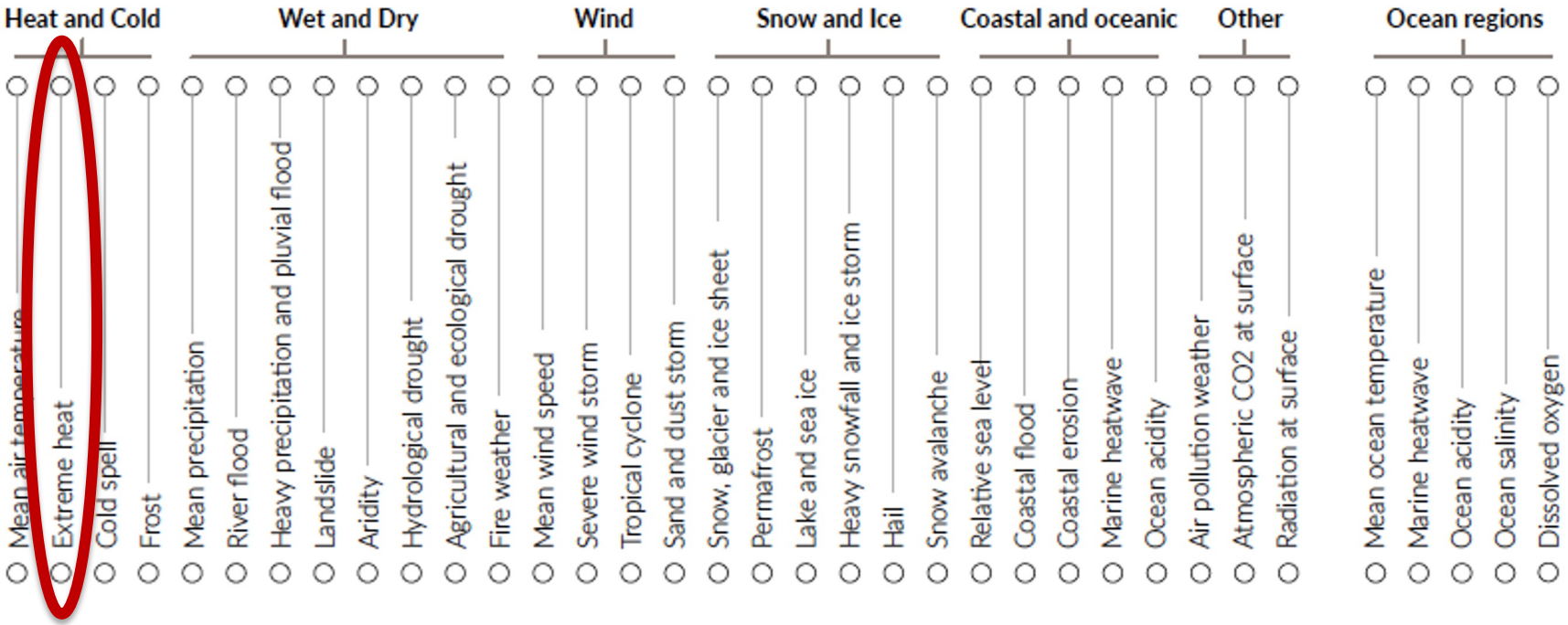
Robert Vautard

08/06/2023

Heat – A single CID for many many consequences



Le lien entre les facteurs climatiques d'impact et les secteurs

Sector	Asset	Climatic Impact-driver: Heat and Cold				Wet and Dry								Wind				Snow and Ice						Coastal			Open Ocean					Other		
		Mean warming	Extreme heat	Cold spell	Frost	Mean precipitation	River flood	Heavy precipitation and pluvial flood	Landslide	Aridity	Hydrological drought	Agricultural and ecological drought	Fire weather	Mean wind speed	Severe wind storm	Tropical cyclone	Sand and dust storm	Snow, glacier and ice sheet	Permafrost	Lake, river and sea ice	Heavy snowfall and ice storm	Hail	Snow avalanche	Relative sea level	Coastal flood	Coastal erosion	Mean ocean temperature	Marine heatwave	Ocean acidity	Ocean salinity	Dissolved oxygen	Air pollution weather	Atmospheric CO_2 at surface	Radiation at surface
Food, Fibre and Other Ecosystem Products (WGII Chapter 5)	Crop systems																																
	Livestock and pasture systems																																
	Forestry systems																																
	Fisheries and aquaculture systems																																
Cities, Settlements and Key Infrastructure (WGII Chapter 6)	Cities																																
	Land and water transportation																																
	Energy infrastructure																																
	Built environment																																
Health, Well-being and Communities (WGII Chapter 7)	Labour productivity																																
	Morbidity																																
	Mortality																																
	Recreation and tourism[a]																																
Poverty, Livelihoods and Sustainable Development (WGII Chapter 8)	Housing stock[b]																																
	Farmland[b]																																
	Livestock mortality[b]																																
	Indigenous traditions																																

[a] The Recreation and tourism asset category includes outdoor exercise and the tourism industry (including ecosystem services) assessed in many WGII chapters.

[b] This asset category is distinguished by the threat of a full loss of key investments and living environments rather than a recoverable damage or loss of productivity or profit.

None/low confidence | Low/moderate | High

Impacts and risk relevance

Climate Change Information for Regional Impact and for Risk Assessment

Climate change already affecting all inhabited regions on earth, in particular with heat extremes

