



UNIVERSITÄT  
LEIPZIG

19. Sächsische Gewässertage

# Änderungen des Niederschlags im Klimawandel - Erkenntnisse aus dem aktuellen Sachstandsbericht des IPCC



Dr Karsten Haustein



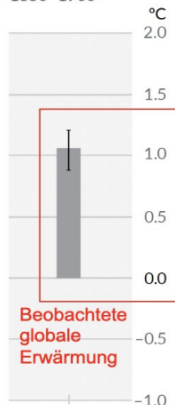
Gewässer in  
Zeiten des Klimawandel

# Globale und regionale Erwärmung

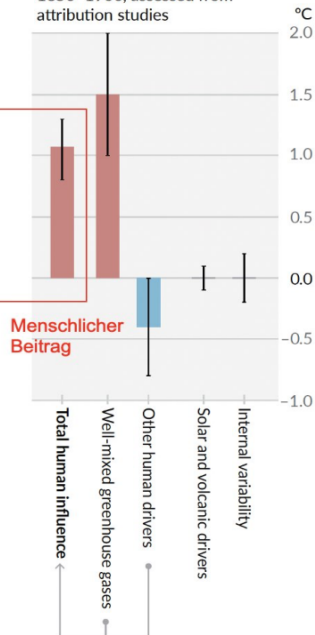


## ENTWICKLUNG DER GLOBALTEMPERATUR SEIT 1850

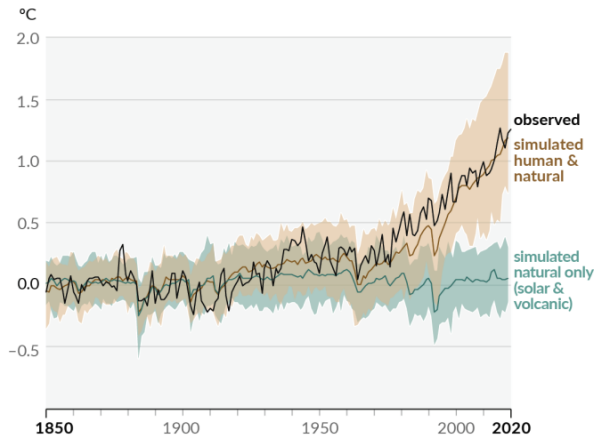
(a) Observed warming 2010–2019 relative to 1850–1900



(b) Aggregated contributions to 2010–2019 warming relative to 1850–1900, assessed from attribution studies

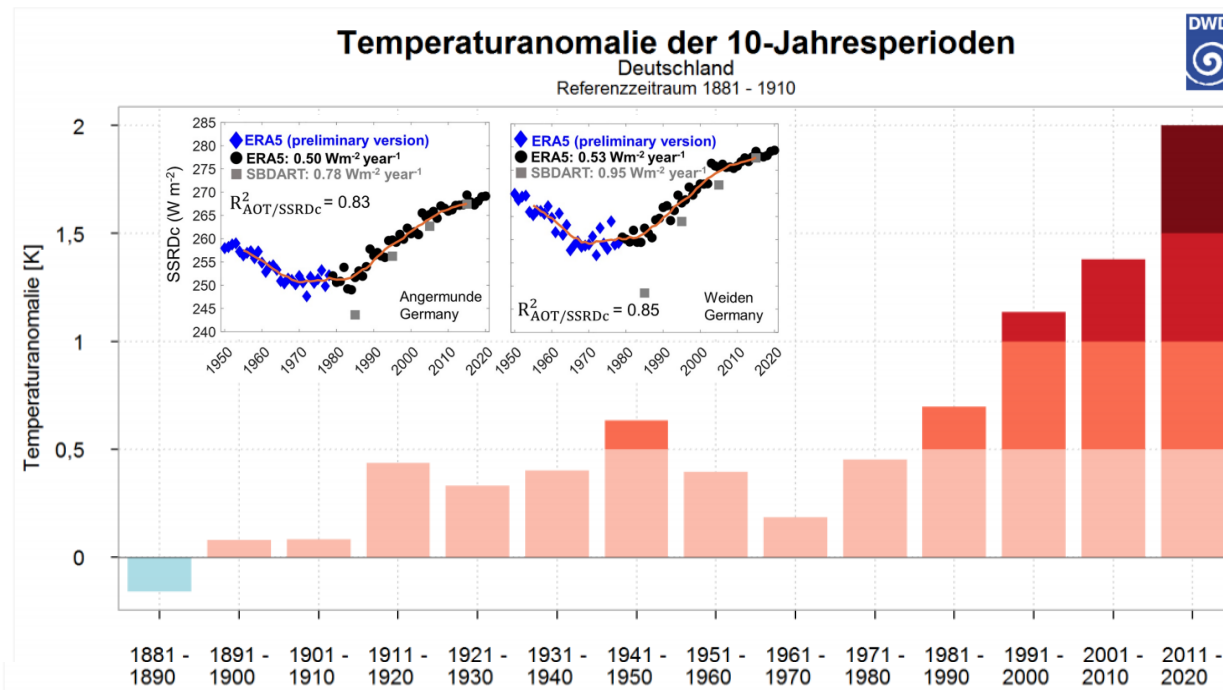


(b) Change in global surface temperature (annual average) as **observed** and simulated using **human & natural** and **only natural** factors (both 1850–2020)



100% der beobachteten globalen Erwärmung seit 1850 sind menschengemacht (IPCC)!

## ENTWICKLUNG DER TEMPERATUR IN DEUTSCHLAND SEIT 1880

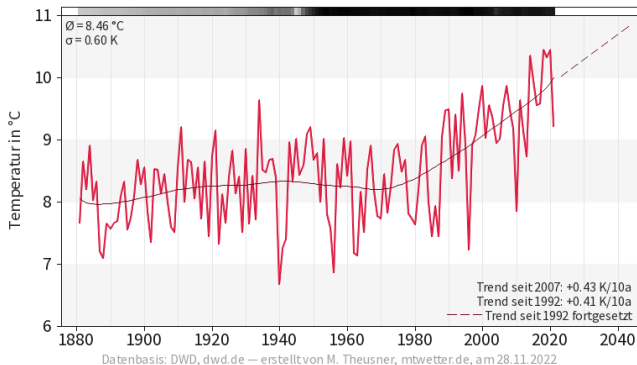


kühlender Aerosoleffekt zwischen 1950-1980; seitdem steiler quasi-linearer Aufwärtstrend

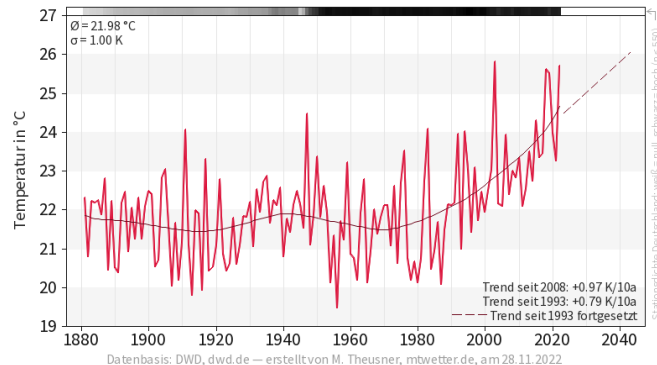


# ENTWICKLUNG DER TEMPERATUR IN DEUTSCHLAND SEIT 1880

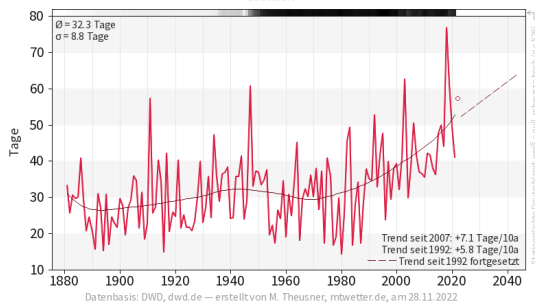
Mittel der Temperatur im Jahr  
Deutschland



