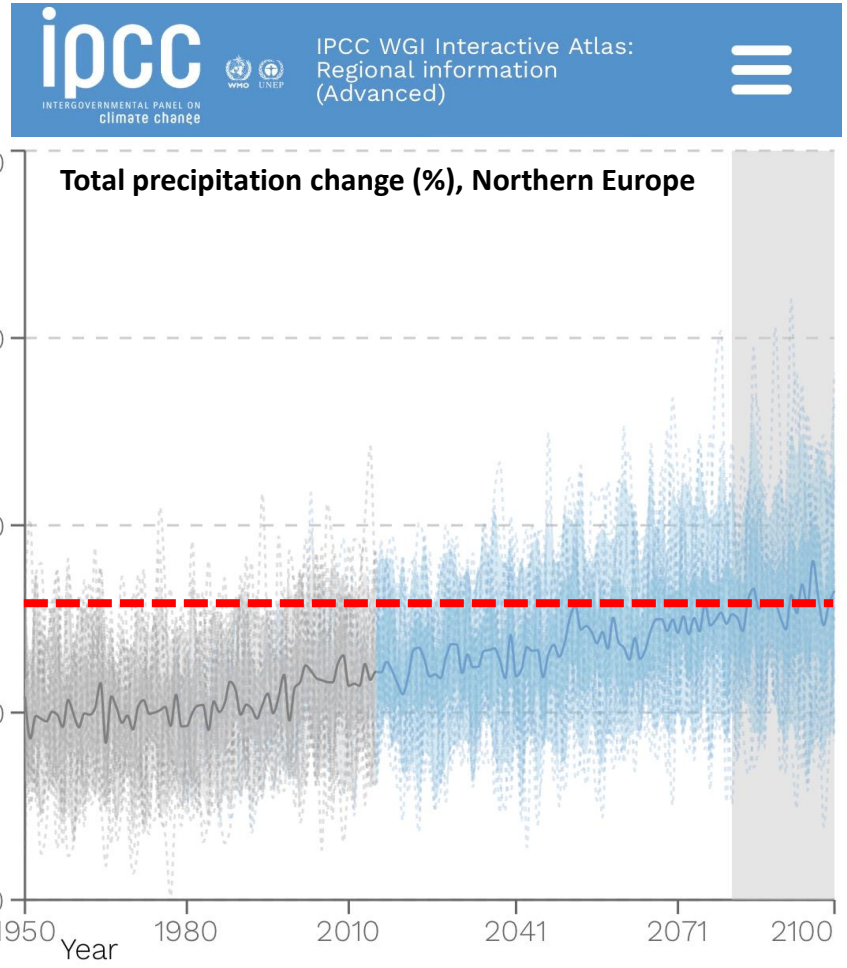
Light / dark area: Spread P10-P90 / P25-75



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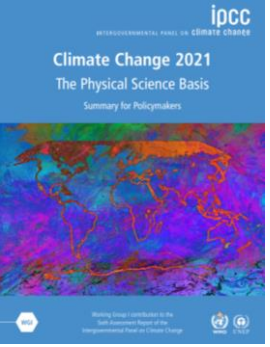

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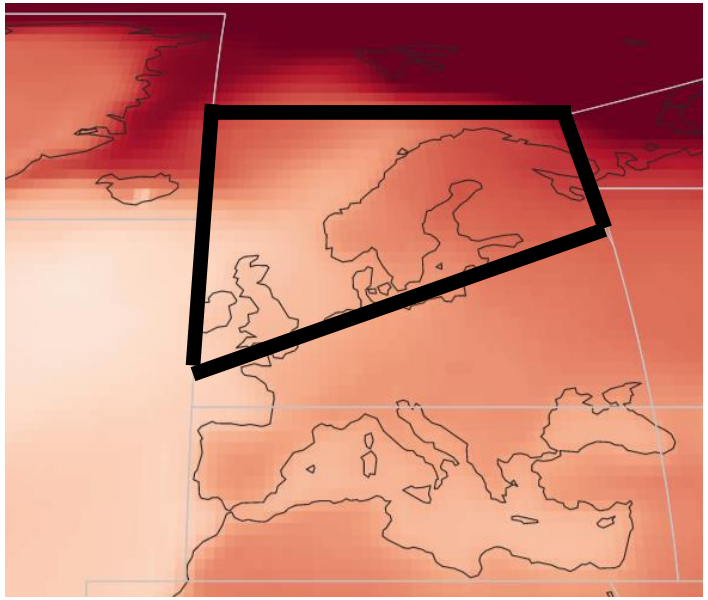
Region: Northern Europe



Scenario: SSP3-7.0

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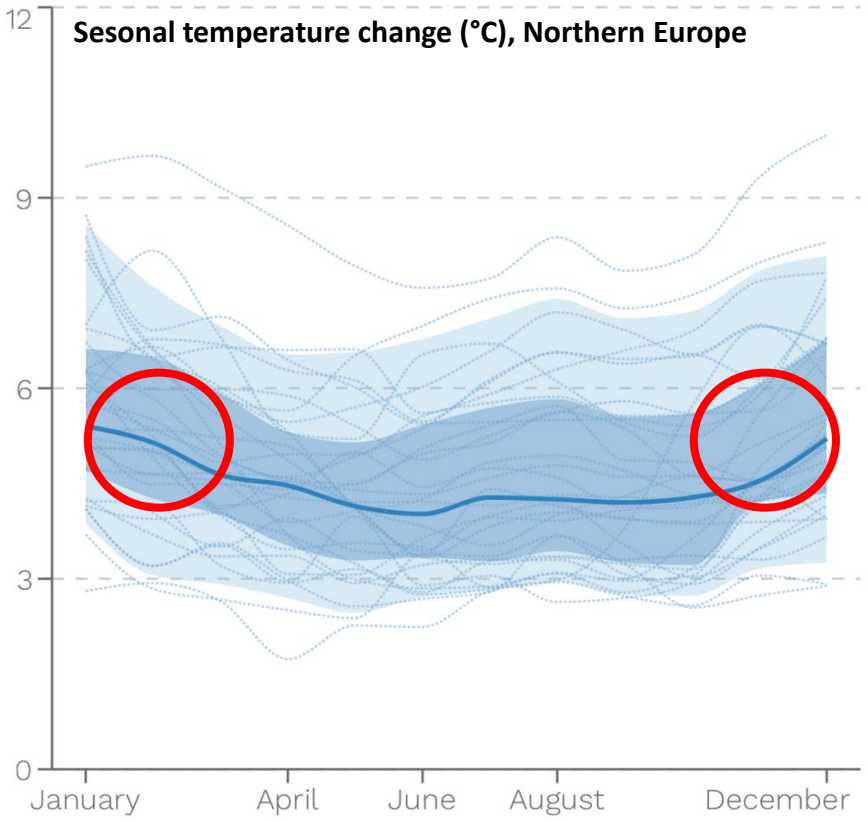
IPCC WGI Interactive Atlas: Regional information (Advanced)



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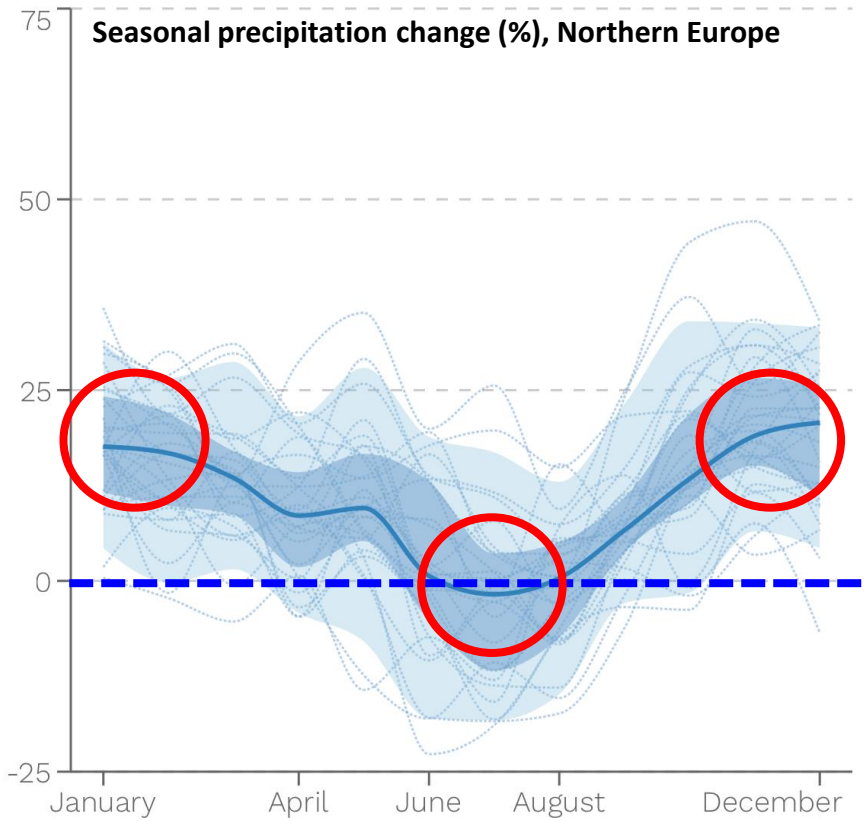