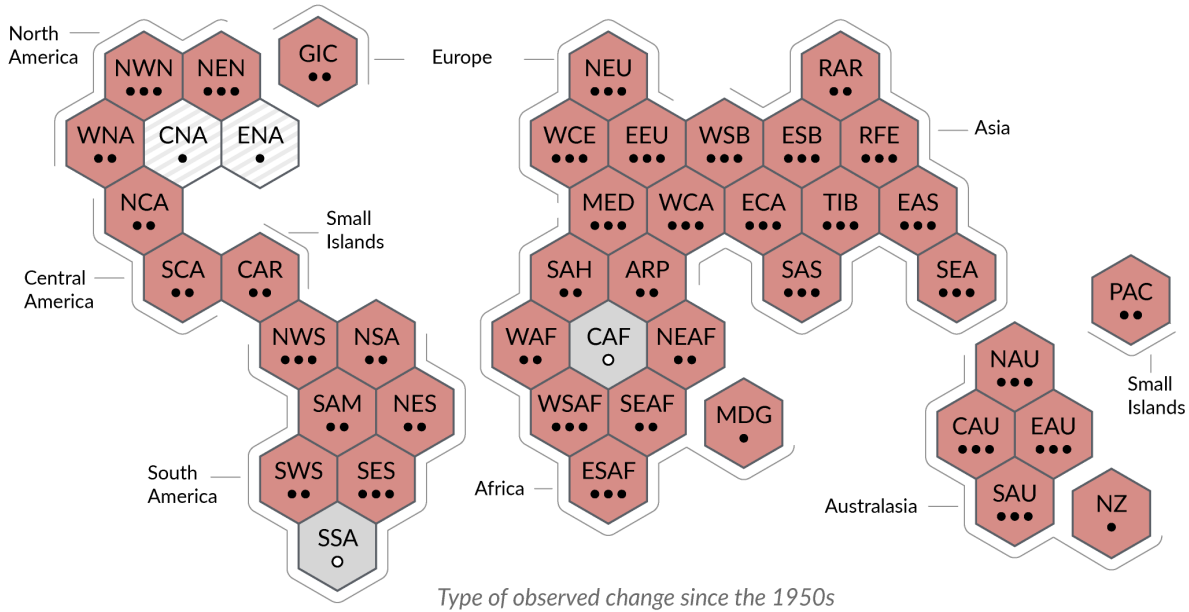
a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions

Type of observed change
in hot extremes

- Increase (41)
- Decrease (0)
- Low agreement in the type of change (2)
- Limited data and/or literature (2)

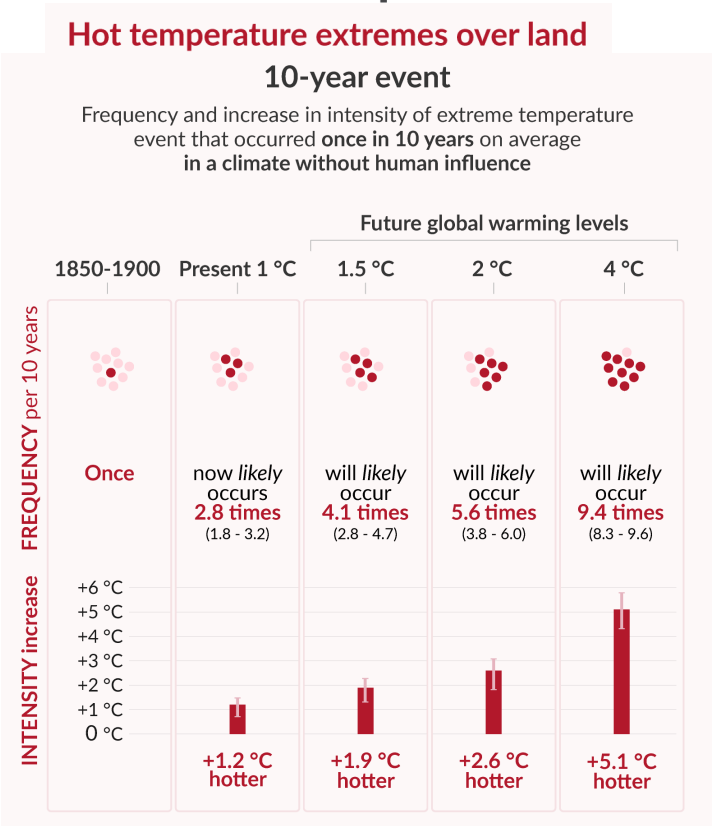
Confidence in human contribution
to the observed change

- ●●● High
- ●● Medium
- ● Low due to limited agreement
- ○ Low due to limited evidence

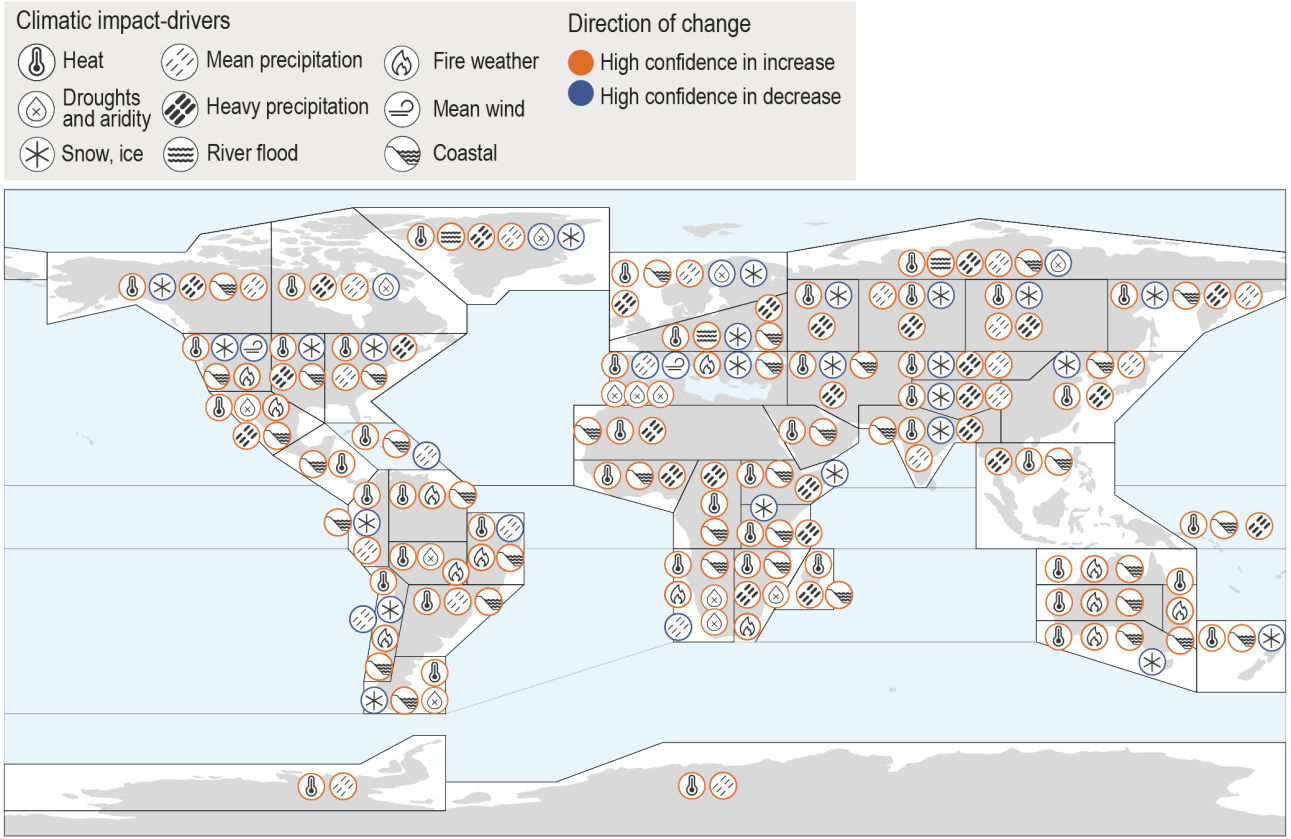


Type of observed change since the 1950s

Hot extremes become more frequent and intense with global warming



High confidence of ID change in 2050/2°C – Heat everywhere



Indices

- Tmax (dry heat, agriculture, health)
- Tmean (better for health indices)
- Including humidity, wind, radiation
  - Apparent temperature
  - Wet bulb T wet bulb globe
  - HUMIDEX
  - Heat Index
  - …

