



# WEATHER EXTREMES

## Are they caused by global warming?

Ralph Alexander

# Weather Extremes: Are they caused by global warming?

Ralph B. Alexander

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## Executive summary

This report discusses the lack of scientific evidence for the popular but mistaken belief that global warming causes weather extremes – a notion hyped by the mainstream media and believers in the narrative of human-caused climate change. If there is any trend at all in extreme weather, it's downward rather than upward. Our most extreme weather, be it heat wave, drought, flood, hurricane or tornado, occurred many years ago, long before the carbon dioxide level in the atmosphere began to climb at its present rate.

The recent atmospheric heat waves in western Europe pale in comparison with the soaring temperatures of the 1930s, a period when three of the seven continents and 32 of the 50 US states set all-time high temperature records, which still stand today. The assertion that marine heat waves have become more severe is dubious because of the unreliability and sparseness of ocean temperature data from the pre-satellite era, for which reason earlier marine heat waves were likely missed.

No long-term trend exists in drought patterns, either in the US or elsewhere in the world. Nor is there any evidence that floods are becoming worse or more common, despite average rainfall getting heavier as the planet warms. Excessive precipitation isn't the only cause of flooding: other influences include alterations to catchment areas such as land-use changes, deforestation and the building of dams.

Hurricanes actually show a decreasing trend around the globe, and the frequency of landfalling hurricanes of any strength (Categories 1 through 5) hasn't changed for at least 50 years. While the frequency of major North Atlantic hurricanes, which are the most studied, has increased during the past 20 years, the current heightened activity level is merely comparable to the 1950s and 1960s – a period when the earth was cooling, not warming as it is now.

Likewise, there is no trend in the frequency of US tornadoes since at least as far back as 1954. The frequency of strong (EF3 or greater) tornadoes has even diminished over that interval. The average number of strong tornadoes annually from 1986 to 2017 was 40% less than from 1954 to 1985.

Wildfires (which are included in the report despite not being a form of extreme weather) are not on the rise either. Although the number of acres burned annually in the US has gone up over the last two decades, the present burned area is still only a small fraction of what it was in the record-breaking







1930s. The same downward trend is evident in the estimated area burned by wildfires in Australia and the Mediterranean, as well as globally.

Extreme weather conditions are produced by natural patterns in the climate system, not global warming. 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. 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. And the recent European heat waves resulted from jet stream blocking rather than global warming.

Although cold weather extremes appear to be on the rise, the Intergovernmental Panel on Climate Change (IPCC), whose assessment reports serve as the voice of authority for climate science, has paid no attention to them. The World Meteorological Organization (WMO) now acknowledges the existence of cold extremes but has no explanation for their origin.

Surprisingly though, the IPCC stands out, among those who believe that global warming comes from human activity, as a voice of restraint on the issue of extreme weather. Even though the panel pays lip service to its supporters by stating that climate change is likely to exacerbate future weather extremes, it has so far adhered to the path of science by finding little to no evidence linking extreme weather to global warming. The IPCC's low confidence in such a link is all that is justified by the empirical evidence.

## 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.









## 1. Introduction

The purported link between extreme weather and global warming has captured the public imagination and attention of the mainstream media far more than any of the other claims made by the narrative of human-caused climate change. However, there is no scientific evidence that global warming triggers extreme weather, or even that extreme weather is becoming more frequent. Anomalous weather events, such as heatwaves, hurricanes, floods, droughts and tornadoes, show no long-term trend over more than a century of reliable data. Weather extremes have occurred from time immemorial, long before industrialization boosted the carbon dioxide level in the atmosphere. As we will see, collective memories of extreme weather are short-lived.

Nonetheless, many people insist that the intensity and frequency of extreme weather events are on the rise. The most recent US National Climate Assessment in 2018, for example, concludes that ‘The last few years have... seen record-breaking, climate-related weather extremes.’<sup>1</sup> A 2019 Special Report from the Intergovernmental Panel on Climate Change (IPCC) states that ‘...the role of climate change in the ocean and cryosphere extreme events is increasingly driving extreme climate and weather events across the globe...’<sup>2</sup> And a 2019 report on the global climate by the World Meteorological Organization (WMO), one of the IPCC’s parent organizations, declares that ‘Extreme heat and heat waves were recorded in many parts of the world during the period 2015–2019,’ together with ‘unprecedented wildfires.’<sup>3</sup>

However, these conclusions rely on so-called ‘event attribution studies,’<sup>4</sup> 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). Not only did the models fail to predict the recent pause or hiatus in global warming from the late 1990s to about 2014, but they have overestimated the warming rate by at least a factor of two, they wrongly predicted a hot spot in the upper atmosphere that isn’t there, and are unable to accurately reproduce sea-level rise. The severe limitations of computer climate models have been summarised by University of Alabama climatologist John Christy in a separate GWPF report.<sup>5</sup>

Aside from attribution studies, the IPCC, whose assessment reports serve as the voice of authority for climate science, finds little to no evidence connecting extreme weather to global warming overall, except for heavier rainfall in some regions – something to be expected in a warming world. The IPCC has done as much or more than any other organization to create widespread alarm about global warming. But, while the panel has stated that climate change is likely to exacerbate *future* extreme weather events and may now be changing its position on past events,<sup>2,6</sup> it stands out currently, among those who believe in human-caused climate change, as a voice of restraint on weather extremes.

Section 2 reviews the IPCC position in more detail. The remainder of this report, much of which is based on a recent series of blog posts,<sup>7</sup> examines the scientific record of recent heatwaves, droughts, major floods, hurricanes, tornadoes and wildfires. The report updates a previous 2013 GWPF report on global warming and extreme weather.<sup>8</sup>

## 2. The IPCC position

While the IPCC is a leading advocate for the theory of man-made climate change, it has hedged its bets on linking weather extremes to global warming. In its 2012 *Special Report on Managing Disaster Risk in a Changing Climate*, 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.<sup>9</sup>

In the same report, however, the IPCC expressed 'medium' confidence that global warming had intensified droughts in certain parts of the world:

There is *medium confidence* that some regions of the world have experienced more intense and longer droughts, in particular in southern Europe and West Africa, but in some regions droughts have become less frequent, less intense, or shorter, for example, in central North America and northwestern Australia.<sup>10</sup>

Yet one year later in its 2013 Fifth Assessment Report, the IPCC appeared to retract its previous drought statement, saying:

...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.<sup>11</sup>

On tropical cyclones, both the 2012 and 2013 reports expressed only 'low' confidence that cyclone activity was increasing over the long term, and that observed global changes in cyclone activity could be attributed to any particular cause.<sup>11, 12</sup> This assertion was repeated again in the 2019 *Special Report on the Global 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...<sup>2</sup>

On heat waves and heavy precipitation, the IPCC has been less equivocal, making the following declaration in its Fifth Assessment Report:

It is *likely* that the frequency of heat waves has increased in large parts of Europe, Asia and Australia. There are *likely* more land regions where the number of heavy precipitation events has increased than where it has decreased. The frequency or intensity of heavy precipitation events has *likely* increased in North America and Europe. In other continents, *confidence* in changes in heavy precipitation events is at most *medium*.<sup>12</sup>

