Temperature conditions and expected future development

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IPCC Contributing Author, AR5 (2009–2013)

Downtown Hamburg, Germany

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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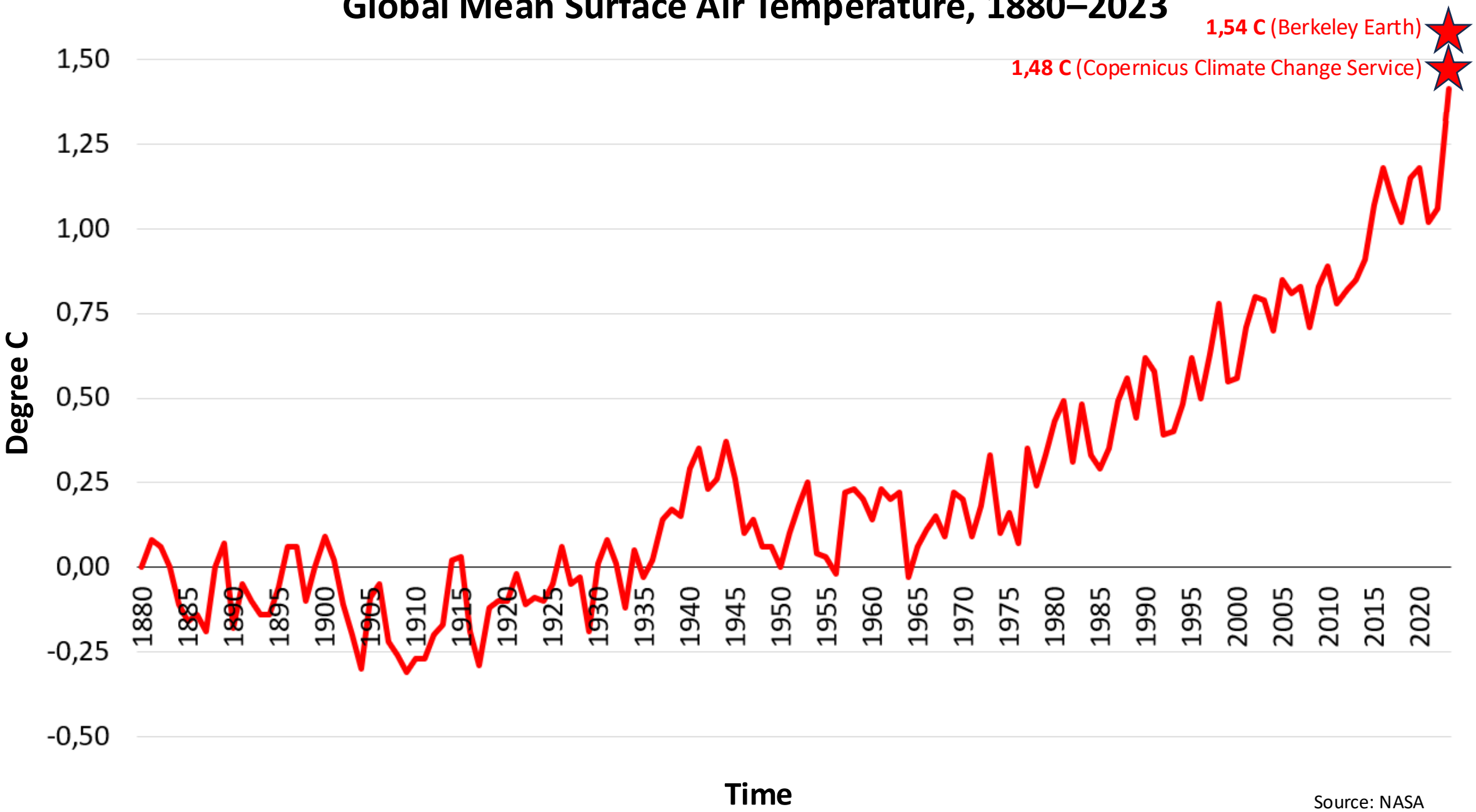
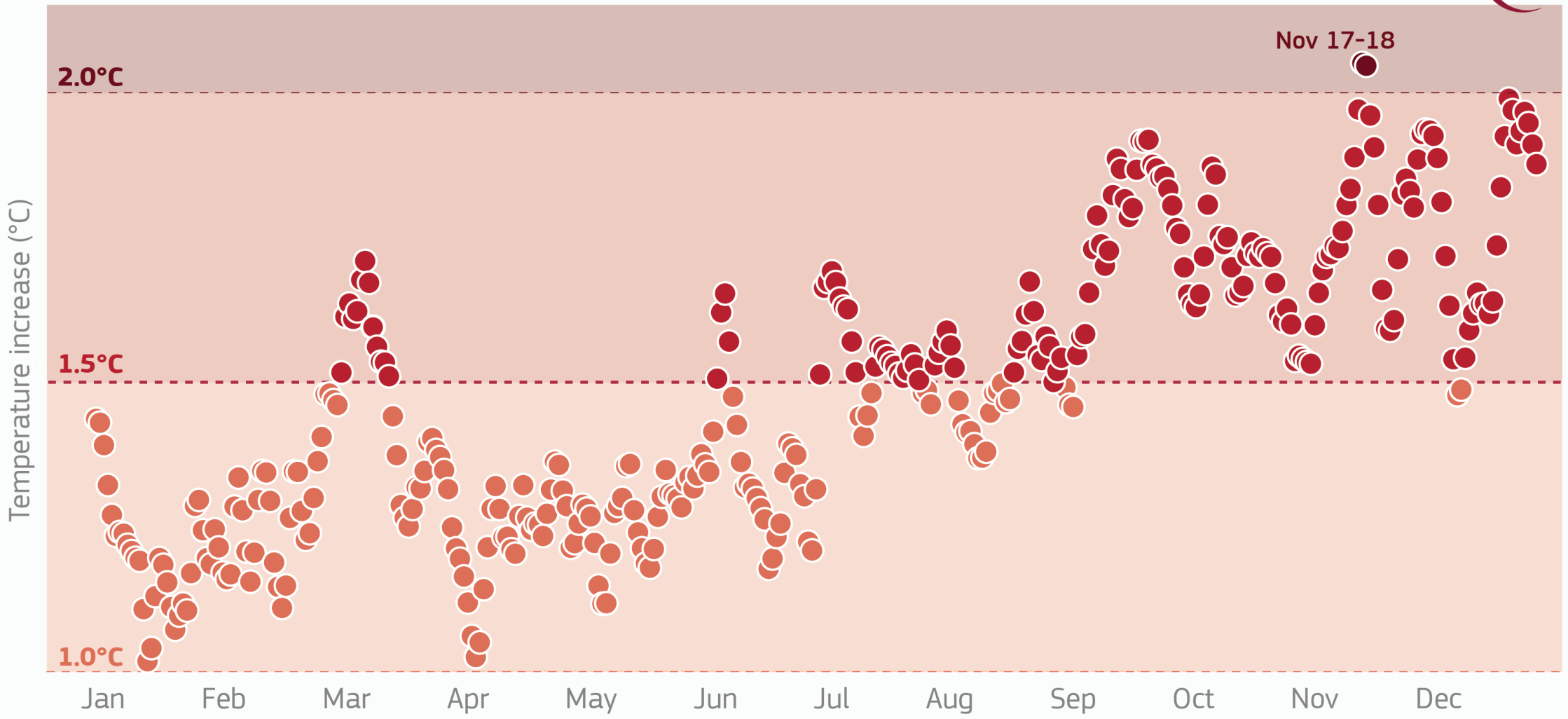
Global Mean Surface Air Temperature, 1880–2023