Heat Index

Relative Humidity %	Air temperature °C										
	21	24	27	29	32	35	38	41	43	46	49
0	18	21	23	26	28	31	33	35	37	39	42
10	18	21	24	27	29	32	35	38	41	44	47
20	19	22	25	28	31	34	37	41	44	49	54
30	19	23	26	29	32	36	40	45	51	57	64
40	20	23	26	30	34	38	43	51	58	66	
50	21	24	27	31	36	42	49	57	66		
60	21	24	28	32	38	46	56	65			
70	21	25	29	34	41	51	62				
80	22	26	30	36	45	58					
90	22	26	31	39	50						
100	22	27	33	42							

Serious risk to health - heatstroke imminent

Prolonged exposure and activity could lead to heatstroke

Prolonged exposure and activity may lead to fatigue

Annex VI (typo warning)

$$\mathrm{HI} = \begin{cases} \mathrm{HI}_1 + \mathrm{HI}_{A1}, & \text{if RH} < 13\,\% \text{ and } 80\,^\circ\mathrm{F} < T_F < 112\,^\circ\mathrm{F} \\ \mathrm{HI}_1 + \mathrm{HI}_{A2}, & \text{if RH} > 85\,\% \text{ and } 80\,^\circ\mathrm{F} < T_F < 87\,^\circ\mathrm{F} \\ \mathrm{HI}_1, & \text{otherwise} \end{cases}$$

with:

$$\mathrm{HI}_1 = c_0 + c_1 \cdot T_F + c_2 \cdot \mathrm{RH} + c_3 \cdot T_F \cdot \mathrm{RH} + c_4 \cdot T_F^2 + c_5 \cdot \mathrm{RH}^2 + c_6 \cdot T_F^2 \cdot \mathrm{RH} + c_7 \cdot T_F \cdot \mathrm{RH}^2 + c_8 \cdot T_F^2 \cdot \mathrm{RH}^2$$

$$\mathrm{HI}_{A1} = (13 - \mathrm{RH})/4 \cdot \sqrt{(17 - |T_F - 95\,^\circ\mathrm{F}|)/17}$$

$$\mathrm{HI}_{A2} = (\mathrm{RH} - 85)/10 \cdot (87\,^\circ\mathrm{F} - T_F)/5$$

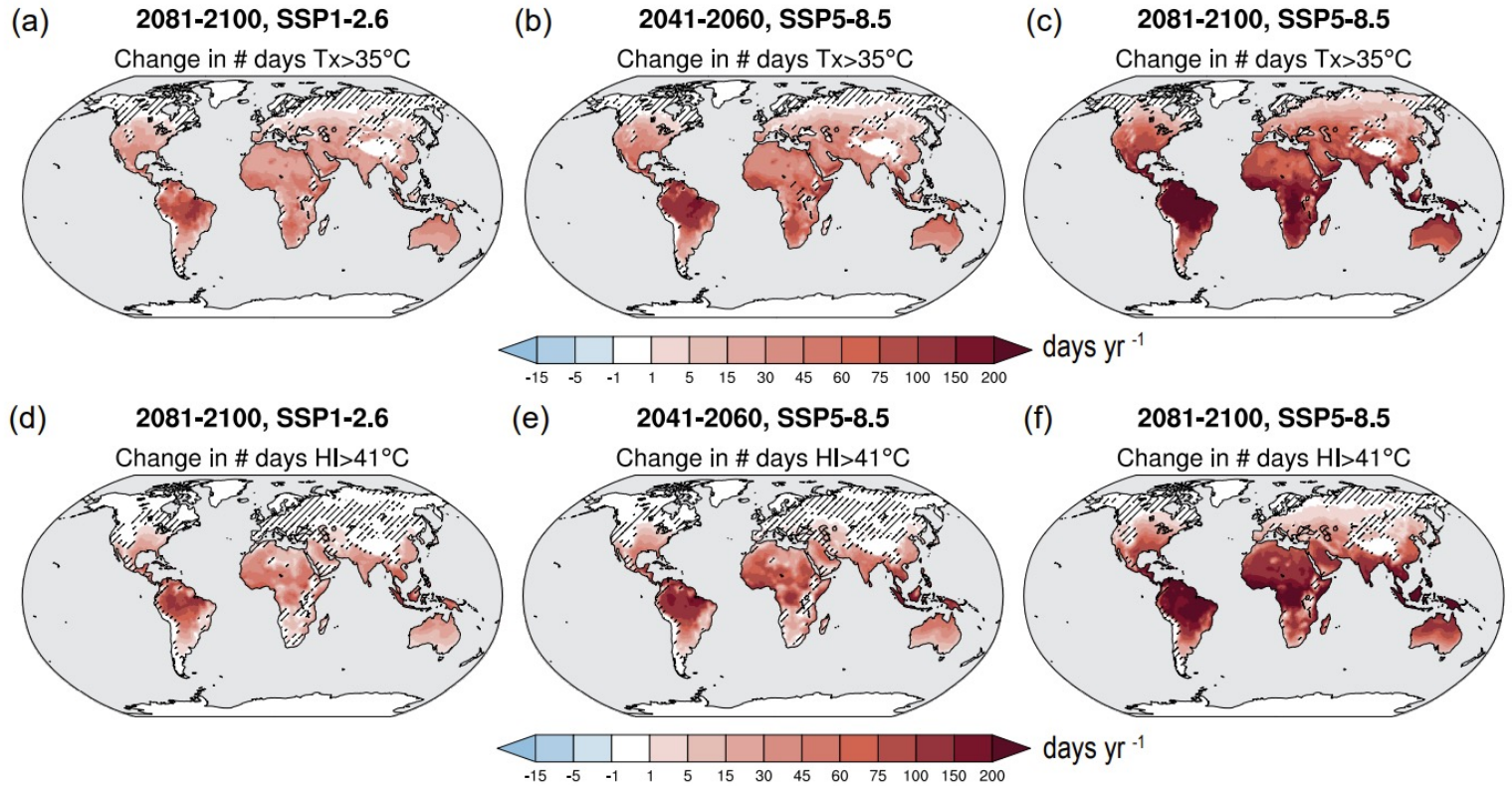
$c_0 = -42.379\,^\circ\mathrm{F}$, $c_1 = 2.04901523$, $c_2 = 10.14333127\,^\circ\mathrm{F}$,
$c_3 = -0.22475541$, $c_4 = -0.00683783\,^\circ\mathrm{F}^{-1}$, $c_5 = -0.05481717\,^\circ\mathrm{F}$,
$c_6 = 0.00122874\,^\circ\mathrm{F}^{-1}$, $c_7 = 0.00085282$, $c_8 = -0.00000199\,^\circ\mathrm{F}^{-1}$

