

Global warming and extreme heat waves

A3: Extreme events

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Overview

- Definitions of terms
- Effects of global mean temperature rise
- Consequences of heat waves
- Cases of deaths from heatwaves
- The 2003 European summer heatwave
- Discussion

Definition of terms



Global warming is a long-term rise in the average temperature of the Earth's climate system, caused mainly by emissions of GHGs from human activities



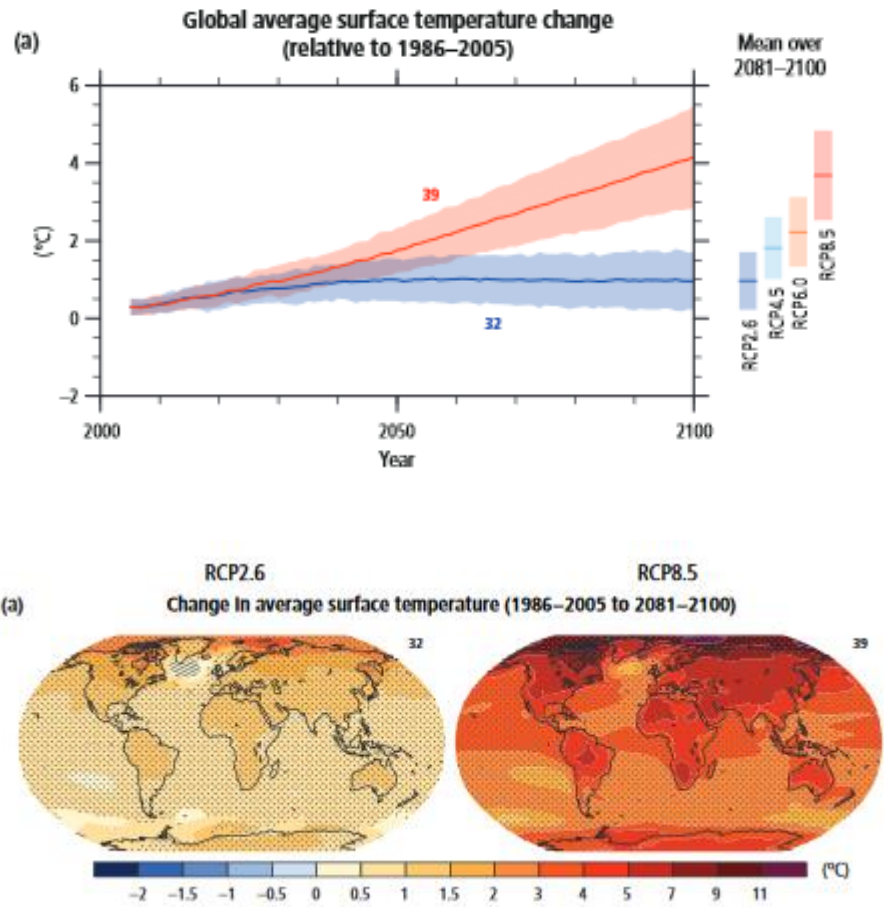
The WMO defines **a heat wave** as 5 or more consecutive days of prolonged heat in which the daily maximum temperature is higher than the average maximum temperature by 9°F (5°C)

Effects of global mean temperature rise

According to the IPCC AR5,

„it is virtually certain that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales as global mean surface temperature increases“

„there is medium confidence that the observed warming has increased heat-related human mortality and...“