Likewise, on the occurrence of *marine* heat waves, the IPCC



asserted in its 2019 Special Report that:

...it is *very likely* that marine heat waves have increased in frequency, duration and intensity since preindustrial [times]...<sup>2</sup>

Although the IPCC expressed 'very high' confidence in this particular claim, such confidence is completely unjustified, as discussed in Section 3. No IPCC report assigns a confidence level to the frequency or intensity of atmospheric heat waves on a global scale. And the reports express only 'medium' or lower confidence that warming has increased heavy precipitation globally.<sup>12</sup>

### 3. Heat waves

Heat waves, or periods of abnormally hot weather, lasting from days to weeks, have been a regular feature of Earth's climate for at least as long as recorded history. The issue here is whether global warming has made heat waves more frequent, hotter or longer. According to the media and environmental activists, atmospheric heat waves like those experienced recently in both northern and southern hemispheres are unprecedented and a harbinger of harsh, searing hot times to come. Supposedly, high temperature records are tumbling all over the world.

But this simply isn't so. The beliefs that the earth is burning up and may shortly be uninhabitable, and that this is all a result of human-caused global warming, are not based on science. And the notion that heat waves are linked to climate change at all is at odds with the actual scientific evidence.

The brouhaha over two almost back-to-back heat waves in western Europe in the summer of 2019 is a case in point. In the second, which occurred toward the end of July, the WMO claimed that the mercury in Paris reached a new record high of 42.6°C (108.7°F) on 25 July, besting the previous record of 40.4°C (104.7°F) set back in July 1947.<sup>13</sup> And a month earlier, during the first heat wave, temperatures in southern France hit a purported record 46.0°C (114.8°F) on 28 June.<sup>14</sup>

However, in August 1930, Australian<sup>15</sup> and New Zealand<sup>16</sup> newspapers gave an account of an earlier French heat wave, 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.

And the same newspaper articles reported a temperature in Paris that day of 38°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).

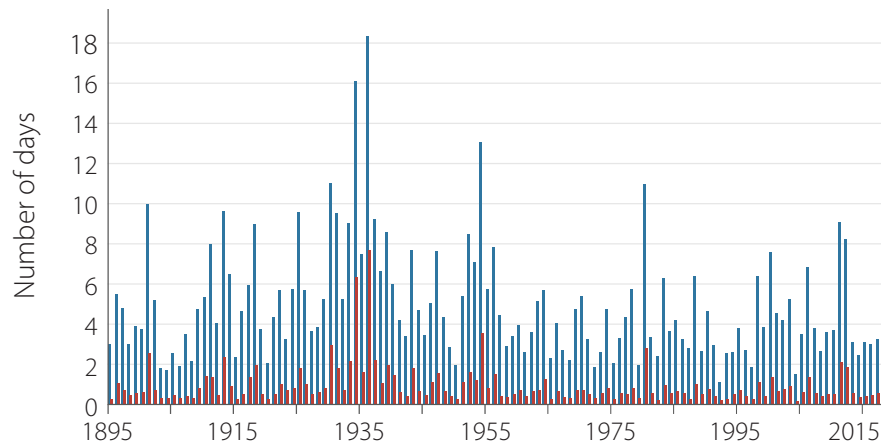
The same discrepancies can be seen in proclamations about past US temperatures. Although it is frequently claimed that heat waves there are increasing in both intensity and frequency, there is no scientific evidence for such a bold assertion. Figure 1 charts official data from the US National Oceanic and Atmospheric Ad-

**Figure 1: Number of daily US maximum temperatures above 100°F and 105°F.**

Average over 982 USHCN stations, 1895–2018. Source: NOAA/NCEI, prepared by John R. Christy.<sup>44</sup>

**Number of days exceeding:**

- 100°F (37.8°C)
- 105°F (40.6°C)



ministration (NOAA) showing, for 1895–2018, the annual number of days on which the average of all US temperature stations exceeded 38°C (100°F) and 41°C (105°F).

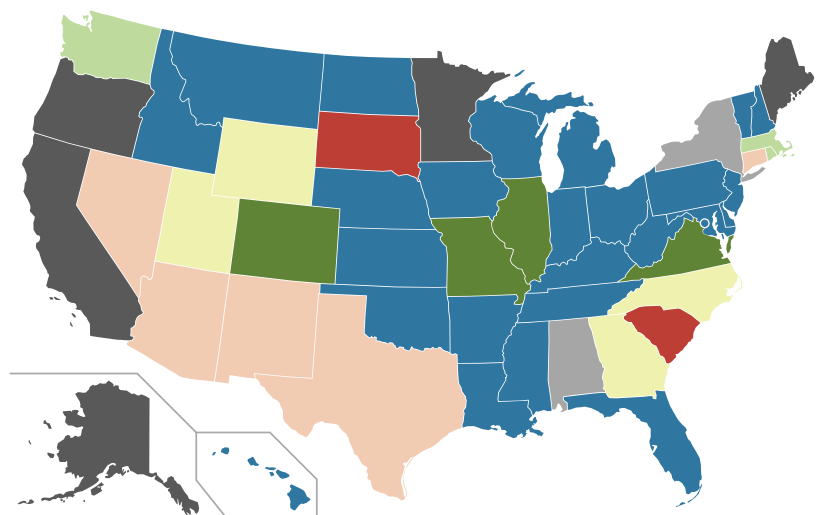
Figure 2 shows NOAA’s data for the year in which the record high temperature in each US state occurred. Of the 50 state records, a total of 32 were set in the 1930s or earlier, but only seven since 1990. It is evident from these two figures that there were more US heat waves in the 1930s, and they were hotter, than in the present era of global warming. Indeed, the annual number of days on which US temperatures reached 100°F, 95°F or 90°F has been falling steadily since the 1930s. The Environmental Protection Agency (EPA)’s Heat Wave Index for the 48 contiguous states also shows clearly that the 1930s were the hottest decade.<sup>17</sup>

**Figure 2: Decades of US state temperature records.**

Source: NOAA.<sup>45</sup>

**Records set:**

- Before 1920
- 1920s
- 1930s
- 1950s
- 1960s–1970s
- 1980s
- 1990s
- 2000s



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 1982,<sup>20</sup> three records dating from the 1930s or before; only Asia has set a record more recently (the WMO hasn’t acknowledged the 122°F 1930 record in the Loire region). And yet the worldwide baking heat of the 1930s didn’t set the stage for more and worse heat waves in the years ahead, even as carbon di-



Table 1: Continental maximum temperature records.

Source: WMO.<sup>46</sup>

	Record (°C)	Year record set
North America	56.7	1913
Europe	48.1	1977
South America	48.9	1905
Asia	53.9	2016
Africa	55.0	1931
Australasia	50.6	1960
Antarctica	19.8	1982

oxide 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.

