Wege aus der Klimafalle

Stefan Rahmstorf Potsdam-Institut für Klimafolgenforschung

Der Mensch verändert das Klima „durch Fällen der Wälder [...] und durch die Entwicklung großer Dampf- und Gasmassen an den Mittelpunkten der Industrie".

Alexander von Humboldt, 1843

Svante Arrhenius 1896

Klimasensitivität

4°C

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 *.

I. *Introduction : Observations of* Langley *on Atmospherical Absorption.*

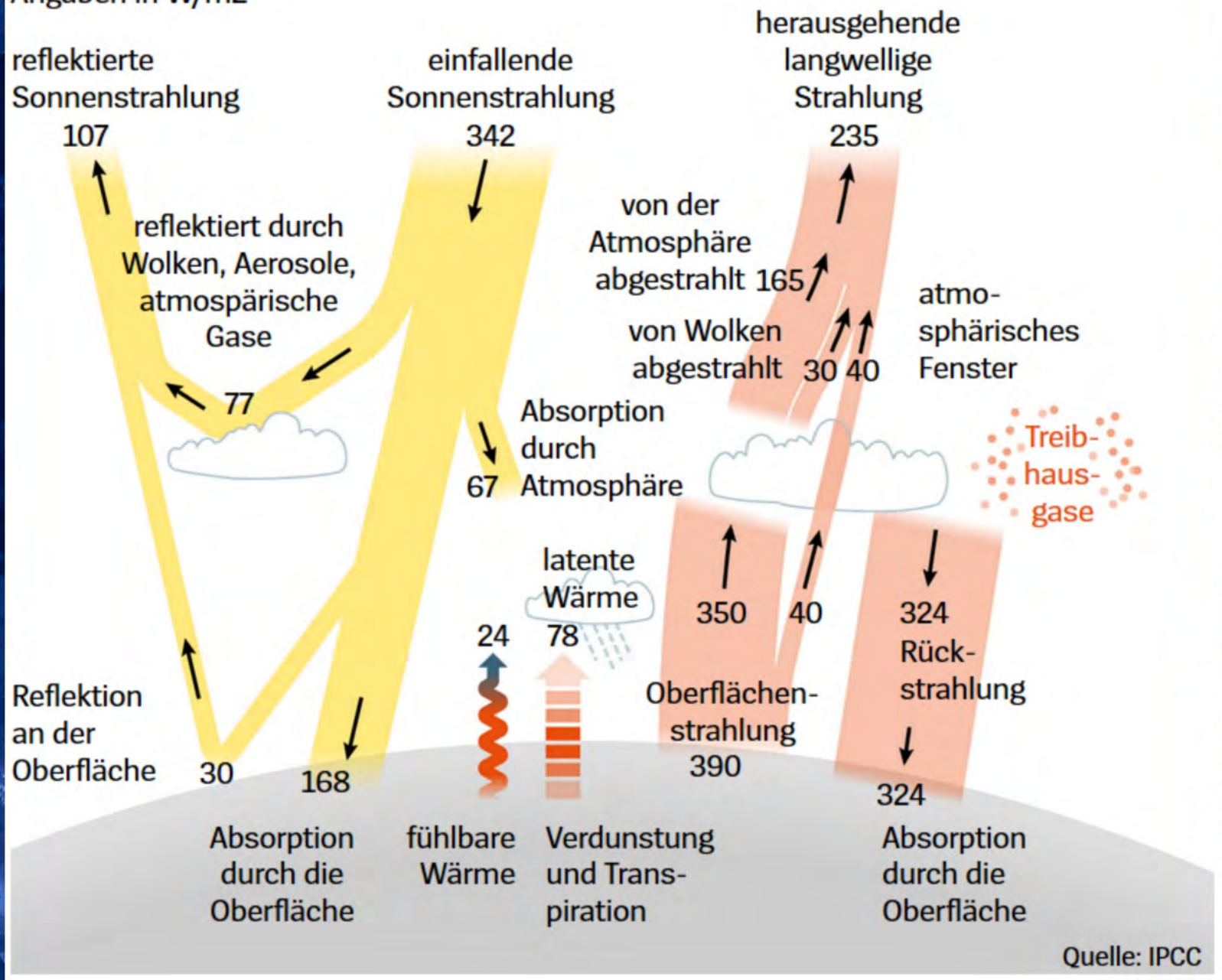
A GREAT deal has been written on the influence of the absorption of the atmosphere upon the climate. Tyndall † in particular has pointed out the enormous importance of this question. To him it was chiefly the diurnal and annual variations of the temperature that were lessened by this circumstance. Another side of the question, that has long attracted the attention of physicists, is this : Is the mean temperature of the ground in any way influenced by the presence of heat-absorbing gases in the atmosphere? Fourier‡ maintained that the atmosphere acts like the glass of a hot-house, because it lets through the light rays of the sun but retains the dark rays from the ground. This idea was elaborated by Pouillet § ; and Langley was by some of his researches led to the view, that "the temperature of the earth under direct sunshine, even though our atmosphere were present as now, would probably fall to −200° C., if that atmosphere did not possess the quality of selective

* Extract from a paper presented to the Royal Swedish Academy of Sciences, 11th December, 1895. Communicated by the Author.
† 'Heat a Mode of Motion,' 2nd ed. p. 405 (Lond., 1865).
‡ *Mém. de l'Ac. R. d. Sci. de l'Inst. de France*, t. vii. 1827.
§ *Comptes rendus*, t. vii. p. 41 (1838).

Fragiles Gleichgewicht

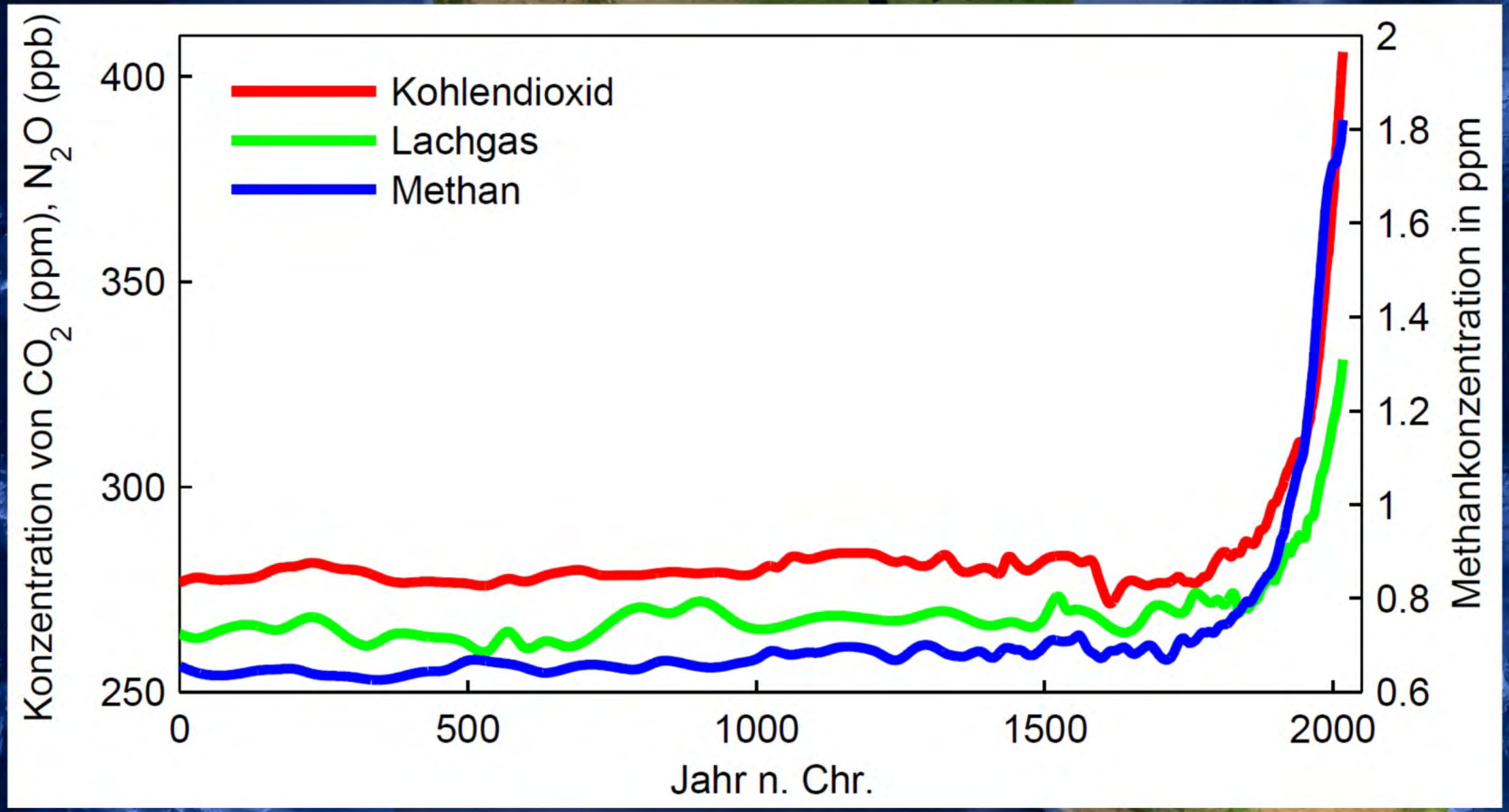
Die Energiebilanz der Erde

Angaben in W/m2



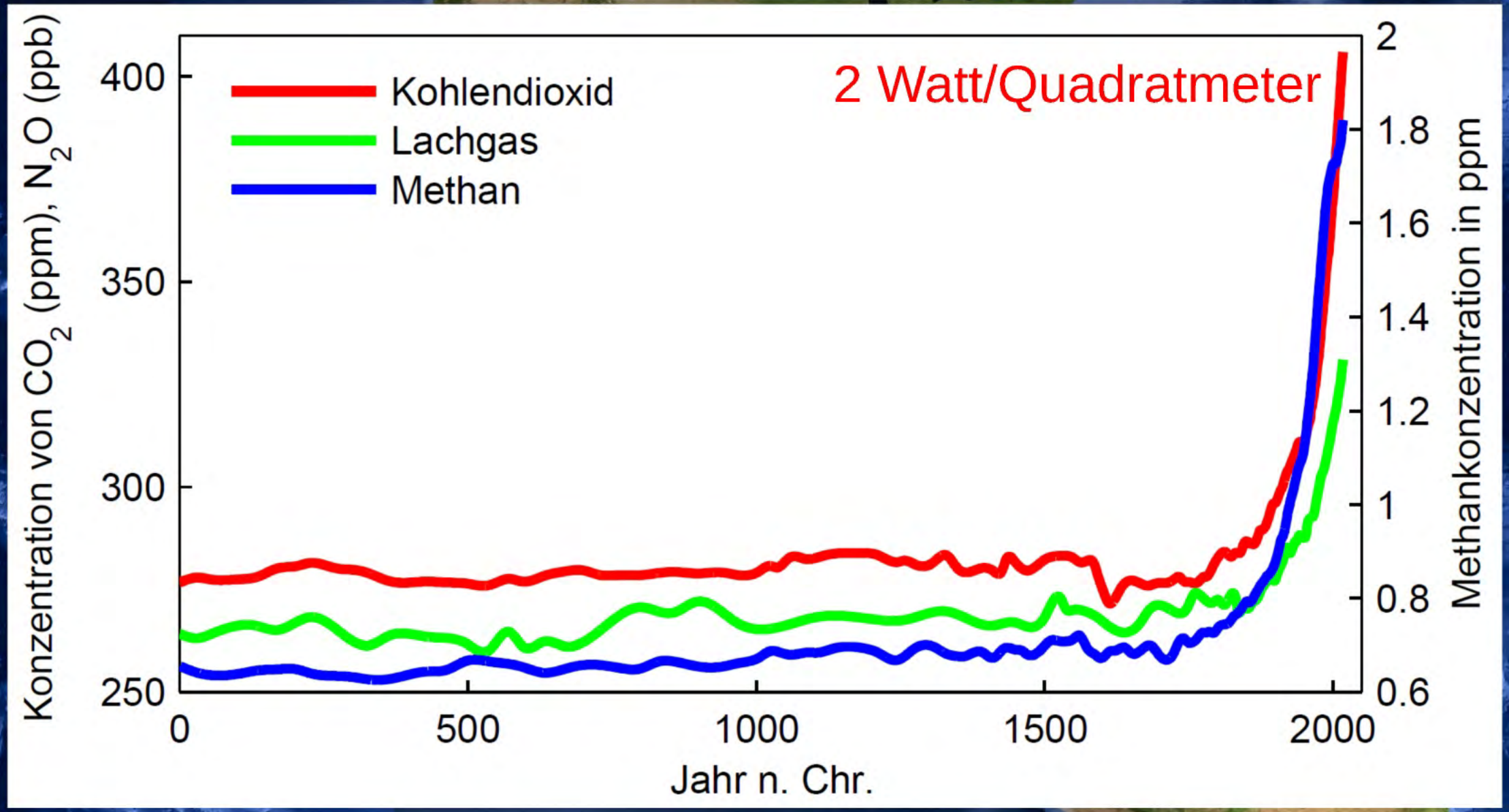
Quelle: IPCC

Treibhausgasmengen in der Atmosphäre

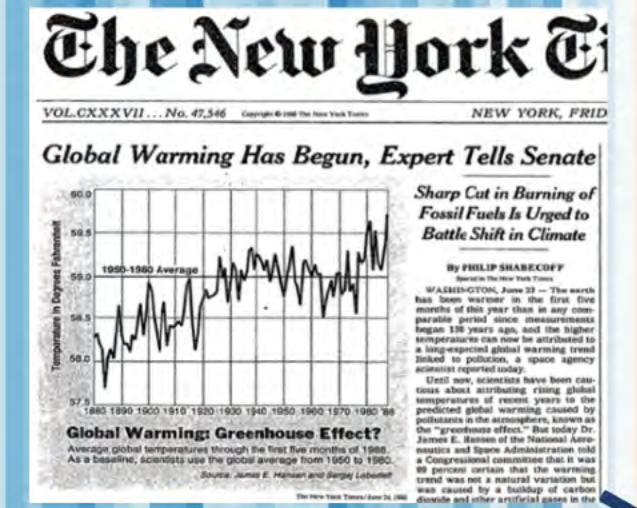


Quelle: Rahmstorf/Schellnhuber, *Der Klimawandel*

Treibhausgasmengen in der Atmosphäre



Quelle: Rahmstorf/Schellnhuber, *Der Klimawandel*



The New York Ti

VOL.CXXXVII . . . No. 47,546 NEW YORK, FRID

Global Warming Has Begun, Expert Tells Senate

Sharp Cut in Burning of Fossil Fuels Is Urged to Battle Shift in Climate

By PHILIP SHABECOFF

WASHINGTON, June 23 — The earth has been warmer in the first five months of this year than in any comparable period since measurements began 130 years ago, and the higher temperatures can now be attributed to a long-expected global warming trend linked to pollution, a space agency scientist reported today.

Until now, scientists have been cautious about attributing rising global temperatures of recent years to the predicted global warming caused by pollutants in the atmosphere, known as the "greenhouse effect." But today Dr. James E. Hansen of the National Aeronautics and Space Administration told a Congressional committee that it was 99 percent certain that the warming trend was not a natural variation but was caused by a buildup of carbon dioxide and other artificial gases in the

Global Warming: Greenhouse Effect?

Average global temperatures through the first five months of 1988. As a baseline, scientists use the global average from 1950 to 1980.

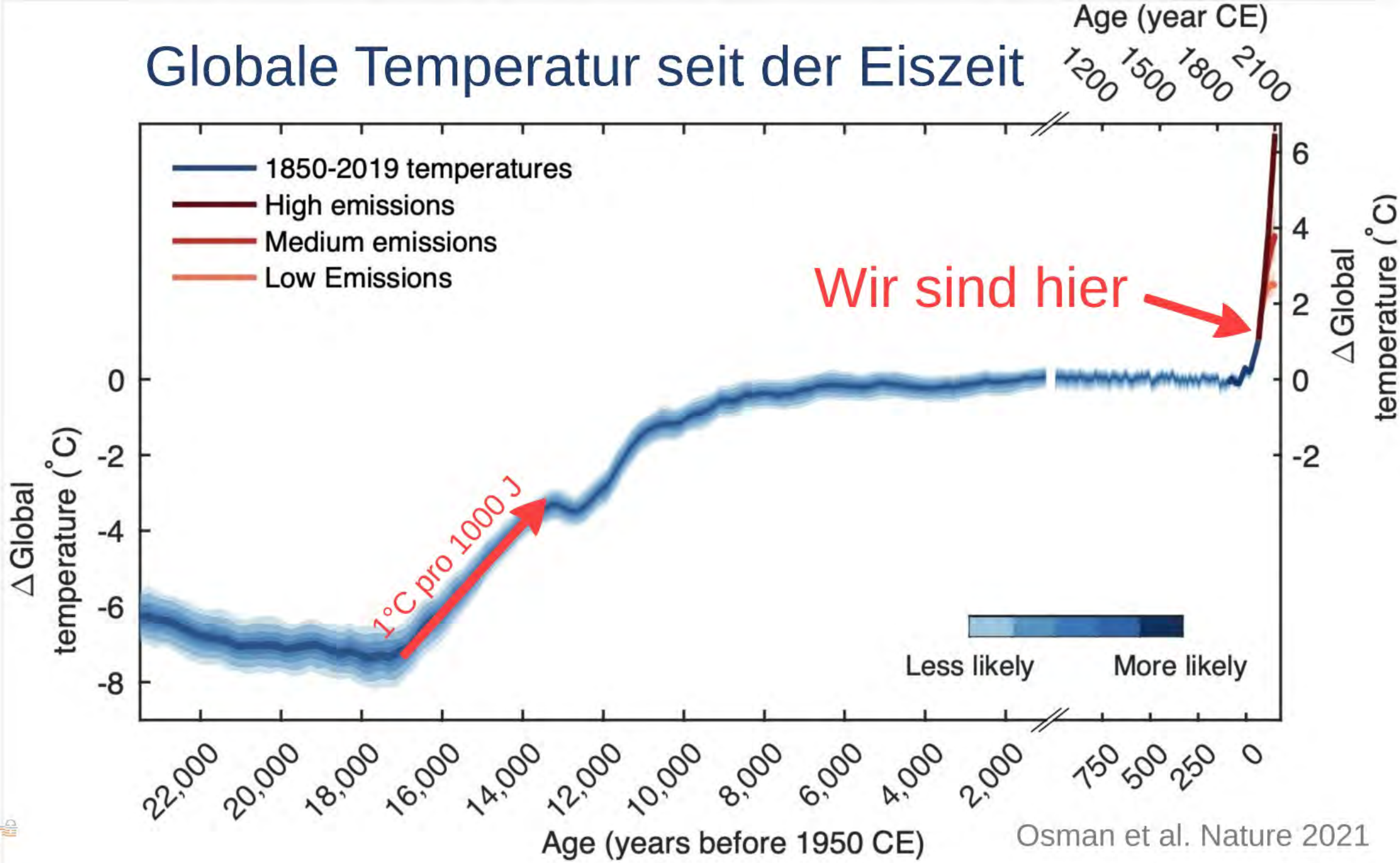
Source: James E. Hansen and Sergej Lebedeff

Erdgipfel Rio

Revelle Report

Man is unwittingly conducting a vast geophysical experiment…The climatic changes that may be produced by the increased CO_2 content could be deleterious from the point of view of human beings.