Source: NASA

DAILY GLOBAL TEMPERATURE INCREASE ABOVE PRE-INDUSTRIAL LEVEL (1850-1900) IN 2023



Data: ERA5 • Credit: C3S/ECMWF

PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

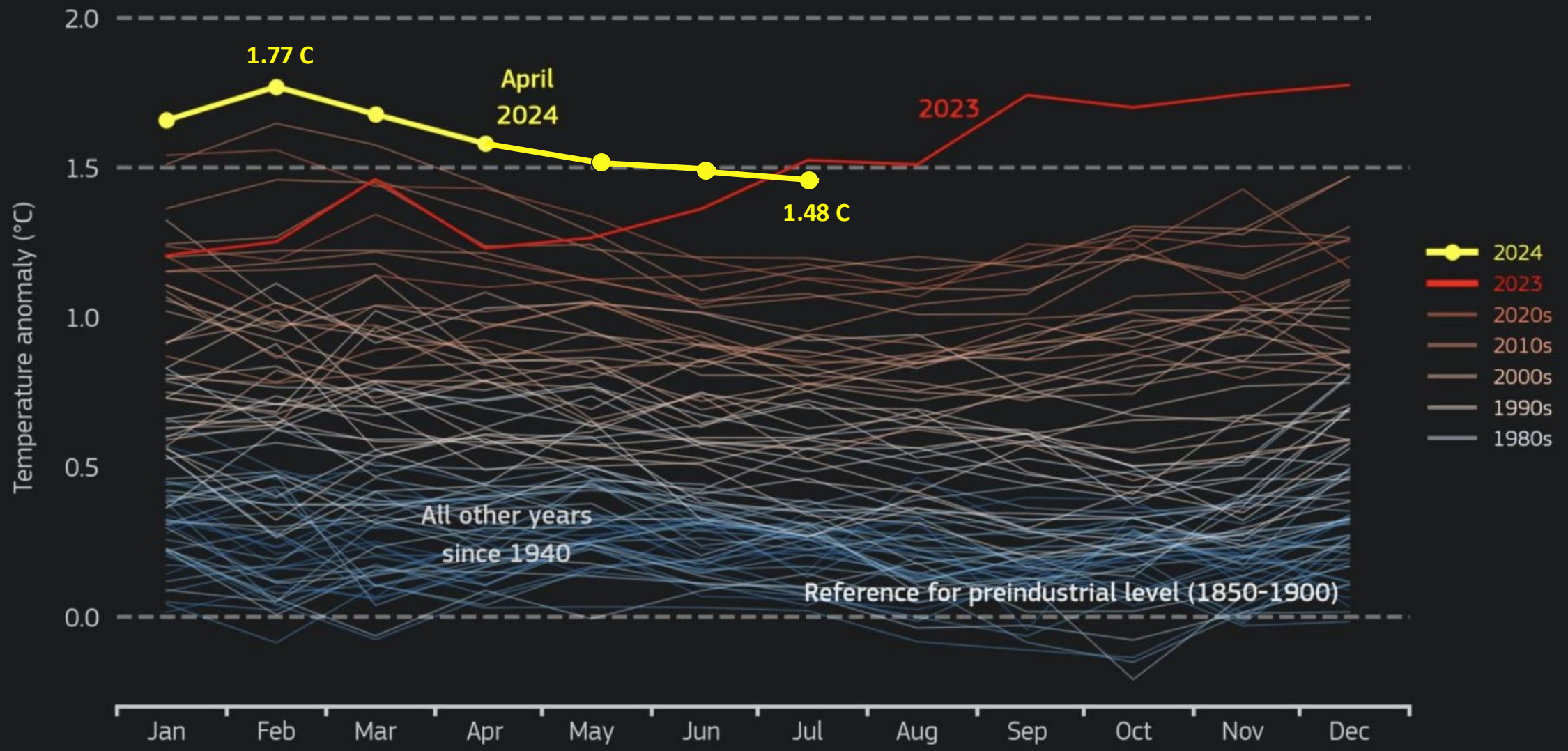
ECMWF

Climate Change Service

climate.copernicus.eu

Monthly global surface air temperature anomalies

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



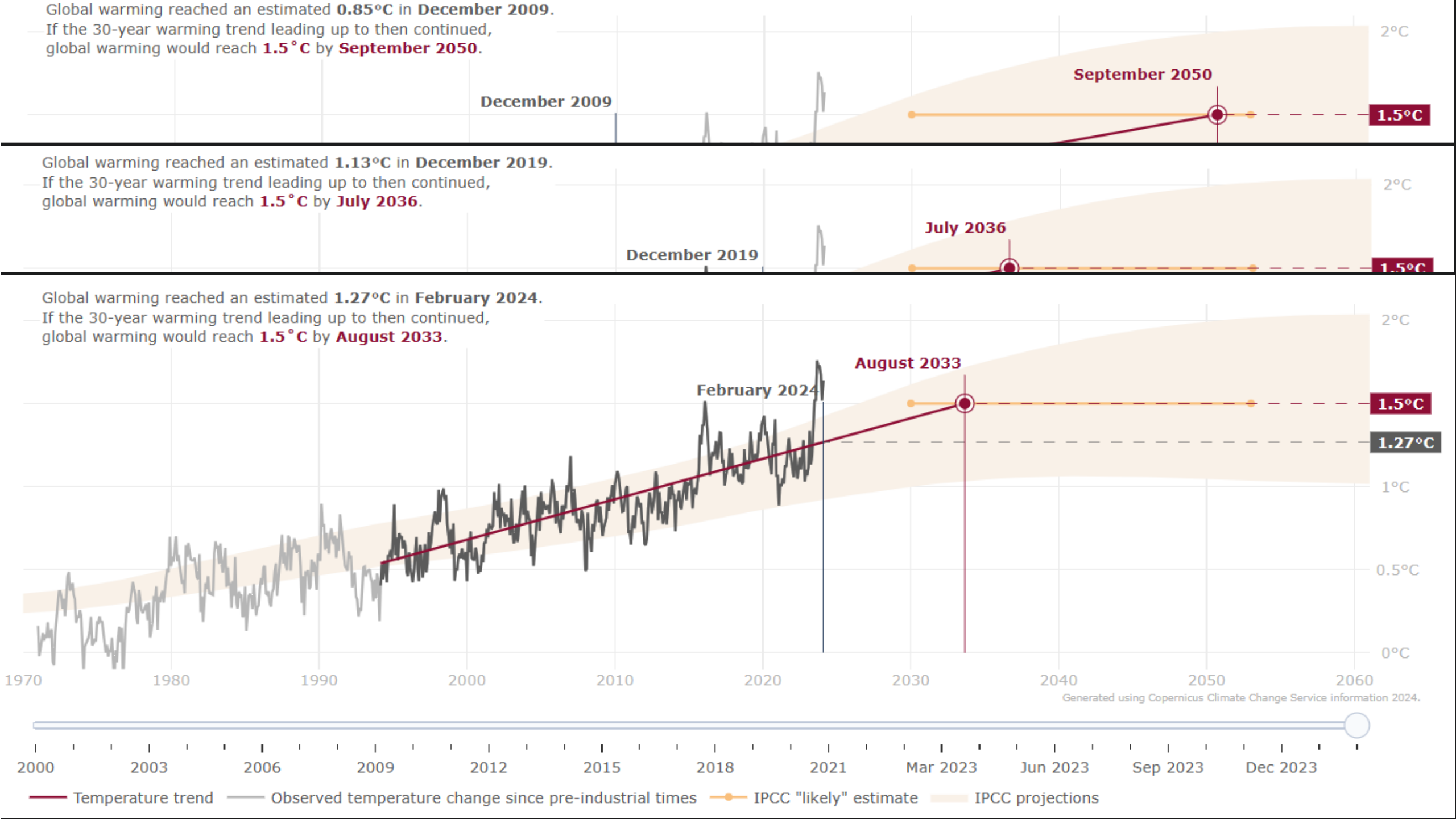
PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

