Regional climate change and weather and climate extremes

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Definitions, data, and methods

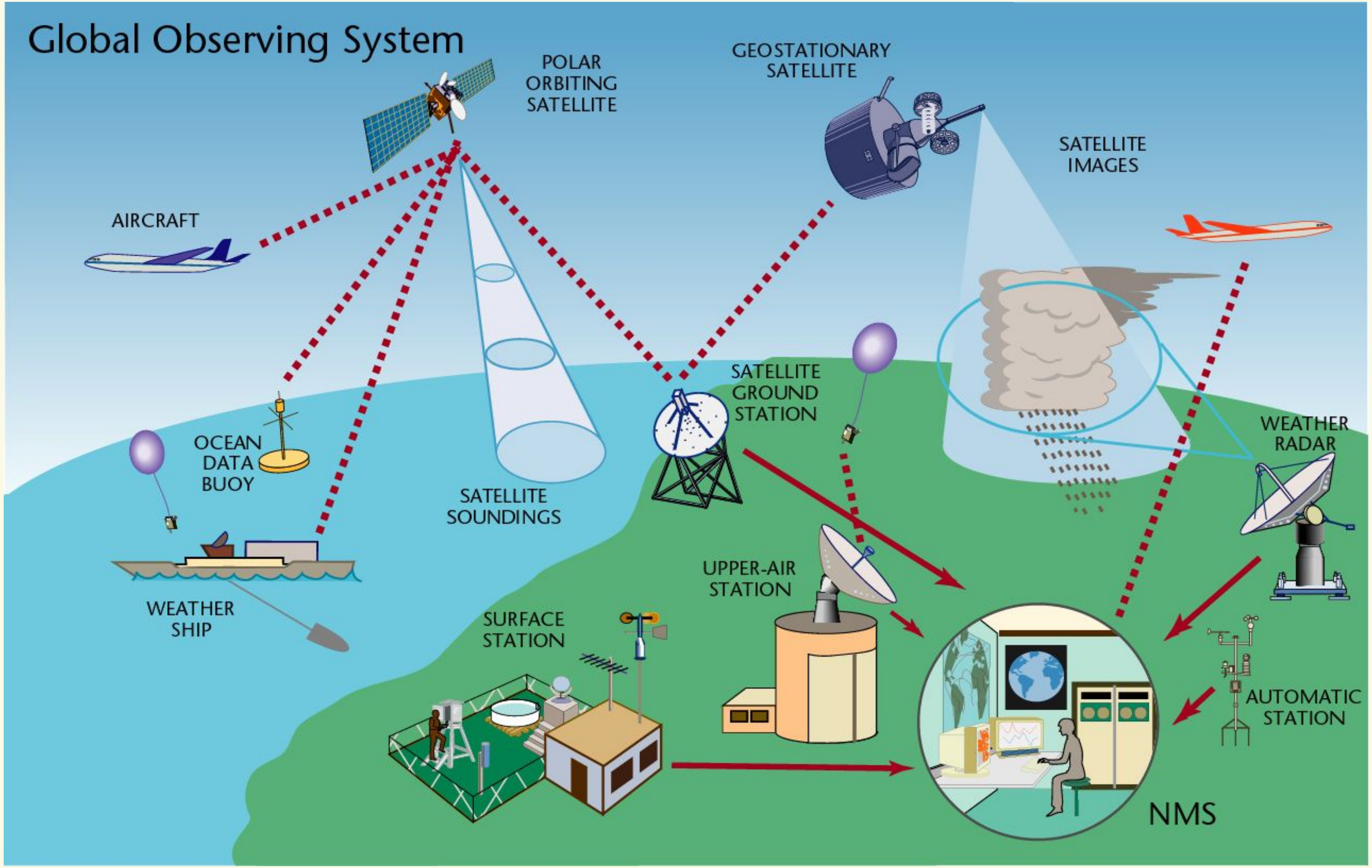
Definitions

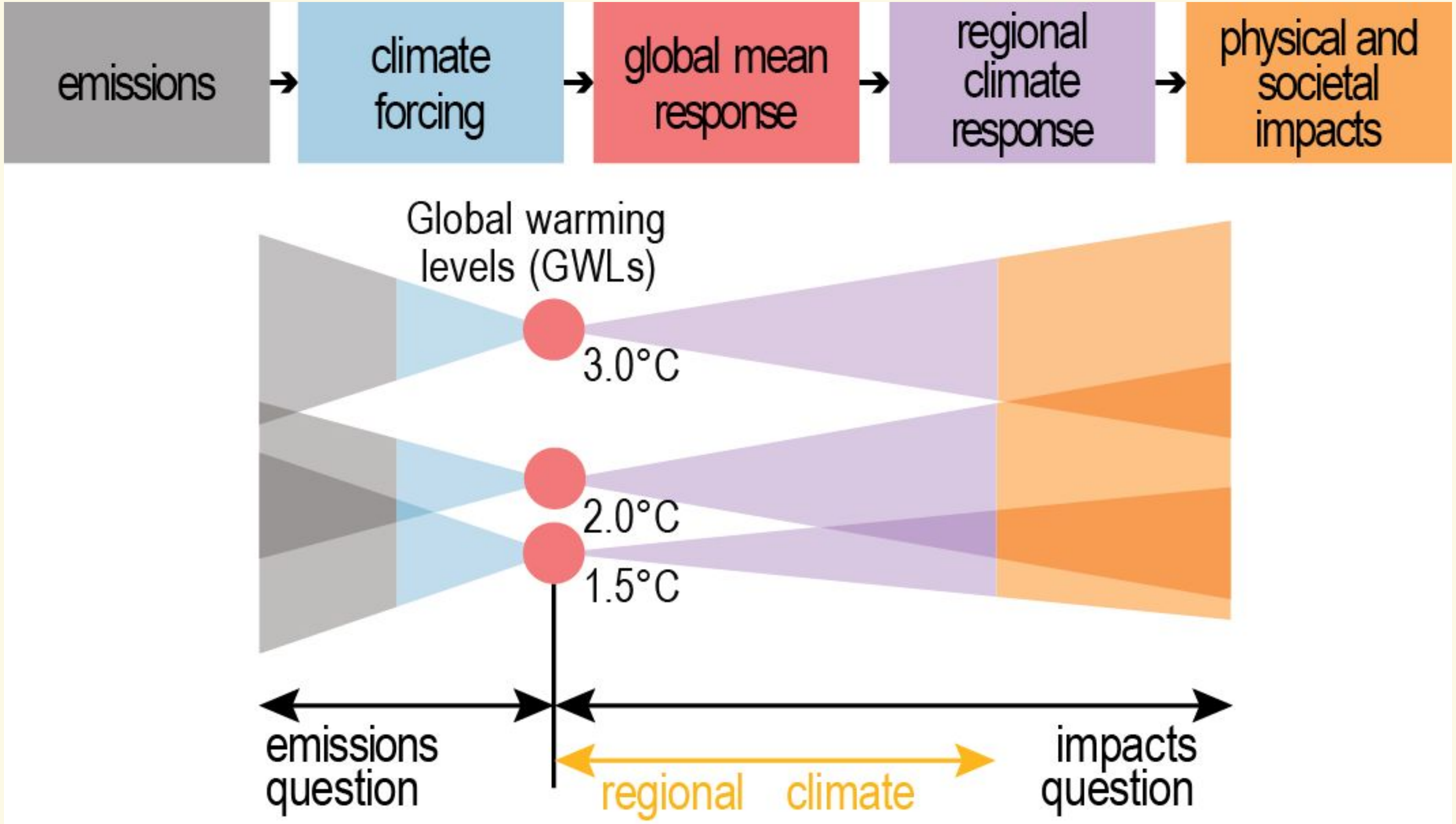
extreme weather event

an event that is rare at a particular place and time of year

extreme climate event

a pattern of extreme weather that persists for some time, such as a season


Global Observing System
POLAR ORBITING SATELLITE
GEOSTATIONARY SATELLITE
SATELLITE IMAGES
AIRCRAFT
SATELLITE GROUND STATION
OCEAN DATA BUOY