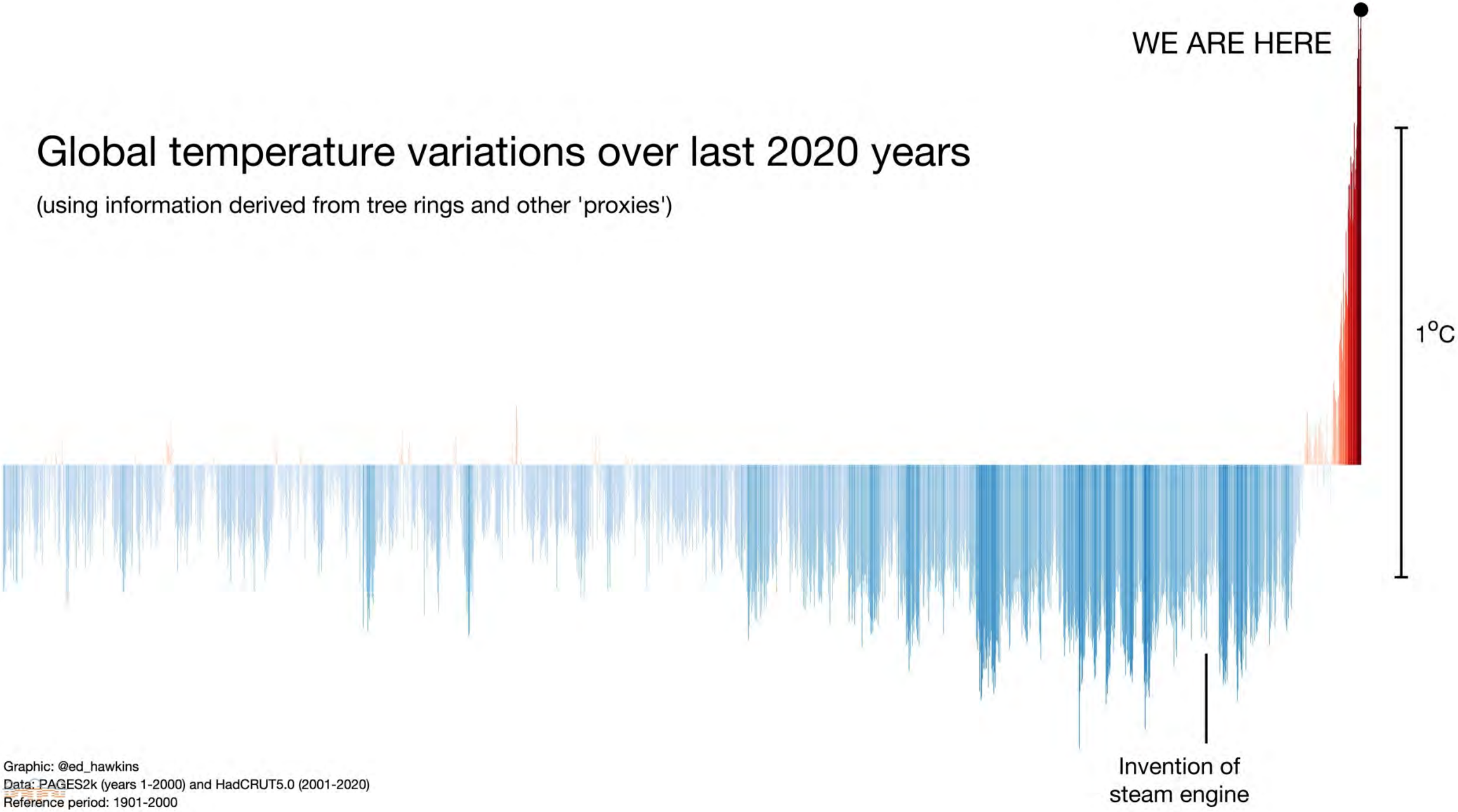
Globale Temperatur seit der Eiszeit



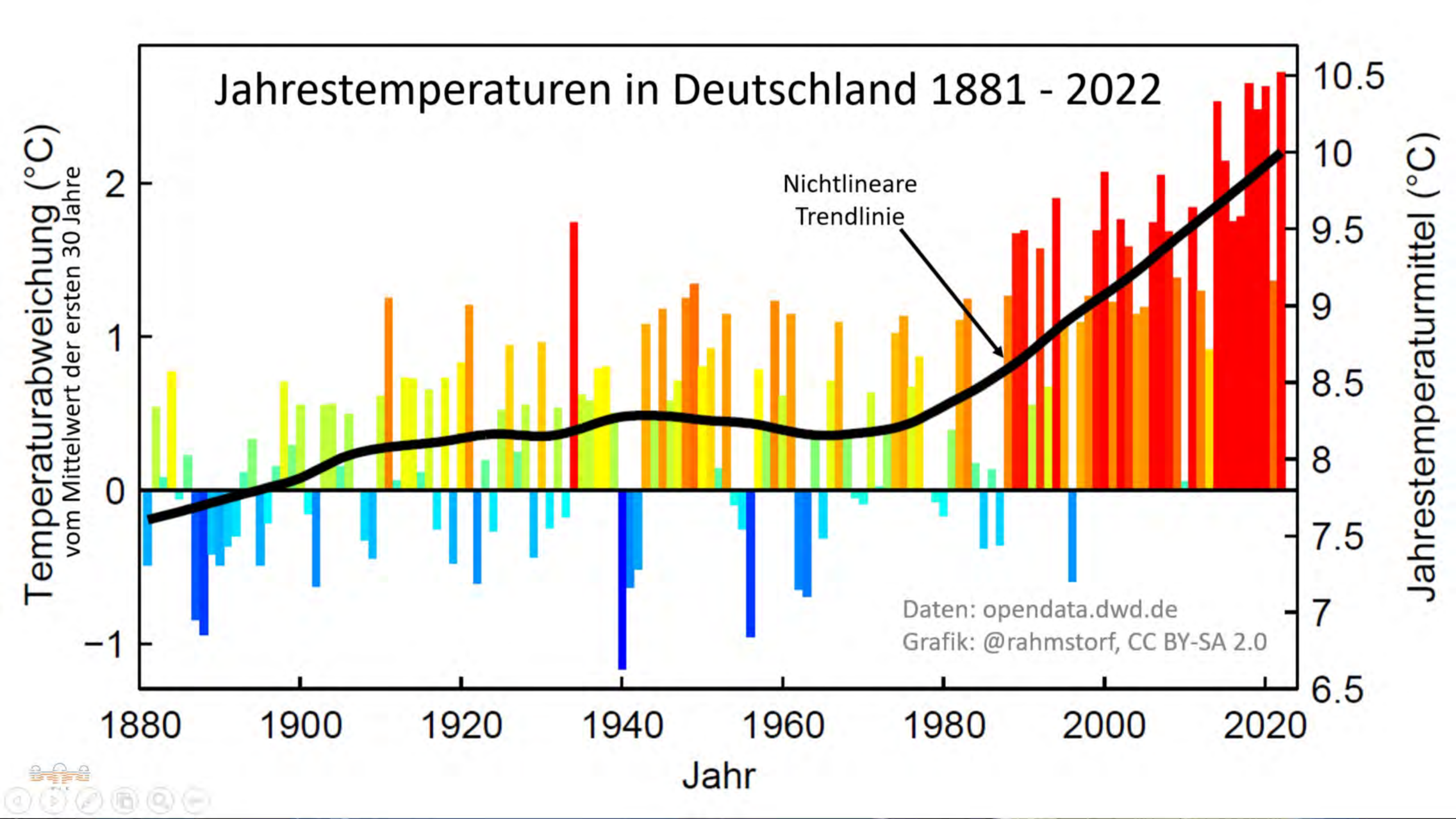
Osman et al. Nature 2021

Global temperature variations over last 2020 years

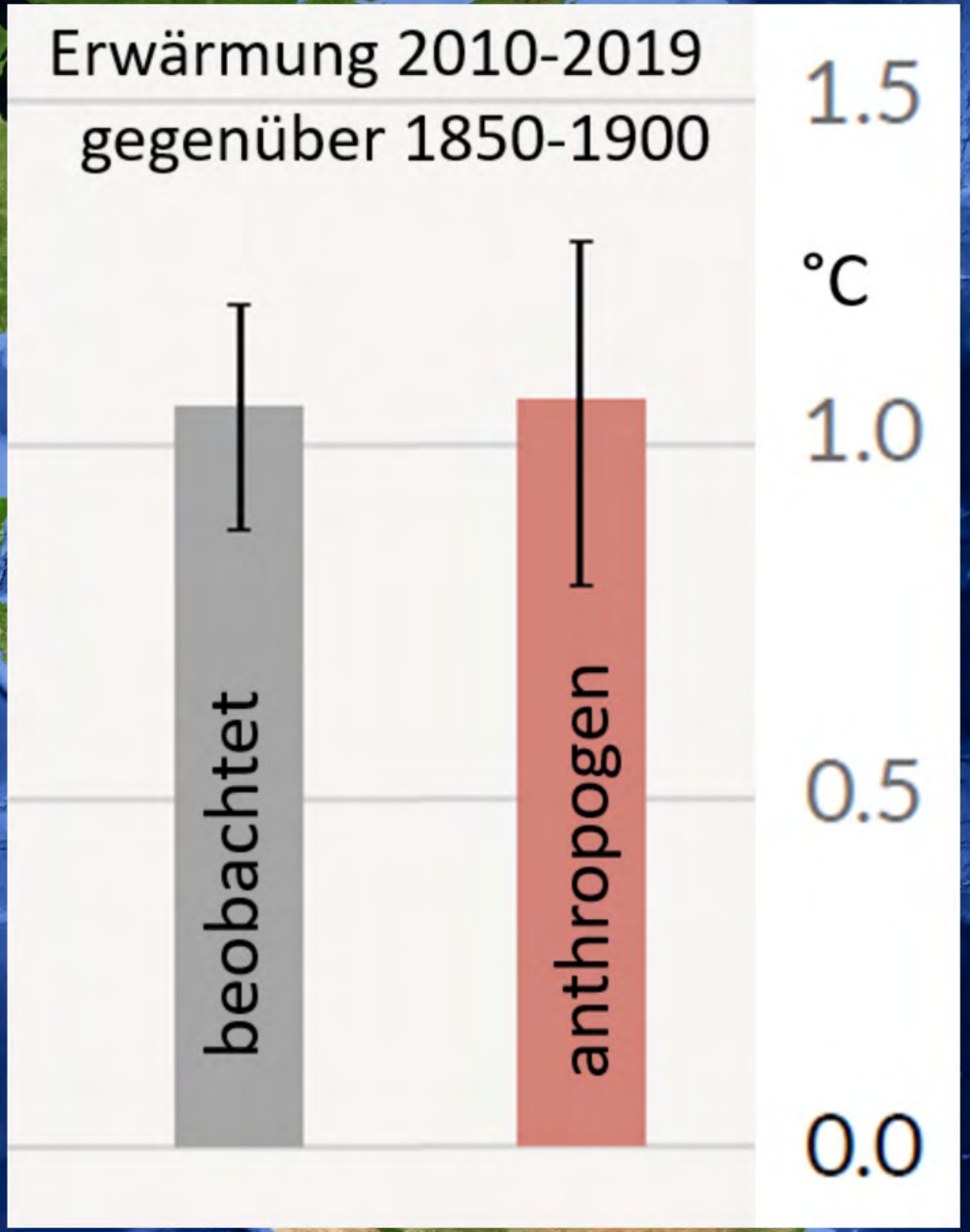
(using information derived from tree rings and other 'proxies')



Graphic: @ed_hawkins
Data: PAGES2k (years 1-2000) and HadCRUT5.0 (2001-2020)
Reference period: 1901-2000

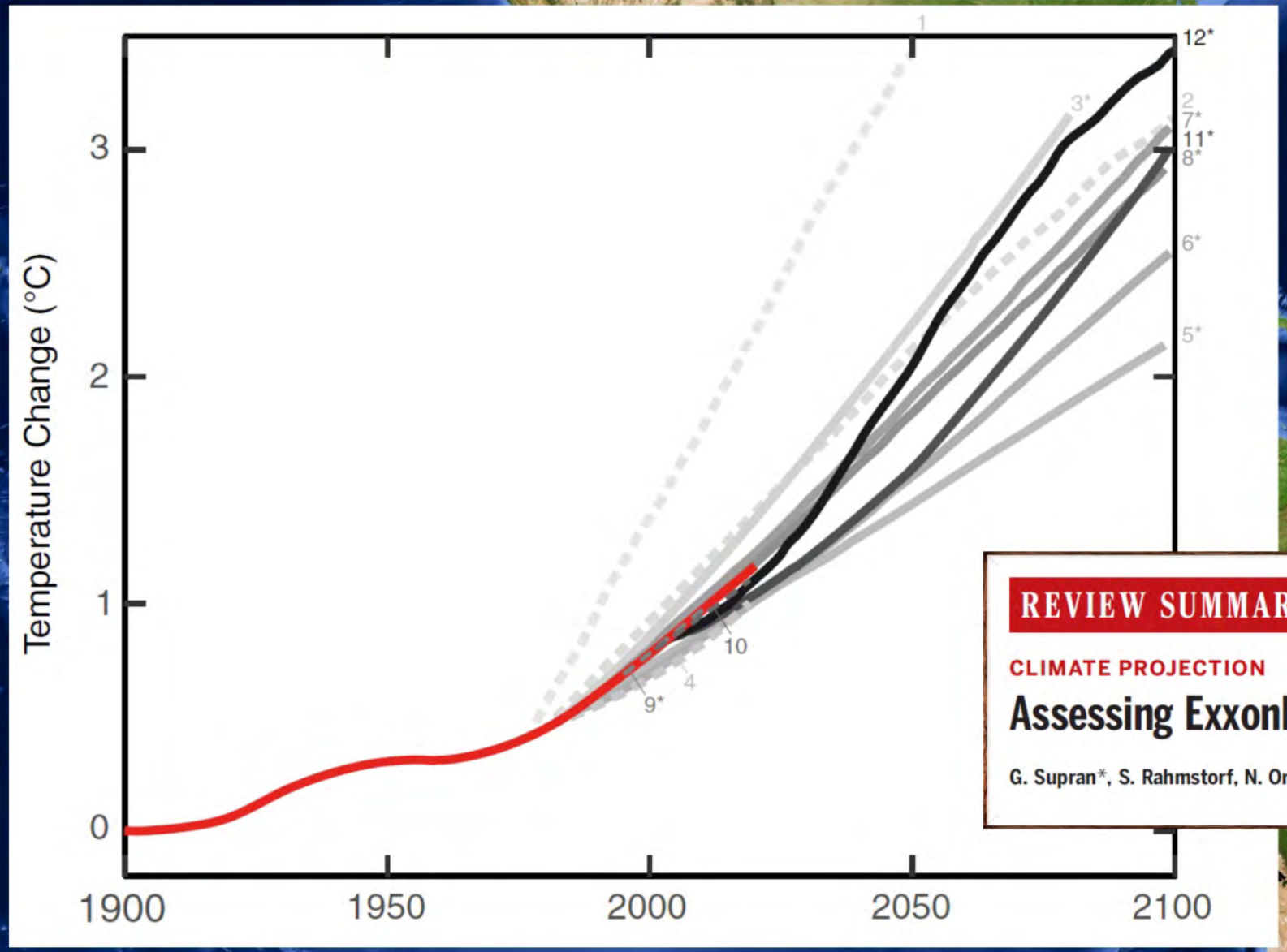

Jahrestemperaturen in Deutschland 1881 - 2022
Temperaturabweichung (°C)
vom Mittelwert der ersten 30 Jahre
Jahrestemperaturmittel (°C)
Nichtlineare
Trendlinie
Daten: opendata.dwd.de
Grafik: @rahmstorf, CC BY-SA 2.0
Jahr
2
1
0
−1
10.5
10
9.5
9
8.5
8
7.5
7
6.5
1880
1900
1920
1940
1960
1980
2000
2020

Die moderne Erwärmung ist komplett menschengemacht!



Quelle:
IPCC 2021

Auch Exxon-Forscher haben das vorhergesagt



REVIEW SUMMARY

Science

CLIMATE PROJECTION

Assessing ExxonMobil's global warming projections

G. Supran*, S. Rahmstorf, N. Oreskes

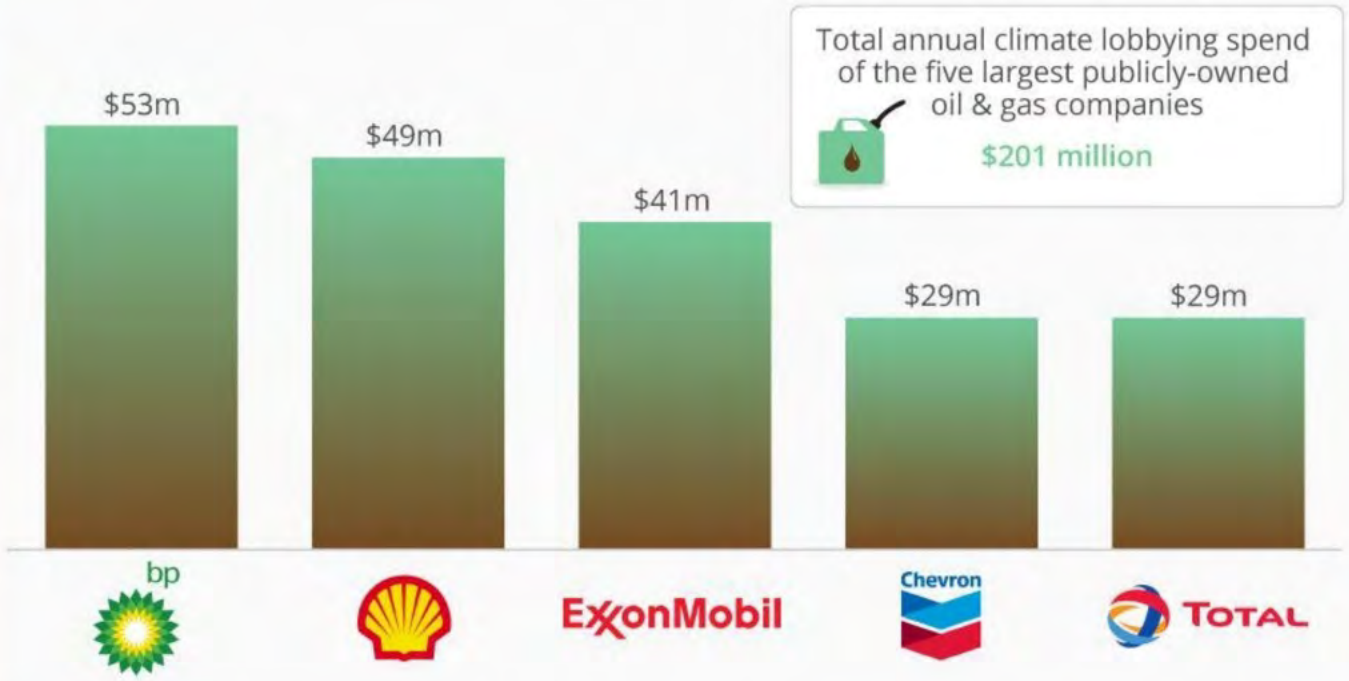
Doubt over climate science is a product with an industry behind it

With its roots in the tobacco industry, climate science denial talking points can be seen as manufactured doubt

The manufacturing of doubt on climate change science, backed by the fossil fuel industry, has its roots with the tobacco industry's assault on climate science in the 1960s. Photograph: Richard Hamilton Smith/Richard Hamilton Smith/Corbis

Oil Firms Spend Millions On Climate Lobbying

Annual expenditure on climate lobbying by oil and gas companies*



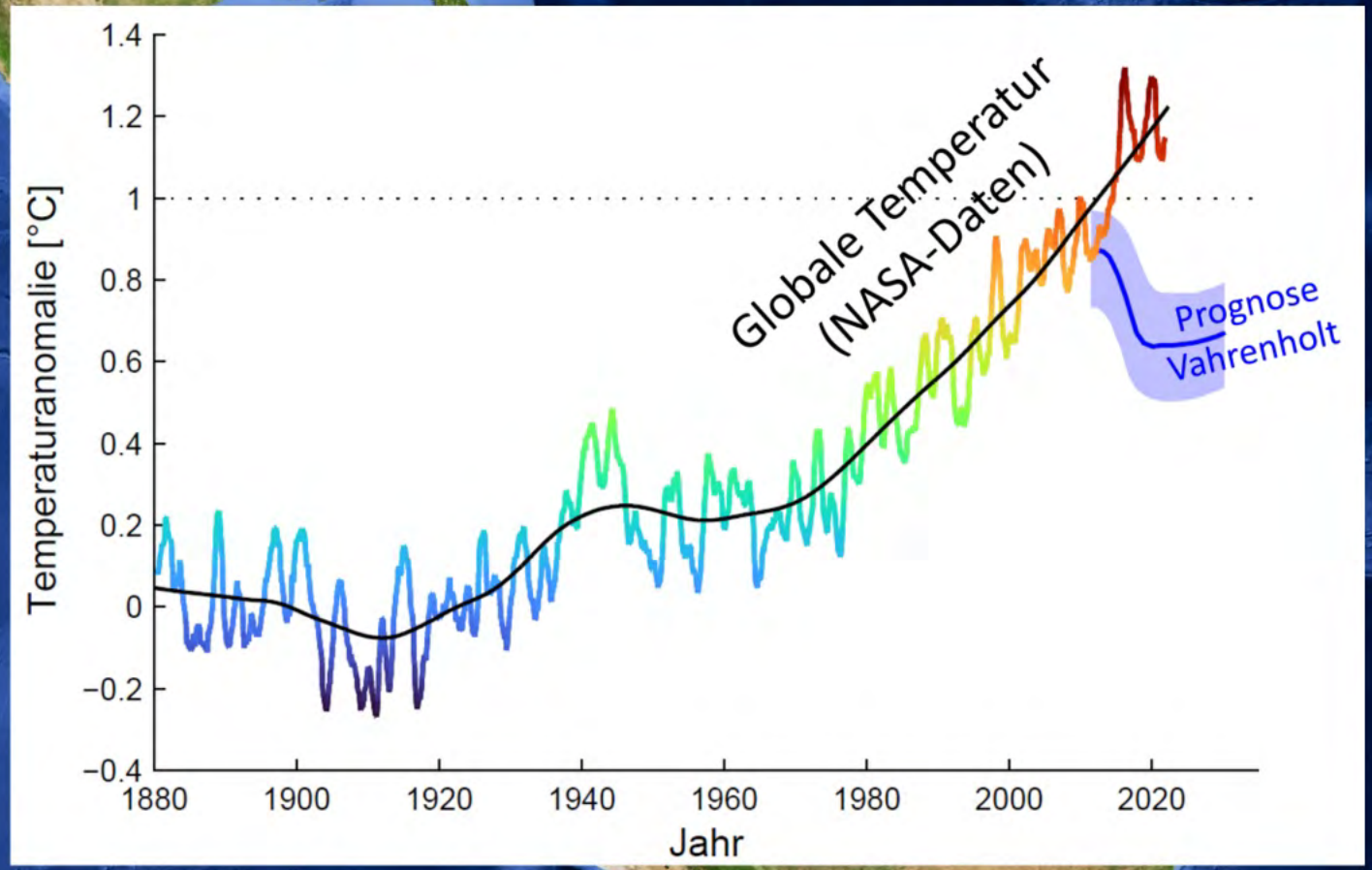
* As of 2019. Climate lobbying means spending to delay, control or block policies to tackle climate change.

@StatistaCharts Source: InfluenceMap

Forbes statista

"It's the sun, stupid!"

Fritz Vahrenholt, RWE



"It's the sun, stupid!"

Fritz Vahrenholt, RWE

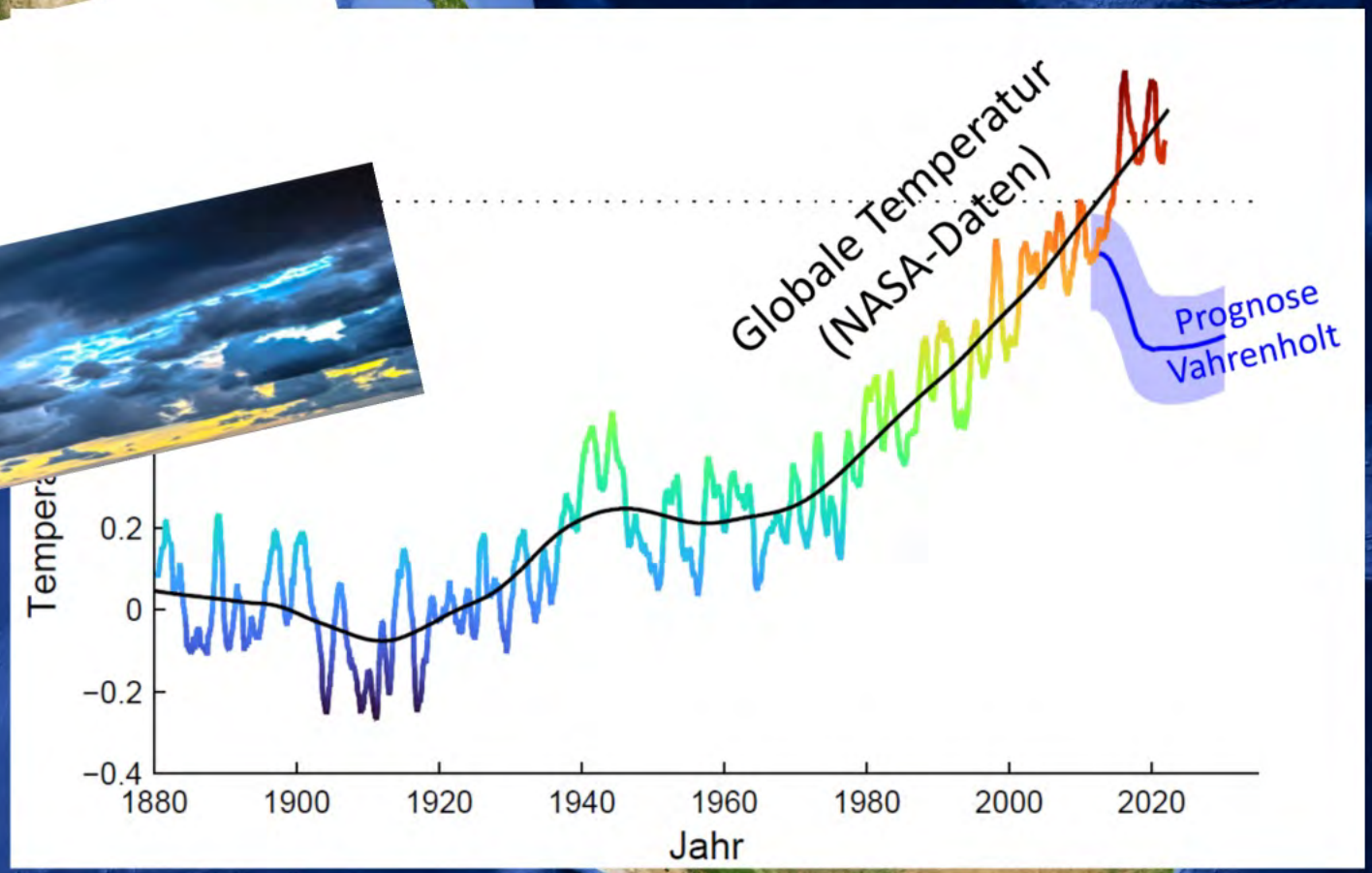
Fritz Vahrenholt
Sebastian L...

SciLogs » KlimaLounge » Medien-Check » Es winkt die RWE-Lobby

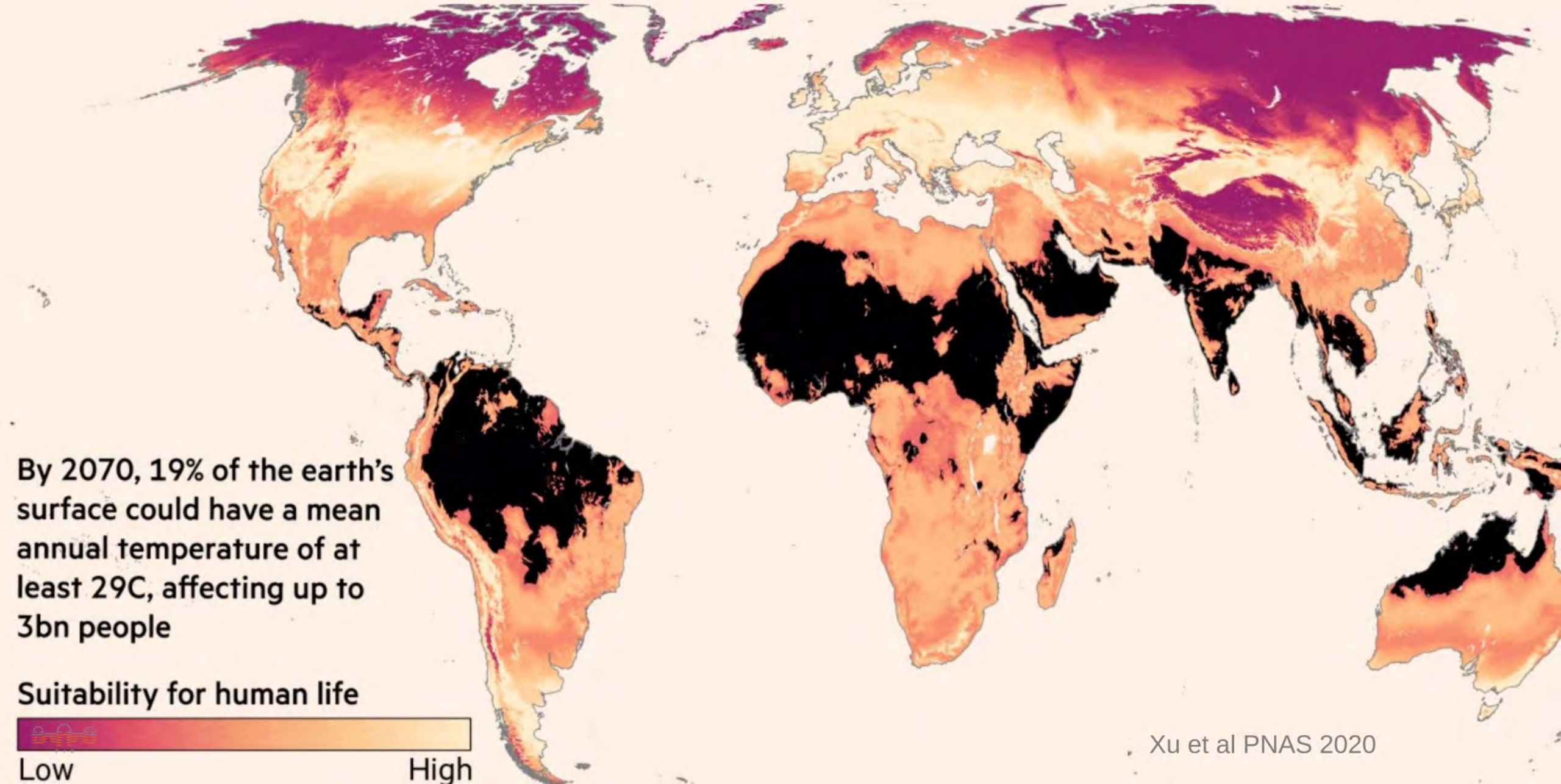
Es winkt die RWE-Lobby

23. Feb 2011
Von Stefan Rahmstorf
Lesedauer ca. 10 Minuten
40 Kommentare

BLOG: **KLIMALOUNGE** Nah dran am Wandel



Nach 3,3 Grad Erwärmung würden große Gebiete zu heiß!