Mittel der Tageshöchsttemperatur im Sommer  
Deutschland

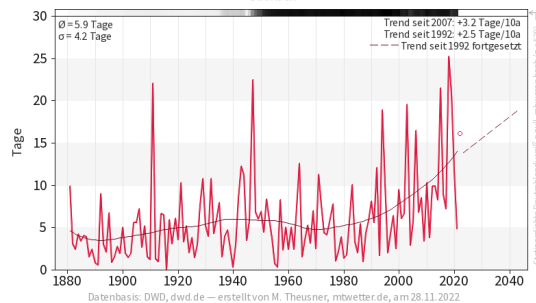


Anzahl der Sommertage im Jahr  
Sachsen



**SACHSEN  
TAGE > 25°C**

Anzahl der Hitzetage im Jahr  
Sachsen



**TAGE > 30°C  
SACHSEN**



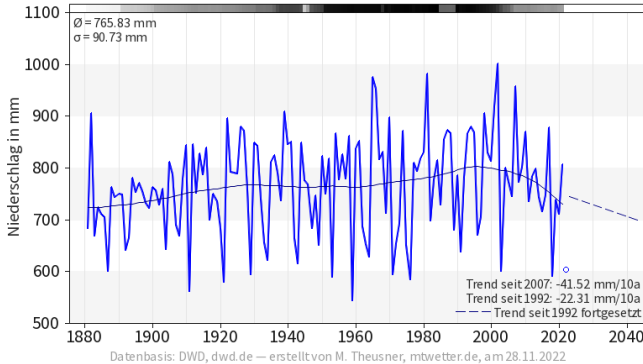
Gewässer in  
Zeiten des Klimawandel

# Änderungen des Niederschlags (IPCC)

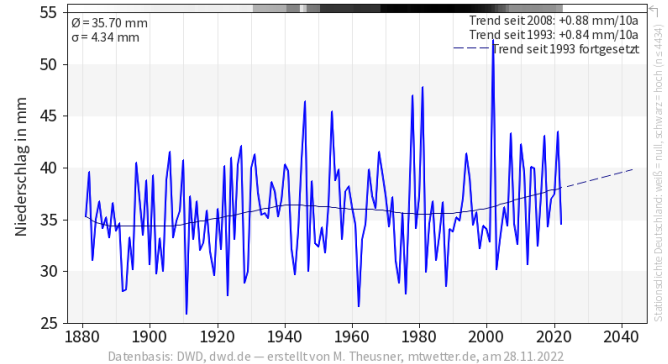


# ENTWICKLUNG DES NIEDERSCHLAG IN DEUTSCHLAND SEIT 1880

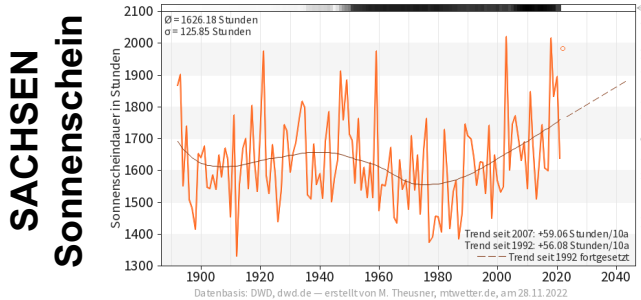
Summe des Niederschlags im Jahr  
Deutschland



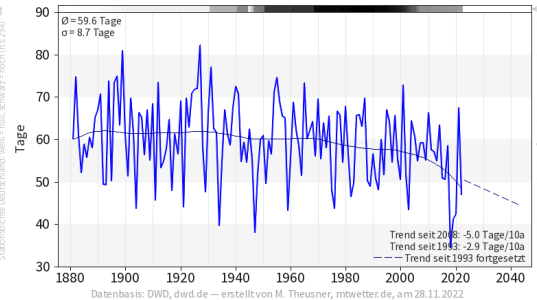
Höchster Tagesniederschlag im Sommerhalbjahr  
Deutschland



Summe der Sonnenscheindauer im Jahr  
Deutschland



Anzahl der Tage mit Niederschlag > 1 mm im Sommerhalbjahr  
Sachsen



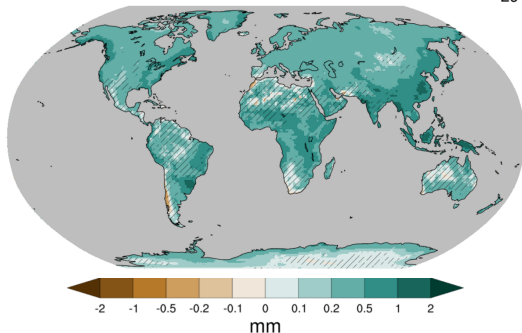
**SACHSEN  
Sonnenschein**

**TAGE > 1mm  
SACHSEN**

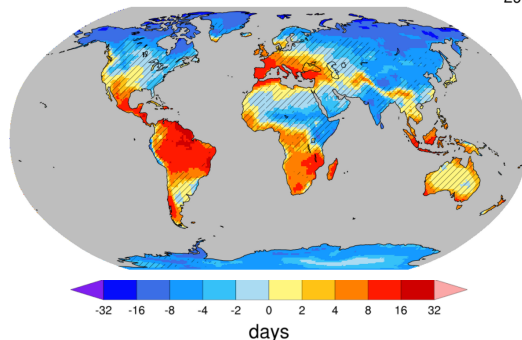
# ENTWICKLUNG DES NIEDERSCHLAG IM KLIMAMODELL-KONTEXT

Multi-model annual mean long-term changes in daily precipitation statistics

(d) SSP2-4.5 daily precipitation intensity

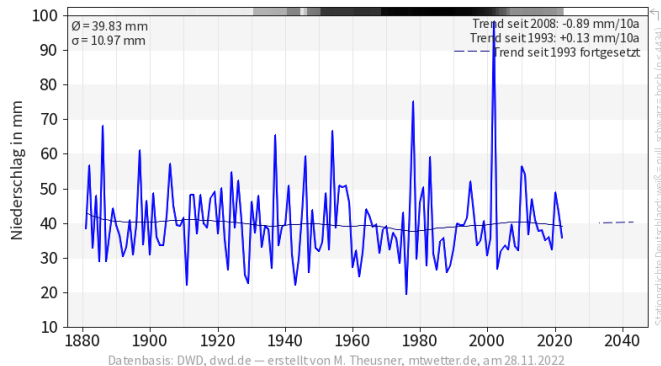


(c) SSP2-4.5 dry days per year



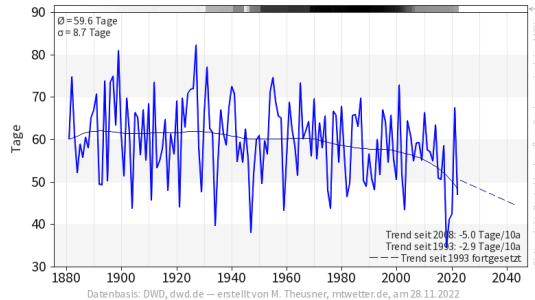
Höchster Tagesniederschlag im Sommerhalbjahr