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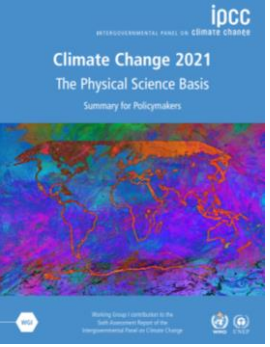
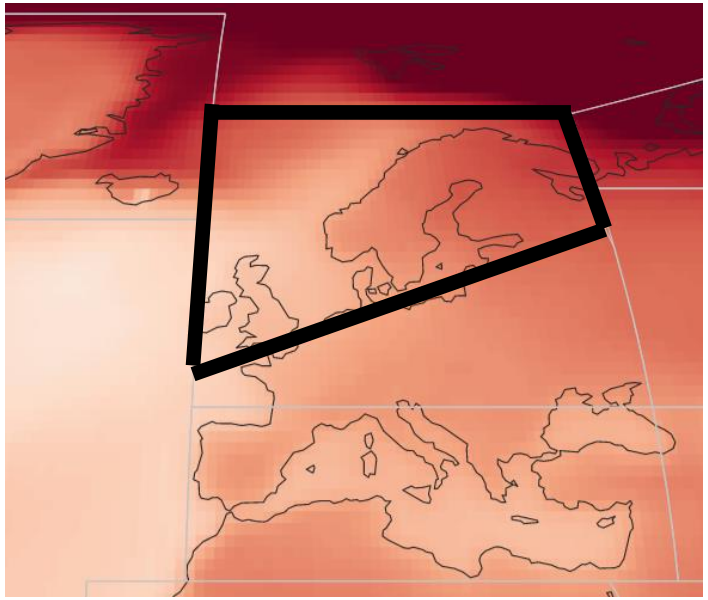
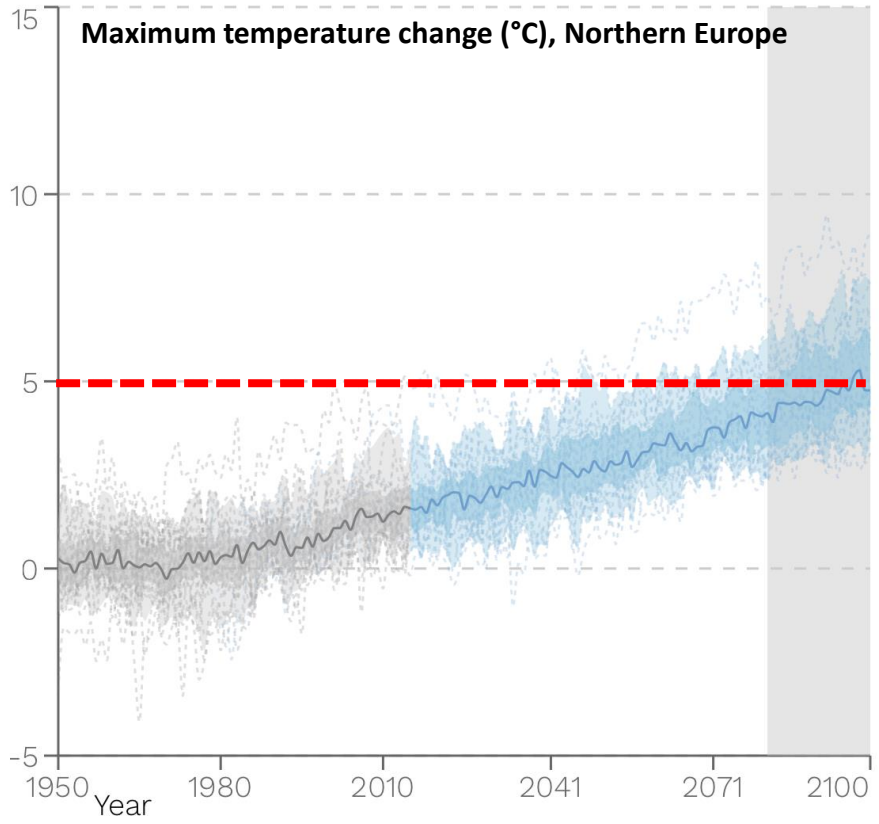


Region: Northern Europe



Scenario: SSP3-7.0

IPCC WGI Interactive Atlas: Regional information (Advanced)



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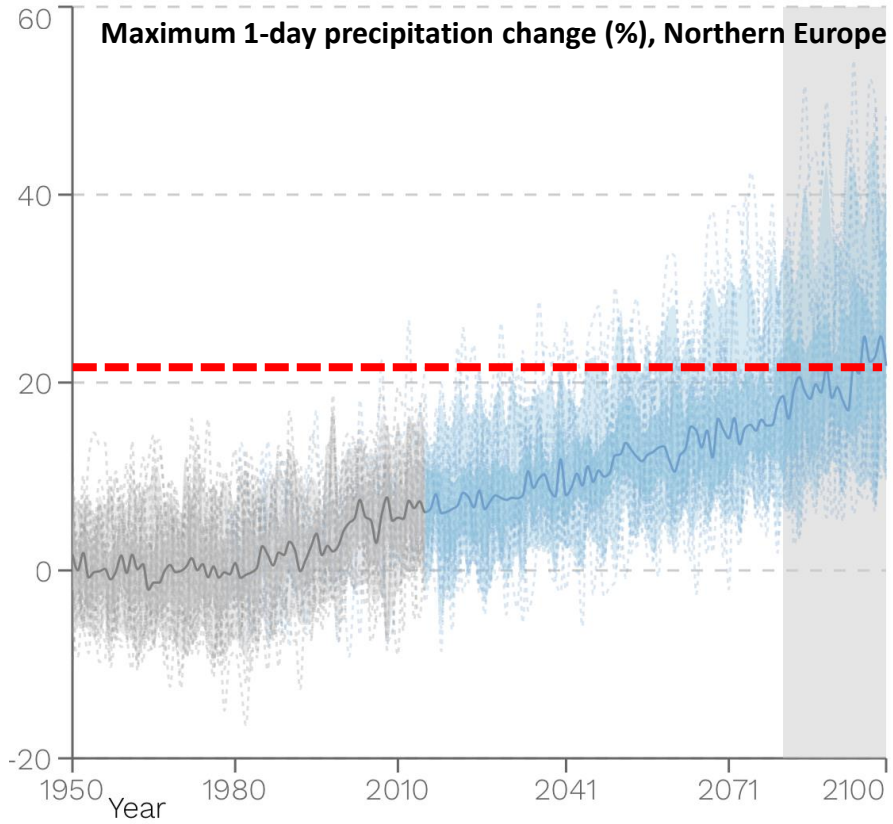

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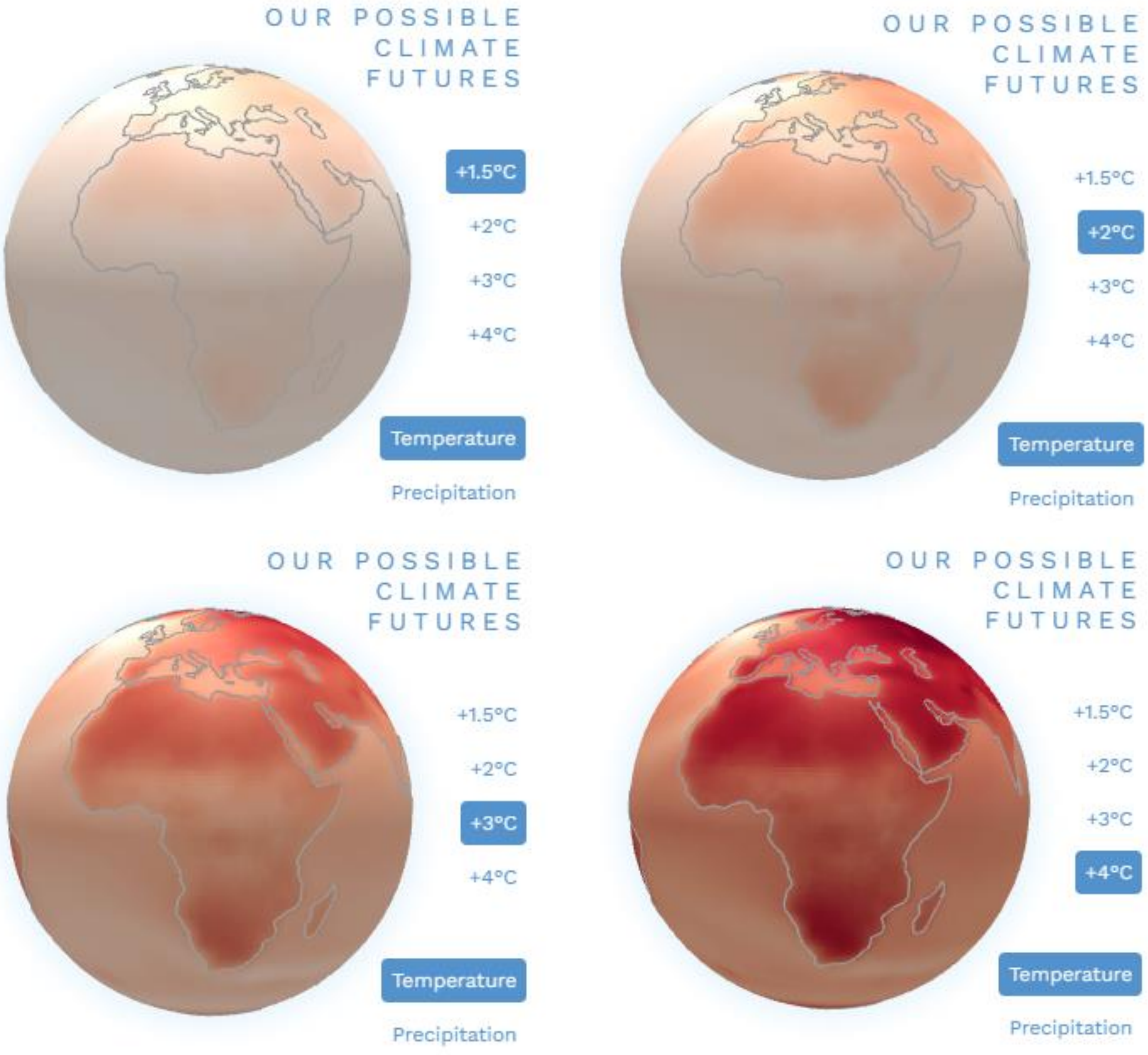
Summary, Overview Table (changes from today and to 2100)