Xu et al PNAS 2020

Arktische Meereisdecke im Spätsommer

Angabe in Millionen Quadratkilometern über die vergangenen 1450 Jahre

Proxydaten ··· Beobachtungsdaten - - Satellitentrend

11
10
9
8
7
6

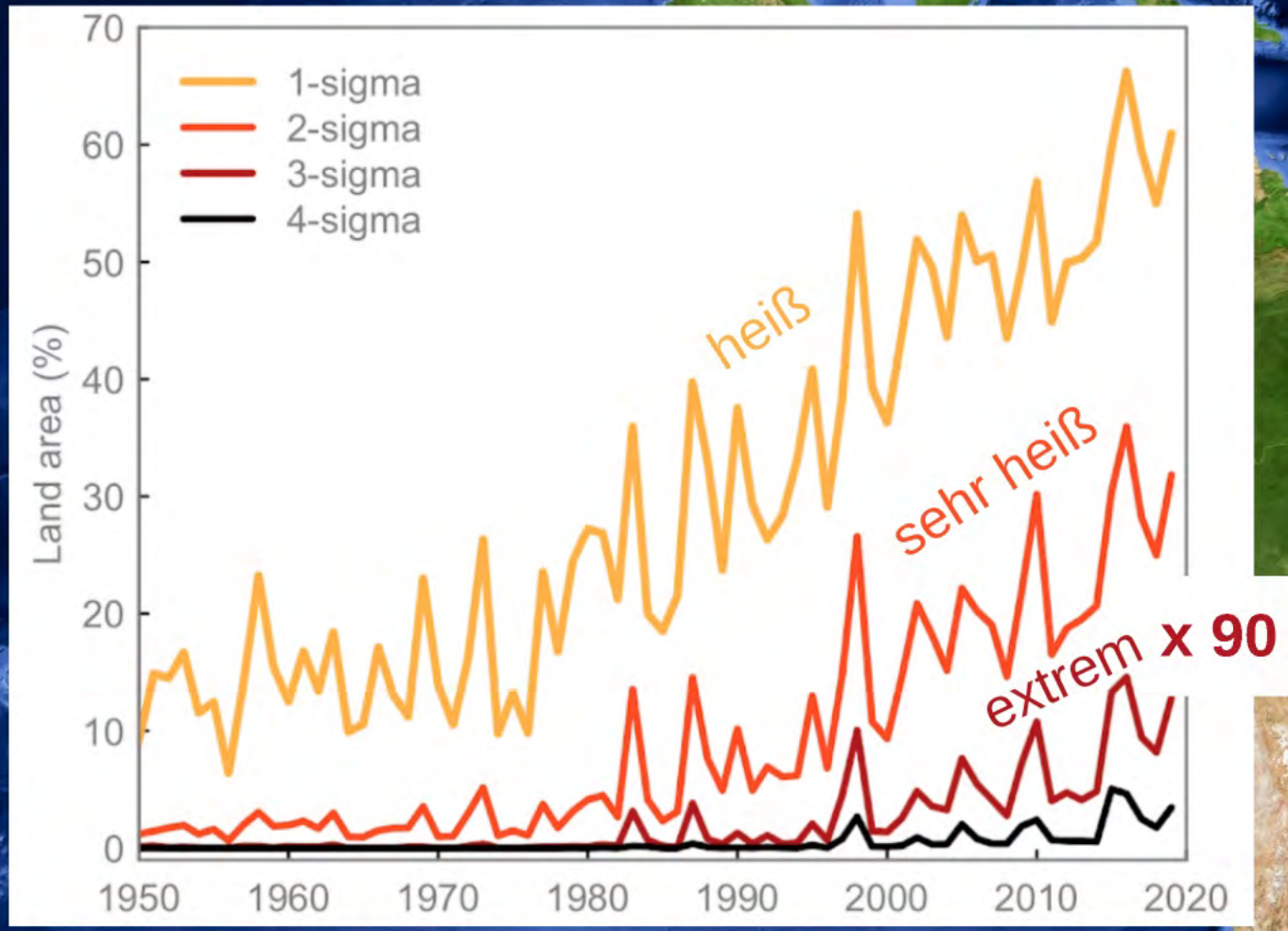
600 800 1000 1200 1400 1600 1800 2000

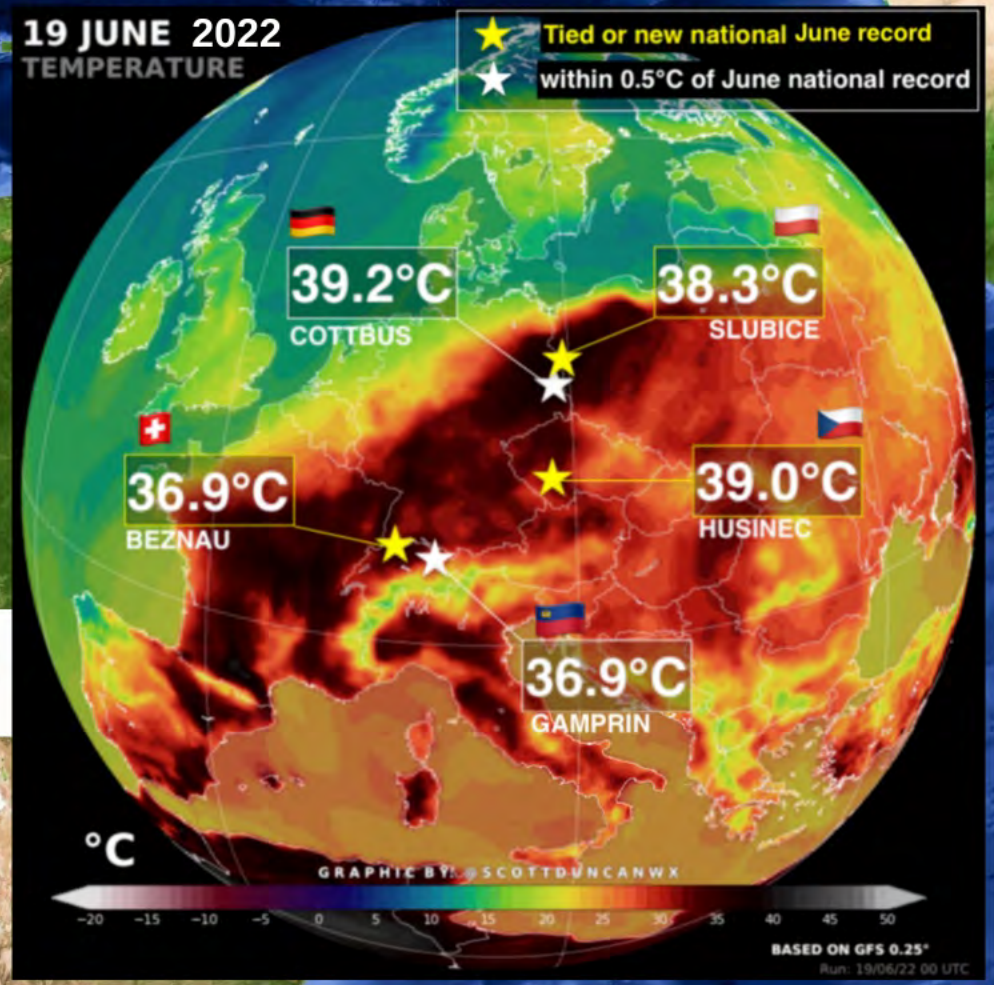
ARKTIS-EXPEDITION

„Wir haben dem Eis beim Sterben zugeschaut“

Quelle: NSIDC; Kinnard et al.

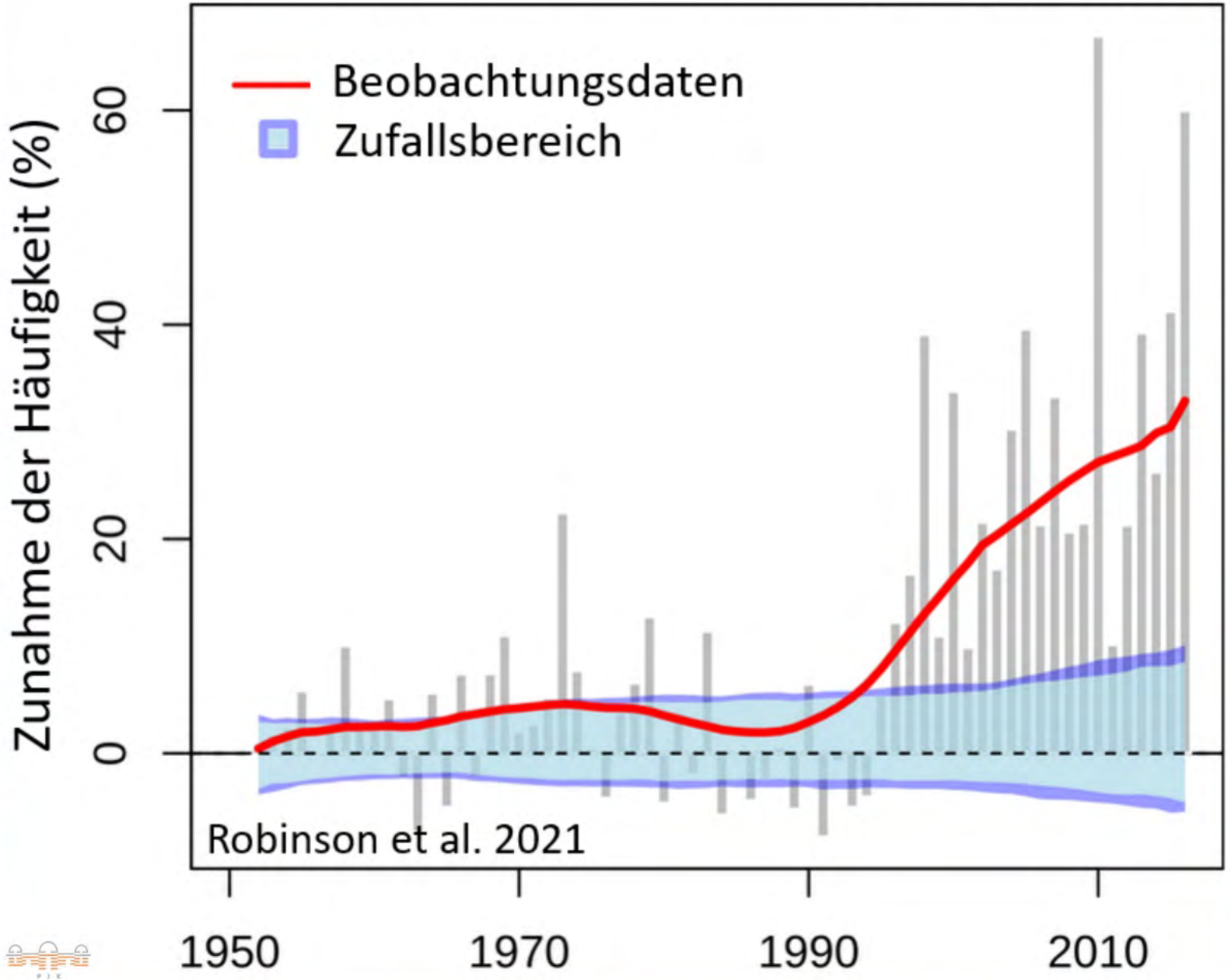
Extreme Hitze nimmt dramatisch zu

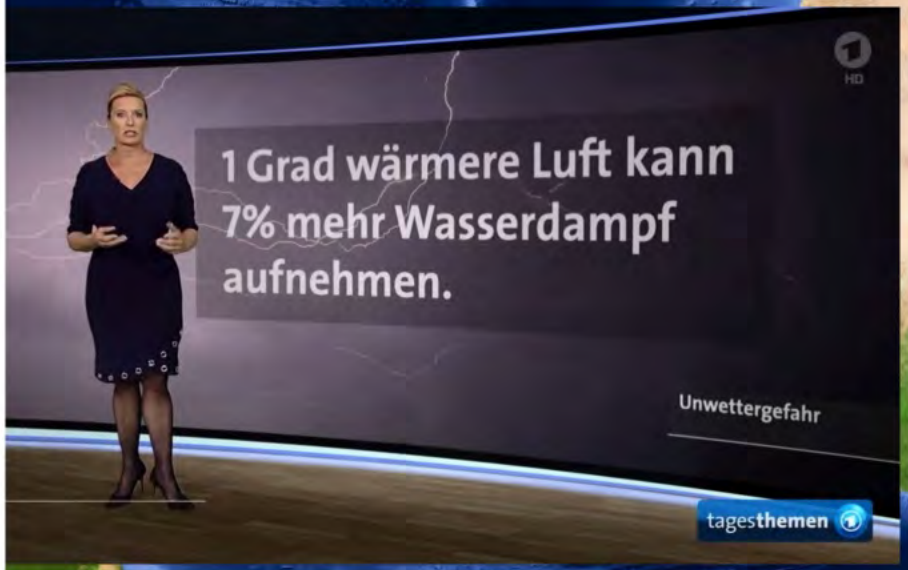




Robinson et al. 2021

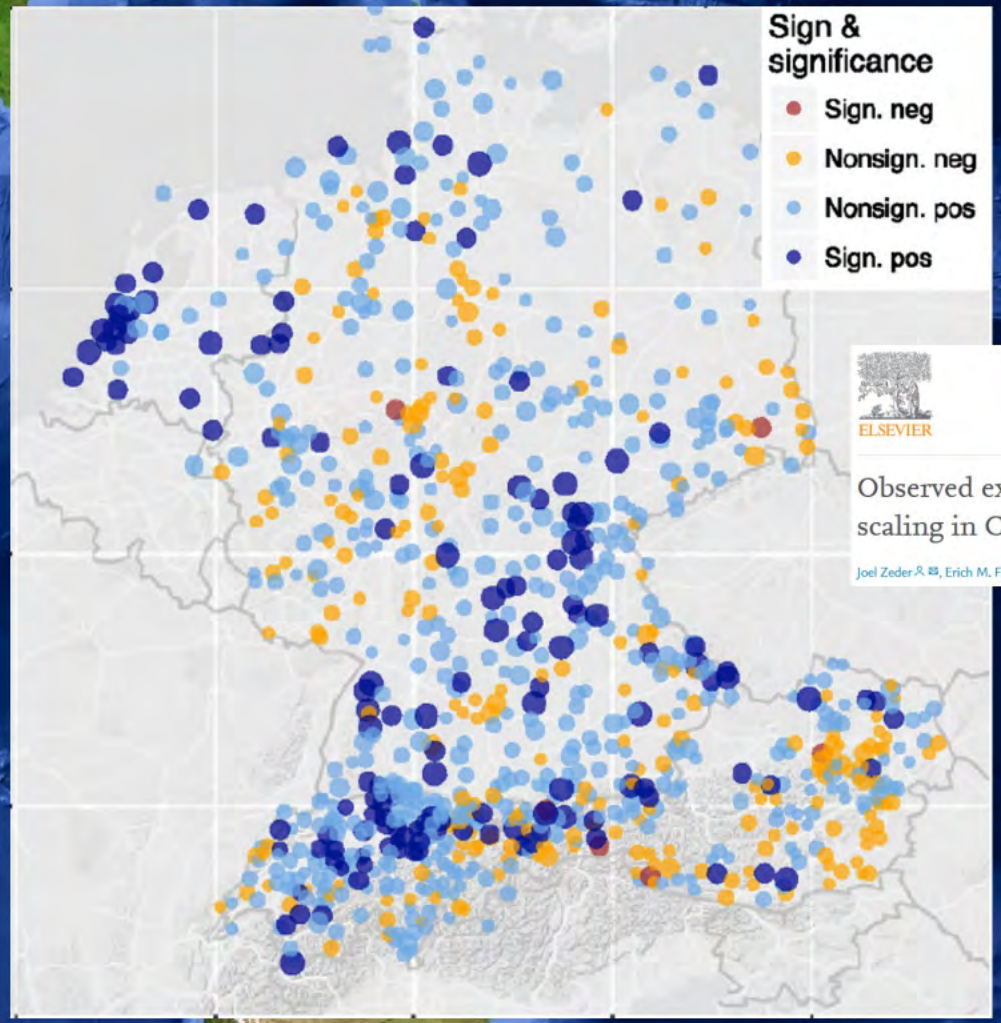
Weltweite Zunahme der Niederschlags-Tagesrekorde





Flutkatastrophe 2021

Auch in Deutschland hat Starkregen zugenommen

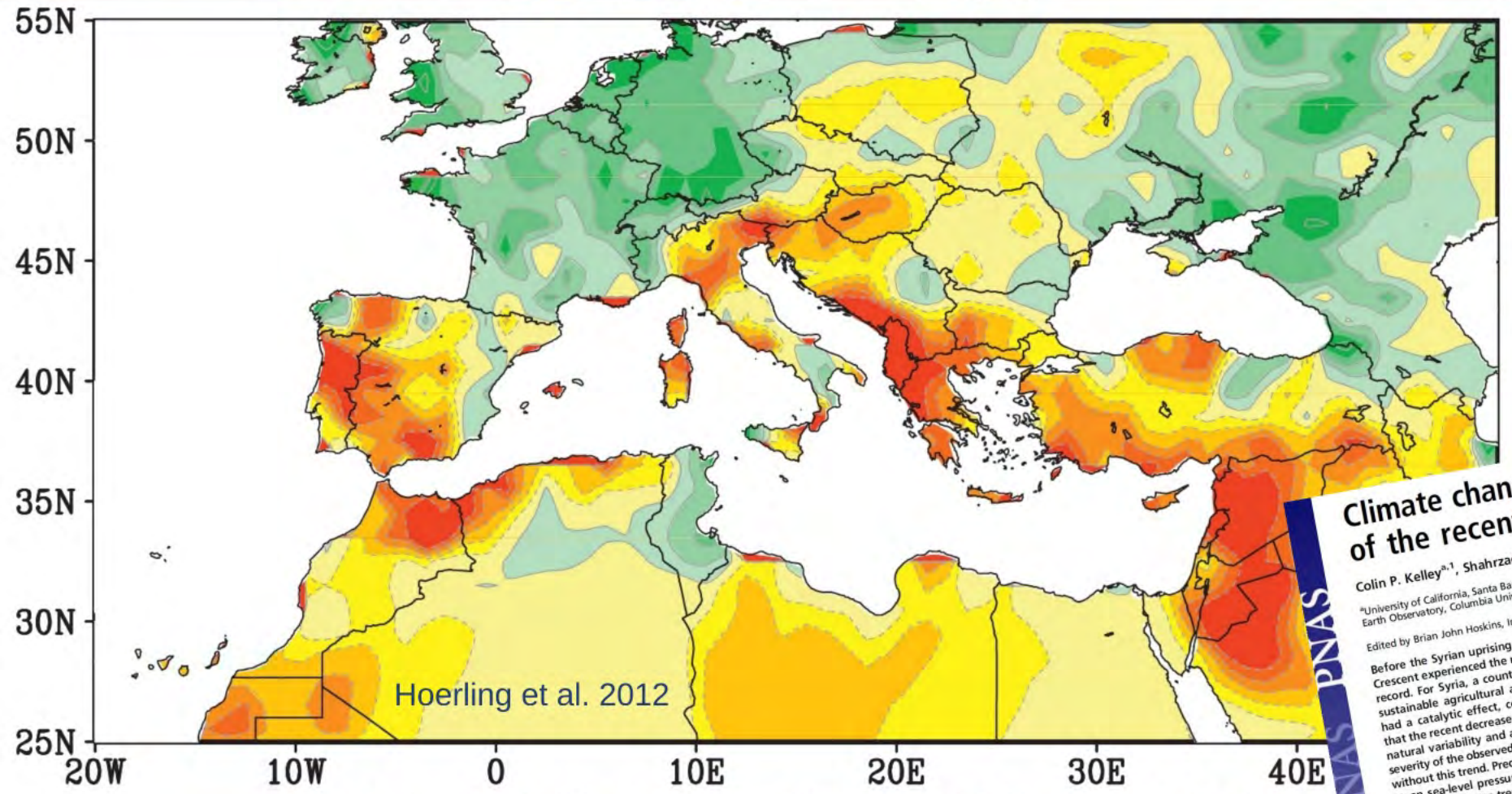


ELSEVIER
Weather and Climate Extremes
Volume 29, September 2020, 100266

Observed extreme precipitation trends and scaling in Central Europe

Joel Zeder, Erich M. Fischer

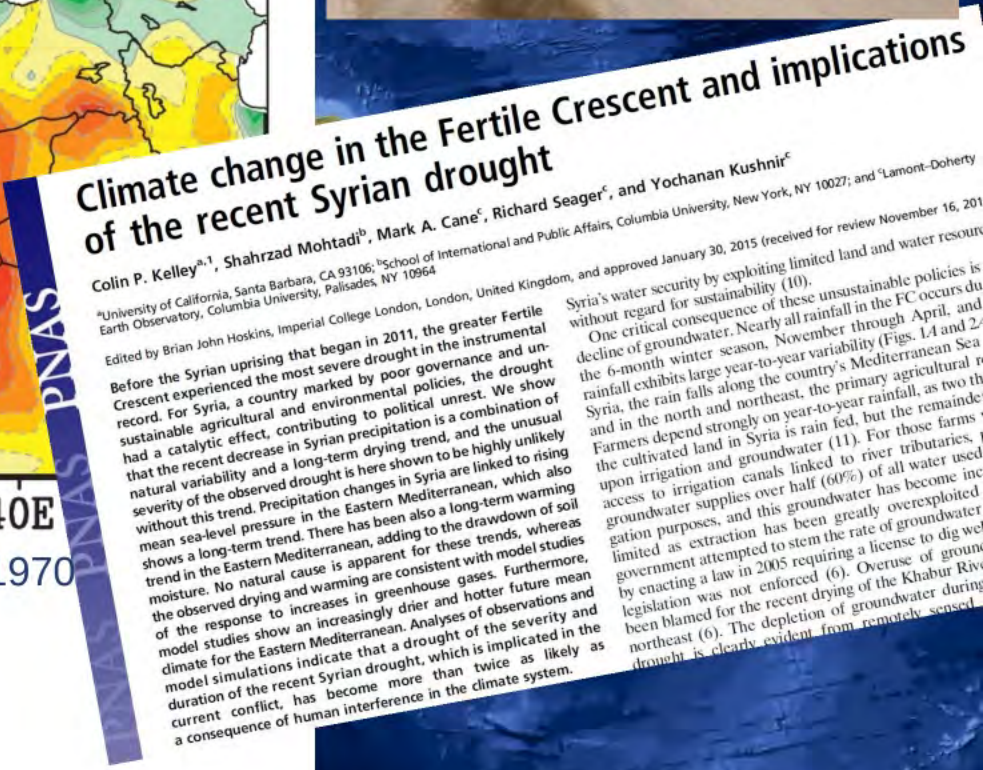
Dürre



Veränderung der Winterniederschläge 1971-2010 relativ zu 1902-1970

Millimeters

−60 −48 −36 −24 −12 0 12 24 36 48 60



Climate change in the Fertile Crescent and implications of the recent Syrian drought

Colin P. Kelley[a,1], Shahrzad Mohtadi[b], Mark A. Cane[c], Richard Seager[c], and Yochanan Kushnir[c]

[a]University of California, Santa Barbara, CA 93106; [b]School of International and Public Affairs, Columbia University, New York, NY 10027; and [c]Lamont–Doherty Earth Observatory, Columbia University, Palisades, NY 10964

Edited by Brian John Hoskins, Imperial College London, London, United Kingdom, and approved January 30, 2015 (received for review November 16, 201

Before the Syrian uprising that began in 2011, the greater Fertile Crescent experienced the most severe drought in the instrumental record. For Syria, a country marked by poor governance and unsustainable agricultural and environmental policies, the drought had a catalytic effect, contributing to political unrest. We show that the recent decrease in Syrian precipitation is a combination of natural variability and a long-term drying trend, and the unusual severity of the observed drought is here shown to be highly unlikely without this trend. Precipitation changes in Syria are linked to rising mean sea-level pressure in the Eastern Mediterranean, which also shows a long-term trend. There has been also a long-term warming trend in the Eastern Mediterranean, adding to the drawdown of soil moisture. No natural cause is apparent for these trends, whereas the observed drying and warming are consistent with model studies of the response to increases in greenhouse gases. Furthermore, model studies show an increasingly drier and hotter future mean climate for the Eastern Mediterranean. Analyses of observations and model simulations indicate that a drought of the severity and duration of the recent Syrian drought, which is implicated in the current conflict, has become more than twice as likely as a consequence of human interference in the climate system.

Syria's water security by exploiting limited land and water resour
without regard for sustainability (10).