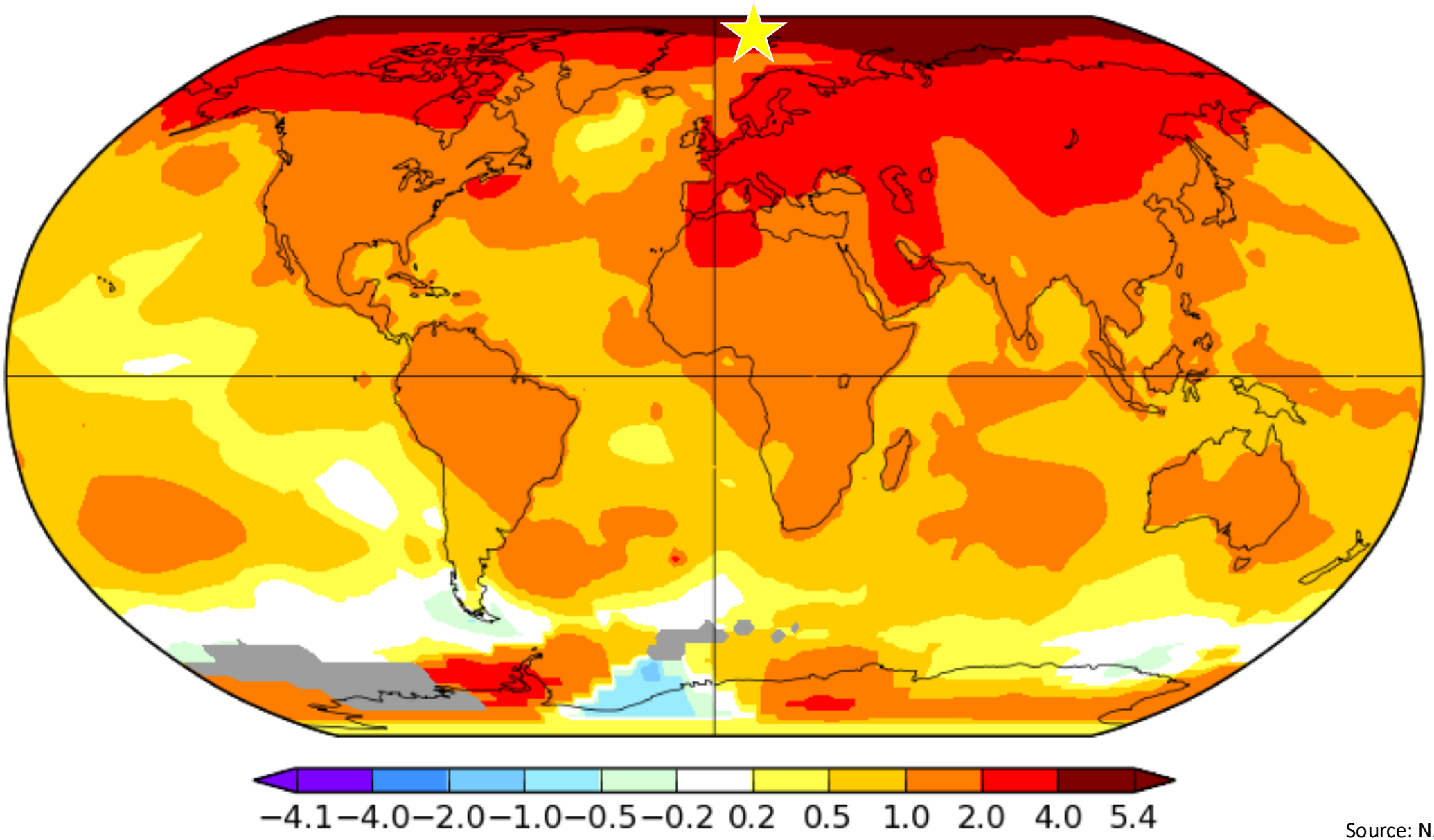
IMPLEMENTED BY ECMWF

Climate Change Service

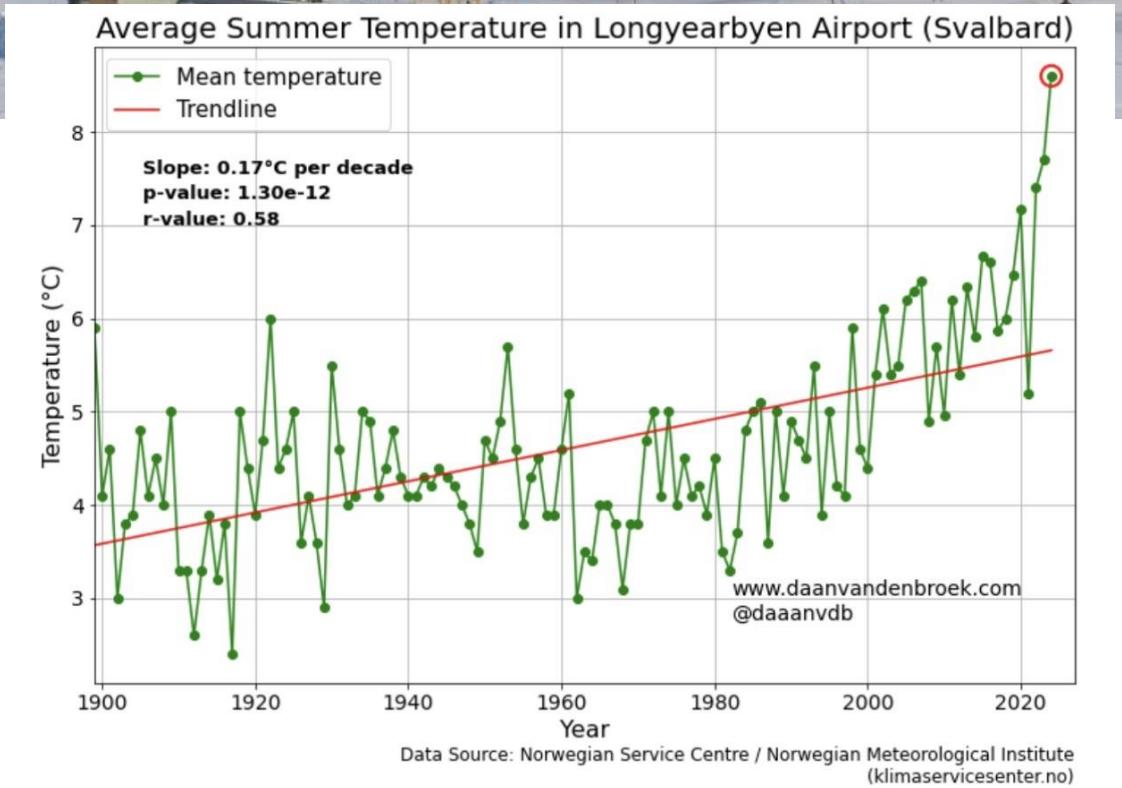
climate.copernicus.eu


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

Annual J-D L-OTI(°C) Change 1960-2023 1.11

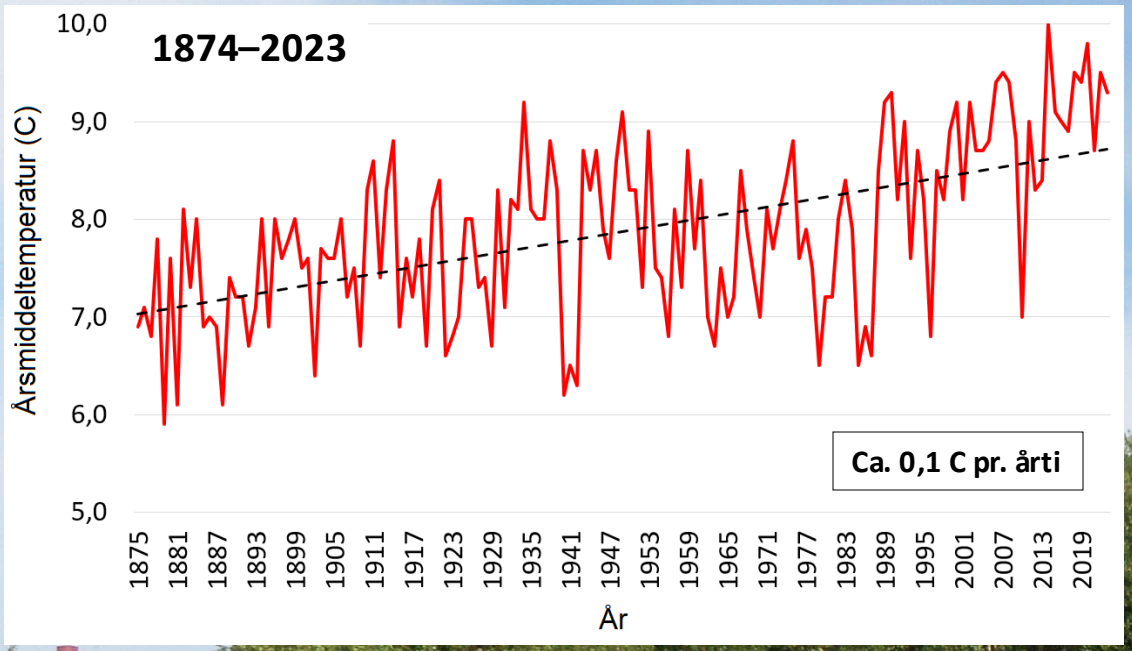


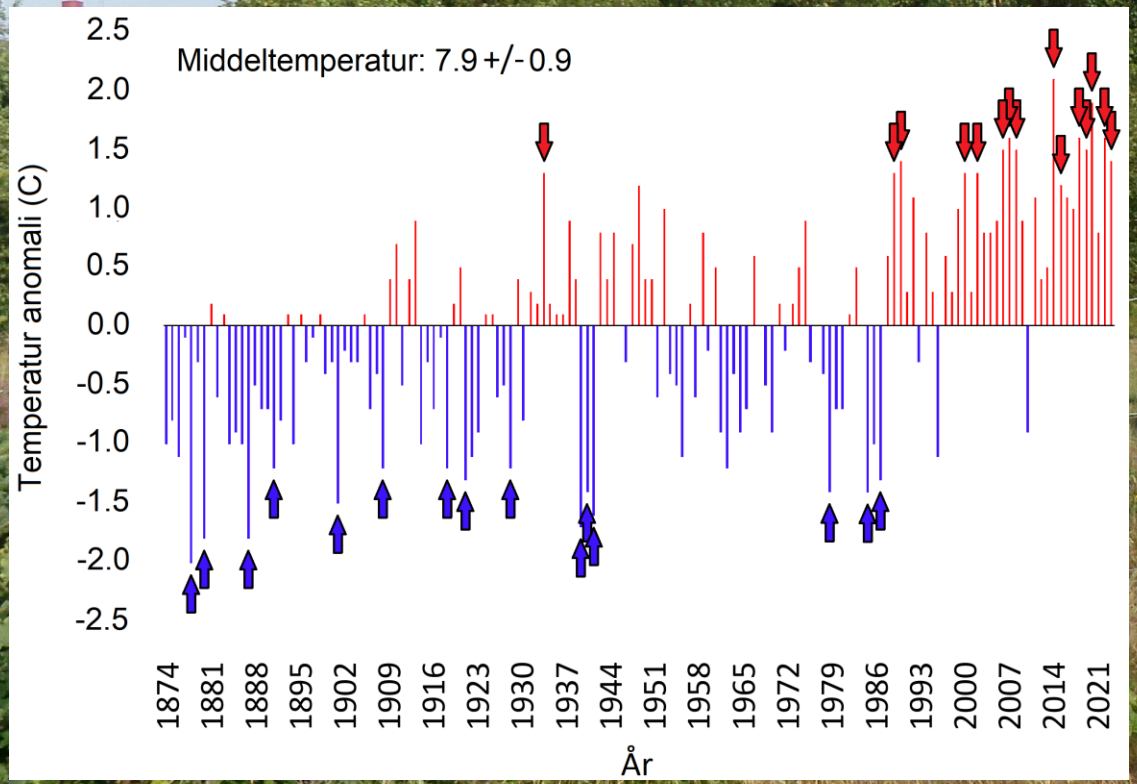
Source: NASA

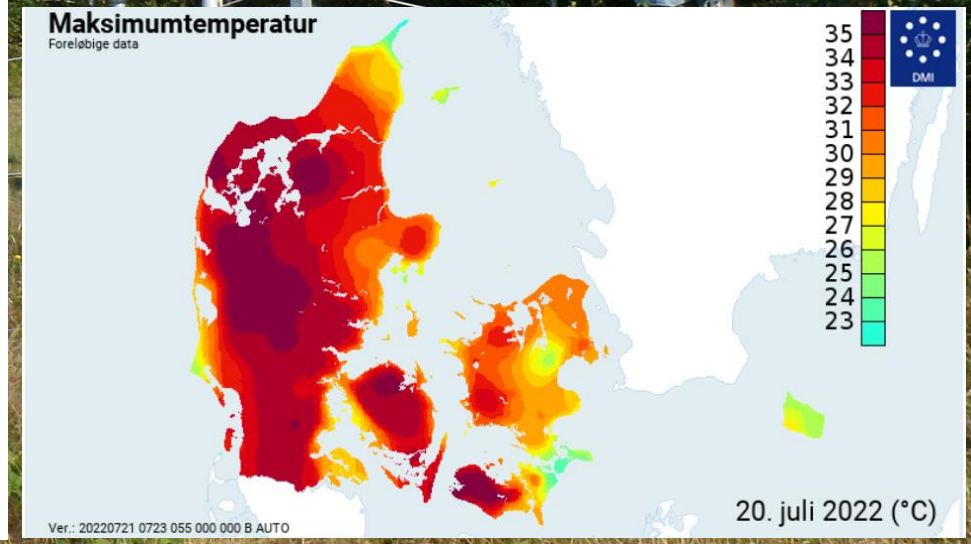


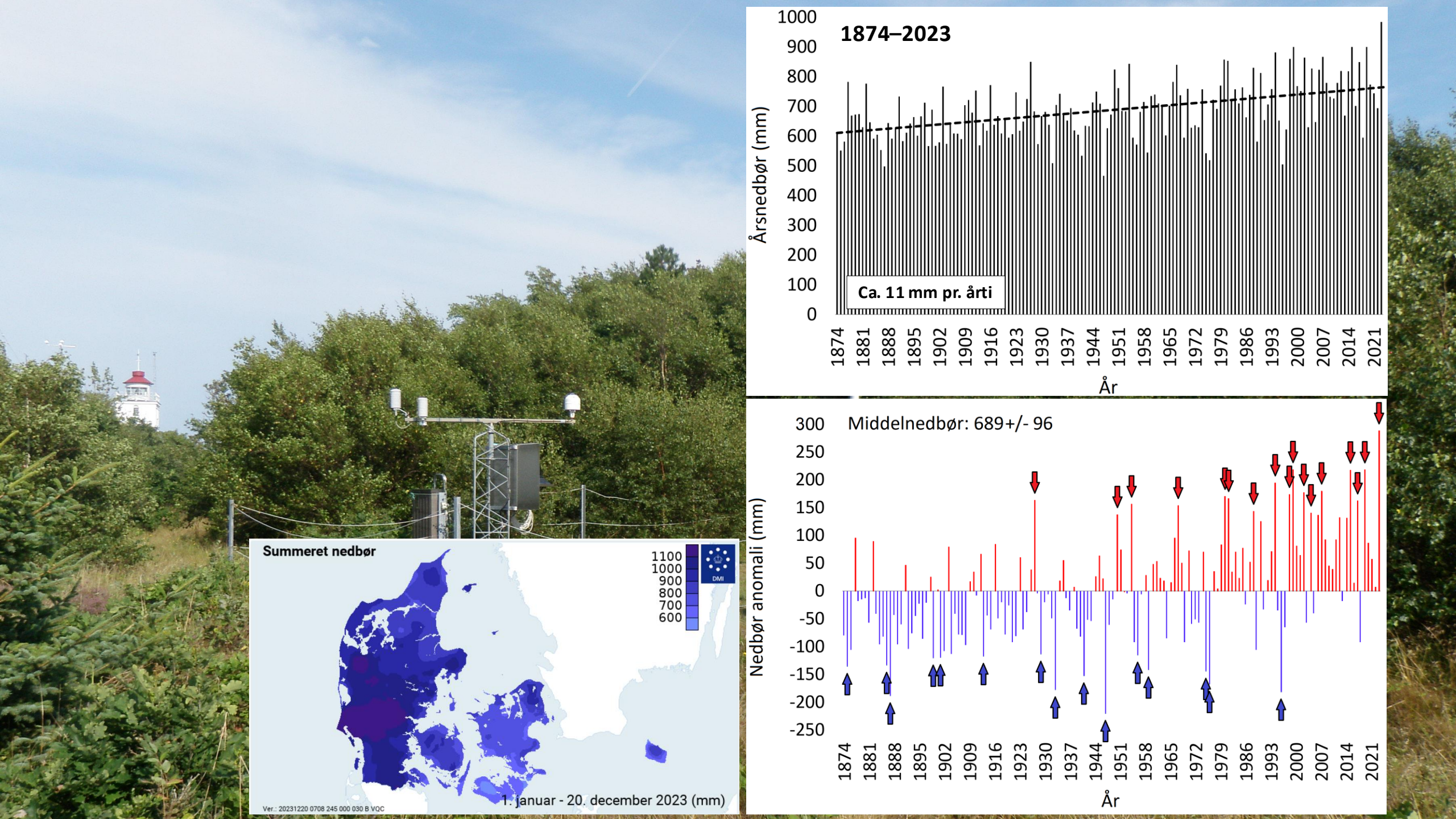
Over the ARO, long-term temperature records are available from Spitsbergen (Svalbard Airport). For the period 1898–2018, the annual mean warming was 0.32°C per decade, about 3.5 times the global mean temperature for the same period and since 1991, it was 1.7°C per decade or about seven times the global average for the same period (Nordli et al., 2020). There is a positive trend in the annual temperature for all stations across Svalbard (Gjelten et al., 2016; Hanssen-Bauer et al., 2019; Dahlke et al., 2020) of 0.64°C–1.01°C per decade for 1971–2017 (Hanssen-Bauer et al., 2019), co-varying with regional changes in sea ice conditions (Dahlke et al., 2020). The largest temperature trends *very likely* occur in winter, with Svalbard Airport warming at 0.43°C per decade during 1898–2018 and 3.19°C per decade during 1991–2018 (Nordli et al., 2020), and Isaksen et al. (2016) reporting on substantial warming in western Spitsbergen, particularly in winter, while the summer warming is moderate.

