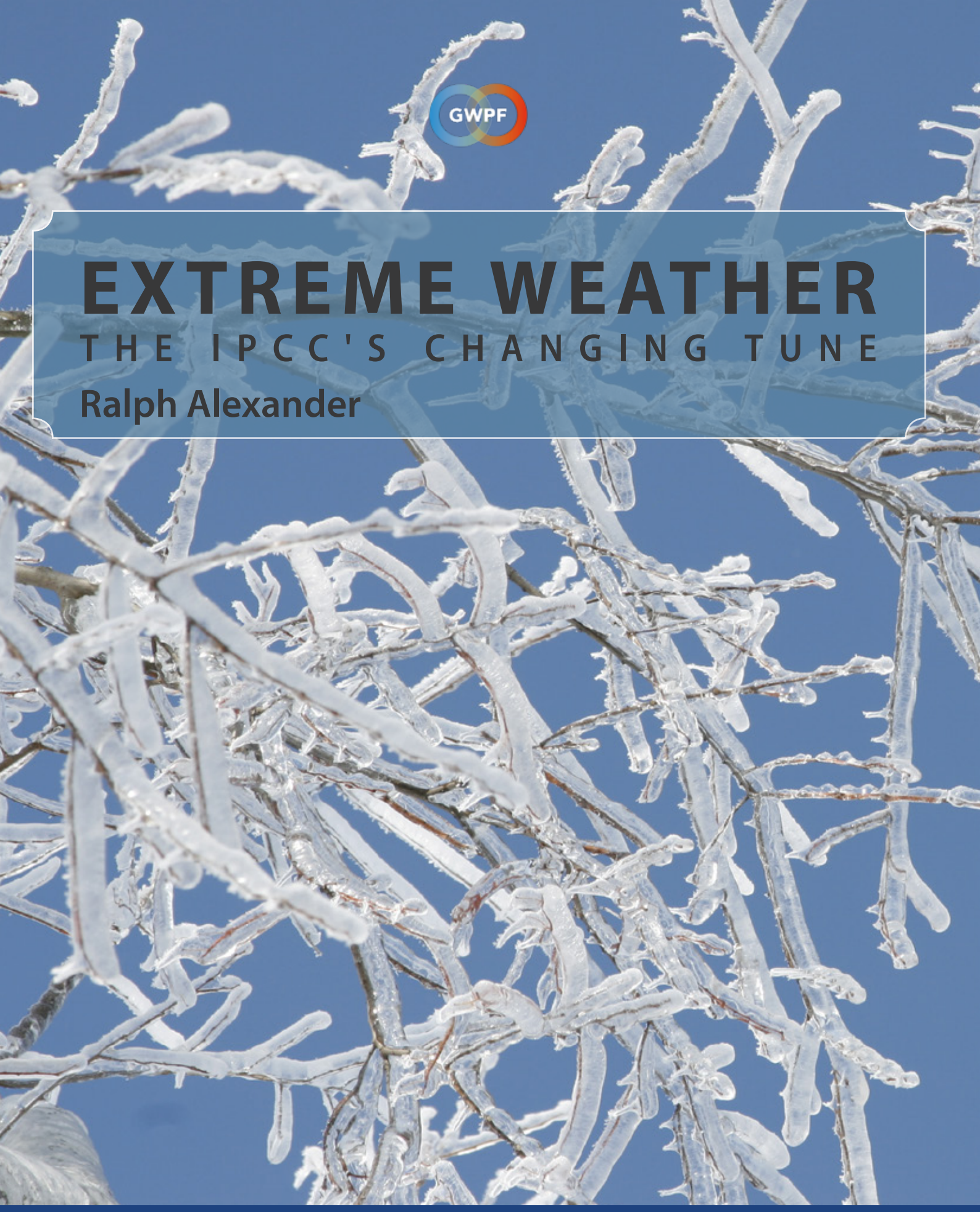


EXTREME WEATHER

THE IPCC'S CHANGING TUNE

Ralph Alexander

The Global Warming Policy Foundation
Report 54

Extreme Weather: The IPCC's Changing Tune

Ralph Alexander

Report 54, The Global Warming Policy Foundation

Contents

About the author

Retired physicist Dr. Ralph B. Alexander is the author of *Global Warming False Alarm* and *Science Under Attack: The Age of Unreason*. With a PhD in physics from the University of Oxford, he is also the author of numerous scientific papers and reports on complex technical issues. His thesis research in the interdisciplinary area of ion-solid interactions reflected his interest in a wide range of scientific topics.

Dr Alexander has been a researcher at major laboratories in Europe and Australia, a professor at Wayne State University in Detroit, the co-founder of an entrepreneurial materials company, and a market analyst in environmentally friendly materials for a small consulting firm.

Note

GWPF invited the Royal Society and the Met Office to review this paper, and to submit a response to be published as an appendix to it. No reply was received.

Executive summary

This paper compares empirical observations of extreme weather events with their coverage in the 2021 Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC). The conclusions of AR6 are contrasted with observational data described in recent research papers and reports, particularly in relation to droughts, tropical cyclones, heatwaves (including marine heatwaves) and cold extremes. The paper also covers major floods, tornadoes, wildfires and coral bleaching, with a short update of the discussion of disaster risk analysis in my report last year.[2]

In a shift of its previous stance, the IPCC claims, for the first time, that climate change is now affecting many weather extremes all over the globe. While this is not true and contrary to the available evidence, AR6 does follow earlier IPCC reports in not making any *strong* statements attributing extreme weather to global warming.

The IPCC claim that agricultural and ecological droughts are increasing is wrong. Several recent research studies have confirmed the lack of any long-term trend in drought worldwide over at least a millennium, with no evidence that modern global warming has played any role so far.

AR6 links tropical cyclones (hurricanes, typhoons and tropical storms) to global warming with a statement that the proportion of major tropical cyclones has increased across the globe since 1980. Although this assertion appears to be correct, a 2021 study found that the observation merely reflects improvements in measurement capabilities since 1970, and is unlikely to be a genuine climate trend. Hurricanes overall show a decreasing trend around the globe, and the frequency of landfalling hurricanes of any strength (Categories 1 through 5) has not changed for at least 50 years.

Claims of strengthened evidence for attribution of heatwaves to global warming, and their more frequent occurrence, can be questioned because data before 1950 is largely ignored in AR6. In the US, for which there are detailed heatwave records back to 1900, a quite different picture emerges. The Hadley temperature compilation, which underlies the IPCC position that heatwaves are on the rise globally, needs to be tested on the much larger US dataset to see if it can reproduce the US data profile. Furthermore, the modern heatwave trend in AR6 is artificially exaggerated because the 1950 start date used is in the middle of a 30-year period of global cooling, from 1940 to 1970.

There is no convincing empirical evidence for the AR6 declaration that the frequency of marine heatwaves has doubled since the 1980s. Because sea-surface temperature data from the pre-satellite era was unreliable and sparse, earlier marine heatwaves were likely missed. And the magnitudes of current marine heatwaves are most likely overestimated due to uncertainties in the marine datasets.

A statement in AR6 that cold extremes have become *less* frequent and severe is also wrong. Observational evidence shows that cold extremes are increasing and may have become more severe, a fact even acknowledged by the IPCC's sister UN agency, the World Meteorological Organization (WMO).

And, although AR6 wrongly states that coral bleaching and mortality events have increased in recent decades, the report fails to note that such phenomena are not new. There is empirical evidence for bleaching of Australia's Great Barrier Reef dating back to 1575, long before modern global warming began. This is another example of the IPCC's neglect of history.

Wisely, AR6 does not change the IPCC's previous position on floods, tornadoes or wildfires. But its conclusions about droughts, tropical cyclones, heatwaves and cold extremes cannot be justified by actual observations.

1. Introduction

Until last year, the ongoing assessment and special reports of the UN's Intergovernmental Panel on Climate Change (IPCC) served as the authority on climate science. And the panel stood out, among those who believe in the narrative of largely human-caused climate change, as a voice of restraint on weather extremes. Reports spanning the period from 1990 to 2019 found little to no evidence attributing extreme weather to global warming, except for heavier rainfall in some regions, and emphasised the difficulty of identifying any robust trends in weather extremes.

The IPCC shifted its stance somewhat in 2021, with the Sixth Assessment Report (AR6) asserting, for the first time, that climate change is 'already affecting many weather and climate extremes in every region across the globe'.[1] However, when it comes to the attribution of changes in climate extremes to human activity, the report still does not make any strong statements, and even the relatively weak claims it makes regarding heatwaves depend on the dataset used.

This paper reviews AR6's coverage of extreme weather events and compares it with empirical data in recent research papers and reports, particularly in the areas of droughts, floods and tropical cyclones (hurricanes, typhoons and tropical storms). It also covers tornadoes, wildfires, heatwaves, cold extremes and coral bleaching. Additionally, it includes a short update of the discussion of disaster-risk analysis in last year's GWPF report on extreme weather.[2]

2. The evolving position of the IPCC

While the IPCC has always been a leading advocate for the theory of man-made climate change, it has hedged its bets on linking weather extremes to global warming. In a 2012 *Special Report on Extreme Events and Disasters*, it limited itself to the statement that a changing climate 'can result' in unprecedented extreme weather, while going on to say:

> Some climate extremes (e.g., droughts) may be the result of an accumulation of weather or climate events that are not extreme when considered independently. Many extreme weather and climate events continue to be the result of natural climate variability.[3]

One year later, in its 2013 Fifth Assessment Report, on the topic of droughts, the IPCC stated:

> …conclusions regarding global increasing trends in droughts since the 1970s should be tempered. There is not enough evidence to support medium or high confidence of attribution of increasing trends to anthropogenic forcings as a result of observational uncertainties and variable results from region to region.[4]

On tropical cyclones, both the 2012 and 2013 reports expressed only 'low' confidence that activity was increasing over the long term, and that observed global changes could be attributed to any particular cause.[3,5] The same claim was made in the 2019 *Special Report on the Ocean and Cryosphere*, in which the IPCC declared:

> The lack of confident climate change detection for most tropical cyclone metrics continues to limit confidence in both future projections and in the attribution of past changes and tropical cyclone events…[6]

Even on heatwaves, the 2013 report restricted itself to the following regional, rather than global, statement:

> It is *likely* that the frequency of heatwaves has increased in large parts of Europe, Asia and Australia.[5]

In many respects, the IPCC's 2021 AR6 endorses its earlier conclusions. However, its language on some topics has changed to suggest that attributable trends now exist. As I will show, this position is not supported by the underlying data. On droughts, tropical cyclones and heatwaves, AR6 has this to say (my emphasis):

> Evidence of observed changes in extremes such as *heatwaves*, heavy precipitation, *droughts*, and *tropical cyclones*, and, in particular, their attribution to human influence, has strengthened since AR5.[1]

and

> Many changes in the climate system become larger in direct relation to increasing global warming. They include increases in the frequency and intensity of…. agricultural and ecological *droughts* in some regions, and proportion of intense *tropical cyclones*…[7]

Nonetheless, an examination of detailed trends shows that the IPCC remains very cautious in its assessments. In addition to the foregoing declarations, AR6 states that few regions exhibit increases in meteorological droughts and that the evidence for attributable trends is inconclusive in most regions studied. On floods, the report maintains the 'low' confidence of AR5 in any global trends. Likewise, it continues to express 'low' confidence in any long-term trends in tropical cyclone intensity, partly due to poor data quality earlier in the 20th century.

On other types of extreme weather, AR6 has intensified the language used in earlier assessment reports. For example, the terms 'very likely' and 'high' confidence have replaced 'likely' and 'medium' confidence, respectively, in many statements about the purported connection between weather extremes and global warming. It should be noted, however, that the IPCC's likelihoods and confidence levels represent a subjective evaluation of the underlying evidence, rather than a statistical analysis of the data.

3. Droughts

In its Summary for Policymakers, AR6 connects droughts to global warming with 'medium' confidence, saying:

> Human-induced climate change has contributed to increases in agricultural and ecological droughts in some regions due to increased land evapotranspiration.[1]

Droughts are usually classified as meteorological, soil moisture (agricultural and ecological), or hydrological, although these are effectively successive stages of the same drought. A meteorological drought describes a precipitation deficit alone, while an agricultural and ecological drought results from a deficit in precipitation combined with abnormal dryness of the soil. This combination has a negative impact on the growth of crops and other aspects of the ecosystem. A hydrological drought refers to the ensuing decreases in streamflow, reservoir levels and groundwater.

While AR6 emphasises the purported effect of global warming on agricultural and ecological droughts, it includes numerous statements linking meteorological and hydrological droughts to climate change as well – although the report does express only 'low' confidence in its conclusions on the latter. The supposed link between drought and global warming is mirrored by another UN agency, the UN Office for Disaster Risk Reduction (UNDRR), in its *Special Report on Drought 2021,* which concludes that:

> …climate change is increasing the frequency, severity and duration of droughts in many regions across the world.[8]

The scientific evidence does not support the two agencies' position that drought conditions around the world are worsening, let alone that it is because of global warming. An examination of the historical record, which the IPCC largely ignores, quickly confirms that droughts have been a continuing feature of the earth's climate for millennia, a fact that has been confirmed by several recent research studies.