SATELLITE SOUNDINGS
WEATHER RADAR
UPPER-AIR STATION
WEATHER SHIP
SURFACE STATION
AUTOMATIC STATION
NMS


emissions
climate forcing
global mean response
regional climate response
physical and societal impacts
Global warming levels (GWLs)
3.0°C
2.0°C
1.5°C
emissions question
regional climate
impacts question

02

Temperature extremes

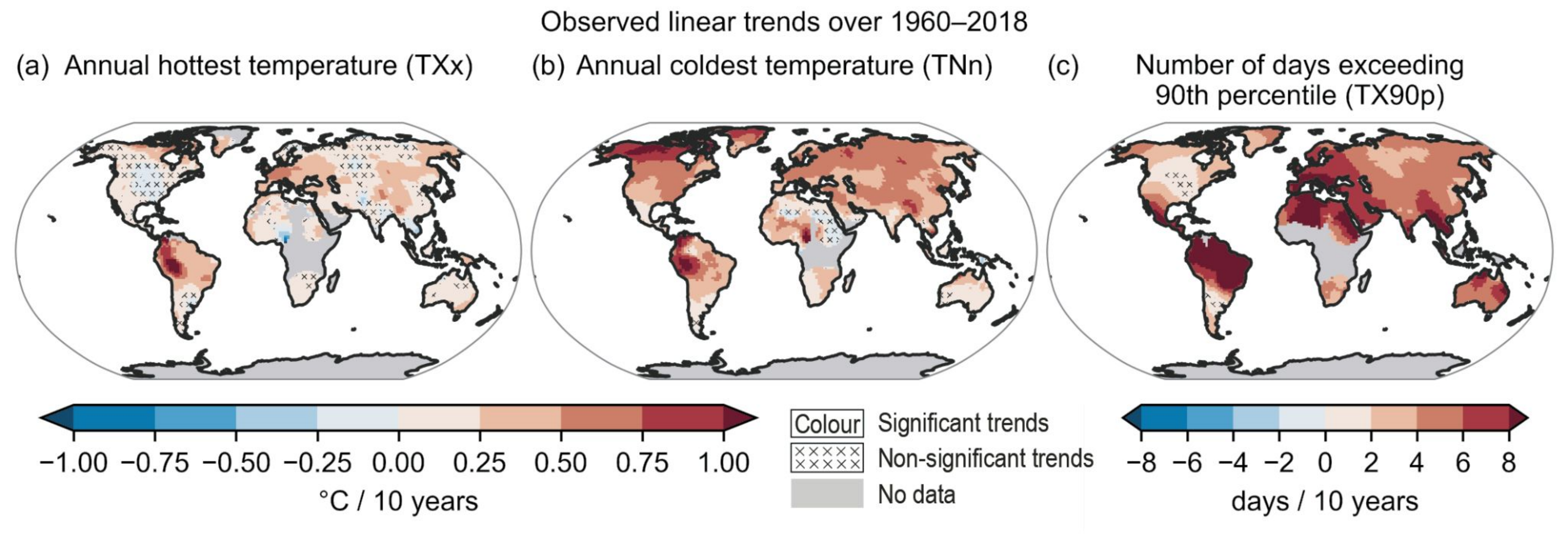

Heatwave hits Europe
BBC NEWS

It is virtually certain that hot extremes have become more frequent and more intense while cold extremes have become less frequent and less severe.