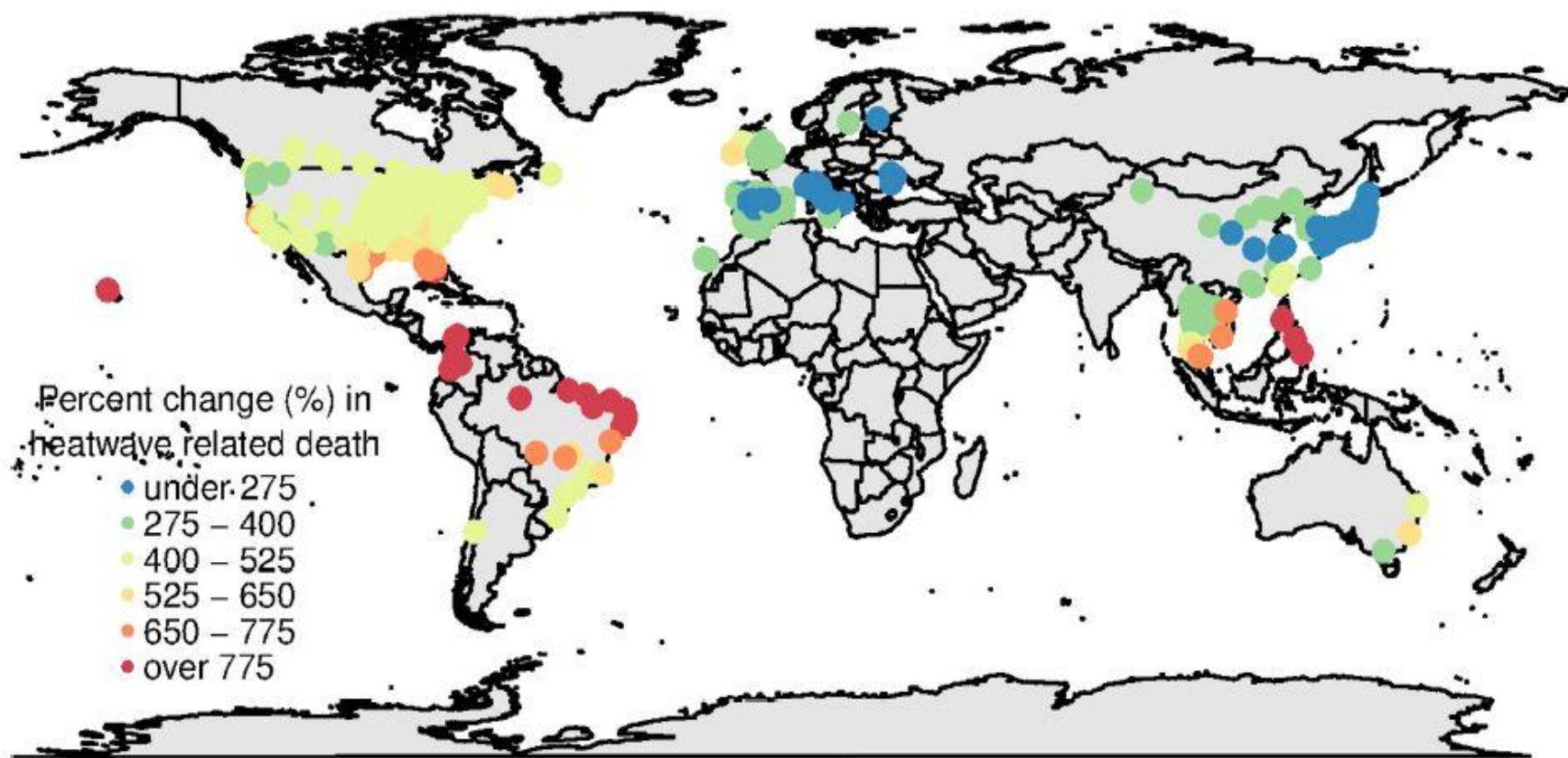


Health consequences of heatwaves

- can cause a significant impact on population health, including a rise in mortality & morbidity
- Heat exhaustion
- Heat stroke (or hyperthermia)
- Heat oedema
- Heat cramps
- Heat syncope
- Induce onset of diseases – cardiovascular, respiratory diseases and diabetes
- thermoplegia

Socio-economic consequences of heatwaves

- Increase in aggressive behaviour
- Crime
- More electricity demand
- Large financial losses due to power outages
- Ruptured waterlines
- Buckled roads
- Wildfires = heatwaves + drought
- Affects crop production and yield
- Death of animal populations



Locations of communities and mean percent change of **heatwave-related excess deaths** in 2031-2080 comparing to 1971-2020, under RCP 8.5 scenario and high-variant population scenario, with assumption of nonadaptation.



