Frequently Asked Questions

FAQ

Frequently Asked Questions

Coordinating Editors:
Sophie Berger (France/Belgium), Sarah L. Connors (France/United Kingdom)

Drafting Authors:
Richard P. Allan (United Kingdom), Paola A. Arias (Colombia), Kyle Armour (United States of America), Terje Berntsen (Norway), Lisa Bock (Germany), Ruth Cerezo-Mota (Mexico), Kim Cobb (United States of America), Alejandro Di Luca (Australia, Canada/Argentina), Paul Edwards (United States of America), Tamsin L. Edwards (United Kingdom), Seita Emori (Japan), François Engelbrecht (South Africa), Veronika Eyring (Germany), Piers Forster (United Kingdom), Baylor Fox- Kemper (United States of America), Sandro Fuzzi (Italy), John C. Fyfe (Canada), Nathan P. Gillett (Canada), Nicholas R. Golledge (New Zealand/United Kingdom), Melissa I. Gomis (France/Switzerland), William J. Gutowski (United States of America), Rafiq Hamdi (Belgium), Mathias Hauser (Switzerland), Ed Hawkins (United Kingdom), Nigel Hawtin (United Kingdom), Darrell S. Kaufman (United States of America), Megan Kirchmeier-Young (Canada/ United States of America), Charles Koven (United States of America), June-Yi Lee (Republic of Korea), Sophie Lewis (Australia), Jochem Marotzke (Germany), Valérie Masson-Delmotte (France), Thorsten Mauritsen (Sweden/Denmark), Thomas K. Maycock (United States of America), Shayne McGregor (Australia), Sebastian Milinski (Germany), Olaf Morgenstern (New Zealand/Germany), Swapna Panickal (India), Joeri Rogelj (United Kingdom/Belgium), Maisa Rojas (Chile), Alex C. Ruane (United States of America), Bjørn H. Samset (Norway), Trude Storelvmo (Norway), Sophie Szopa (France), Jessica Tierney (United States of America), Russell S. Vose (United States of America), Masahiro Watanabe (Japan), Sönke Zaehle (Germany), Xuebin Zhang (Canada), Kirsten Zickfeld (Canada/Germany)

These Frequently Asked Questions have been extracted from the chapters of the underlying report and are compiled here. When referencing specific FAQs, please reference the corresponding chapter in the report from where the FAQ originated (e.g., FAQ 3.1 is part of Chapter 3).

Frequently Asked Questions

FAQ 11.1 | How Do Changes In Climate Extremes Compare With Changes In Climate Averages?

Human-caused climate change alters the frequency and intensity of climate variables (e.g., surface temperature) and phenomena (e.g., tropical cyclones) in a variety of ways. We now know that the ways in which average and extreme conditions have changed (and will continue to change) depend on the variable and the phenomenon being considered. Changes in local surface temperature extremes closely follow the corresponding changes in local average surface temperatures. On the contrary, changes in precipitation extremes (heavy precipitation) generally do not follow those in average precipitation, and can even move in the opposite direction (e.g., with average precipitation decreasing but extreme precipitation increasing).