For example, a 2007 US study[9] was able to reconstruct the drought pattern in North America over the last 1200 years, using tree rings as a proxy. The width and colour of the rings constitute a record of past climate, including droughts. The reconstruction, illustrated in Figure 1, reveals that several unprecedently long and severe 'megadroughts' have occurred in western North America since the year 800, droughts that the study authors remark have never been experienced in the modern era. This is emphasised in Figure 1 by the comparison between the period from 1900 to 2003 and the much more arid, 400-year interval from 900 to 1300.

As evidence that the 2007 study's conclusions extend beyond 2003, Figure 2 depicts observational data showing the percentage of the contiguous US in drought from 1895 up until 2015.[10] Comparison of Figure 2 with the yearly data in Figure 1

Figure 1: Drought area in western North America, 800–2003.

The thick blue and red horizontal lines represent the average drought area during 1900–2003 and 900–1300, respectively. Source: Edward R. Cook et al.[9]

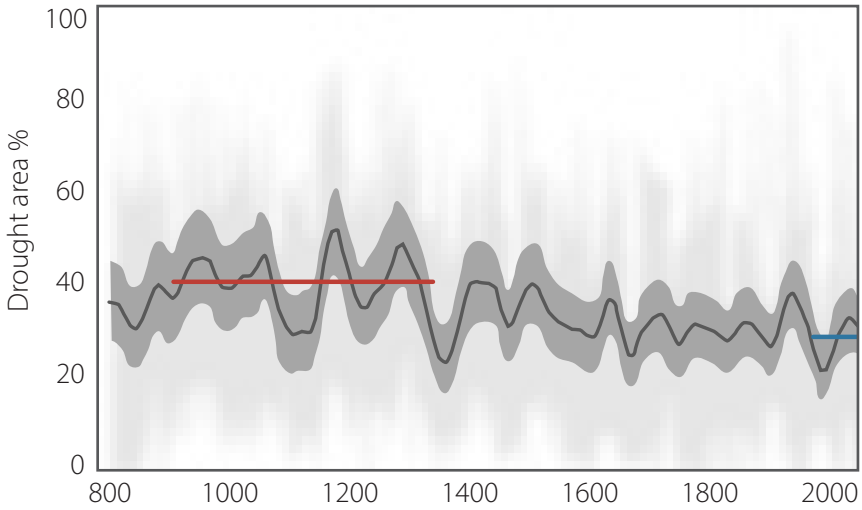
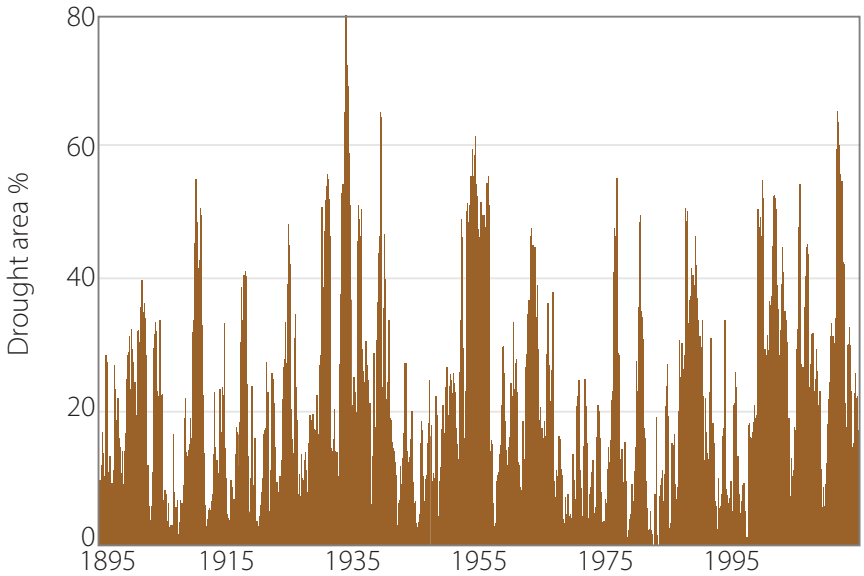


Figure 2: Percentage of contiguous US in drought, 1895–2015.

Based on the Palmer Drought Severity Index (PDSI). Source: NOAA/NCEI.[10]



(indicated in gray; the thick black line is a 60-year mean), shows that the long-term pattern of overall drought in North America continues to be featureless, despite global warming during both the Mediaeval Warm Period and today. A similar conclusion was reached by a 2021 study[11] that compared the duration and severity of US hydrological droughts between 1475 and 1899 to those from 1900 to 2014.

There are regional variations, however. A 2021 research paper found that, from 1901 to 2017, the risk of meteorological droughts increased in the southwestern and southeastern US, while it decreased in northern states.[12] A very recent 2022 paper claims that the southwestern US is currently experiencing its driest 22-year period since at least the year 800, although it does not attribute this entirely to climate change.[13] The UNDRR report finds that such regional differences in drought are not restricted to the US, but occur worldwide.[8] And AR6, despite its blanket statement above about increased regional droughts caused by climate change, concedes that a recent harsh drought in Madagascar cannot be attributed to global warming.[1]

Just like North America, Europe has also experienced megadroughts over the past millennium, although in different periods. Figure 3 shows a 2021 European reconstruction,[14] also from tree ring proxies, of the drought pattern in central Europe from 1000 to 2012, with observational data from 1901 to 2018 superimposed. (Note that dryness is denoted by negative values in Figure 3, compared to positive values of drought area in Figures 1 and 2.) The authors of the study point out that the droughts from 1400 to 1480 and from 1770 to 1840 were much longer and more severe than those of the 21st century. Their conclusions are reinforced by the results of another recent study, which failed to find any statistically significant trend in meteorological droughts in western Europe during the last 170 years.[15]

What stands out in all these studies is the lack of any long-term trend in drought worldwide over at least a millennium. There is no evidence of the warming that began in the late 19th century, after the Little Ice Age ended, having played any role so far. Indeed, ice cores from Antarctica demonstrate that much more dust – a sign of a dry climate – was deposited during the ice ages than during warmer interglacial periods. Even the UNDRR acknowledges that one of the main sources of episodic droughts globally is the natural El Niño Southern Oscillation.[8]

In conclusion, although AR6 claims with high confidence that 'the frequency of concurrent heatwaves and droughts on the global scale' are increasing,[1] the scientific evidence doesn't support such a bold assertion.

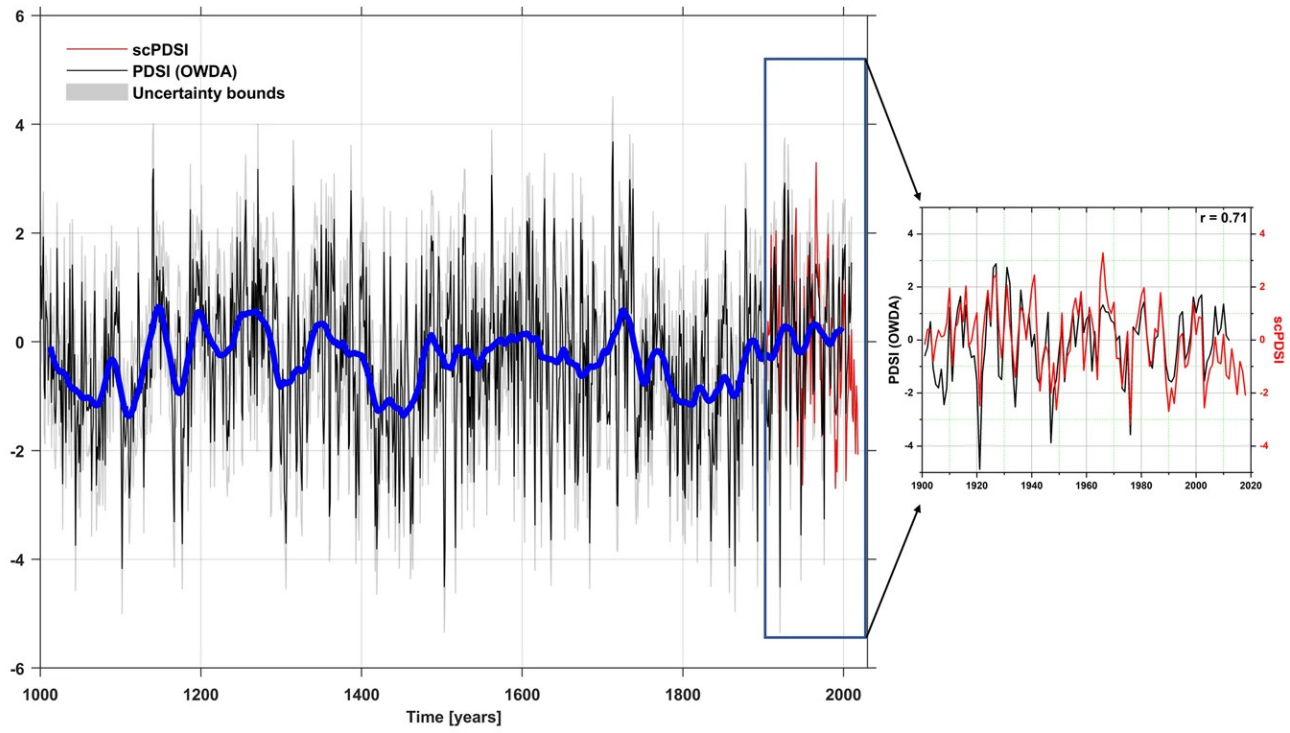


Figure 3: Drought in central Europe, 1000–2018.

Black: Palmer Drought Severity Index (PDSI); red: self-calibrated PDSI (scPDSI); blue: 31-year mean. Source: M. Ionita et al.[14]

4. Floods

On floods, AR6 has little to say, conceding that:

> *Confidence* is in general *low* in attributing changes in the probability or magnitude of flood events to human influence because of a limited number of studies and differences in the results of these studies…[16]

A 2022 assessment of possible trends in extreme weather goes even further than the IPCC, observing that 'a long list of studies shows little or no evidence of increased flood magnitudes, with some studies finding more evidence of decreases than increases'.[17]

Just as for heatwaves and droughts, there is no evidence that floods are becoming worse or more common. Precipitation tends to increase in a warmer world because of enhanced evaporation from tropical oceans, resulting in more water vapour in the atmosphere. Yet floods caused by rain occur only under specific weather conditions.

A 2017 study of global flood risk concluded there is very little evidence that flooding is becoming more prevalent worldwide.[18] Despite average rainfall getting heavier as the planet warms, the study authors pointed out that excessive precipitation is not the only cause of flooding; alterations to catchment areas – such as land-use changes, deforestation and the building of dams – also play a major role. AR6 recognises this, saying that:

> In addition to precipitation, flooding also depends on basin and river characteristics such as permeability, antecedent soil moisture, and antecedent flow levels for river flooding, so projections of extreme precipitation and flooding are not always closely linked.[19]

The same 2017 study found that major floods in the northern hemisphere between 1931 and 2010 were not caused by global warming, although they were influenced by the climate. The strongest influence is the Atlantic Multidecadal Oscillation, a natural ocean cycle that causes heavier-than-normal rainfall in Europe and lighter rainfall in North America during its warm phase, leading to an increase in major European floods and a decrease in North American ones.

Widespread flooding in Europe and western Canada in 2021 occurred too late for consideration in AR6. But despite the hoopla in the mainstream media, it is not the first time the flooded areas have suffered catastrophic flooding. For example, the Ahr valley in Germany, which was struck in July 2021, experienced major floods in the same locations on 12 June 1910, when at least 52 people were killed.[20] Germany in fact has been battered by devastating floods many times during the last few centuries, including a 1717 Christmas Eve flood that killed 13,700 people.[21] Likewise, the British Columbia flooding caused by record rainfall in November 2021 was no worse in extent than that of a flood in 1894.[22]

5. Hurricanes

As with drought, AR6 for the first time links tropical cyclones to global warming with 'medium' confidence, stating:

> It is *likely* that the global proportion of major (Category 3–5) tropical cyclone occurrence has increased over the last four decades, and the latitude where tropical cyclones in the western North Pacific reach their peak intensity has shifted northward; these changes cannot be explained by internal variability alone.[1]

and, with 'high' confidence:

> …it is *very likely* that the recent active tropical cyclone seasons in the North Atlantic, the North Pacific, and Arabian basins cannot be explained without an anthropogenic influence.[16]

But an examination of the historical record and recent research papers reveals that there is no empirical evidence for either of these assertions, once the paucity of data in the early 20th century is taken into account.

Hurricanes are classified by their sustained wind speeds on the Saffir-Simpson scale, ranging from Category 1, the weakest, to Category 5, the strongest. A major hurricane is defined as one in Category 3, 4 or 5, corresponding to a top wind speed of 178 km per hour (111 mph) or greater. Hurricanes occur in the Atlantic and northeastern Pacific Oceans, especially in and around the Gulf of Mexico; their cousins, typhoons, occur in the northwestern Pacific.