If HI < 80 °F, the following equation is used:

$$\mathrm{HI} = 0.5 \cdot (T_F + 61\,^\circ\mathrm{F} + 1.2 \cdot (T_F - 68\,^\circ\mathrm{F}) + 0.094\,^\circ\mathrm{F} \cdot \mathrm{RH})$$

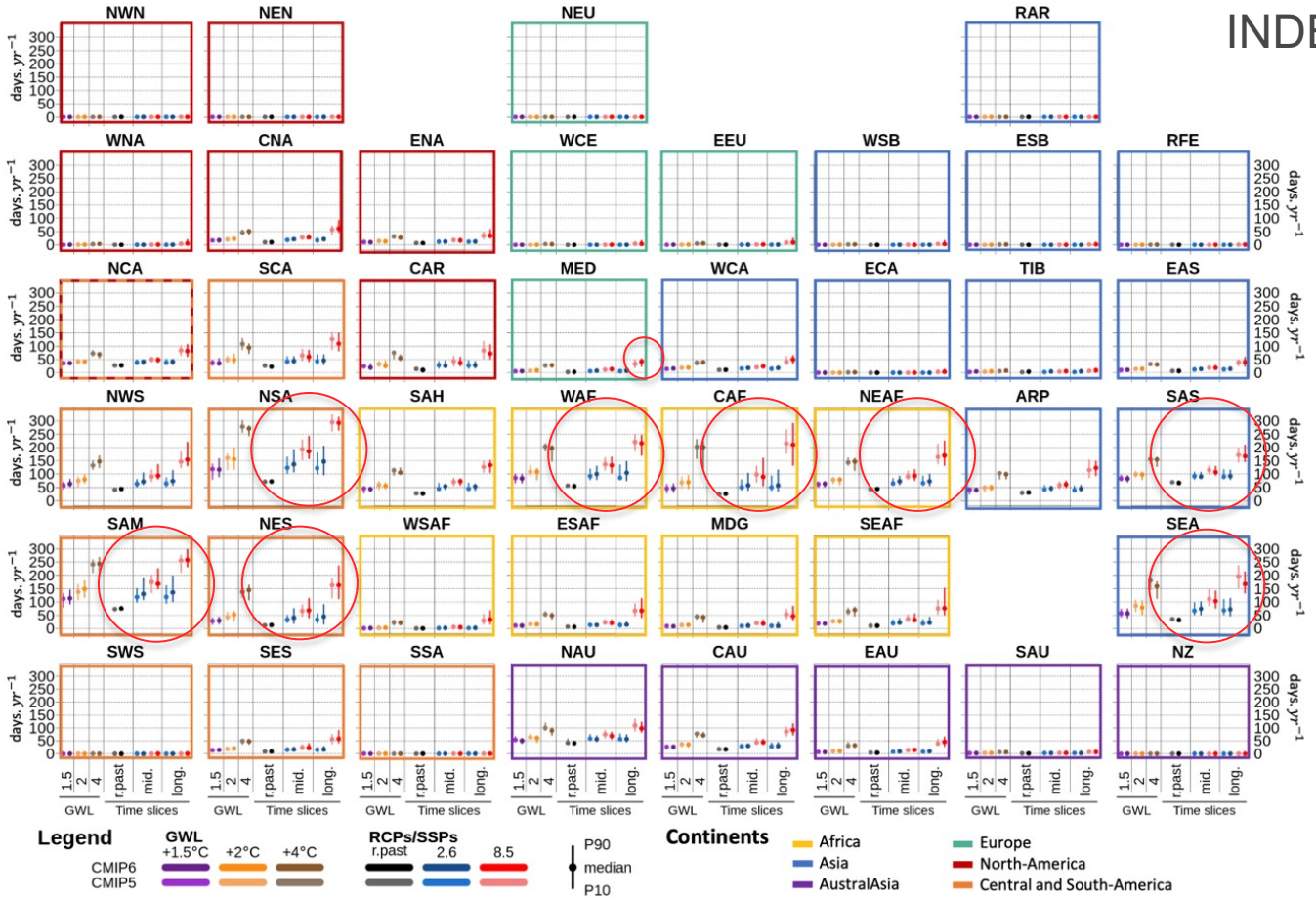
The calculated HI is converted into °C.

Dry and humid heat rising dangerously in many tropical areas



Humid heat: change in #days/year with NOAA index HI>41° (dangerous conditions)