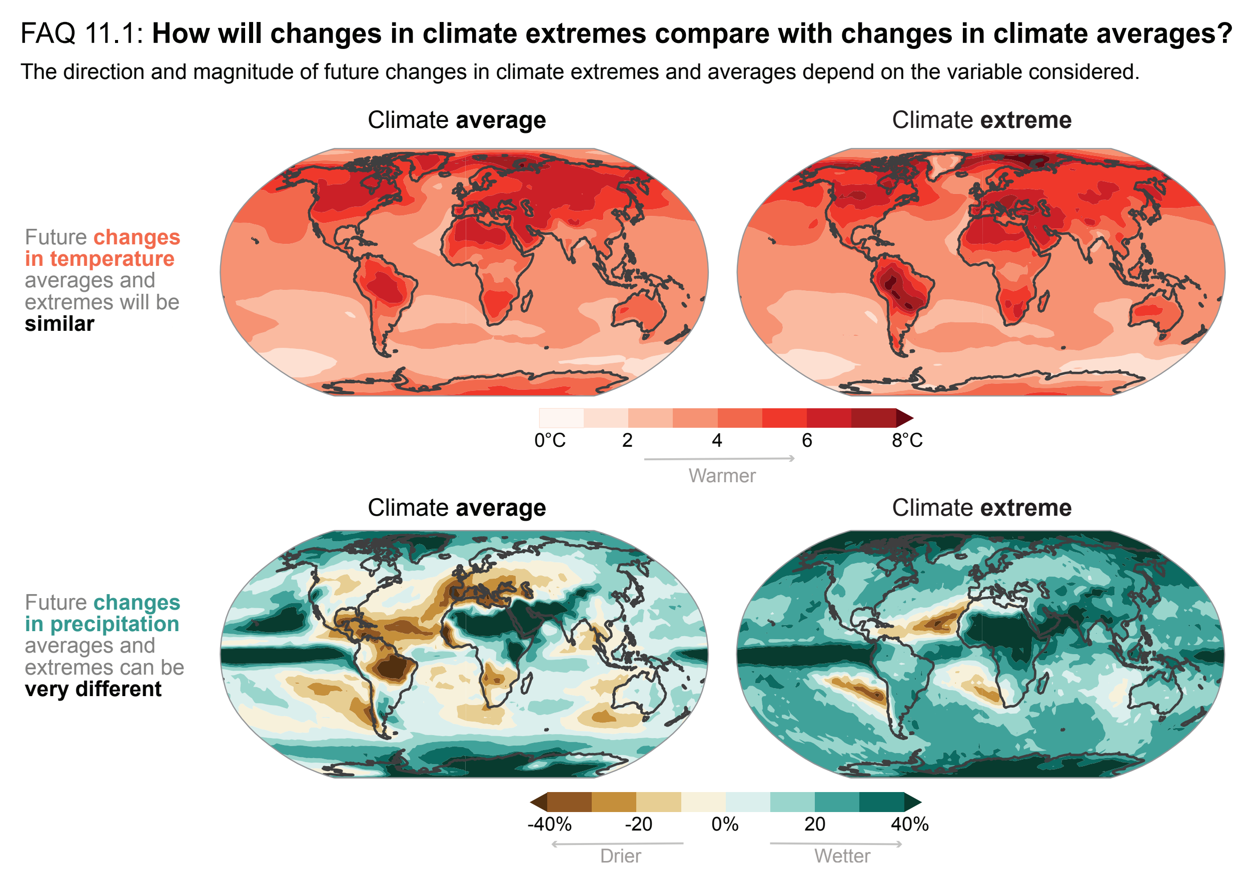
Climate change will manifest very differently depending on which region, season and variable we are interested in. For example, over some parts of the Arctic, temperatures will warm at rates about three to four times higher during winter compared to summer months. And in summer, most of northern Europe will experience larger temperatures increases than most places in south-east South America and Australasia, with differences that can be larger than 1°C, depending on the level of global warming. In general, differences across regions and seasons arise because the underlying physical processes differ drastically across regions and seasons.

Climate change will also manifest differently for different weather regimes and can lead to contrasting changes in average and extreme conditions. Observations of the recent past and climate model projections show that, in most places, changes in daily temperatures are dominated by a general warming where the climatological average and extreme values are shifted towards higher temperatures, making warm extremes more frequent and cold extremes less frequent. The top panels in FAQ 11.1, Figure 1 show projected changes in surface temperature for long-term average conditions (left) and for extreme hot days (right) during the warm season (summer in mid- to high latitudes). Projected increases in long-term average temperature differ substantially between different places, varying from less than 3°C in some places in central South Asia and southern South America to over 7°C in some places in North America, North Africa and the Middle East. Changes in extreme hot days follow changes in average conditions quite closely, although, in some places, the warming rates for extremes can be intensified (e.g., southern Europe and the Amazon basin) or weakened (e.g., northern Asia and Greenland) compared to average values.