Figure 4 shows clearly that the frequency of tropical cyclones has diminished globally since 1981.[23] But because the number of major hurricanes (Category 3 or greater) has essentially remained

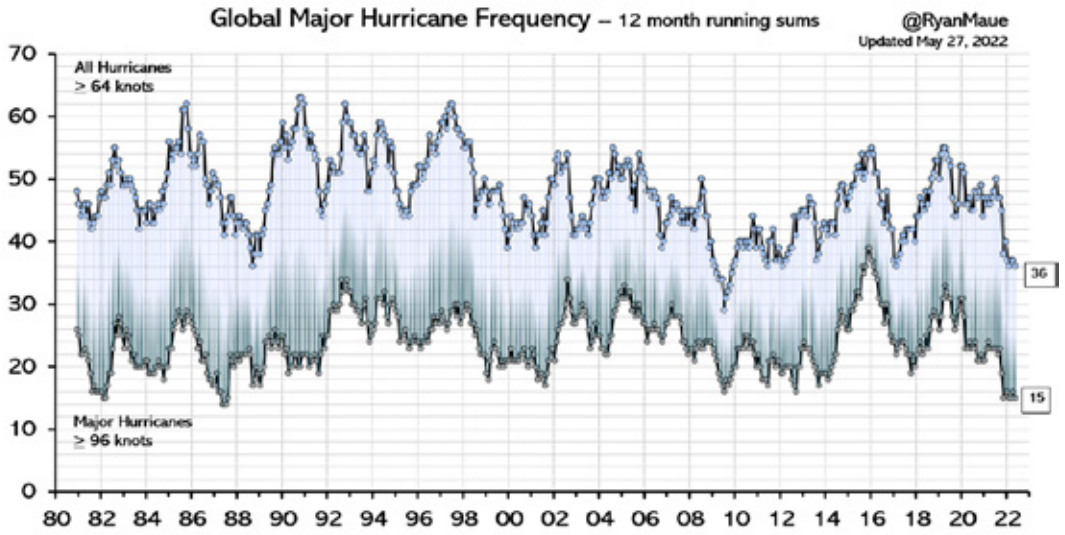


Figure 4: Annual number of global hurricanes, 1981–2021.

Maximum wind speed at least Category 1 hurricane strength (top), Category 3 hurricane strength (bottom). Source: Ryan N. Maue.[23]

constant over that period, it appears that the IPCC's assertion above about the *proportion* of major hurricanes increasing is correct. However, a team of experts concluded in a 2021 study that, at least in the Atlantic, the recent apparent increase in major hurricanes (Figure 5) simply reflects improvements in observational capabilities since 1970 and is unlikely to be a true climate trend.[24]

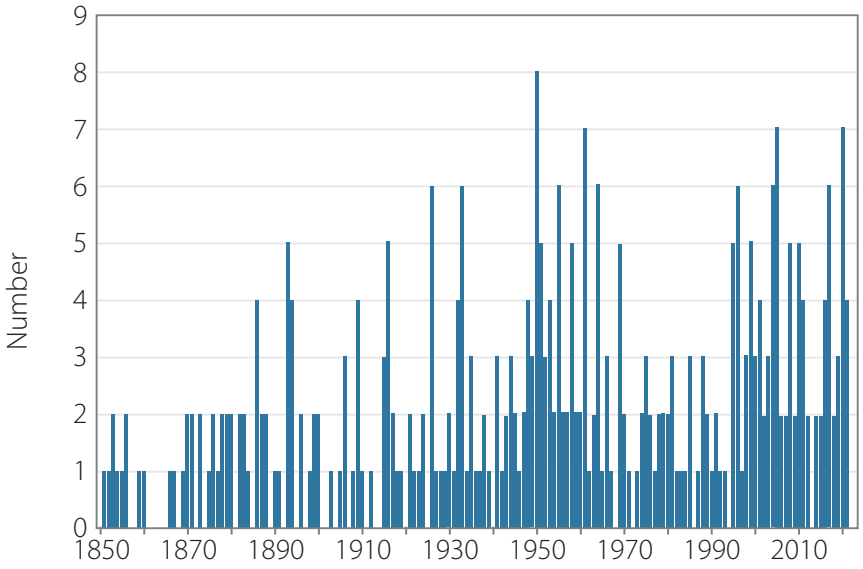


Figure 5: Annual number of major North Atlantic hurricanes, 1851–2021.

At least Category 3 hurricane strength. Source: Paul Homewood.[27]

While long-term data on major typhoons is not available, the frequency of all typhoon categories combined appears to be unchanged since 1951.[25] Yet a 2022 study demonstrates a decline in both total and major typhoons for the 32-year period from 1990 to 2021.[26] The same study reinforces the recent decrease in total global hurricanes seen in Figure 4.

Data for the North Atlantic basin, which has the best quality data in the world, do indeed show heightened hurricane activity over the last 20 years, particularly in 2005 and 2020. Figure 5 illustrates the frequency of all major North Atlantic hurricanes from 1851 to 2021.[27] It shows that the frequency of major North Atlantic hurricanes in recent decades is comparable to that in the 1950s and 1960s. However, because the Earth was cooling during the increased activity in the 1950s and 1960s, global warming does *not* offer a satisfactory explanation for the present uptick in major North Atlantic hurricanes, as the IPCC's second assertion above insists it does. The US National Oceanic and Atmospheric Administration (NOAA) links heightened Atlantic hurricane activity to the warm phase of the Atlantic Multidecadal Oscillation (AMO).[28]

The lower numbers before 1940 reflect the relative lack of observations in early years of the record; satellite coverage of hurricanes dates only from the 1960s. The team of experts mentioned above found that once they corrected the data for undercounts in the pre-satellite era, there were no significant recent increases in the frequency of either major or all North Atlantic hurricanes. They suggest that the reduction in major hurricanes between the 1970s and the 1990s could have been the result of

multidecadal internal climate variability (such as the AMO) or possibly aerosol-induced weakening.[24]

The lack of any long-term trend in major global hurricanes is borne out by the number of hurricanes that have made landfall over the last 50 years, illustrated in Figure 6. The apparent slight upturn in both total and major landfalling hurricanes over this period is statistically insignificant,[29] and could be an artifact, as discussed for North Atlantic hurricanes above. In the US, major landfalling hurricanes correlate with La Niña cycles in the Pacific Ocean, not with global warming.[30]

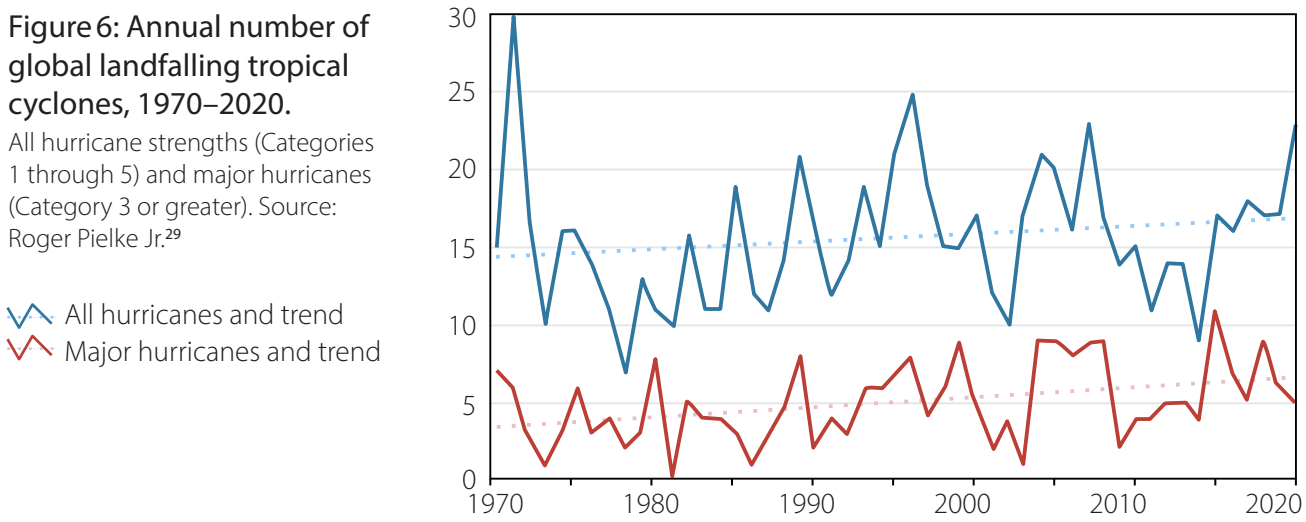


Figure 6: Annual number of global landfalling tropical cyclones, 1970–2020.
All hurricane strengths (Categories 1 through 5) and major hurricanes (Category 3 or greater). Source: Roger Pielke Jr.[29]

The second part of the IPCC's first assertion above, about poleward migration of typhoons in the North Pacific not being attributable to internal variability alone, is dubious. The poleward shift of approximately 56 km (35 miles) per decade since 1980 is a well-established phenomenon, but there is significant disagreement on its causes and what role, if any, global warming plays.[31]

AR6 mentions two other aspects of tropical cyclones that have been observed recently, namely more rapid intensification and slower forward speed. Both phenomena result in heavier rain following landfall. However, the IPCC does not attribute them to global warming, and indeed their origins are not yet understood.

6. Tornadoes

As with floods, AR6 has relatively little to say about tornadoes. The IPCC report does concede, with 'medium' confidence, that:

> …the mean annual number of tornadoes in the United States has remained relatively constant…since the 1970s,

but goes on to state that:

> …their variability of occurrence has increased, particularly over the 2000s, with a decrease in the number of days per year and an increase in the number of tornadoes on these days.[16]

The second statement may be true, but any change since 2000 is not likely to be associated with global warming, which began a century or more earlier.

A tornado is a rapidly rotating column of air, usually visible as a funnel cloud, that extends like a dagger from a parent thunderstorm to the ground. While tornadoes are smaller and claim fewer lives than hurricanes, they form rapidly, and frequently demolish homes and buildings in their often narrow path. Tornadoes are categorised according to wind speed, using the Fujita Scale, which goes from EF0 to EF5. EF5 tornadoes have wind speeds of up to 480 km per hour (300 mph).

As shown in Figure 7, the annual incidence of all EF1 or stronger tornadoes in the US[32] shows no meaningful trend from 1950 to 2021, reinforcing the AR6 statement above. This is a period that included both warming and cooling spells, with net global warming of approximately 1.0°C (1.8°F) during that time.[33] If EF0 tornadoes are included, the same plot shows an apparent increase in annual number since 1990, but that is simply due to the introduction of Doppler weather radar in the early 1990s, which led to the reporting of more tornadoes than before.[34]

However, as shown in the lower panel, the annual number of *strong* tornadoes (EF3 or greater)[35] has declined dramatically over the last 72 years. In fact, the average number of strong tornadoes annually from 1986 to 2017 was 40% less than from 1954 to 1985.[36] Global warming, which might be expected to increase strong tornado activity, cannot have played any role.

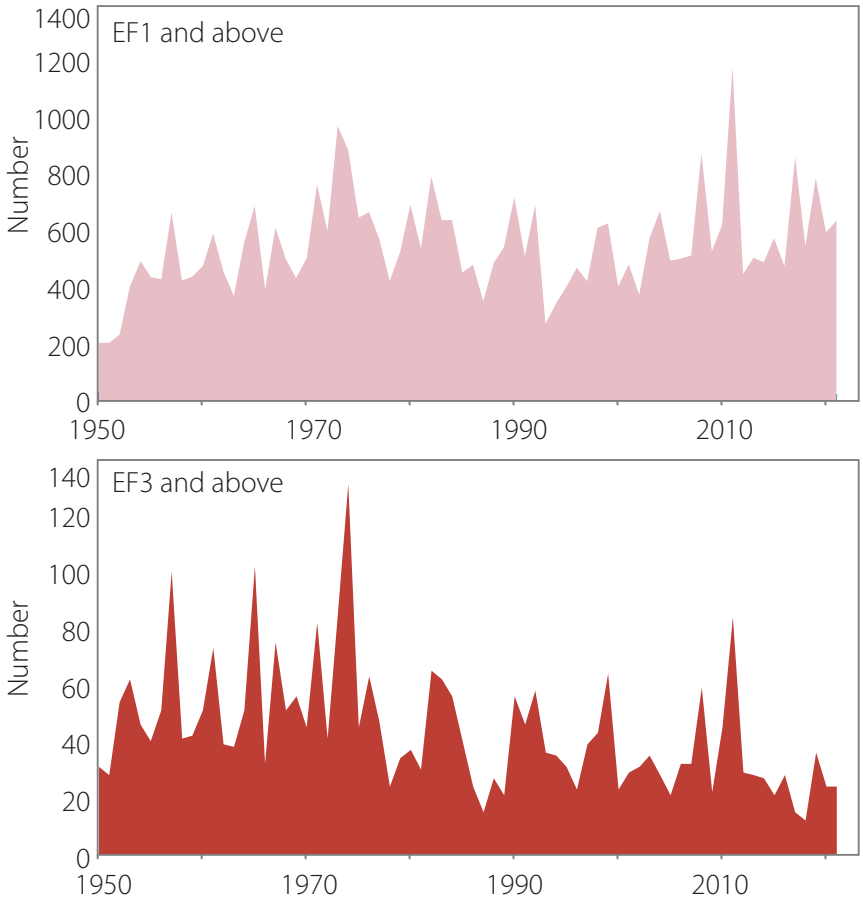


Figure 7: Annual count of tornadoes in the US, 1950–2021.

