EXTREME WEATHER IN 2020

Ralph Alexander

The Global Warming Policy Foundation
Report 49

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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.

Executive summary

The most striking feature of weather extremes in 2020 was not the extremes themselves, but the use of socio-economic studies of natural disasters to link extreme weather to global warming. Two international agencies, the UN Office for Disaster Risk Reduction (UNDRR) – in conjunction with the Centre for Research on the Epidemiology of Disasters (CRED) – and the International Red Cross (IFRC), both issued reports claiming that climate-related disasters are currently escalating.

However, such claims are wrong, as clearly shown by data presented in the two reports. Two different sections of the CRED-UNDRR report state that since 2000 the annual number of disasters has either risen significantly or been 'relatively stable'. But these statements are completely contradicted by data in the same report showing that the number of climate-related disasters fell by 11% from 2000 to 2020.

The CRED-UNDRR report also falsely contends that more disasters occurred between 2000 and 2019 than during the preceding 20 years. This assertion is mirrored in the IFRC report, which makes the erroneous claim that annual climate-related disasters have risen almost 35% since the 1990s. Both spurious claims arise from a failure to account for the major increase in disaster reporting engendered by the arrival of the Internet in the late 1990s.

Not only has the annual number of global disasters over the last 20 years declined, but the number of people killed by weather extremes has also been falling steadily over the past century – though this is due as much to improvements in planning, engineering and early warning systems as it is to diminishing natural disasters. And once financial losses from climate-related disasters, which are currently increasing, are corrected for population gain and the ever-rising value of property in harm's way, there is very little evidence to support any connection between natural disasters and global warming.

Just as in previous years, little persuasive scientific evidence emerged in 2020 to support the mistaken belief that weather extremes are caused by emissions of greenhouse gases, or that the frequency or intensity of extreme weather is on the rise. No evidence was found for a 2020 study's claim that the Great Barrier Reef lost 50% of its corals between 1995 and 2017 because of global warming.

Notable extremes in 2020 included a prolonged heatwave in Siberia, an unusually cold summer in the northern hemisphere, a very active hurricane season in the North Atlantic, and wildfires in the Arctic and the western US. Yet nearly all of these extremes can be attributed to naturally occurring cycles: the Siberian heatwave to the Arctic Oscillation, cold extremes to the North Atlantic Oscillation and the Pacific Decadal Oscillation, and both North Atlantic hurricanes and Arctic wildfires to the warm phase of the Atlantic Multidecadal Oscillation.

1. Introduction

The year 2020 saw continued hype in the mainstream media about the purported link between extreme weather and global warming, but with an added dimension: the widespread use of socio-economic studies of natural disasters, which assess both human and economic vulnerability to natural hazards, as supporting evidence. But, just as in previous years, no good scientific evidence emerged in 2020 to support claims that weather extremes are caused by emissions of greenhouse gases, or that the frequency or intensity of weather extremes are on the rise.

Section 2 examines two reports on natural disaster analysis issued in 2020 by major international institutions. Subsequent sections update last year's GWPF report on global warming and extreme weather.[1] As well as disaster analysis, the present report covers recent heatwaves, coral bleaching, cold extremes, droughts, major floods, hurricanes, tornadoes and wildfires.

2. Natural disaster analysis

The mistaken belief that global warming causes weather extremes is often buttressed by studies of the socio-economic risk of natural disasters. In 2020, the Centre for Research on the Epidemiology of Disasters (CRED) and the UN Office for Disaster Risk Reduction (UNDRR) issued a joint report, insisting that the impacts of a warming world 'are being felt in the increased frequency of extreme weather events including heatwaves, droughts, flooding, winter storms, hurricanes and wildfires'.[2] The report draws a strong link between global warming and weather extremes, the majority of which are floods and storms. Ironically, however, the same CRED-UNDRR report reveals that its claim of a 'staggering rise' in climate-induced disasters during the last 20 years is wrong.

Figure 1 is a modified version of the report's Figure 5 and shows the yearly number of climate-related disasters globally from 2000 through 2020. In order to be recorded as a disaster in CRED's EM-DAT (Emergency Events Database), an event must meet at least one of the following criteria: 10 or more people reported killed; 100 or more people reported affected; a state of emergency declared; or a call put out for international assistance. The disasters included in Figure 1 are those in EM-DAT's hydrological (floods, landslides and wave action), meteorological (storms, extreme temperatures and fog), and climatological (droughts, glacial lake outbursts and wildfires) categories.

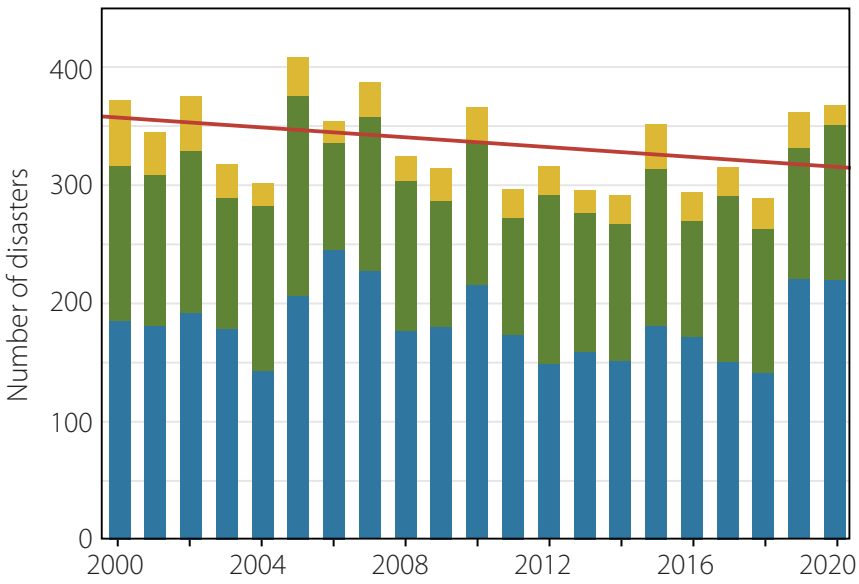


Figure 1: Annual number of climate-related disasters by disaster category, 2000–2020.
The trendline is a least-squares linear fit to the yearly disaster totals. Source: CRED/UNDRR.[2]

The figure shows that the total number of climate-related disasters exhibits a distinctly declining trend since 2000, falling by 11% over the last 21 years. This completely contradicts the claims in two different sections of the CRED-UNDRR report that the annual number of disasters since 2000 has either risen significantly from before or been 'relatively stable'. Another striking inconsistency in the report, and one that bolsters its false assertion of a recent sharp increase in disasters, is a comparison be-

tween the period from 2000 to 2019 and the preceding 20 years from 1980 to 1999. The report contends that the earlier 20 years saw only 4,212 disasters, compared with 7,348 during the later period.[2]

But the University of Colorado's Roger Pielke Jr., who studies natural disasters, says these numbers are flawed.[3] Data from 20th-century disasters are unreliable because disasters were reported differently before the Internet existed, a fact implicitly conceded by CRED itself in its 2004 disaster report:

> Over the past 30 years, development in telecommunications, media and increased international cooperation has played a critical role in the number of disasters reported at an international level.[4]

Climate writer Paul Homewood has uncovered a sudden jump – a near doubling – in the annual number of disasters listed in EM-DAT in 1998 and the years thereafter.[5] The abrupt change was 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.[6]

So CRED's claim that the number of disasters over 20 years jumped from 4,212 to 7,348 is meaningless.

A second recent report on global disasters, by the Red Cross (International Federation of Red Cross and Red Crescent Societies, IFRC) and sponsored in part by UNDRR,[7] reaches the same erroneous conclusions as the CRED-UNDRR report – not surprisingly, since they are both based on CRED's EM-DAT. As seen in Figure 2, which is the same as the Red Cross report's Figure 1.1, climate- and weather-related disasters since 2000 have declined by approximately the same 11% noted in Figure 1.

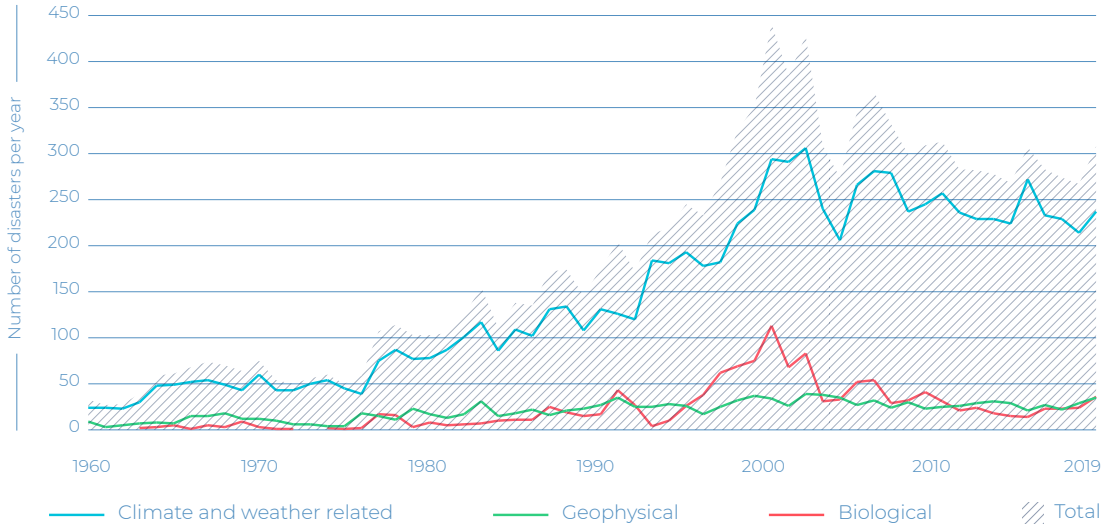


Figure 2: Comparison of annual number of natural disasters by disaster category, 1960–2019.
Source: IFRC.[7]

Figure 3, the same as the Red Cross report's Figure 2.7, gives a breakdown of annual climate- and weather-related disasters by category, for a more detailed comparison with Figure 1. The report's misleading assertion that such disasters have risen almost 35% since the 1990s relies on the same failure, discussed above, to account for a major increase in disaster reporting since 1998 due to the arrival of the Internet.

All these conclusions rely on so-called 'event attribution studies',[8] which, it is claimed, can assign specific extremes to either natural variability or human causes. This methodology is highly questionable, depending on computer climate models that have a dismal track record in predicting the future (or indeed of hindcasting the past). The shortcomings of event attribution studies have been discussed by statistician William Briggs in a recent GWPF report.[9]

That the impact of natural disasters appears to be diminishing over time can be seen in data on the associated loss of life. Figure 4 illustrates the annual global number of deaths from natural disasters, including weather extremes, corrected for population increase over time and averaged by decade from 1900 to 2015.

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 have been falling since the 1920s and are now approaching zero. However, this is due as much to improvements in planning and

