THE US CLIMATE IN 2019

Paul Homewood

The Global Warming Policy Foundation
Briefing 50

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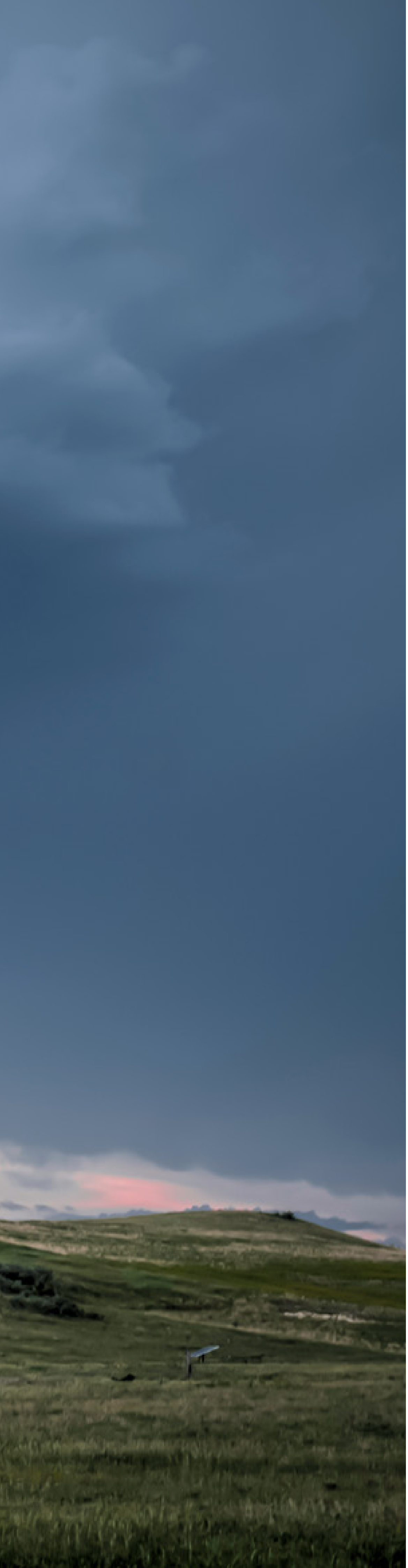
Briefing 50, The Global Warming Policy Foundation

Contents

About the author

Paul Homewood had a career as an accountant in industry. He has been writing on climate and energy issues since 2011.



Summary

According to the recent US National Climate Assessment in 2018, 'The last few years have seen record-breaking, climate-related weather extremes'. This is a commonly made claim, and one that is widely hyped by the media.

But what does the data say? How has the US climate changed in the last century or so, and is the climate becoming more extreme? This study uses official data, mainly from the National Oceanic and Atmospheric Administration, to analyse trends in temperature, precipitation, droughts, floods, hurricanes, tornadoes, sea-level rise and wildfires. In particular it takes account of the widely varying regional climates. It finds that:

- Average temperatures have risen by 0.15°F/decade since 1895, with the increase most marked in winter.
- There has been little or no rise in temperatures since the mid 1990s.
- Summers were hotter in the 1930s than in any recent years.
- Heatwaves were considerably more intense in decades up to 1960 than anything seen since.
- Cold spells are much less severe than they used to be.
- Central and Eastern regions have become wetter, with a consequent drastic reduction in drought. In the west, there has been little long-term change.
- While the climate has become wetter in much of the country, evidence shows that floods are not getting worse.
- Hurricanes are not becoming either more frequent or powerful.
- Tornadoes are now less common than they used to be, particularly the stronger ones.
- Sea-level rise is currently no higher than around the mid-20th century.
- Wildfires now burn only a fraction of the acreage they did prior to the Second World War.

In short, the US climate is in most ways less extreme than it used to be. Temperatures are less extreme at both ends of the scale, storms less severe and droughts far less damaging. While it is now slightly warmer, this appears to have been largely beneficial.

Introduction

According to the US National Climate Assessment in 2018, 'The last few years have seen record-breaking, climate-related weather extremes'. The report goes on to list several examples of these phenomena.[1] But how has the US climate actually been changing since the start of the 20th century, and is there any evidence to back such claims?