INDEX HI>41°


NWN
NEN
NEU
RAR
WNA
CNA
ENA
WCE
EEU
WSB
ESB
RFE
NCA
SCA
CAR
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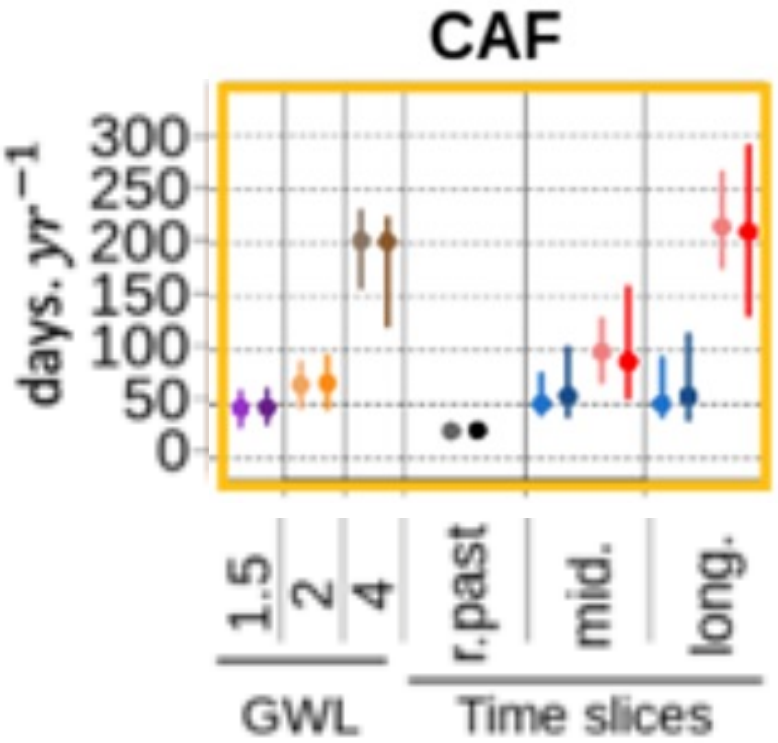
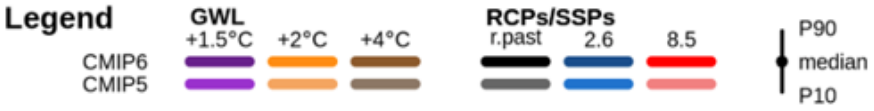
WCA
ECA
TIB
EAS
NWS
NSA
SAH
WAF
CAF
NEAF
ARP
SAS
SAM
NES
WSAF
ESAF
MDG
SEAF
SEA
SWS
SES
SSA
NAU
CAU
EAU
SAU
NZ
days, yr⁻¹
0
50
100
150
200
250
300
1.5
2
4
r.past
mid.
long.
GWL
Time slices
Legend
GWL
+1.5°C
+2°C
+4°C
CMIP6
CMIP5
RCPs/SSPs
r.past
2.6
8.5
P90
median
P10
Continents
Africa
Asia
AustralAsia
Europe
North-America
Central and South-America

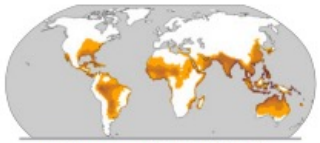
#days/year with
INDEX HI>41°
For Central Africa



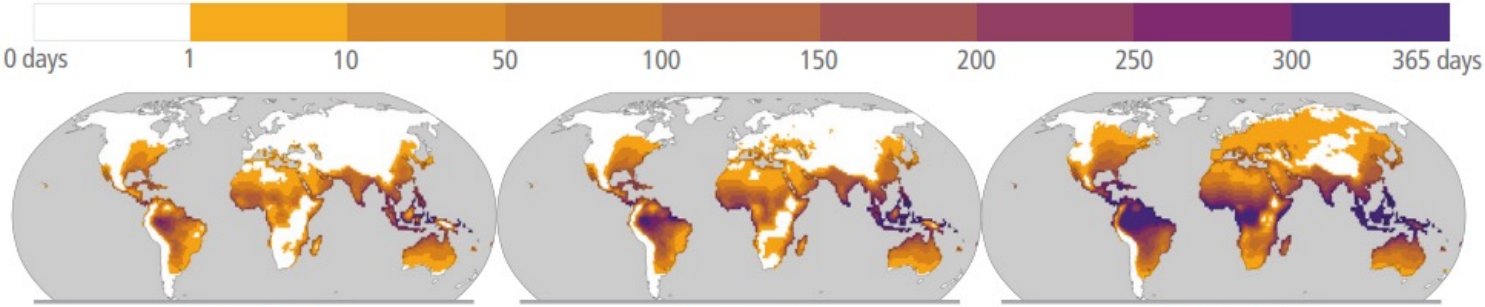


Dry and humid heat rising dangerously in many tropical areas

b) Heat-humidity risks to human health



Historical 1991–2005



Days per year where combined temperature and humidity conditions pose a risk of mortality to individuals[3]

[3]Projected regional impacts utilize a global threshold beyond which daily mean surface air temperature and relative humidity may induce hyperthermia that poses a risk of mortality. The duration and intensity of heatwaves are not presented here. Heat-related health outcomes vary by location and are highly moderated by socio-economic, occupational and other non-climatic determinants of individual health and socio-economic vulnerability. The threshold used in these maps is based on a single study that synthesized data from 783 cases to determine the relationship between heat-humidity conditions and mortality drawn largely from observations in temperate climates.