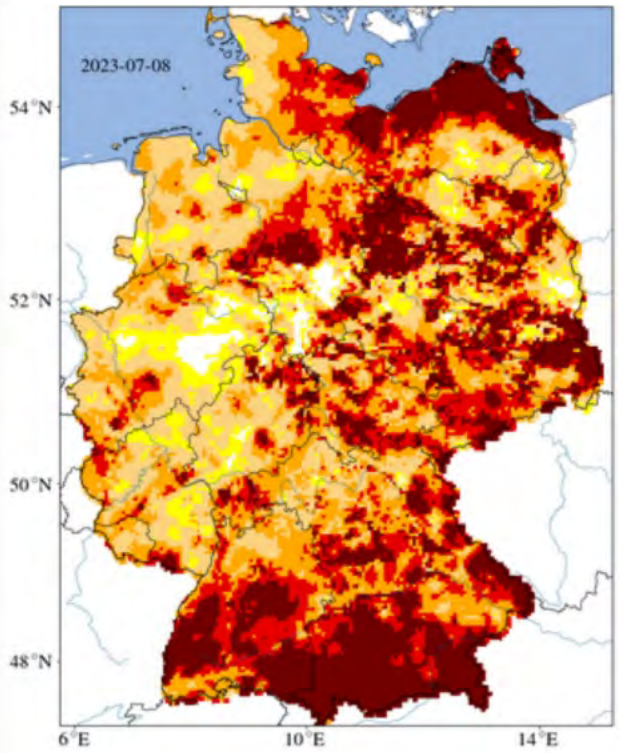
One critical consequence of these unsustainable policies is
decline of groundwater. Nearly all rainfall in the FC occurs du
the 6-month winter season, November through April, and
rainfall exhibits large year-to-year variability (Figs. 1*A* and 2*
Syria, the rain falls along the country's Mediterranean Sea
and in the north and northeast, the primary agricultural r
Farmers depend strongly on year-to-year rainfall, as two th
the cultivated land in Syria is rain fed, but the remainde
upon irrigation and groundwater (11). For those farms
access to irrigation canals linked to river tributaries,
groundwater supplies over half (60%) of all water used
gation purposes, and this groundwater has become inc
limited as extraction has been greatly overexploited
government attempted to stem the rate of groundwater
by enacting a law in 2005 requiring a license to dig wel
legislation was not enforced (6). Overuse of groun
been blamed for the recent drying of the Khabur Riv
northeast (6). The depletion of groundwater during
drought is clearly evident from remotely sensed

Dürre in Deutschland: Aktuelle Lage

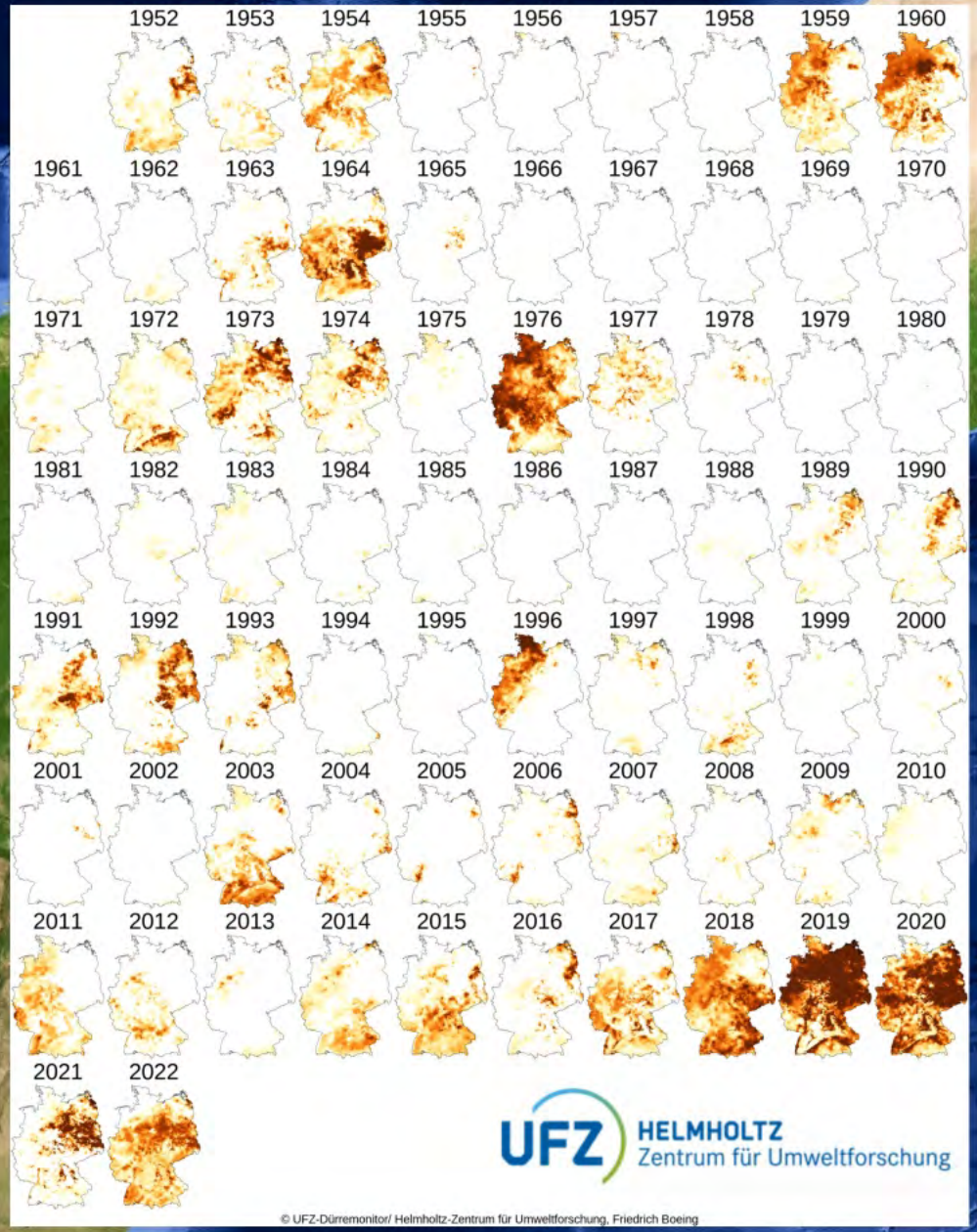
1952-2022

Dürremonitor Gesamtboden

ca. 1.8 m



- ungewöhnlich trocken
- moderate Dürre
- schwere Dürre
- extreme Dürre
- außergewöhnliche Dürre



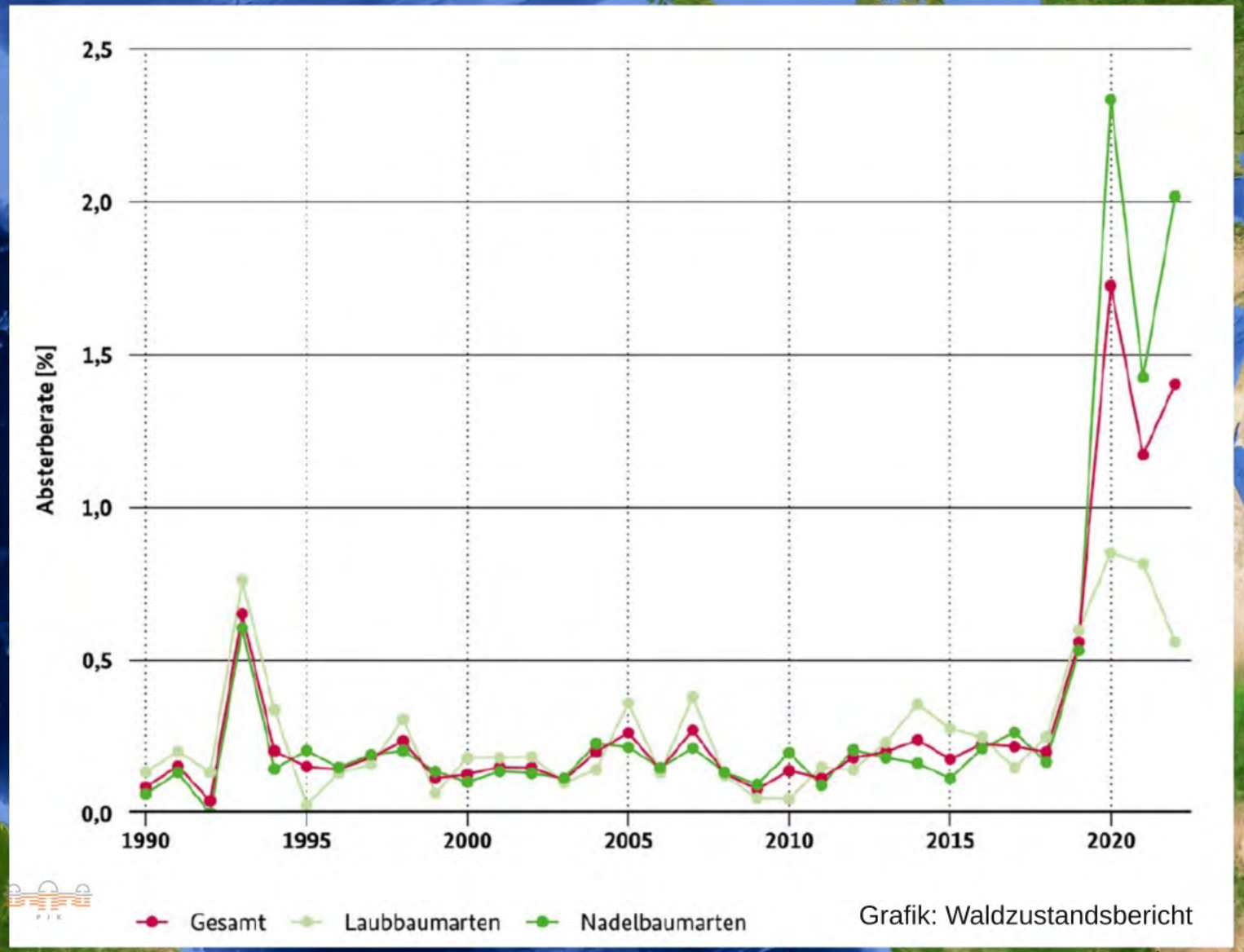
UFZ HELMHOLTZ Zentrum für Umweltforschung

Hauptaussagen des IPCC Klimaberichts 2023

„ Der vom Menschen verursachte Klimawandel wirkt sich bereits auf viele Wetter- und Klimaextreme in allen Regionen der Welt aus.
Dies hat zu weitverbreiteten nachteiligen Folgen und damit verbundenen Verlusten und Schäden für Natur und Menschen geführt (hohes Vertrauen). “

Hunderte Wissenschaftler aus aller Welt haben 8 Jahre an diesem Bericht gearbeitet.
Deutsche Übersetzung der Hauptaussagen: https://www.de-ipcc.de/media/content/Hauptaussagen_AR6-SYR.pdf