This study uses official data, mainly from the National Oceanic and Atmospheric Administration (NOAA), the agency responsible for maintaining climate data, to analyse the trends in:

- temperature
- temperature extremes
- precipitation
- precipitation extremes
- floods
- hurricanes
- tornadoes
- sea-level rise
- wildfires.

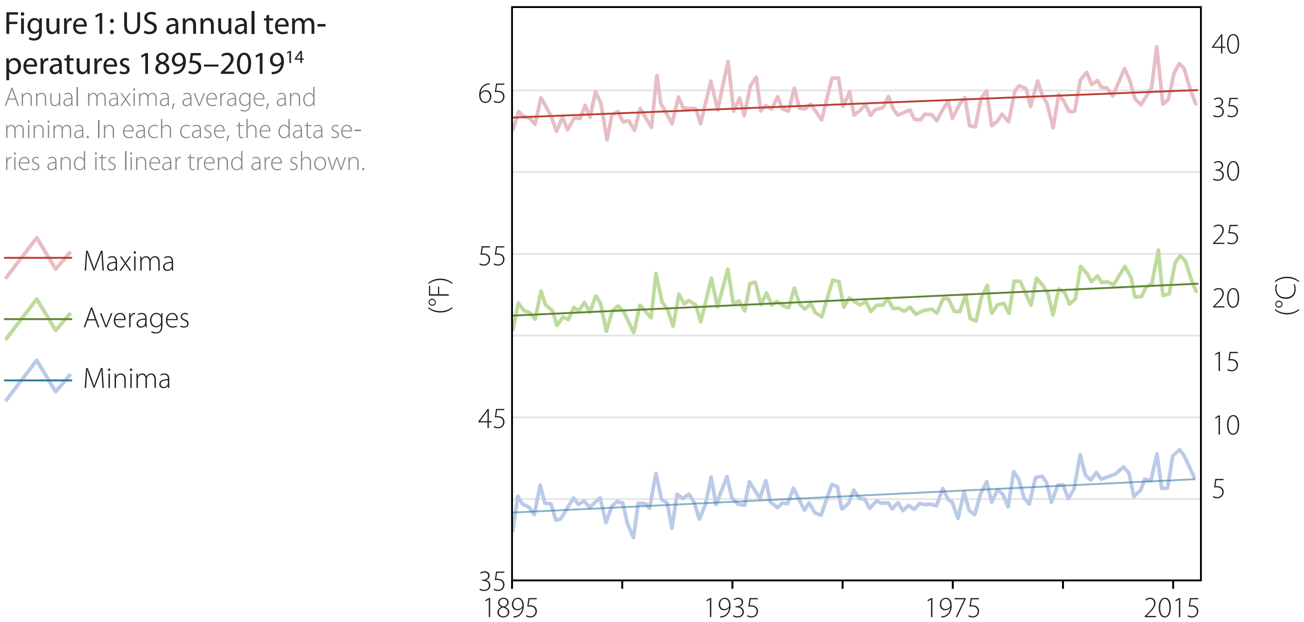
As the US is a large country, encompassing several climatic zones, the study looks closely at regional trends in climate as well.

Temperature trends

Since 1895, average annual temperatures have been rising by 0.15°F/decade. But this increase has not been at a consistent rate. There was a rapid rise in temperature until about 1940, followed by a fall that lasted until the 1970s. Then temperatures increased rapidly up to the 1990s, but there has been no warming since then (Figure 1).

Figure 1: US annual temperatures 1895–2019[14]

Annual maxima, average, and minima. In each case, the data series and its linear trend are shown.