Contrary to the climate change narrative, the recent European heat waves came about, not because of global warming, but rather a weather phenomenon known as jet stream blocking. Blocking results from an entirely different mechanism than the buildup of atmospheric carbon dioxide, namely a weakening of the sun’s output that may portend a period of cooling ahead. A less active sun generates less UV radiation, which in turn perturbs winds in the upper atmosphere, locking the jet stream in a holding or blocking pattern. In this case, blocking kept a surge of hot Saharan air in place over Europe for extended periods.<sup>18</sup>

Marine heat waves, a relatively new term, describe extended periods of abnormally high ocean temperatures. Examples are the so-called ‘Blob,’ observed in the northeast Pacific Ocean from 2013 to 2015, and a similar temperature spike seen in Australia’s Tasman Sea from 2015 to 2016. The phenomenon affects marine organisms and ecosystems, causing bleaching of coral reefs or loss of kelp forests, for example. Temperatures in a marine heat wave typically range from about 2°C (3.6°F) to 5°C (9°F) above normal.<sup>19</sup>

The IPCC asserts that marine heat waves doubled in frequency from 1982 to 2016 and that they have also become longer-lasting, more intense and more extensive.<sup>2</sup> However, these are dubious claims since the observations supporting them were made during the satellite era. Satellite measurements of ocean temperature are far more accurate and broader in coverage than measurements made by the old-fashioned methods used in earlier times. These cruder methods included placing a thermometer in seawater collected in wooden, canvas or insulated buckets tossed overboard from ships and hauled back on deck, or in seawater retained in ship engine-room inlets from several different depths; and data from moored or drifting buoys.<sup>20</sup>

Because of the unreliability and sparseness of sea surface temperature data from the pre-satellite era, it’s obvious that earlier marine heat waves may well have been missed. Indeed, it would be surprising if no significant marine heat waves occurred during the period of record-high atmospheric temperatures recorded in the 1930s, discussed previously.



Even without good quality data for these earlier periods, it has been found that from 1925 to 2016, the global average marine heatwave frequency and duration increased by only 34% and 17%, respectively.<sup>22</sup> Given the shortcomings of the early data, these are hardly dramatic increases. And in any case, the sample size for observations made since satellite observations began in 1982 is statistically small.

Coral bleaching is a controversial subject. Although some reef scientists claim that bleaching only began in the 1980s as global warming surged, and that it is therefore an entirely manmade problem, others point to scientific records that reveal coral bleaching events around the globe throughout the 20th century, including the heatwave years of the 1930s. Peter Ridd emphasizes this fact in a recent GWPF article, remarking that corals are capable of rapid recovery from bleaching events – in a decade or so.<sup>21</sup>

All this evidence demonstrates that heat waves, 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 heat waves and climate change is completely unwarranted.

#### 4. Cold extremes

As well as heat waves, the earth's temperature excursions include prolonged cold spells, sometimes accompanied by other extremes, such as unusually heavy snowfalls. Yet those who promulgate the notion that weather extremes result from global warming have been mostly silent about cold extremes.

The only attention the IPCC has paid to cold extremes is to note a decrease in the number of cold days and nights since about 1950.<sup>12</sup> But this is only to be expected as the world warms, and warmer nights come as much from the urban heat island effect as from global warming. However, the WMO includes a list of recent cold extremes, along with lists of the other extremes covered in this report, in its report on the global climate from 2015 to 2019<sup>3</sup> – the first official acknowledgment by the IPCC or WMO that cold weather extremes even exist.

That cold extremes might actually be increasing was explored by Madhav Khandekar in his 2013 GWPF report<sup>8</sup> and in a more recent publication.<sup>22</sup> 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. But 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.<sup>23</sup>

Yet the IPCC, 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

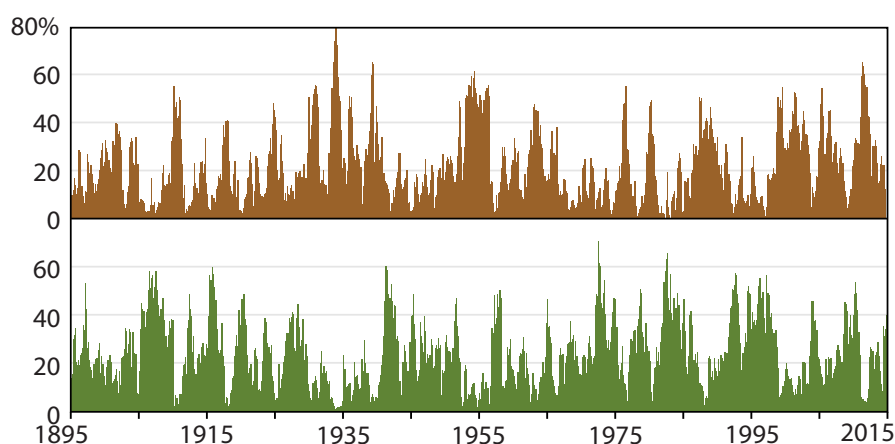
Droughts have also been a continuing feature of the earth's climate for millennia. Although generally caused by a severe fall-off in precipitation, and not by global warming as environmentalists sometimes claim, droughts can be aggravated by factors such as elevated temperatures, soil erosion and overuse of available groundwater. The consequences of drought, which can be disastrous for human and animal life, include crop failure, starvation and mass migration. A major exodus of early humans out of Africa about 135,000 years ago is thought to have been driven by drought.

Getting a good handle on drought has only been possible since the end of the 19th century, when the instrumentation needed to measure extreme weather accurately was first developed. The most widely used gauge of dry conditions is the Palmer Drought Severity Index (PDSI),<sup>24</sup> which measures both dryness and wetness and classifies events as 'moderate', 'severe' or 'extreme.' Figure 3 depicts the PDSI for the US during the past century or so, for all three drought or wetness classifications combined.

**Figure 3: Proportion of USA in moderate to extreme drought, 1900–2015.**

Based on the PDSI. Source: NCEI/NOAA.<sup>47</sup>

■ Moderate–extreme dry  
■ Moderate–extreme wet



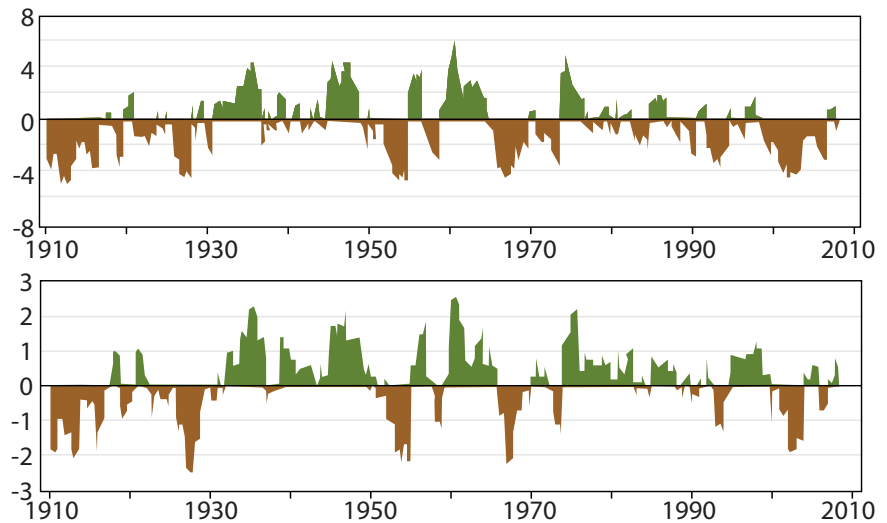
What jumps out immediately is the lack of any long-term trend in either dryness or wetness in the US. With the exception of the 1930s' Dust Bowl years, the pattern of drought (upper graph) looks boringly similar over the entire 120-year period, as does the pattern of excessive rain (lower graph).