Region, Today–2100	Northern Europe	Central Europe	Southern Europe	Western US	Central US	Eastern US	SE South America	S South America	Southern Australia	New Zealand	East Asia
Mean temperature change (C)	2.5 to 3.5	2.5 to 4.0	2.5 to 3.5	3.0 to 4.5	**3.5 to 5.5**	3.5 to 4.5	2.5 to 3.5	**1.5 to 2.5**	2.0 to 3.0	2.0 to 3.0	3.0 to 4.0
Maximum temperature change (C)	2.5 to 3.5	3.0 to 4.0	3.0 to 4.0	3.0 to 4.5	**3.5 to 5.0**	3.5 to 4.5	2.5 to 3.5	**1.5 to 2.5**	2.0 to 3.0	2.0 to 3.0	3.0 to 4.0
Seasonal variability, temperature	W (++) S (+)	W (+) S (++)	W (+) S (++)	W (+) S (++)	W (+) S (++)	W (+) S (+)	W (+) S (+)	W (++) S (+)	W (++) S (+)	W (++) S (+)	W (+) S (+)
Total precipitation change (%)											
Maximum precipitation change (%)											
Seasonal variability, precipitation											

Summary, Overview Table (changes from today and to 2100)

Region, Today–2100	Northern Europe	Central Europe	Southern Europe	Western US	Central US	Eastern US	SE South America	S South America	Southern Australia	New Zealand	East Asia
Mean temperature change (C)	2.5 to 3.5	2.5 to 4.0	2.5 to 3.5	3.0 to 4.5	**3.5 to 5.5**	3.5 to 4.5	2.5 to 3.5	**1.5 to 2.5**	2.0 to 3.0	2.0 to 3.0	3.0 to 4.0
Maximum temperature change (C)	2.5 to 3.5	3.0 to 4.0	3.0 to 4.0	3.0 to 4.5	**3.5 to 5.0**	3.5 to 4.5	2.5 to 3.5	**1.5 to 2.5**	2.0 to 3.0	2.0 to 3.0	3.0 to 4.0
Seasonal variability, temperature	W (++) S (+)	W (+) S (++)	W (+) S (++)	W (+) S (++)	W (+) S (++)	W (+) S (+)	W (+) S (+)	W (++) S (+)	W (++) S (+)	W (++) S (+)	W (+) S (+)
Total precipitation change (%)	5 to 8	-5 to 10	**-10 to -20**	**7 to 15**	-8 to 12	5 to 10	0 to 15	0 to 7	0 to -10	5 to -5	0 to 15
Maximum precipitation change (%)	8 to 18	10 to 20	**4 to 9**	10 to 20	10 to 25	10 to 25	10 to 20	10 to 20	10 to 20	**15 to 25**	**15 to 25**
Seasonal variability, precipitation	W (+) S (same)	W (+) S (-)	W (-) S (-)	W (+) S (-, same)	W (+) S (-)	W (+) S (-)	W (-) S (+)	W (+) S (-)	W (-) S (-)	W (same) S (same)	W (-, same) S (+)

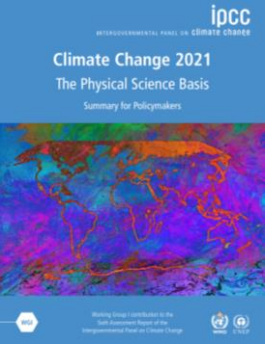


Region: Africa

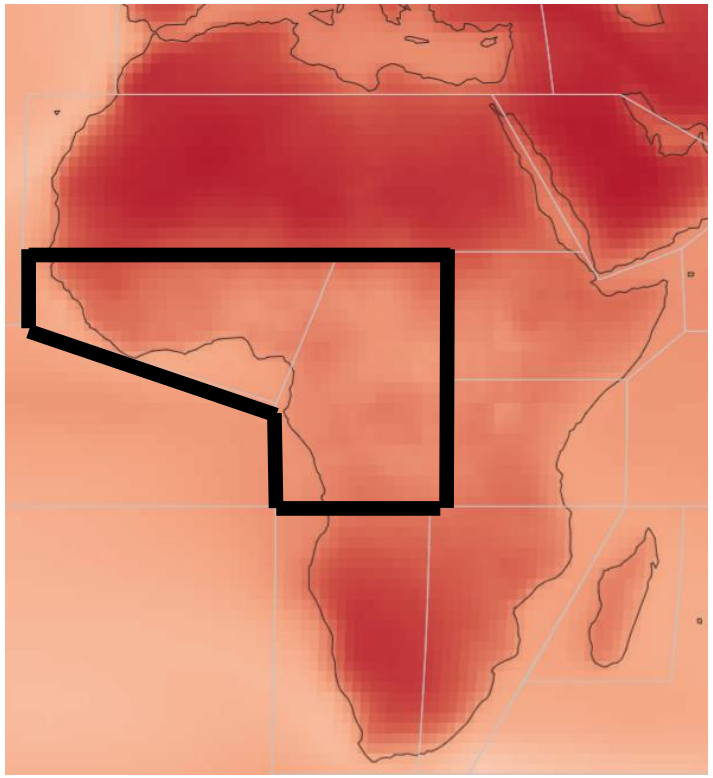
Over most parts of Africa, **minimum temperatures have warmed more rapidly than maximum temperatures** during the last 50 to 100 years (medium confidence).

In the same period, **minimum and maximum temperatures have increased by more than 0.5°C** relative to 1850–1900 (high confidence).

Surface air temperatures in Africa are projected to rise **faster than the global average increase** and are likely to increase by more than **2°C and up to 6°C by the end of the century**, relative to the late 20th century, if global warming reaches 2°C.

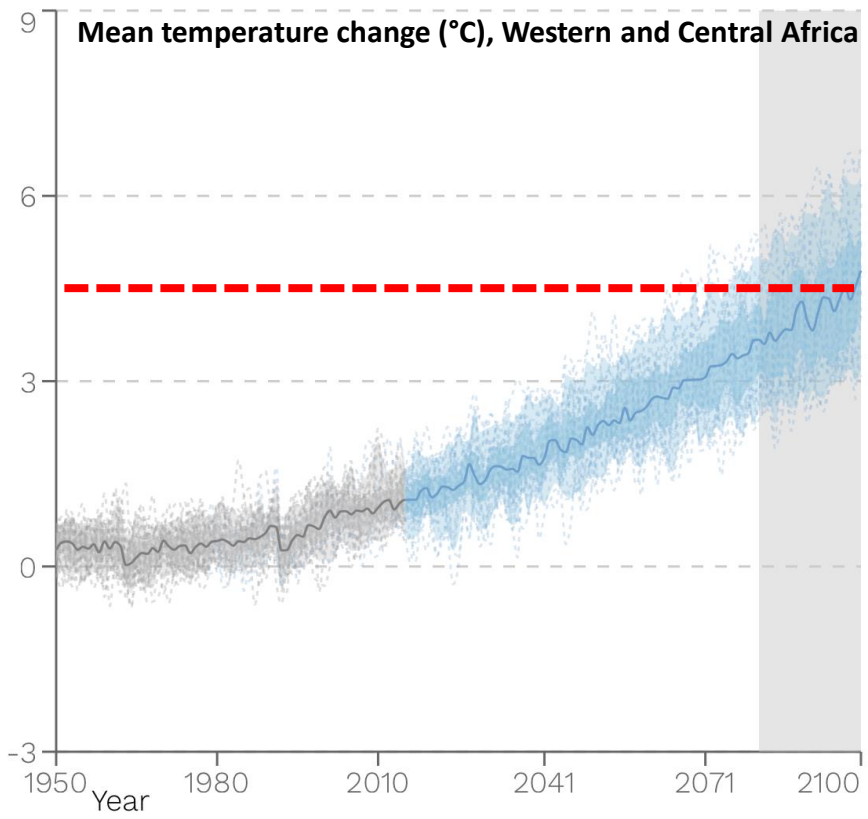


Region: Western and Central Africa



Scenario: SSP3-7.0

IPCC WGI Interactive Atlas: Regional information (Advanced)



Dotted line: Model
Solid line: P50 (Median)
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Light / dark area: Spread P10-P90 / P25-75

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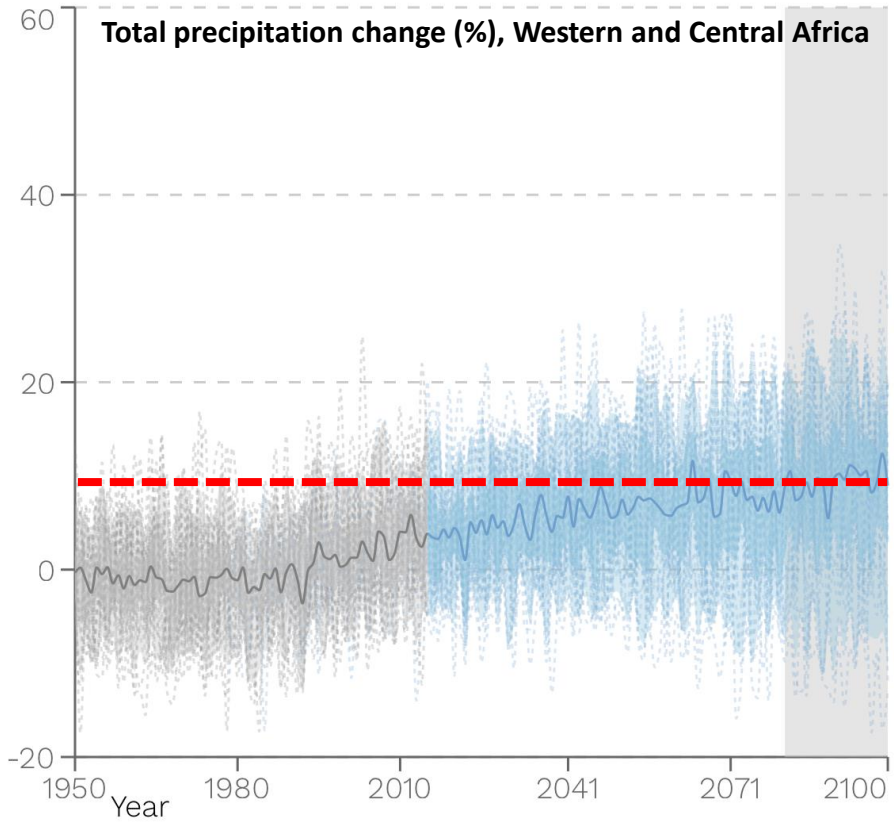