Das neue Waldsterben in Deutschland

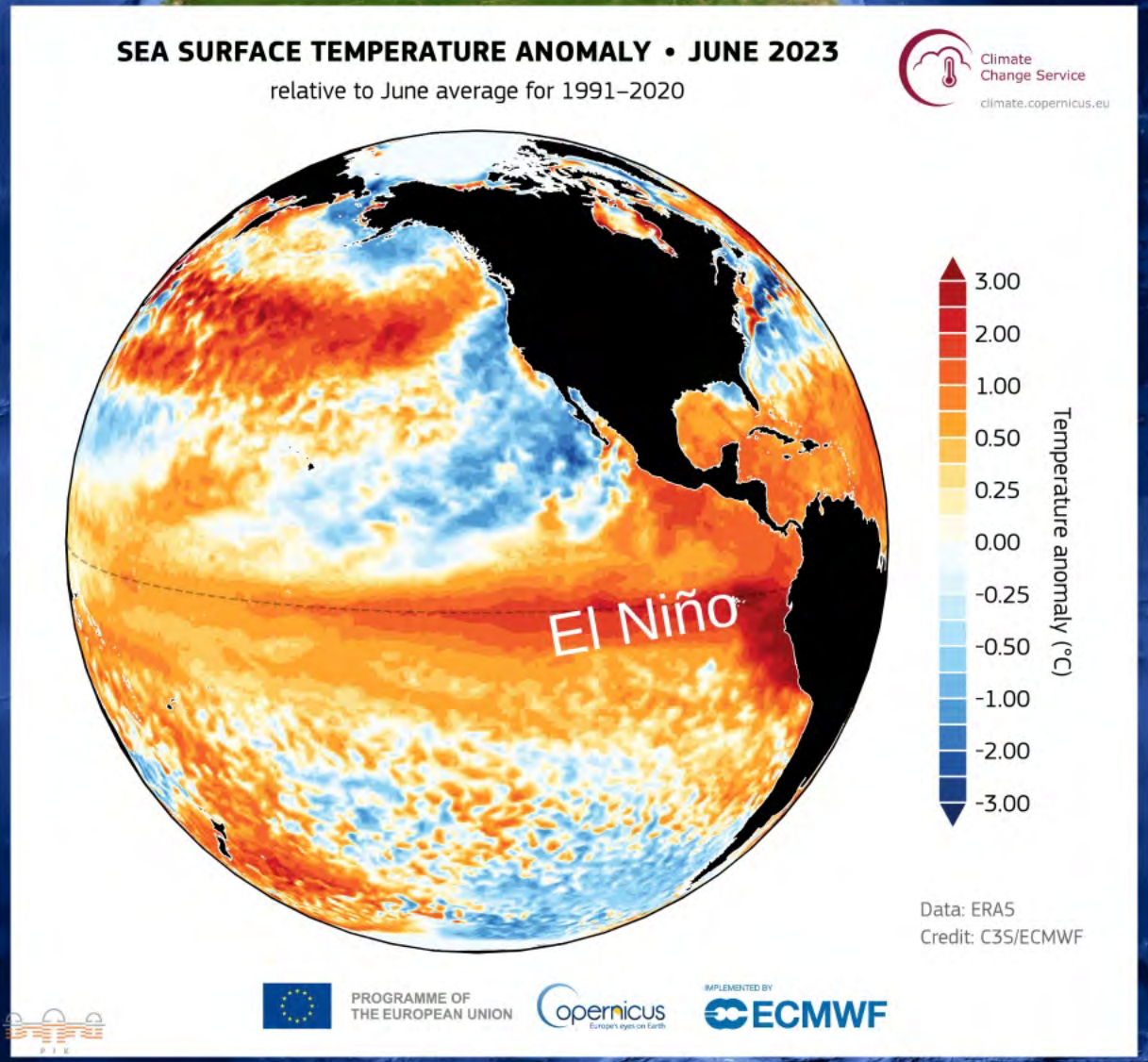


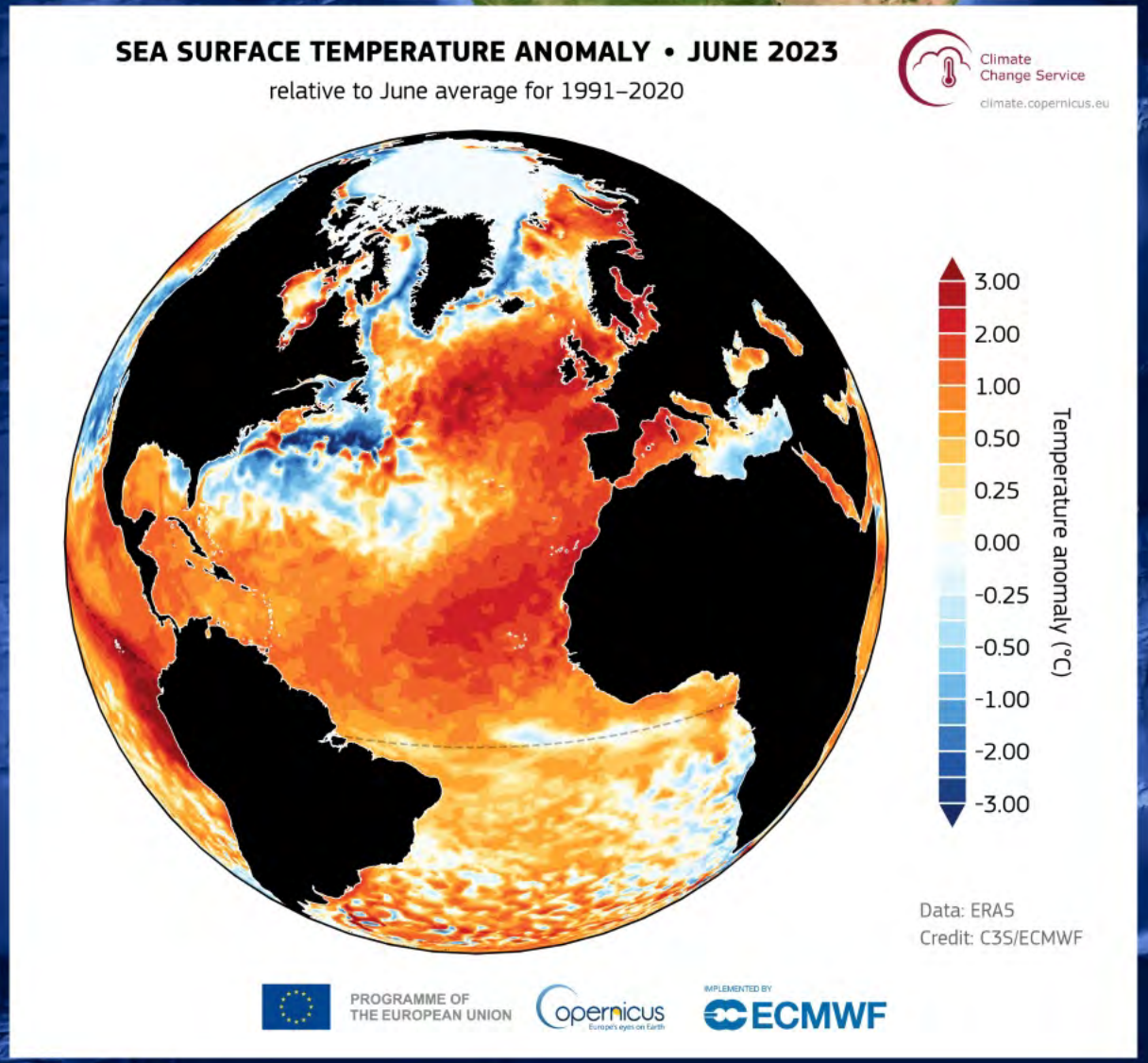
Grafik: Waldzustandsbericht

Brandenburg 2018

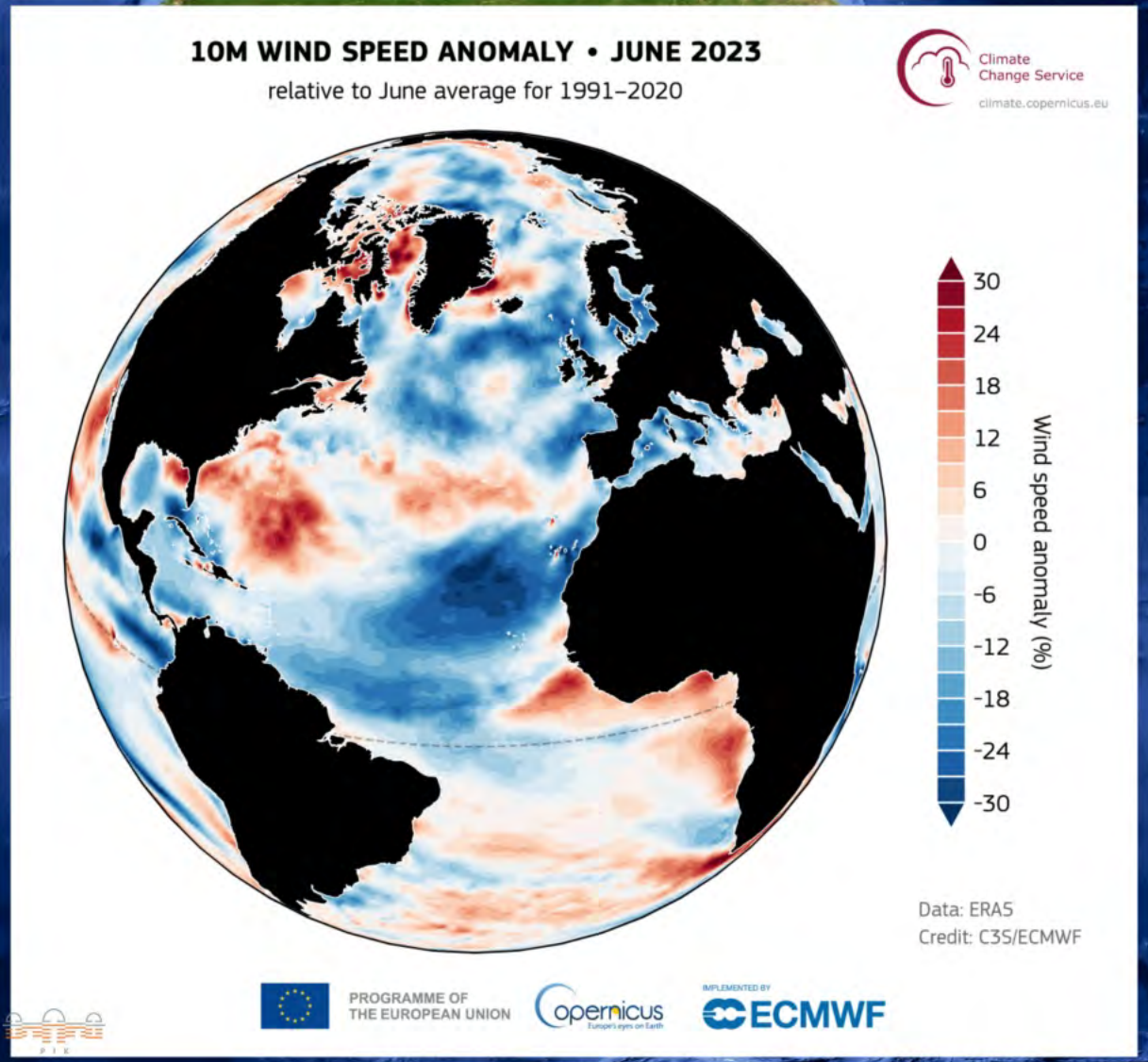
Siegerland 2021

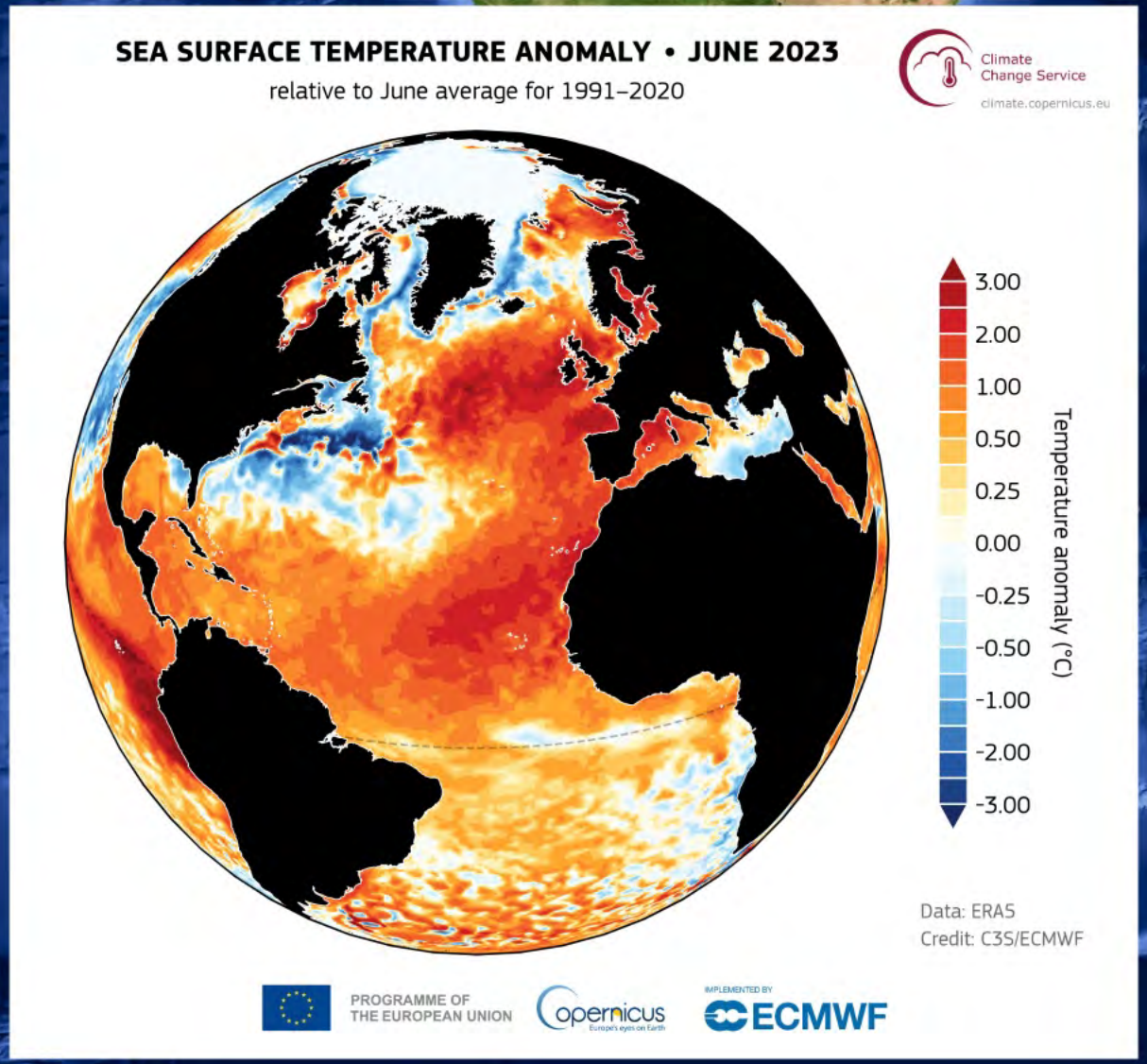
Rekord-Meerestemperaturen Juni 2023





Rekord-Meerestemperaturen Juni 2023

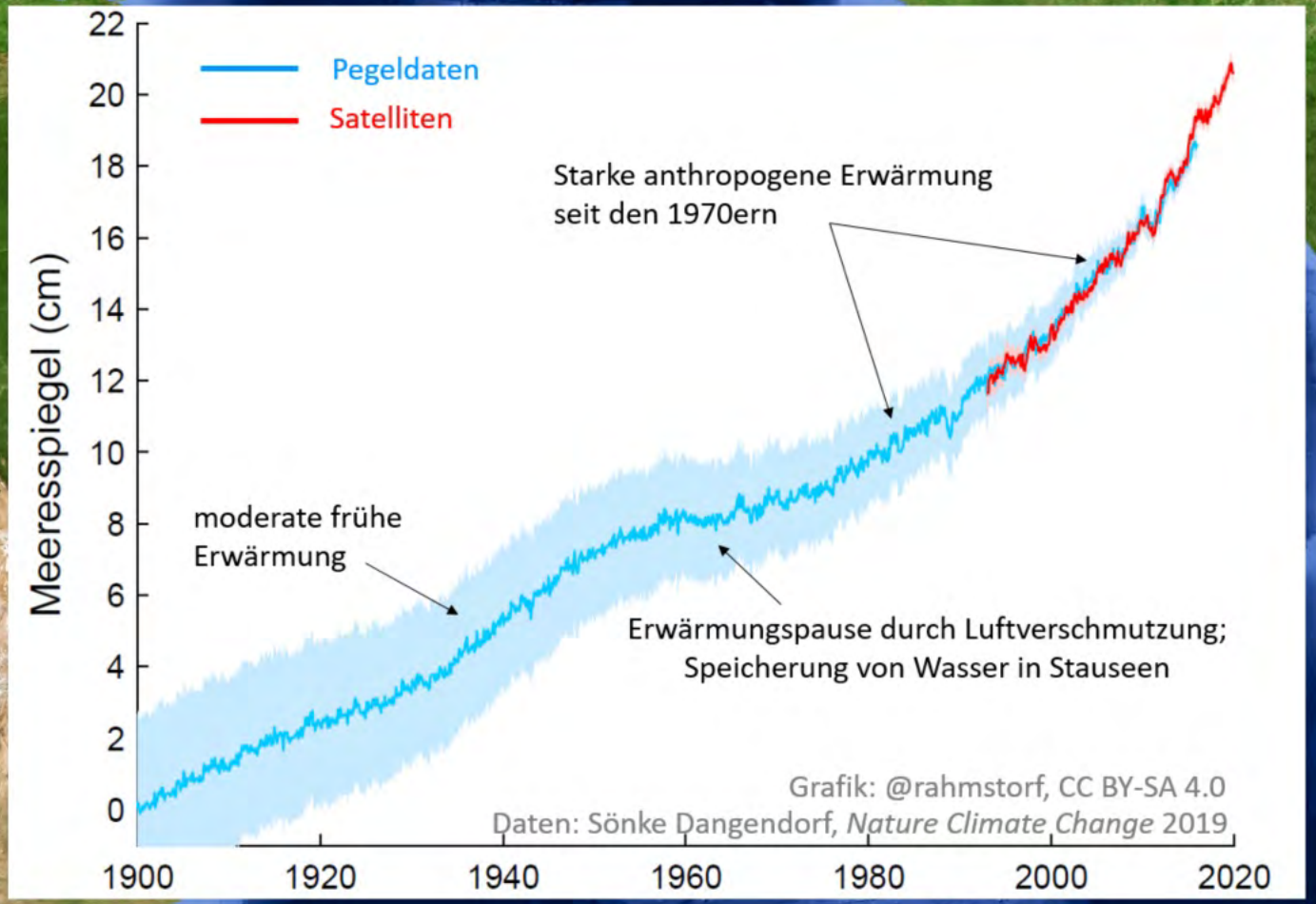


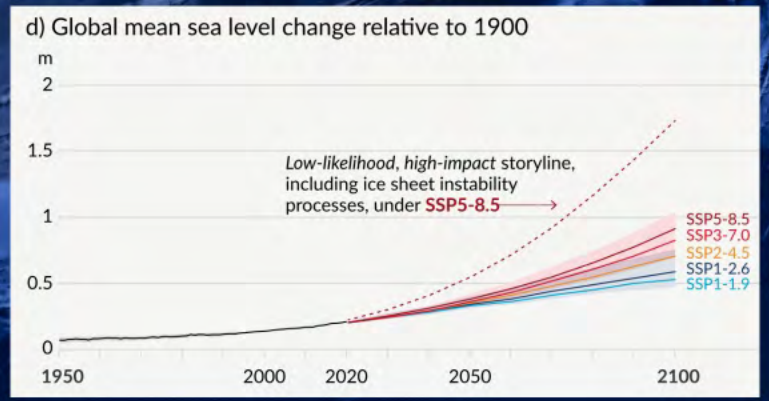


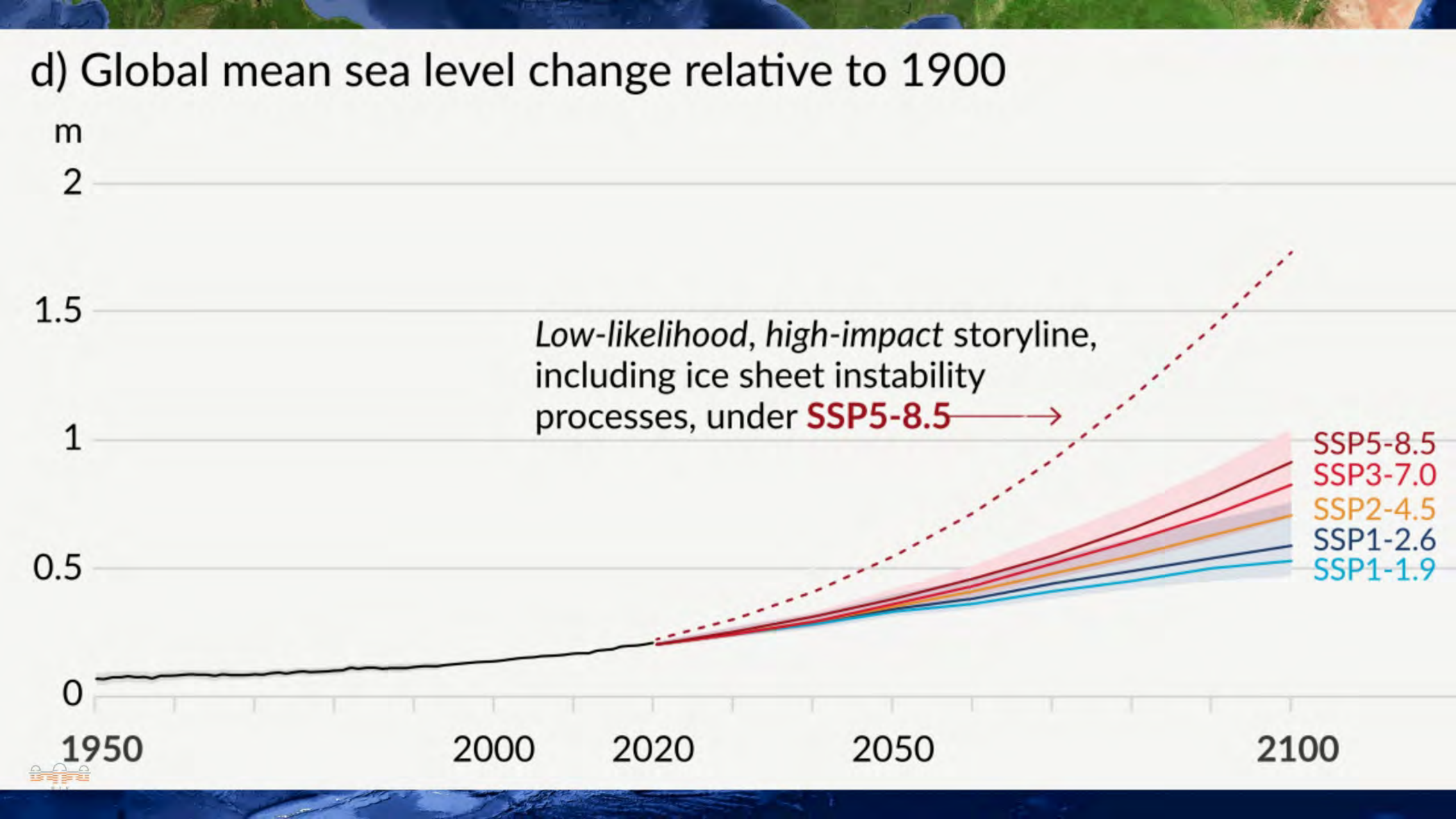
Es gibt genug Eis auf der Erde
für einen Meeresanstieg um

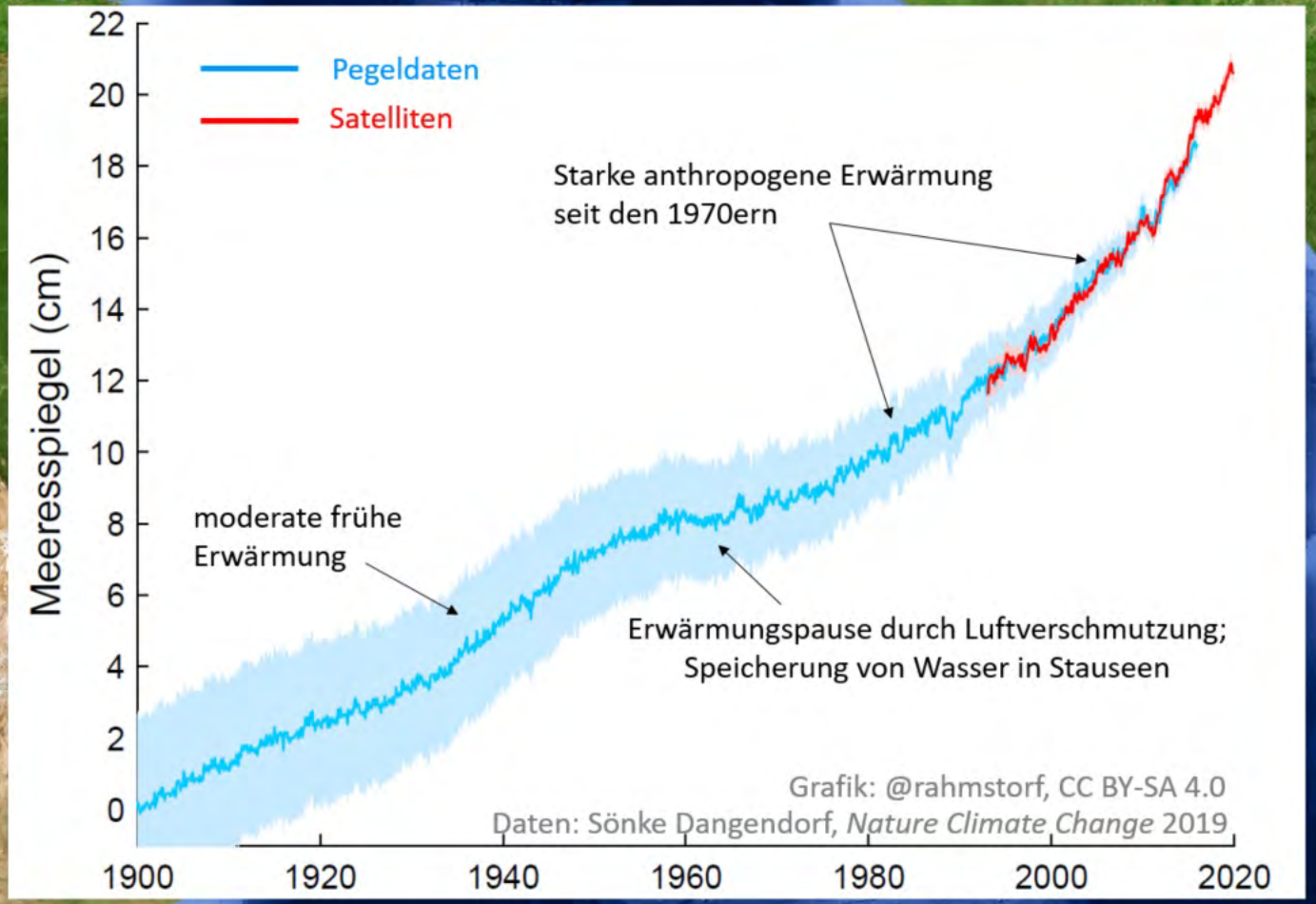
65 m

Anstieg des Meeresspiegels

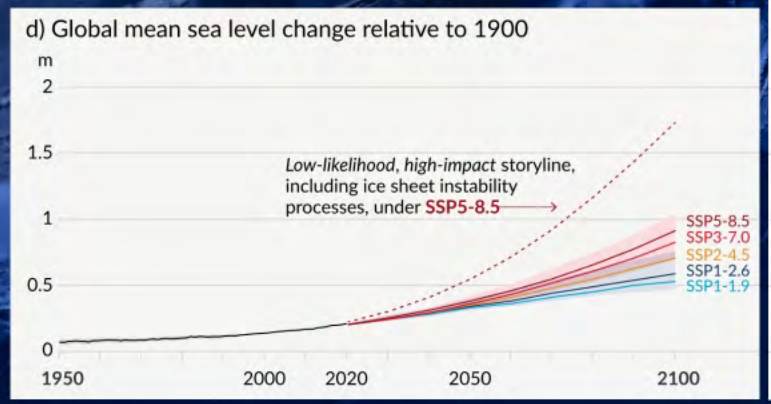


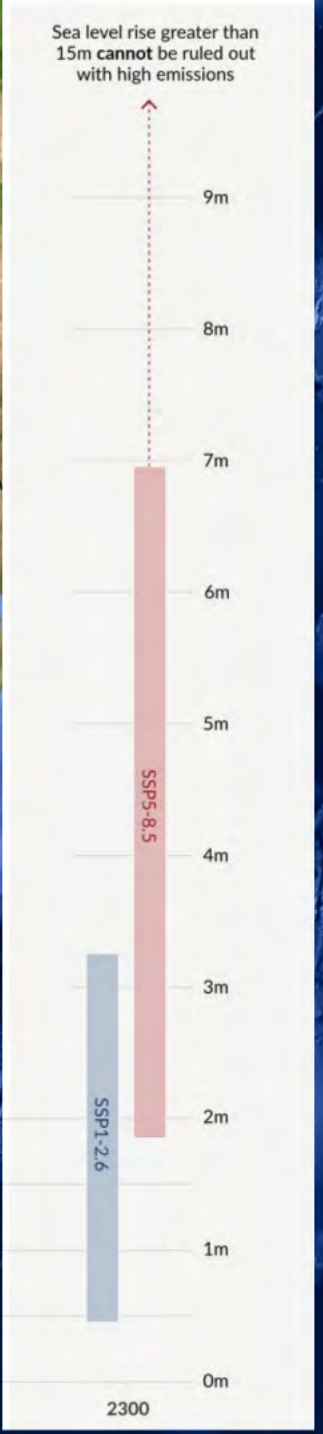



d) Global mean sea level change relative to 1900
m
2
1.5
1
0.5
0
1950
2000
2020
2050
2100
Low-likelihood, *high-impact* storyline, including ice sheet instability processes, under **SSP5-8.5**
SSP5-8.5
SSP3-7.0
SSP2-4.5
SSP1-2.6
SSP1-1.9



Anstieg des Meeresspiegels



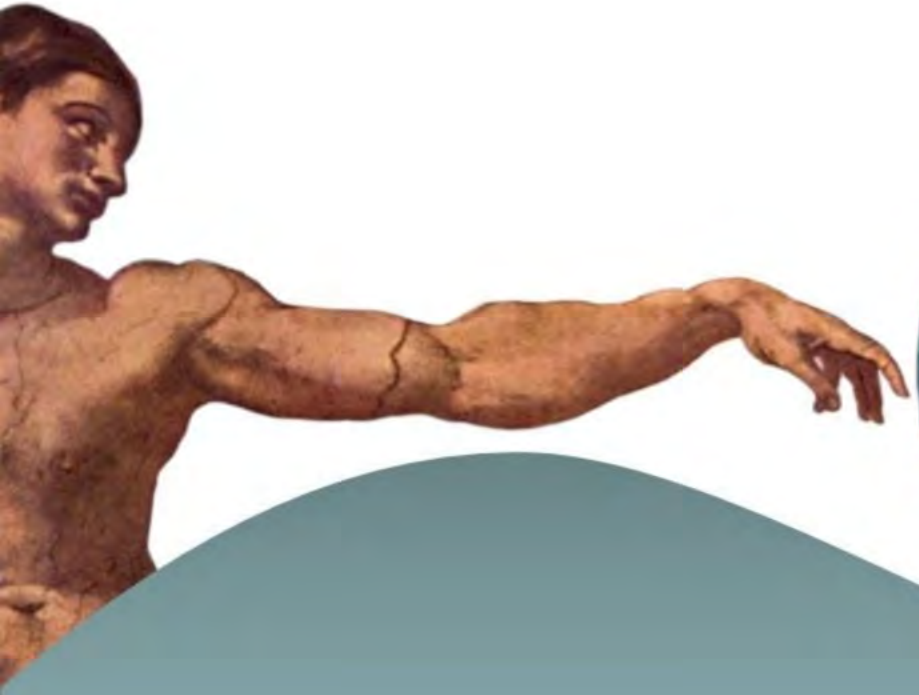



Malediven

Zwischenfazit

Der Klimawandel ist real und zweifelsfrei durch fossile Energienutzung sowie Entwaldung verursacht

Schon jetzt leiden viele Millionen Menschen unter Folgen wie Wetterextremen, Bränden, Dürren und steigendem Meeresspiegel

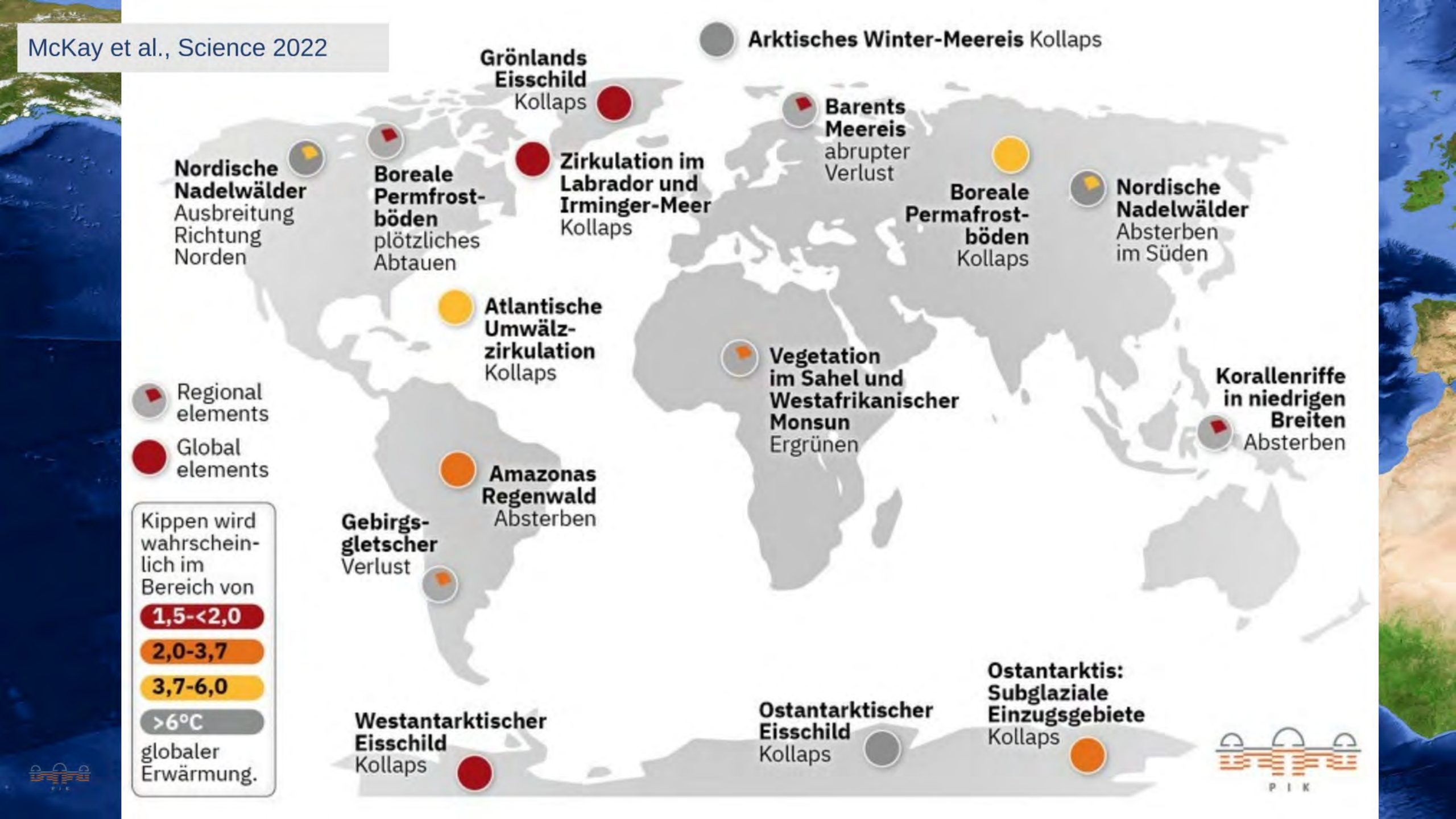


Kipppunkte im Klimasystem

Stefan Rahmstorf

Potsdam-Institut für Klimafolgenforschung

McKay et al., Science 2022



Wald macht Regen

Atmos. Chem. Phys., 14, 13337–13359, 2014
www.atmos-chem-phys.net/14/13337/2014/
doi:10.5194/acp-14-13337-2014

Atmospheric Chemistry and Physics
Open Access

On the importance of cascading moisture recycling in South America

D. C. Zemp[1,2], C.-F. Schleussner[1,3], H. M. J. Barbosa[4], R. J. van der Ent[5], J. F. Donges[1,6], J. Heinke[1,7], G. Sampaio[8], and A. Rammig[1]