Sachsen



Anzahl der Tage mit Niederschlag > 1 mm im Sommerhalbjahr

Sachsen



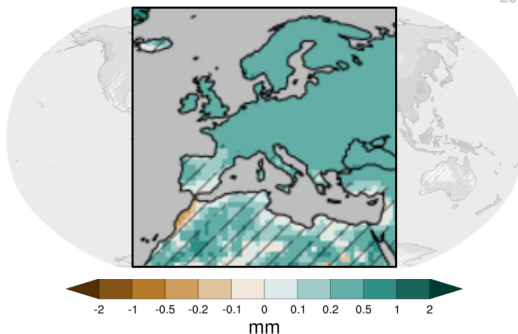
**TAGE > 1mm  
SACHSEN**



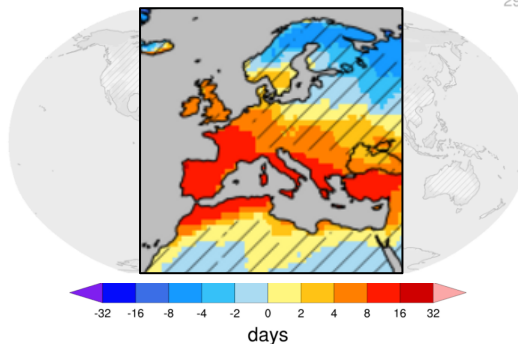
# ENTWICKLUNG DES NIEDERSCHLAG IM KLIMAMODELL-KONTEXT

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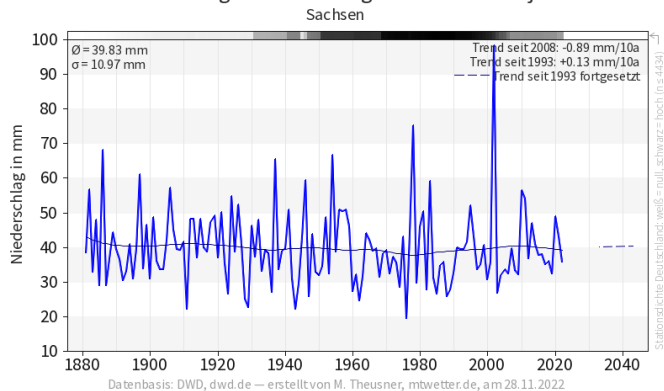


(c) SSP2-4.5 dry days per year



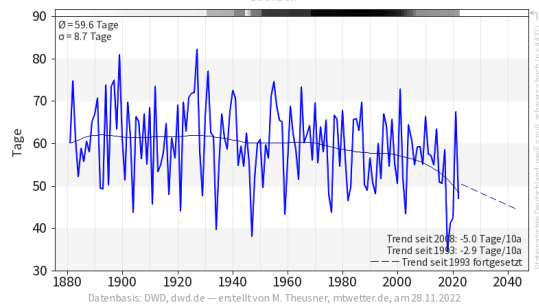
29

Höchster Tagesniederschlag im Sommerhalbjahr



29

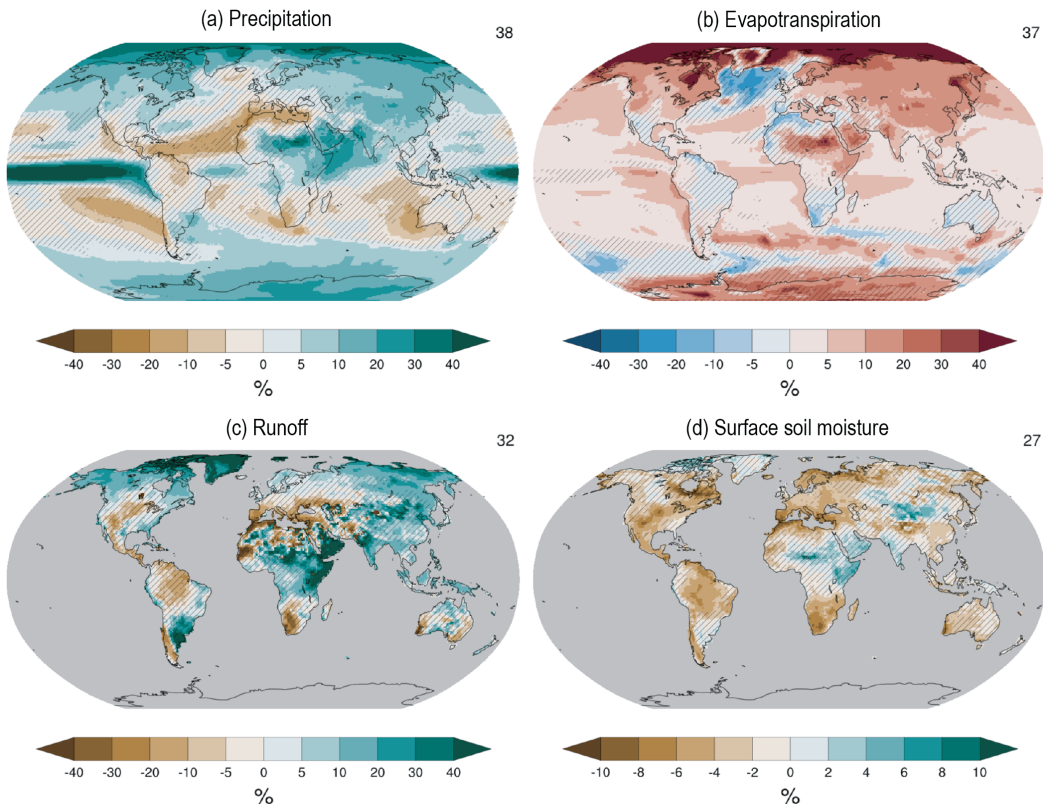
Anzahl der Tage mit Niederschlag > 1 mm im Sommerhalbjahr