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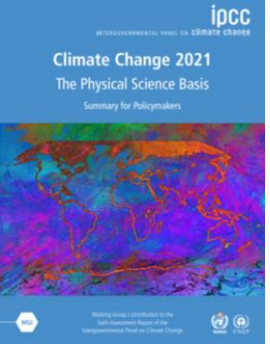
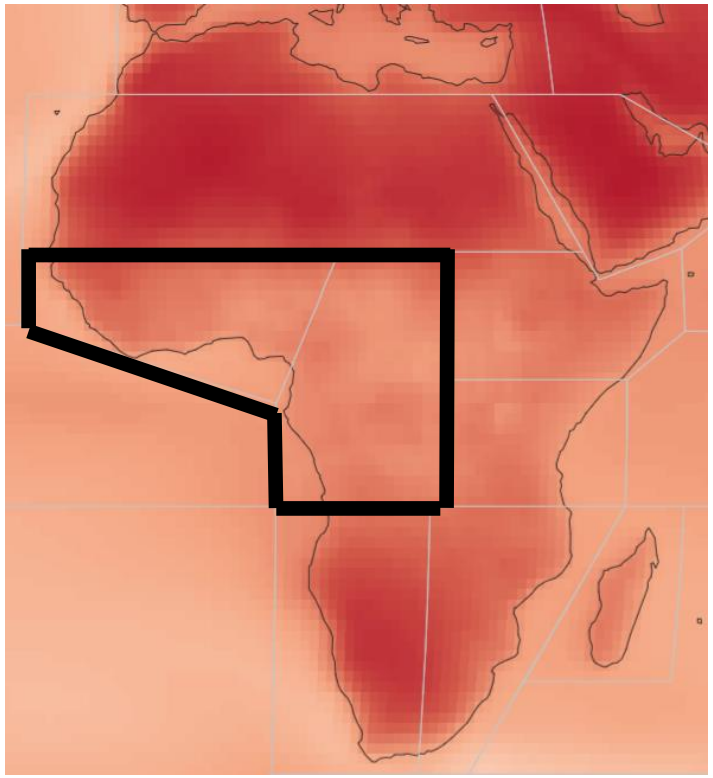


Region: Western and Central Africa



Scenario: SSP3-7.0

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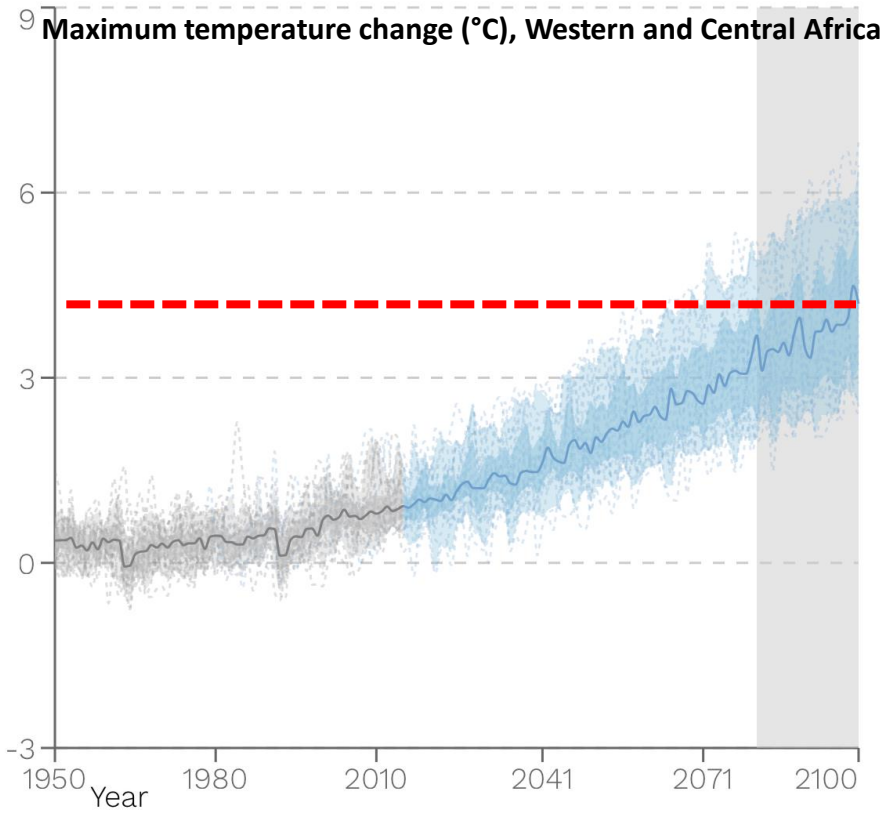
IPCC WGI Interactive Atlas: Regional information (Advanced)

Maximum temperature change (°C), Western and Central Africa



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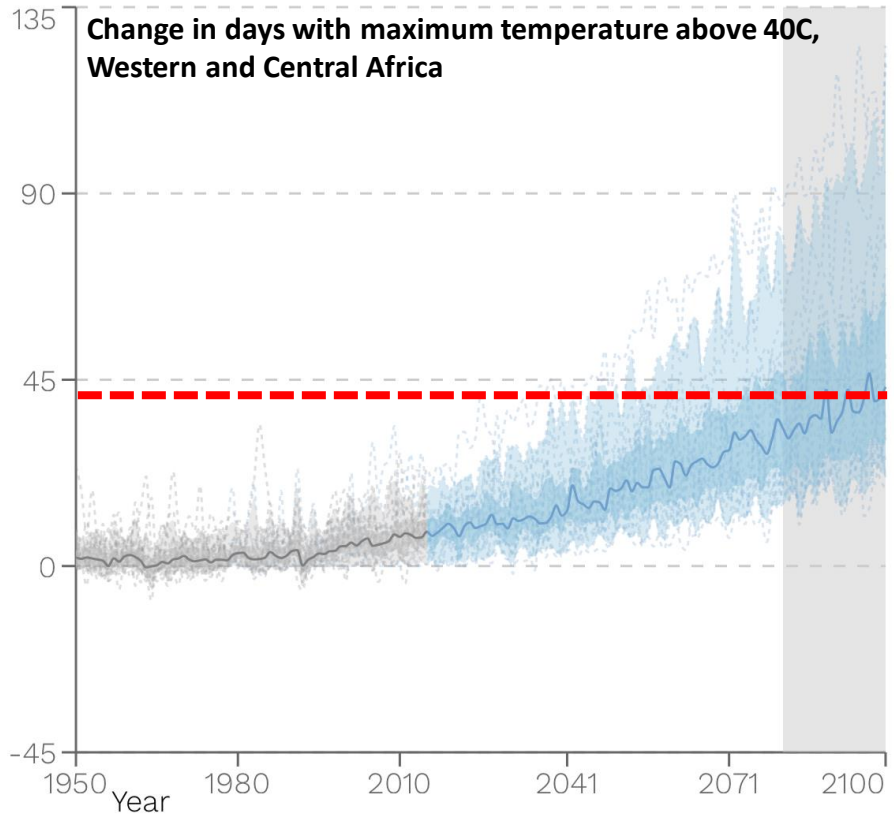
IPCC WGI Interactive Atlas: Regional information (Advanced)

Change in days with maximum temperature above 40C, Western and Central Africa



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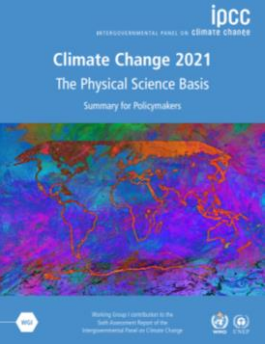
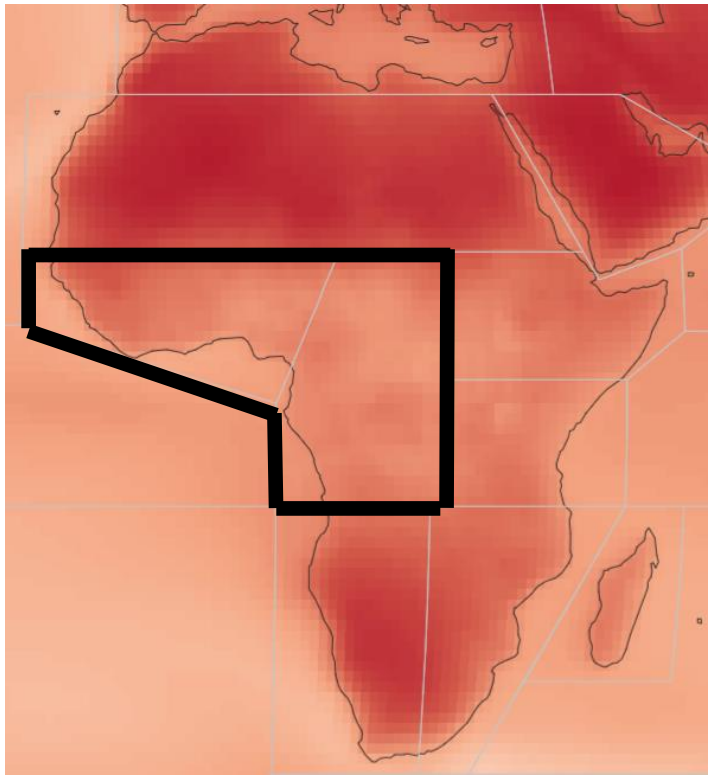