[1]Potsdam Institute for Climate Impact Research (PIK), 14473 Potsdam, Germany
[2]Department of Geography, Humboldt Universität zu Berlin, Berlin, Germany
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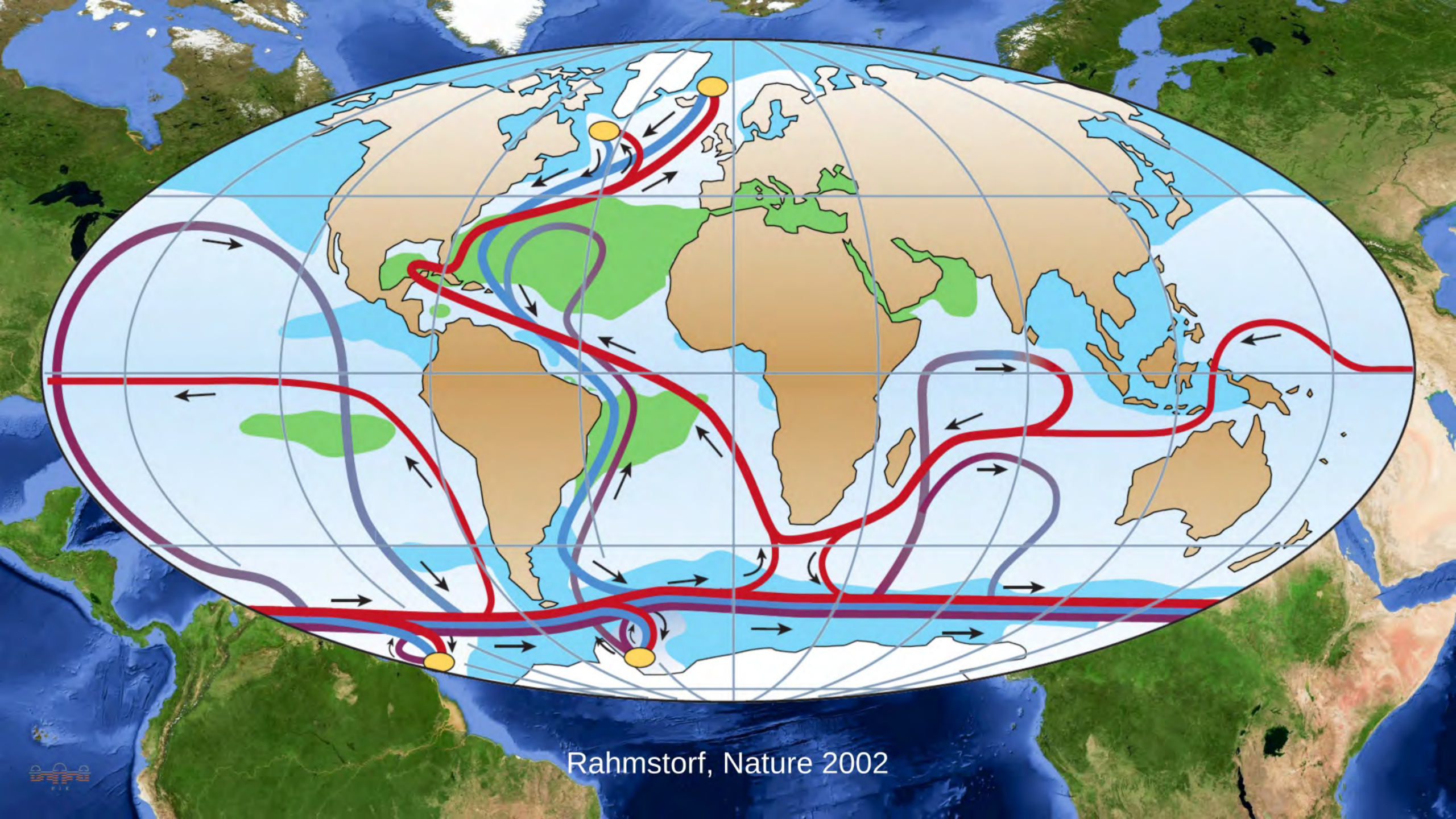
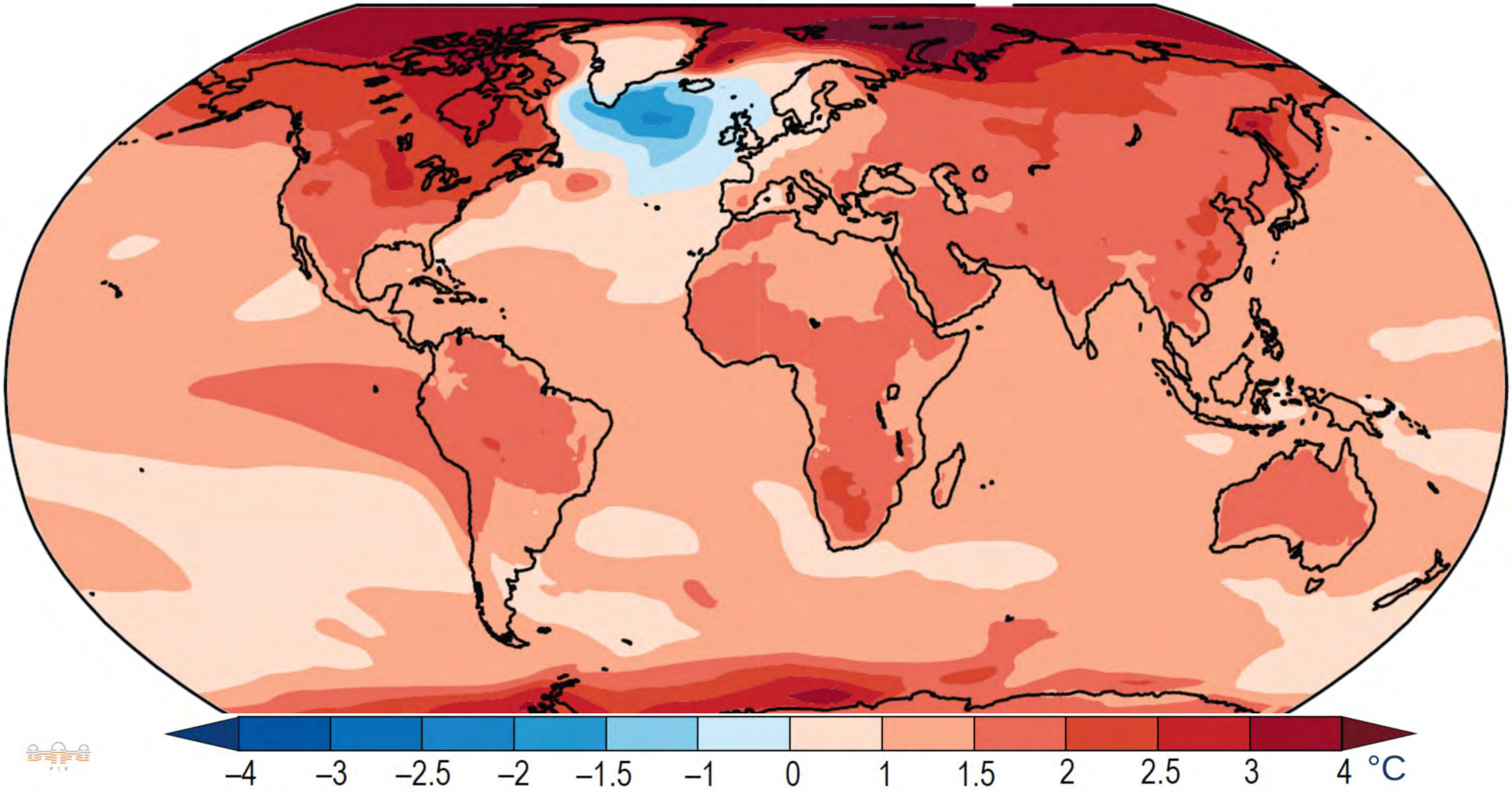
Beispiel Grönland

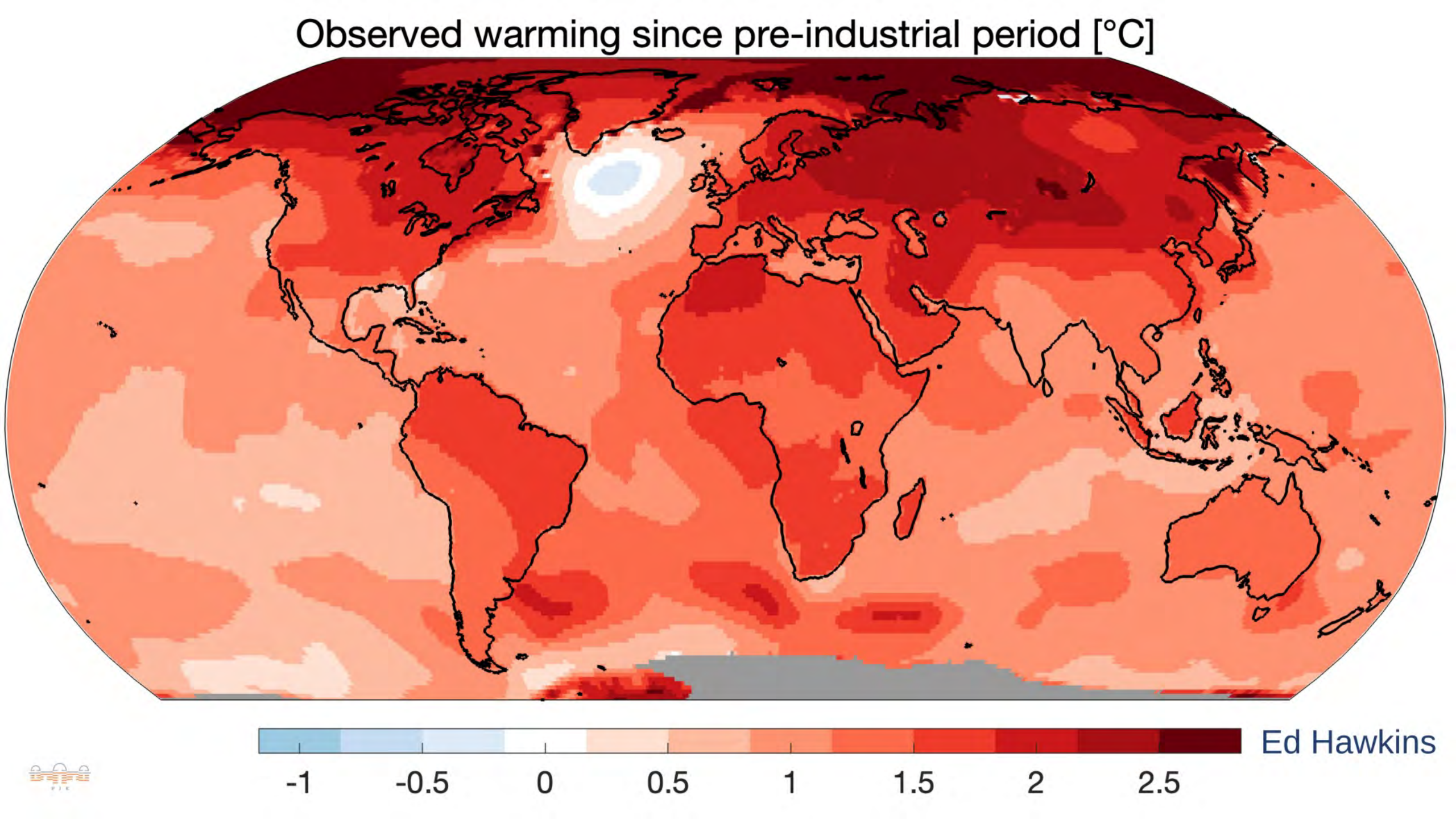
- Das Grönlandeis schmilzt
- Es hat einen Kipppunkt durch die Eis-Höhen-Rückkopplung
- Der liegt bei 1,1°C – 2,3°C lokaler Erwärmung
- Er führt zu 7 Meter Meeresspiegelanstieg

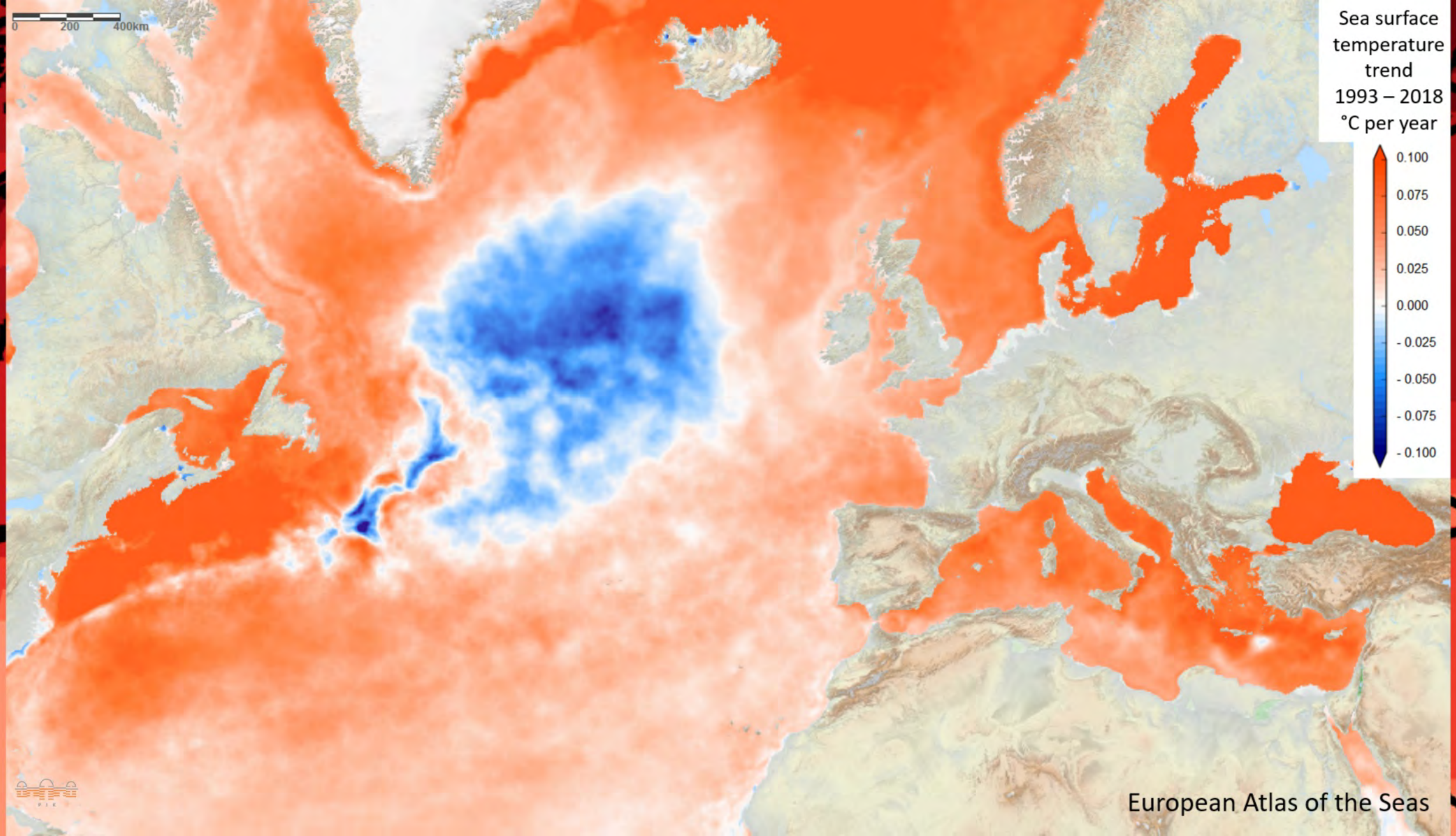


Rahmstorf, Nature 2002

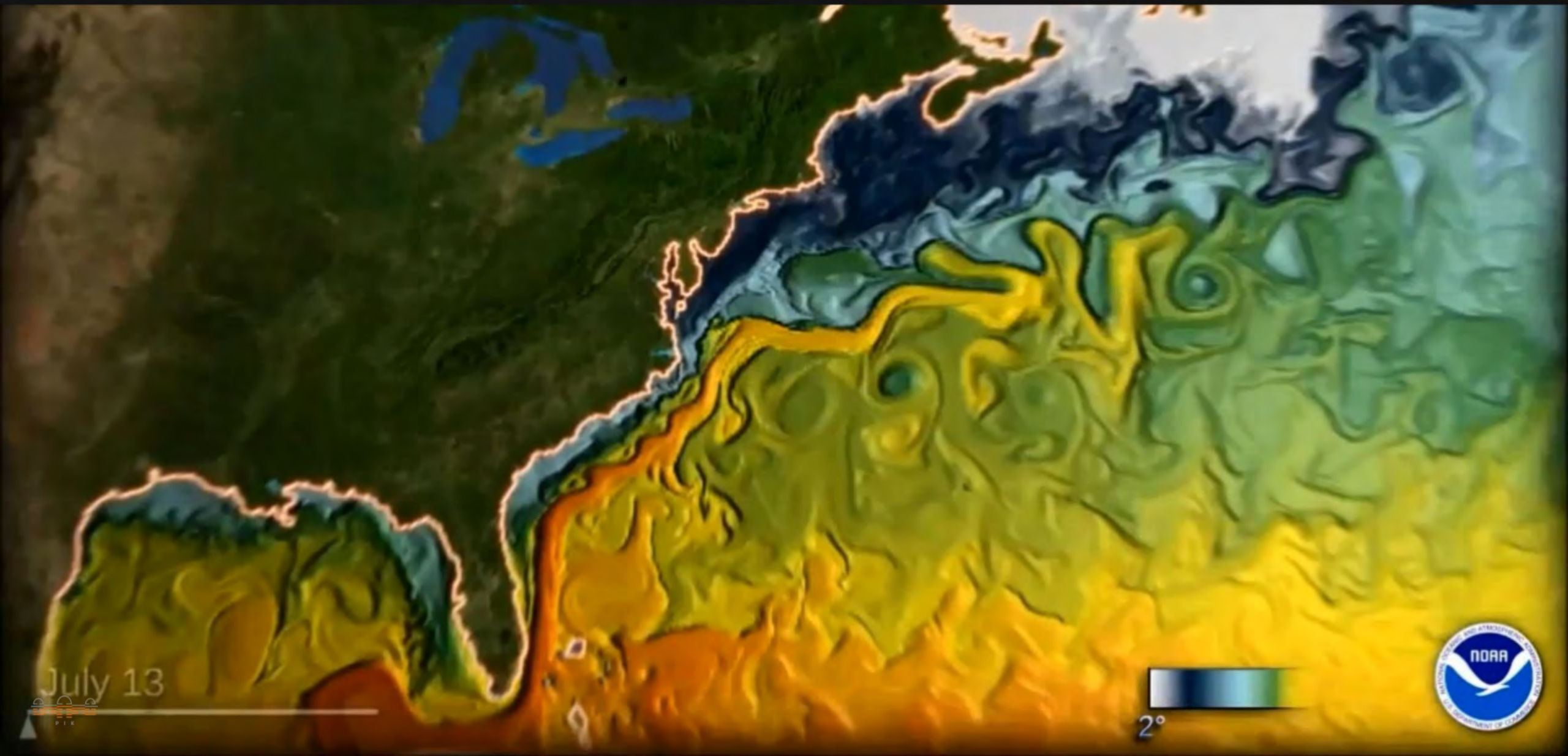
'High warming projection' IPCC AR6

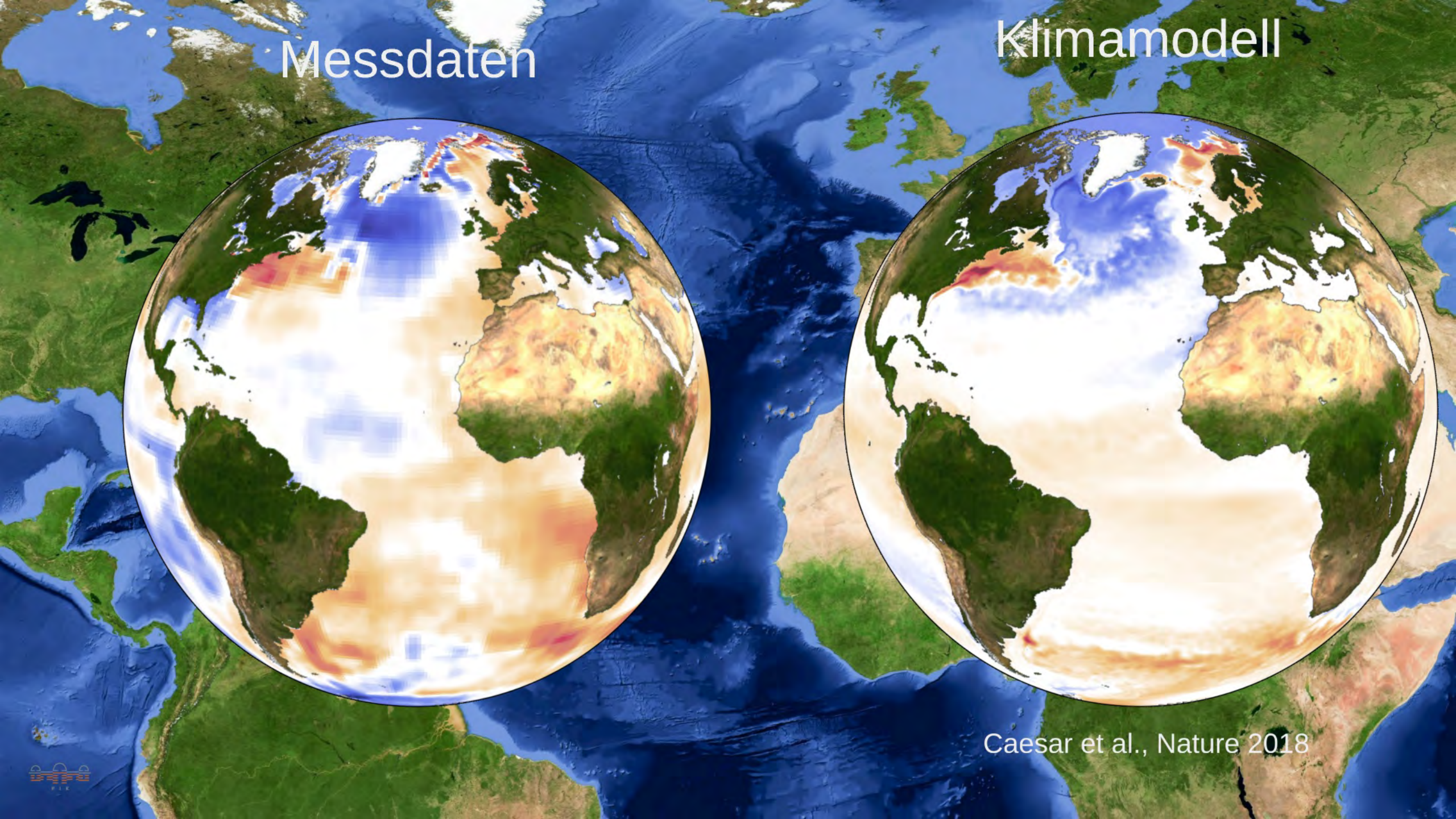



Observed warming since pre-industrial period [°C]
-1
-0.5
0
0.5
1
1.5
2
2.5
Ed Hawkins

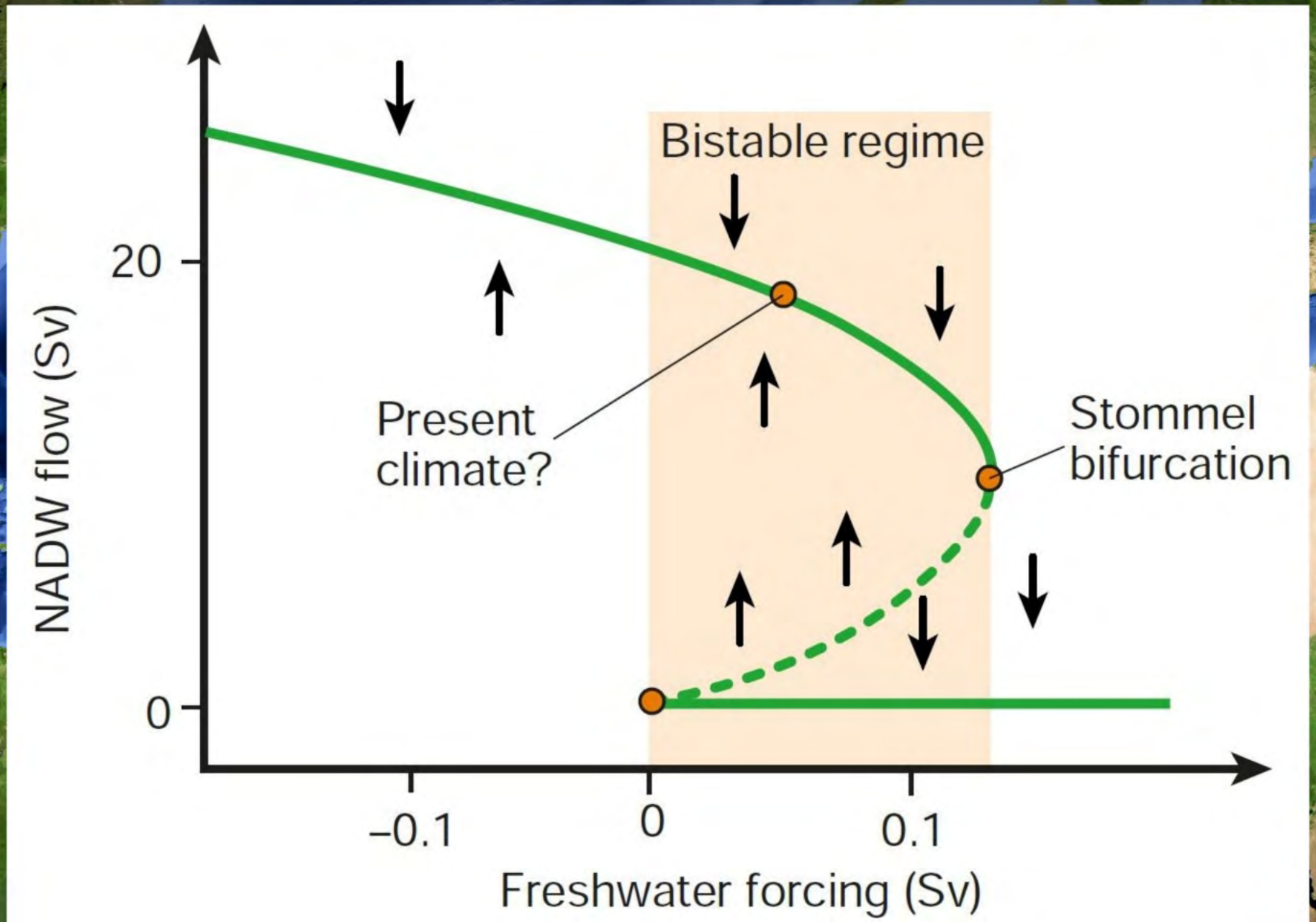

0
200
400km
Sea surface temperature trend 1993 – 2018 °C per year
0.100
0.075
0.050
0.025
0.000
- 0.025
- 0.050
- 0.075
- 0.100
European Atlas of the Seas