**TAGE > 1mm  
SACHSEN**

# ÄNDERUNGEN DES WASSERKREISLAUF (BAU IPCC)

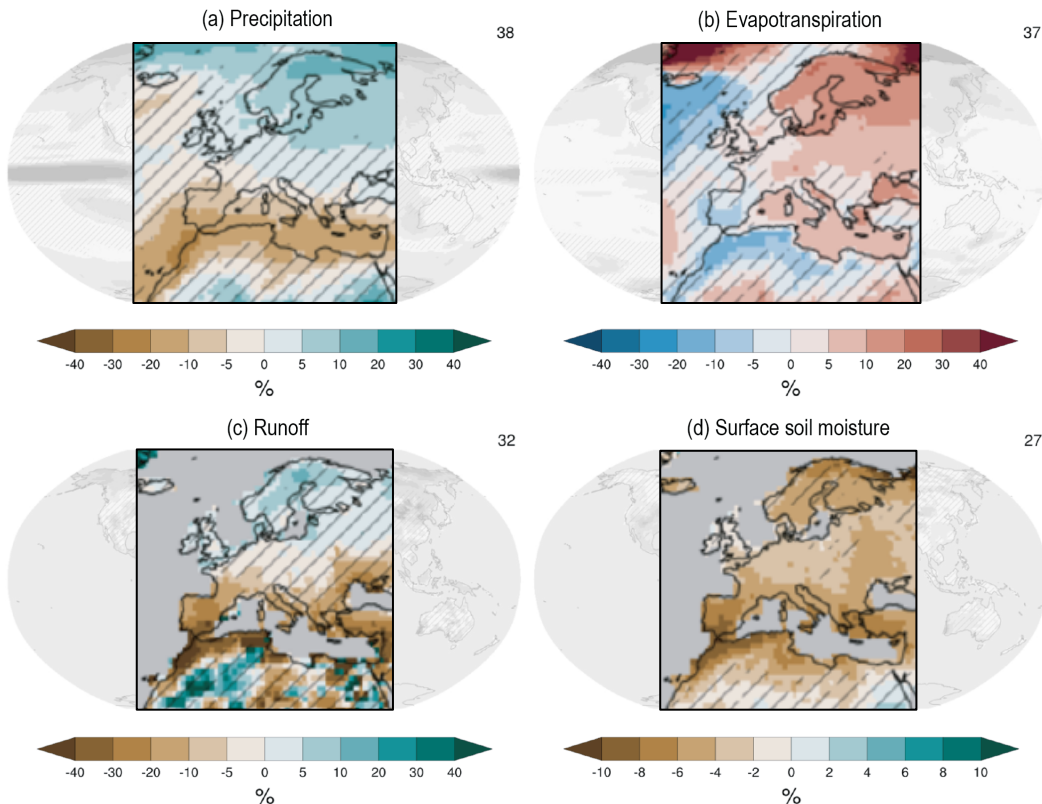
Long-term water cycle variables for SSP2-4.5 (2081–2100 vs 1995–2014)





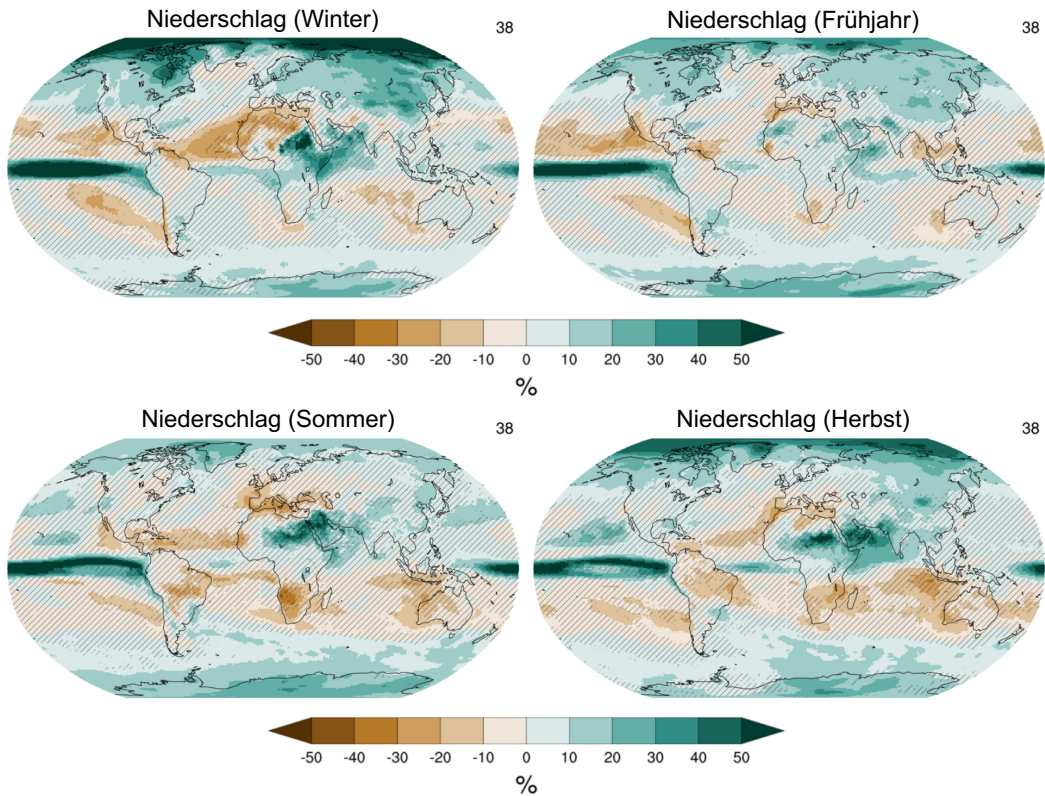
# ÄNDERUNGEN DES WASSERKREISLAUF (BAU IPCC)

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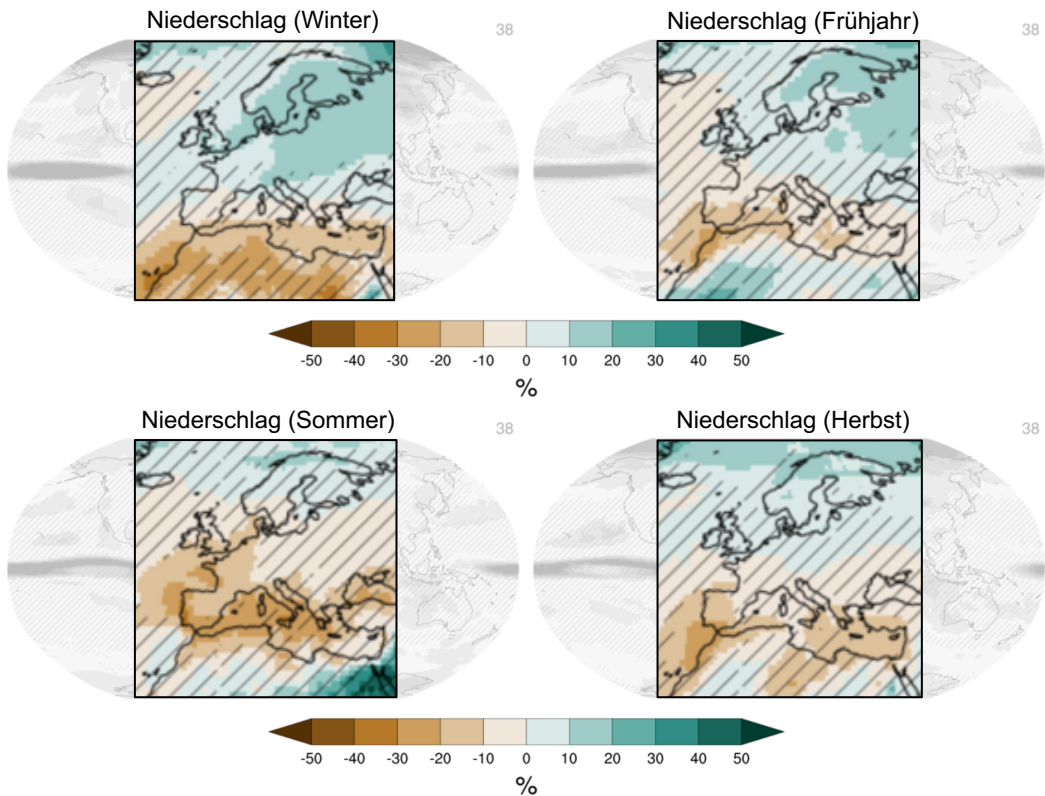
## ÄNDERUNGEN DES WASSERKREISLAUF (SAISONAL)