Top, EF1 and above; bottom, major tornadoes (defined as EF3 and above). Source: NOAA/NCEI.[32,35]

As AR6 points out, tornado activity can vary markedly from year to year. For example, 13 successive days of US tornado outbreaks in 2019 saw well over 400 tornadoes touch down in May, with June a close second – and this following seven quiet years ending in 2018, which was the quietest year in the entire record since 1954.[37] However, there is no scientific evidence linking the increase in daily-scale variability and climate change.[38]

Another apparent trend is geographic. A 2018 study[39] found that EF1 or stronger tornadoes and tornado-favourable conditions have become more frequent in the mid-south of the US and less frequent in the traditional 'Tornado Alley', an area extending northward from central Texas through the plains states. But again, this eastward shift has not been linked to climate change.

7. Wildfires

On wildfires, AR6 has even less to say than on floods or tornadoes, with no mention of the subject in the Summary for Policymakers. This is appropriate because wildfires are not a form of extreme weather, or indeed of weather at all, although they can produce their own weather. However, wildfires are included in this report, as they have been in previous GWPF reports on extreme weather,[2] since they can be made worse by weather extremes such as heatwaves or drought. In addition to drying out of vegetation, wildfires require sustained high temperatures, low humidity, winds, and a source of ignition. A common form of ignition is lightning strikes during dry thunderstorms.

The only statements that AR6 does make on wildfires are:

> There is *medium confidence* that weather conditions that promote wildfires have become more probable in southern Europe, northern Eurasia, the USA, and Australia over the last century.[40]

and

> Climatic conditions conducive to wildfire have increased in Mexico, Western and Northwest North America, essentially due to warming (*high confidence*).[41]

However, as discussed elsewhere, there is so far almost no evidence that either heatwaves (Section 8) or drought (Section 3) are becoming more frequent or more intense with global warming – which means that the IPCC's statements about wildfires are invalid.

In fact, the evidence shows that the annual area burned by wildfires, at least in southern Europe and Australia, is declining, despite hysterical claims to the contrary by the mainstream media. This is illustrated in Figures 8 and 9.[42,43] As can be seen, the area burned annually in southern Europe has dropped by half over the last 40 years; the trend is also strongly downward for the rest of the European Union. The area burned in Australia (Figure 9) has fallen by a similar amount since 1980.

Figure 8: Annual forest area in southern Europe burned by wildfires, 1980–2019.

Southern EU defined as Portugal, Spain, France, Italy, Greece. Least-squares trend lines. Source: Bjørn Lomborg.[42]

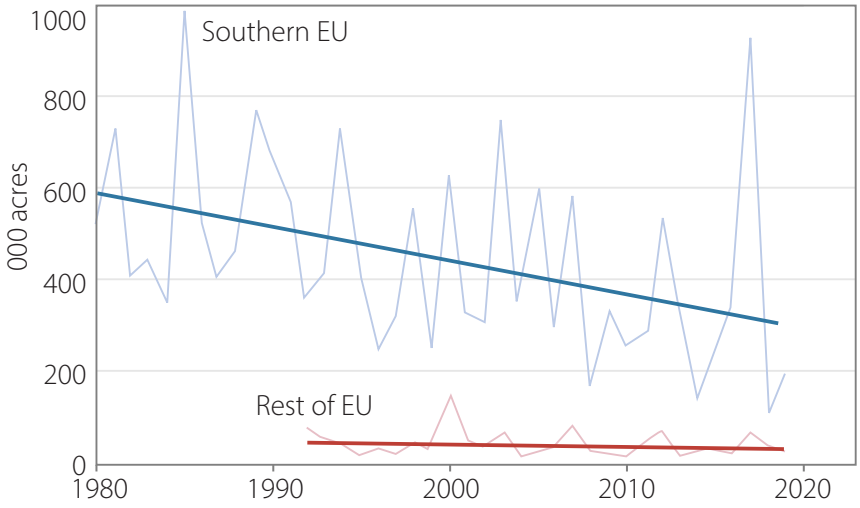


Figure 9: Australian area burned by wildfires, 1905–2020.

Percentage of total land area of 769 million hectares; estimates by decade 1905–1995, satellite measurements 1997–2020. Source: Bjørn Lomborg.[43]

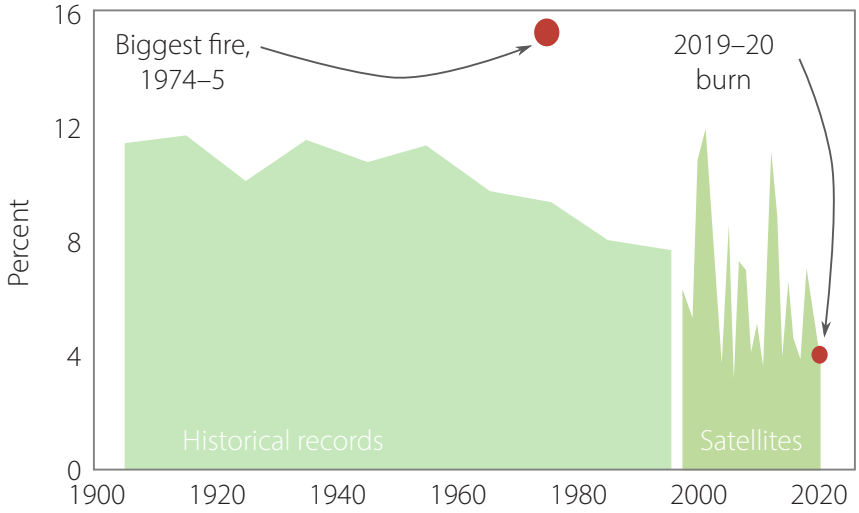
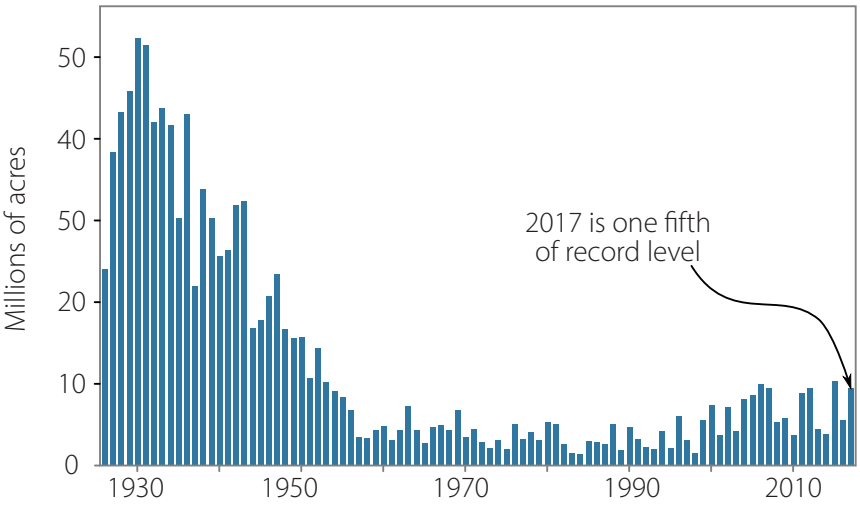


Figure 10 shows that in the US, while the number of acres burned annually has gone up over the last 20 years or so, the present area consumed is still only a small fraction of what it was back in the 1930s – when modern global warming was barely underway.[44] The main reason for the recent uptick in US fires is decades of wildfire suppression, which has led to considerable increases in forest density and the buildup of undergrowth. Both of these factors greatly enhance the potential for bigger and sometimes hotter fires. Poor management of California's forests has resulted in overcrowding, which leaves them 'susceptible to

Figure 10: Annual US forest area burned by wildfires, 1926–2017.

Source: National Interagency Fire Center.[44]



disease, insects and wildfire', noted the Little Hoover Commission in 2018.[45] An encouraging sign is that US fire scientists, who understand the need to thin forests and clear undergrowth, are successfully pushing back against environmental activists who blame global warming for the massive wildfires that erupt in the western US every year.[46] In Europe, better forest management is largely responsible for the downward trend in wildfires.

A more detailed discussion of wildfires and global warming can be found in last year's GWPF extreme weather report.[2]

8. Heatwaves

Atmospheric heatwaves

A heatwave is defined as a period of abnormally hot weather, lasting from days to weeks. On atmospheric heatwaves, AR6 makes the following declarations:[1]

> Evidence of observed changes in extremes such as heatwaves…and, in particular, their attribution to human influence, has strengthened since AR5.

and

> It is *virtually certain* that hot extremes (including heatwaves) have become more frequent and more intense across most land regions since the 1950s…

Nevertheless, these claims of strengthened evidence for attribution of heatwaves to global warming – and their more frequent occurrence – can be questioned, because data before 1950 is largely ignored in AR6. In the US, which has detailed heatwave records back to 1900, a quite different picture emerges.

Figure 11 shows the frequency and magnitude of heatwaves in the US from 1901 to 2018. The frequency (top panel) is defined as the annual number of calendar days the average US maximum temperature exceeded the 90th percentile for 1961–1990 for at least six consecutive days, in a window centered on that calendar day;[47] it represents the total duration of all heatwaves of six days or longer in that year.

It is clear from Figure 12 that there were far more frequent and/or longer US heatwaves, and they were hotter, in the 1930s than in the present era of global warming. The total annual heatwave (warm spell) duration is seen to have dropped from 11 days during the 1930s to about 6.5 days during the 2000s. The peak heatwave index (lower panel) in 1936 was a full three times higher than in 2012 and up to nine times higher than in many other years. In addition, the average maximum temperature during any particular heatwave has declined from 38°C (101°F) in the 1930s to 37°C (99°F) since the 1980s.[47]

Further evidence that current US heatwaves are nothing remarkable is provided by Figure 12, which shows the average number of daily high-temperature records set per decade from 1922 to 2021.[48] With the exception of the abnormally hot 1930s,

Figure 11: Observed changes in atmospheric heatwaves in the contiguous US, 1901–2018.

Top: frequency; bottom: magnitude. Source: CSSR.[47]