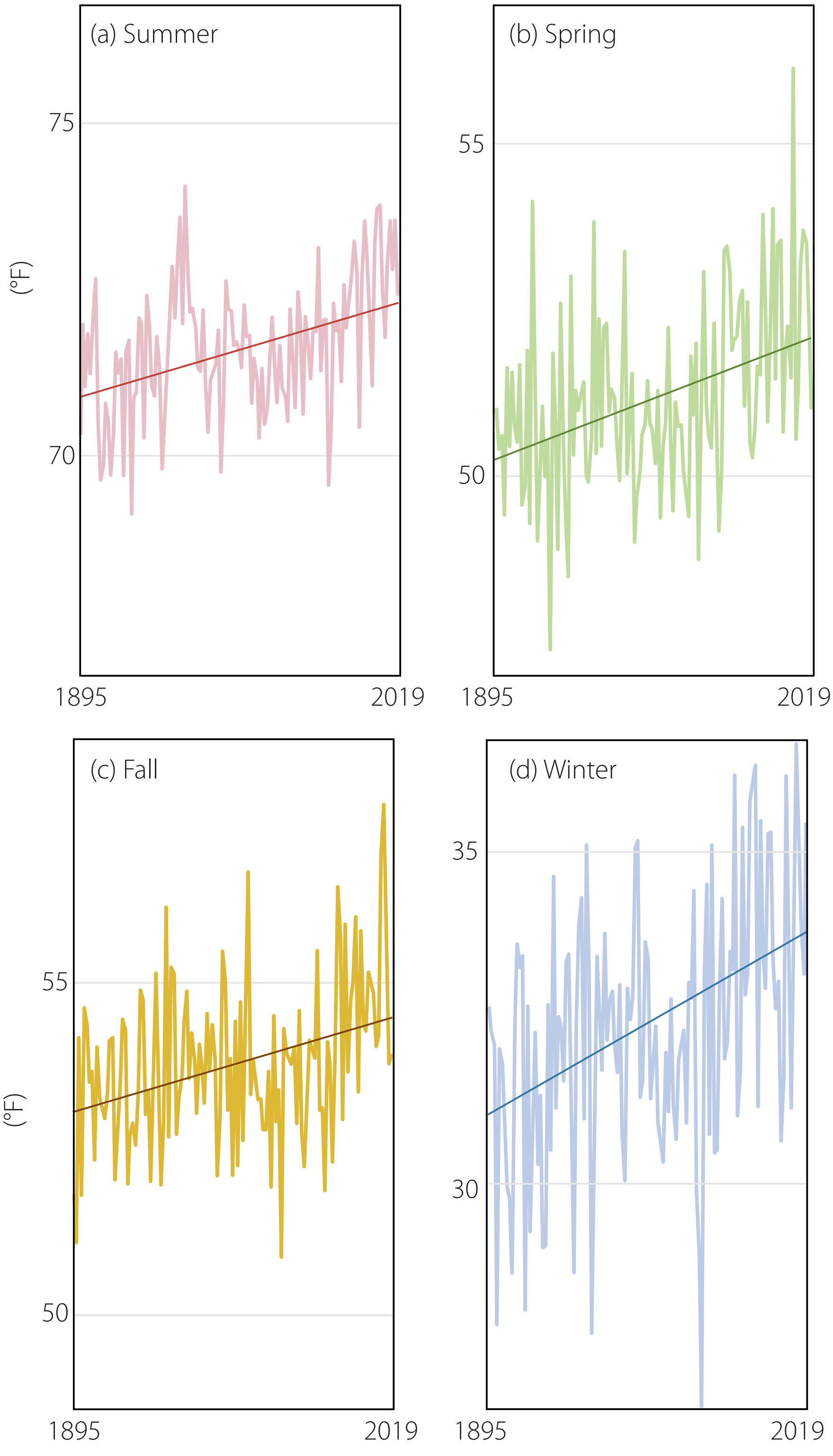


There have also been differing trends between daily maximum and minimum temperatures: 0.13°F and 0.17°F/decade respectively. This difference may be caused by the urban heat island effect (UHI), which tends to be greater at night.[2] No specific allowance is made for UHI in NOAA's figures, despite substantial urbanisation since 1895.

There are marked differences in seasonal trends as well (see Figure 2). While winter temperatures have increased at a rate of 0.23°F/decade, the rise in summer and fall has been a much more modest 0.11°F/decade.

Figure 2: Seasonal temperature trends 1895–2019.[14]

In each case, the data series and its linear trend are shown.