Recent observations and global and regional climate model projections point to changes in precipitation extremes (including both rainfall and snowfall extremes) differing drastically from those in average precipitation. The bottom panels in FAQ 11.1, Figure 1 show projected changes in the long-term average precipitation (left) and in heavy precipitation (right). Averaged precipitation changes show striking regional differences, with substantial drying in places such as southern Europe and northern South America and wetting in places such as the Middle East and southern South America. Changes in extreme precipitation are much more uniform, with systematic increases over nearly all land regions. The physical reasons behind the different responses of averaged and extreme precipitation are now well understood. The intensification of extreme precipitation is driven by the increase in atmospheric water vapour (about 7% per 1°C of warming near the surface), although this is modulated by various dynamical changes. In contrast, changes in average precipitation are driven not only by moisture increases but also by slower processes that constrain future changes over the globe to only 2–3% per 1°C of warming near the surface.

In summary, the specific relationship between changes in average and extreme conditions strongly depends on the variable or phenomenon being considered. At the local scale, average and extreme surface temperature changes are strongly related, while average and extreme precipitation changes are often weakly related. For both variables, the changes in average and extreme conditions vary strongly across different places due to the effect of local and regional processes.

FAQ 11.1 (continued)



FAQ 11.1, Figure 1 | Global maps of future changes in surface temperature (top panels) and precipitation (bottom panels) for long-term average (left) and extreme conditions (right). All changes were estimated using the Coupled Model Intercomparison Project Phase 6 (CMIP6) ensemble median for a scenario with a global warming of 4°C relative to 1850–1900 temperatures. Average surface temperatures refer to the warmest three-month season (summer in mid- to high latitudes) and extreme temperatures refer to the hottest day in a year. Precipitation changes, which can include both rainfall and snowfall changes, are normalized by 1850–1900 values and shown as a percentage; extreme precipitation refers to the largest daily precipitation in a year.

Frequently Asked Questions

FAQ 11.2 | Will Unprecedented Extremes Occur As a Result Of Human-Induced Climate Change?

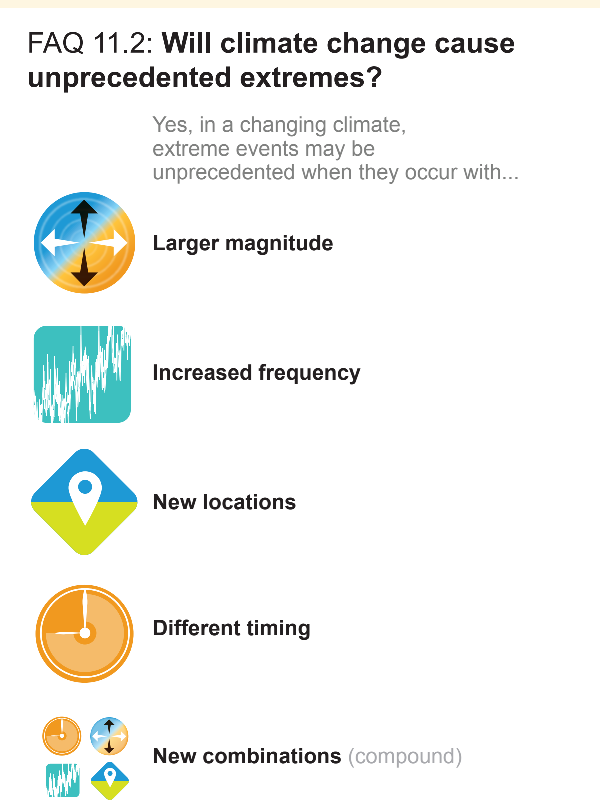
Climate change has already increased the magnitude and frequency of extreme hot events and decreased the magnitude and frequency of extreme cold events, and, in some regions, intensified extreme precipitation events. As the climate moves away from its past and current states, we will experience extreme events that are unprecedented, either in magnitude, frequency, timing or location. The frequency of these unprecedented extreme events will rise with increasing global warming. Additionally, the combined occurrence of multiple unprecedented extremes may result in large and unprecedented impacts.