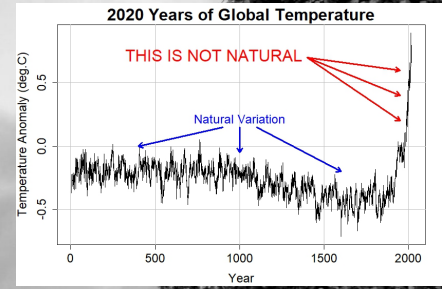
Multi-model seasonal mean precipitation percentage change for SSP2-4.5 (2081-2100 vs 1995-2014)



## ÄNDERUNGEN DES WASSERKREISLAUF (SAISONAL)

Multi-model seasonal mean precipitation percentage change for SSP2-4.5 (2081-2100 vs 1995-2014)





Gewässer in  
Zeiten des Klimawandel

# Attribution der Änderungen



## EXTREMWETTER (EXTREMER NIEDERSCHLAG)

Climate change is already affecting every inhabited region across the globe, with human influence contributing to many observed changes in weather and climate extremes

(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)

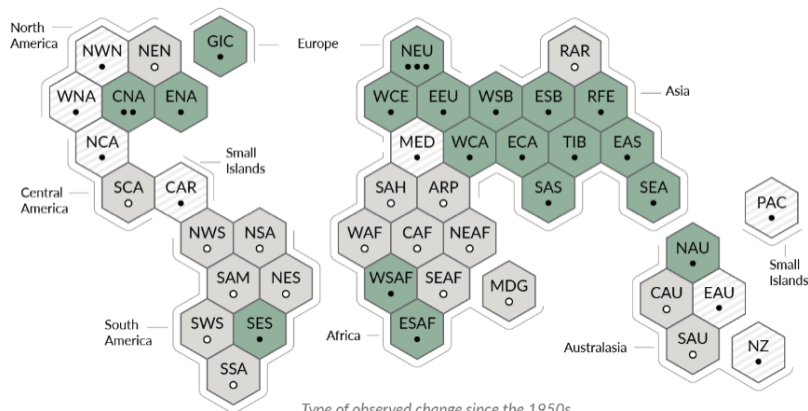
Confidence in human contribution to the observed change

●●● High

●● Medium

● Low due to limited agreement

○ Low due to limited evidence



Type of observed change since the 1950s

IPCC AR6 fasst die attributierbaren Änderungen per Kategorie nach Region zusammen.

## ATTRIBUTION VON EXTREMWETTER (ÜBERSCHWEMMUNG)



Home > Extreme rainfall > Heavy rainfall which led to severe flooding in Western Europe made more likely by climate change

### Heavy rainfall which led to severe flooding in Western Europe made more likely by climate change

23 August, 2021

**EXTREME RAINFALL**  
**EUROPE**

From the 12th to the 15th of July, heavy rainfall associated with cut-off low-pressure system “Bernd” led to severe flooding particularly in the German states North Rhine-Westphalia and Rhineland-Palatinate, as well as in Luxembourg, and along the river Meuse and some of its tributaries in Belgium and the Netherlands.

#### Full study

- [Download the full study: Rapid attribution of heavy rainfall events leading to the severe flooding in Western Europe during July 2021, pdf \(54 pages, 2.6 MB\)](#)

World Weather Attribution das bisher erfolgreichste Projekt die Problematik zu verstehen

## EXTREMWETTER (EXTREME DÜRRE)

Climate change is already affecting every inhabited region across the globe, with human influence contributing to many observed changes in weather and climate extremes

(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)

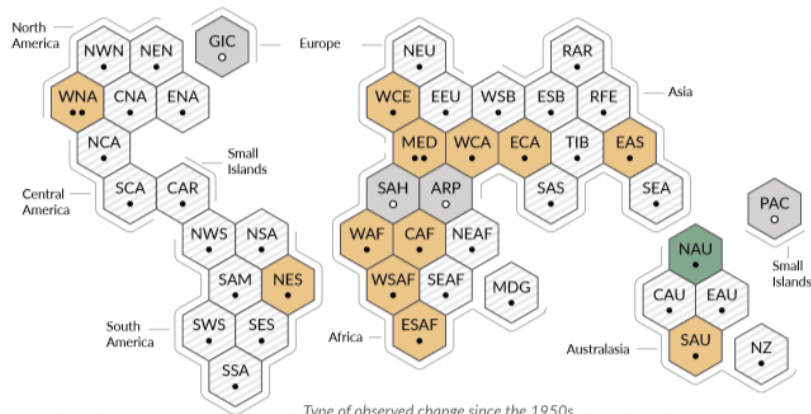
Confidence in human contribution  
to the observed change

●● High

●● Medium

● Low due to limited agreement

○ Low due to limited evidence



Type of observed change since the 1950s

IPCC AR6 fasst die attributierbaren Änderungen per Kategorie nach Region zusammen.

## ATTRIBUTION VON EXTREMWETTER (DÜRRE)



Home > Drought > High temperatures exacerbated by climate change made 2022 Northern Hemisphere droughts more likely

### High temperatures exacerbated by climate change made 2022 Northern Hemisphere droughts more likely

05 October, 2022

**DROUGHT**  
EUROPE, NORTH  
AMERICA, NORTHERN  
ASIA

Western Central Europe, North America, China, and other parts of the Northern Hemisphere faced water shortages, extreme heat, and soil moisture drought conditions throughout the summer of 2022

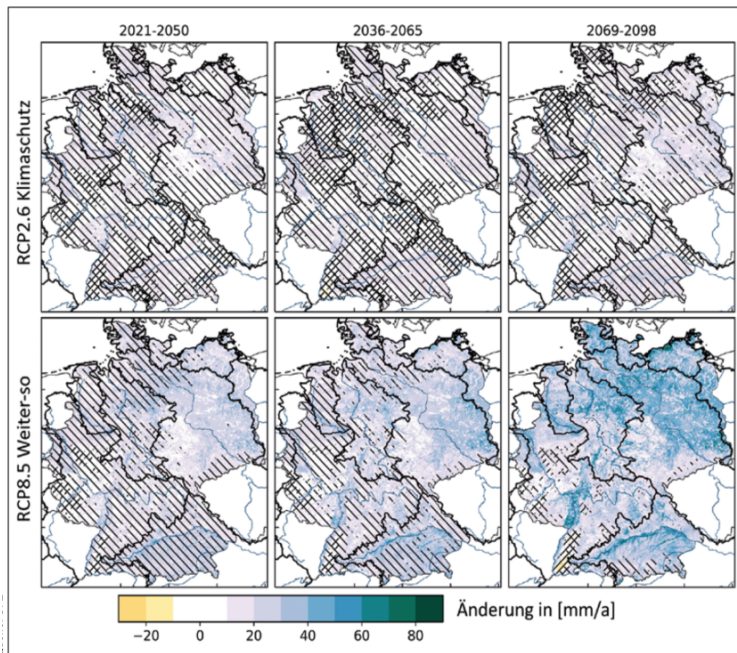
#### Full study

- Download the full study: High temperatures exacerbated by climate change made 2022 Northern Hemisphere droughts more likely, pdf (55 pages, 5.2 MB)