Cases of heat waves

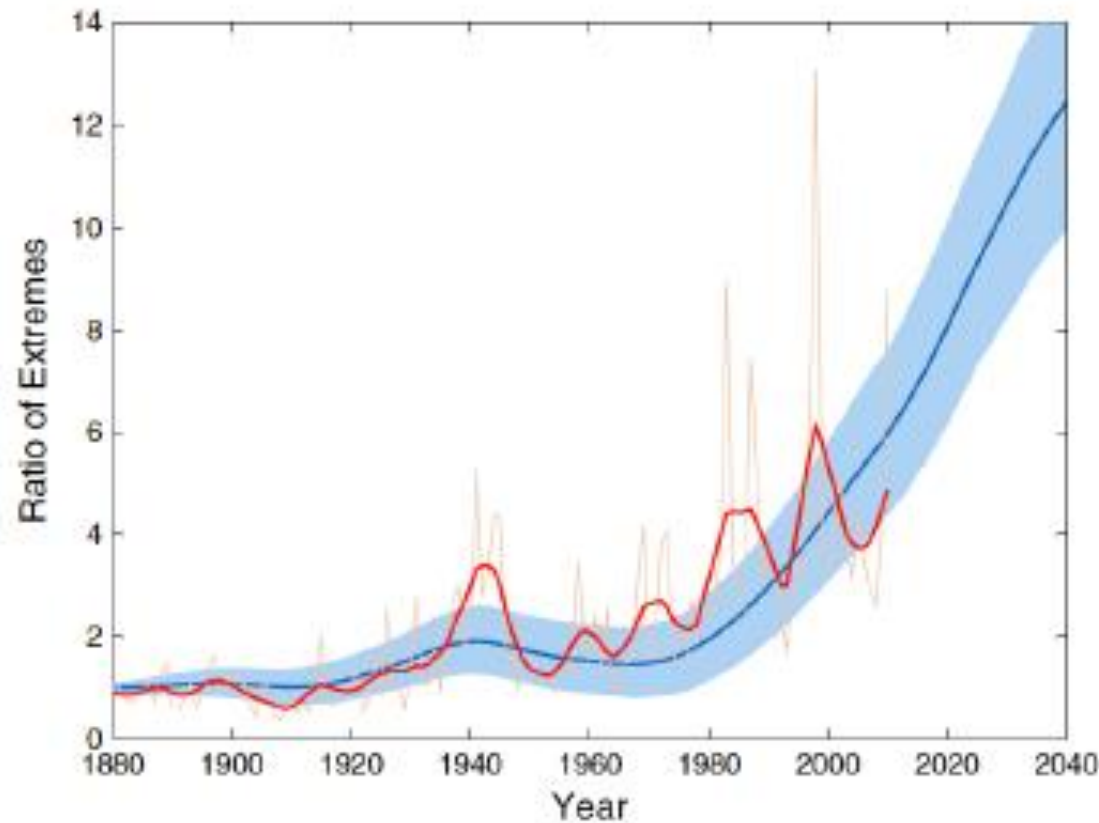
- **European heat wave of 2003:** (70,000 deaths)
- Greek heat wave of 2007
- Australian heat wave of 2009:
- Russian heat wave of 2010: (55,000 deaths)
- Texan heat wave of 2011
- US heat wave of 2012

➤ occurrence-probability of these events had increased due to greenhouse gas forcing.

FACTS

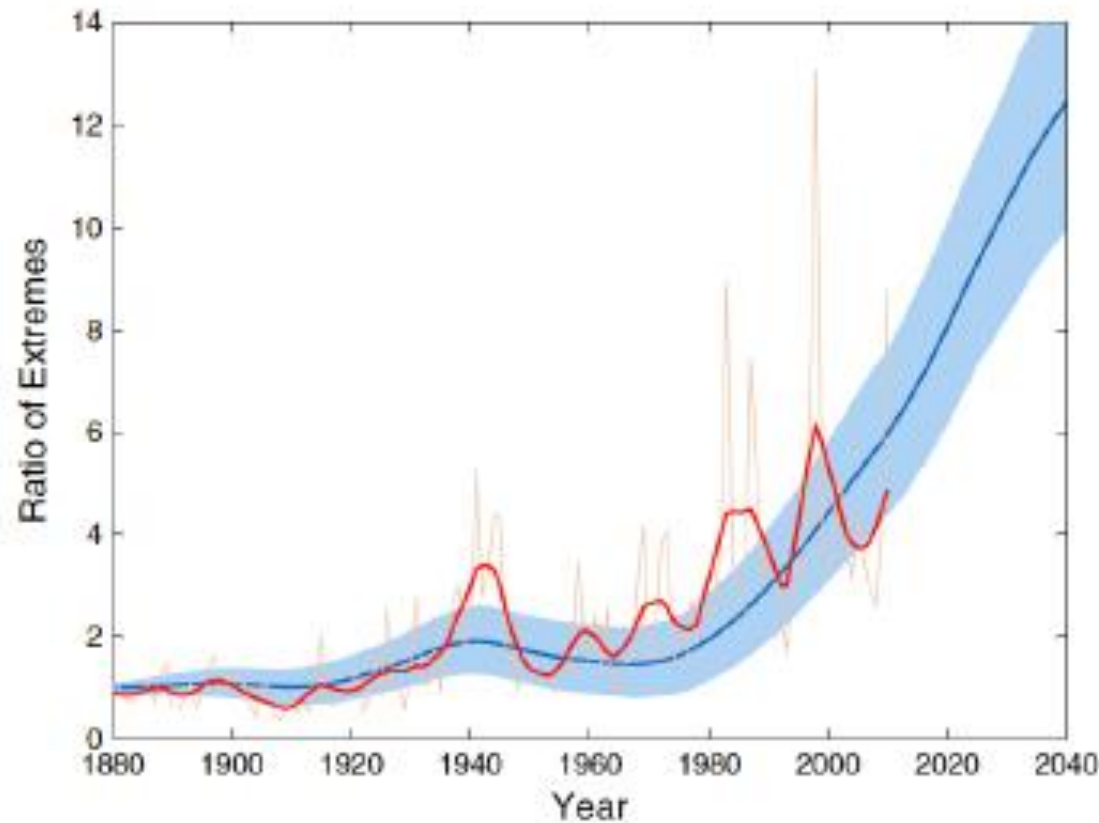
- Global warming is increasing the frequency, duration and intensity of heatwaves
- Record-breaking monthly temperature records are already occurring five times more often than they would in a non-warming world.
- There is an 80% chance that any monthly heat record today is due to global warming.