Much the same is true for the rest of the world. Figure 4 illustrates two different drought indices during the period 1910–2010 for India, a country subject to parching summer heat followed by drenching monsoonal rains; negative values denote drought and positive values wetness. The two indices are a version of the PDSI (sc-PDSI, top graph), and the Standardized Precipitation Index<sup>25</sup> (SPI, bottom graph). The SPI, which relies on rainfall data only, is easier to calculate than the PDSI, which depends on both rainfall and temperature. While both indices are useful, the SPI is better suited to making comparisons between different regions.

We see that the SPI in India shows no particular trend toward either dryness or wetness over the 100-year period, although there are 20-year intervals exhibiting one of the two conditions;

**Figure 4: Drought and wetness in India, 1910–2010.**

Top: Self-calibrated Palmer Drought Severity Index; bottom: Standardized Precipitation Index. In both graphs, negative values indicate drought, positive values wetness. Source: SPEI.<sup>25</sup>



the apparent trend of the PDSI toward drought since 1990 is an artifact of the index. Similar records for other countries around the globe all show the same pattern – no drying of the planet as a whole over more than 100 years.

Recently, the mainstream 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’.<sup>26</sup> 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 are 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 of any link between drought and climate change. The IPCC was right to express low confidence in any global-scale observed trend.<sup>12</sup>

## 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 heat waves and drought, there is no evidence that floods are becoming worse or more common.

This was underlined by a 2017 Australian study of global flood risk,<sup>27</sup> which concluded very little evidence exists that worldwide flooding is becoming more prevalent. 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 the catchment area – such as land-use changes, deforestation and the building of dams – also play a major role.

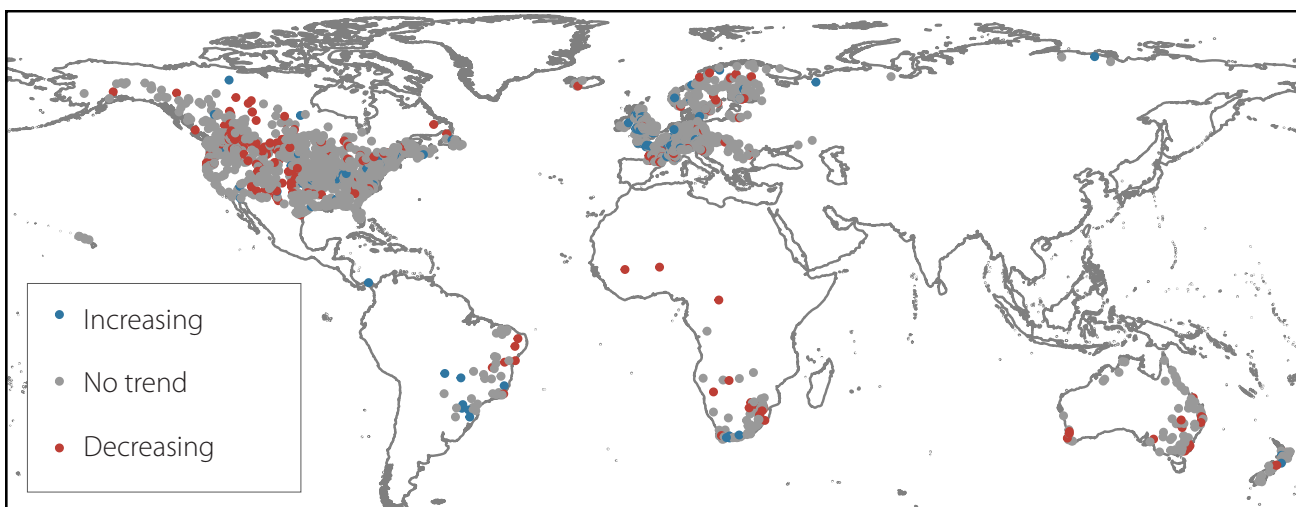
Yet the study found that the biggest influence on flood trends is not more intense precipitation, changes in forest cover or the presence of dams, but the *size* of the catchment area. Previous studies had emphasized small catchment areas, as these were thought less likely to have been extensively modified. 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 5, 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 that the lower flood trend in larger catchment areas is due to the expanding presence of agriculture and urbanization.

Another 2017 study, this time restricted to North America and Europe,<sup>28</sup> 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.

Figure 6 shows the likelihood of a 100-year flood occurring in North America or Europe in any given year, during two slightly different periods toward the end of the 20th century. A 100-year

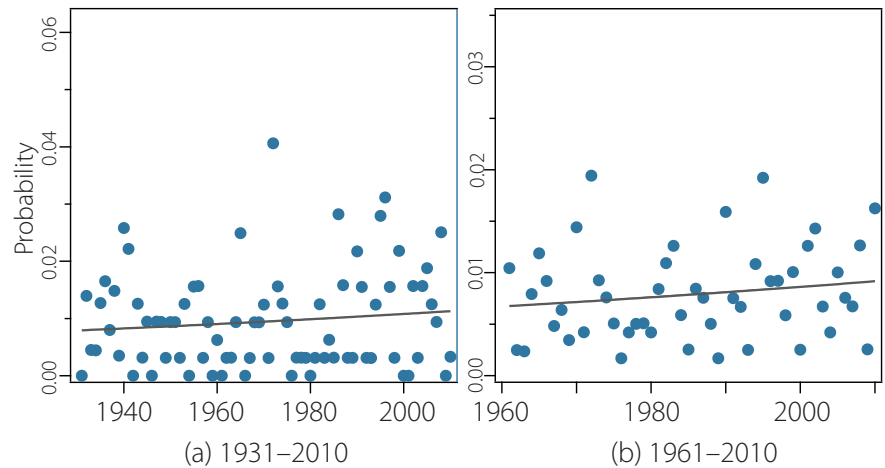


**Figure 5: Trends in magnitude of flooding events, 1966–2005.**

Data from 1,907 locations. The coloured dots show statistically significant trends at the 10% level.  
Source: Hong X. Do et al.<sup>27</sup>

**Figure 6: Probability of a 100-year flood in North America or Europe.**

(a) 1931–2010, (b) 1961–2010. Blue dots represent observed values, lines a logistic regression fit to the data. Source: Glenn A. Hodgkins et al.<sup>28</sup>



flood is a massive flood that occurs on average only once a century, and has a 1 in 100 or 1% chance of occurring or being exceeded in any given year – although the actual interval between 100-year floods is often less than 100 years.