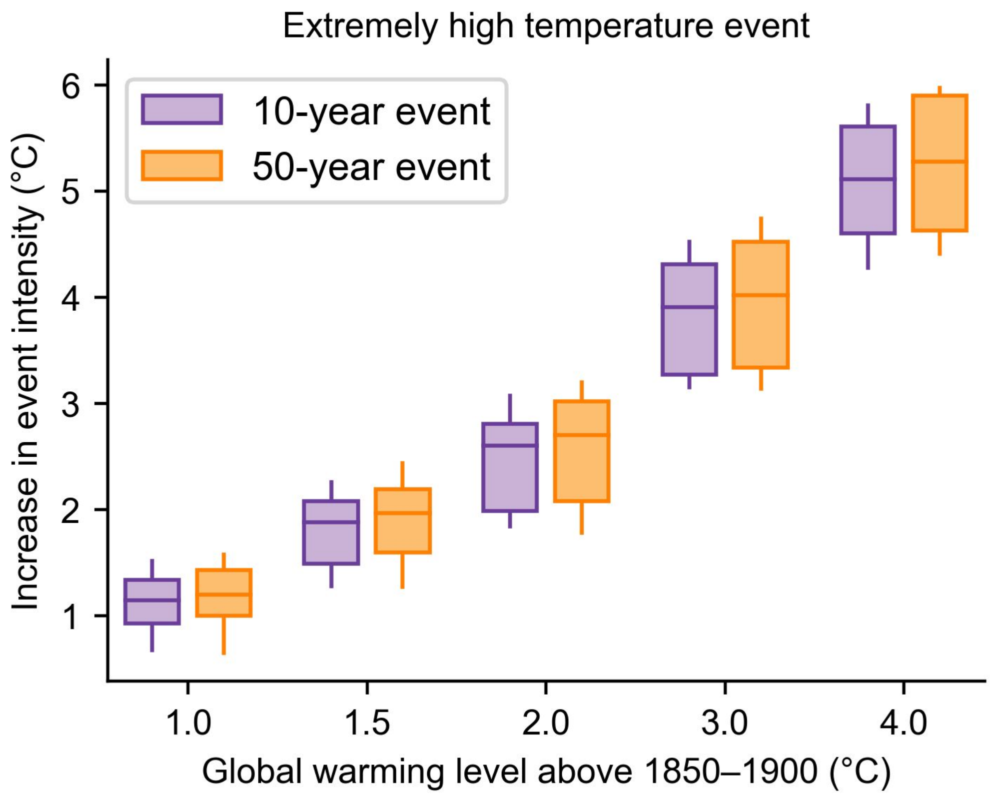
Mechanisms and drivers

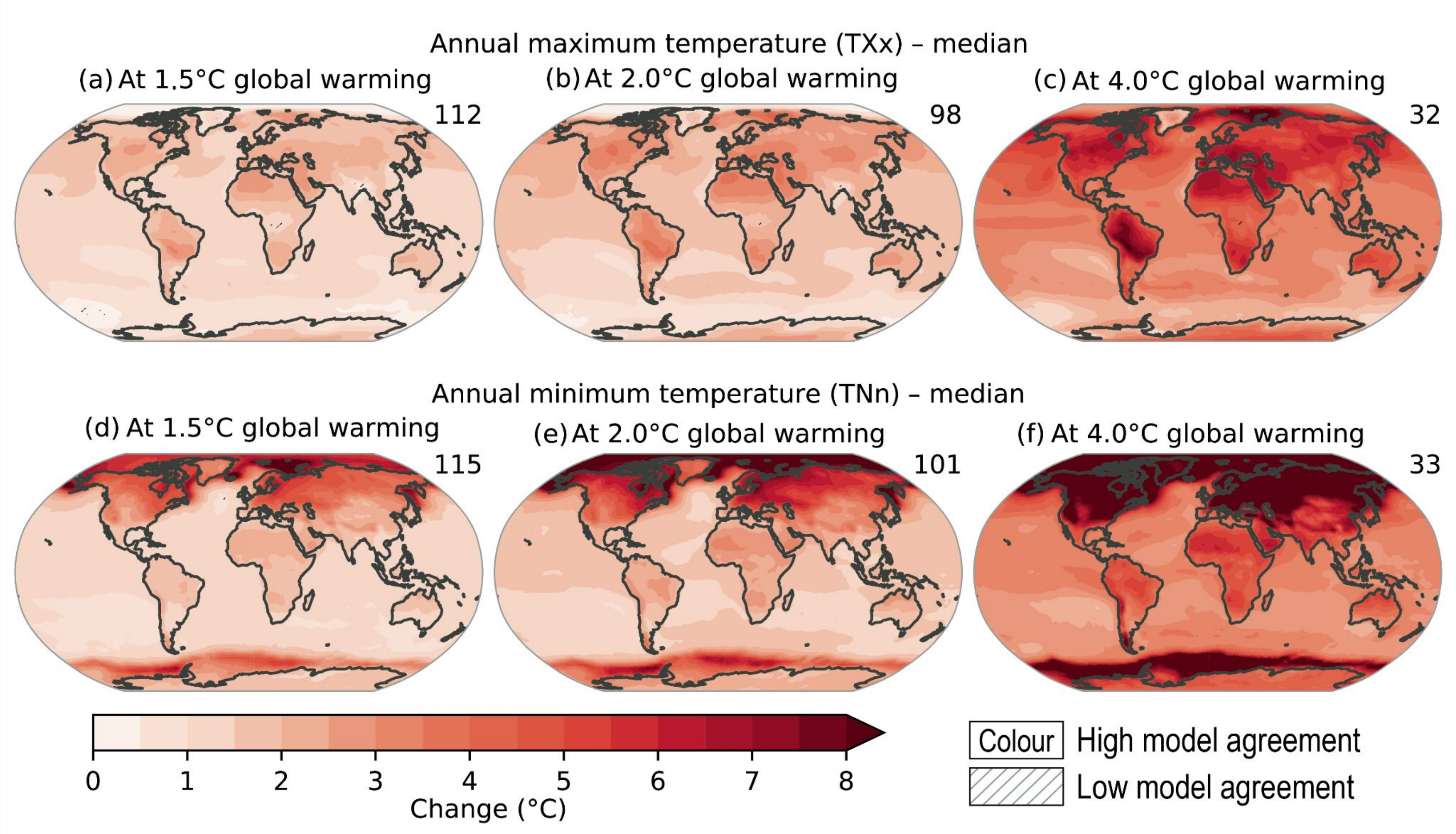
- Global greenhouse effect
- Large-scale atmospheric circulation patterns
- Regional feedbacks e.g. snow/ice albedo
- Local forcings e.g. from land use