https://www.ipcc.ch/report/ar6/wg1/

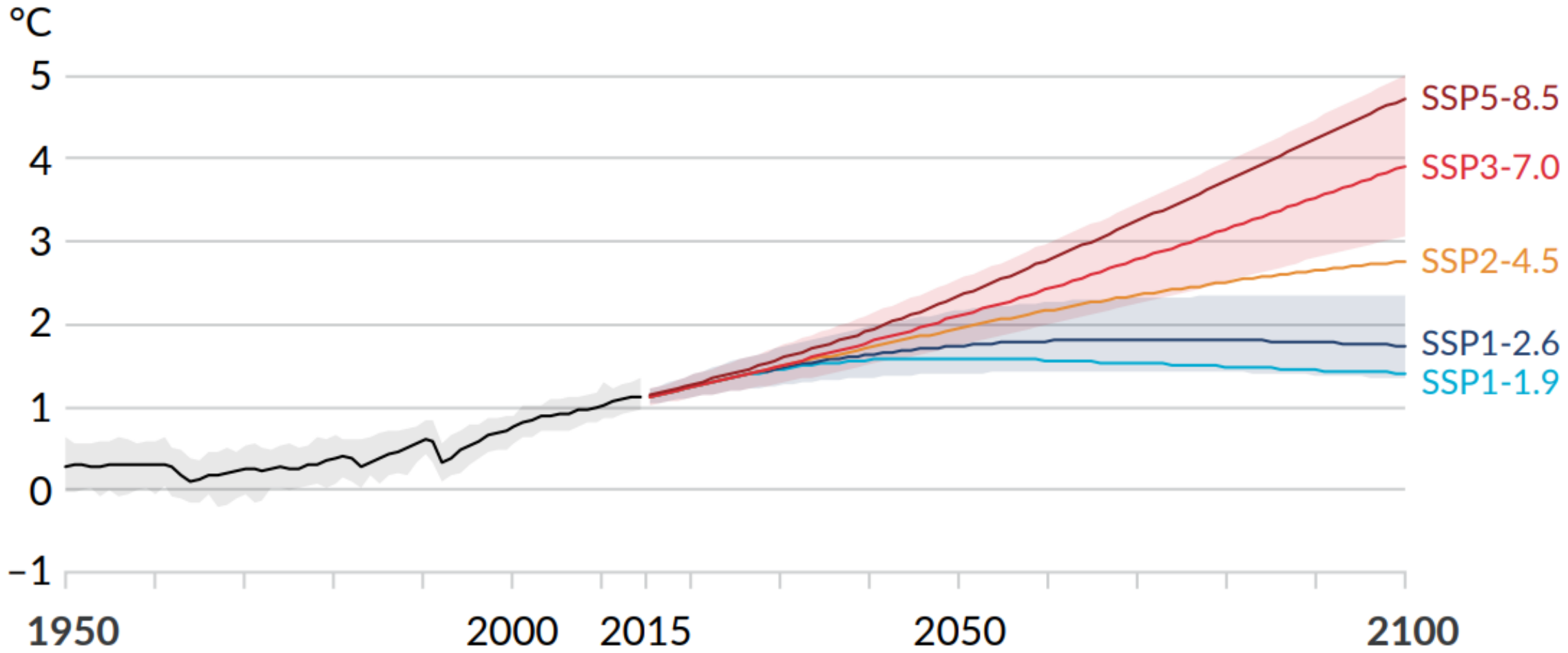

1874–2023
Årsmiddeltemperatur (C)
10,0
9,0
8,0
7,0
6,0
5,0
1875
1881
1887
1893
1899
1905
1911
1917
1923
1929
1935
1941
1947
1953
1959
1965
1971
1977
1983
1989
1995
2001
2007
2013
2019
År
Ca. 0,1 C pr. årti


Middeltemperatur: 7.9 +/- 0.9
Temperatur anomali (C)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
1874
1881
1888
1895
1902
1909
1916
1923
1930
1937
1944
1951
1958
1965
1972
1979
1986
1993
2000
2007
2014
2021
År

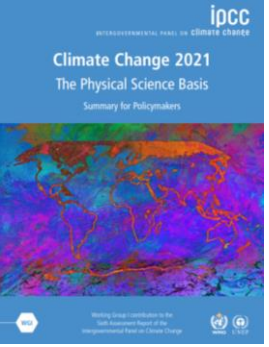

Maksimumtemperatur
Foreløbige data
35
34
33
32
31
30
29
28
27
26
25
24
23
DMI
Ver.: 20220721 0723 055 000 000 B AUTO
20. juli 2022 (°C)


1874–2023
Årsnedbør (mm)
1000
900
800
700
600
500
400
300
200
100
0
Ca. 11 mm pr. årti
1874
1881
1888
1895
1902
1909
1916
1923
1930
1937
1944
1951
1958
1965
1972
1979
1986
1993
2000
2007
2014
2021
År
Middelnedbør: 689+/- 96
Nedbør anomali (mm)
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
1874
1881
1888
1895
1902
1909
1916
1923
1930
1937
1944
1951
1958
1965
1972
1979
1986
1993
2000
2007
2014
2021
År
Summeret nedbør
1100
1000
900
800
700
600
DMI
1. januar - 20. december 2023 (mm)
Ver.: 20231220 0708 245 000 030 B VQC

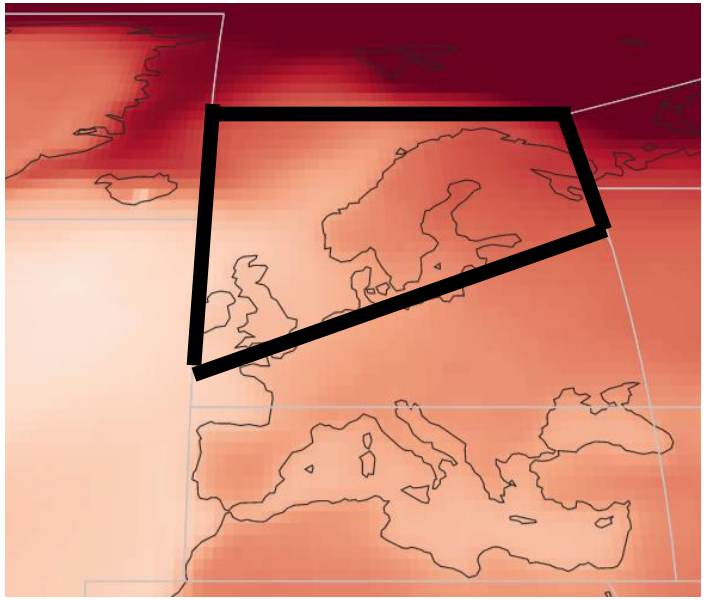
Global surface temperature change relative to 1850–1900



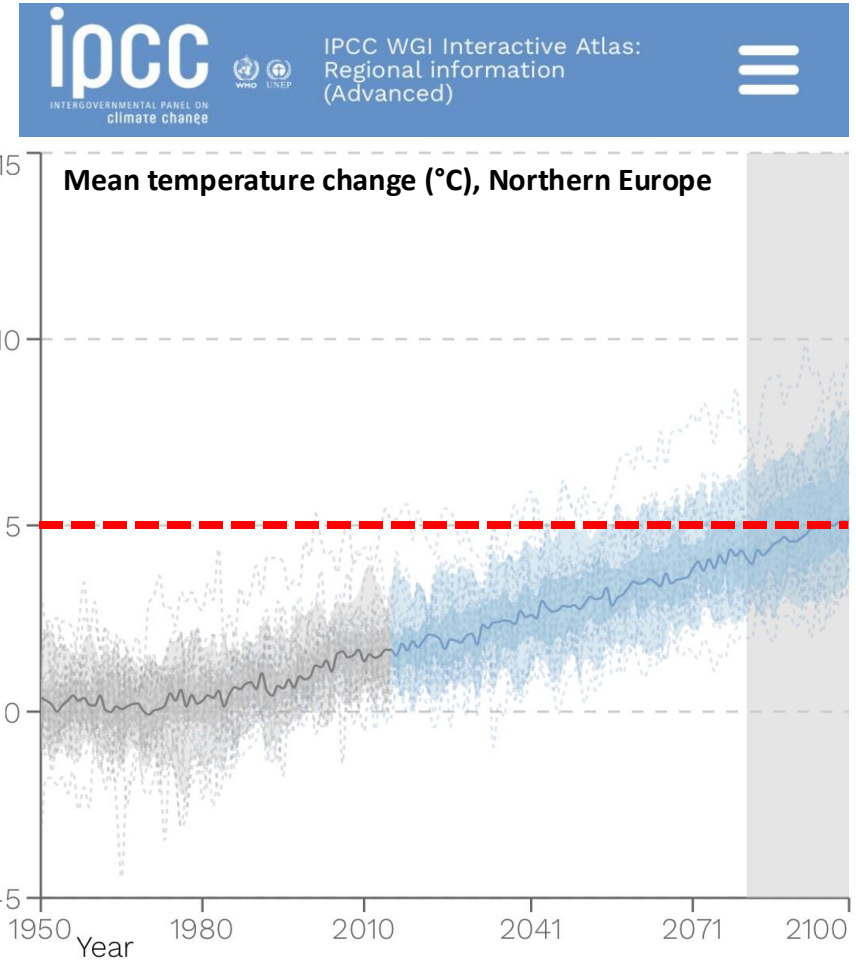
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf



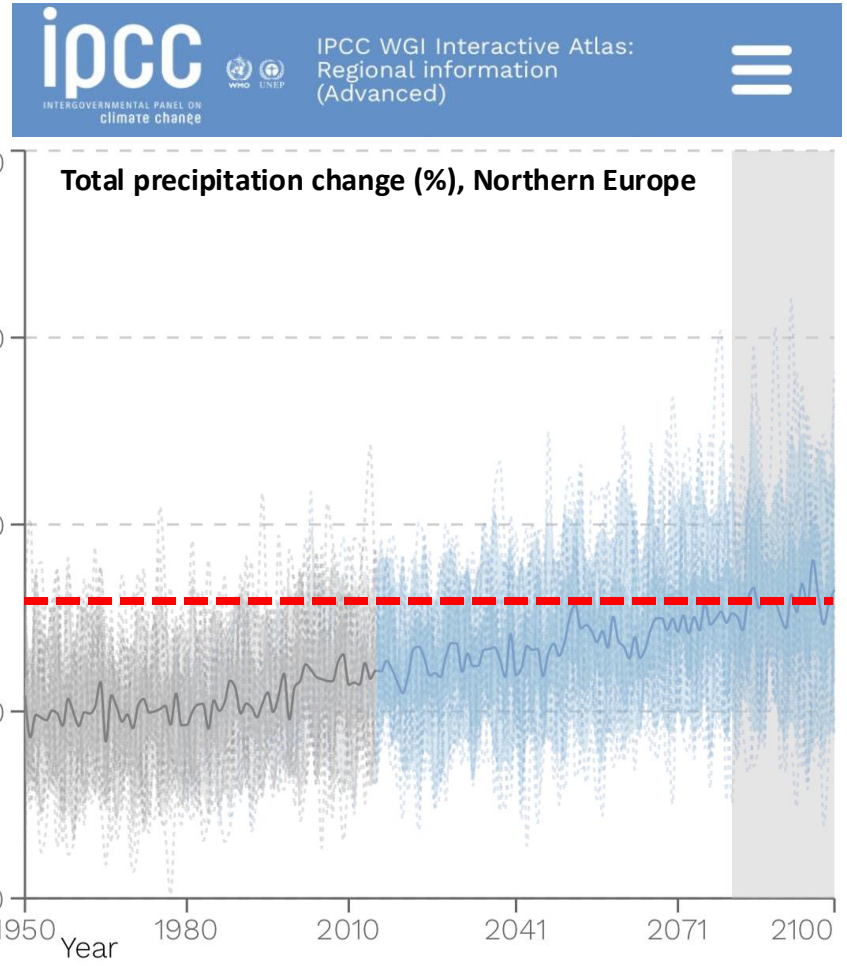
Region: Northern Europe



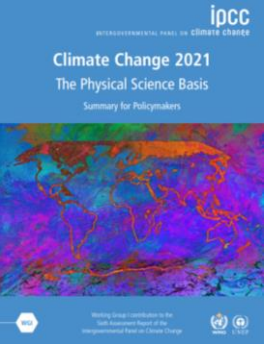
Scenario: SSP3-7.0



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



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



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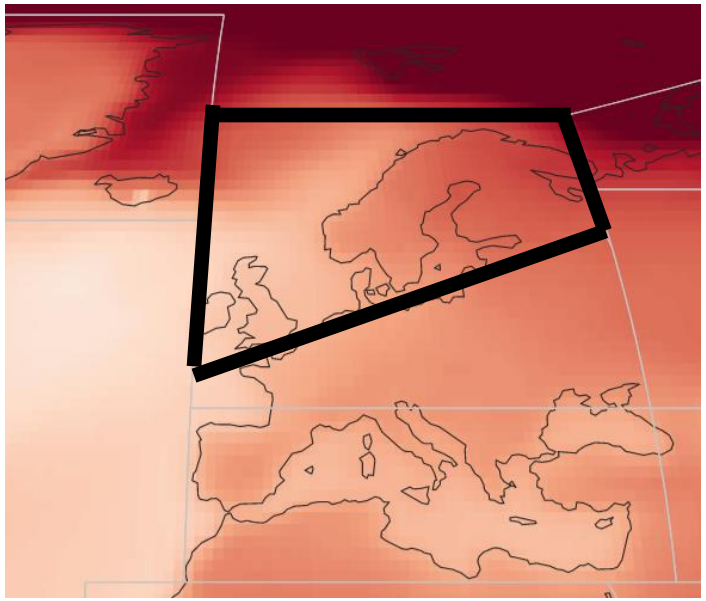
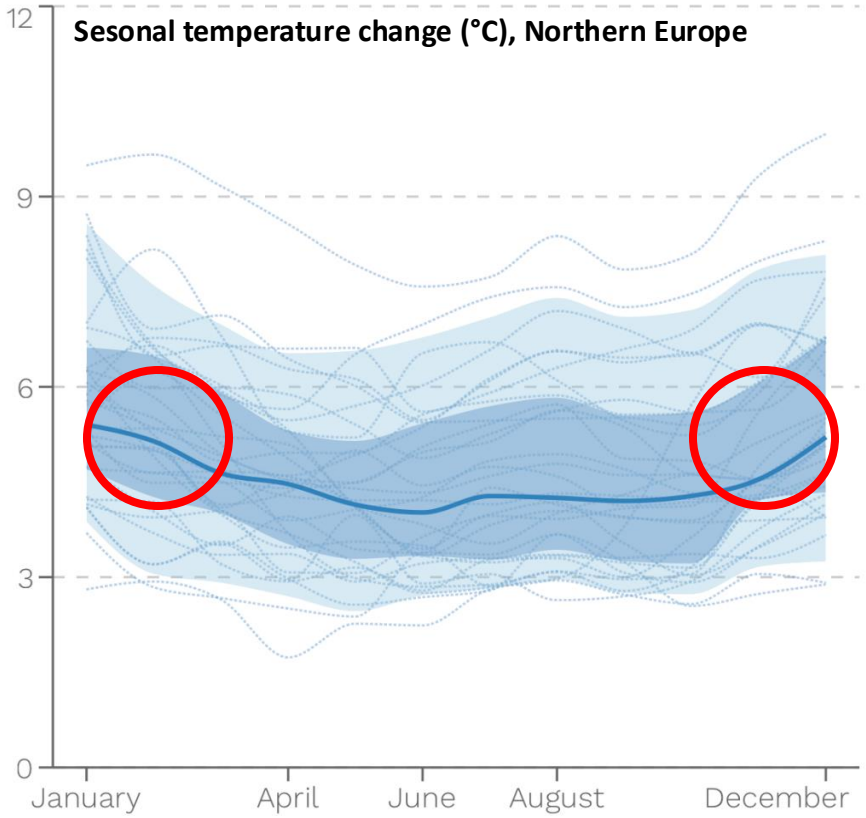
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

Region: Northern Europe



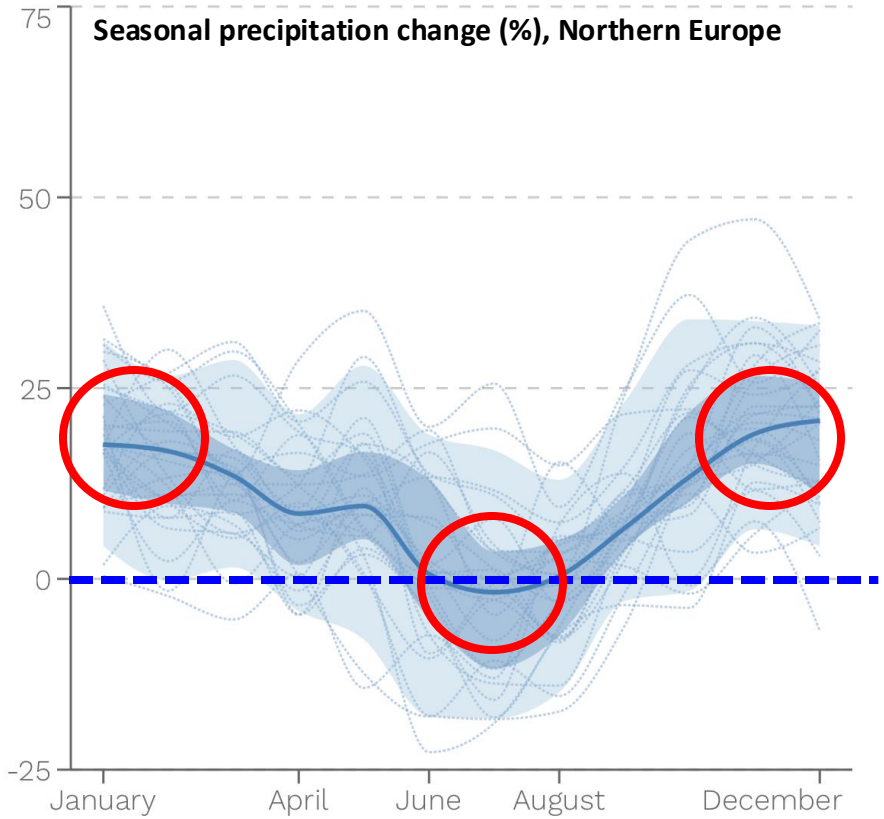
Scenario: SSP3-7.0

ipcc INTERGOVERNMENTAL PANEL ON climate change WMO UNEP
IPCC WGI Interactive Atlas: Regional information (Advanced)



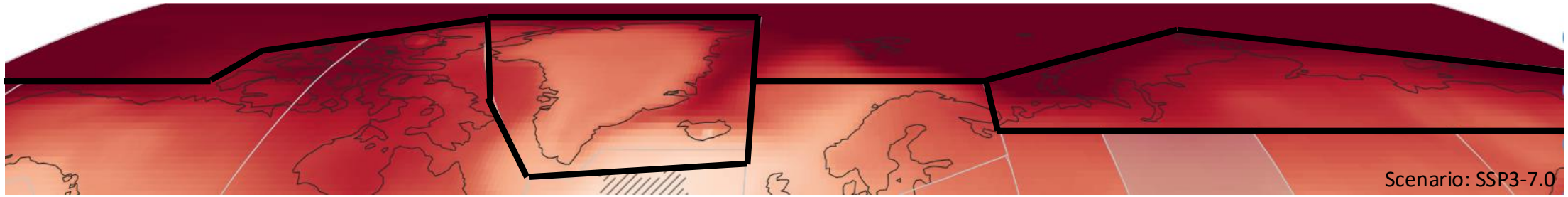
Dotted line: Model
Solid line: P50 (median)
Light / dark areas: Spread P10-P90 / P25-75

ipcc INTERGOVERNMENTAL PANEL ON climate change WMO UNEP
IPCC WGI Interactive Atlas: Regional information (Advanced)