We see that for both periods studied, the probability of a 100-year flood in North America or Europe hovers around the 1% (0.01) level or below, implying that 100-year floods were no more or less likely to occur during those intervals than at any other time. The straight lines drawn through the data points show no significant trend. Similar results were obtained for 50-year floods.

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 naturally occurring Atlantic Multidecadal Oscillation, an ocean cycle that causes heavier-than-normal rainfall in Europe and lighter rainfall in North America during its positive 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 people building their dream homes in harm's way, on river or coastal floodplains, where rainfall-swollen rivers or storm surges result in intermittent flooding and subsequent devastation. It is changing human wants rather than climate change that are responsible for disastrous floods.

## 7. Hurricanes

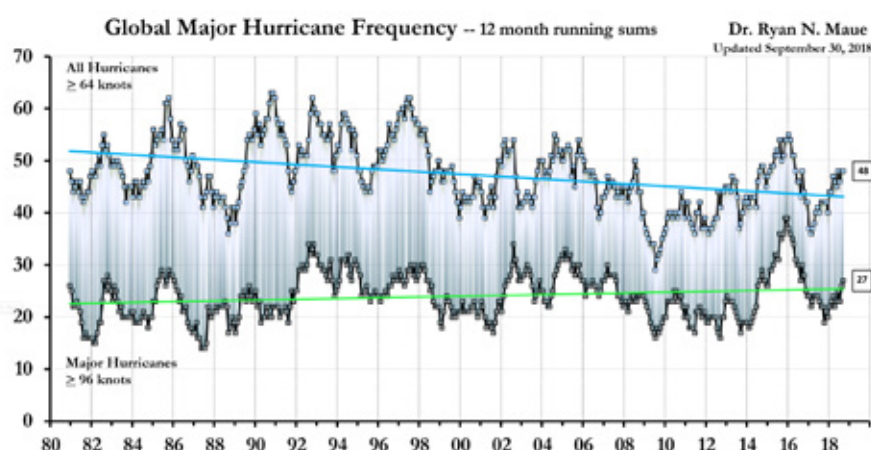
Hurricanes – powerful tropical cyclones that all too dramatically demonstrate the fury nature is capable of unleashing – attract immediate media attention, just like heat waves. But, while the IPCC has noted an apparent increase in the strongest (Category 4 and 5) hurricanes in the Atlantic Ocean, there is almost no evidence for any global trend in hurricane strength. And the IPCC has found 'no significant observed trends' in the *number* of global hurricanes each year.<sup>29</sup>

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. Hurricanes can be hundreds of kilometers in extent, with wind speeds up to 240 km per hour (150 mph) or more, and often exact a heavy toll in human lives and personal property. The deadliest US hurricane in recorded history struck Galveston, Texas in 1900, killing an estimated 8,000 to 12,000 people. In the Caribbean, the Great Hurricane of 1780 killed 27,500 and winds exceeded an estimated 320 km per hour (200 mph). The worst hurricanes and typhoons worldwide have each claimed hundreds of thousands of lives.

How often hurricanes have occurred globally since 1981 is depicted in Figure 7.

**Figure 7: Annual number of global tropical cyclones, 1981–2018.**

Maximum wind speed at least hurricane force (top), major hurricane strength (bottom). Source: Ryan N. Maue.<sup>48</sup>



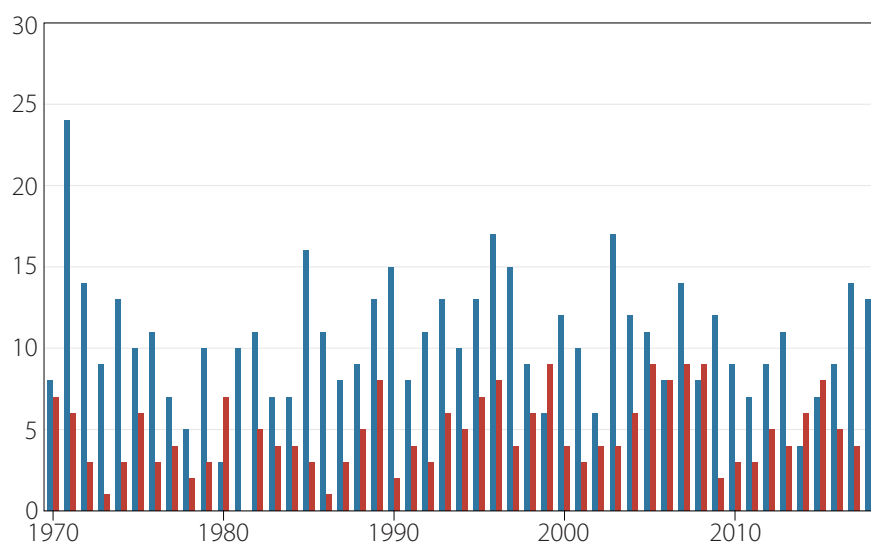
It's seen that the frequency of tropical cyclones overall is diminishing. However, though the number of major hurricanes of Category 2, 3, 4 or 5 strength seems to show a slight increase over this period, the trend has been ascribed to improvements in observational capabilities,<sup>30</sup> rather than warming oceans that provide the fuel for cyclones. The IPCC has noted the apparent upward trend of Category 4 and 5 hurricanes.<sup>2</sup>

The lack of any trend in major global hurricanes is borne out by the number of Category 3, 4 or 5 global hurricanes that make landfall, illustrated in Figure 8.

**Figure 8: Annual number of global landfalling tropical cyclones, 1970–2018.**

Source: Roger Pielke Jr.<sup>49</sup>

Category 1–2  
Category 3–5





We see that the frequency of landfalling hurricanes of any strength (Categories 1 through 5) hasn't changed in the nearly 50 years since 1970 – during a time when the globe warmed by approximately 0.6°C (1.1°F). So the strongest hurricanes today 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.