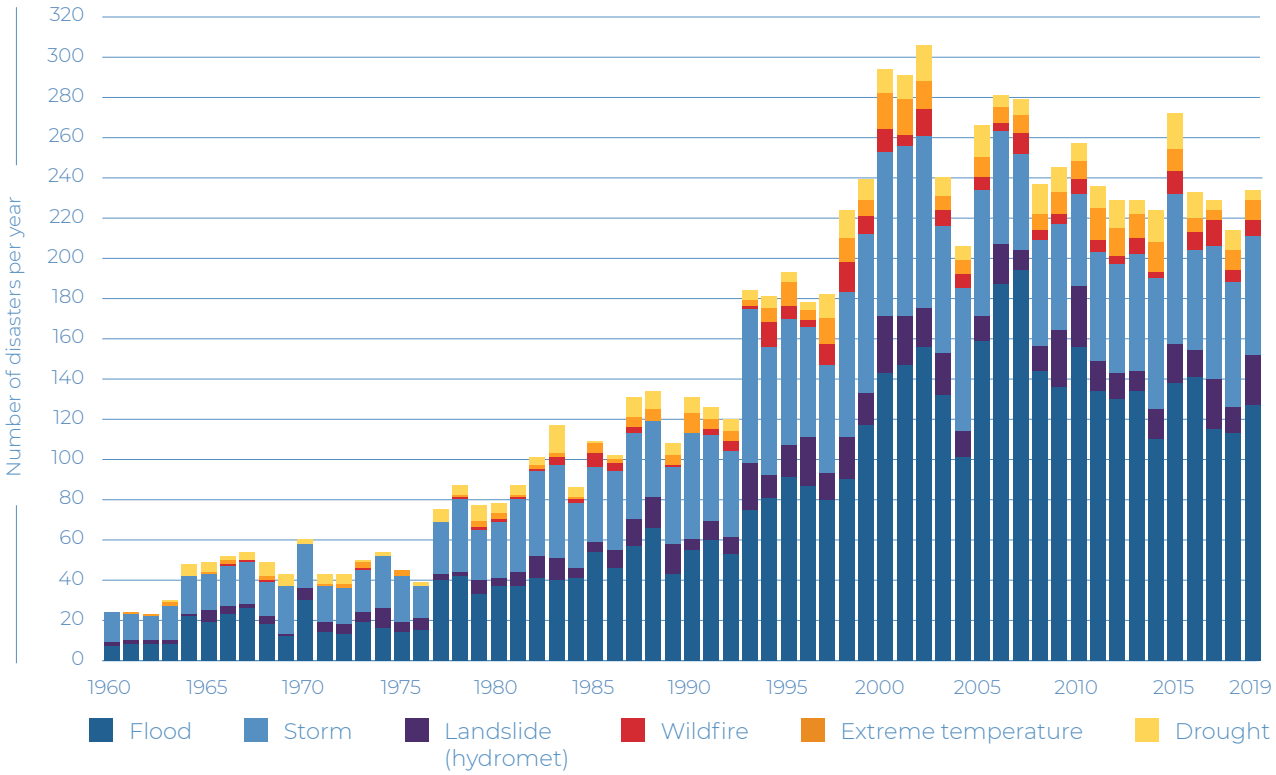
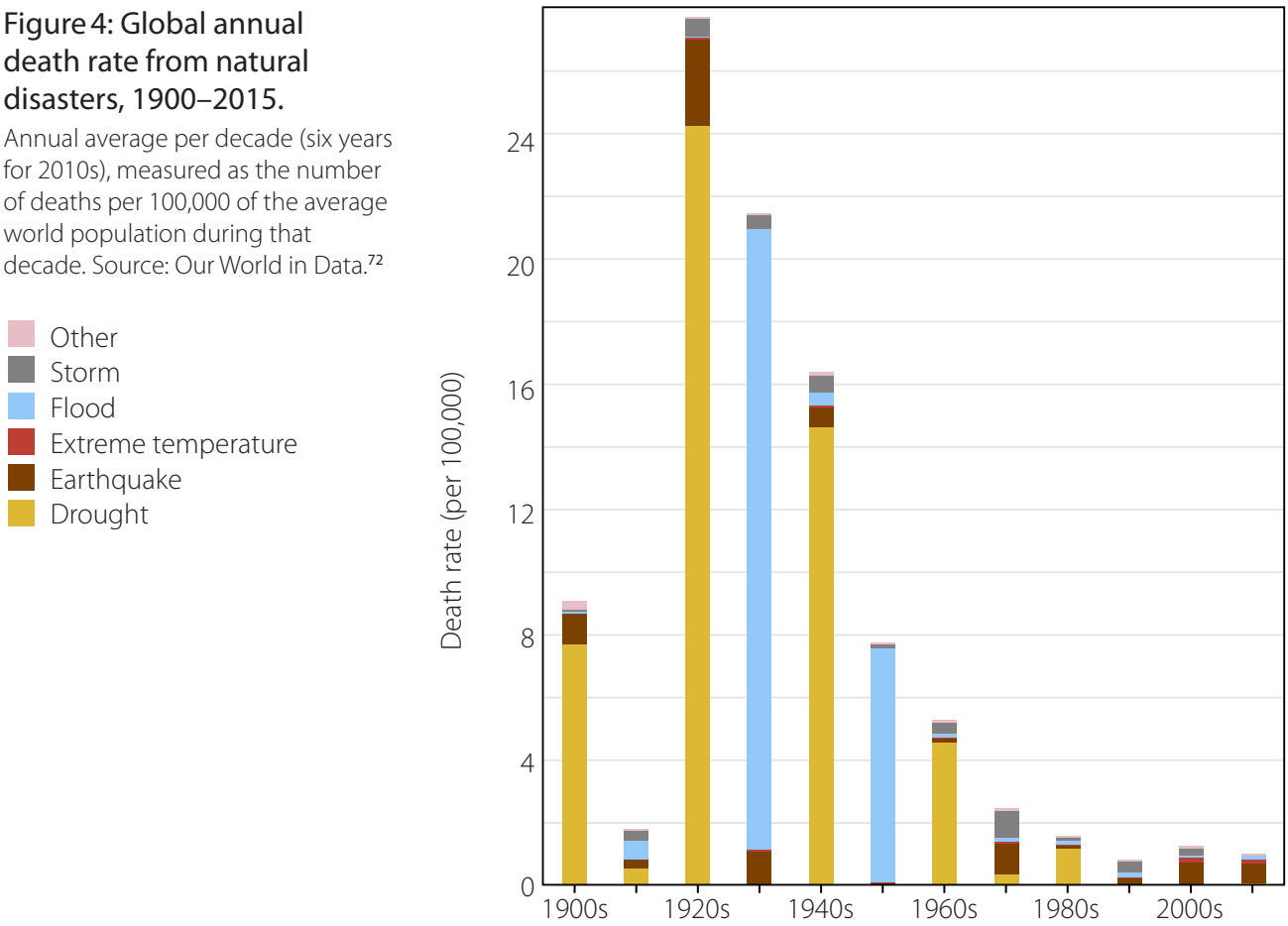


Figure 3: Annual number of climate-related disasters by category, 1960–2019.

Source: IFRC.[7]

Figure 4: 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.[72]



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 4 also shows that the number of people killed by weather extremes (storm, flood, extreme temperature or drought) has been falling steadily over the past century, with the exception of storm deaths, which briefly spiked in the 1970s. As discussed in Section 7, this surge was due to enhanced hurricane activity in the North Atlantic basin in those years.

Economic loss studies of natural disasters have been quick to blame human-caused climate change for the apparently increasing frequency and intensity of weather-related events. But such studies ignore what has been termed the 'Expanding Bull's-Eye Effect' (see Figure 14, p. 18), describing how damage from natural disasters becomes worse with increasing population and growing wealth. Once the losses are corrected for population gain and the ever-escalating value of property in harm's way, there is very little evidence to support any connection between natural disasters and global warming. As political scientist Bjørn Lomborg puts it, 'The cause [of higher costs] is not climate change but social change'.[10]

According to numerous analyses by Pielke,[11] the frequency and intensity of the phenomena causing financial losses show no detectable trend to date. Climate-related losses themselves are actually declining as a percentage of global gross domestic product (GDP), as depicted in Figure 5.

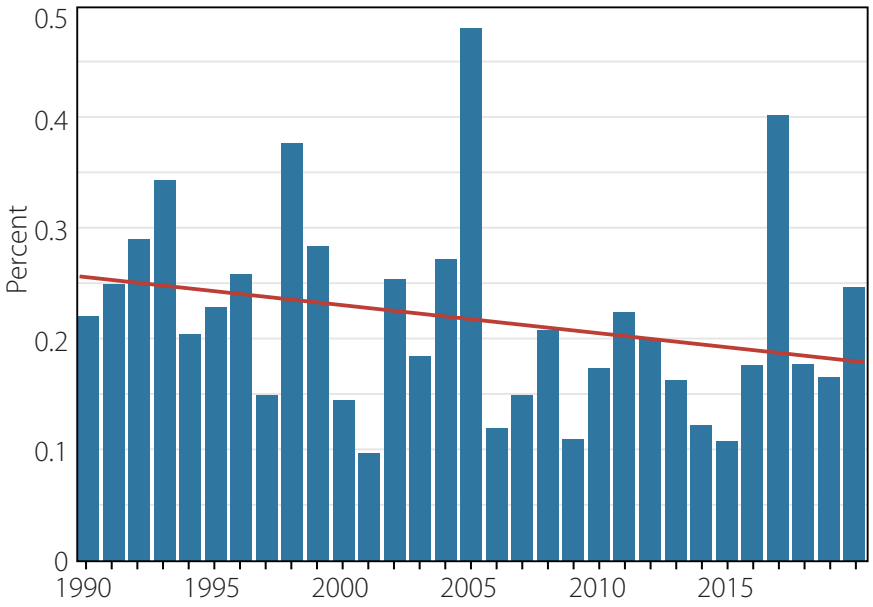


Figure 5: Global climate-related disaster losses as a percentage of GDP, 1990–2020.
Source: Roger Pielke Jr.[73]

Another research study,[12] based on the NatCatSERVICE database of reinsurance giant Munich Re, has also concluded that both human and economic vulnerability to climate-related disasters exhibit a decreasing trend, and that average disaster mortality has fallen by a sizeable factor of 6.5 between 1980–1989 and 2007–2016.

The Intergovernmental Panel on Climate Change (IPCC) is in accord with these findings, concluding in its report Climate Change 2014: Impacts, Adaptation, and Vulnerability that:

> Economic growth, including greater concentrations of people and wealth in periled areas and rising insurance penetration, is the most important driver of increasing [financial] losses…loss trends have not been conclusively attributed to anthropogenic climate change.[13]

The IPCC's current position is consistent with its earlier reports, which argue that little to no evidence exists linking extreme weather to global warming.

3. Heatwaves

Atmospheric

A prolonged heatwave in northeastern Siberia during the first half of 2020 was labelled 'startling' and 'truly staggering' by the media and environmental activists.[14] The reported maximum temperature of 38°C (100°F) in the Arctic town of Verhojansk on June 20 was claimed to be an all-time record for anywhere north of the Arctic Circle. And an attribution study maintained that the extended six-month heatwave in the region around Verhojansk was 'at least 600 times more likely as a result of human-induced climate change'.[15]

But such highly exaggerated claims are not based on science and simply reveal how our collective memories of extreme

weather are short-lived. As illustrated in Figure 6, the hottest June in Verhojansk occurred way back in 1912; the hottest summer on record was in 1917.[16] As the 1910s were well before atmospheric carbon dioxide surged, it is most unlikely that the 2020 heat spike had any connection to today's higher carbon dioxide levels.

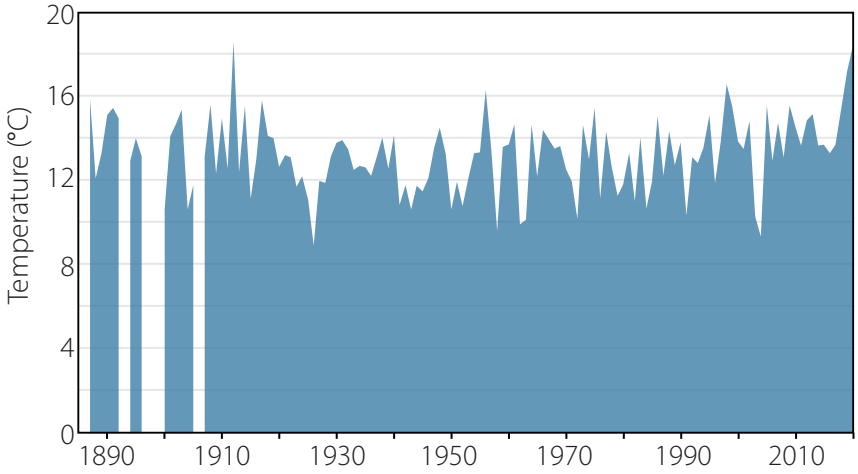


Figure 6: Average June temperature at Verhojansk, Siberia, 1885–2020.
Source: Paul Homewood.[16]

In fact, the Siberian heatwave has been attributed to an entirely natural atmospheric cycle known as the Arctic Oscillation, which describes Arctic wind circulation and is related to the polar vortex.[17] The Arctic Oscillation was strongly positive in the first part of 2020, causing the polar jet stream to become locked in a holding or blocking pattern that brought hot air up from the south for an extended period.

On the east coast, the mercury in Sydney exceeded 40°C (104°F) on back-to-back days, well above the average daytime high for November of only 24°C (75°F). This was an unprecedented event in 160 years of record keeping – and the city also experienced its hottest November night on record. New state records for the spring were set in New South Wales and South Australia.[18] Nevertheless, activists soon had to withdraw their claims about human-caused global warming when the highest Sydney temperature reached in December was only 30.8°C (87.4°F), and December in the country as a whole was cooler than November for the first time in 70 years.[19]

In 2019, a brouhaha erupted over two consecutive heatwaves in western Europe. The World Meteorological Organization (WMO) alleged that during the second, which occurred toward the end of July, the temperature in Paris reached a new record high of 42.6°C (108.7°F), besting the previous record of 40.4°C (104.7°F) set back in July 1947.[20] A month earlier, during the first heatwave, temperatures in southern France hit a purported record 46.0°C (114.8°F) on 28 June.[21]

However, in August 1930, Australian[22] and New Zealand[23] (and presumably French) newspapers gave an account of an earlier French heatwave, in which the temperature soared to a staggering 50°C (122°F) in the Loire valley. And if 1930 saw temperatures in central France a full 4.0°C (7.2°F) above the so-called

record just mentioned for a location in the south of France, it is likely that temperatures in 1930 in the south equaled or exceeded those in the Loire. The same newspaper articles reported a temperature in Paris that day of 37.8°C (100°F), stating that back in 1870 the thermometer had reached an even higher, unspecified level there – quite possibly above the July 2019 'record' of 42.6°C (108.7°F).