Global trends



Projections





Projected changes at different levels of global warming compared to 1850-1900 baseline

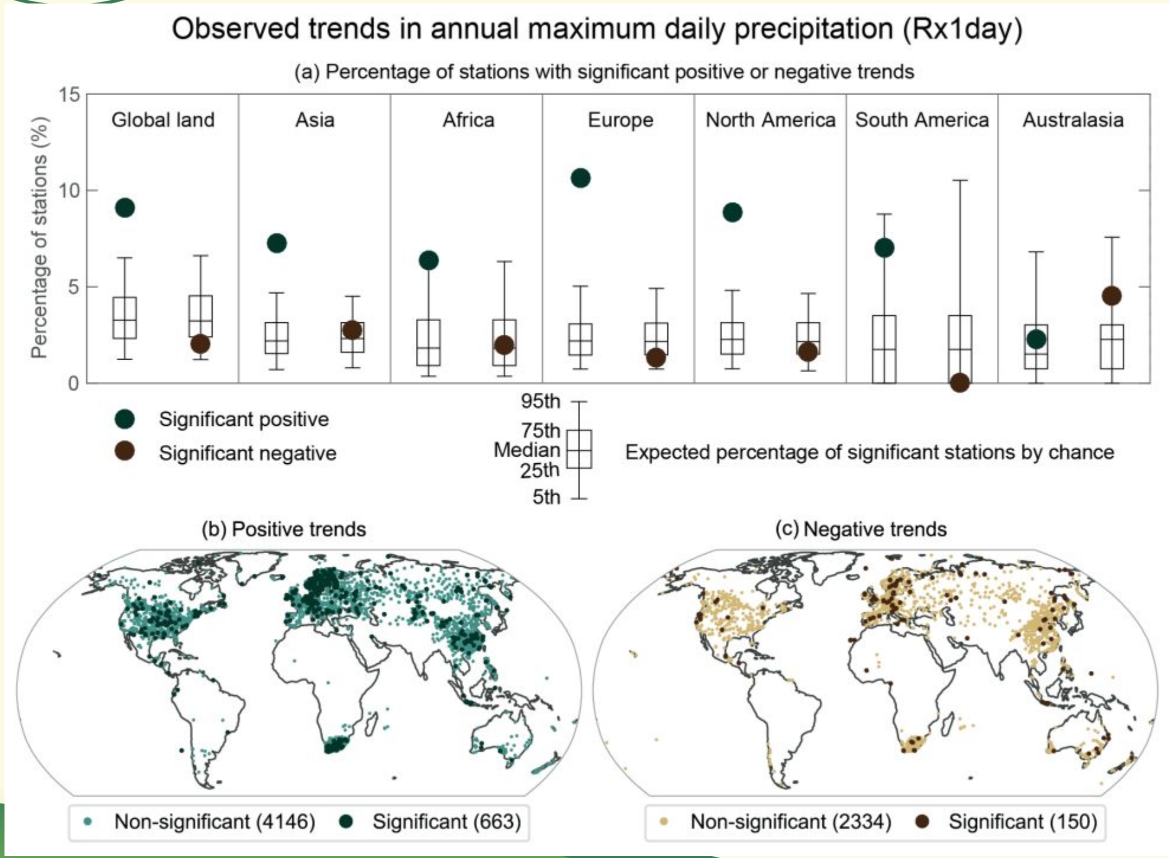
03

Heavy precipitation

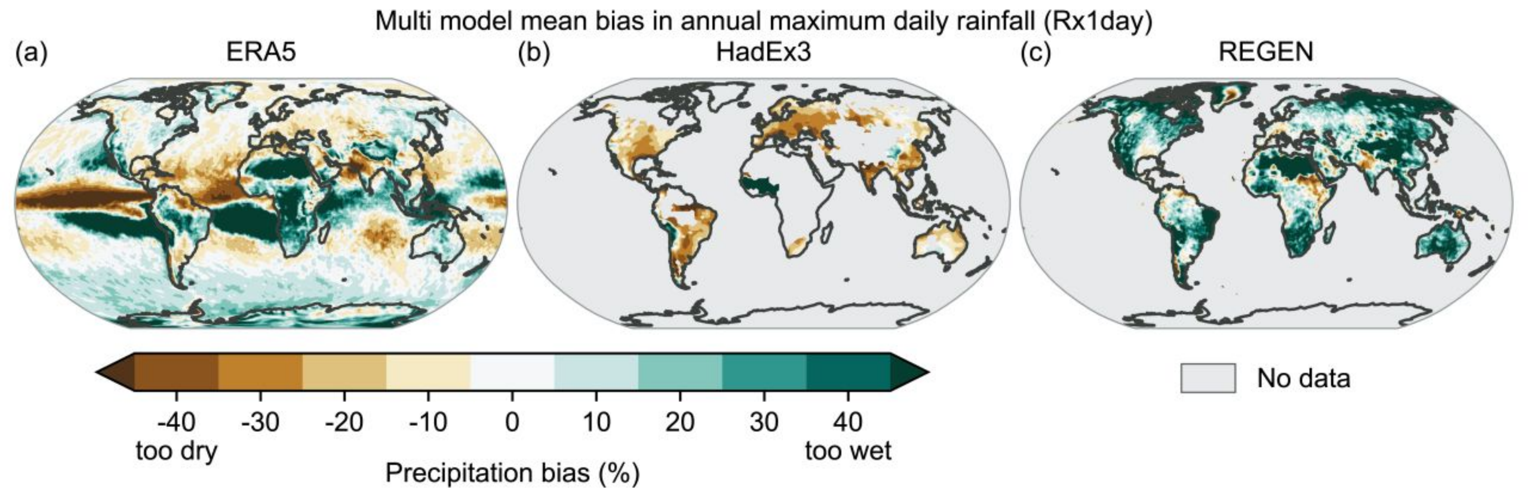
Mechanisms and Drivers

Precipitation extremes are controlled by both thermodynamic and dynamic processes. Warming-induced thermodynamic change results in an increase in extreme precipitation, at a rate that closely follows the C-C relationship at the global scale (high confidence). The effects of warming-induced changes in dynamic drivers on extreme precipitation are more complicated, difficult to quantify, and are an uncertain aspect of projections. Precipitation extremes are also affected by forcings other than changes in greenhouse gases, including changes in aerosols, land-use and land-cover change, and urbanization (medium confidence).