Human-induced climate change has already affected many aspects of the climate system. In addition to the increase in global surface temperature, many types of weather and climate extremes have changed. In most regions, the frequency and intensity of hot extremes have increased and those of cold extremes have decreased. The frequency and intensity of heavy precipitation events have increased at the global scale and over a majority of land regions. Although extreme events such as land and marine heatwaves, heavy precipitation, drought, tropical cyclones, and associated wildfires and coastal flooding have occurred in the past and will continue to occur in the future, they often come with different magnitudes or frequencies in a warmer world. For example, future heatwaves will last longer and have higher temperatures, and future extreme precipitation events will be more intense in several regions. Certain extremes, such as extreme cold, will be less intense and less frequent with increasing warming.

Unprecedented extremes – that is, events not experienced in the past – will occur in the future in five different ways (FAQ 11.2, Figure 1). First, events that are considered to be extreme in the current climate will occur in the future with unprecedented magnitudes. Second, future extreme events will also occur with unprecedented frequency. Third, certain types of extremes may occur in regions that have not previously encountered those types of events. For example, as the sea level rises, coastal flooding may occur in new locations, and wildfires are already occurring in areas, such as parts of the Arctic, where the probability of such events was previously low. Fourth, extreme events may also be unprecedented in their timing. For example, extremely hot temperatures may occur either earlier or later in the year than they have in the past.

Finally, compound events – where multiple extreme events of either different or similar types occur simultaneously and/or in succession – may be more probable or severe in the future. These compound events can often impact ecosystems and societies more strongly than when such events occur in isolation. For example, a drought along with extreme heat will increase the risk of wildfires and agriculture damages or losses. As individual extreme events become more severe as a result of climate change, the combined occurrence of these events will create unprecedented compound events. This could exacerbate the intensity and associated impacts of these extreme events.

Unprecedented extremes have already occurred in recent years, relative to the 20th century climate. Some recent extreme hot events would have had very little chance of occurring without human influence on the climate (see FAQ 11.3). In the future, unprecedented extremes will occur as the climate continues to warm. Those extremes will happen with larger magnitudes and at higher frequencies than previously experienced. Extreme events may also appear in new locations, at new times of the year, or as unprecedented compound events. Moreover, unprecedented events will become more frequent with higher levels of warming, for example at 3°C of global warming compared to 2°C of global warming.



FAQ 11.2, Figure 1 | New types of unprecedented extremes that will occur as a result of climate change.

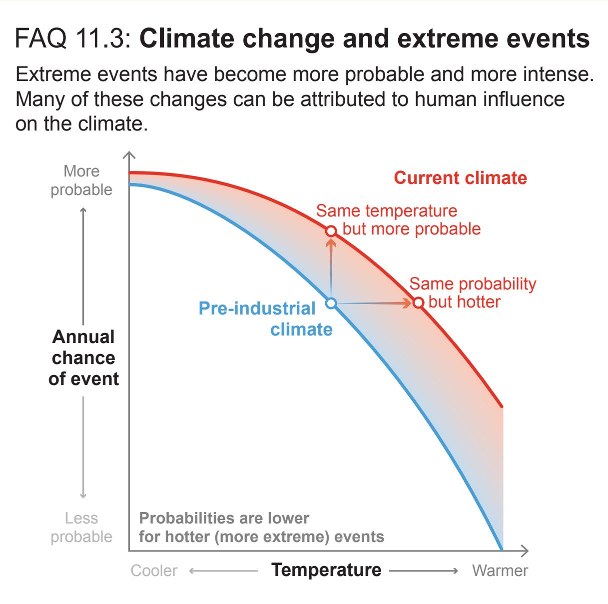
Frequently Asked Questions

FAQ 11.3 | Did Climate Change Cause That Recent Extreme Event In My Country?