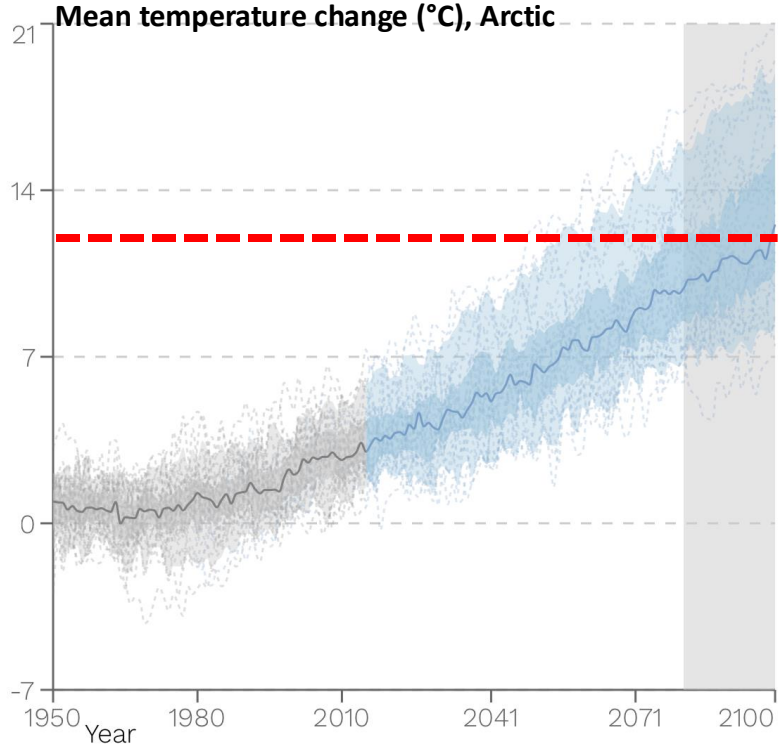
Dotted line: Model
Solid line: P50 (median)
Light / dark areas: Spread P10-P90 / P25-75

Region: Arctic, Greenland and Sibiria



IPCC WGI Interactive Atlas: Regional information (Advanced)

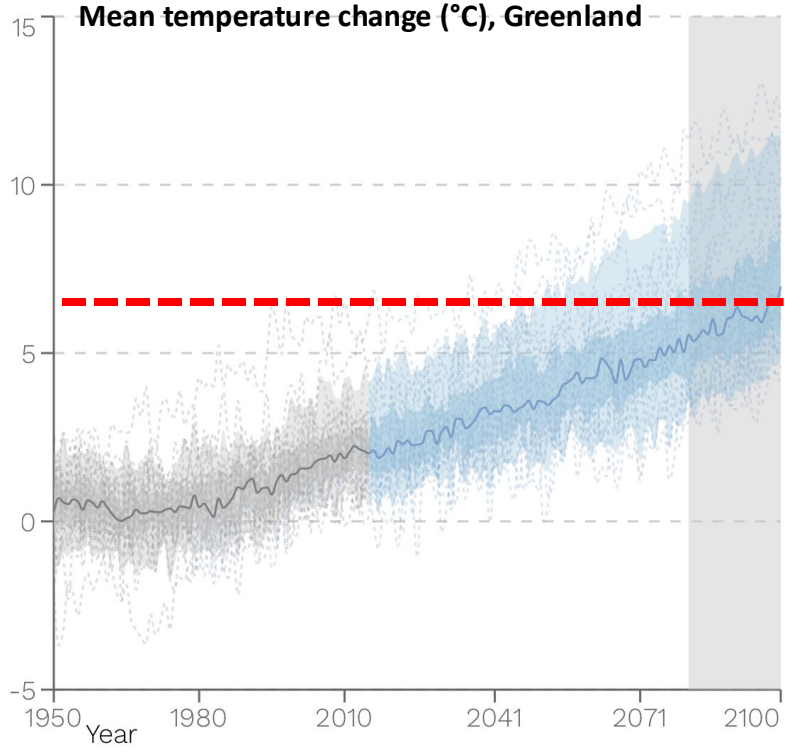
Mean temperature change (°C), Arctic



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)

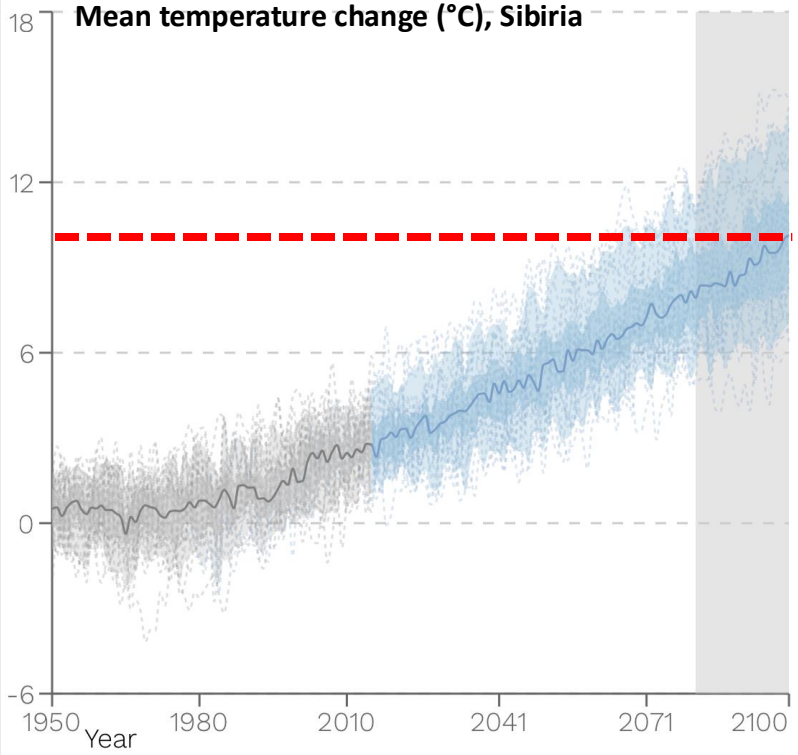
Mean temperature change (°C), Greenland



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

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

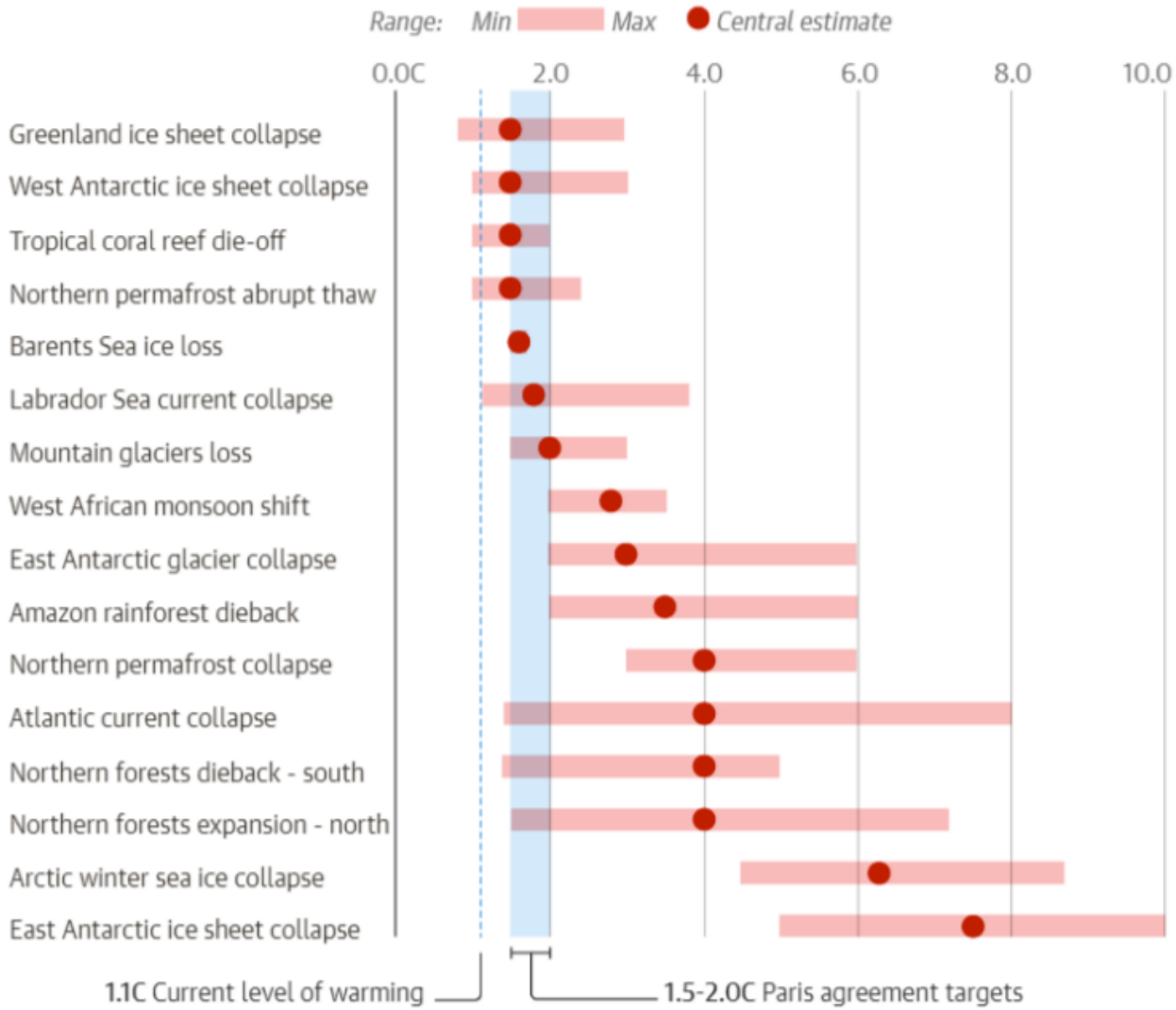
Region, Today–2100	Northern Europe	Central Europe	Southern Europe	Western US	Central US	Eastern US	SE South America	S South America	Southern Australia	New Zealand	East Asia
Mean temperature change (C)	2.5 to 3.5	2.5 to 4.0	2.5 to 3.5	3.0 to 4.5	**3.5 to 5.5**	3.5 to 4.5	2.5 to 3.5	**1.5 to 2.5**	2.0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