Region: Western and Central Africa



Scenario: SSP3-7.0

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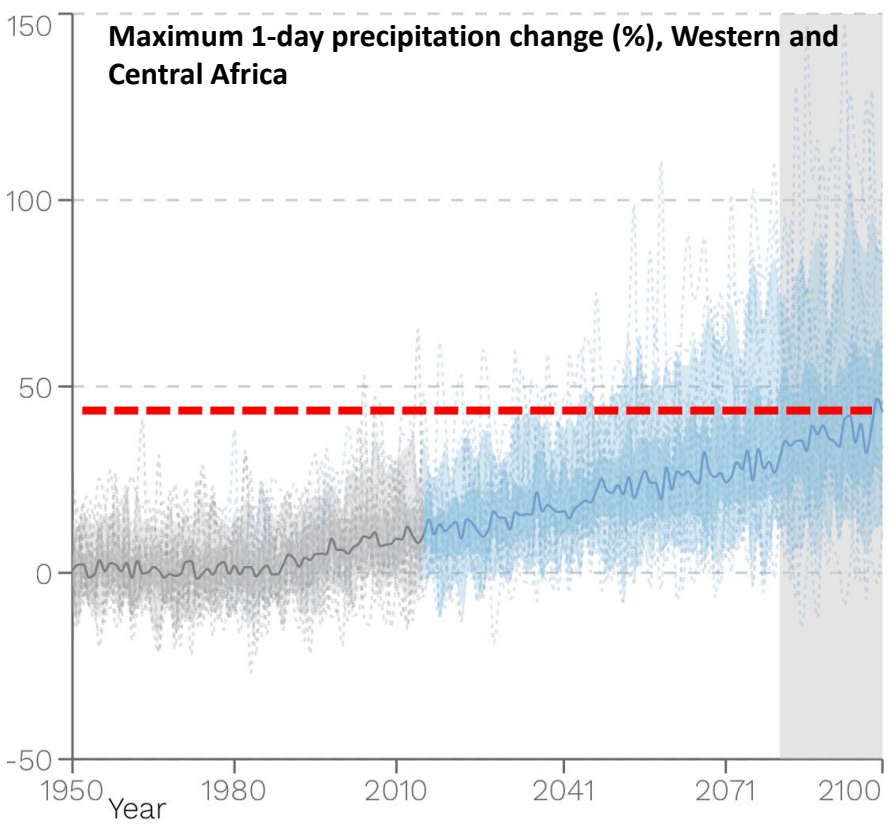
IPCC WGI Interactive Atlas: Regional information (Advanced)



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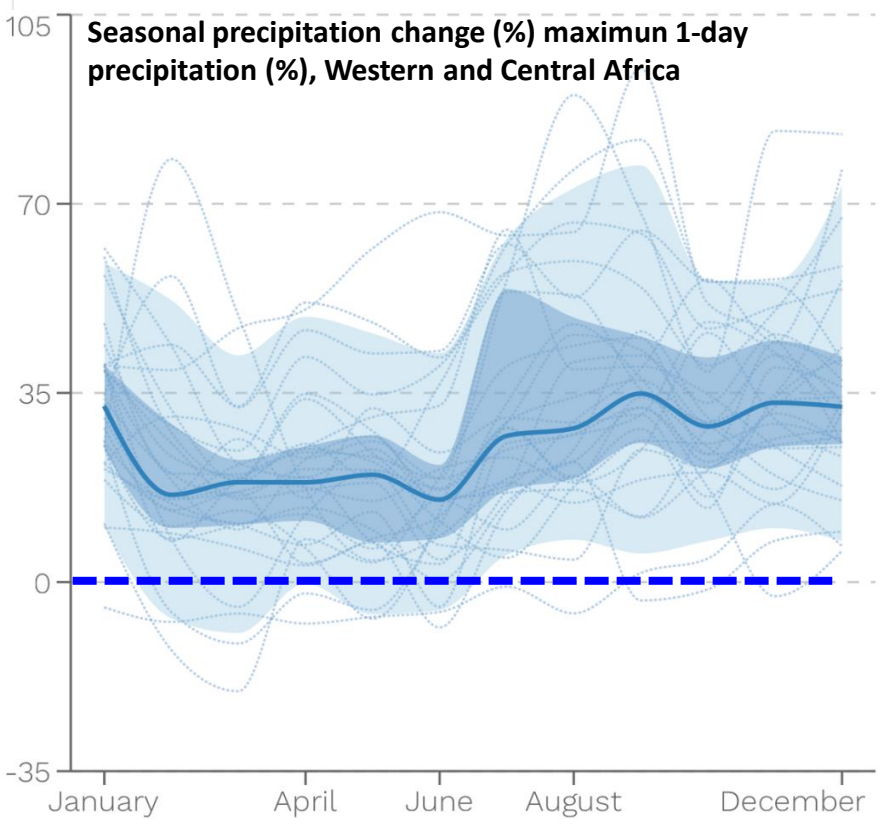

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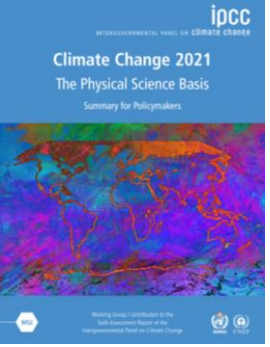
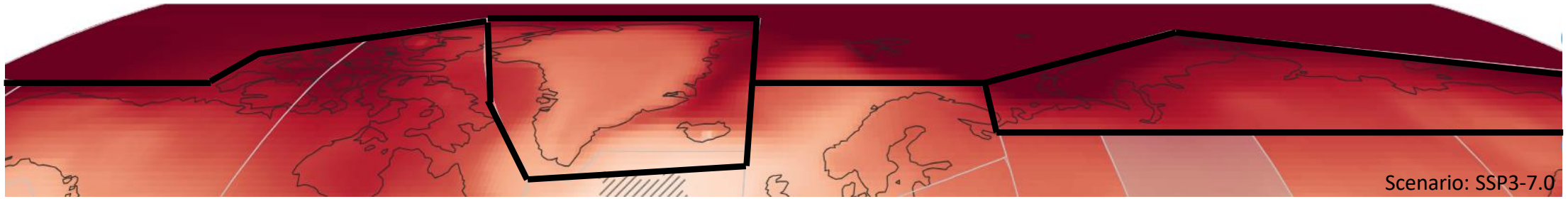
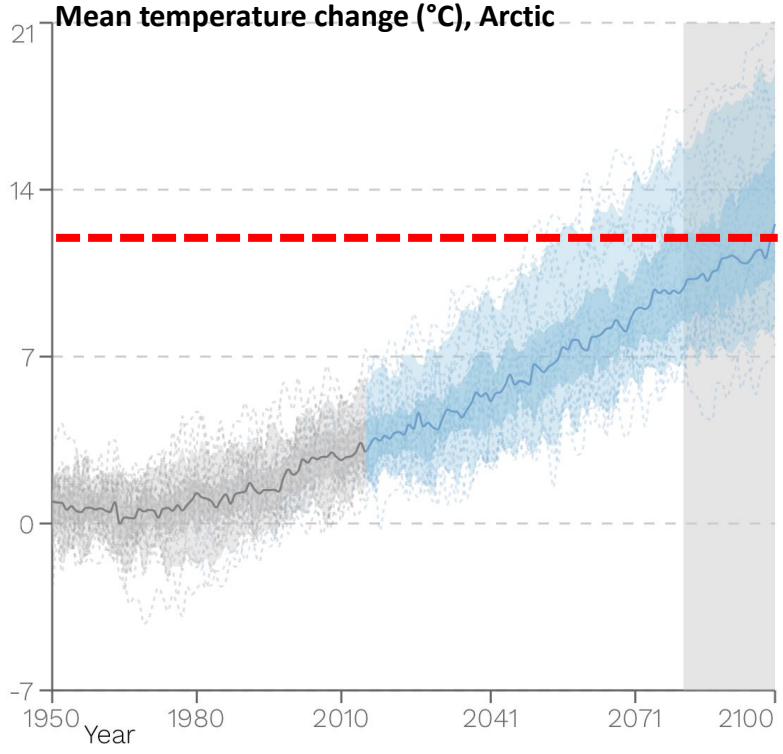


Region: Arctic, Greenland and Sibiria



IPCC WGI Interactive Atlas: Regional information (Advanced)

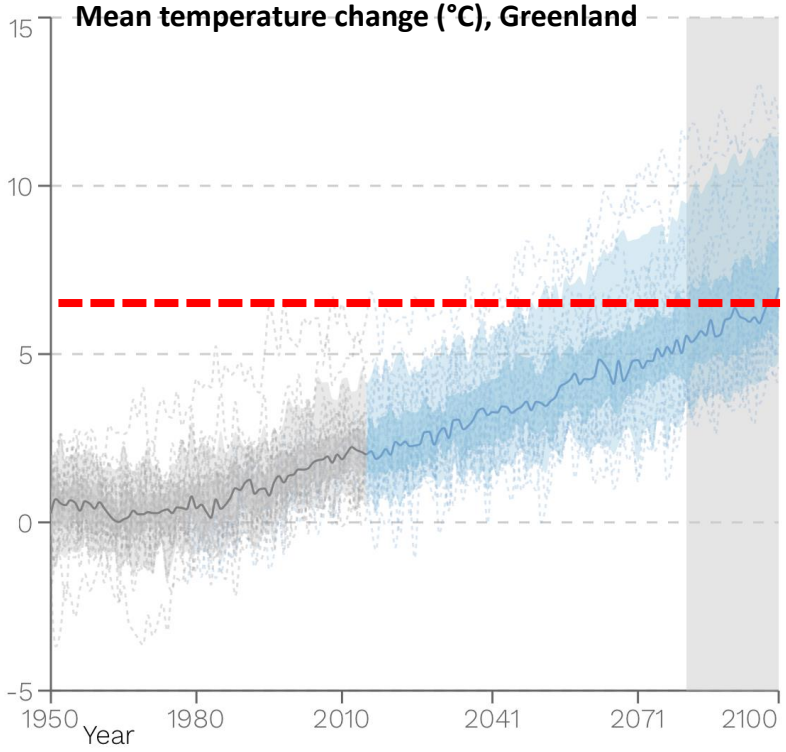
Mean temperature change (°C), Arctic



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

IPCC WGI Interactive Atlas: Regional information (Advanced)