Global trends of heatwaves over time



Observed record ratio -- the increase in the number of **heat records** compared to those expected in a world without global warming -- for **monthly heat records** as it changes over time. This is compared with predictions from a **simple stochastic model** based only on the global mean temperature evolution.

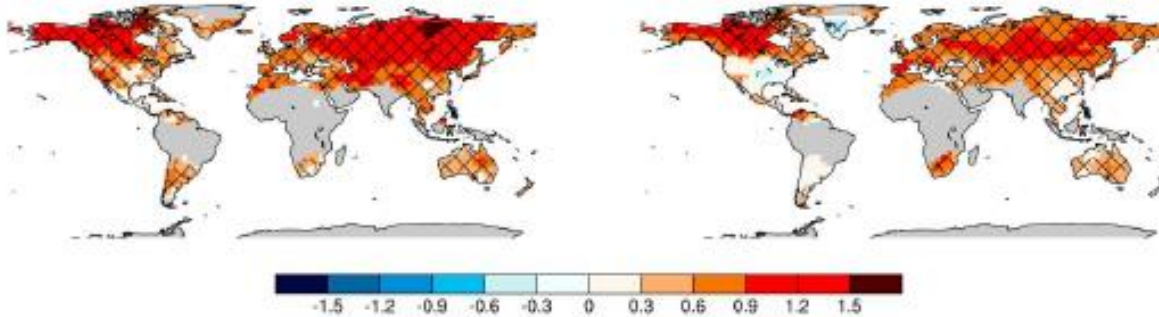
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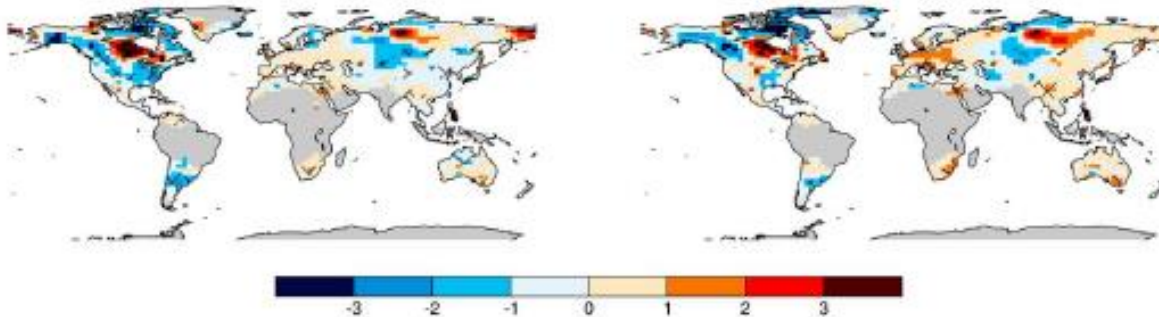
Under a moderate emission scenario (RCP 4.5), where emissions peak around 2040. Monthly heat records in 2040 will have become 12 times more likely to occur than in a non-warming world.