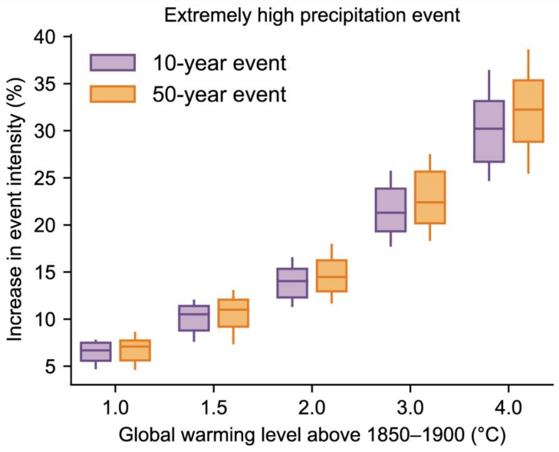
T R E N D


Observed trends in annual maximum daily precipitation (Rx1day)
(a) Percentage of stations with significant positive or negative trends
Percentage of stations (%)
15
10
5
0
Global land
Asia
Africa
Europe
North America
South America
Australasia
Significant positive
Significant negative
95th
75th
Median
25th
5th
Expected percentage of significant stations by chance
(b) Positive trends
(c) Negative trends
Non-significant (4146)
Significant (663)
Non-significant (2334)
Significant (150)

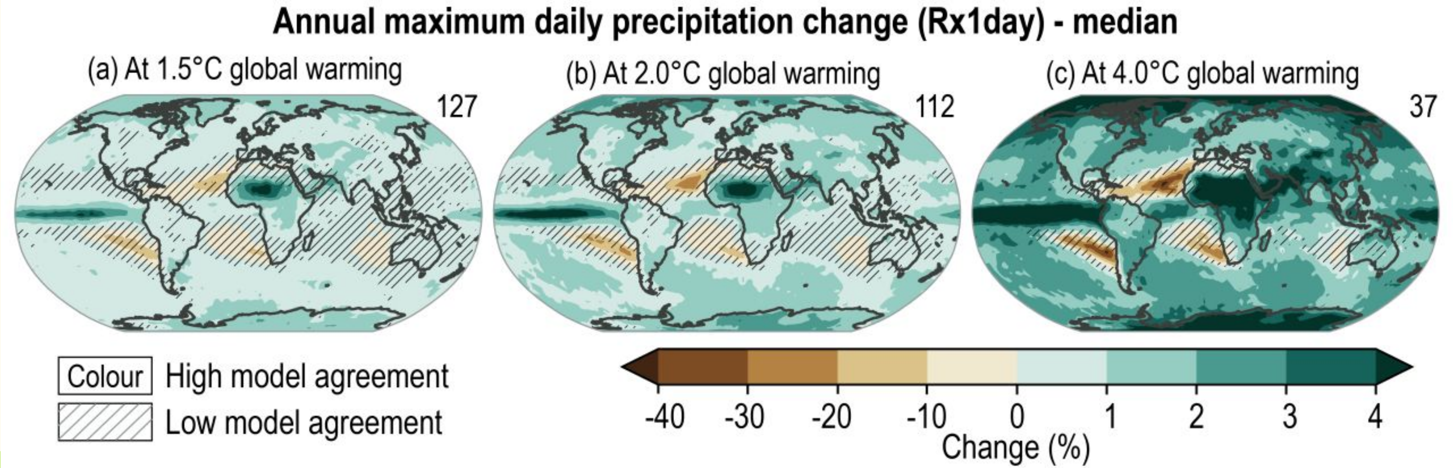
Model Evaluation and attribution



Anthropogenic forcing has contributed to a global-scale intensification of heavy precipitation over the second half of the 20th century.