Similar discrepancies can be seen in proclamations about past US temperatures. Although it is frequently claimed that heatwaves there are increasing in both intensity and frequency, the scientific evidence does not support such a bold assertion. Figure 7 shows the frequency and magnitude of US heatwaves from 1900 to 2018. The frequency (top panel) is the annual number of calendar days the maximum temperature exceeded the 90th percentile for 1961–1990 for at least six consecutive days, in a window centered on that calendar day.[24]

Figure 8 charts official data from the US National Oceanic and Atmospheric Administration (NOAA) showing, for 1895–2018, the annual number of days on which the average of all US temperature stations exceeded 37.8°C (100°F) and 40.6°C (105°F).

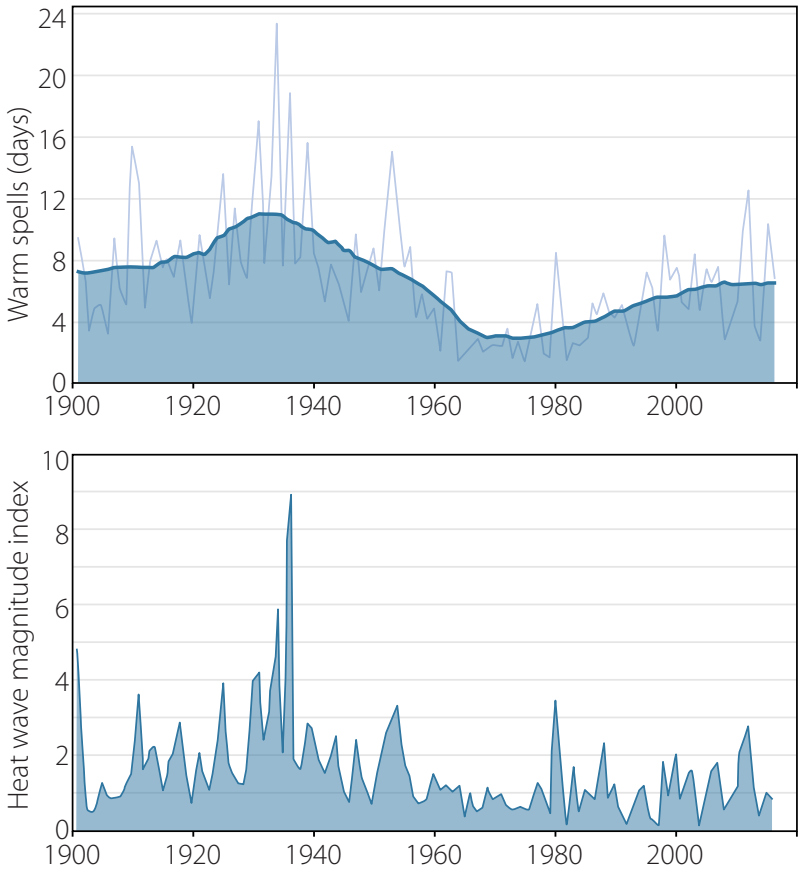
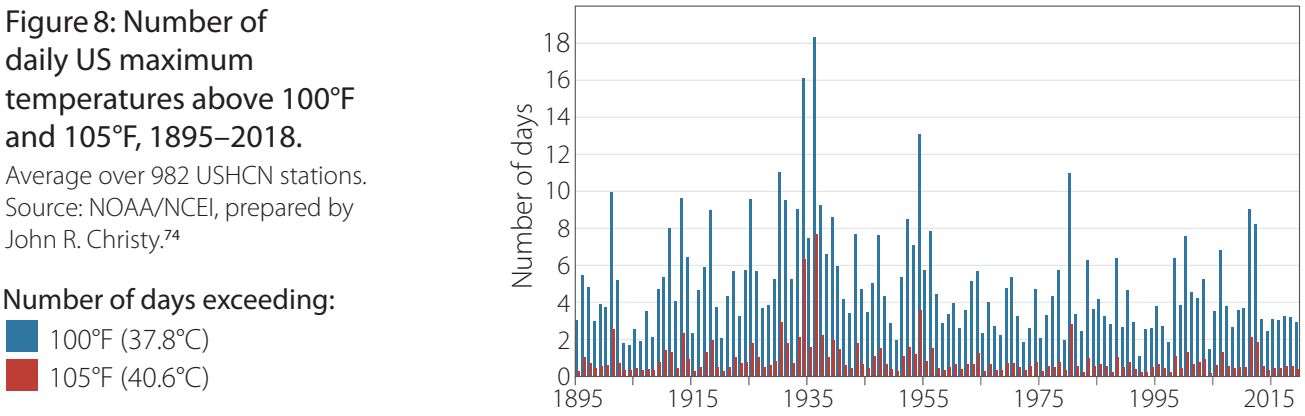


Figure 7: Observed changes in heatwaves in the contiguous US, 1900–2018.
Top: frequency; bottom: magnitude. Source: CSSR.[24]

It is clear from these two figures that there were more US heatwaves, and they were hotter, in the 1930s than in the present era of global warming. Indeed, the annual number of days on which US temperatures reached 100°F, 95°F or

Figure 8: Number of daily US maximum temperatures above 100°F and 105°F, 1895–2018.

Average over 982 USHCN stations. Source: NOAA/NCEI, prepared by John R. Christy.[74]



90°F has been falling steadily since the 1930s.

Globally, it's exactly the same story, as depicted in Table 1. Of the seven continents, six recorded their all-time record high temperatures before 1983, three records dating from the 1930s or before; only Asia has set a record more recently (the WMO hasn't acknowledged the 50°C 1930 record in the Loire region). And yet the worldwide baking heat of the 1930s didn't set the stage for more and worse heatwaves in the years ahead, even as carbon dioxide kept pouring into the atmosphere – the scenario we're told, erroneously, that we face today. In fact, the sweltering 1930s were followed by global cooling from 1940 to 1970.

The IFRC report on natural disasters, discussed in Section 2, asserts that 'The [global] number of recorded heatwaves per decade has been steadily rising since the 1960s, reaching a peak of 40 in the 2000s.'[7] But this claim is just as incorrect as the IFRC's contention that the tally of climate-related disasters themselves has risen since the 1990s – both errors being due to the failure to acknowledge a major increase in reporting of disasters, including heatwaves, after the advent of the Internet.

Contrary to the climate change narrative, the 2019 European heatwaves are thought to have come about not Contrary to the climate change narrative, the 2019 European

Table 1: Continental maximum temperature records.

Source: WMO.[75]

	Record (°C)	Year record set
North America	56.7	1913
Europe	48.0	1977
South America	48.9	1905
Asia	53.9	2016
Africa	55.0	1931
Australasia	50.7	1960
Antarctica	19.8	1982

heatwaves are thought to have come about not because of global warming, but rather the phenomenon of jet-stream blocking mentioned earlier. As well as the Arctic Oscillation, blocking can also arise as a result of a weakening of the Sun's output, as is occurring currently. A less active Sun generates less UV radiation, which in turn perturbs winds in the upper atmosphere and locks the polar jet stream in a blocking pattern. In 2019, blocking kept a surge of hot Saharan air in place over Europe for more than a month.[25]

Marine

As discussed in last year's report,[1] marine heatwaves are increasingly in the news. Notable recent marine heatwaves include the so-called 'Blob', observed in the northeast Pacific Ocean from 2013 to 2015, a similar temperature spike seen in Australia's Tasman Sea from 2015 to 2016, and another off the west coast of Australia from 2011 to 2013.Marine heatwaves affect marine organisms and ecosystems, causing bleaching of coral reefs or loss of kelp forests, for example. Temperatures typically range from about 2°C (3.6°F) to 5°C (9°F) above normal.[26] But this is not because they are a new occurrence; rather, the apparent increase in frequency of marine heatwaves since 1982 reflects the start of satellite measurements of ocean temperature, which are far more accurate and broader in coverage than measurements made by the old-fashioned methods used in earlier times.

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. Indeed, it would be surprising if no significant marine heatwaves happened during the period of record-high atmospheric temperatures recorded in the 1930s, discussed above.

Even without good quality data for these earlier periods, it has been estimated that from 1925 to 2016, the global average marine heatwave frequency and duration increased by only 34% and 17%, respectively.[26] Given the shortcomings of the early data, these are hardly dramatic increases. In any case, the sample size for observations made since satellite observations began in 1982 is statistically small.

Coral bleaching

Coral bleaching is a controversial subject. Some researchers claim that bleaching only began in the 1980s as global warming escalated, and that it is therefore an entirely manmade problem. But others point to scientific records that reveal multiple coral bleaching events around the globe throughout the 20th century, including the heatwave years of the 1930s. Leading coral reef authority Peter Ridd emphasised this in a 2018 GWPF article, remarking that corals are capable of rapid recovery from bleaching events – in a decade or so.[27]

A recently reported survey of the Rowley Shoals, a chain of three coral atolls 300 km (190 miles) off the coast of northwest Western Australia, showed that up to 60% of the delicate corals had bleached following a short-lived marine heatwave in 2019. Yet a follow-up survey just six months later revealed that much of the bleached coral had already recovered and that perhaps only 10% of the reef had been killed.[28]

The world's largest coral reef system is the Great Barrier Reef. Labelled by CNN as one of the seven natural wonders of the world, the 2,300 km-(1,400 mile)-long reef hugs the northeastern coast of Australia and is visible from outer space. During the prolonged El Niño of 2016–17, higher temperatures caused mass bleaching in portions of the northern and central regions of the reef. Ridd's fellow reef scientists contended at the time that as much as 30% to 95% of the reef's corals had died. However, Ridd estimated that only 8% of the Great Barrier Reef suffered; most of the southern end of the reef wasn't affected at all.[29]

Likewise, Ridd has found no evidence for a 2020 study's claim that the Great Barrier Reef lost 50% of its corals between 1995 and 2017 because of global warming,[30] an assertion that set alarm bells ringing in the mainstream media. He says 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 shows that coral cover fluctuates dramatically with time, but that there is approximately the same amount of Great Barrier Reef coral today as in 1995.[31]

All this evidence demonstrates that heatwaves, whether atmospheric or marine, have nothing at all to do with global warming, which has continued steadily, albeit with interruptions, ever since the Little Ice Age ended around 1850. The current mass panic over heatwaves and climate change is completely unwarranted.

4. Cold extremes

Evidence for increasing cold extremes continued to accumulate in 2020, with cold temperature records being broken all over the globe. During the 2020 southern winter and northern summer, the Australian island state of Tasmania recorded its most frigid winter minimum ever, exceeding the previous low of −13.0°C (8.6°F) by 1.2°C (2.2°F); Norway endured its chilliest July in 50 years; neighbouring Sweden shivered through its coldest summer since 1962; and Russia was also bone-chilling cold.[32]

In the northern autumn of 2020, bitterly cold temperatures afflicted many communities in the US and Canada. The northern US state of Minnesota experienced its largest early-season snowstorm in recorded history, going back about 140 years. The cities of Alexandria and St. Cloud, Minnesota saw their snowiest October on record, snow records also falling in towns and cities across Montana and South Dakota.[33] And in late December, the subfreezing polar vortex began to expand out of the Arctic.

Earlier in the year, massive snowstorms covered much of Patagonia in more than 150 cm (60 inches) of snow, and buried alive at least 100,000 sheep and 5,000 cattle.[34] Snowfalls not seen for decades occurred in other parts of South America, and in South Africa, southeastern Australia and New Zealand.

That cold extremes are indeed increasing was explored by Madhav Khandekar in a 2013 GWPF report[35] and in a more recent publication.[36] Although his emphasis was on harsh winters in Canada, he has catalogued cold weather extremes in the US and South America, Europe and Asia as well. Figure 9 shows the locations of 4,145 daily low-temperature records broken or tied

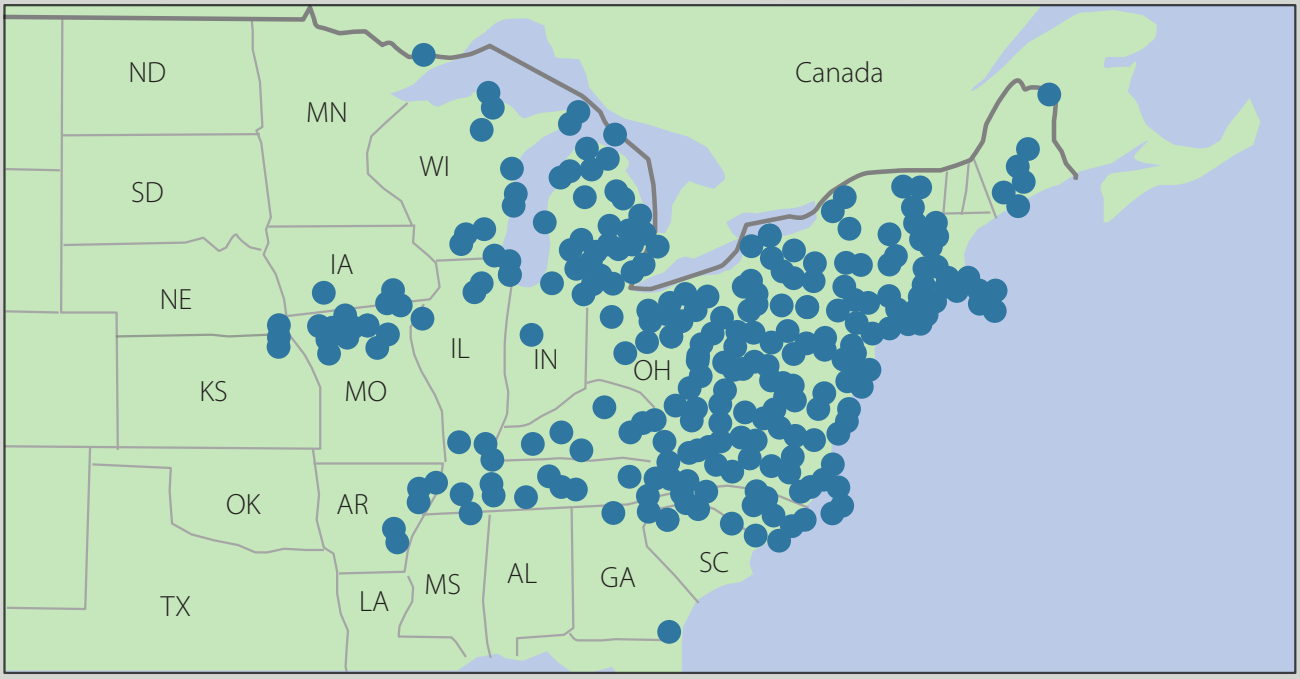


Figure 9: Locations of low-temperature records broken or tied in the US northeast, February 2015.
3,573 record lows broken, 572 tied (total 4,145). Source: E. Ray Garnett and Madhav L. Khandekar.[36]

in the northeastern US during an ice-cold February 2015; 2015 tied with 1904 for the coldest January to March period in the northeast, on records extending back to 1895.