Changes in daily minimum and maximum temperature anomalies between two time periods (1951-1980, 1981-2010)

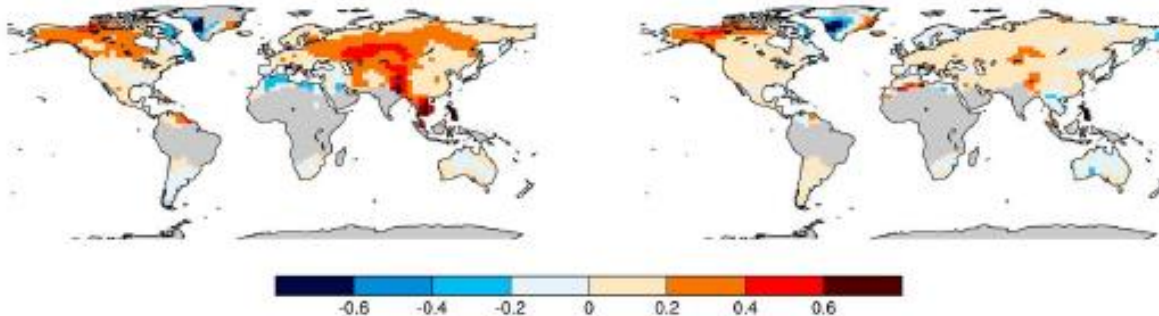
(a) Mean



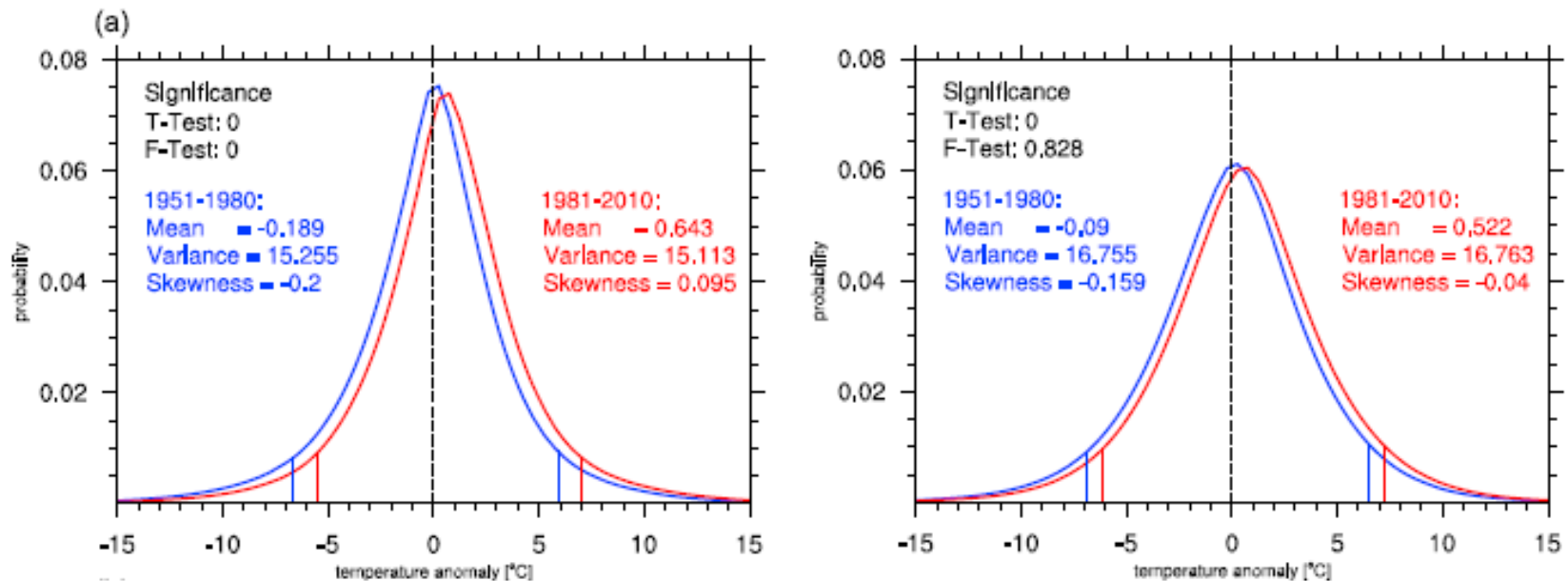
(b) Variance



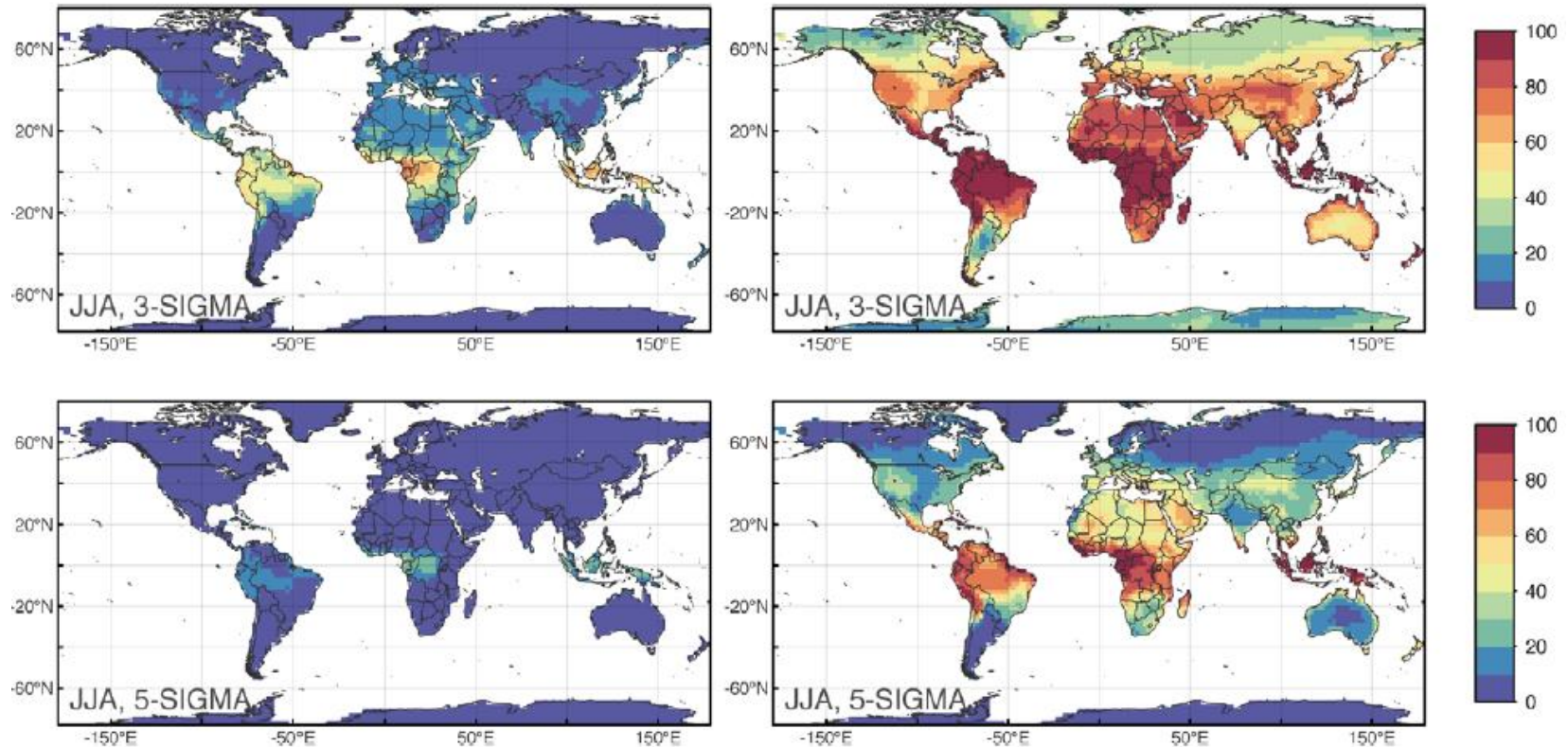
(c) Skewness



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Heatwaves in the future



Multi-model mean of the percentage of boreal summer months in the time period 2017—2099 with temperatures beyond 3-sigma (top) and 5-sigma (bottom) under RCP2.6 (left) and RCP8.5 (right)

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- more heatwaves in the tropics than extratropical areas?