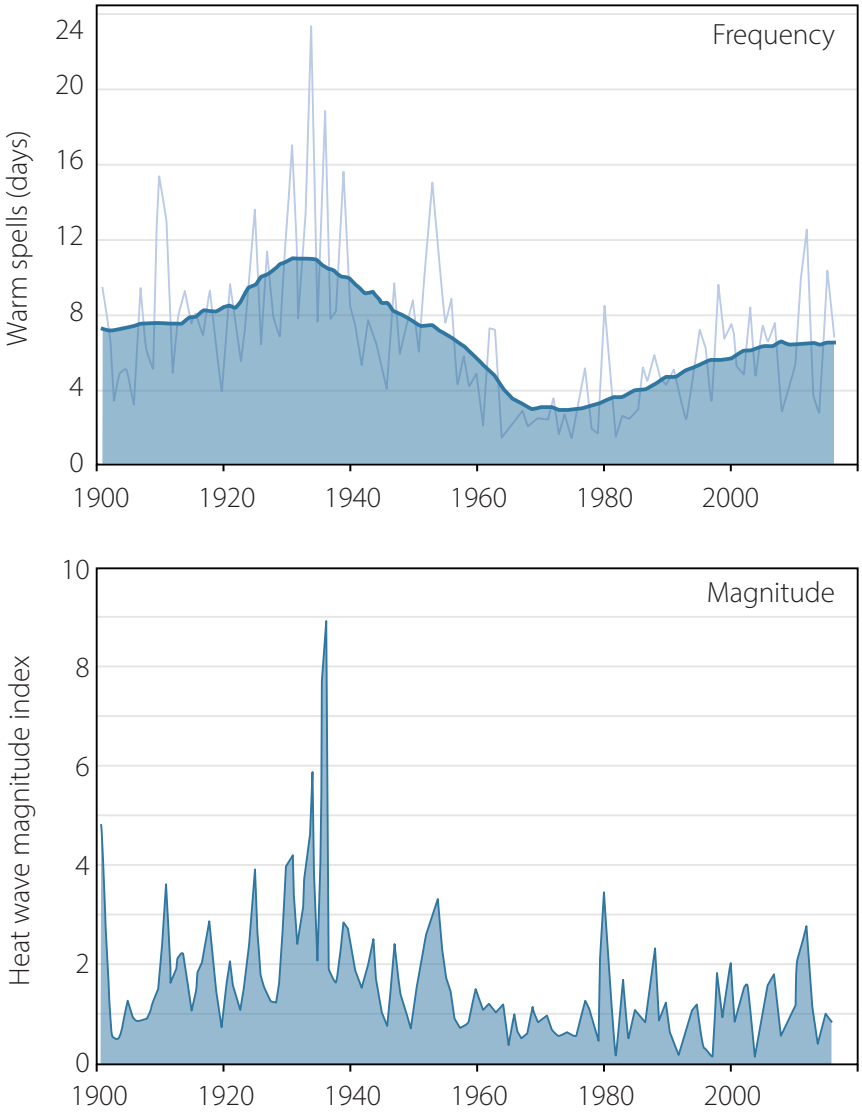
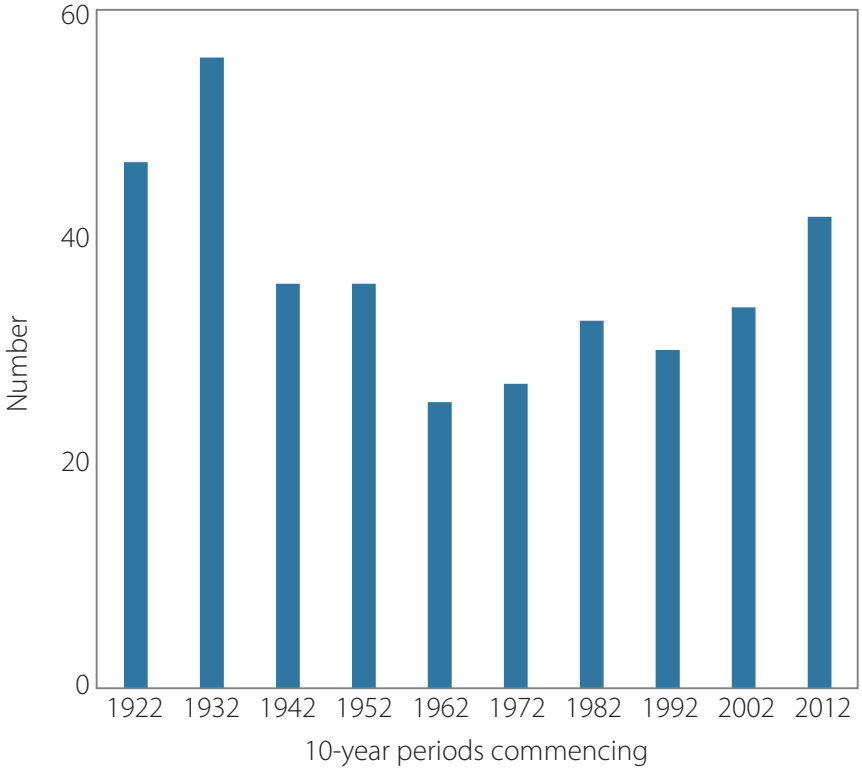


Figure 12: Average number of US daily high-temperature records per station, 1922–2021.

Average over 534 stations, each with more than 105 years of data. Source: NOAA/NCEI/USHCN, prepared by John R. Christy.[48]



the number of records per decade is seen to be almost constant over the last 100 years.

One of the main sources of global heatwave and other temperature data for AR6 is a compilation by a large international group of climate scientists and meteorologists, who last updated their dataset in 2020.[49] The dataset is derived from the UK Met Office Hadley Centre's HadGHCND gridded daily temperature database. Figure 13 shows the group's global heatwave frequency (lower panel) from 1901 to 2018, and the calculated global trend (upper panel) from 1950 to 2018. The definition of heatwave frequency is the same as for Figure 11.

It is apparent from Figure 13 that the Hadley Centre dataset does indeed support the AR6 position that heatwaves are on the rise globally. The post-1950 heatwave frequency can be seen to exceed that in the 1930s, when the US heatwave frequency peaked so dramatically (Figure 11). However, the Hadley global dataset used only 942 US temperature stations to calculate the

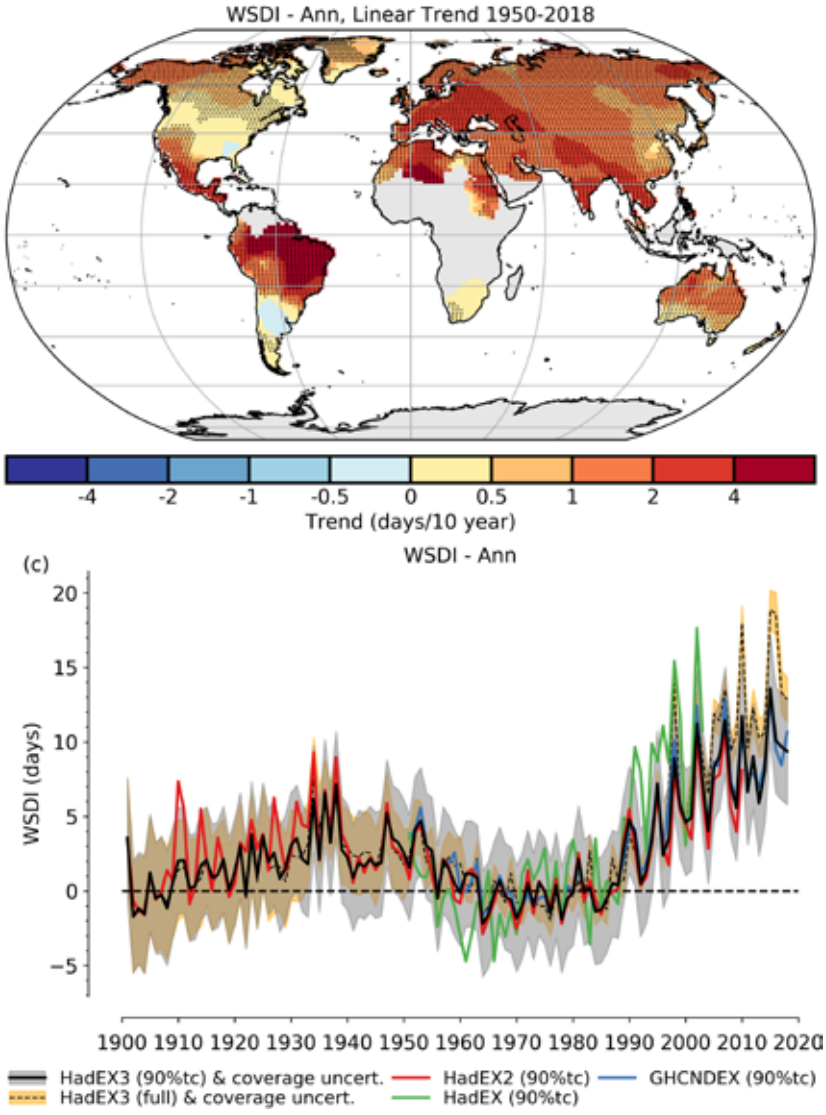


Figure 13: Observed changes in atmospheric heatwaves across the whole globe, 1901–2018.

Top: global trend from 1950; bottom: frequency. Source: Robert J. H. Dunn et al.[49]

average maximum temperature,[49] compared with as many as 11,000 stations in the US dataset used for Figure 11.[50] Although both US and global records show an increase in the total annual heatwave duration since 1970, the US increase to 6.5 days is well below its 1930s level of 11 days – a level that is only about 7 days in the global record depicted in Figure 13. Before one can have any confidence in the Hadley global compilation, it needs to be tested on the much larger US dataset to see if it can reproduce the US data profile.

Another 2020 compilation[51] of global heatwave data cited in AR6 draws on the much larger Berkeley Earth temperature dataset. The Berkeley Earth dataset employs five times as many stations as other gridded temperature products, thus providing much greater spatial coverage, and at a finer resolution, than the Hadley database used in Figure 13. Nonetheless, this alternative heatwave compilation is incomplete since, like AR6, it neglects data before 1950.

A significant feature of the global trend data from 1950 in Figure 13 is a strong variation from country to country. The purported trend varies from an increase of more than 4 heatwave days per decade in countries such as Brazil, to an increase of less than 0.5 days per decade in much of the US and South Africa, and a decrease of 0.5 days per decade in northern Argentina. While regional differences are to be expected, it seems very unlikely that global warming would result in such large variations in heatwave trend worldwide; the disparities are more likely to arise from insufficient data. In addition, the trend is artificially exaggerated because the start date of 1950 was in the middle of a 30-year period of global cooling, from 1940 to 1970. A recent GWPF investigation of heatwaves in the UK found an increasing trend in heatwave frequency and duration at some locations, but a decreasing trend at others.[52]

A record-shattering 2021 heatwave in the Pacific northwest of North America occurred too late for consideration in AR6, but environmental activists and the mainstream media were quick to link the event, during which several cities experienced temperatures a full 5°C (9°F) above previous records, to global warming. A subsequent attribution study claimed this 1 in 1,000-year heatwave was virtually impossible, and would have been at least 150 times rarer, without human-caused climate change.[53]

Nevertheless, meteorologist Cliff Mass, who has published several research papers on Pacific northwest heatwaves, has shown that the study is deeply flawed, with errors of both science and interpretation.[54] Furthermore, event attribution studies that assign specific extremes to either natural variability or human causes use highly questionable methodology in general, the shortcomings of which have been discussed by statistician William Briggs in other recent GWPF publications.[55,56]

Marine heatwaves

On marine heatwaves, AR6 expresses 'high' confidence in the following declaration:

> Marine heatwaves have approximately doubled in frequency since the 1980s, and human influence has *very likely* contributed to most of them since at least 2006.[1]

Again, there is no convincing observational evidence for either of these assertions. The apparent increase in frequency of marine heatwaves since 1982 partly reflects the start of satellite measurements of ocean temperature, which are far more accurate and broader in coverage than measurements made by older methods such as ship thermometers and drifting buoys, or even the recently deployed Argo profiling floats. Because of the unreliability and sparseness of sea-surface temperature data from the pre-satellite era, it's obvious that earlier marine heatwaves may well have been missed.

But apart from this deficiency, analysis of the data that *is* available can be questioned. To begin with, nearly all of the studies cited in AR6 fail to take into account the overall ocean warming trend as the climate changes. Marine heatwaves are generally measured relative to the average sea surface temperature over a 30-year baseline period. This means that any heatwave measured toward the end of that period will appear hotter than it really is, since the actual temperature at that time will be higher than the 30-year baseline. As pointed out in a 2019 research paper from NOAA, not adjusting for the underlying warming falsely conflates natural regional variability with climate change, and overestimates the heatwave magnitude.[57]

Another shortcoming of marine data analysis is uncertainty about the dataset. As AR6 explains, two separate (but related) sets of marine temperatures exist: sea surface temperatures (SSTs), which measure the temperature of the water itself just under the surface, and marine air temperatures (MATs), which measure the near-surface air temperature over the oceans. Because ships' decks are heated and therefore cause a warm bias in MAT observations during the day, nighttime (NMAT) measurements are generally used, although the spatial coverage of NMAT data is less extensive than that of SSTs.[58] By definition, marine heatwaves include all days on which the SST exceeded the 99th percentile for 1982–2016, a slightly different definition than that of heatwaves on land.

However, a 2019 study discovered that NMATs increased 8–17% more rapidly than SSTs from 1900 to 2010, but 11–15% less rapidly than SSTs in the tropics from 1979 to 2010.[59] Such differences, together with the IPCC's lack of baseline adjustment discussed above, make it difficult to draw *any* conclusions about marine heatwaves. There is no justification, therefore, for AR6 asserting that marine heatwaves are becoming more common.

9. Cold extremes

Contradicting its sister agency the WMO, the IPCC in AR6 accompanies its comments on heatwaves by stating:

> …cold extremes (including cold waves) have become less frequent and less severe,[1]

with 'high' confidence that human-induced climate change is the main driver:

> It is *extremely likely* that human influence is the main contributor to the observed decrease in the likelihood and severity of cold extremes.[60]

That cold extremes are becoming less frequent is untrue, since they actually appear to be on the rise – as borne out by several recent research papers[61,62] of environmental scientist Madhav Khandekar, who also authored a 2013 GWPF report[63] on the topic.

Cold extremes, as defined by the WMO, include prolonged cold spells, unusually heavy snowfalls and longer winter seasons, as well as the IPCC's narrower definition of cold days and nights, and cold spells/cold waves. While cold extremes are becoming less severe according to the IPCC definition, Khandekar's evidence casts doubt on the assertion under the WMO's broader definition. In any case, the decrease in cold days and nights identified by the IPCC is expected as the world warms, and warmer nights may come as much from the urban heat island effect as from global warming. Alabama state climatologist John Christy has pointed out that the observed decline in the occurrence of record US low temperatures since 1911 can be explained by urbanisation around weather stations.[48]

While the emphasis of Khandekar's publications has been on recent harsh winters in North America, he has catalogued cold extremes in South America, Europe and Asia as well. Figure 14 shows the locations of the 4145 daily low-temperature records broken or tied in the northeastern US during the ice-cold February of 2015; that year tied with 1904 for the coldest January to March period in the northeast, in records extending back to 1895.