Projected changes in annual maximum daily precipitation at (a) 1.5°C, (b) 2°C, and (c) 4°C of global warming compared to the 1850–1900 baseline



04

Floods

FLOODS

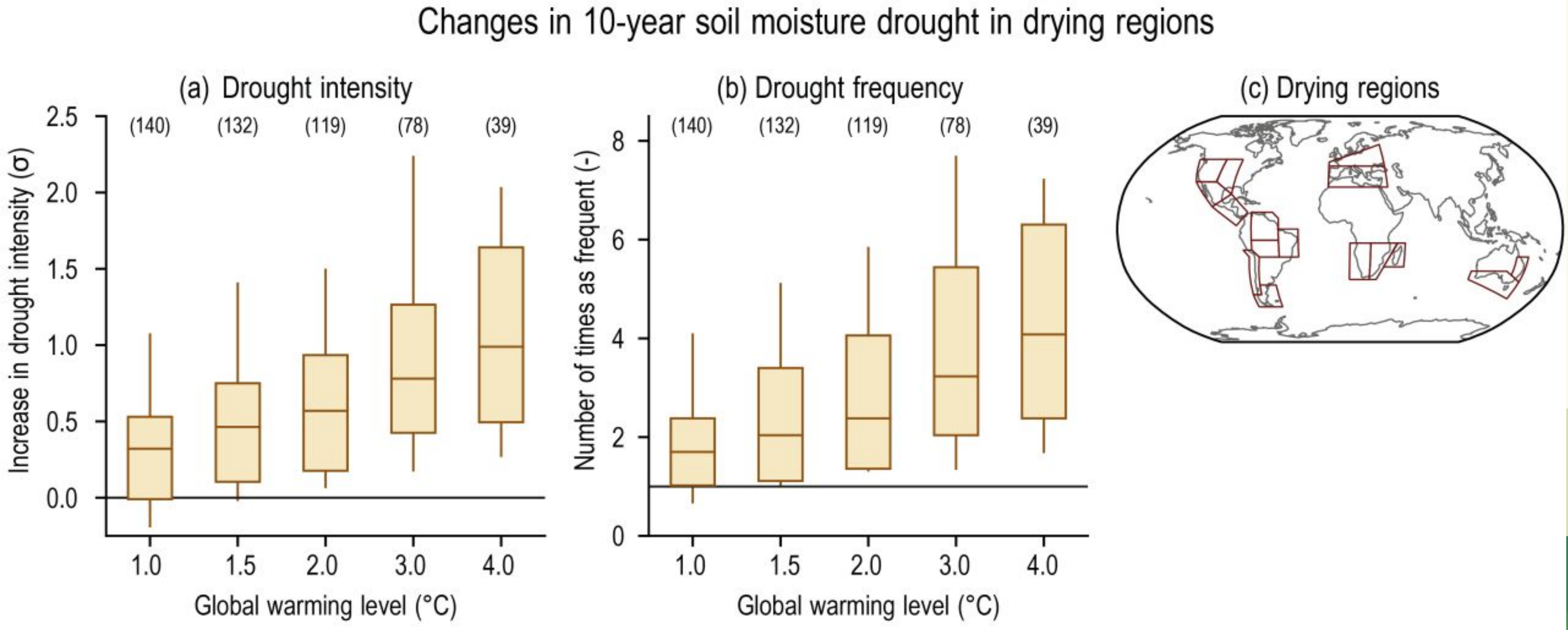
“In summary, global hydrological models project a larger fraction of land areas to be affected by an increase in river floods than by a decrease in river floods (medium confidence).

05 Droughts

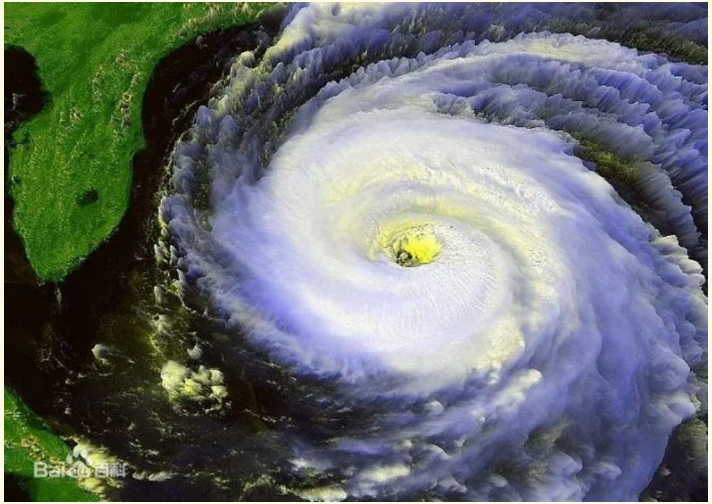
Mechanisms and Drivers

Similar to many other extreme events, droughts occur as a combination of thermodynamic and dynamic processes (Box 11.1). Thermodynamic processes contributing to drought, which are modified by greenhouse gas forcing both at global and regional scales, are mostly related to heat and moisture exchanges, and are also partly modulated by plant coverage and physiology.

Trend


Changes in 10-year soil moisture drought in drying regions
(a) Drought intensity
Increase in drought intensity (σ)
2.5
2.0
1.5
1.0
0.5
0.0
(140)
(132)
(119)
(78)
(39)
1.0
1.5
2.0
3.0
4.0
Global warming level (°C)
(b) Drought frequency
Number of times as frequent (-)
8
6
4
2
0
(140)
(132)
(119)
(78)
(39)
1.0
1.5
2.0
3.0
4.0
Global warming level (°C)
(c) Drying regions