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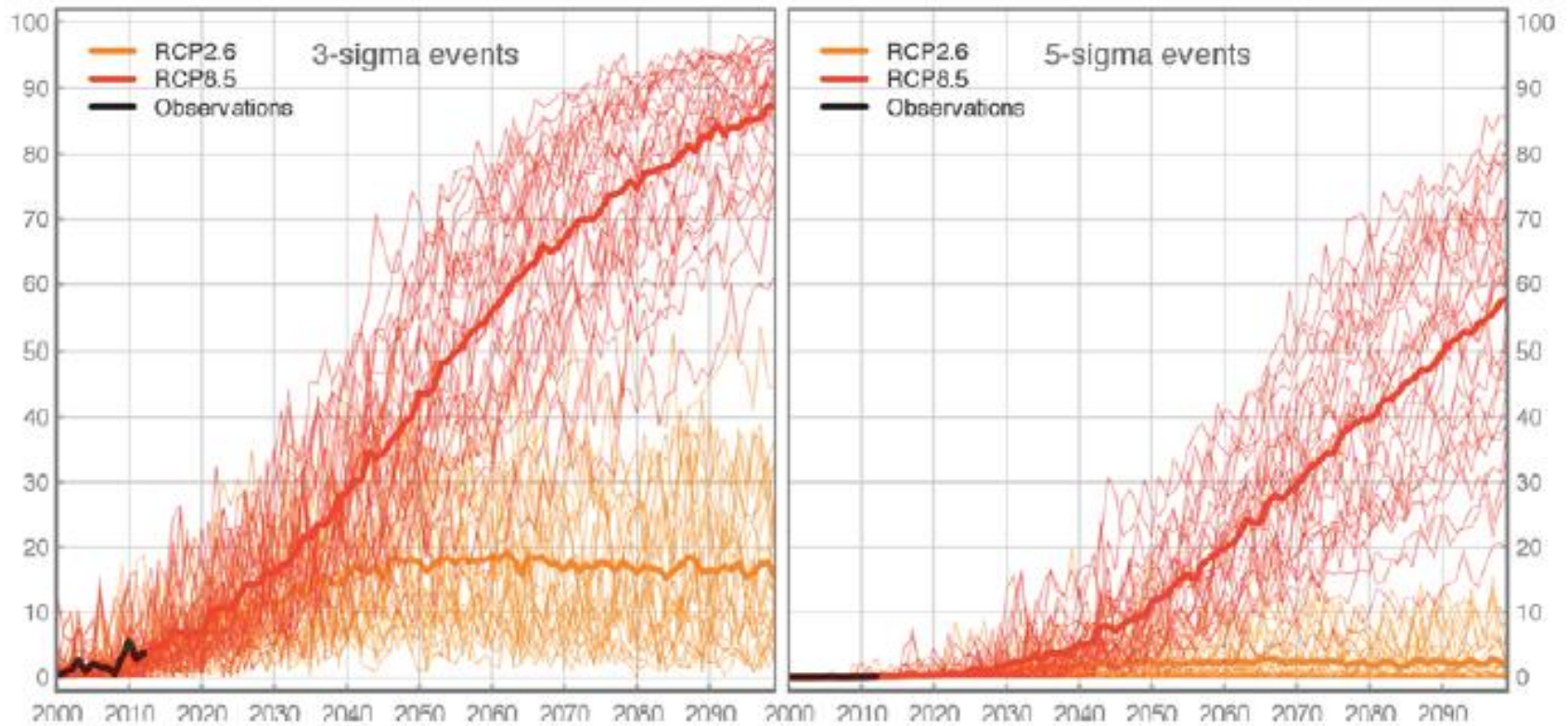
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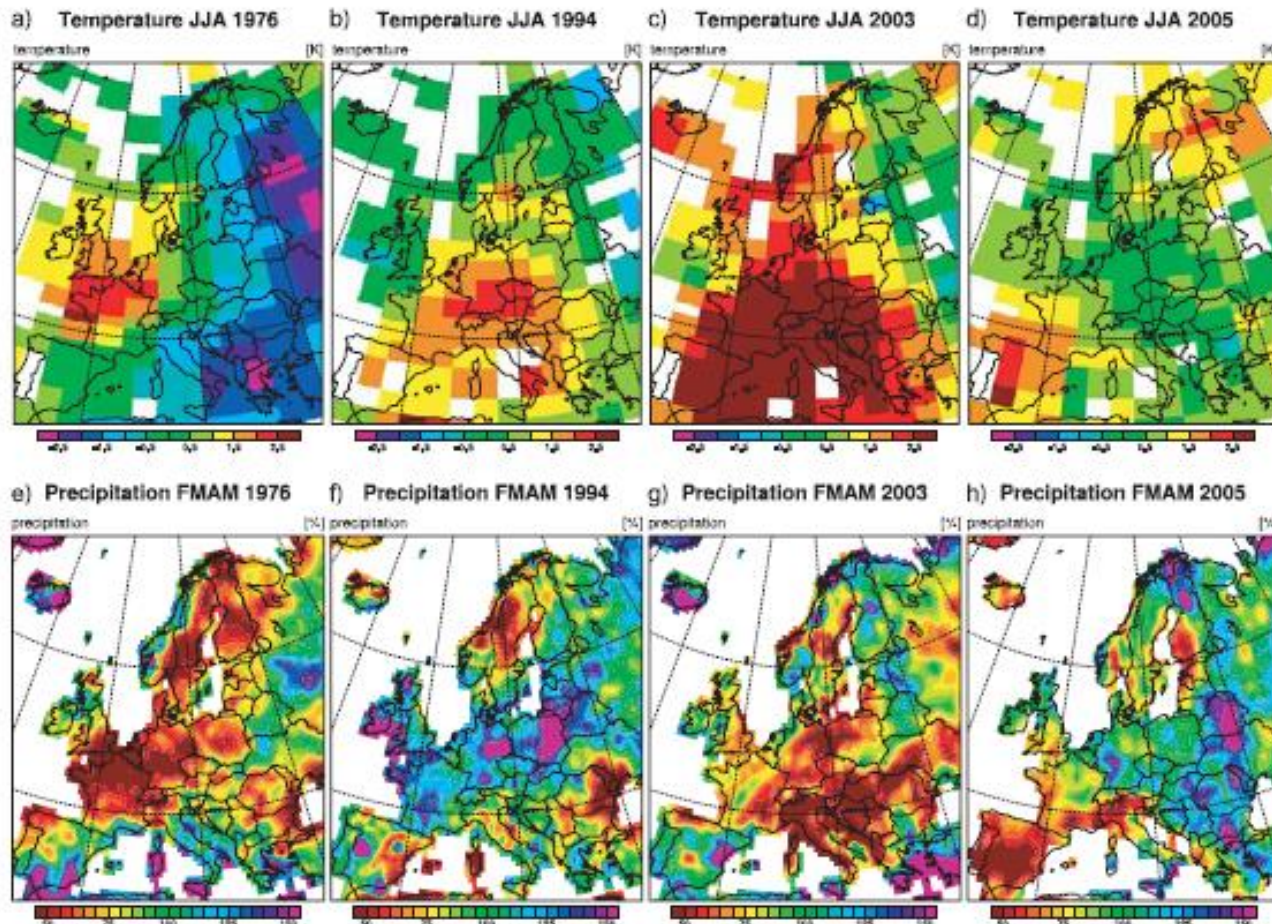
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 - for extra-tropics, summer months will be beyond 3-sigma and 5-sigma events will be common.