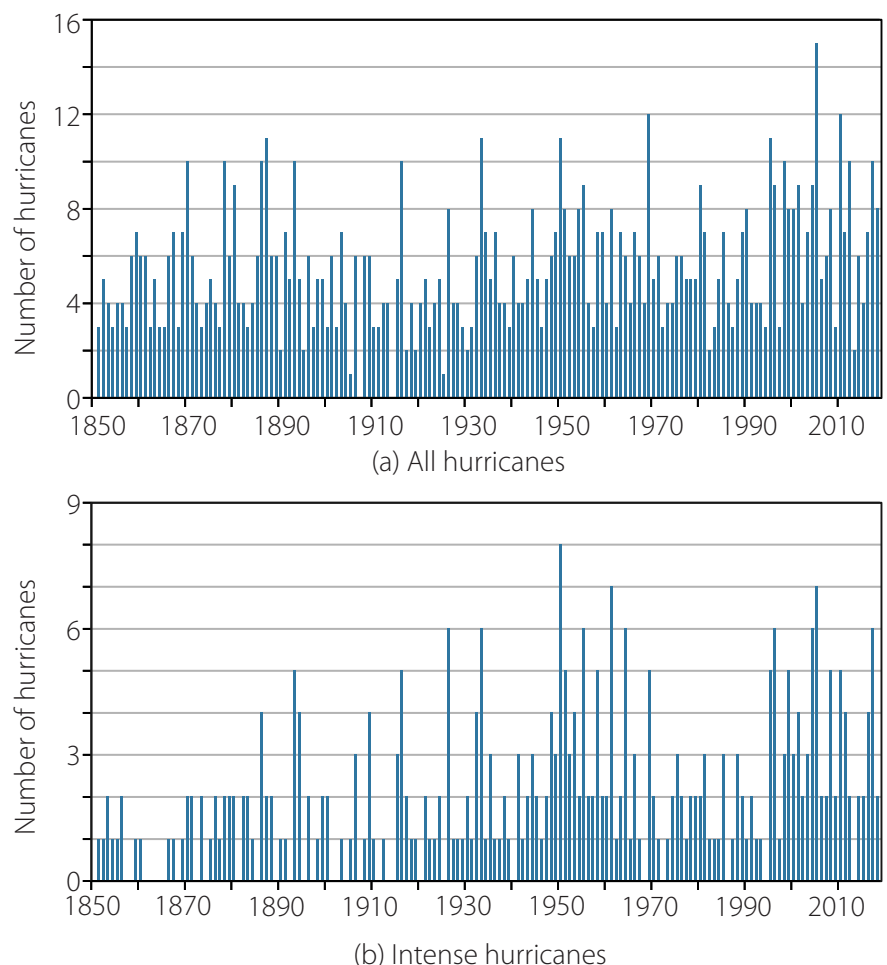
Data for the North Atlantic basin, which has the best quality data available in the world, do, however, show heightened hurricane activity over the last 20 years. Figure 9 illustrates the frequency of all North Atlantic hurricanes (top graph) and major hurricanes (bottom graph) for the much longer period from 1851 to 2018.

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, the present enhanced hurricane activity in the North Atlantic is highly unlikely to result from global warming. In fact, the pattern is more likely to be linked to the cyclical behavior of the Atlantic Multidecadal Oscillation.<sup>31</sup>

Even though it appears from Figure 9 that major North Atlantic hurricanes were less frequent before about 1940, the lower numbers reflect the relative lack of observations in early years of

**Figure 9: Annual number of North Atlantic hurricanes, 1851–2018.**

Source: NOAA Hurricane Research Division.<sup>50</sup>



the record. Aircraft reconnaissance flights to gather data on hurricanes only began in 1944, while satellite coverage dates only from the 1960s. While the data in Figure 9 have been adjusted to compensate for these deficiencies, the number of major North Atlantic hurricanes before 1944 is probably still undercounted.<sup>32</sup>

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 tracking of these violent storms that has been observed recently. Both of 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. In summarizing paleogeological studies of storms that raged prior to the historical record, climate scientist Judith Curry suggests that changes in hurricane activity similar to those seen recently are not at all uncommon, with several periods of frequent intense hurricane strikes having occurred thousands of years ago.<sup>32</sup>

## 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. Demolishing homes and buildings in its often narrow path, it can travel many kilometers before dissipating. The most violent EF5 tornadoes attain wind speeds of up to 480 km per hour (300 mph).

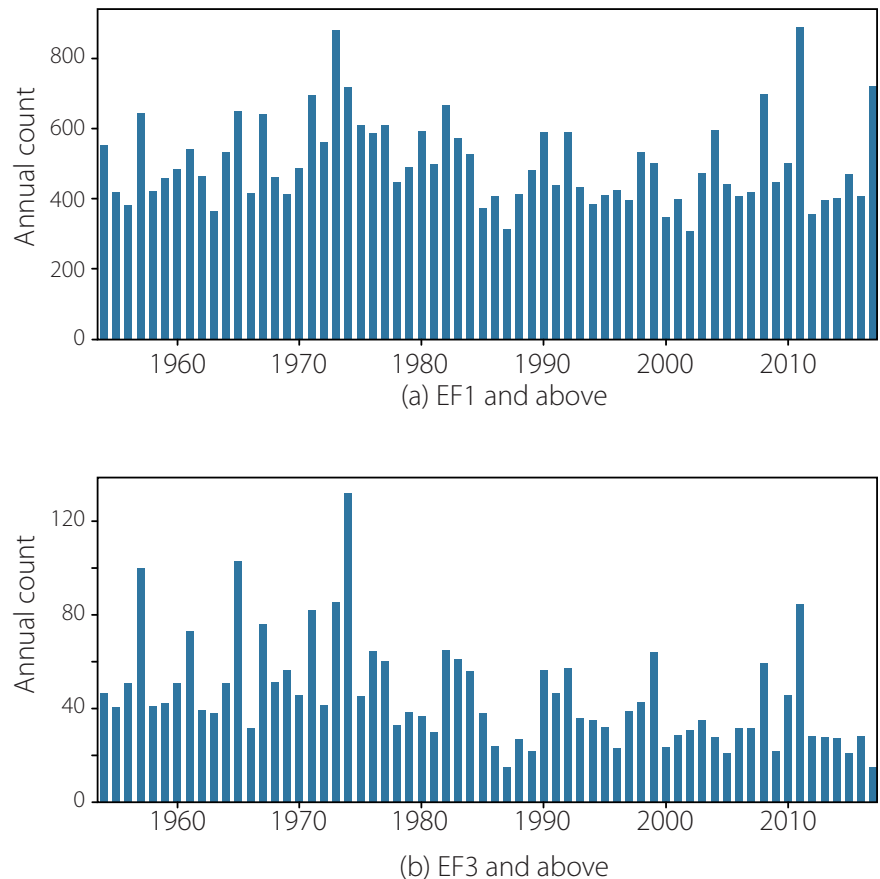
Tornadoes are smaller and claim fewer lives than hurricanes. But the roaring twisters can be more terrifying because of their rapid formation and their ability to hurl objects such as cars, structural debris, animals and even people through the air. Nonetheless, the narrative that climate change is producing stronger and more deadly tornadoes is as incorrect as the other nonexistent links between climate change and weather extremes already examined.

As with hurricanes, the IPCC has dismissed any connection between global warming and tornadoes. While it concedes that escalating temperatures and humidity may create atmospheric instability conducive to tornadoes, it also points out that other factors governing tornado formation, such as wind shear, diminish in a warming climate. In reality, it says, the apparent increasing trend in tornadoes simply reflects their reporting by a larger number of people now living in remote areas.<sup>33</sup>

The US endures by far the most tornadoes of any country, mostly in so-called 'Tornado Alley', an area extending northward from central Texas through the plains states. The annual incidence of all US tornadoes from 1954 to 2017 is shown in Figure 10a. It's obvious that there is no meaningful trend, over a period that included both cooling and warming spells, but with net global

**Figure 10: Annual number of tornadoes in USA, 1954–2017.**

(a) EF1 and above, (b) EF3 and above. Source: NOAA/NWS Storm Prediction Center.<sup>51</sup>



warming of approximately 0.7°C (1.3°F) during that time.

But, as an illustration of how US tornado activity can vary drastically from year to year, 13 successive days of 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.<sup>34</sup>

Figure 10b depicts the number of strong (EF3 or greater) tornadoes observed in the US each year during the same period. 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.<sup>35</sup> Once more, global warming cannot have played a role.