In remarking recently that extreme weather – both hot and cold – is part of natural climate variability, Khandekar points out:

> Even when the earth's climate was cooling down during the 1945–77 period there were as many extreme weather events as there are now.[37]

Khandekar links colder and snowier-than-normal winters in North America not to climate change, but to the naturally occurring North Atlantic Oscillation and Pacific Decadal Oscillation, and those in Europe to the slowing down in solar activity mentioned in Section 3. Yet the WMO and similar organizations, who are convinced that climate change causes other weather extremes, have no explanation for the origin of cold extremes nor their apparently rising frequency.

5. Drought

The scientific evidence does not support the assertion that drought conditions are worsening, let alone because of climate change. The long-term pattern of drought worldwide is featureless over periods of decades to more than a century. Figure 10, from a study published in 2020,[38] shows that the average global area and intensity of drought remained unchanged on average from 1950 to 2019, even though the earth warmed by about 1.1°C (2.0°F) over that interval.[39] Drought here is characterised by the self-calibrating Palmer Drought Severity Index (scPDSI), which measures both dryness and wetness and classifies events as 'moderate', 'severe' or 'extreme'.[40]

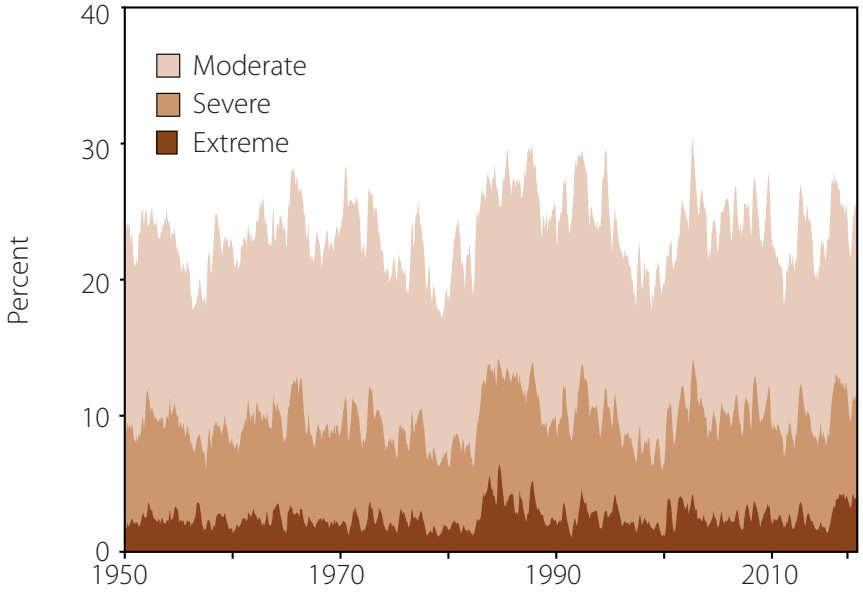


Figure 10: Global drought area and intensity, 1950–2019.
Drought area as percentage of global land area, excluding ice sheets and deserts; monthly degree of drought intensity based on the scPDSI. Source: J. Barichivich et al.[38]

Figure 11 depicts the PDSI for the US during the longer interval from 1895 to 2015, for all three drought or wetness classifications combined. What jumps out again is the lack of any long-term trend in either dryness or wetness in the US. With the exception of the 1930s' Dust Bowl years, the pattern of drought (upper graph) looks boringly similar over the entire 120-year period, as does the pattern of excessive precipitation (lower graph).

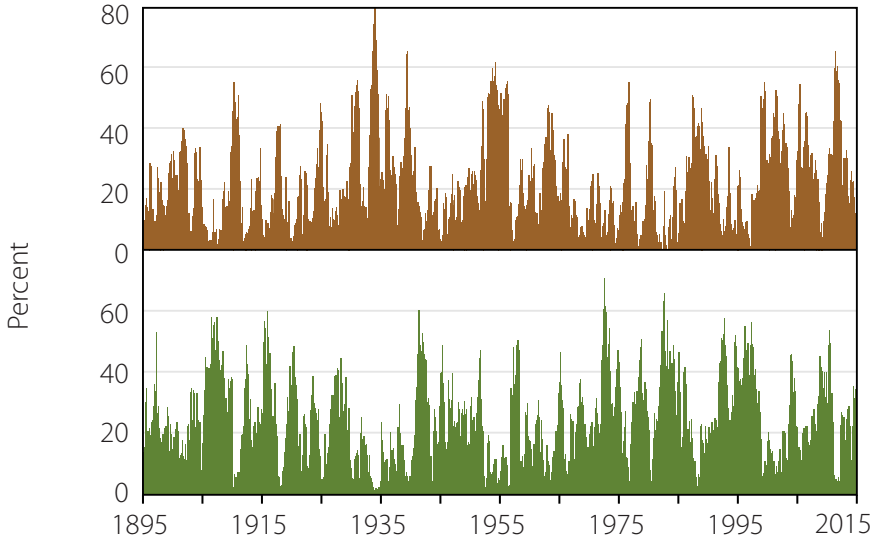


Figure 11: Percentage of US in moderate to extreme dryness or wetness, 1895–2015.
Based on the PDSI. Source: NOAA/NCEI.[76]

Moderate–extreme dry
Moderate–extreme wet

Droughts have been a continuing feature of the Earth's climate for millennia. Although generally caused by a severe fall-off in precipitation, and not by global warming as environmentalists sometimes claim, droughts can be aggravated by factors such as elevated temperatures, soil erosion and overuse of available groundwater. The consequences of drought, which can be disastrous for human and animal life, include crop failure, starvation and mass migration.

Recently, the media created a false alarm over drought by thoughtlessly broadcasting the results of a new study, claiming to demonstrate that global warming will soon result in 'unprecedented drying'.[41] By combining computer models with long-term observations, the study's authors maintained they had definitively connected global warming to drought.

But this claim doesn't hold up. Although the authors were able to match warming to drought conditions during the first half of the 20th century, their efforts were a total failure beyond that. From 1950 to 1980, the 'fingerprint' of human-caused global warming completely disappeared, in spite of ever-increasing carbon dioxide in the atmosphere. And from 1981 onward, the fingerprint was so faint that it couldn't be distinguished from background noise. So the assertion by the authors that global warming causes drought is merely a perverse kind of wishful thinking.

The scientific evidence simply does not support the idea that drought is being made worse by global warming. Ice cores from Antarctica reveal that much more dust – a sign of a dry climate – was deposited during the ice ages than during warmer interglacial periods. The IPCC was right to express low confidence in any global-scale observed trend in drought.[42]

6. Precipitation and floods

While a deficiency in precipitation can result in drought, excess rain can cause severe flooding. Widespread flooding in the US Midwest during the spring of 2019 only served to amplify the voices of those who insist that climate change has intensified weather extremes. Like-minded voices in other countries have also fallen into the same trap of linking major floods to global warming.

But, just as for heatwaves and drought, 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. There is no reason, says meteorologist William Kininmonth,[43] to expect any change in the frequency or intensity of weather systems that produce rain flood events unless it can be demonstrated that global warming changes the dynamics of the atmosphere.

The increase in precipitation in the US due to global warming is clearly visible in Figure 12, showing the frequency of the wettest years since 1900 in each of nine regions. Regionally, the Upper Midwest and the Ohio Valley have seen increased rainfall over the last few decades, while the Southwest has dried out.

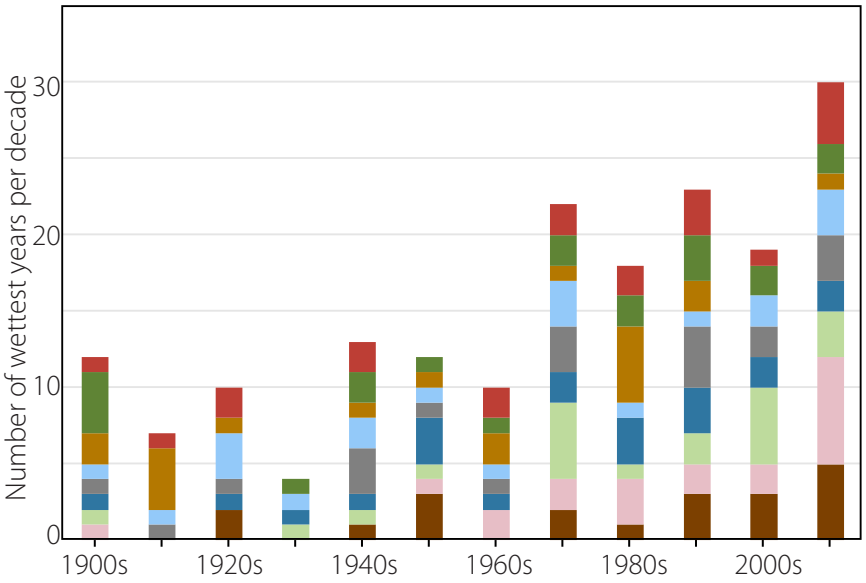


Figure 12: Regional analysis of wettest years in the US.
The 20 wettest years for each region since 1900 are sorted by decade. Source: NOAA/NCEI, prepared by Paul Homewood.[77]

A 2017 Australian study of global flood risk concluded very little evidence exists that flooding is becoming more prevalent worldwide.[44] Despite average rainfall getting heavier as the planet warms, the study authors point 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.

Yet the study found that the biggest influence on flood trends is not more intense precipitation, changes in forest cover or the presence of dams, but the size of the catchment area. Pre-

vious studies had emphasised small catchment areas, as these were thought less likely to have been extensively modified. However, the new study discovered that, even though smaller catchments do show a trend in flood risk that is increasing over time, larger catchments exhibit a decreasing trend.

Globally, larger catchments dominate, so the trend in flood risk is actually decreasing rather than increasing in most parts of the globe, if there is any trend at all. This is illustrated in Figure 13, the data coming from 1907 different locations over the 40 years from 1966 to 2005. Additional data from other locations and for a longer (93-year) period show the same global trend.

But while the overall trend is decreasing, the local trend in regions where smaller catchments are more common, such as Europe, eastern North America and southern Africa, is toward more flooding. The study authors suggest the lower flood trend in larger catchment areas is due to the expanding presence of agriculture and urbanization, together with construction of dams that have eliminated minor flood events.

Another 2017 study, this time restricted to North America and Europe,[45] found 'no compelling evidence for consistent changes over time' in the occurrence of major floods from 1931 to 2010. Like the study described above, this research included both small and large catchment areas. But the only catchments studied were those with minimal alterations and less than 10% urbanization, so as to focus on any trends driven by climate change.