06 Extreme Storms


Baidu百科


07

Compound extremes

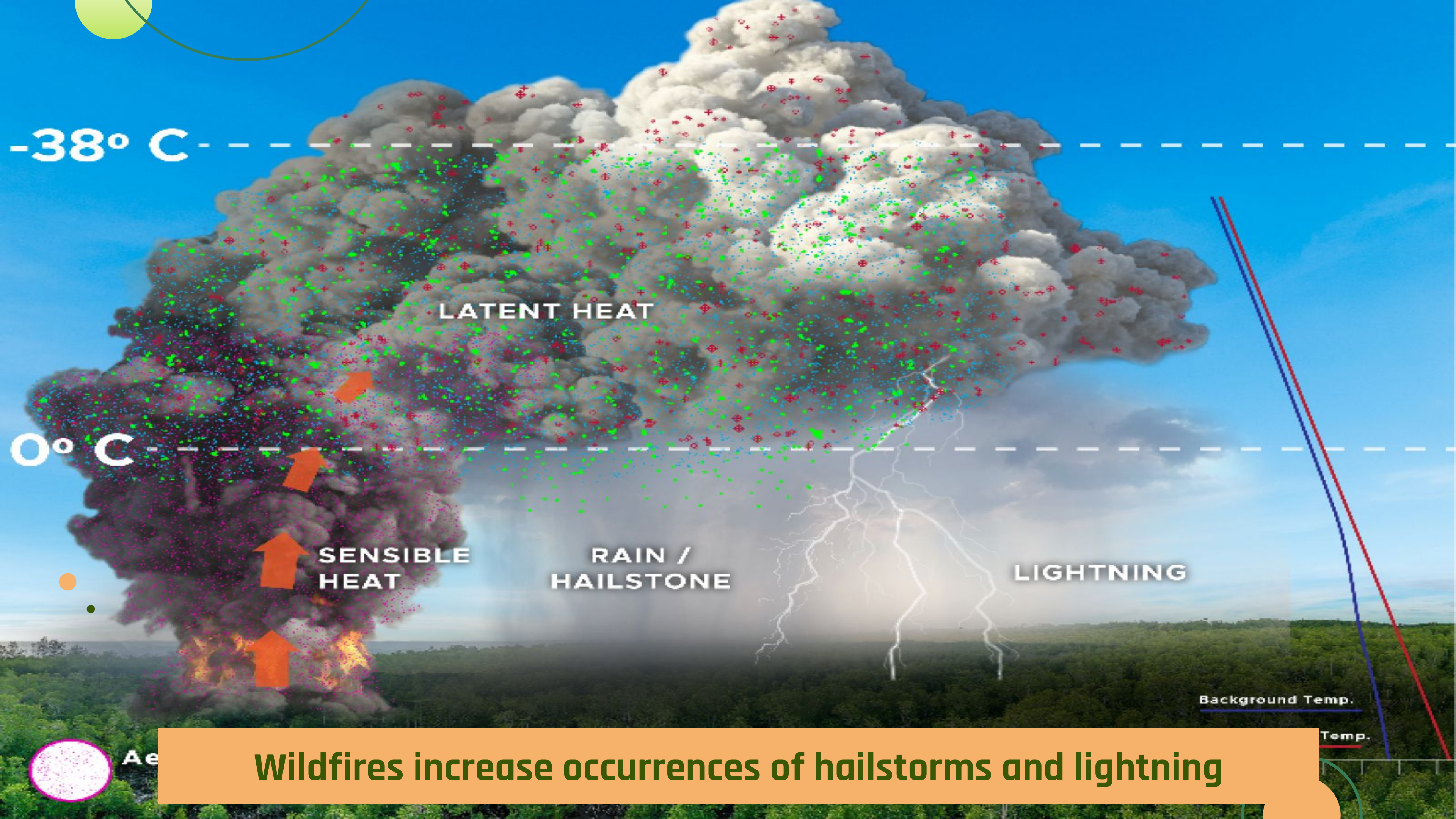
Compound Events-definitions

I. two or more extreme events occurring simultaneously or successively
II. combinations of extreme events with underlying conditions that amplify the impact of the events
III. combinations of events that are not themselves extremes but lead to an extreme event or impact when combined

Co-occurring extreme precipitation and extreme winds can result in infrastructural damage

The compounding of storm surge and precipitation extremes can cause coastal floods

The combination of drought and heat can lead to tree mortality



Wildfires increase occurrences of hailstorms and lightning

Compound storm types consisting of co-located cyclone, front and thunderstorm systems have a higher chance of causing extreme rainfall and extreme winds than individual storm types

“Extremes may occur at similar times at different locations but affect the same system, for instance, spatially concurrent climate extremes affecting crop yields and food prices”

"It is virtually certain that hot extremes have become more frequent and more intense while cold extremes have become less frequent and less severe."

Concurrent Droughts and Heatwaves

- Between 1979 and 2013, the global burnable area affected by long fire weather seasons doubled, and the mean length of the fire weather season increased by 19%. However, at the global scale, the total burned area has been decreasing between 1998 and 2015 due to human activities mostly related to changes in land use. Given the projected high confidence increase in compound hot and dry conditions, there is high confidence that fire weather conditions will become more frequent at higher levels of global warming in some regions.

I

- -There is high confidence that concurrent heatwaves and droughts have increased in frequency over the last century at the global scale due to human influence.

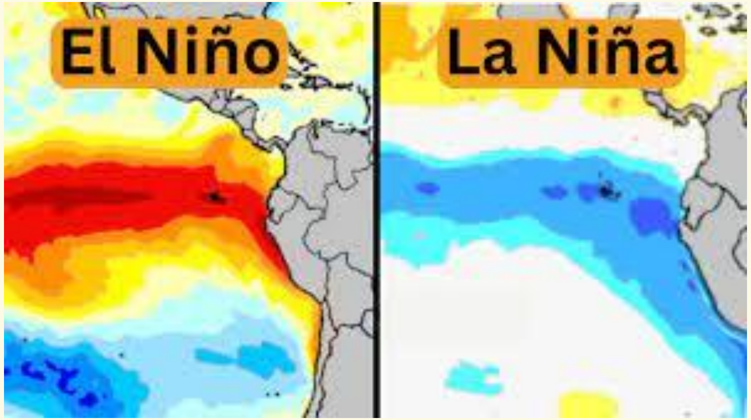
  -There is medium confidence that weather conditions that promote wildfires (fire weather) have become more probable in southern Europe, northern Eurasia, the USA, and Australia over the last century.