A 2021 example of a cold extreme was the North American cold wave in February, which brought record-breaking subfreezing temperatures to much of the central US, as well as Canada and northern Mexico. Texas experienced its coldest February in 43 years; the frigid conditions lasted several days and resulted in widespread power outages and damage to infrastructure. The deep freeze, which occurred after the cutoff for consideration in AR6, was ascribed to global warming by a team of climate scientists, who linked it to stretching of the Arctic stratospheric polar vortex.[64] Nevertheless, AR6 appears to contradict this conclusion, stating that 'it is likely that the northern lower stratospheric vortex has *weakened* [my emphasis] since the 1980s in midwinter'.[58]

Other exceptional cold extremes in 2021 included:

- the lowest average UK minimum temperature for April since 1922
- record low temperatures in both Switzerland and Slovenia the same month
- the coldest winter on record at the South Pole
- an all-time high April snowfall in Belgrade, in record books dating back to 1888
- the heaviest April snow in decades in Finland and Russia.[65]

Khandekar links colder and snowier-than-normal winters in North America not to climate change, but to the naturally occurring North Atlantic and Pacific Decadal Oscillations, and those in Europe to a slowdown in solar activity.

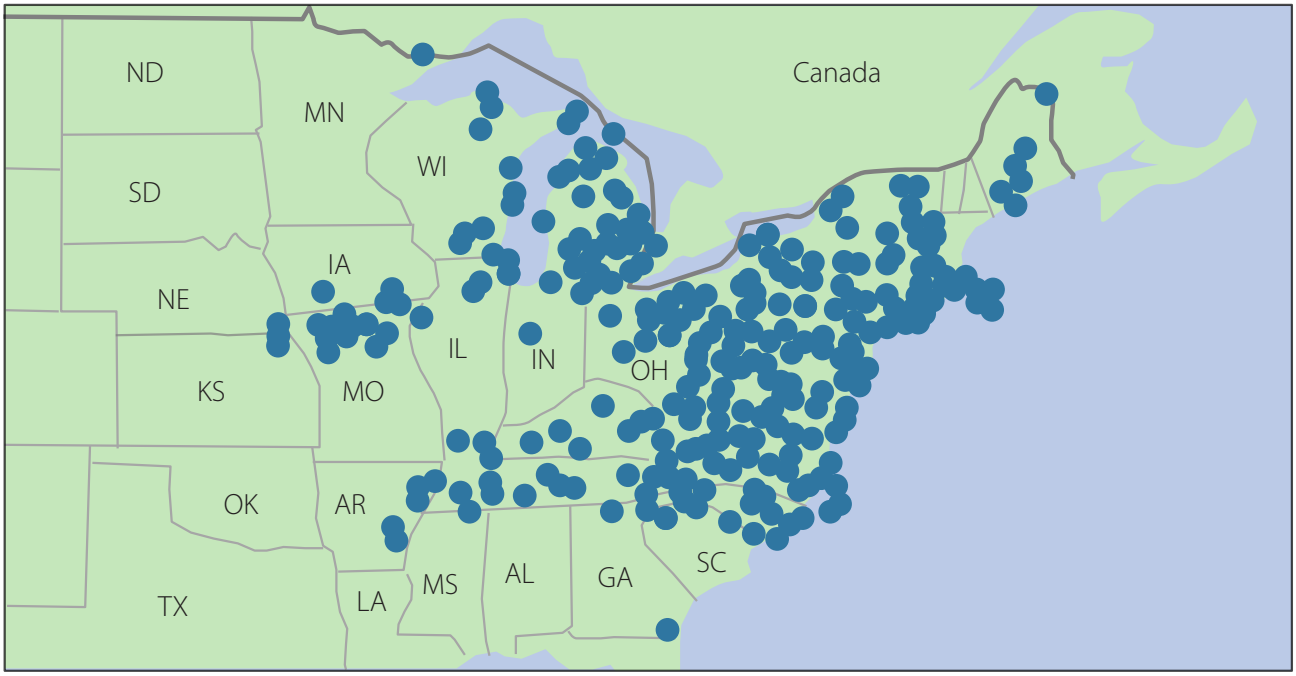


Figure 14: Locations of low-temperature records broken or tied in the US northeast, February 2015.

3573 record lows broken, 572 tied (total 4145).
Source: E. Ray Garnett and Madhav L. Khandekar.[61]

10. Coral bleaching

Although AR6 states that:

> The scope and severity of coral bleaching and mortality events have increased in recent decades,[66]

the report fails to note that bleaching is not a new phenomenon. A 2018 research paper found evidence for bleaching of Australia's celebrated Great Barrier Reef dating back to 1575,[67] long before modern global warming began. As with heatwaves, the IPCC has ignored history.

In fact, despite global warming, the Great Barrier Reef is doing better than ever. The most reliable data on coral extent comes from the Australian Institute of Marine Science (AIMS), which has been measuring over 100 reefs every year since 1986. AIMS data released last year shows that, while coral cover has fluctuated dramatically over time, the amount of coral on the reef in 2021 was at record high levels[68] – higher than when measurements began 35 years previously, as shown in Figure 15.

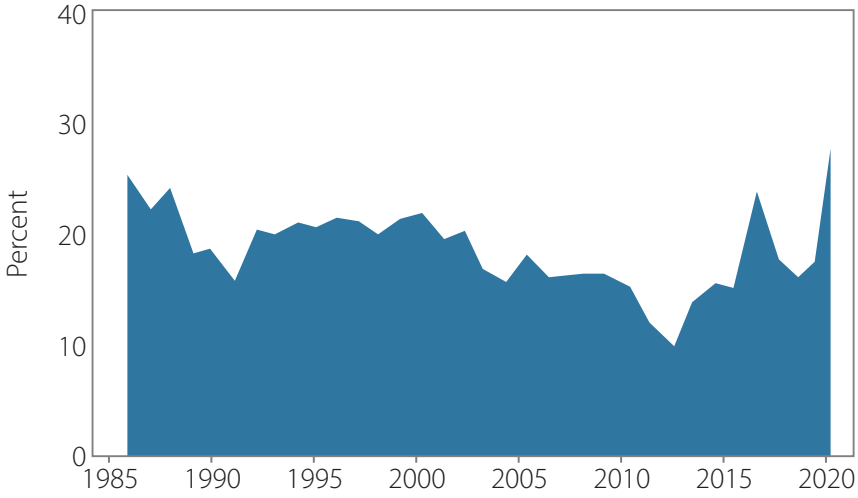


Figure 15: Coral cover on the Great Barrier Reef, 1986–2021.
Source: AIMS.[68]

This recovery of the Great Barrier Reef from extensive bleaching during the prolonged El Niño of 2016–17 vindicated coral reef authority Peter Ridd, who had emphasised in a 2018 GWPF article that corals are capable of rapid recovery from bleaching events – in a decade or less.[69] The recovery probably also helped save the reef from being added to a list of World Heritage Sites that are 'in danger'. This classification had been recommended in 2021 by a committee of another UN panel, the UN Educational, Scientific and Cultural Organization (UNESCO), to counter the supposed deleterious effects of climate change. However, an angry Australian government was able to ward off what it called a politically motivated recommendation, by agreeing to produce an updated report on the state of the reef in 2022.[70]

Reinforcing the fact that corals worldwide are not 'rapidly disappearing', as AR6 insists,[67] was a 2021 study by four researchers at Australia's James Cook University (JCU).[71] Their paper completely contradicted previous apocalyptic predictions of the imminent demise of coral reefs, predictions that included an ear-

lier warning, from three of the same authors (who subsequently switched sides) and others,[72] of ongoing coral degradation from global warming.

The JCU paper estimated the total number of corals that exist on reefs across the Pacific Ocean – from Indonesia to French Polynesia – at approximately half a trillion, similar to the number of trees in the Amazon or birds in the world. This colossal population is for a mere 300 species, a small fraction of the 2175 coral species estimated to exist worldwide by the International Union for Conservation of Nature (IUCN). So the global extinction risk of most coral species is much lower than previously thought, even though a local loss can be ecologically devastating to coral reefs in the vicinity.

11. Natural disaster trends

The 2020 GWPF report on extreme weather[2] included a discussion of how socio-economic studies of natural disasters are being used to link weather extremes to global warming. This particular aspect of extremes is not covered in the contribution to AR6 of IPCC Working Group I, published in August 2021, which concentrates on the science and is the source of all the claims about extreme weather discussed in the present report. Coverage in AR6 of natural disaster analysis appears in the contributions of Working Groups II and III, which focus on the impact and mitigation of global warming. These contributions were only published in 2022 and will be discussed in a future GWPF report.

However, it is worth noting here that, in a 2021 report, yet another UN agency made the erroneous claim that climate-related disasters are currently escalating. The WMO has now joined the UNDRR and the International Red Cross (IFRC) in asserting that the annual number of weather and climate extremes is increasing, as depicted in Figure 16.[73] All the disaster data compiled by the WMO, UNDRR and IFRC comes from the Emergency Events Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED).[74]

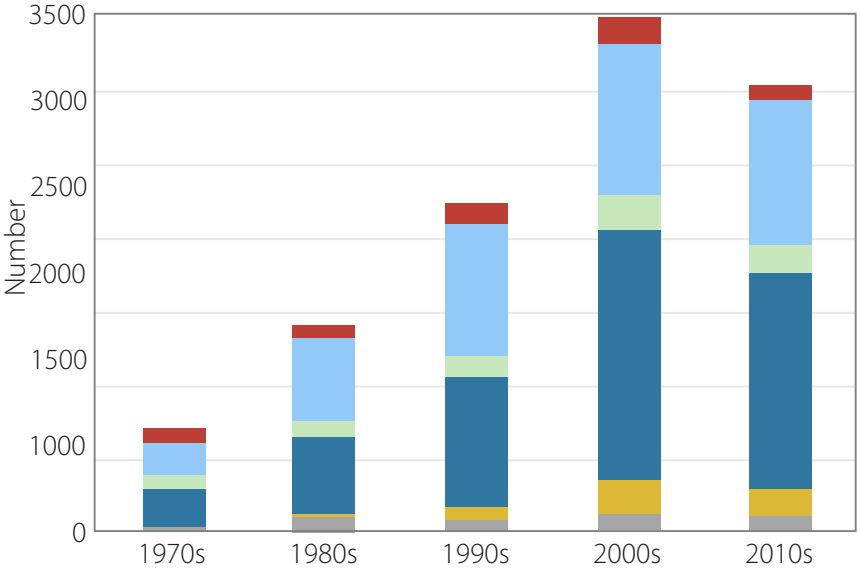


Figure 16: Apparent annual number of climate-related disasters by decade, 1970–2019.

Source: WMO.[73]

But the WMO's claim is just as wrong, and its graph just as misleading, as those presented previously by the UNDRR and IFRC, because they all fail to take into account a major increase in disaster reporting since 1998 due to the arrival of the Internet. Climate writers Paul Homewood and Roger Pielke Jr. uncovered a sudden jump – a near doubling – in the annual number of disasters listed in EM-DAT in 1998 and the years thereafter.[75,76] The abrupt change was even acknowledged in the CRED 2006 disaster report:

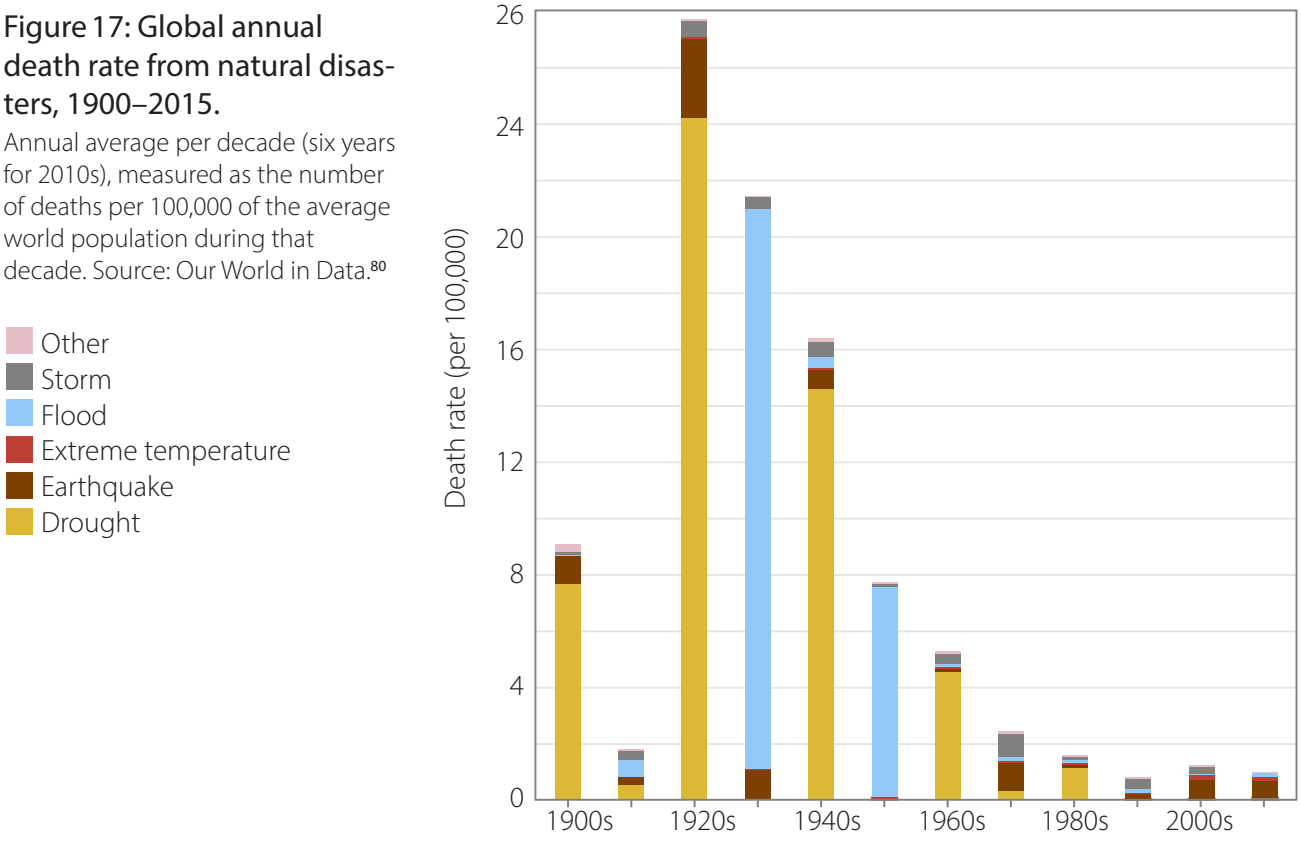
> Two periods can be distinguished: 1987–1997, with the number of disasters varying generally between 200 and 250; and 2000–2006, with the number of disasters increasing by nearly a multiple factor of two. An increase of this magnitude can be partially explained by increased reporting of disasters, particularly by press organizations and specialized agencies.[77]

That the impact of natural disasters is diminishing over time can be seen in data on the associated loss of life. Figure 17 illustrates the annual global number of deaths from natural disasters, including weather extremes, from 1900 to 2015, corrected for population increase over time and averaged by decade.[80]

Because the data is compiled from the same EM-DAT database, the annual number of deaths shows an uptick from the 1990s to the 2000s. It is clear though that disaster-related deaths from extreme weather have been falling since the 1920s and are now approaching zero. However, this is due more to improvements in planning and engineering to safeguard structures, and to early warning systems that allow evacuation of threatened communities, as it is to diminishing numbers of natural disasters.

Figure 17: Global annual death rate from natural disasters, 1900–2015.

Annual average per decade (six years for 2010s), measured as the number of deaths per 100,000 of the average world population during that decade. Source: Our World in Data.[80]



12. Conclusions

The IPCC's new position, in AR6, on weather extremes – that trends in heatwaves, droughts and tropical cyclones attributable to global warming now exist – is not supported by the scientific evidence presented in this report. The IPCC position results partly from neglect of history, with data before 1950 being ignored in AR6, and partly from choosing a trend starting date that fell during a 30-year period of global cooling from 1940 to 1970. Such a choice artificially inflates the magnitude of subsequent warming and its effect on extreme weather.

The mistaken belief that weather extremes are worsening because of climate change is more a perception, fostered by media coverage, than reality. A steady drumbeat of articles in the mainstream media, eager to promote the latest climate scare, as well as reports from other organisations, only serve to amplify the false narrative. A new trend is the accompaniment of news releases by 'climate pornography,' in the form of graphic depictions of the latest weather disaster. Even the UN Secretary-General has hysterically described AR6 as 'code red for humanity.'[78]

At the same time, however, the voice of reason is slowly making itself heard. A recently published study of possible trends in extreme weather[17] makes the following statement:

> None of these response indicators show a clear positive trend of extreme events. In conclusion on the basis of observational data, the climate crisis that, according to many sources, we are experiencing today, is not evident yet.

Climate writer Fred Pearce makes the point that weather disasters are often the result of land-use changes and poor planning, rather than climate.[79] For example, a severe shortage of food in Madagascar in 2020 was caused primarily by poor water infrastructure, not the ongoing drought, as recognized in AR6 and noted earlier in Section 3. And the continuing dry state of Lake Chad in West Africa is a consequence not of climate change, but of the diversion of rivers in neighboring countries that once supplied most of its water, for irrigation of frequently inefficient rice farms. Another example is wildfires caused by lack of fire suppression, as discussed in Section 7.

Extreme weather conditions are produced by natural patterns in the climate system, not global warming. As mentioned earlier in this report, the Atlantic Multidecadal Oscillation governs many extremes, such as intense hurricanes in the North Atlantic basin and major floods in eastern North America and western Europe; cold extremes in North America are tied to the North Atlantic and Pacific Decadal Oscillations. The El Niño and La Niña cycles in the Pacific Ocean often cause catastrophic flooding in the western Americas, as well as severe droughts in Australia. La Niña has also been connected to major landfalling hurricanes in the US.

AR6 wisely does not change the IPCC's previous stance on floods, tornadoes or wildfires. But its conclusions about droughts, tropical cyclones, heatwaves (including marine heatwaves) and cold extremes cannot be justified by actual observations.

References

1. IPCC, 'Climate Change 2021: The Physical Science Basis', Summary for Policymakers, A.3, The Current State of the Climate (2021), https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.
2. Ralph B. Alexander, 'Extreme Weather in 2020', GWPF Report 49 (2021), https://www.thegwpf.org/content/uploads/2021/04/Extreme-Weather-2020.pdf.
3. IPCC, 'Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation', Summary for Policymakers, A. Context (2012), https://www.ipcc.ch/site/assets/uploads/2018/03/SREX_FD_SPM_final-2.pdf.
4. IPCC, 'Fifth Assessment Report', Chapter 10, Section 10.6.1 (2013), https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter10_FINAL.pdf.
5. AR5, Ibid, Summary for Policymakers, B.1 Atmosphere (2013), https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_SPM_FINAL.pdf.
6. IPCC, 'Special Report on the Ocean and Cryosphere in a Changing Climate', Chapter 6 (2019), https://www.ipcc.ch/site/assets/uploads/sites/3/2022/03/08_SROCC_Ch06_FINAL.pdf.
7. IPCC, 'Climate Change 2021: The Physical Science Basis', Summary for Policymakers, B.2 Possible Climate Futures (2021), https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.
8. UNDRR, 'GAR Special Report on Drought 2021' (2021), https://www.undrr.org/publication/gar-special-report-drought-2021.
9. Edward R. Cook, Richard Seager, Mark A. Cane and David W. Stahle, 'North American drought: Reconstructions, causes, and consequences', Earth-Science Rev., 81, 93–134 (2007), https://www.sciencedirect.com/science/article/abs/pii/S0012825206001784.
10. NOAA/NCEI (2016), https://www.ncei.noaa.gov/access/monitoring/monthly-report/drought/201606.
11. Gregory J. McCabe and David M. Wolock, 'Multi-year hydroclimatic droughts and pluvials across the conterminous United States', Int. J. Climatol., 41, 1731–1746 (2021), https://rmets.onlinelibrary.wiley.com/doi/epdf/10.1002/joc.6925.
12. Tushar Apurv and Ximing Cai, 'Regional Drought Risk in the Contiguous United States', Geophys. Res. Lett., 48, e2020GL092200 (2021), https://doi.org/10.1029/2020GL092200.
13. A. Park-Williams, Benjamin I. Cook and Jason E. Smerdon, 'Rapid intensification of the emerging southwestern North American megadrought in 2020–2021', Nat. Clim. Chang., 12, 232–234 (2022), https://doi.org/10.1038/s41558-022-01290-z.
14. M. Ionita, M. Dima, V. Nagavciuc et al., 'Past megadroughts in central Europe were longer, more severe and less warm than modern droughts', Commun. Earth Environ., 2:61, 1–9 (2021), https://doi.org/10.1038/s43247-021-00130-w.
15. Sergio M. Vicente-Serrano, Fernando Domínguez-Castro, Conor Murphy et al., 'Long-term variability and trends in meteorological droughts in Western Europe (1851–2018)', Int. J. Climatol., 41, E690–E717 (2020), https://doi.org/10.1002/joc.6719.
16. IPCC, 'Climate Change 2021: The Physical Science Basis', Chapter 11: Weather and climate extreme events in a changing climate (2021), https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.
17. Gianluca Alimonti, Luigi Mariani, Franco Prodi and Renato Angelo Ricci, 'A critical assessment of extreme events trends in times of global warming', Eur. Phys. J. Plus, 137:112 (2022), https://doi.org/10.1140/epjp/s13360-021-02243-9.
18. Hong X. Do, Seth Westra and Michael Leonard, 'A global-scale investigation of trends in annual maximum streamflow', J. Hydrol., 552, 28–43 (2017), https://www.sciencedirect.com/science/article/pii/S0022169417304171.

19. IPCC, 'Climate Change 2021: The Physical Science Basis', Chapter 8: Water cycle changes (2021), https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.
20. Nick Finnis, 'Europe floods July 2021: What caused them and why people were caught out' (2021), https://www.netweather.tv/weather-forecasts/news/10984-europe-floods-july-2021-what-caused-them-and-why-people-were-caught-out.
21. Joanne Nova, 'A world protected by windmills? In 1717 Christmas Floods in Germany killed 14,000' (2021), https://joannenova.com.au/2021/07/a-world-protected-by-windmills-in-1717-christmas-floods-in-germany-killed-14000/.
22. Wikipedia, 'History of flooding in Canada', https://en.wikipedia.org/wiki/History_of_flooding_in_Canada#1948_Fraser_River_flood.
23. Ryan N. Maue, 'Global Tropical Cyclone Activity' (updated October 31, 2021), https://climatlas.com/tropical/.
24. Gabriel A. Vecchi, Christopher Landsea, Wei Zhang at al., 'Changes in Atlantic major hurricane frequency since the late-19th century', Nat. Commun., 12, 4054 (2021), https://doi.org/10.1038/s41467-021-24268-5.
25. Japan Meteorological Agency (2021), https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/climatology.html.
26. Philip J. Klotzbach, Kimberly M. Wood, Carl J. Schreck III et al., 'Trends in Global Tropical Cyclone Activity: 1990–2021', Geophys. Res. Lett., 49, e2021GL095774 (2022), https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021GL095774.
27. Paul Homewood, private communication (2022).
28. NOAA (2019), https://www.noaa.gov/stories/atlantic-high-activity-eras-what-does-it-mean-for-hurricane-season.
29. Roger Pielke Jr., 'A remarkable decline in landfalling hurricanes' (2021), https://rogerpielkejr.substack.com/p/a-remarkable-decline-in-landfalling.
30. Jeff Masters, 'La Niña has begun, could bring more landfalling hurricanes to U.S.' (2020), https://yaleclimateconnections.org/2020/09/la-nina-has-begun-could-bring-more-landfalling-hurricanes-to-u-s/.
31. Thomas Knutson, Suzana J. Camargo, Johnny C. L. Chan et al., 'Tropical Cyclones and Climate Change Assessment', Bull. Am. Meteorol. Soc., 100, 1987–2007 (2019), https://academiccommons.columbia.edu/doi/10.7916/d8-8bv7-z497/download.
32. NOAA/NCEI (2022), https://www.ncei.noaa.gov/products/land-based-station/us-historical-climatology-network.
33. NASA (2022), https://climate.nasa.gov/vital-signs/global-temperature/.
34. Daniel McCarthy and Joseph Schaefer (2003), 'Tornado Trends Over the Past Thirty Years', https://www.spc.noaa.gov/publications/mccarthy/tor30yrs.pdf.
35. NOAA/NWS Storm Prediction Center (2022), https://www.spc.noaa.gov/exper/outbreaks/#.
36. Joseph D'Aleo and Anthony Lupo (2019), https://alarmistclaimresearch.files.wordpress.com/2019/05/ac-rebuttals-tornadoes-051919.pdf.
37. Joseph D'Aleo and Anthony Lupo (2019), https://alarmistclaimresearch.files.wordpress.com/2019/05/ac-tornado-and-flooding-2019-claims-060219.pdf.
38. Bob Henson, 'Climate change and tornadoes: Any connection?' (2021), https://yaleclimateconnections.org/2021/07/climate-change-and-tornadoes-any-connection/.
39. Vittorio A. Gensini and Harold E. Brooks, 'Spatial trends in United States tornado frequency,' npj Clim. Atmos. Sci., 1, 38 (2018), https://doi.org/10.1038/s41612-018-0048-2.
40. IPCC, 'Climate Change 2021: The Physical Science Basis', Technical Summary, TS.4 Regional Climate Change: (2021), https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.
41. IPCC, 'Climate Change 2021: The Physical Science Basis', Chapter 12: Climate change infor-