Although the study authors concluded that major floods in the northern hemisphere between 1931 and 2010 were not caused by global warming, and were no more likely than expected from chance alone, they did find that floods were influenced by the climate. The strongest influence is the Atlantic Multidecadal Oscillation, a natural ocean cycle that causes heavier-than-

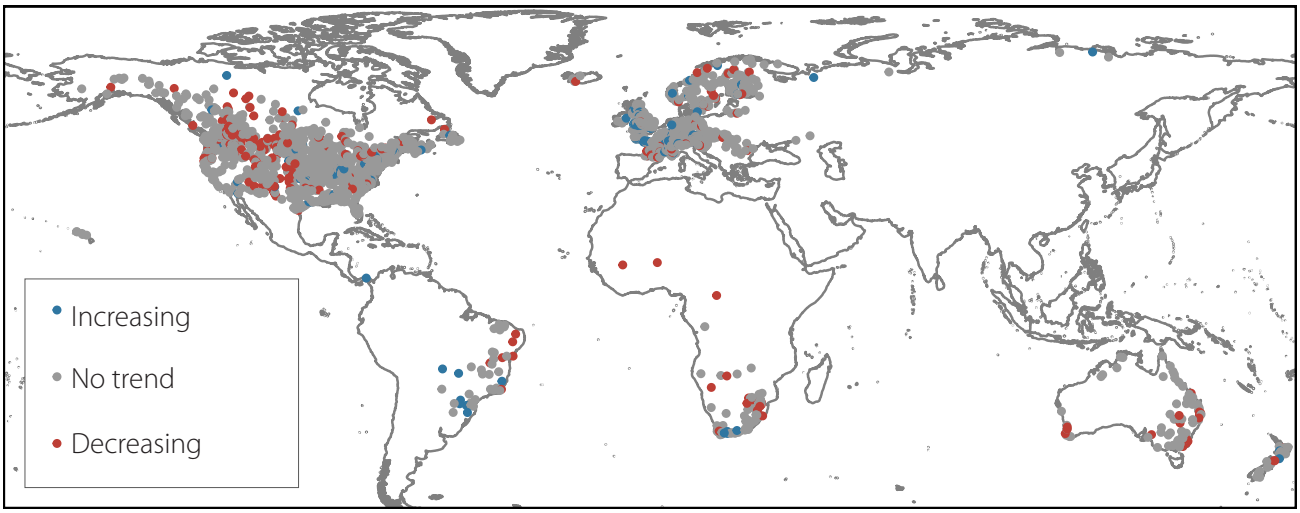


Figure 13: Trends in magnitude of flooding events, 1966–2005.

Data from 1907 locations. The coloured dots show statistically significant trends at the 10% level.

Source: Hong X. Do et al.[44]

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.

The illusion that major floods are becoming more frequent is due in part to the world's growing population and the appeal, in the more developed countries at least, of living near water. This has led to more people building their dream homes in vulnerable locations, on river or coastal floodplains, as shown in Figure 14, which depicts the Expanding Bull's-Eye Effect discussed in Section 2. A larger population exposes more individuals and property to the devastation wrought by intermittent flooding from rainfall-swollen rivers or storm surges. It is changing human wants rather than climate change that are responsible for disastrous floods.

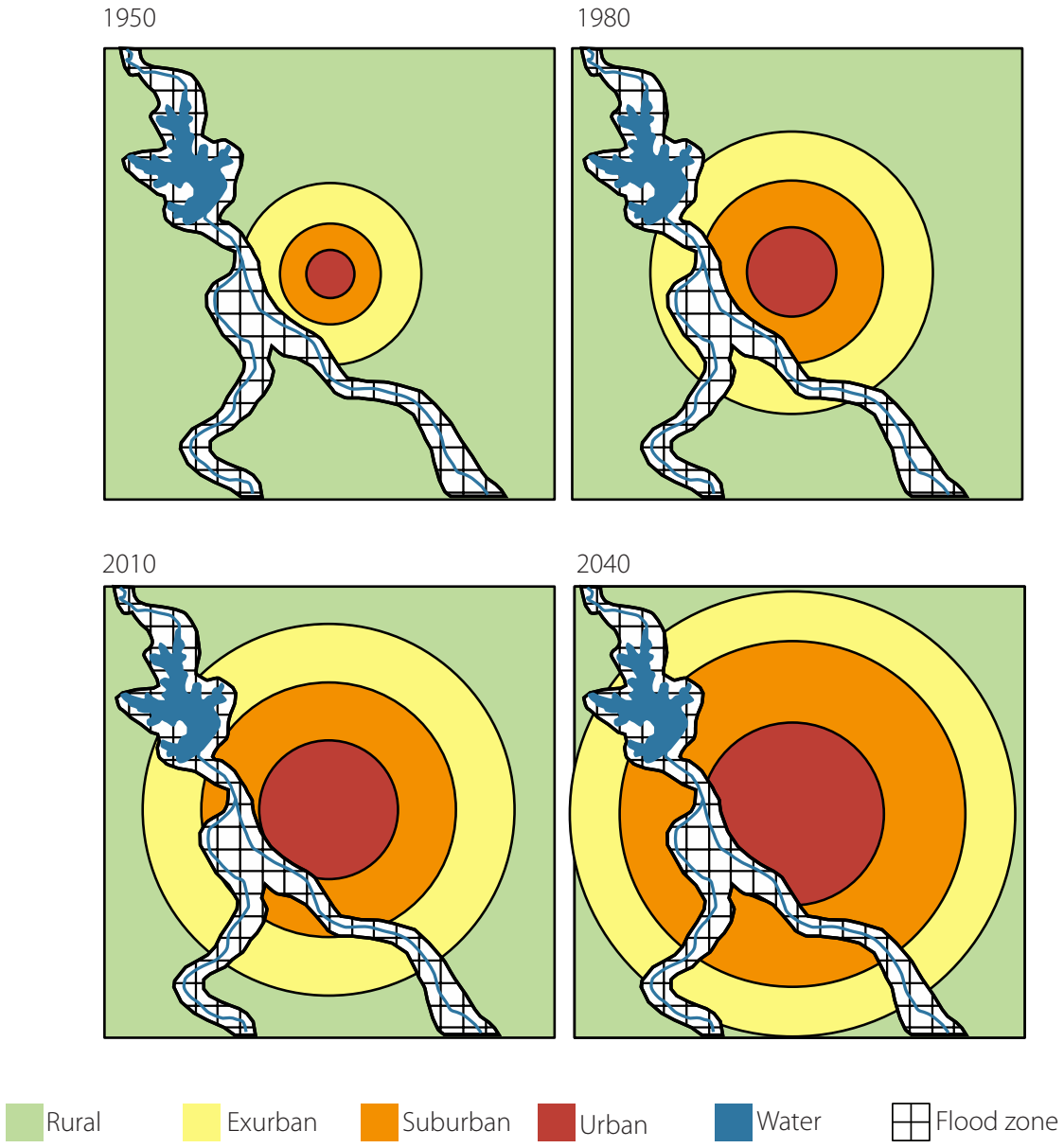


Figure 14: The Expanding Bull's-Eye Effect for floods.

A hypothetical flood impacting a growing city will cause much more destruction in 2040 than in 1950. Source: Bjørn Lomborg.[10]

7. Hurricanes

The mainstream media were quick to declare last year's North Atlantic hurricanes 'unprecedented' and 'record-shattering'.[46] However, while a very active 2020 hurricane season saw a record-breaking 30 named storms, only 13 of these became hurricanes. That was fewer than the historical high of 15 recorded in 2005 and only one more than the 12 hurricanes recorded in 1969 and 2010, according to NOAA.[47] And of 2020's 13 hurricanes, only 6 were major hurricanes, less than the record 8 in 1950 and 7 in 1961 and 2005.

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.

Data for the North Atlantic basin, which has the best quality data available in the world, do show heightened hurricane activity over the last 20 years, particularly in 2005 and 2020. Figure 15 illustrates the frequency of all North Atlantic hurricanes (top graph) and major hurricanes (bottom graph) for the period from 1851 to 2020.

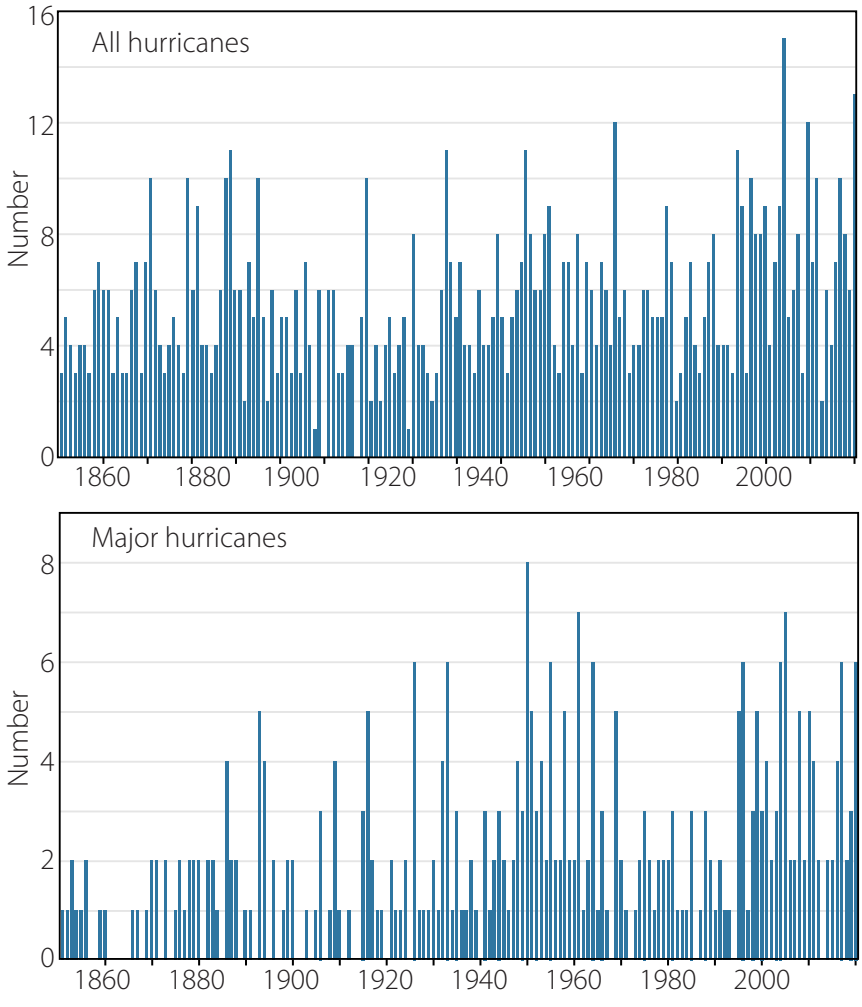


Figure 15: Annual number of North Atlantic hurricanes, 1851–2020.
Source: NOAA Hurricane Research Division[47] and Paul Homewood.[78]

Although it appears that major Atlantic hurricanes were less frequent before about 1940, the lower numbers reflect the relative lack of observations in early years of the record. Aircraft reconnaissance flights to gather data on hurricanes only began in 1944, while satellite coverage dates only from the 1960s.

What the data reveals is that the frequency of major North Atlantic hurricanes in the 1950s and 1960s was at least comparable to that in the last two decades when, as can be seen, it took a sudden upward hike from the 1970s, 1980s and 1990s. But, because the Earth was cooling during the increased activity in the 1950s and 1960s, global warming fails to offer a neat explanation for the present enhanced hurricane activity in the North Atlantic.

Despite the lack of any significant trend in Atlantic hurricanes in a warming world, the frequency of hurricanes globally has slightly diminished on average since 1981, as seen in Figure 16; major hurricanes show no apparent trend. Figure 17 plots the frequency of typhoons since 1951.

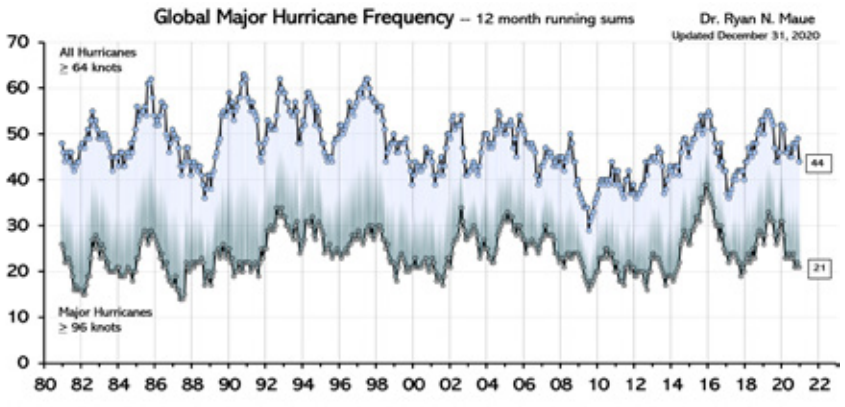


Figure 16: Annual number of global hurricanes, 1981–2020.