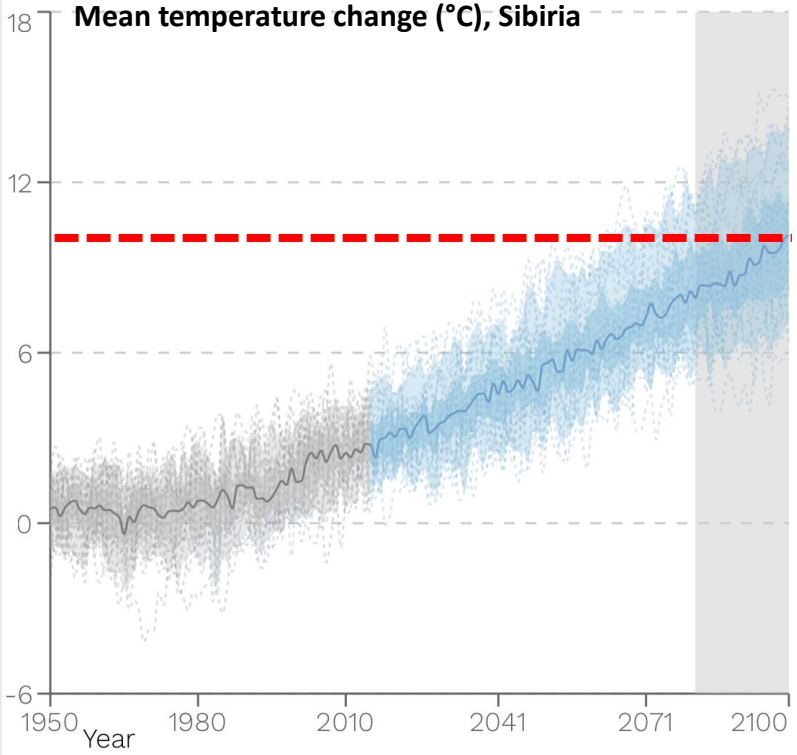
Mean temperature change (°C), Greenland



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

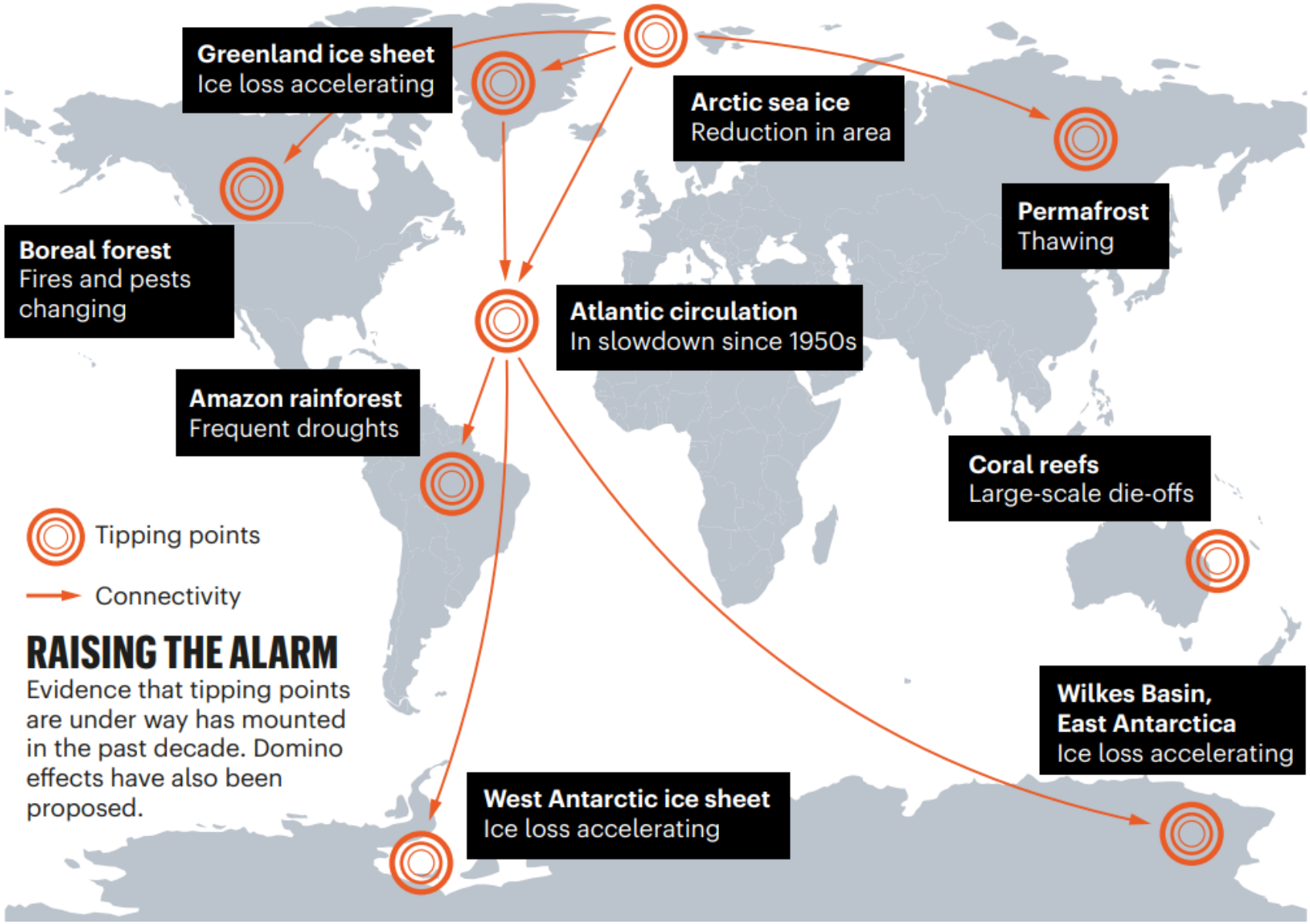
IPCC WGI Interactive Atlas: Regional information (Advanced)

Mean temperature change (°C), Sibiria



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

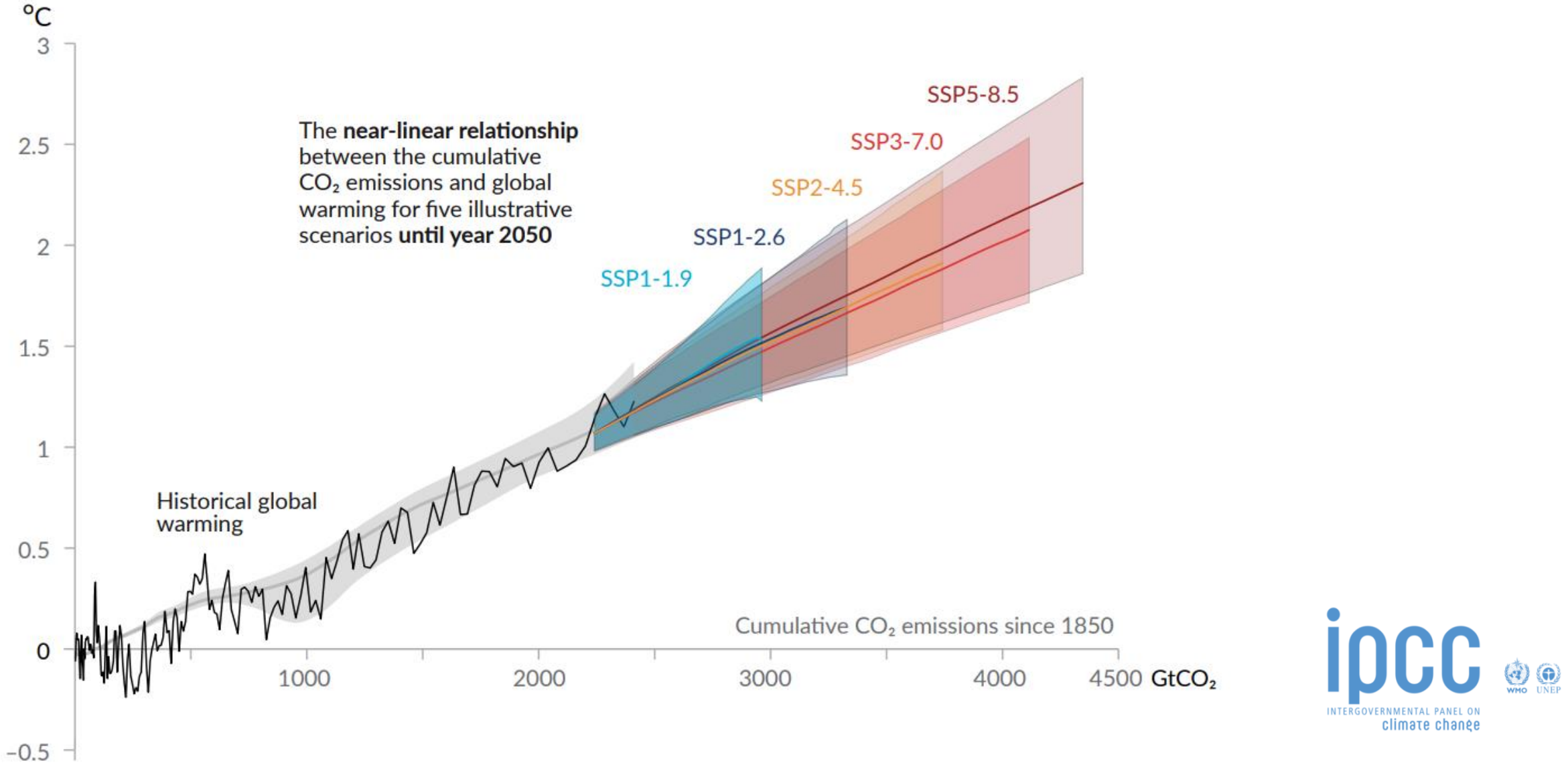
Evidence that tipping point are under way…



Risks associated with large-scale singular events or ***tipping points***, such as ice sheet instability or ecosystem loss from tropical forests, **transition to high risk between 1.5°C–2.5°C** (*medium confidence*) **and to very high risk between 2.5°C–4.0°C** (*low confidence*).