  -There is high confidence that compound hot and dry conditions become more probable in nearly all land regions as global mean temperature increases.

  -There is high confidence that fire weather conditions will become more frequent at higher levels of global warming in some regions.

The extreme El Niño in 2015-2016

- The 2015– 2016 extreme El Niño event was one of the three extreme El Niño events since the 1980s and the availability of satellite rainfall observations. According to some measures, it was the strongest El Niño in the past 145 years. The 2015–2016 warmth was unprecedented at the central equatorial Pacific and this exceptional warmth was unlikely to have occurred entirely naturally, appearing to reflect an anthropogenically forced trend. Amplitude and the frequency of high-magnitude events since 1950 is higher than over the pre-industrial period (medium confidence), suggesting that global extremes similar to those associated with the 2015–2016 extreme El Niño would occur more frequently under further increases in global warming.



Will climate change cause unprecedented extremes?

Large Tables

Table 11.4 | Observed trends, human contribution to observed trends, and projected changes at 1.5°C, 2°C and 4°C of global warming for temperature extremes in Africa, subdivided by AR6 regions. See Sections 11.9.1 and 11.9.2 for details. CMIP6: Coupled Model Intercomparison Project Phase 6; TXx: hottest daily maximum temperature; TNn: coldest daily minimum temperature; CORDEX: Coordinated Regional Downscaling Experiment; RCM: regional climate model.

Fact	Virtually certain	Extremely likely	Very likely	Likely	High confidence	Medium confidence	Low confidence
Increasing hot extremes, decreasing cold extremes							All

	Observed trends	Detection and Attribution; Event Attribution	Projections		
			1.5°C	2°C	4°C
All Africa	Insufficient data for the continent, but there is *high confidence* of an increase in the intensity and frequency of hot extremes and decrease in the intensity and frequency of cold extremes in all subregions with sufficient data	*Limited evidence* for the continent, but there is *medium confidence* in a human contribution to the observed increase in the intensity and frequency of hot extremes and decrease in the intensity and frequency of cold extremes for all subregions with sufficient data	CMIP6 models project a robust increase in the intensity and frequency of TXx events, and a robust decrease in the intensity and frequency of TNn events (Li et al., 2021; 11.SM. Median increase of more than 0.5°C in the 50-year TXx and TNn events compared to the 1°C warming level (Li et al., 2021)	CMIP6 models project a robust increase in the intensity and frequency of TXx events and a robust decrease in the intensity and frequency of TNn events (Li et al., 2021; 11.SM). Median increase of more than 1°C in the 50-year TXx and TNn events compared to the 1°C warming level (Li et al., 2021)	CMIP6 models project a robust increase in the intensity and frequency of TXx events and a robust decrease in the intensity and frequency of TNn events (Li et al., 2021; 11.SM). Median increase of more than 3°C in the 50-year TXx and TNn events compared to the 1°C warming level (Li et al., 2021)
	Medium confidence in the increase in the intensity and frequency of hot extremes and decrease in the intensity and frequency of cold extremes	*Medium confidence* in a human contribution to the observed increase in the intensity and frequency of hot extremes and decrease in the intensity and frequency of cold extremes	Increase in the intensity and frequency of hot extremes: *Very likely* (compared with the recent past, 1995–2014) *Extremely likely* (compared with pre-industrial) Decrease in the intensity and frequency of cold extremes: *Very likely* (compared with the recent past, 1995–2014) *Extremely likely* (compared with pre-industrial)	Increase in the intensity and frequency of hot extremes: *Extremely likely* (compared with the recent past, 1995–2014) *Virtually certain* (compared with pre-industrial) Decrease in the intensity and frequency of cold extremes: *Extremely likely* (compared with the recent past, 1995–2014) *Virtually certain* (compared with pre-industrial)	Increase in the intensity and frequency of hot extremes: *Virtually certain* (compared with the recent past, 1995–2014) *Virtually certain* (compared with pre-industrial) Decrease in the intensity and frequency of cold extremes: *Virtually certain* (compared with the recent past, 1995–2014) *Virtually certain* (compared with pre-industrial)

Table 11.5 | Observed trends, human contribution to observed trends, and projected changes at 1.5°C, 2°C and 4°C of global warming for heavy precipitation in Africa, subdivided by AR6 regions. See Sections 11.9.1 and 11.9.3 for details.

Fact	*Virtually certain*	*Extremely likely*	*Very likely*	*Likely*	*High confidence*	*Medium confidence*	*Low confidence*
Increasing heavy precipitation							All

Region	Observed Trends	Detection and Attribution; Event Attribution	Projections		
			1.5°C	2°C	4°C
All Africa	Insufficient data to assess trends	*Limited evidence*	CMIP6 models project an increase in the intensity and frequency of heavy precipitation (Li et al., 2021). Median increase of more than 2% in the 50-year Rx1day and Rx5day events compared to the 1°C warming level (Li et al., 2021)	CMIP6 models project a robust increase in the intensity and frequency of heavy precipitation (Li et al., 2021). Median increase of more than 6% in the 50-year Rx1day and Rx5day events compared to the 1°C warming level (Li et al., 2021)	CMIP6 models project a robust increase in the intensity and frequency of heavy precipitation (Li et al., 2021). Median increase of more than 20% in the 50-year Rx1day and Rx5day events compared to the 1°C warming level (Li et al., 2021)
	Low confidence	*Low confidence*	Intensification of heavy precipitation: *High confidence* (compared with the recent past, 1995–2014) *Likely* (compared with pre-industrial)	Intensification of heavy precipitation: *Likely* (compared with the recent past, 1995–2014) *Very likely* (compared with pre-industrial)	Intensification of heavy precipitation: *Extremely likely* (compared with the recent past, 1995–2014) *Virtually certain* (compared with pre-industrial)