The risk of climate tipping points is rising rapidly as the world heats up

Estimated range of global heating needed to pass tipping point temperature

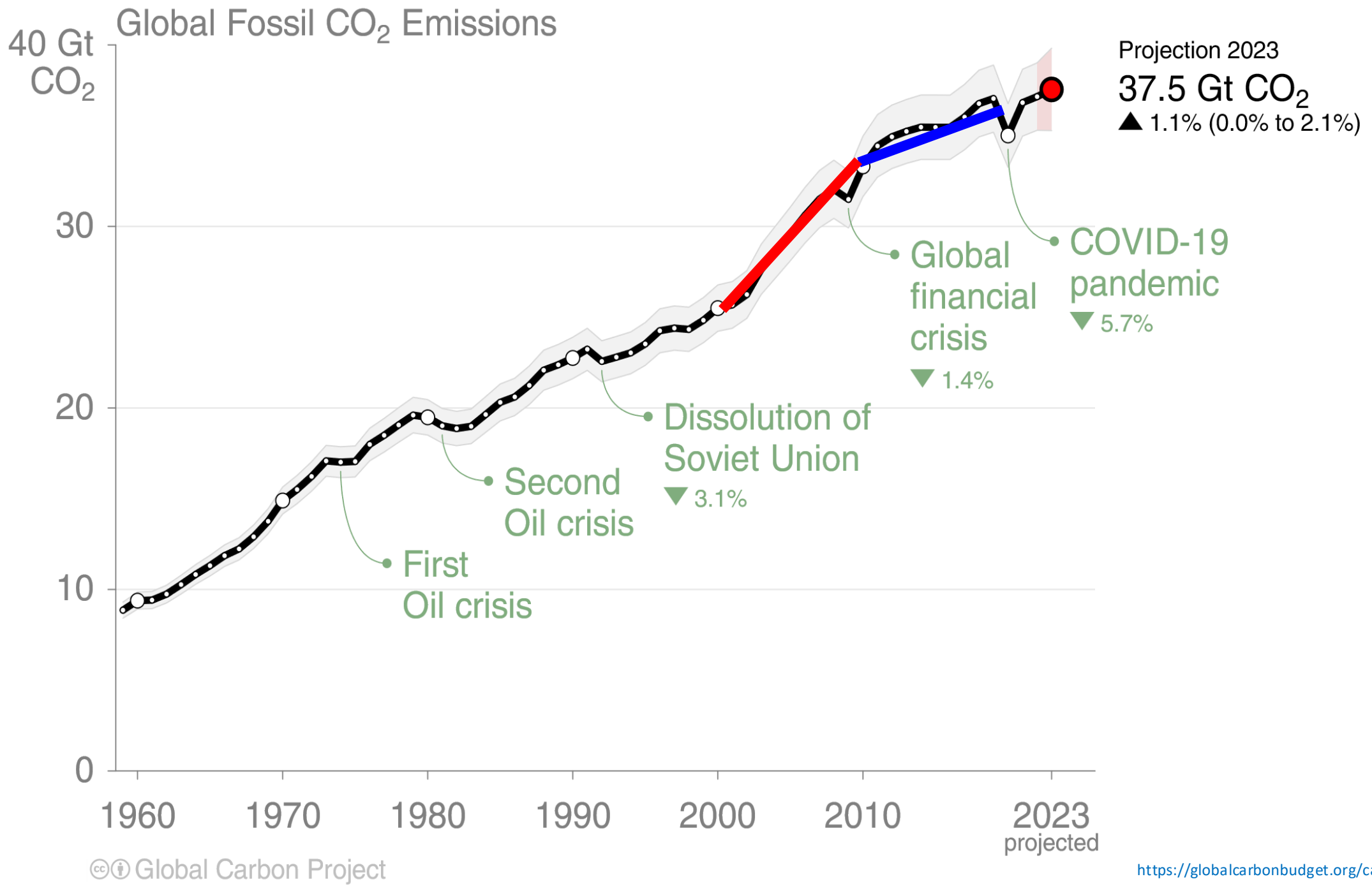


Guardian graphic. Source: Armstrong McKay et al, Science, 2022. Note: Current global heating temperature rise 1.1C Paris agreement targets 1.5-2.0C

AR6, WG1 (2021):

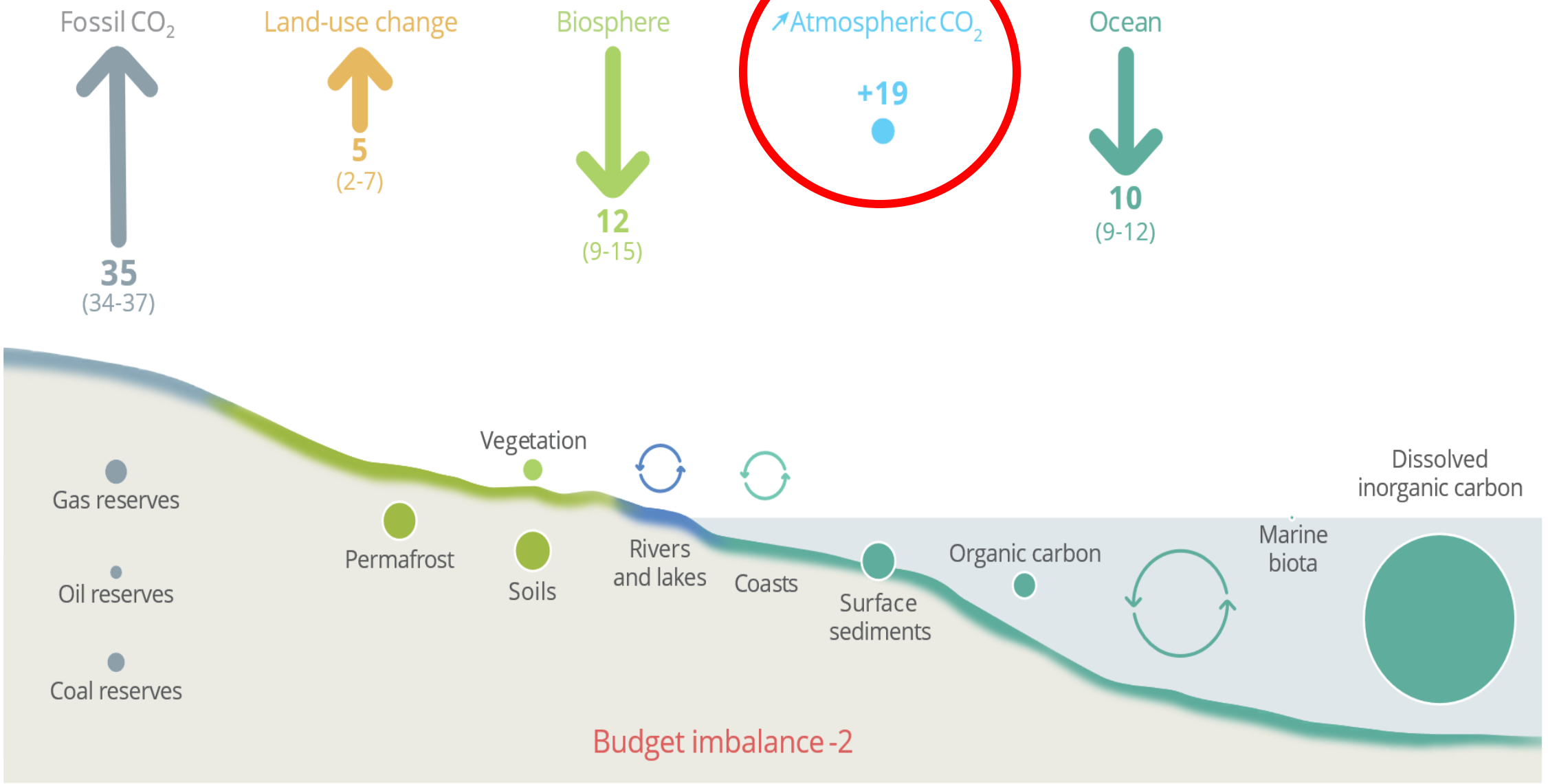
Estimated remaning carbon budgets from
the beginning of 2020 (GtCO2).....it is about likelihood!

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



https://globalcarbonbudget.org/carbonbudget2023/

Perturbation of **the global carbon cycle** caused by anthropogenic activities, global annual average for the decade 2013–2022 ($GtCO_2$/yr)



https://globalcarbonbudget.org/carbonbudget2023/

Thank you for your attention…

mernild@sdu.dk

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