Every tonne of CO_2 emissions adds to global warming

Global surface temperature increase since 1850–1900 (°C) as a function of cumulative CO_2 emissions ($GtCO_2$)



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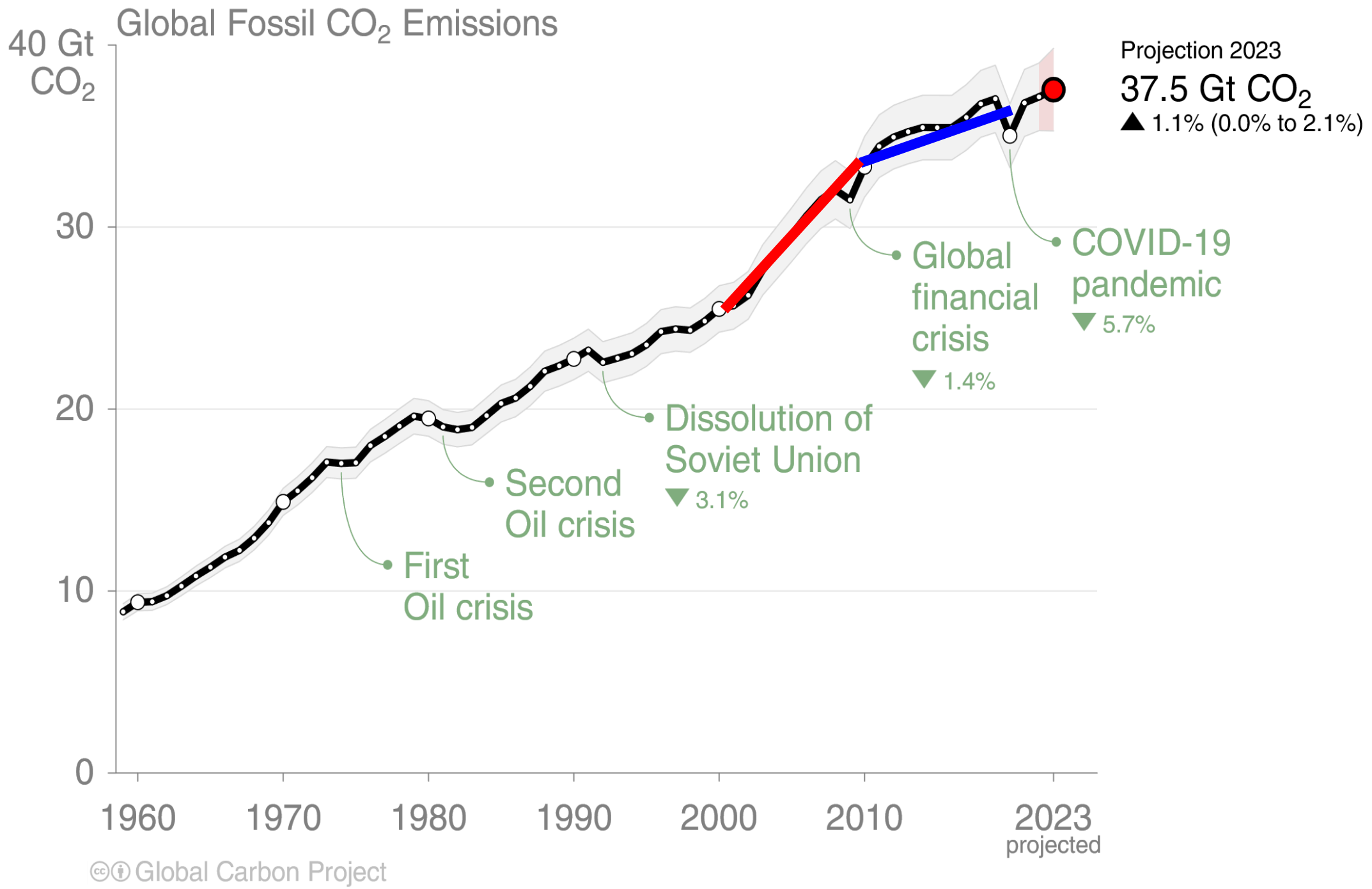
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

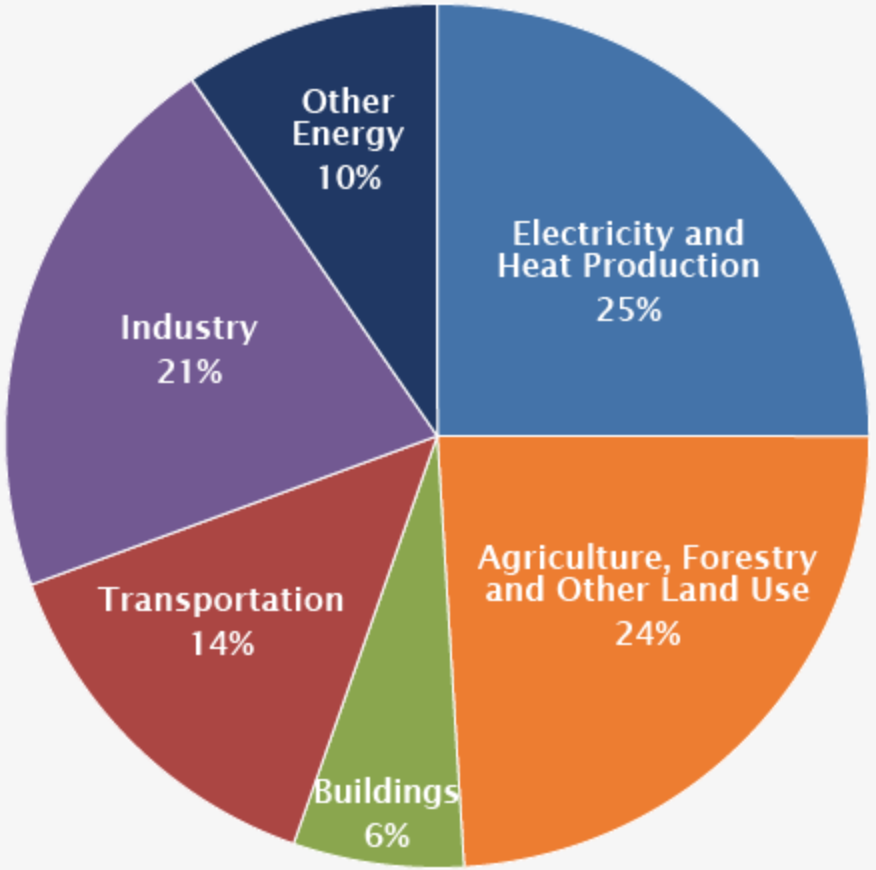
AR6, WG1 (2021):

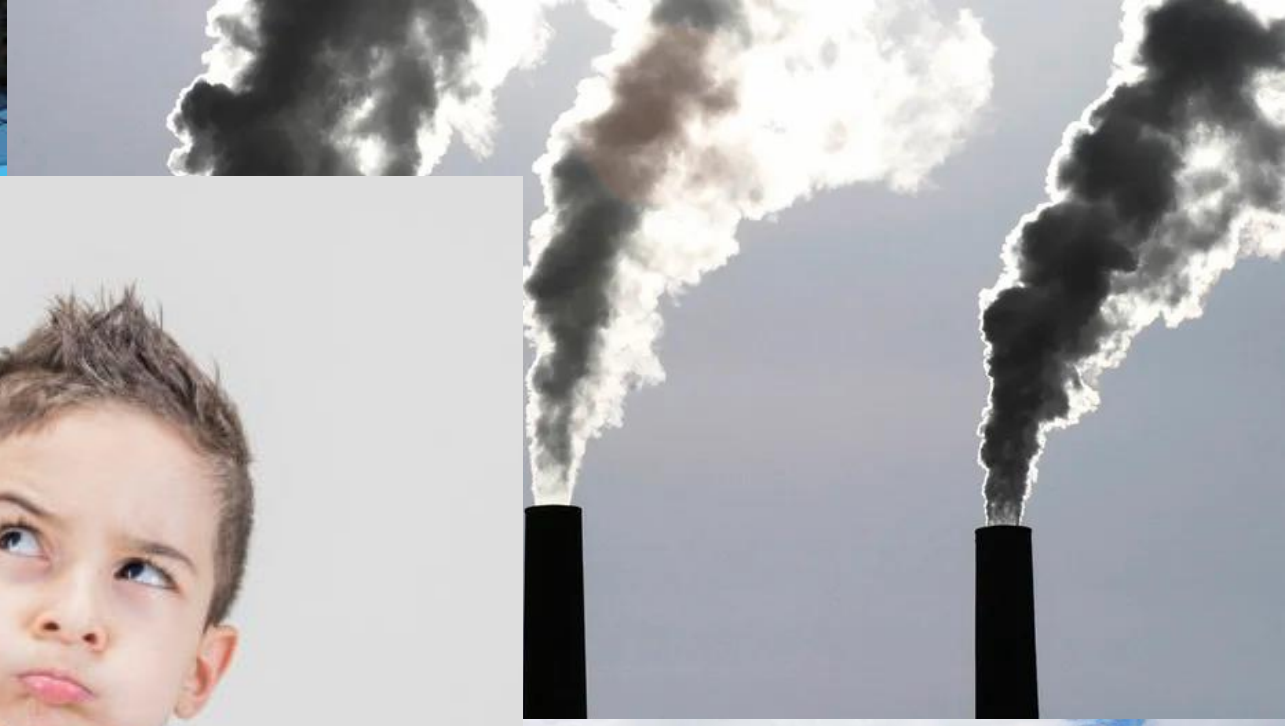
Estimated remaning carbon budgets from
the beginning of 2020 (GtCO2)……it is about likelihood!