Hot extremes do not come alone, and health is at risk

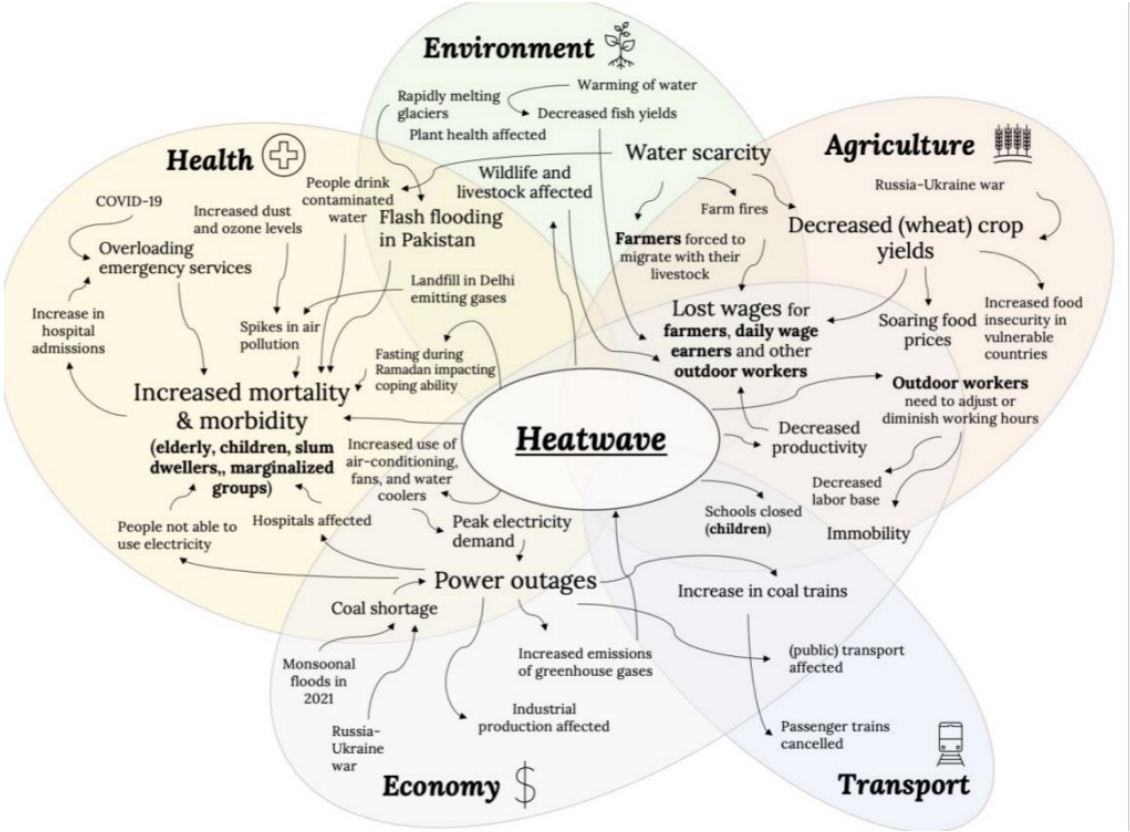


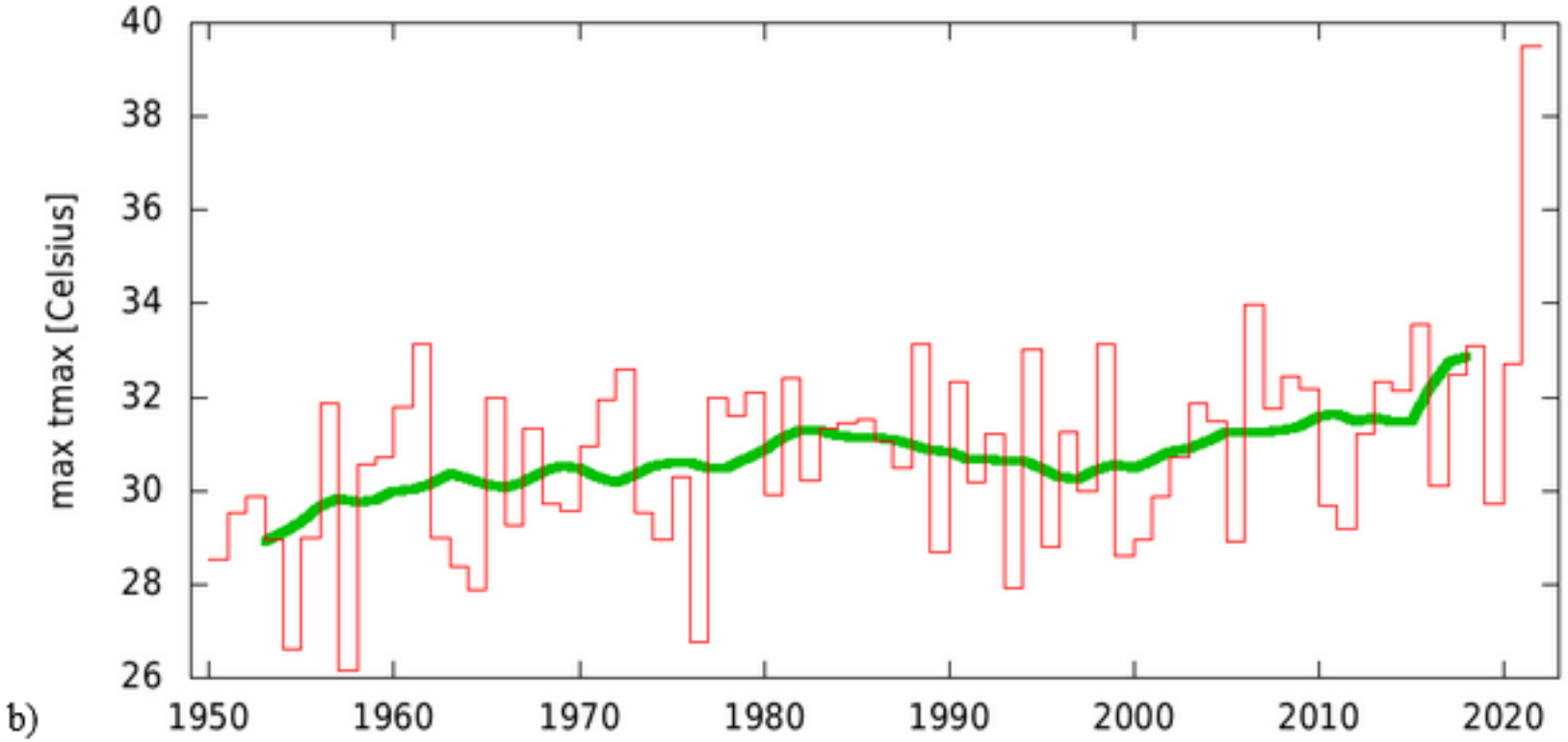
***Fig 9**: Conceptual map of impact pathways during the heatwave*

Zachariah et al., 2022

https://www.worldweatherattribution.org

Since IPCC 2021

More science and results, more events


max tmax [Celsius]
40
38
36
34
32
30
28
26
1950
1960
1970
1980
1990
2000
2010
2020

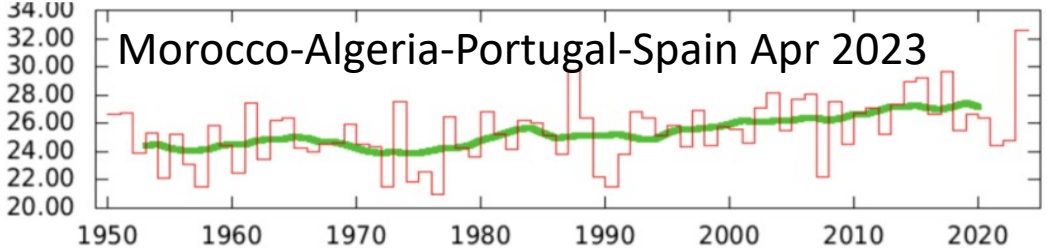
b)