Maximum wind speed at least Category 1 hurricane strength (top), Category 3 hurricane strength (bottom). Source: Ryan N. Maue.[79]

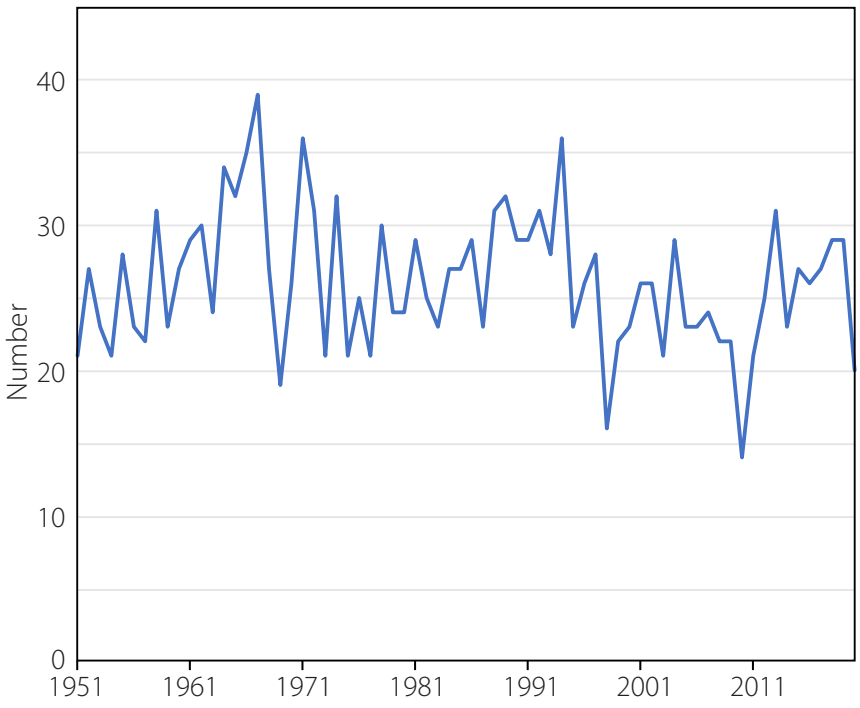


Figure 17: Annual number of typhoons, 1951–2020.

All hurricane strengths (Categories 1 through 5). Source: RSMC Tokyo-Typhoon Center.
[80]

The lack of any long-term trend in major global hurricanes is borne out by the number of hurricanes that make landfall, illustrated in Figure 18. The apparent slight uptick in both total and major landfalling hurricanes is statistically insignificant, and could reflect improvements in observational capabilities since 1970.

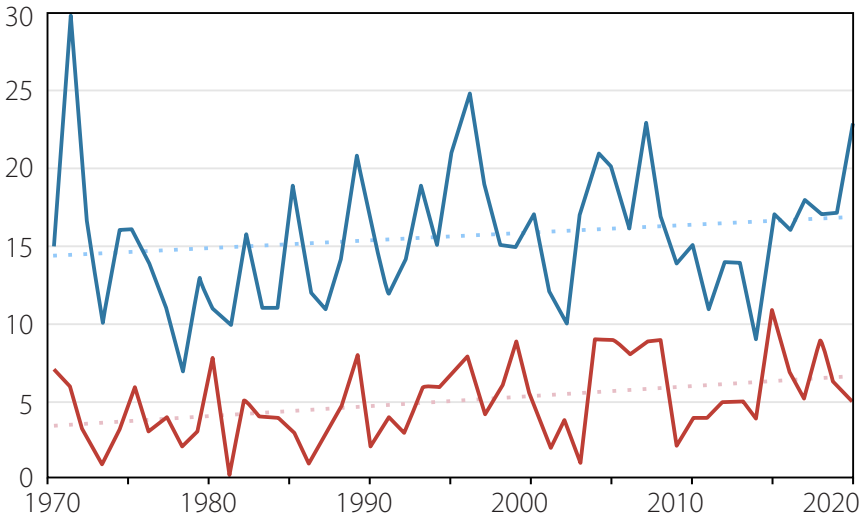


Figure 18: Annual number of global landfalling tropical cyclones, 1970–2020.
All hurricane strengths (Categories 1 through 5) and major hurricanes (Category 3 or greater). Source: Roger Pielke Jr.[81]

With 23 total landfalls, 2020 saw the most hurricane strikes since 2007, and the third most since 1970. Contributing to the large number of 2020 landfalls was the very active North Atlantic hurricane season discussed previously, which accounted for 9 out of the 23 total landfalls. From 1970 to 2019, the North Atlantic averaged 2.5 landfalls per year.[81]

Likewise, there is no significant trend in the number of US landfalling hurricanes in all categories over more than a century, as shown in Figure 19.

The frequency of global landfalling hurricanes of any strength (Categories 1 to 5) has not changed since 1970, nor has the frequency of US landfalling hurricanes since 1900 – during periods when the globe warmed by approximately 1.0°C (1.8°F) and 1.2°C (2.2°F), respectively.[39] So the strongest hurricanes to-

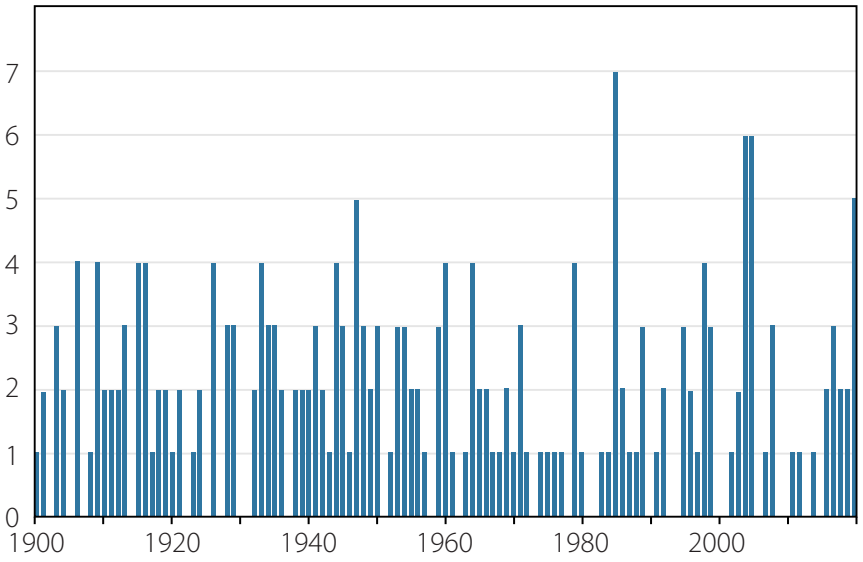


Figure 19: Annual number of continental US landfalling hurricanes, 1900–2020.
All categories. Source: Roger Pielke Jr.[82]

day are no more extreme or devastating than those in the past. If anything, major landfalling hurricanes in the US are tied to La Niña cycles in the Pacific Ocean, not to global warming.

As further evidence that recent hurricane activity is nothing unusual, Figure 20 depicts what is known as the Accumulated Cyclone Energy (ACE) index for the Atlantic basin from 1851 to 2020. The ACE index is an integrated metric combining the number of storms each year, how long they survive and how intense they become. Mathematically, the index is calculated by squaring the maximum sustained wind speed in a named storm every six hours that it remains above tropical storm intensity and summing that up for all storms in the season. For 2020, the Atlantic ACE index was 179.8, which ranks 13th behind 2017, 2005, the peak in 1933 and nine other years.

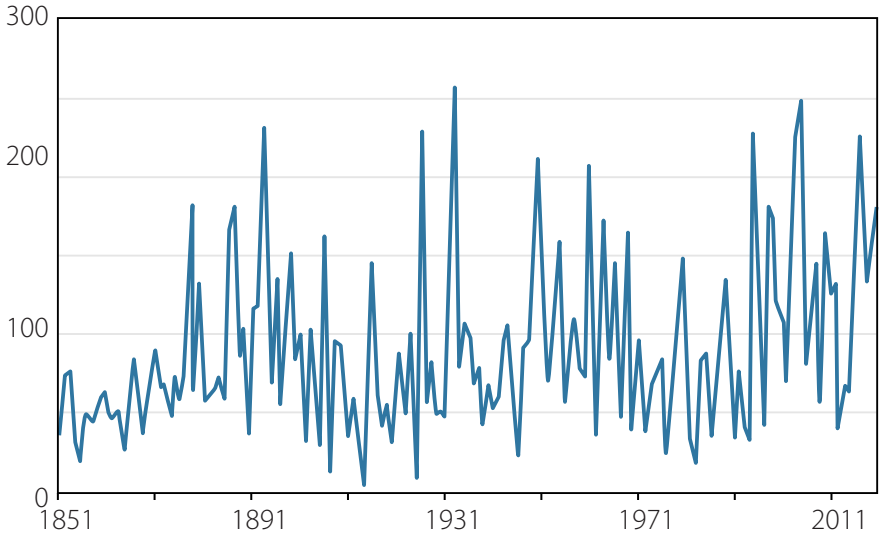


Figure 20: North Atlantic Accumulated Cyclone Energy index, 1851–2020.
Source: Joseph D'Aleo.[83]

NOAA has acknowledged that the current uptick in North Atlantic hurricanes is associated not with global warming, but with the warm phase of the naturally occurring Atlantic Multidecadal Oscillation (AMO) which began in 1995.[48] The AMO, which has a cycle time of approximately 65 years and alternates between warm and cool phases, governs many Atlantic weather extremes such as hurricanes and severe flooding (Section 6). Another contribution to heightened hurricane activity in the Atlantic comes from La Niña cycles in the Pacific, as mentioned above.

The true picture is much more complicated, and any explanation of changing hurricane behaviour needs to account for other factors too, for example the more rapid intensification and slower forward speed of these violent storms that has been observed recently. Both these phenomena result in heavier rain following landfall.

The short duration of the observational record, and the even shorter record from the satellite era, make it impossible to assess whether recent hurricane activity is unusual for the present interglacial period. The deadliest storm in recorded history was the Great Hurricane of 1780 in the Caribbean, which killed 27,500 people and had wind speeds exceeding an estimated 320 km per hour

(200 mph). In summarising paleogeological studies of storms that raged prior to the historical record, climate scientist Judith Curry suggests that changes in hurricane activity, such as those seen recently, are not at all uncommon, with several periods of frequent intense hurricane strikes having occurred thousands of years ago.[49]

Yet there is almost no evidence for any current global trend in hurricane strength. Even the IPCC has found 'no significant observed trends' in the number of global hurricanes each year.[50]

8. Tornadoes

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. Like hurricanes, tornadoes are categorised according to wind speed, using the Fujita Scale going from EF0 to EF5; EF5 tornadoes attain wind speeds up to 480 km per hour (300 mph).

Tornadoes, which occur predominantly in the US, did not distinguish 2020 any more than hurricanes. The annual tornado count was just below the mean since 2005, and the US is currently in its second-longest period between observations of the strongest EF5 tornadoes, the last having been observed in 2013.[51]

The annual incidence of all US tornadoes from 1950 to 2020 is shown in Figure 21. There is no meaningful trend over a period that included both warming and cooling spells, but with net global warming of approximately 1.1°C (2.0°F) during that time.[39]

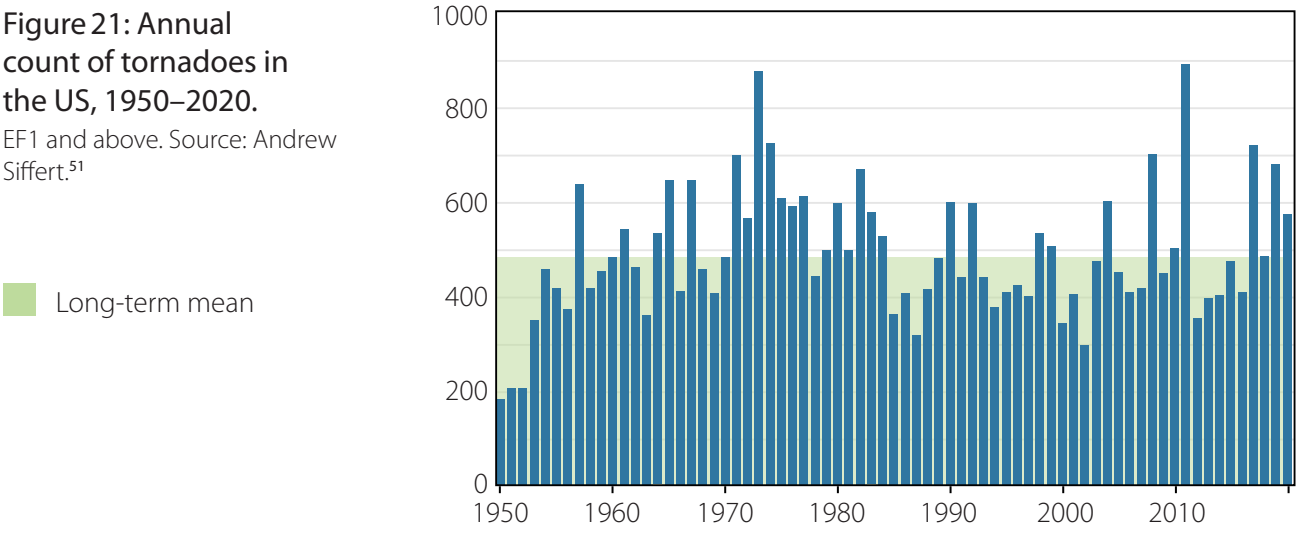


Figure 21: Annual count of tornadoes in the US, 1950–2020.
EF1 and above. Source: Andrew Siffert.[51]

Figure 22 depicts the number of strong (EF3 or greater) tornadoes observed in the US each year from 1954 to 2017. Clearly, the trend is downward instead of upward. The average number of strong tornadoes annually from 1986 to 2017 was 40% less than from 1954 to 1985.[52] Global warming, which might be expected to increase tornado activity, cannot have played any role.