In the US, tornadoes cause about 80 deaths and more than 1500 injuries per year. The most deadly 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.<sup>36</sup> 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.<sup>37</sup> 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, especially in the US.

## 9. Wildfires

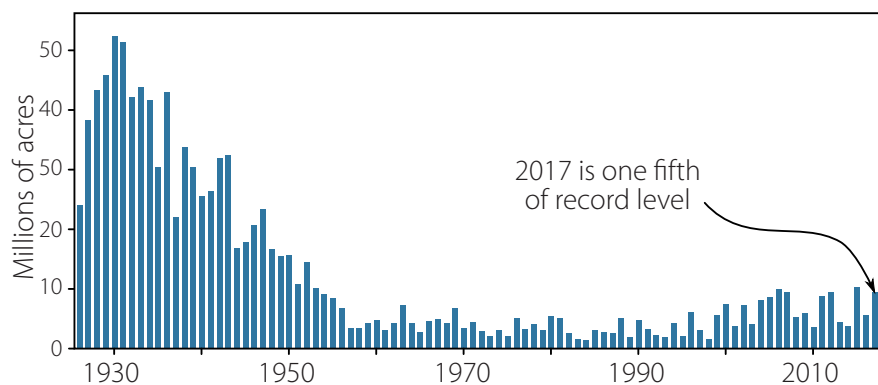
Wildfires are not a form of extreme weather, or indeed of weather at all, although they can produce their own weather. However, wildfires are included in this report because they are often made worse by weather extremes such as heat waves or drought, as the WMO rightly points out,<sup>3</sup> and because of the hysteria generated by the mainstream media almost every time a wildfire breaks out, especially in naturally dry climates such as those in California, Australia or Spain.

Together with tornadoes, wildfires are probably the most fearsome of the weather extremes commonly blamed on human-caused climate change. Both can arrive with little or no warning, making it difficult or impossible to flee, are often deadly, and typically destroy hundreds of homes and other structures. But, just like tornadoes, there is no scientific evidence that the frequency or severity of wildfires are on the rise in a warming world.

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 11.

Figure 11: US forest area burned by wildfires, 1926–2017.

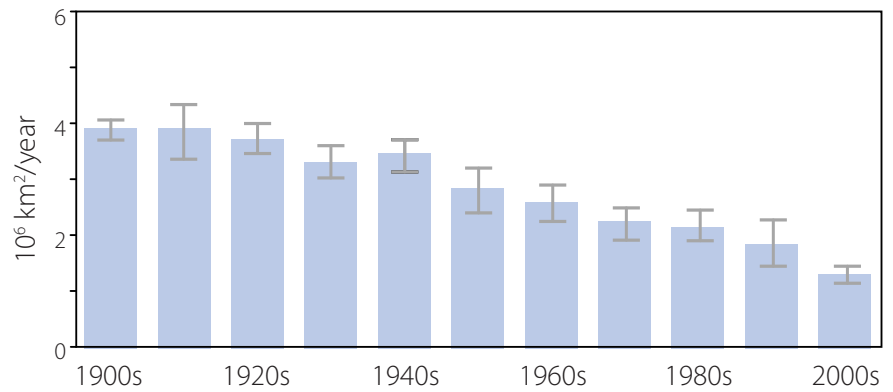
Source: National Interagency Fire Center.<sup>52</sup>



Because modern global warming was barely underway in the 1930s, climate change clearly has nothing to do with the incineration of US forests. Exactly the same trend is apparent in Figure 12, which depicts the estimated area worldwide burned by wildfires, by decade from 1900 to 2010. Clearly, wildfires have diminished globally as the planet has warmed. A recent study attributes this declining 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.<sup>38</sup>

Figure 12: Global forest area burned by wildfires, 1900-2010.

Source: Jia Yang et al.<sup>53</sup>

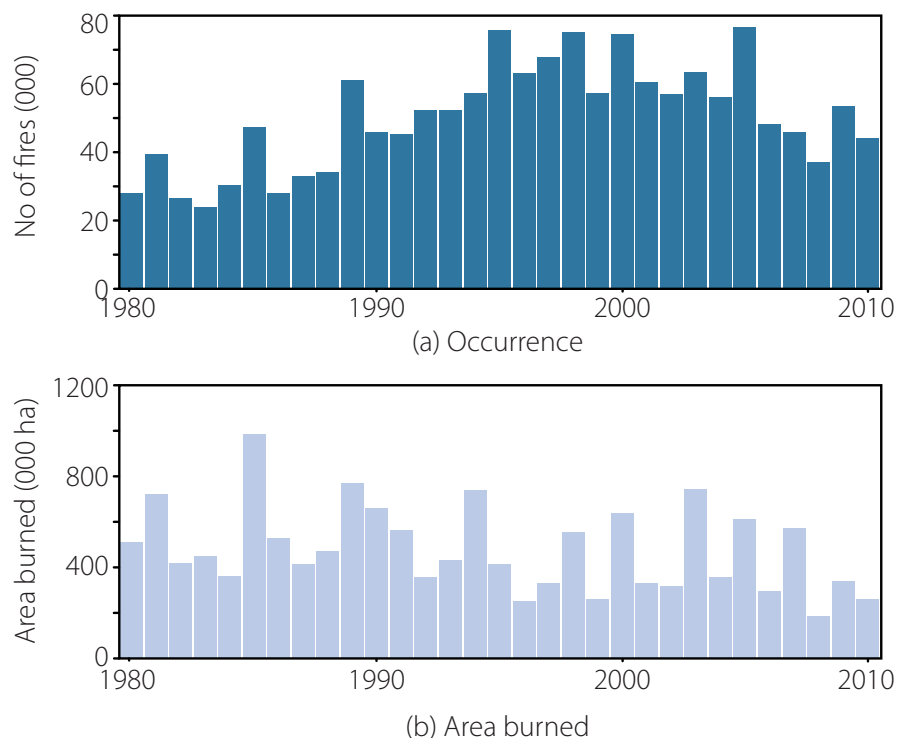


The recent bushfires in Australia that have burned almost 20 million hectares (50 million acres, cf. Figure 11)<sup>39</sup> have been called unprecedented and blamed on global warming by adherents to the human-caused climate change narrative. But just as in the US, past Australian bushfires burned even larger areas. During the 1974-75 bushfire season, for example, a total of 117 million hectares (300 million acres) were consumed.<sup>40</sup>

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 13).

Figure 13: Mediterranean (a) wildfire occurrence, and (b) burned forest area, 1980-2010.