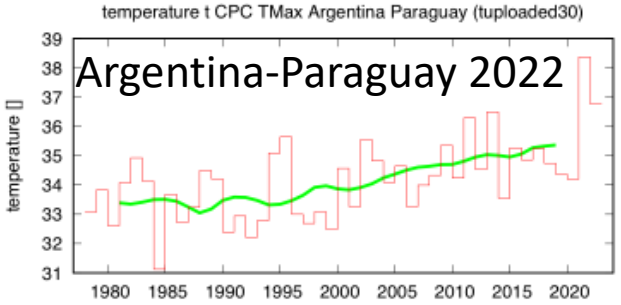
Record-shattering extremes

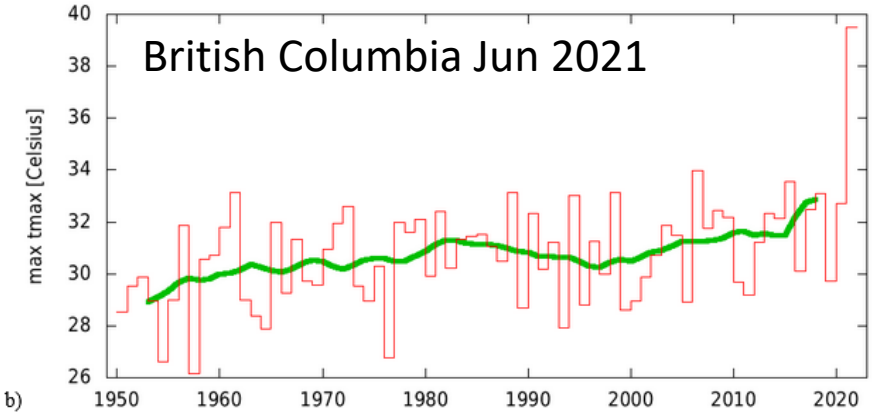
calling for better understanding causes and calling adaptation to unseen events

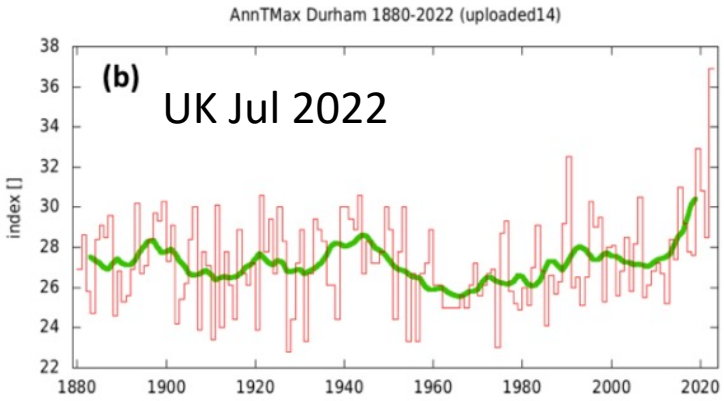
Particularly in cities.

A collection of recent RS heat Extremes



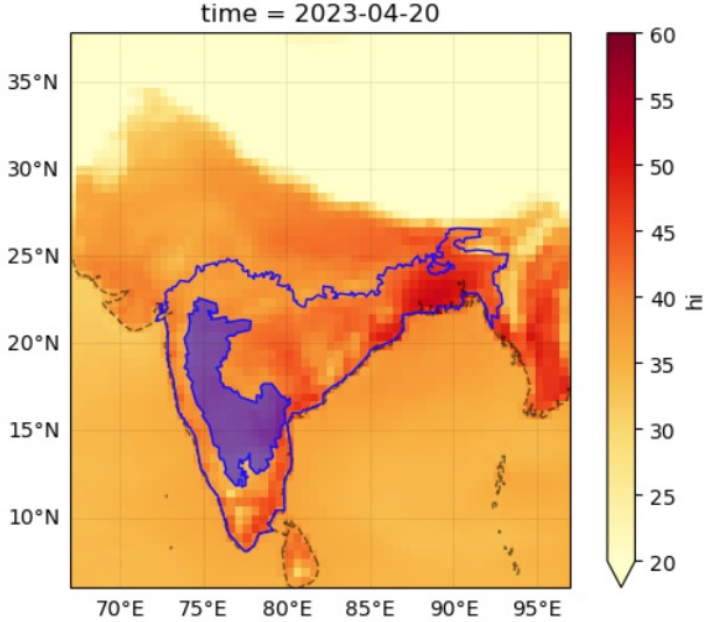




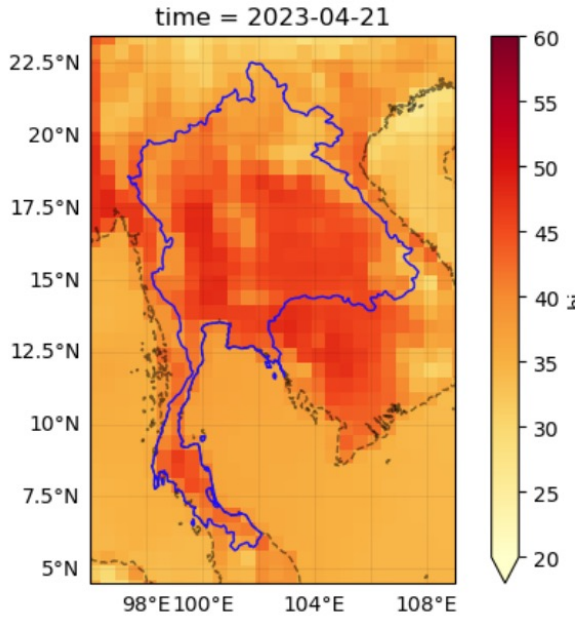


Attribution of humid heat extremes

Heat in South-East Asia in April 2023



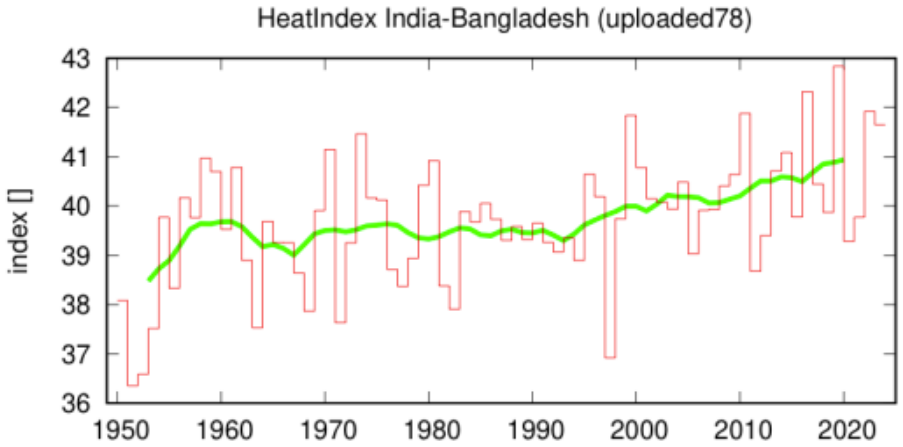
Heat Index in ℃ showing 4-day average daily maximum during 17-20 April, 2023 for the India-Bangladesh region (highlighted in blue).



4-day average daily maximum Heat Index during 18-21 April, 2023, over the Thailand-Lao PDR region (highlighted in blue).