Future projections



The 2003 European summer heatwave



Observed summer temperature and precipitation anomalies in JJA with respect to the climatological mean 1970 – 2000 over Central Europe

The 2003 European summer heatwave

- ~35,000 people died
- france had the greatest increase in mortality
- highest mortality among the elderly population
- more deaths among women than men
- more victims in the urban than suburban areas
- lower social class groups were at more risk
- persons disabled were also more exposed
- $T_{\max} = >35^{\circ}\text{C}$, $T_{\min} = >20^{\circ}\text{C}$
- 42% of the 15,000 excess deaths registered in France occurred in hospitals, 35% at home, 19% in retirement homes, and 3% in private clinics

The 2003 European summer heatwave

- preceded by a winter and spring precipitation deficit
- amplification of summer temperature extremes
- temperatures exceeded the 1961-1990 mean by 3°C == an excess of 5 s.d.
- land-atmosphere coupling plays an important role in the evolution of EUR heatwave
- Soil moisture-temperature interactions increase the heat wave duration
- ...account for 50-80% of the number of hot summer days
- caused by increased temperature variability in response to greenhouse gas forcing

DISCUSSIONS

- What was the highest temperature you've experienced while outside and where were you?
- What was the major cause of a heatwave you've experienced before?
- Would you agree with the results of the paper?
- More severe heatwaves over Europe and North America in the future
 - What are your thoughts?
 - Any ideas for prevention?
 - Do you really believe that things would get better?