Das Golfstromsystem im Modell




Messdaten
Klimamodell
Caesar et al., Nature 2018

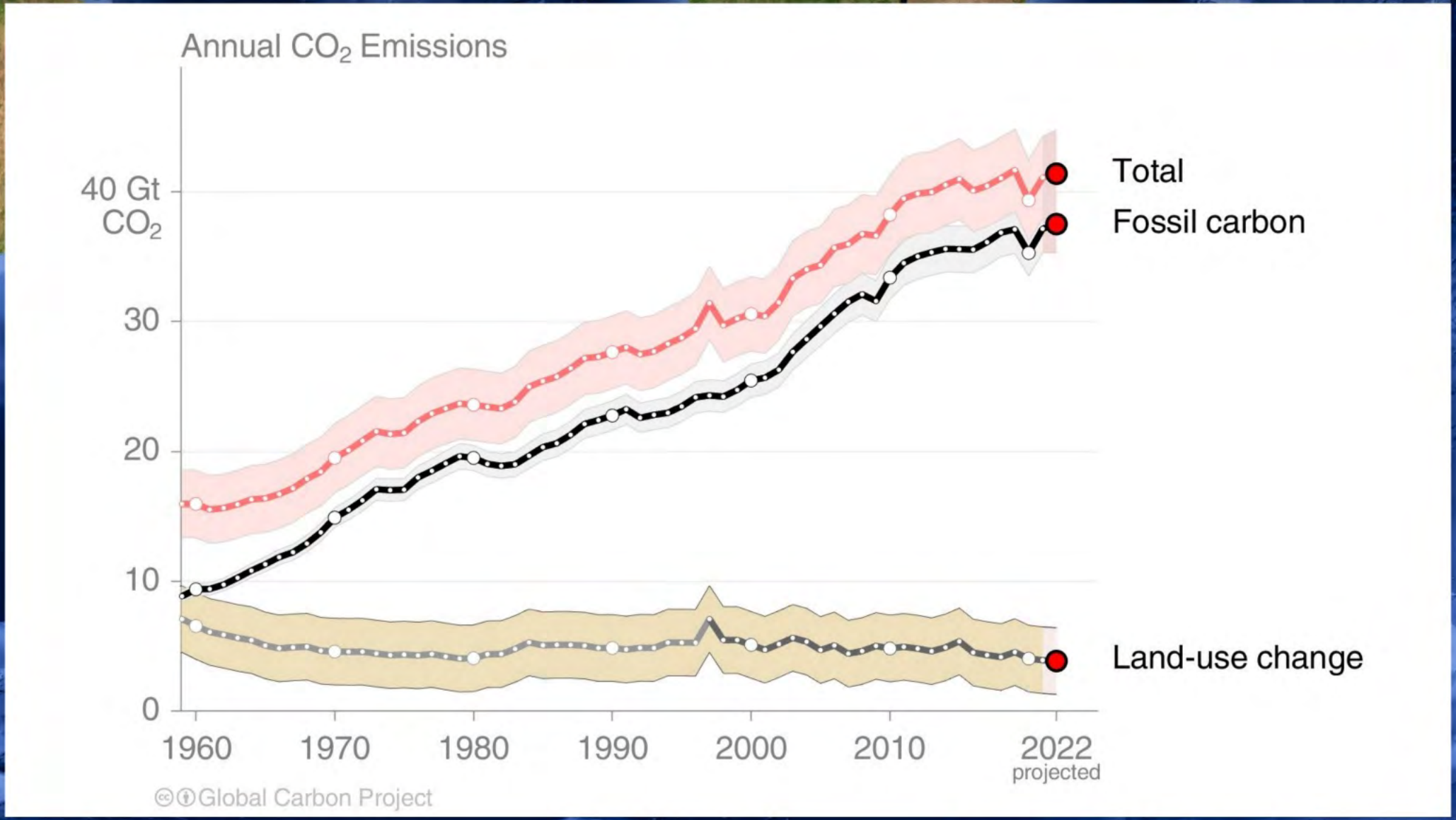
Kipppunkt der Atlantikzirkulation



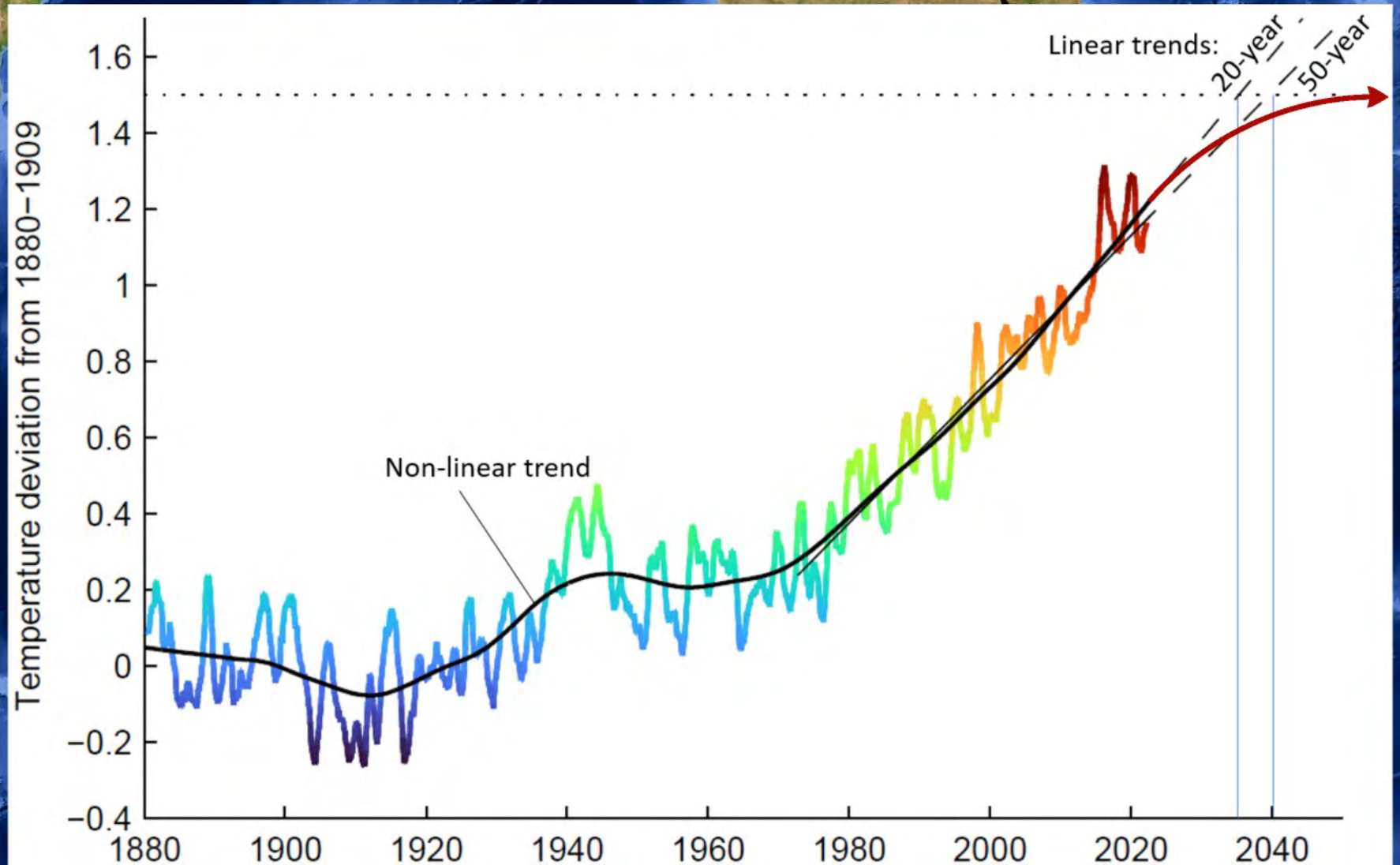
Der Klimavertrag von Paris

"...der Anstieg der durchschnittlichen Erdtemperatur deutlich unter 2 °C über dem vorindustriellen Niveau gehalten wird und Anstrengungen unternommen werden, um den Temperaturanstieg auf 1,5 °C über dem vorindustriellen Niveau zu begrenzen".

Globale CO2-Emissionen

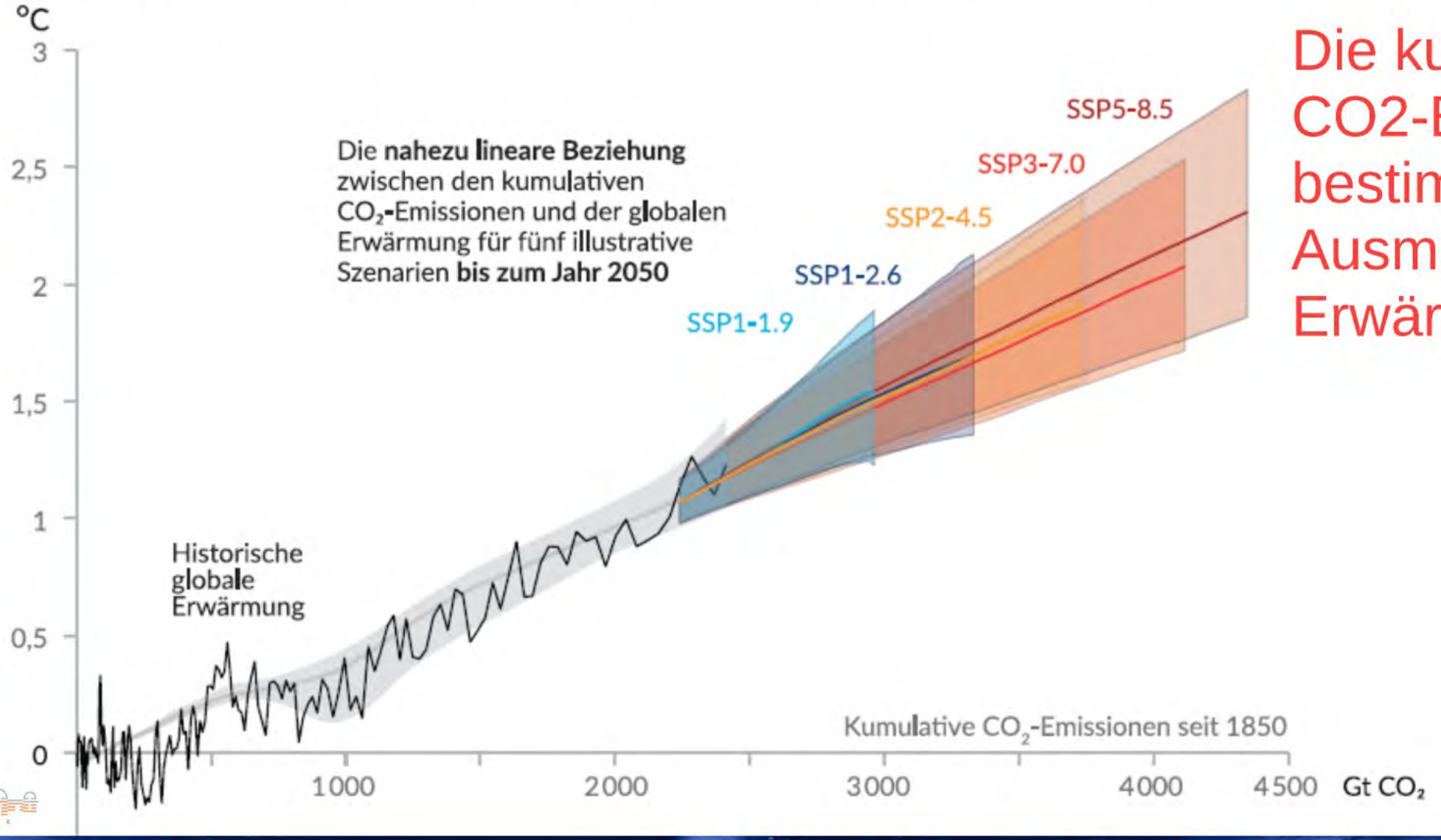


Können wir 1,5 Grad noch halten?

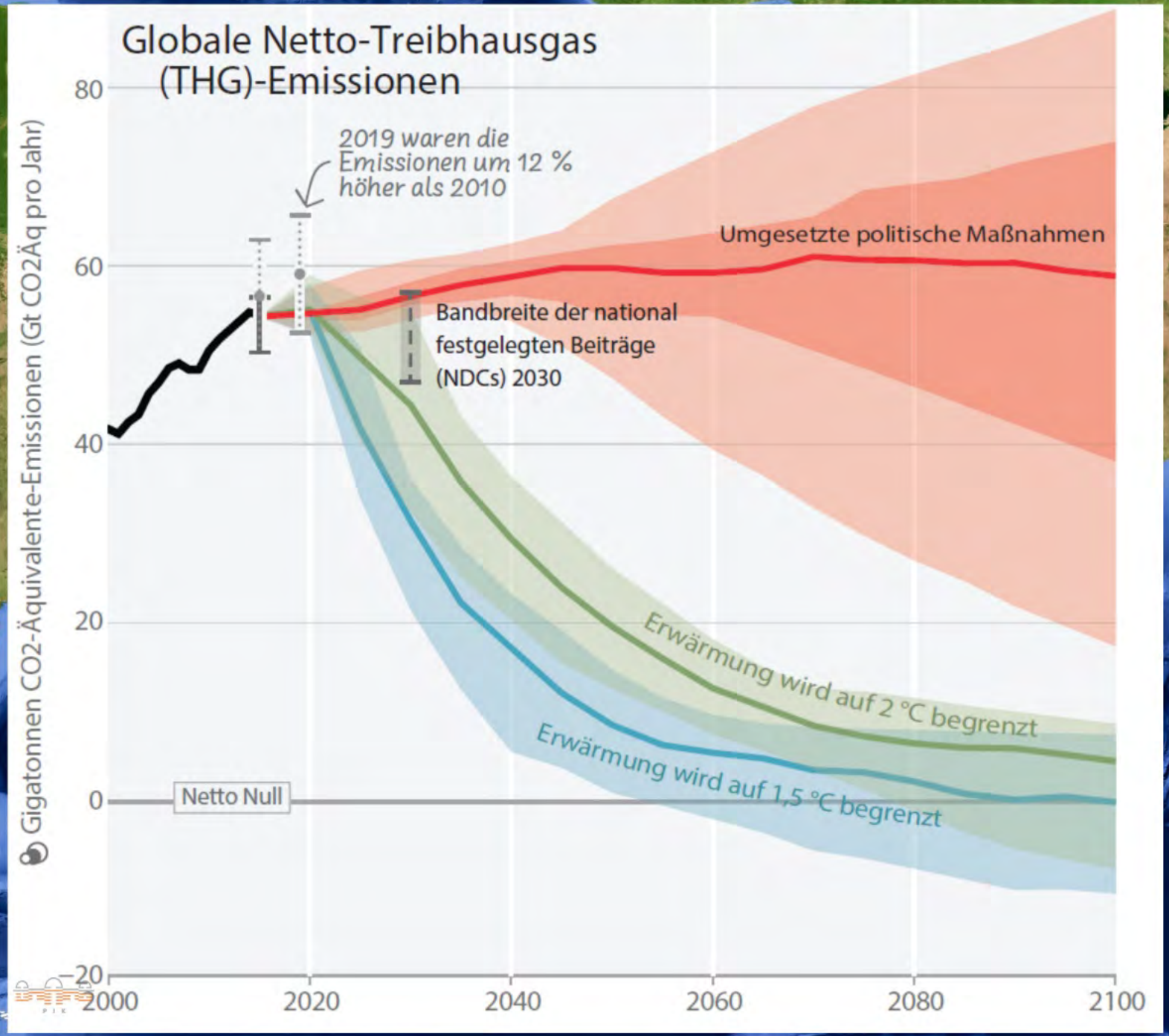


Jede Tonne CO_2-Emissionen erhöht die globale Erwärmung

Anstieg der globalen Oberflächentemperatur seit 1850–1900 (°C) als Funktion der kumulativen CO_2-Emissionen (Gt CO_2)



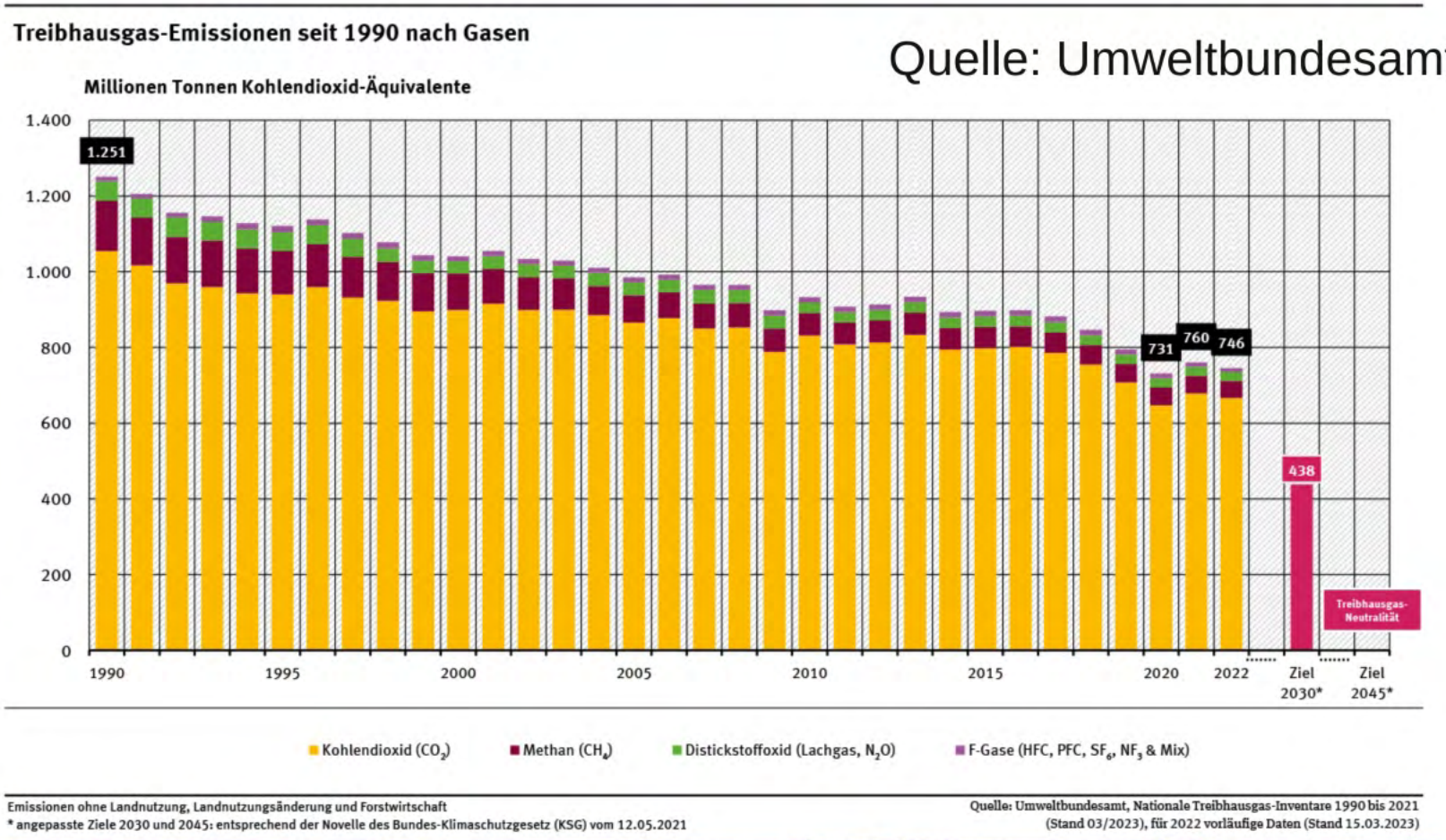
Die kumulativen CO2-Emissionen bestimmen das Ausmaß der Erwärmung!



IPCC 2023:

"Die begrenzung der Erwärmung auf 1,5°C und 2°C erfordert **schnelle** und **tiefgreifende** sowie in den meisten Fällen **sofortige** Senkungen der Treibhausgasemissionen in **allen Sektoren** in diesem Jahrzehnt."

Treibhausgas-Ausstoss in Deutschland

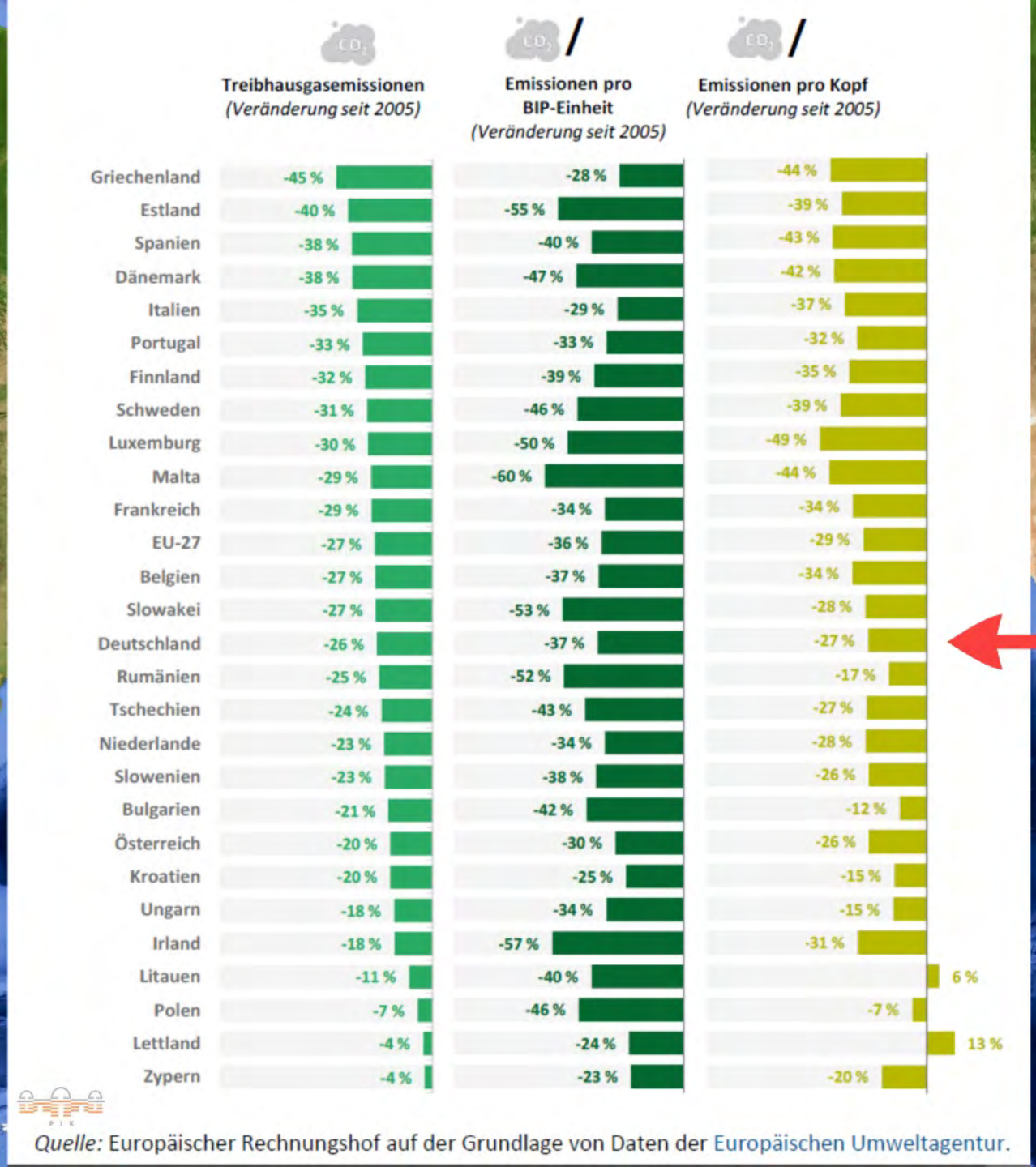


Quelle: Umweltbundesamt

1% der Bevölkerung
2% der CO2 Emissionen

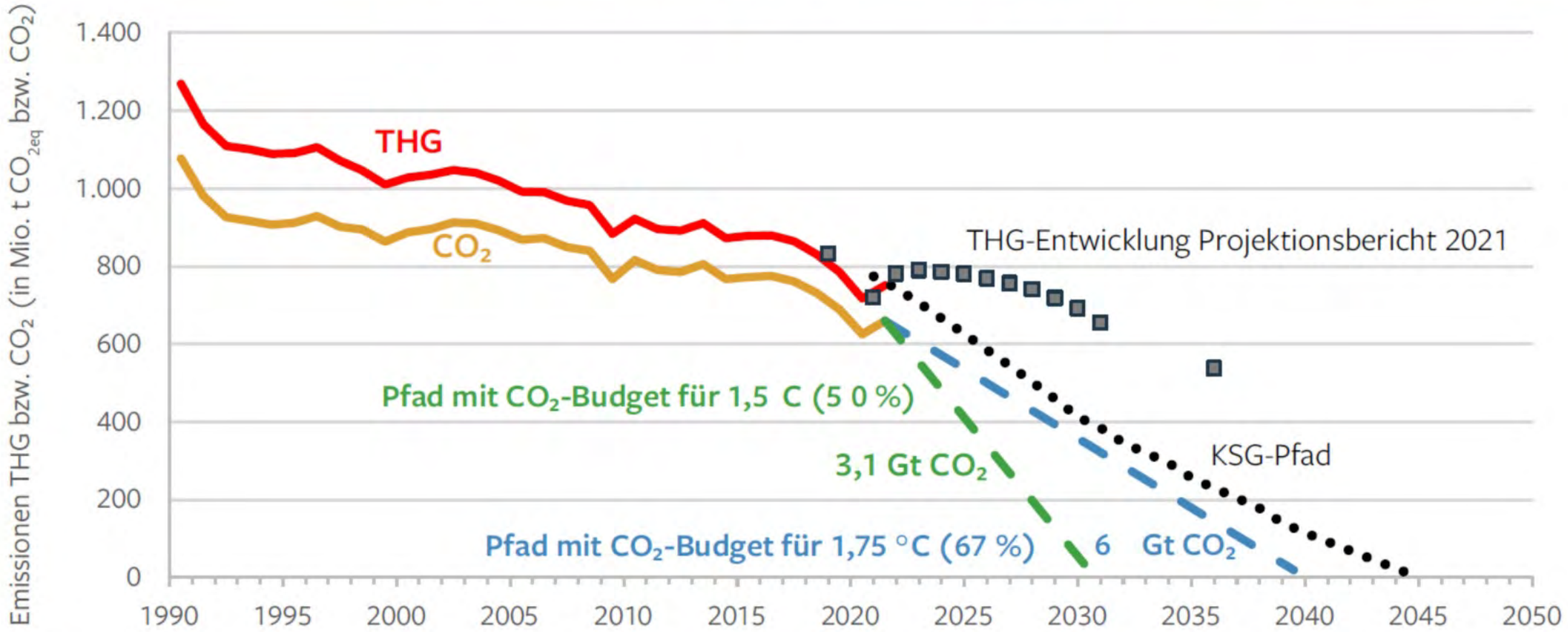
#6 bei aktuellen,
#4 bei historischen fossilen CO2-Emissionen

Treibhausgas-Minderung in EU-Staaten seit 2005



Quelle: Europäischer Rechnungshof auf der Grundlage von Daten der Europäischen Umweltagentur.