mation for regional impact and for risk assessment (2021), https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.
42. JRC Technical Report, 'Forest Fires in Europe, Middle East and North Africa 2019', p. 157 (2020), https://publications.jrc.ec.europa.eu/repository/handle/JRC122115.
43. Bjørn Lomborg, https://twitter.com/BjornLomborg/status/1368550005787787270.
44. National Interagency Fire Center (2017), https://www.nifc.gov/fire-information/statistics.
45. Little Hoover Commission, 'Fire on the Mountain: Rethinking Forest Management in the Sierra Nevada', Report #242 (2018), https://lhc.ca.gov/report/fire-mountain-rethinking-forest-management-sierra-nevada.
46. Healthy Forests, Healthy Communities, 'Researchers are pushing back against "agenda-driven science" ' (2021), https://healthyforests.org/2021/11/researchers-are-pushing-back-against-agenda-driven-science/.
47. 'Climate Science Special Report: Fourth National Climate Assessment (CSSR)', Volume I, Chapter 6 (2017), https://science2017.globalchange.gov/downloads/CSSR_Ch6_Temperature.pdf.
48. John R. Christy, 'A Practical Guide to Climate Change in Alabama' (2022), https://www.nsstc.uah.edu/aosc/climatechangePDF/AlabamaClimatePracticalGuide_HR.pdf.
49. Robert J. H. Dunn, Lisa V. Alexander, Markus G. Donat et al., 'Development of an Updated Global Land In Situ-Based Data Set of Temperature and Precipitation Extremes: HadEX3', J. Geophys. Res. Atmos., 125, 1–28 (2020), https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019JD032263.
50. Matthew J. Menne, Imke Durre, Russell S. Vose et al., 'An Overview of the Global Historical Climatology Network-Daily Database', J. Atmos. Ocean. Tech., 29, 897–910 (2012), https://journals.ametsoc.org/view/journals/atot/29/7/jtech-d-11-00103_1.xml?tab_body=pdf.
51. S. E. Perkins-Kirkpatrick and S. C. Lewis, 'Increasing trends in regional heatwaves', Nat. Commun., 11, 3357 (2020), https://doi.org/10.1038/s41467-020-16970-7.
52. Harry Wilkinson, 'UK Heatwaves', GWPF Factsheet 3 (2020), https://www.netzerowatch.com/content/uploads/2020/09/Heatwaves.pdf.
53. World Weather Attribution, 'Western North American extreme heat virtually impossible without human-caused climate change' (2021), https://www.worldweatherattribution.org/western-north-american-extreme-heat-virtually-impossible-without-human-caused-climate-change/.
54. Cliff Mass, 'Flawed Heatwave Report Leads to False Headlines in Major Media' (2021), https://cliffmass.blogspot.com/2021/07/flawed-heatwave-report-leads-to-false.html.
55. William M. Briggs, 'The Climate Blame Game: Are we really causing extreme weather?', GWPF Note 25 (2021), https://www.thegwpf.org/content/uploads/2021/04/Briggs-Climate-Attribution.pdf.
56. William M. Briggs, 'How the IPCC Sees What Isn't There', GWPF Note 27 (2021), https://www.thegwpf.org/content/uploads/2021/10/Briggs-IPCC-Attribution.pdf.
57. Michael G. Jacox, 'Marine heatwaves in a changing climate', Nature, 571, 485–487 (2019), https://media.nature.com/original/magazine-assets/d41586-019-02196-1/d41586-019-02196-1.pdf.
58. IPCC, 'Climate Change 2021: The Physical Science Basis', Chapter 2: Changing state of the climate system (2021), https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.
59. Robert A. Junod and John R. Christy, 'A new compilation of globally gridded night-time marine air temperatures: The UAHNMATv1 dataset', Int. J. Climatol., 40, 2609–2623 (2019), https://rmets.onlinelibrary.wiley.com/doi/10.1002/joc.6354.
60. IPCC, 'Climate Change 2021: The Physical Science Basis', Technical Summary, TS.2 Large-scale Climate Change: Mean Climate, Variability and Extremes (2021), https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.
61. E. Ray Garnett and Madhav L. Khandekar, 'Increasing cold weather extremes since the new

millennium: an assessment with a focus on worldwide economic impacts', Mod. Environ. Sci. Eng., 4, 427–438 (2018), http://www.academicstar.us/UploadFile/Picture/2019-3/2019313412613.pdf.
62. Madhav Khandekar and Ray Garnett, 'Global warming (gw) & extreme weather (ew) link: are cold extremes on the rise?', Earth & Environ. Sci. Res. & Rev., 3, 64–66 (2020), http://www.opastonline.com/wp-content/uploads/2020/04/global-warming-extreme-weather-link-are-cold-extremes-on-the-rise-eesrr-20-.pdf.
63. Madhav L. Khandekar, 'The Global Warming–Extreme Weather Link: A Review of the State of Science', GWPF Report 11 (2013), https://www.thegwpf.org/content/uploads/2013/11/Khandekar-Extreme-Weather.pdf.
64. Judah Cohen, Laurie Agel, Mathew Barlow et al., 'Linking Arctic variability and change with extreme winter weather in the United States', Science, 373, 1116–1121 (2021), https://www.science.org/doi/10.1126/science.abi9167.
65. Ralph B. Alexander, 'Is Recent Record Cold Just La Niña, or the Onset of Global Cooling?' (2021), https://www.scienceunderattack.com/blog/2021/5/17/is-recent-record-cold-just-la-nina-or-the-onset-of-global-cooling-77.
66. IPCC, 'Climate Change 2021: The Physical Science Basis', Chapter 1: Framing, context, and methods (2021), https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.
67. Nicholas A. Kamenos and Sebastian J. Hennige, 'Reconstructing Four Centuries of Temperature-Induced Coral Bleaching on the Great Barrier Reef', Front. Mar. Sci., 5:283, 1–12 (2018), https://www.frontiersin.org/articles/10.3389/fmars.2018.00283/full.
68. Peter Ridd, 'Record coral cover of Great Barrier Reef shames climate alarmists', GWPF Net Zero Watch (2021), https://www.netzerowatch.com/peter-ridd-record-coral-cover-of-great-barrier-reef-refutes-climate-alarmists/#.
69. Peter Ridd, 'Crying wolf over the Great Barrier Reef', GWPF 'The Climate Record' (2018), https://www.netzerowatch.com/peter-ridd-crying-wolf-over-the-great-barrier-reef/.
70. Reuters (July 24, 2021), https://www.reuters.com/business/environment/unesco-keeps-great-barrier-reef-off-danger-list-after-australian-lobbying-2021-07-23/.
71. Andreas Dietzel, Michael Bode, Sean R. Connolly and Terry P. Hughes, 'The population sizes and global extinction risk of reef-building coral species at biogeographic scales', Nat. Ecol. Evol., 5, 663–669 (2021), https://doi.org/10.1038/s41559-021-01393-4.
72. Terry P. Hughes, James T. Kerry, Andrew H. Baird et al., 'Global warming transforms coral reef assemblages', Nature, 556, 492–496 (2018), https://doi.org/10.1038/s41586-018-0041-2.
73. WMO, 'Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2019)' (2021), https://library.wmo.int/doc_num.php?explnum_id=10989.
74. CRED, 'The International Disaster Database', https://www.emdat.be/.
75. Paul Homewood, 'UN claim "staggering rise in climate emergencies since 2000"' (2020), https://notalotofpeopleknowthat.wordpress.com/2020/10/13/un-claimstaggering-rise-in-climate-emergencies-since-2000/.
76. Edwin Timmer, De Telegraaf (October 14, 2020), 'New UN climate row: alarming report contradicts its own data', https://www.netzerowatch.com/new-un-climate-row-alarming-report-contradicted-by-its-own-data/.
77. CRED, 'Annual Disaster Statistical Review: Numbers and Trends 2006' (2007), https://www.eird.org/isdr-biblio/PDF/Annual%20Disaster%20Statistical%20Review.pdf.
78. UN News, 9 August 2021, 'IPCC report: "Code red" for human driven global heating, warns UN chief', https://news.un.org/en/story/2021/08/1097362.
79. Fred Pearce, 'It's Not Just Climate: Are We Ignoring Other Causes of Disasters?' (2022), https://e360.yale.edu/features/its-not-just-climate-are-we-ignoring-other-causes-of-disasters.
80. Hannah Ritchie and Max Roser, 'Natural Disasters' (2019), Our World in Data, https://ourworldindata.org/uploads/2018/04/Global-annual-death-rate-from-natural-disasters-01.png.

Review process

GWPF publishes papers in a number of different formats, with a different review process pertaining to each.

- Our flagship long-form GWPF Reports are all reviewed by our Academic Advisory Council.
- GWPF Briefings and Notes are shorter documents and are reviewed internally and/or externally as required.

Part of the function of the review process is to ensure that any materials published by the GWPF are of a proper academic standard, and will serve the GWPF's educational purpose. As a charity, we recognise that educational material should provide any reader the opportunity to understand, and explore different perspectives on a subject.

This means that, for most publications, we also invite an external review from a party who we would expect to take a different view to the publication's author. We offer to publish any substantive comments alongside the main paper, provided we are satisfied they will enhance the educational experience of the reader. In this way, we hope to encourage open and active debate on the important areas in which we work.

This enhanced review process for GWPF papers is intended to take the content and analysis beyond a typical review for an academic journal:

- More potential reviewers can be involved
- The number of substantive comments will typically exceed journal peer review, and
- The identity of the author is known to the potential reviewers.

As an organisation whose publications are sometimes the subject of assertive or careless criticism, this review process is intended to enhance the educational experience for all readers, allowing points to be made and considered in context and observing the standards required for an informed and informative debate. We therefore expect all parties involved to treat the reviews with the utmost seriousness.

Final responsibility for publication rests with the Chairman of the Trustees and the GWPF Director. But in every case, the views expressed are those of the author. GWPF has never had any corporate position beyond that dictated by its educational objectives.

About the Global Warming Policy Foundation

People are naturally concerned about the environment, and want to see policies that protect it, while enhancing human wellbeing; policies that don't hurt, but help.

The Global Warming Policy Foundation (GWPF) is committed to the search for practical policies. Our aim is to raise standards in learning and understanding through rigorous research and analysis, to help inform a balanced debate amongst the interested public and decision-makers. We aim to create an educational platform on which common ground can be established, helping to overcome polarisation and partisanship. We aim to promote a culture of debate, respect, and a hunger for knowledge.

RECENT GWPF REPORTS

18	Goklany	Carbon Dioxide: The Good News
19	Adams	The Truth About China
20	Laframboise	Peer Review: Why Scepticism is Essential
21	Constable	Energy Intensive Users: Climate Policy Casualties
22	Lilley	£300 Billion: The Cost of the Climate Change Act
23	Humlum	The State of the Climate in 2016
24	Curry et al.	Assumptions, Policy Implications and the Scientific Method
25	Hughes	The Bottomless Pit: The Economics of CCS
26	Tsonis	The Little Boy: El Niño and Natural Climate Change
27	Darwall	The Anti-development Bank
28	Booker	Global Warming: A Case Study in Groupthink
29	Crockford	The State of the Polar Bear Report 2017
30	Humlum	State of the Climate 2017
31	Darwall	The Climate Change Act at Ten
32	Crockford	The State of the Polar Bear Report 2018
33	Svensmark	Force Majeure: The Sun's Role in Climate Change
34	Humlum	State of the Climate 2018
35	Peiser (ed)	The Impact of Wind Energy on Wildlife and the Environment
36	Montford	Green Killing Machines
37	Livermore	Burnt Offering: The Biomess of Biomass
38	Kelly	Decarbonising Housing: The Net Zero Fantasy
39	Crockford	The State of the Polar Bear Report 2019
40	Darwall	The Climate Noose: Business, Net Zero and the IPCC's Anticapitalism
41	Goklany	The Lancet Countdown on Climate Change: The Need for Context
42	Humlum	The State of the Climate 2019
43	Alexander	Weather Extremes: Are They Caused by Global Warming?
44	Constable	Hydrogen: The Once and Future Fuel?
45	Kessides	The Decline and Fall of Eskom: A South African Tragedy
46	Goklany	Impacts of Climate Change: Perception and Reality
47	Constable	A Little Nudge with a Big Stick
48	Crockford	The State of the Polar Bear Report 2020
49	Alexander	Weather Extremes in 2020
50	Humlum	The State of the Climate 2020
51	Humlum	The State of the Climate 2021
52	Constable	Europe's Green Experiment
53	Montford	Adaptation: The Rational Climate Policy
54	Alexander	Extreme Weather: The IPCC's Changing Tune

For further information about the Global Warming Policy Foundation, please visit our website at www.thegwpf.org.

The GWPF is a registered charity, number 1131448.