But, as an illustration of how tornado activity can vary drasti-

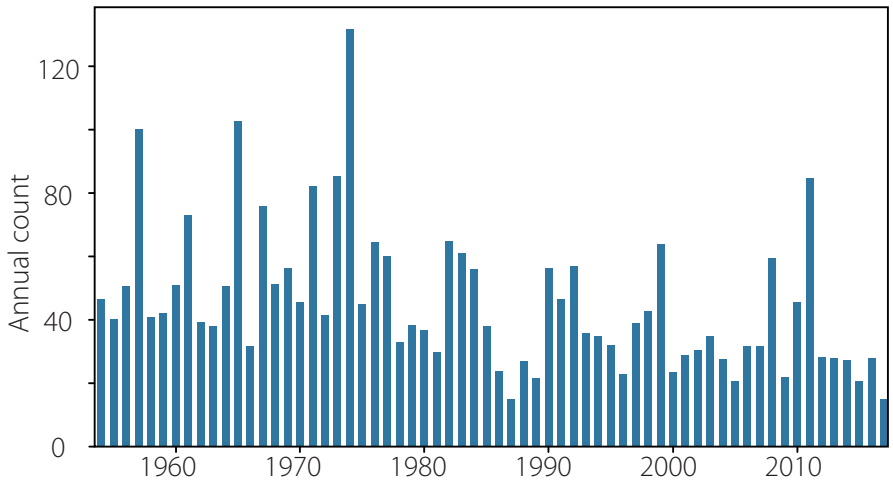


Figure 22: Annual count of strong to violent tornadoes in the US, 1954–2017.
EF3 and above. Source: NOAA.[84]

cally from year to year, 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. The tornado surge, however, had nothing to do with climate change, but rather an unusually cold winter and spring in the west that, combined with heat from the southeast and late rains, provided the ingredients for severe thunderstorms.[53]

Tornadoes are not the only damaging wind phenomenon that results from severe thunderstorms. In 2020, the most destructive wind event in the US was the Midwest derecho.[54] A derecho is a widespread, long-lived, straight-line wind storm spawned by a rapidly moving group of strong thunderstorms. The 2020 derecho, with winds up to 225 km per hour (140 mph), caused torrential rain, extensive damage and several deaths in multiple states. Yet climate scientists could not agree on whether climate change played a role.

As with hurricanes, the IPCC has dismissed any connection between global warming and tornadoes. While it concedes that rising temperatures and humidity may create atmospheric instability conducive to tornadoes, it also points out that other relevant factors, such as wind shear, diminish in a warming climate.[55]

In the US, tornadoes cause about 80 deaths and more than 1500 injuries per year. The deadliest episode of all time in a single day was the 'tri-state' outbreak in 1925, which killed 747 people and resulted in the most damage from any tornado outbreak in US history. The most ferocious tornado outbreak ever recorded, spawning a total of 30 EF4 or EF5 tornadoes, was in 1974.

Tornadoes also occur more rarely in other parts of the world. The earliest known tornado in history occurred in Ireland in 1054.[56] The human toll from tornadoes in Bangladesh actually exceeds that in the US, at an estimated 179 deaths per year, partly due to the region's high population density.[57]

It is population growth and expansion outside urban areas that have caused the cost of property damage from tornadoes to escalate in the last few decades, as noted in earlier sections. The narrative that climate change is producing stronger and more deadly tornadoes is as incorrect as the other nonexistent links between climate change and weather extremes already examined.

9. Wildfires

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 because they are often made worse by weather extremes such as heatwaves or drought, as the WMO rightly points out,[58] and because of the hysteria generated by the mainstream media almost every time a wildfire occurs, especially in naturally dry climates such as those in Australia, California or Spain. In addition to drying out of vegetation, wildfires require sustained high temperatures and winds plus a source of ignition. A common form of ignition is lightning strikes during dry thunderstorms.

The media wasted no time attributing 2020's Arctic heatwave and associated wildfires to climate change, despite the lack of any evidence for connection between heatwaves and global warming (Section 3). Although the Arctic wildfires were caused in part by exceptionally high temperatures in northern Russia during the 2020 spring and summer, record high numbers of wildfires in both the Arctic and the US last year were more than counterbalanced by record low numbers of fires in Canada and Africa.[59]

In the Arctic, there is in fact no discernible trend in the total area burned over the past 20 years, as shown in Figure 23. One of the contributions to Arctic warming comes from a natural ocean cycle, the Atlantic Multidecadal Oscillation (AMO) mentioned previously (Sections 6 and 7). The current warm phase of the AMO heats the northern waters of the Atlantic Ocean, which are carried by the North Atlantic current into the Arctic Ocean. There, the warm Atlantic water makes its way beneath the ice to points as far away as the coast of Siberia[60] – the locus of the 2020 wildfires, some of which burned to within 11 km (7 miles) of the sea.

More media clamour over wildfires occurred later in 2020 when massive fires erupted in the western US, especially in California. By the end of the year, a total of 1.7 million hectares (4.3 million acres), or more than 4% of California's land area, had burned in the state, making 2020 the largest wildfire season re-

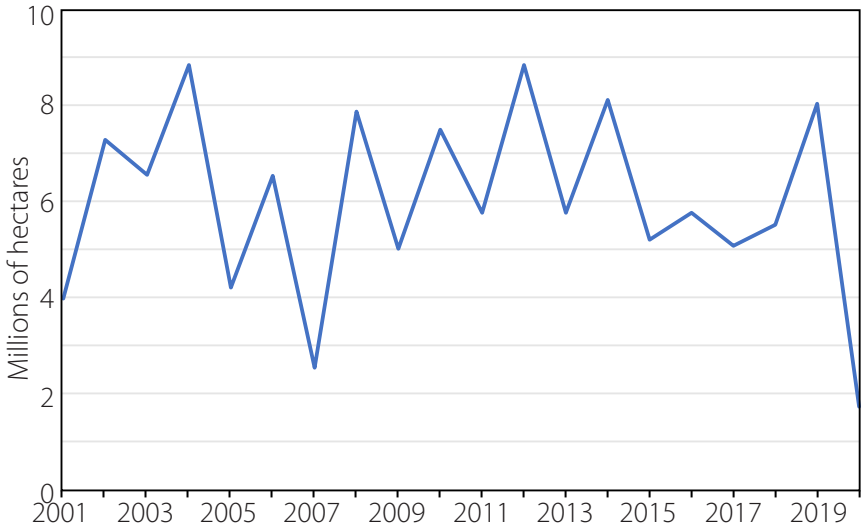


Figure 23: Annual Arctic forest area burned by wildfires, 2001-June 2020.
Circumpolar high northern latitudes, 55°N to 70°N; 2020 data incomplete. Source: NOAA.[85]

corded in California's modern history.[61] However, the burned area was no more than the typical acreage torched annually in the 1700s before Europeans arrived, which averaged around 1.8 million hectares (4.4 million acres) yearly and up to 4.8 million hectares (12 million acres) in peak years.[62]

The 2019–2020 bushfires in Australia, which burned an estimated 30 million hectares (74 million acres),[63] were called 'unprecedented' and blamed on global warming by adherents to the climate change narrative. But just as in the US, past Australian bushfires burned even larger areas. During a 30-year period of global cooling from 1940 to 1970, an average of about 80 million hectares (200 million acres) were consumed annually. Figure 24 shows a recent estimate of the percentage of the continent's land surface burned every year from 1900 to 2020.[64]

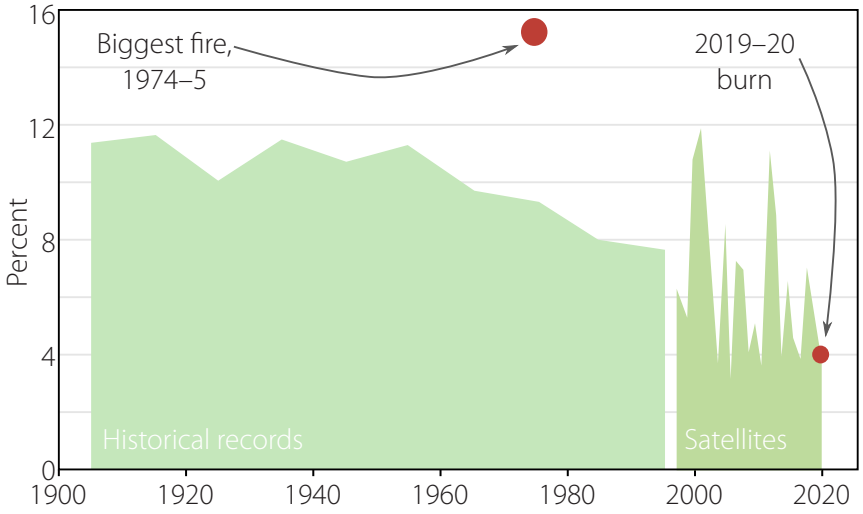


Figure 24: Australian area burned by wildfires, 1900–2020.
Percentage of total land area of 769 million hectares; estimates by decade 1900–2000, satellite measurements 1997–2020 with linear best trend. Source: Bjørn Lomborg.[64]

While it's true that the number of acres burned annually in the US has gone up over the last 20 years or so, the present burned area is still only a small fraction of what it was back in the 1930s, as seen in Figure 25. Because modern global warming was barely underway in the 1930s, climate change clearly has nothing to do with the incineration of US forests.

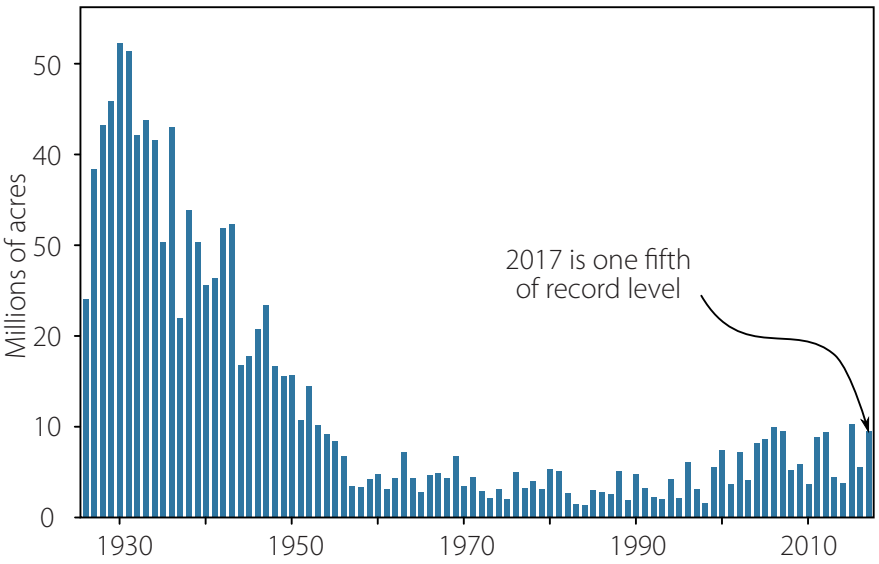


Figure 25: Annual US forest area burned by wildfires, 1926–2017.
Source: National Interagency Fire Center.[86]

Exactly the same trend is apparent in Figure 26, which depicts the estimated worldwide area burned by wildfires by decade from 1900 to 2010. Unquestionably, global wildfires have diminished as the planet has warmed.

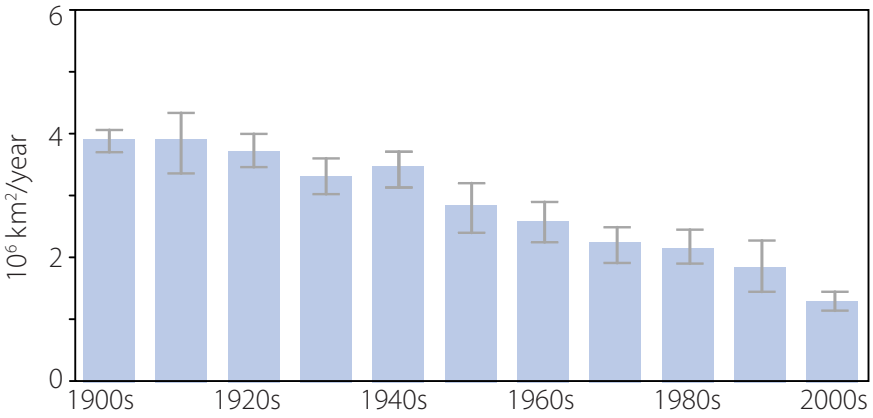


Figure 26: Global forest area burned by wildfires, 1900–2010.
Source: Jia Yang et al.[87]

A 2017 study estimated that the area burned globally decreased by 24% between 1998 and 2015, largely due to agricultural expansion and intensification, especially in savannas and grasslands.[65] Over the century from 1915 to 2015, the global burned area declined steadily at a rate of approximately 7% per decade, calculated from the data in Figure 26 and the 2017 study. A recent study attributes this trend to the dominance over higher temperatures of heavier precipitation (Section 6) and increased population density: while warming enhances wildfires by drying out vegetation, population increases lead to a reduction in vegetation through clearing of land.[66] In arid climates such as California and Australia, not only does warming dry out the land but the dry land results in warmer temperatures, in a feedback effect.