World Weather Attribution hat auch hier jüngst erste interessante Ergebnisse geliefert



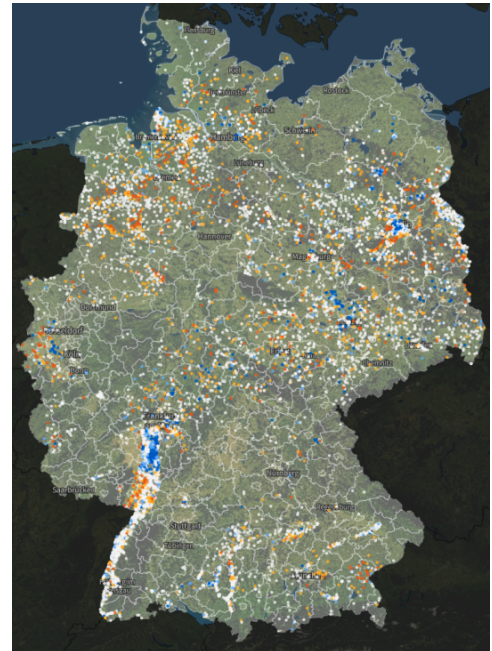
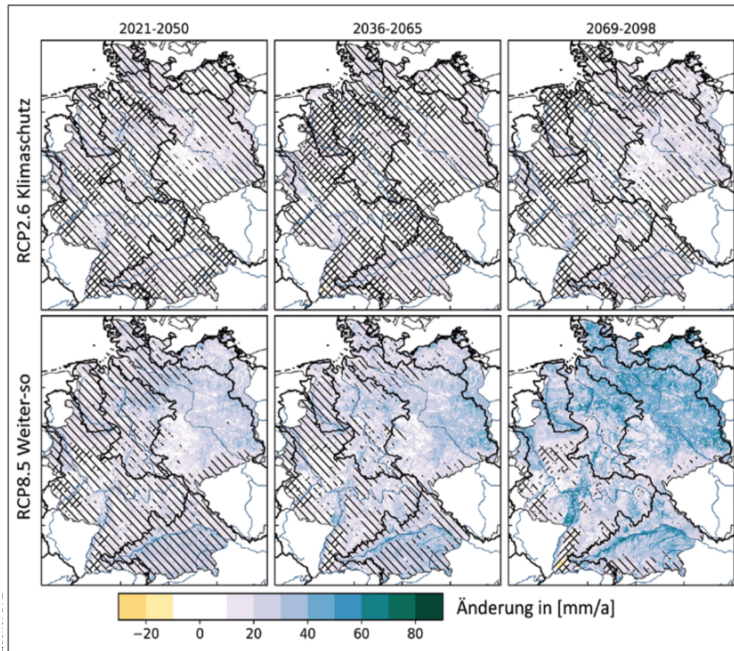
## ATTRIBUTION VON EXTREMWETTER (DÜRRE)



**Abb. 2:** Median der absoluten Änderung der jährlichen Grundwasserneubildung [mm/a] in drei Zukunftszeit-scheiben verglichen mit 1971 bis 2000. Oben ist das Klimaschutzszenario RCP2.6, unten das Weiter-So-Szenario RCP8.5 dargestellt. Die Schraffuren kennzeichnen die Robustheit. Unschraffierte Bereiche zeigen dabei robuste Änderungen, gekreuzte Schraffur bedeutet, dass keine Änderung im Vergleich zur Vergangenheit festgestellt wird.

Die Frage ist bisher, ob nur ein Ausreißer oder doch eher 'neues Normal' im Sommer?

## ATTRIBUTION VON EXTREMWETTER (DÜRRE)



Insbesondere im Kontext teils sinkender Grundwasserspiegel eine entscheidende Frage

- mittlerweile  $> 2^{\circ}\text{C}$  *Erwärmung in Deutschland* bei  $1.25^{\circ}\text{C}$  globaler Erwärmung
- *sämtliche Erwärmung* ist durch anthropogene GHG Emissionen verursacht
- *Hitzeextreme* sind oft um ein Mehrfaches wahrscheinlicher geworden (WWA)
- *Niederschlagsextreme* (insbesondere Trockenheit) etwas komplizierter
- dennoch sehr *gutes physikalisches Verständnis* der involvierten Prozesse
- insbesondere *sommerliche Dürre* bereits ein ernsthaftes Problem
- *Anpassung* sollte sich daher am worst case orientieren

Gewässer in  
Zeiten des Klimawandel

# Zusammenfassung



- mittlerweile  $> 2^{\circ}\text{C}$  *Erwärmung in Deutschland* bei  $1.25^{\circ}\text{C}$  globaler Erwärmung
- *sämtliche Erwärmung* ist durch anthropogene GHG Emissionen verursacht
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**VIELEN DANK!**



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[karsten.haustein@uni-leipzig.de](mailto:karsten.haustein@uni-leipzig.de)





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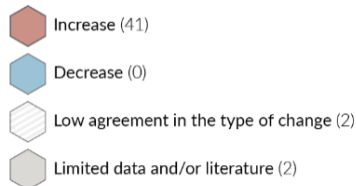
# SPARE SLIDES

## EXTREMWETTER (EXTREME HITZE)

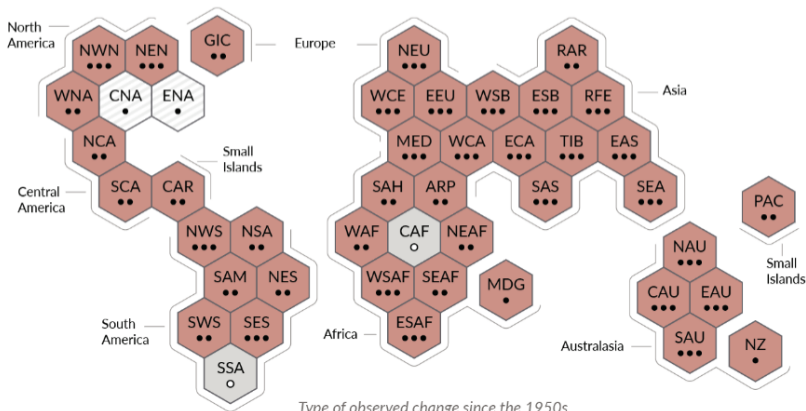
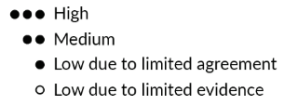
Climate change is already affecting every inhabited region across the globe, with human influence contributing to many observed changes in weather and climate extremes

(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



Confidence in human contribution to the observed change



IPCC AR6 fasst die attributierbaren Änderungen per Kategorie nach Region zusammen.