While it is difficult to identify the exact causes of a particular extreme event, the relatively new science of event attribution is able to quantify the role of climate change in altering the probability and magnitude of some types of weather and climate extremes. There is strong evidence that characteristics of many individual extreme events have already changed because of human-driven changes to the climate system. Some types of highly impactful extreme weather events have occurred more often and have become more severe due to these human influences. As the climate continues to warm, the observed changes in the probability and/or magnitude of some extreme weather events will continue as the human influences on these events increase.

It is common to question whether human-caused climate change caused a major weather- and climate-related disaster. When extreme weather and climate events do occur, both exposure and vulnerability play an important role in determining the magnitude and impacts of the resulting disaster. As such, it is difficult to attribute a specific disaster directly to climate change. However, the relatively new science of event attribution enables scientists to attribute aspects of specific extreme weather and climate events to certain causes. Scientists cannot answer directly whether a particular event was caused by climate change, as extremes do occur naturally, and any specific weather and climate event is the result of a complex mix of human and natural factors. Instead, scientists quantify the relative importance of human and natural influences on the magnitude and/or probability of specific extreme weather events. Such information is important for disaster risk reduction planning, because improved knowledge about changes in the probability and magnitude of relevant extreme events enables better quantification of disaster risks.

On a case-by-case basis, scientists can now quantify the contribution of human influences to the magnitude and probability of many extreme events. This is done by estimating and comparing the probability or magnitude of the same type of event between the current climate – including the increases in greenhouse gas concentrations and other human influences – and an alternate world where the atmospheric greenhouse gases remained at pre-industrial levels. FAQ 11.3 Figure 1 illustrates this approach using differences in temperature and probability between the two scenarios as an example. Both the pre-industrial (blue) and current (red) climates experience hot extremes, but with different probabilities and magnitudes. Hot extremes of a given temperature have a higher probability of occurrence in the warmer current climate than in the cooler pre-industrial climate. Additionally, an extreme hot event of a particular probability will be warmer in the current climate than in the pre-industrial climate. Climate model simulations are often used to estimate the occurrence of a specific event in both climates. The change in the magnitude and/or probability of the extreme event in the current climate compared to the pre-industrial climate is attributed to the difference between the two scenarios, which is the human influence.



FAQ 11.3, Figure 1 | Changes in climate result in changes in the magnitude and probability of extremes. Example of how temperature extremes differ between a climate with pre-industrial greenhouse gases (shown in blue) and the current climate (shown in orange) for a representative region. The horizontal axis shows the range of extreme temperatures, while the vertical axis shows the annual chance of each temperature event's occurrence. Moving towards the right indicates increasingly hotter extremes that are more rare (less probable). For hot extremes, an extreme event of a particular temperature in the pre-industrial climate would be more probable (vertical arrow) in the current climate. An event of a certain probability in the pre-industrial climate would be warmer (horizontal arrow) in the current climate. While the climate under greenhouse gases at the pre-industrial level experiences a range of hot extremes, such events are hotter and more frequent in the current climate.

Attributable increases in probability and magnitude have been identified consistently for many hot extremes. Attributable increases have also been found for some extreme precipitation events, including hurricane rainfall events, but these results can vary among events. In some cases, large natural variations in the climate system prevent attributing changes in the probability or magnitude of a specific extreme to human influence. Additionally, attribution of certain classes of extreme weather (e.g., tornadoes) is beyond current modelling and theoretical capabilities. As the climate continues to warm, larger changes in

FAQ 11.3 (continued)

probability and magnitude are expected and, as a result, it will be possible to attribute future temperature and precipitation extremes in many locations to human influences. Attributable changes may emerge for other types of extremes as the warming signal increases.

In conclusion, human-caused global warming has resulted in changes in a wide variety of recent extreme weather events. Strong increases in probability and magnitude, attributable to human influence, have been found for many heatwaves and hot extremes around the world.