In the Mediterranean, although the annual number of wildfires has more than doubled since 1980, the burned area over three decades has mimicked the global trend and declined.

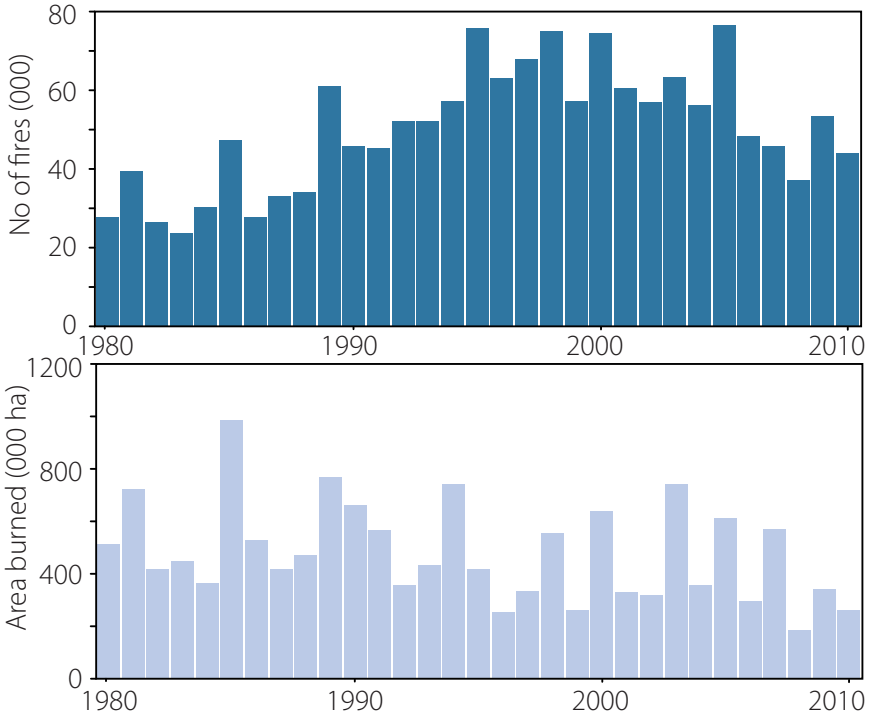


Figure 27: Mediterranean (a) wildfire occurrence, and (b) burned forest area, 1980–2010.
Source: Stefan H. Doerr and Cristina Santín.[88]

The contrast between the Mediterranean and the US, where wildfires are becoming fewer but larger in area, has been attributed to different forest management policies on the two sides of the Atlantic – despite the protestations of US politicians and some firefighting officials in western states that climate change is responsible for the recent uptick in fire size. Figure 28 illustrates the timeline from 1600 onwards of fire occurrence at more than 800 different sites in western North America.

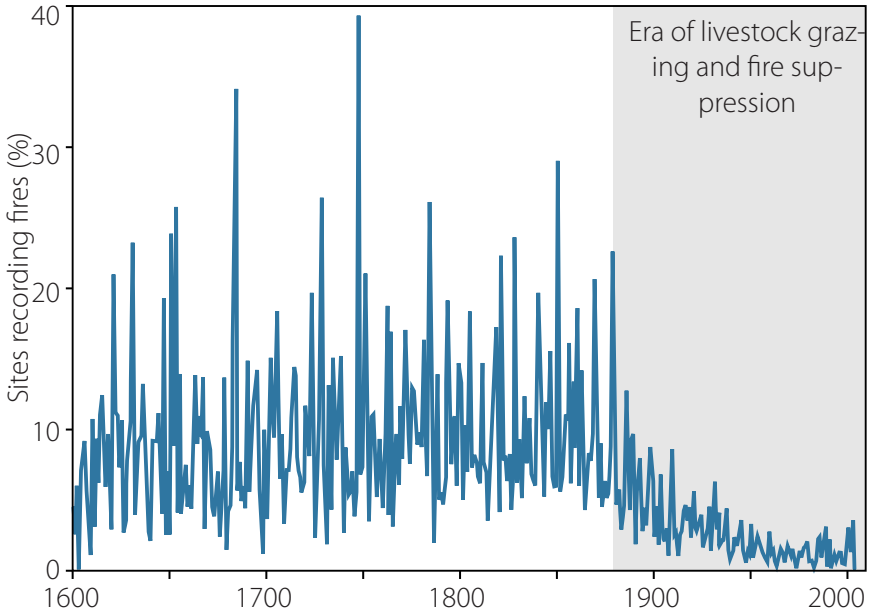


Figure 28: Western North America wildfire occurrence, 1600–2000.
Data from 800+ sites. Source: Thomas W. Swetnam et al.[89]

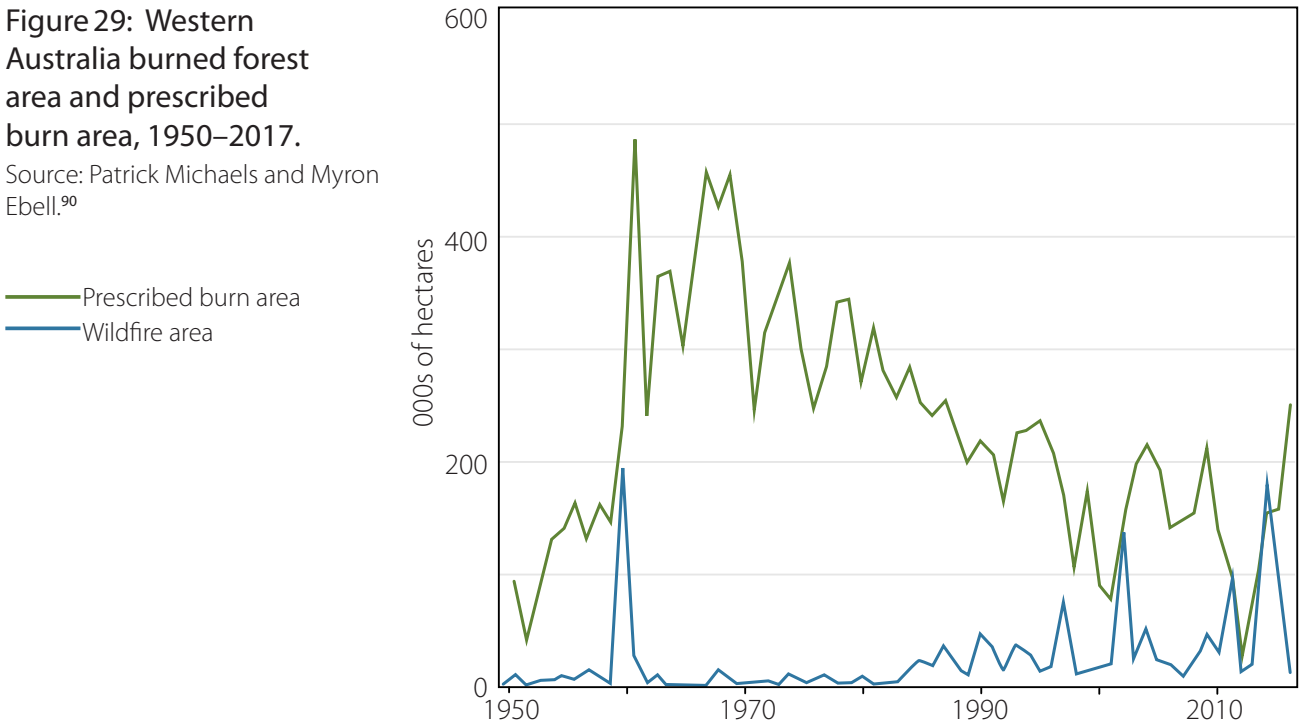
The sudden drop in wildfire occurrence around 1880 has been ascribed to the expansion of American livestock grazing in order to feed a rapidly growing population. The depletion of fuel by grazing cattle, together with the firebreaks created by the arrival of railroads, drastically reduced the incidence of wildfires. And once mechanical equipment for firefighting such as fire engines and aircraft became available in the 20th century, more and more emphasis was placed on wildfire prevention.

But wildfire suppression in the US has led to considerable increases in forest density and the buildup of undergrowth, both of which greatly enhance the potential for bigger and sometimes hotter fires. Decades of fire suppression and poor management of California's forests have resulted in overcrowding that leaves them 'susceptible to disease, insects and wildfire', noted the Little Hoover Commission in 2018.[67]

Intentional burning, long used by native tribes and early settlers, has become a thing of the past. Only now, after several devastating wildfires in California, is the idea of controlled burning being revived in the US. Direct recent evidence of the efficacy of controlled burning is presented in Figure 29, which shows how bushfires in Western Australia expanded significantly as prescribed burning was suppressed over the 50 years from 1963 to 2013. In Europe, on the other hand, prescribed burning has been supported by land managers for many years.

Figure 29: Western Australia burned forest area and prescribed burn area, 1950–2017.

Source: Patrick Michaels and Myron Ebell.[90]



Combined with overgrowth, global warming does play a role in wildfire intensity by drying out vegetation and forests more rapidly than before, as discussed earlier. But there is no evidence at all for the notion peddled by the media that climate change has amplified the impact of fires on the ecosystem, known technically as fire severity. Indeed, at least ten published studies of forest fires in the western US have found no recent trend of increasing fire severity.[89]

The ever-rising level of carbon dioxide in the atmosphere would be expected to increase wildfire risk, since carbon dioxide promotes plant growth. The concentration of carbon dioxide in the atmosphere is currently rising by about 2.4 parts per million (ppm) per year and the global average reached 414 ppm in 2020. But at the same time, higher carbon dioxide levels reduce plant transpiration, meaning that plants' stomata or breathing pores open less, the leaves lose less water and more moisture is retained in the soil. Increased soil moisture has led to a worldwide greening of the planet.

So the false belief that the 'new normal' of devastating wildfires around the globe is a result of climate change is not supported by the evidence. Although a recent attribution study claims that climate change made the 2019–2020 Australian bushfires at least 30% more likely,[68] those fires burned a much smaller area than in several previous fire seasons, as mentioned above. Just like hurricanes and tornadoes, there is no scientific evidence that the frequency or severity of wildfires are on the rise across the world.

Humans, nevertheless, are the primary reason that wildfires have become larger and more destructive today. Population growth has caused more people to build in fire-prone areas, where fires are frequently sparked by an aging network of power lines and other electrical equipment; a larger population also raises the risk of accidental ignition on hot days. Coupled with inadequate forest management, this constitutes a recipe for disaster.

10. Conclusions

The solid scientific evidence presented in this report shows how the belief that weather extremes are worsening because of climate change is badly mistaken and more a perception, fostered by media coverage, than reality. Sociologist Frank Furedi, who has studied the exploitation of fear in modern culture, has argued that:

> The term 'extreme weather' … works not so much as a scientific but as a cultural metaphor to capture the anxieties of our time. In contemporary culture, extreme weather is often interpreted through a moralistic narrative that presents it as the inevitable threatening outcome of irresponsible human behaviour.[69]

Careful examination of the actual data reveals that if there is any trend in weather extremes, it is downward rather than upward. In fact, a 2016 survey of extreme weather events since 1900 found strong evidence that the first half of the 20th century saw more weather extremes than the second half, when human emissions of greenhouse gases are alleged to have been mainly responsible for global warming[70] And as well-known climate scientist Richard Lindzen has remarked:

> Of course, even where trends exist, they are generally not unambiguously predicted, and hence don't constitute evidence. Moreover, even evidence is not proof, because, among other things, there are always confounding variables.[71]

Rather than global warming, it is natural patterns in the climate system that produce extreme weather conditions. The Atlantic Multidecadal Oscillation controls many extremes, including intense hurricanes in the North Atlantic basin as well as major floods in eastern North America and western Europe. The North Atlantic Oscillation and Pacific Decadal Oscillation have been linked to cold weather extremes in North America, while the Arctic Oscillation governs heatwaves in the Arctic.

Similarly, it is the familiar El Niño and La Niña cycles in the Pacific Ocean that often cause catastrophic flooding in the western Americas and flooding or severe drought in Australia. La Niña has also been connected to major landfalling hurricanes in both the US and the western Pacific. Moreover, as discussed in Section 3, recent Arctic and European heatwaves are thought to have resulted from jet stream blocking, which can arise from natural sources such as changes in the Sun or in upper atmosphere winds.

Although extreme weather occurs regardless of human activity, we do play a big role in determining its consequences. Droughts are intensified by poor farming practices that lead to soil erosion or depletion of groundwater. The increasingly popular habit of building homes near water, either along rivers or on the sea coast, has greatly increased the property damage brought about by major floods and hurricanes. Population expansion beyond urban areas has worsened the death toll and property damage from tornadoes and wildfires; wildfires in the US and Australia have also been exacerbated by the trend away from controlled burning.

Hysteria over extreme weather, and the attempt to link it to global warming, are simply unwarranted.

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