## ATTRIBUTION VON EXTREMWETTER (HITZEWELLE)



Home • Heatwave - Without human-caused climate change temperatures of 40°C in the UK would have been extremely unlikely

Without human-caused climate change temperatures of 40°C in the UK would have been extremely unlikely

28 JULY 2022

HEATWAVE  
EUROPE

On Monday and Tuesday, 18 & 19 July 2022, an exceptional heatwave affected large parts of the UK. It was the first time that temperatures of 40°C and above have been forecast in the UK.

On Tuesday, 40.3°C was reached in Coningsby in Lincolnshire, breaking the previous maximum temperature record of 38.7°C set in 2019. Local records have also been broken in 46 stations across the country. Minimum temperatures were also extremely high with 25.8°C provisionally being recorded in Kenley in Surrey, breaking the previous record from 1990 by 1.9°C.

The heatwave was very well forecast, and the UK Met Office issued severe weather warnings well ahead of the heat. A Level 4 UK Health Security Agency **Heat Health Alert** had been issued for Monday and Tuesday. This level of alert is used when a heatwave is so severe and/or prolonged that its effects extend outside the health and social care system. At this level, illness may occur among the fit and healthy, not just in high-risk groups.

Scientists from South Africa, Germany, France, Switzerland, New Zealand, Denmark, United States of America and the United Kingdom, collaborated to assess to what extent human-induced climate change altered the likelihood and intensity of the heatwave.

### Full study

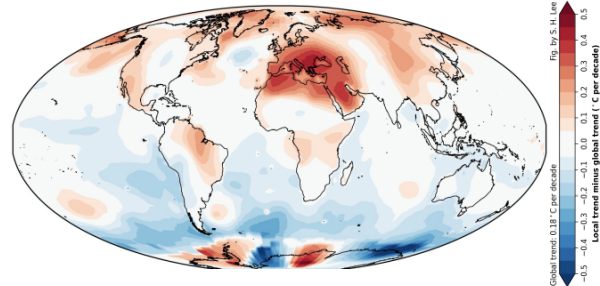
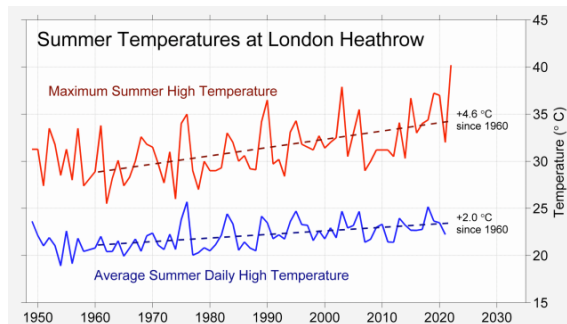
- Download the full study: Without human-caused climate change temperatures of 40°C in the UK would have been extremely unlikely (26 pages, 3.9 MB)

### Guide for journalists

- Reporting extreme weather and climate change: a guide for journalists – in a number of languages)

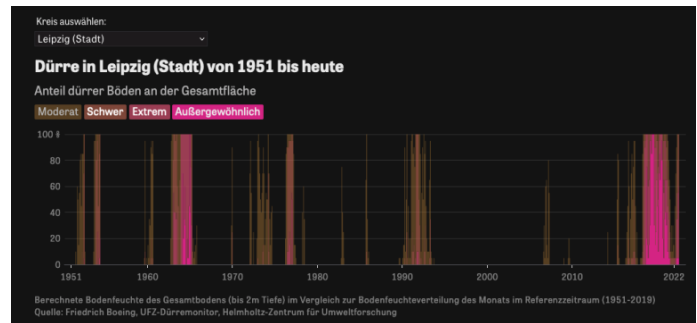
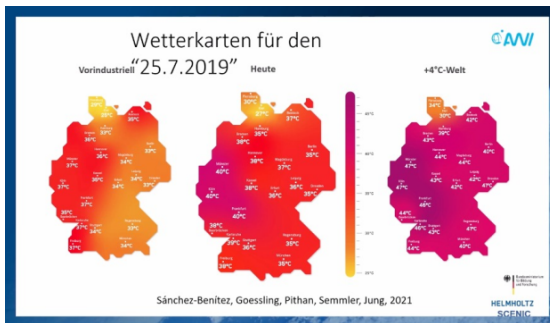
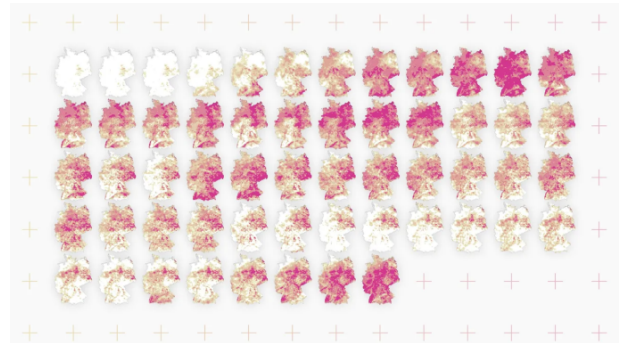
### You may also be interested in...

- Climate Change made devastating early heat in India and Pakistan 30 times more likely
- Western North American extreme heat virtually impossible without human-caused climate change
- Siberian heatwave of 2020 almost impossible without climate change
- Attribution of the Australian bushfire risk to anthropogenic climate change



Die gemessenen 40°C in UK wären ohne Klimawandel im Prinzip nicht möglich gewesen.

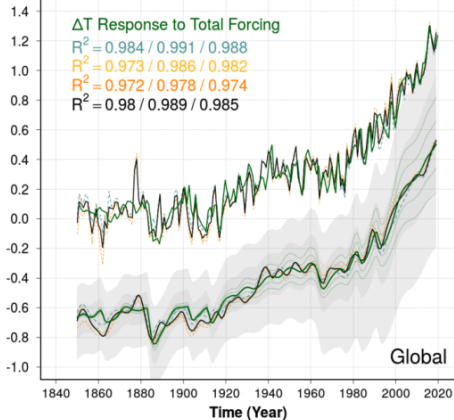
## ATTRIBUTION VON EXTREMWETTER (DÜRRE)



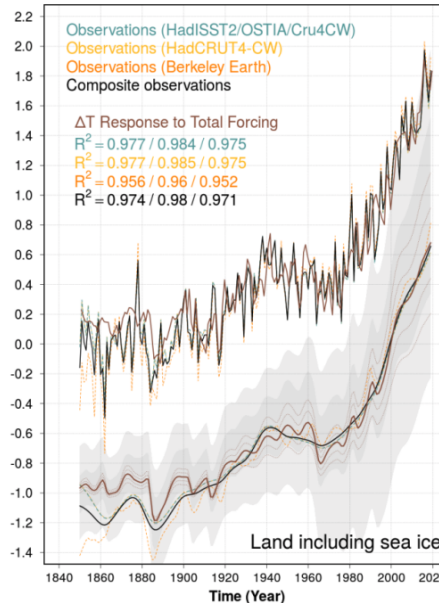
Nach der 2021er Flutkatastrophe war Dauerdürre erneut das Hauptthema in 2022 in DE.