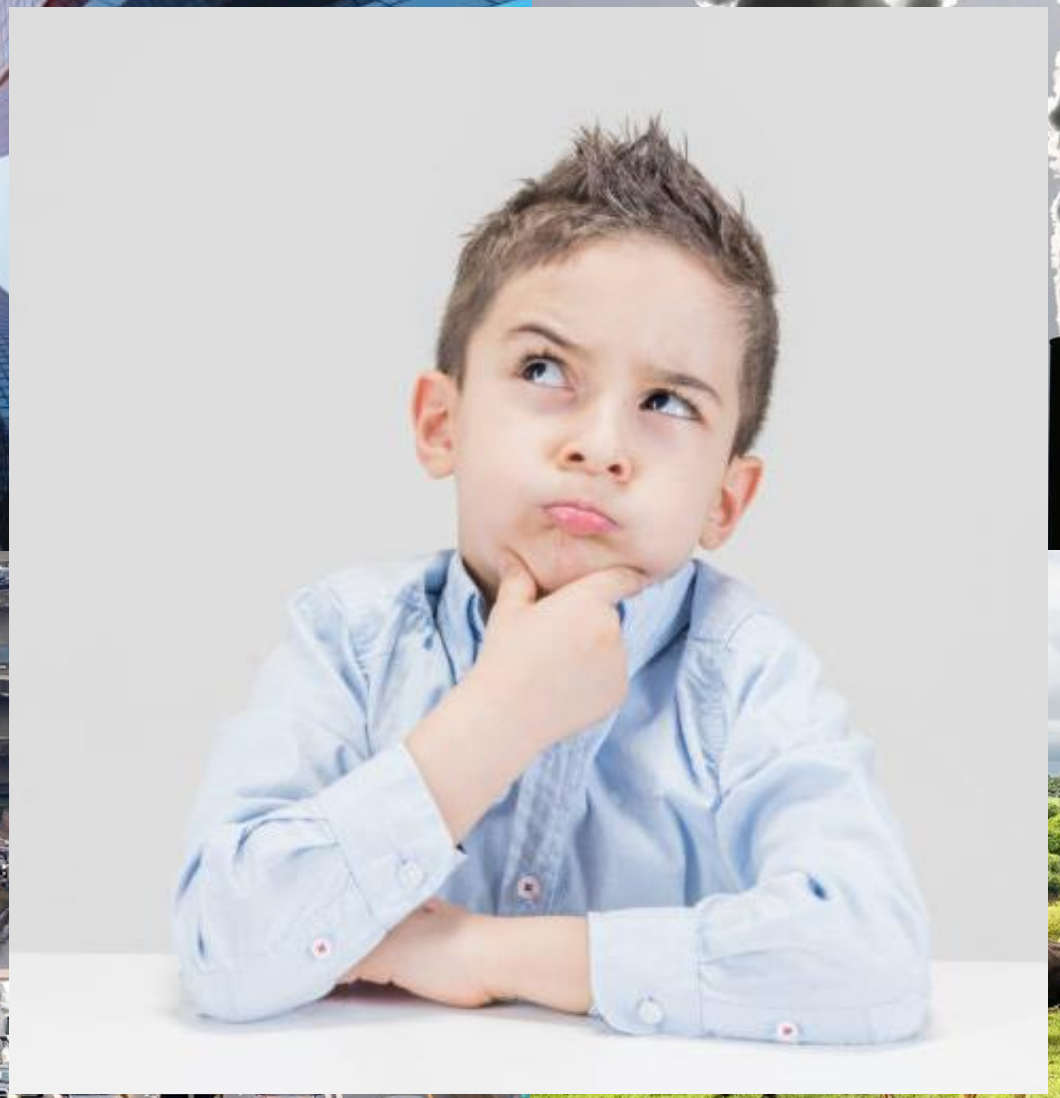
Approximate global warming relative to 1850–1900 until temperature limit (°C)[a]	Estimated remaining carbon budgets from the beginning of 2020 ($GtCO_2$) *Likelihood of limiting global warming to temperature limit*[b]				
	17%	*33%*	*50%*	*67%*	*83%*
1.5	900	650	500	400	300
2.0	2300	1700	1350	1150	900


Global Fossil CO_2 Emissions
40 Gt CO_2
30
20
10
0
1960
1970
1980
1990
2000
2010
2023
projected
Projection 2023
37.5 Gt CO_2
▲ 1.1% (0.0% to 2.1%)
First Oil crisis
Second Oil crisis
Dissolution of Soviet Union
▼ 3.1%
Global financial crisis
▼ 1.4%
COVID-19 pandemic
▼ 5.7%
Global Carbon Project

Global Greenhouse Gas Emissions by Economic Sector







Impacts of Climate Change on Human Health

The Lancet Countdown Report, 2019

For the ***Lancet*** **report** see https://www.thelancet.com/climate-and-health

and for more on the **accompanying materials** see www.lancetcountdown.org

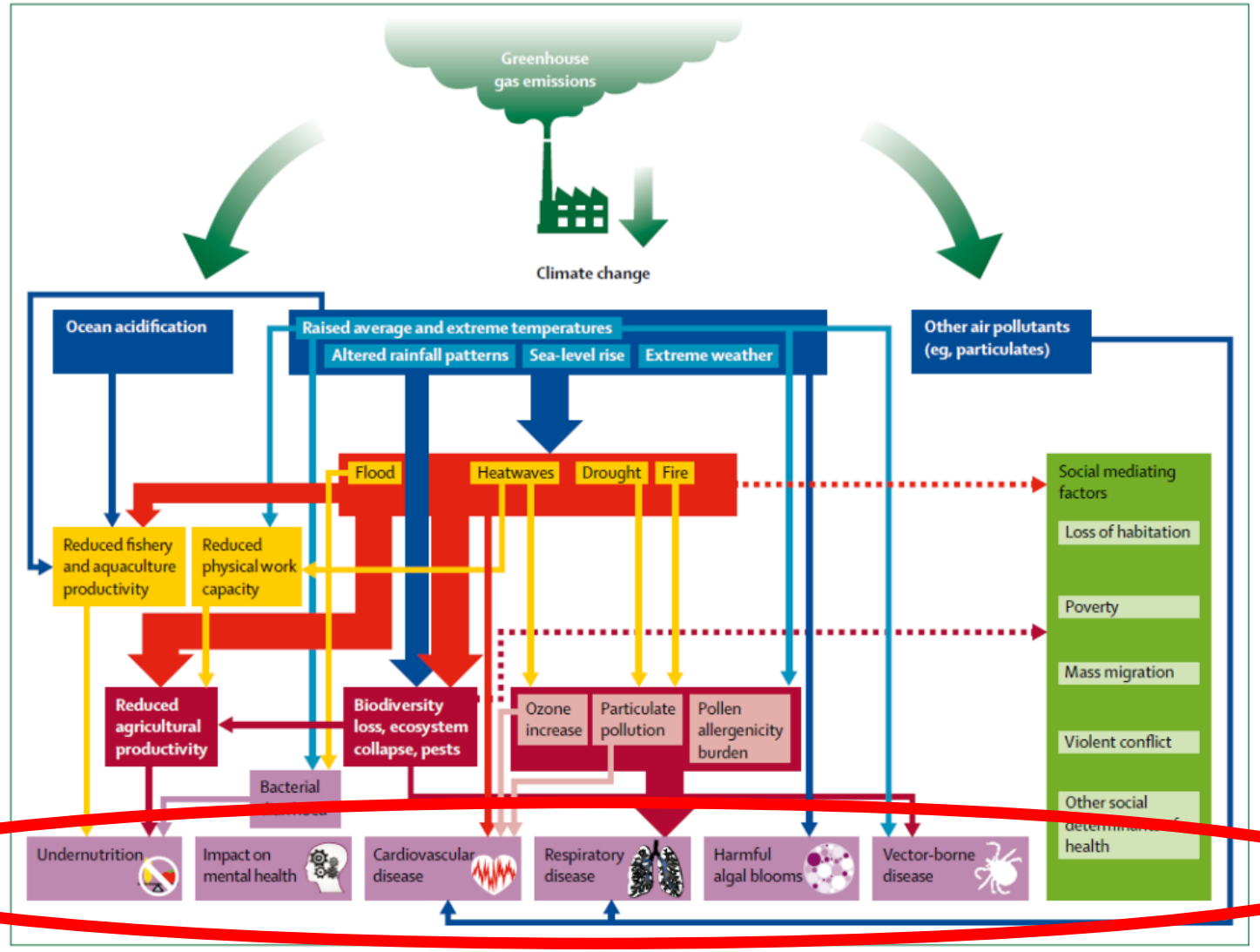


Figure 1: The pathways between climate change and human health

- **Undernutrition**
- **Impact on mental health**
- **Cardiovascular disease**
- **Respiratory disease**
- **Harmful algal blooms**
- **Vector-borne disease**


Thank you for your attention…
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INTERGOVERNMENTAL PANEL ON
climate change
WMO
UNEP
SCC
SDU Climate Cluster