Das Emissionsbudget

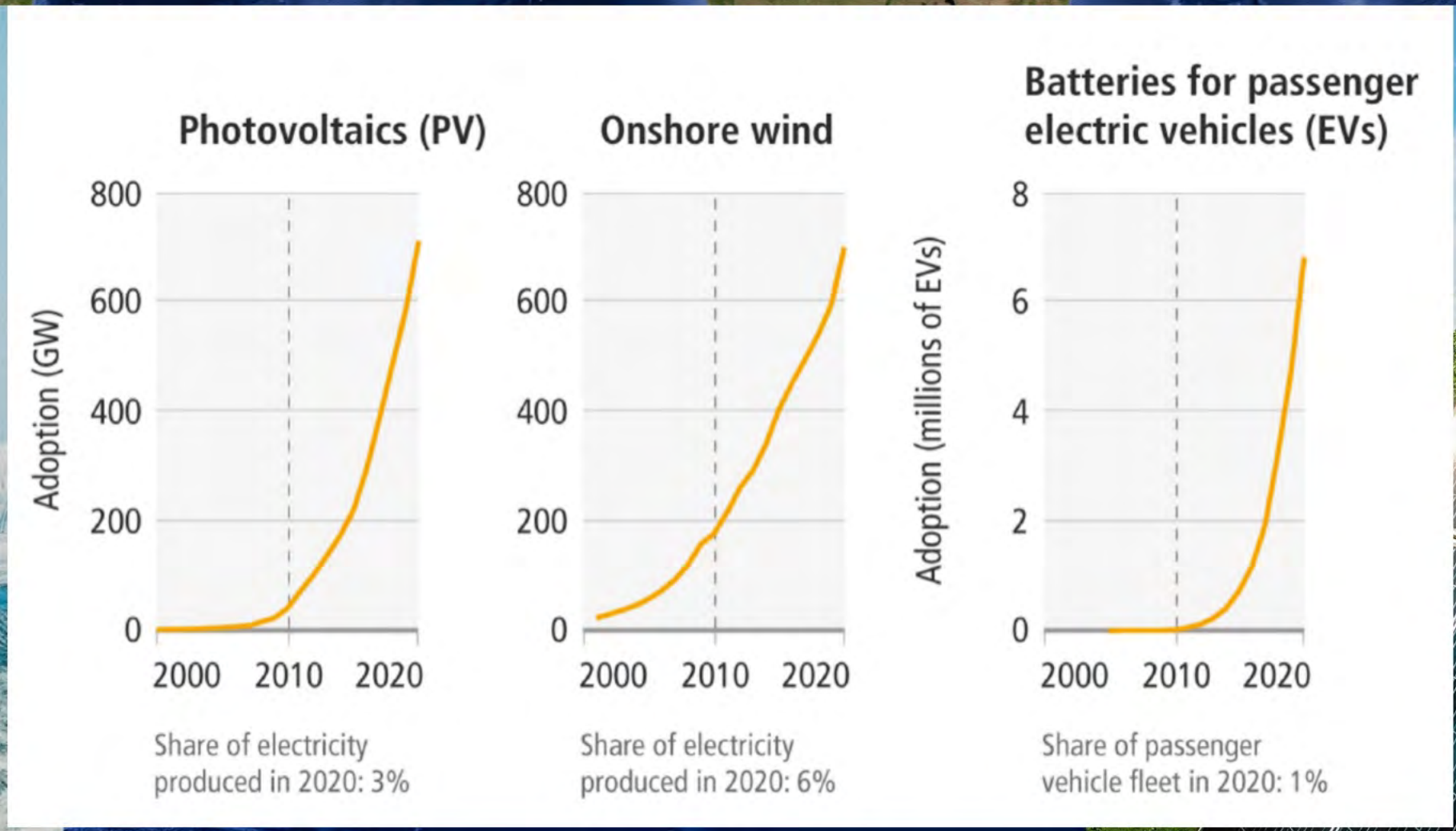


1.000 Mio. t CO_2 bzw. CO_{2eq} = 1 Gt CO_2 bzw. CO_{2eq}

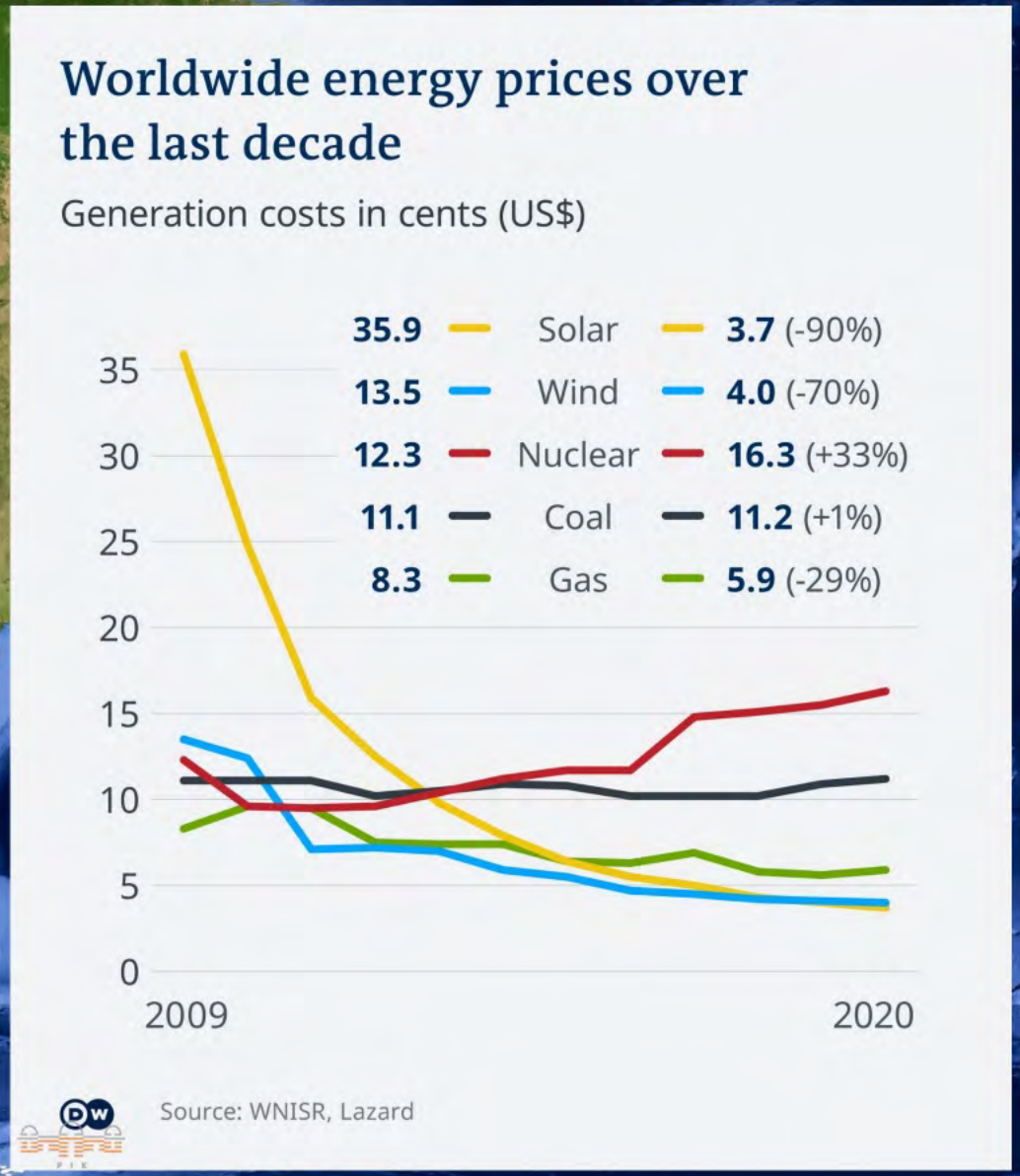
SRU 2022; Datenquellen: REPENNING et al. 2021, Tab. 126; UBA 2022b; KSG 2021 § 3a sowie Anlage 2 und 3

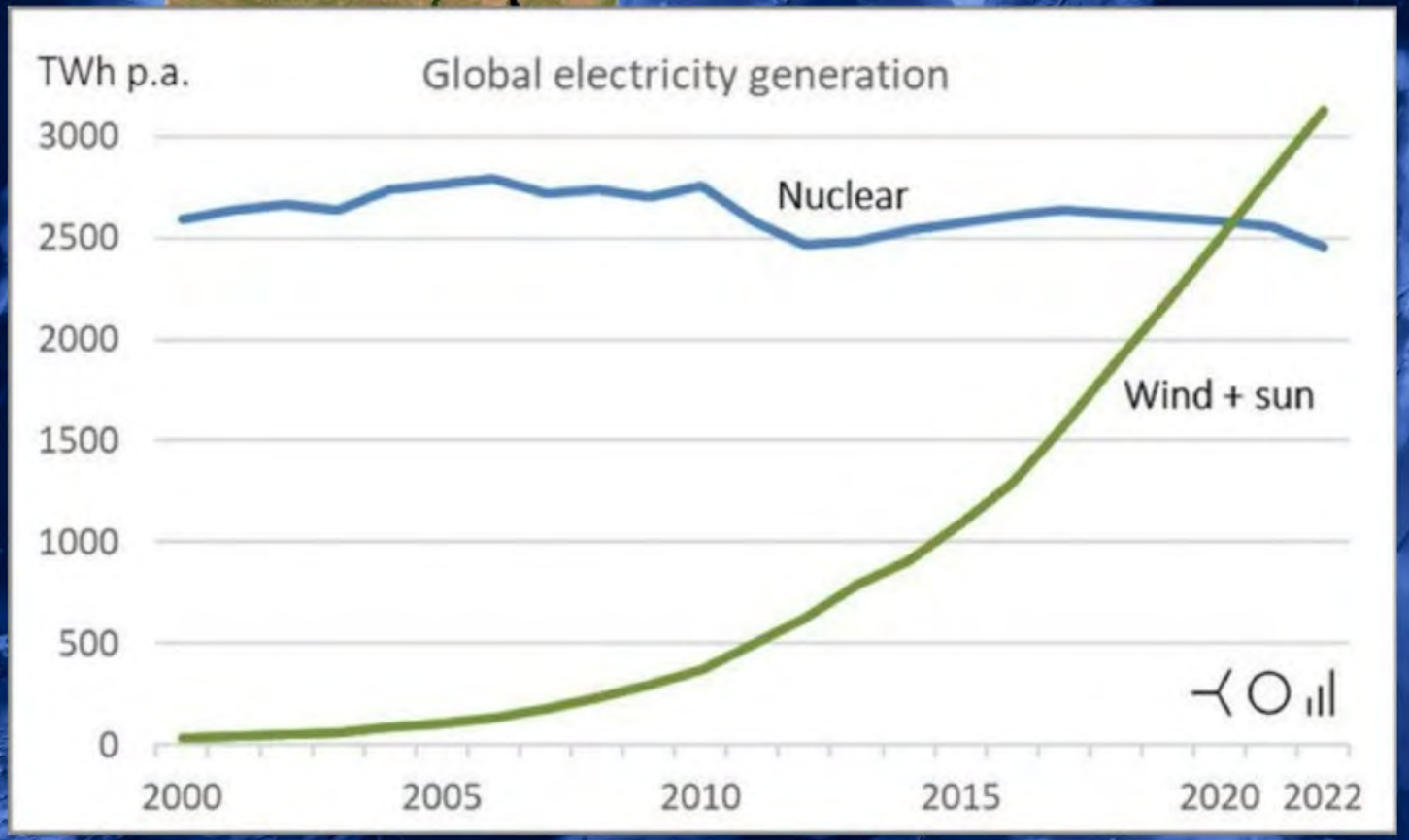
Weltklimarat IPCC: Es gibt die Lösungen

Und sie wachsen exponentiell und werden immer billiger!

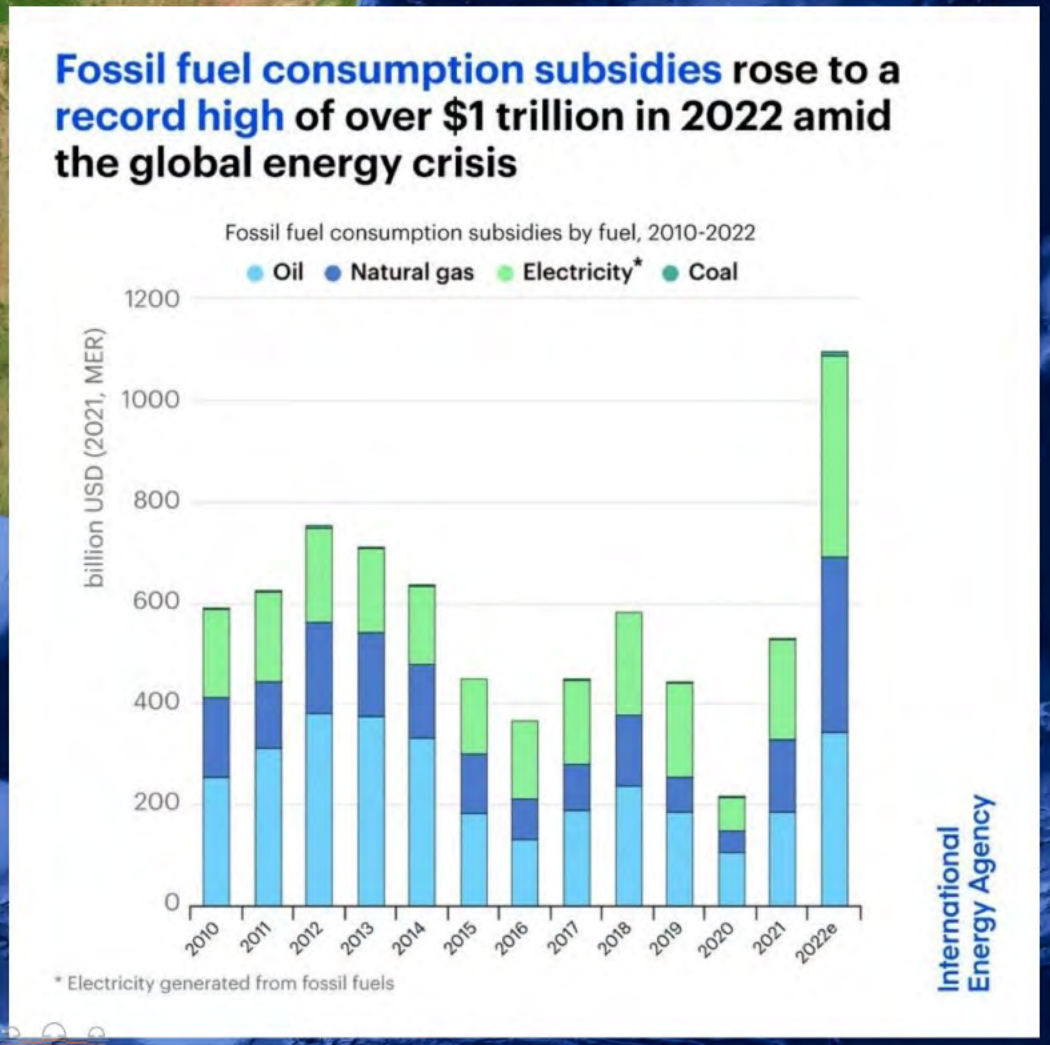


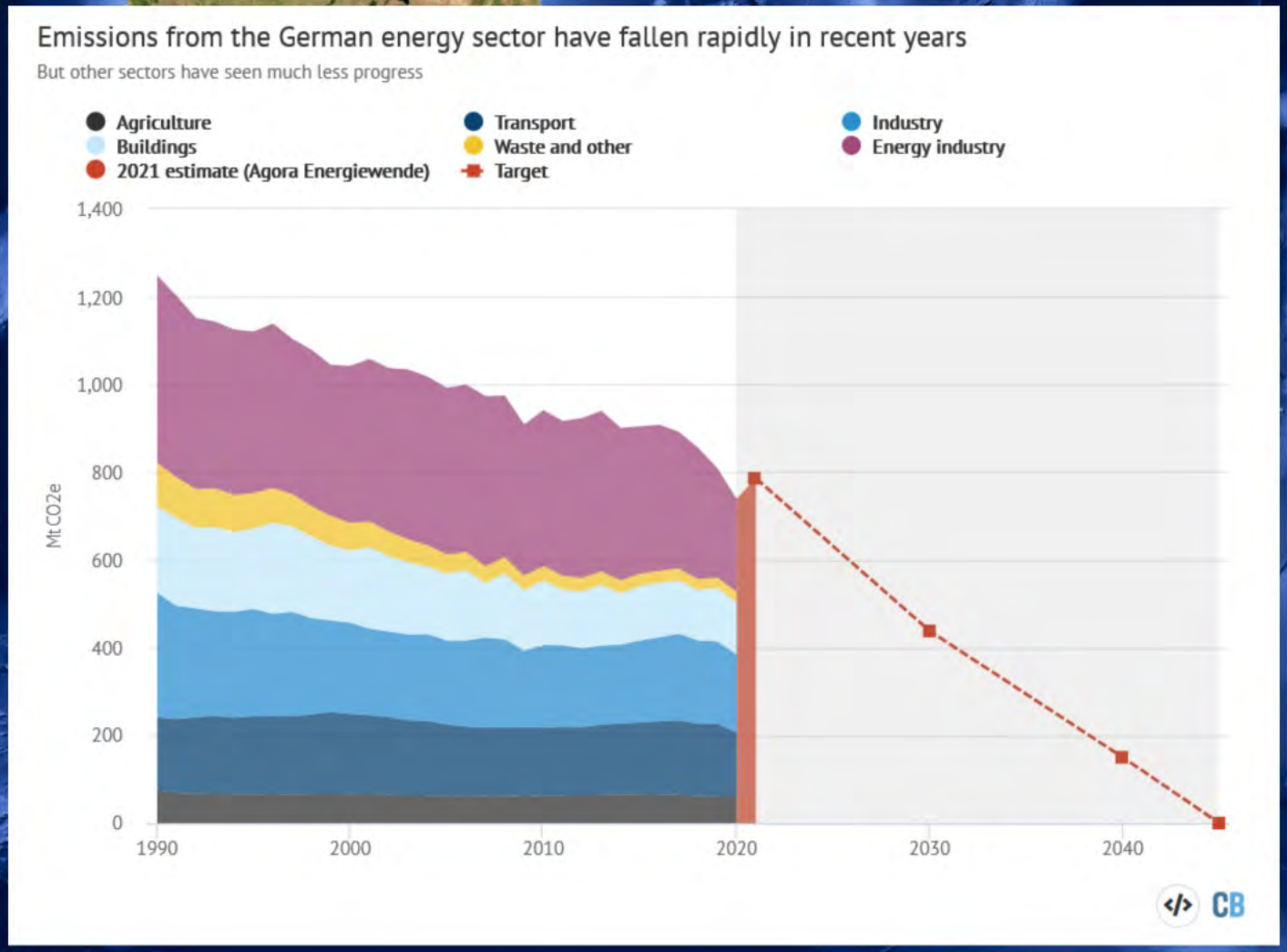
IEA: über 80 % der Strom-Investitionen gehen in EE





Ist also alles gut? Leider nein...





Wärmepumpen

Hat sich die Wärmepumpe für Sie gelohnt?

Angaben in Prozent

Quelle: ZEIT ONLINE Leserbefragung April 2023, 3.366 Haushalte

Rank	Country	Stock per 100 households
1	Norway	60.4
2	Sweden	42.7
3	Finland	40.8
4	Estonia	34.3
5	Denmark	19.1

Hauptaussagen des IPCC Klimaberichts 2023

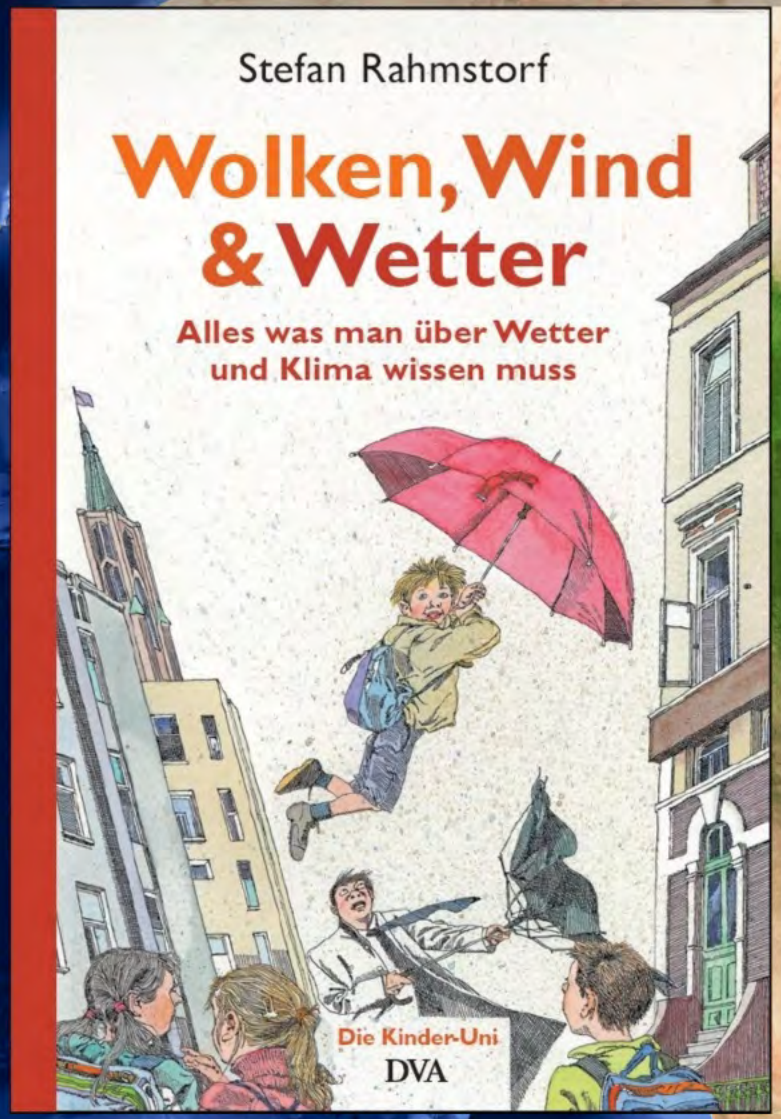
„Das Zeitfenster, in dem eine lebenswerte und nachhaltige Zukunft für alle gesichert werden kann, schließt sich rapide (*sehr hohes Vertrauen*).“

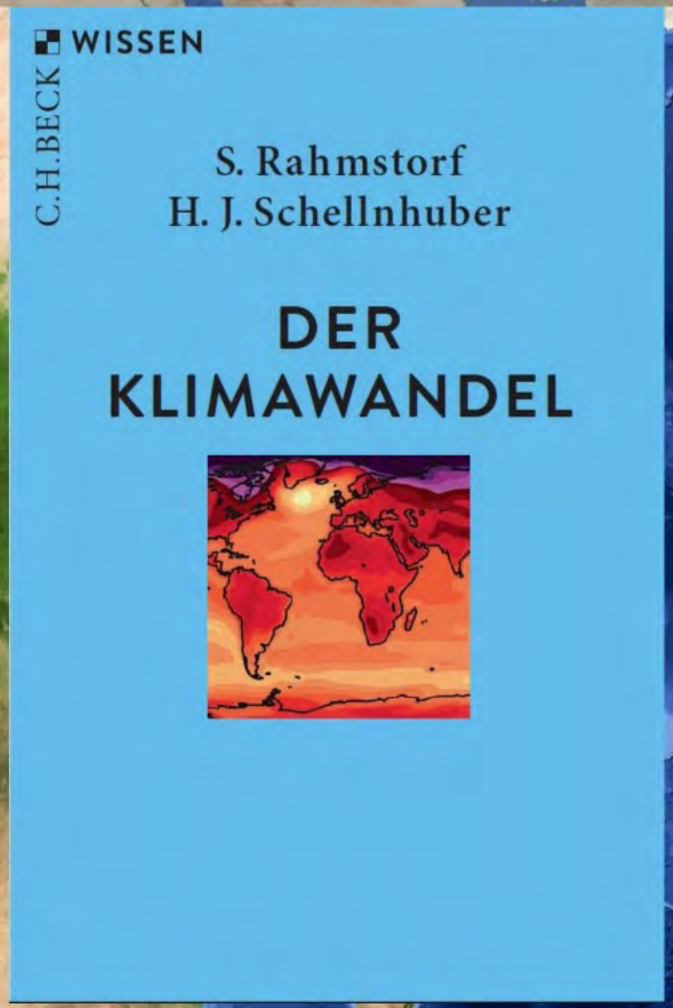
„Die in diesem Jahrzehnt getroffenen Entscheidungen und durchgeführten Maßnahmen werden sich jetzt und für Tausende von Jahren auswirken (hohes Vertrauen).“

Hunderte Wissenschaftler aus aller Welt haben 8 Jahre an diesem Bericht gearbeitet.
Deutsche Übersetzung der Hauptaussagen: https://www.de-ipcc.de/media/content/Hauptaussagen_AR6-SYR.pdf

Kommt der gesellschaftliche Kipppunkt?

Herzlichen Dank für Ihr Interesse!





Folgen Sie mir:
@rahmstorf

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