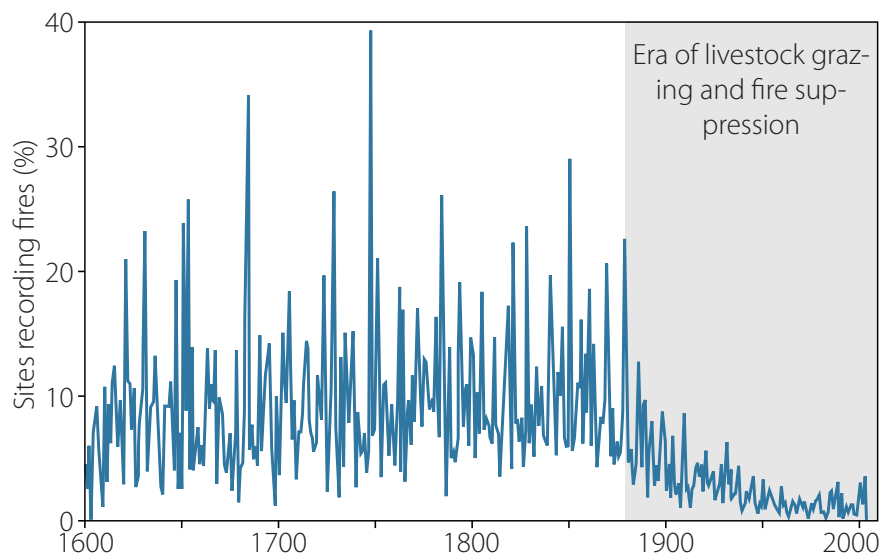
Source: Stefan H. Doerr and Cristina Santín.<sup>54</sup>



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 firefighting officials in western states that climate change is responsible for the uptick in fire size. Figure 14 illustrates the timeline from 1600 onwards of fire occurrence at more than 800 different sites in

**Figure 14: Western North America wildfire occurrence, 1600–2000.**

Data from 800+ sites. Source: Thomas W. Swetnam et al.<sup>55</sup>



western North America.

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. Intensive sheep and cattle grazing after that time consumed most of the grasses that previously constituted wildfire fuel. This depletion of fuel, together with the firebreaks created by the constant trampling of herds moving back and forth to water sources, and 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 – the latter characterized by a growing number of terrifying, superhot ‘firenadoes’ or fire whirls occasionally observed in today’s wildfires.

Intentional burning, long used by native tribes and early settlers and even advocated by some environmentalists who point out that fire is in fact a natural part of forest ecology<sup>41</sup> as seen in Figure 14, 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 15, 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.

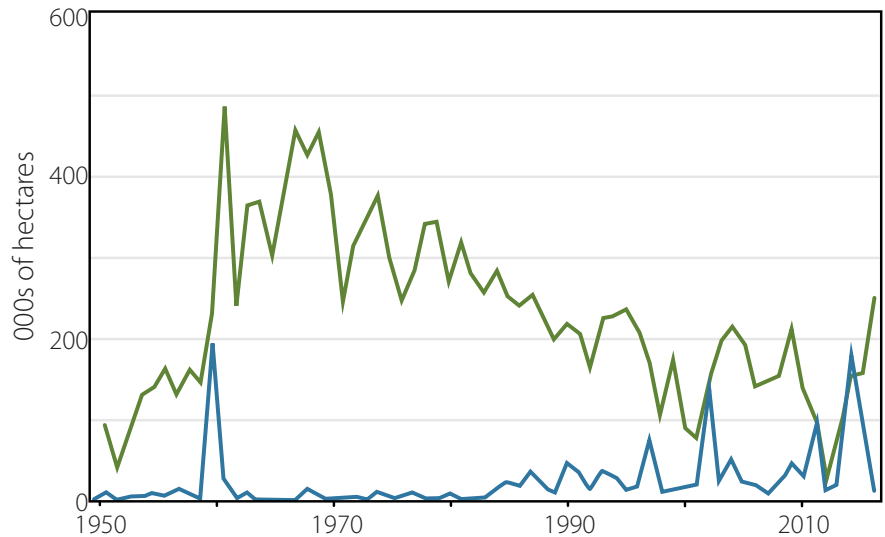
Combined with overgrowth, global warming does play a role in wildfire intensity by drying out vegetation and forests more rapidly than before, as mentioned earlier. But there is no evidence at all for the notion peddled by the media that climate change has amplified the impact of fires on the ecosystem, known technically



Figure 15: Western Australia burned forest area and prescribed burn area, 1950–2017.

Source: Patrick Michaels and Myron Ebell.<sup>56</sup>

— Prescribed burn area  
— Wildfire area



as fire severity. Indeed, at least ten published studies of forest fires in the western US have found no recent trend in increasing fire severity.<sup>55</sup>

It might be thought that the ever-rising level of carbon dioxide in the atmosphere would increase wildfire risk, since carbon dioxide promotes plant growth. The concentration of carbon dioxide in the atmosphere has been rising by about 2 parts per million (ppm) per year since 1995 and reached 409 ppm in 2019. 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 erroneous belief that the 'new normal' of devastating wildfires around the globe is a result of climate change is not supported by the evidence. It is interesting to note here that a limited number of attribution studies (see Section 1) of human influence on wildfires have actually been inconclusive.<sup>3</sup> 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. Coupled with poor 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 linked to climate change is badly mistaken and more a perception, fostered by media coverage, than reality. Careful examination of the actual data reveals that if there is any trend in weather extremes, it is downward rather than upward. 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.<sup>42</sup>

The most extreme weather, be it heatwave, drought, hurricane or tornado, occurred many years ago, long before the carbon dioxide level in the atmosphere began to climb at its present rate. Rather than global warming, it is natural patterns in the climate system that produce extreme weather conditions. The Atlantic Multidecadal Oscillation, which has a cycle time of approximately 65 years and alternates between warm and cool phases, governs many extremes, such as intense hurricanes in the North Atlantic basin and 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.

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 severe droughts in Australia. La Niña has also been connected to major landfalling hurricanes in the US. Moreover, as discussed in Section 3, the recent European heat waves resulted from jet stream blocking, which arises from natural sources such as changes in the sun and winds in the upper atmosphere.

Although human activity does not cause extreme weather, humans do play a 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 carnage and property damage brought about by major floods and hurricanes – a topic addressed by both the IPCC<sup>9</sup> and WMO.<sup>3</sup> 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. Nonetheless, the annual number of global deaths from natural disasters, which include weather extremes, has dropped by more than two orders of magnitude over the past century, from 1.2 million to 11,700.<sup>43</sup>

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





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## About the Global Warming Policy Foundation

The Global Warming Policy Foundation is an all-party and non-party think tank and a registered educational charity which, while openminded on the contested science of global warming, is deeply concerned about the costs and other implications of many of the policies currently being advocated.

Our main focus is to analyse global warming policies and their economic and other implications. Our aim is to provide the most robust and reliable economic analysis and advice. Above all we seek to inform the media, politicians and the public, in a newsworthy way, on the subject in general and on the misinformation to which they are all too frequently being subjected at the present time.

The key to the success of the GWPF is the trust and credibility that we have earned in the eyes of a growing number of policy makers, journalists and the interested public. The GWPF is funded overwhelmingly by voluntary donations from a number of private individuals and charitable trusts. In order to make clear its complete independence, it does not accept gifts from either energy companies or anyone with a significant interest in an energy company.

**Views expressed in the publications of the Global Warming Policy Foundation are those of the authors, not those of the GWPF, its trustees, its Academic Advisory Council members or its directors.**



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The GWPF is a registered charity, number 1131448.