Zachariah et al., 2023 https://www.worldweatherattribution.org

Heat in South-East Asia in April 2023



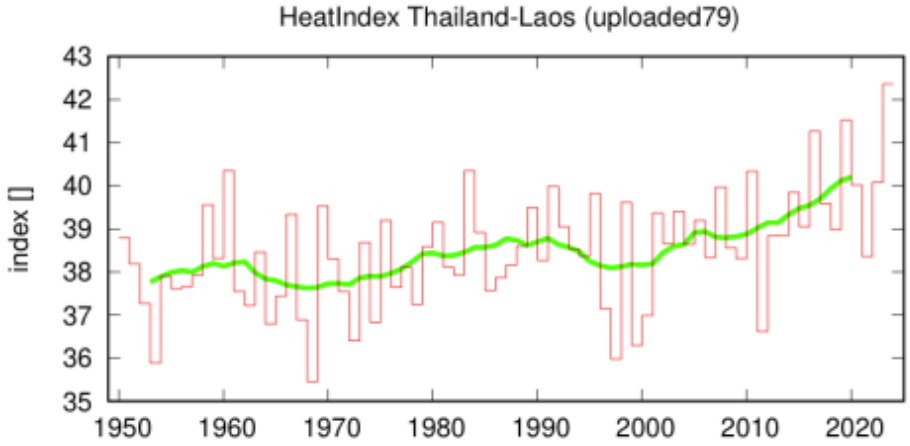


Figure 6: *Time series of April HIx4d over IB region in ERA5, along with the ten-year running mean (green line).*

Conclusion of this attribution study

- Humid heat increases strongly in South East Asia, due to climate change drivers, could hardly have occurred without CC
- Future ~+1°C in South Asia for a +2°C global warming, making it frequent
- Probability of exceeding very dangerous thresholds increasing
- "…heat-related fatalities have decreased in regions where heat action plans have been in place, e.g. in the city of Ahmedabad and the region of Odisha in India. However, these solutions are often out of reach for the most vulnerable people, highlighting the need to improve vulnerability assessments and design interventions that account for group-specific needs".

Thanks for your attention

Challenges for IPCC Cycle #7?

- Relief time
- Epidemics, interactions with biodiversity
- Dynamics and circulation
- Other forcings and regional assessments of their effects
- Landuse/land cover effects, also on LU management
- Waterborne diseases
- Air pollution including wildfires
- Assessing the effects of heat plans
- Effects on children
- Building storylines tipping points
- Impacts on indigenous populations
- Careful communication on high extremes, anxiety issues
- Health mechanistic models
- Cascading risks
- Habitability should be scientfically assessed
- Early warning systems
- Increasing research on socio-economic inequalities
- Effect of shifting dirunal cycle
- Pressure on health insurance
- Freak events

Challenges for IPCC Cycle #7? – chat comments

- this is more of a comment, in the recent Lancet report for South America, they address the problem of air pollution caused by fires and the mortality by heat waves
- Monday ADIAHA to Everyone 2:47 PM
- I think air pollution with tendencies of latent heat build up in the atmosphere coupled with global circulation of heat has moved to worsen the situation of the heating earth
- Cristy Gallano to Everyone 3:02 PM
- thank you for the presentation.
- Nadia Itzel Castillo Pérez to Everyone 3:04 PM
- green belt arround the city
- Cristy Gallano to Everyone 3:04 PM
- will these projections affect the cost of life/non-life insurances? "risks are increasing with every degree of warming"
- Monday ADIAHA to Everyone 3:11 PM
- Thank you very for the Presentation.
- Nadia Itzel Castillo Pérez to Everyone 3:16 PM
- Monday u have the micro open
- VINCENT OTIENO to Everyone 3:21 PM
- In north eastern part of the greater horn of Africa, dry and hot condition we have witnessed mortality due to heat stress. The area is not humid at all. The worse of it is that recorded mortalies are higher when it rains after long drought which has been attributed to drastic drop in temperatures … what could be causing this .. is the temperature changes alone or there could be some other factors ?
- Emre Salkım to Everyone 3:31 PM
- Political conflicts due to hydropolitics etc.
- As a result lethargy in data transparency
- Monday ADIAHA to Everyone 3:32 PM
- I think looking at biodiversity can also play a role in it.
- VINCENT OTIENO to Everyone 3:38 PM
- climate variability and extremes and conflict. discussed WGII ch16
- the confidence waqs medium whether climate and extremes can be linked to risks of conflict or there are some other socio-economic factorsthis is more of a comment, in the recent Lancet report for South America, they address the problem of air pollution caused by fires and the mortality by heat waves
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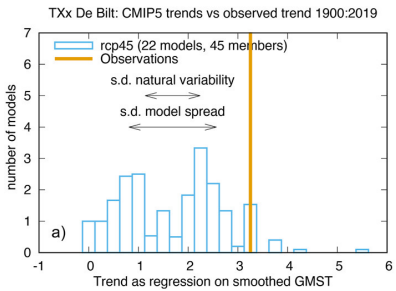
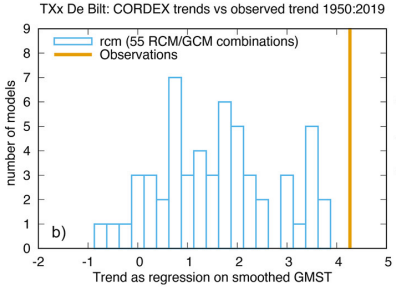
- As a result lethargy in data transparency

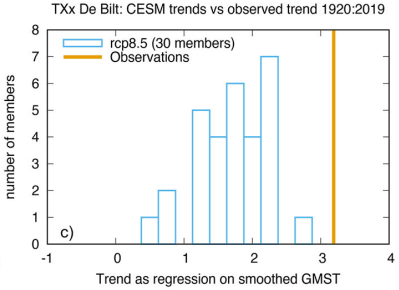
Understand regional model/obs mismatches and the role of change in dynamics

Attributing and Projecting Heatwaves Is Hard: We Can Do Better

Geert Jan Van Oldenborgh, Michael F. Wehner, Robert Vautard, Friederike E. L. Otto, Sonia I. Seneviratne, Peter A. Stott, Gabriele C. Hegerl, Sjoukje Y. Philip, Sarah F. Kew







Atmospheric circulation compounds anthropogenic warming and impacts of climate extremes in Europe

Davide Faranda, Gabriele Messori, Aglae Jezequel, +1, and Pascal Yiou Authors Info & Affiliations

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March 21, 2023 | 120 (13) e2214525120 | https://doi.org/10.1073/pnas.2214525120