## GLOBAL TEMPERATURE EVOLUTION SINCE 1850

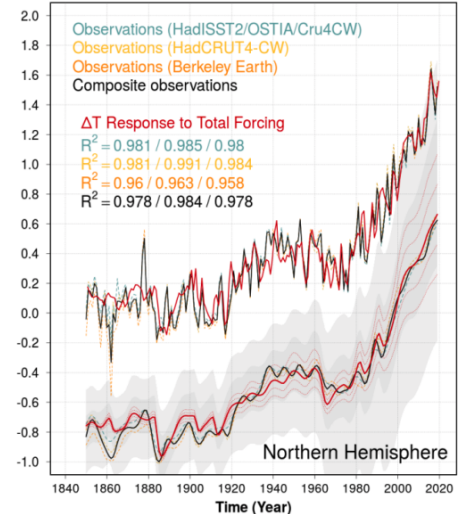
Impulse Response Model (1850-2019)



Impulse Response Model (1850-2019)



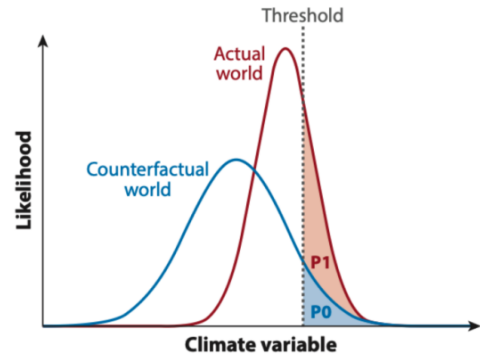
Impulse Response Model (1850-2019)



Dabei können wir sowohl Kurz- als auch Langfristschwankungen genau attributieren.



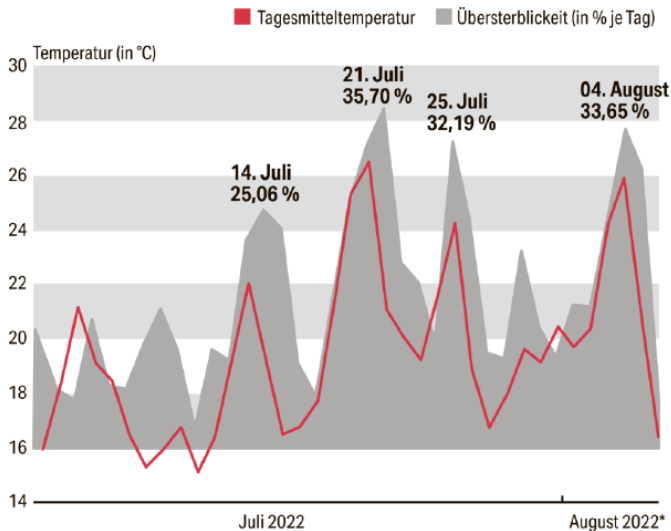
## EXTREME WEATHER EVENTS



Analogie des gezinkten Würfel (loaded dice) bzgl der statistischen Effekte von Extremen.

# EXTREME WEATHER EVENTS: HEAT

## Übersterblichkeit bei Hitzewellen



\* bis zum 06.08.2022.

Quelle: mtwetter, DWD, Statistisches Bundesamt, eigene Berechnungen



Homo + Drought + High temperatures exacerbated by climate change made 2022 Northern Hemisphere droughts more likely

### High temperatures exacerbated by climate change made 2022 Northern Hemisphere droughts more likely

05 October, 2022

DROUGHT  
EUROPE, NORTH  
AMERICA, NORTHERN  
ASIA

Western Central Europe, North America, China, and other parts of the Northern Hemisphere faced water shortages, extreme heat, and soil moisture drought conditions throughout the summer of 2022

Water shortages, extensive fires, high food prices and severe crop losses were among the most important impacts of one of the hottest European summers on record, with heat waves and exceptionally low rainfall across the Northern Hemisphere. These conditions led to very dry soils particularly in France, Germany and other central European countries (called West-Central Europe in the following; mainland China also experienced exceptionally high temperatures and dryness. These deficits in soil moisture led to poor harvests in the affected regions. Increased fire risk, and, in combination with already very high food prices, is expected to threaten food security across the world.

Scientists from Switzerland, India, the Netherlands, France, the United States of America and the United Kingdom, collaborated to assess to what extent human-induced climate change altered the likelihood and intensity of the low soil moisture, both at the surface and the root zones for most crops.

#### Full study

Download the full study: High temperatures exacerbated by climate change made 2022 Northern Hemisphere droughts more likely.pdf (55 pages, 5.2 MB)

#### Guide for journalists

Reporting extreme weather and climate change: a guide for journalists - in a number of languages)

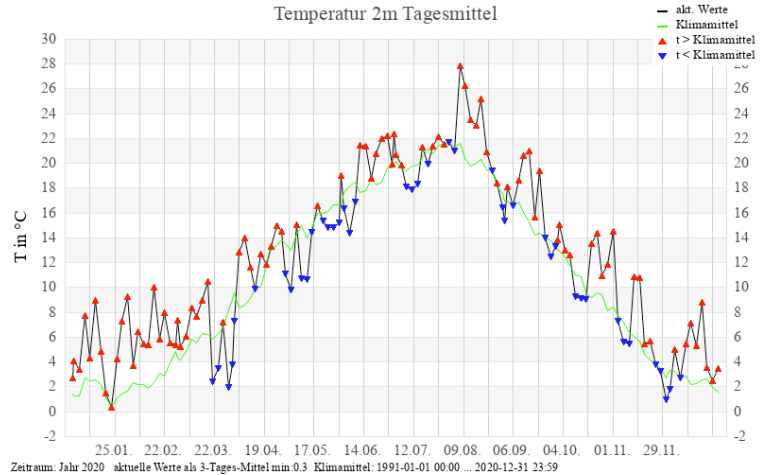
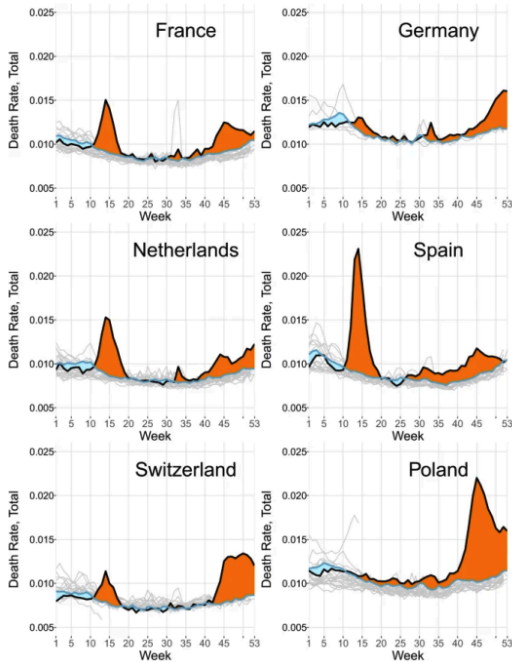
#### You may also be interested in...

- Factors other than climate change are the main drivers of recent food insecurity in Southern Madagascar
- Attribution of the Australian bushfire risk to anthropogenic climate change
- Likelihood of Cape Town water crisis tripled by climate change
- Rapid analysis of drought in Somalia, 2016

\* taz grafik: infotext-berlin.de/A.E.

Und das Ganze hat sich in 2022 episodisch wiederholt! Attribution ebenfalls verfügbar!

## EXTREME WEATHER EVENTS: HEAT



Nicht so eindrücklich wie Überschwemmungen, aber mit deutlich mehr Todesopfern.