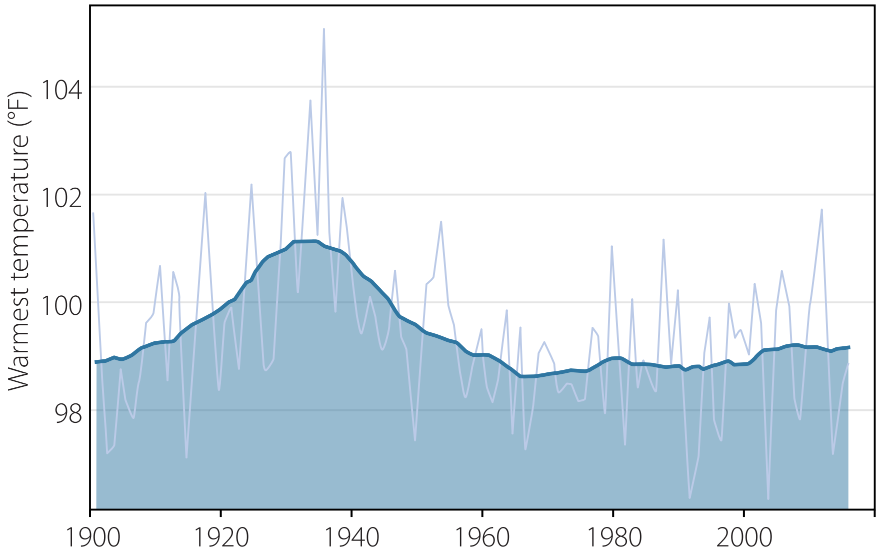
Winter, spring and autumn trends are similar to annual ones, in that there has been little or no warming since the mid-1990s. Summer temperatures, however, buck the trend: there has been a steady rise since the mid-1990s. However, despite this, summer temperatures in recent years have still been lower than in the 1930s.

Temperature extremes

As noted above, average summer temperatures were highest in the 1930s, but this does not tell the whole story. Much higher temperatures were experienced in most of the US prior to 1960, compared to the period since. And those higher temperatures were not just confined to a few years in the 1930s. Temperatures were also high in the 1910s, 1920s and 1950s (Figure 3).

Figure 3: Changes in warmest daily temperatures recorded in contiguous US each year.

Warmest daily temperatures (°F) of the year in the contiguous United States, and area-weighted average (shaded area).[1] Estimates are derived from long-term stations with minimal missing data in the Global Historical Climatology Network–Daily dataset.



Analysis of individual station records shows that for most of the contiguous US, recent warmest temperatures are below those seen in the past (Figure 4).

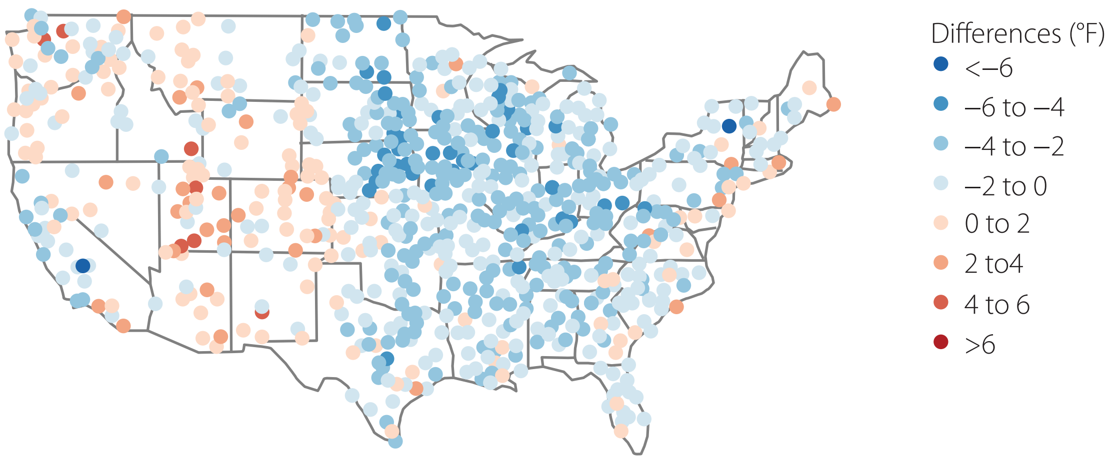


Figure 4: Changes in warmest temperature recorded each year

1986–2016 average minus 1901–1960 average.[1]

When the length and magnitude of heatwaves are analysed, a similar pattern is seen (Figure 5); that is, heat waves peaked before the 1960s. Apart from the summer of 2012, there have been no extreme heat waves since the 1980s.

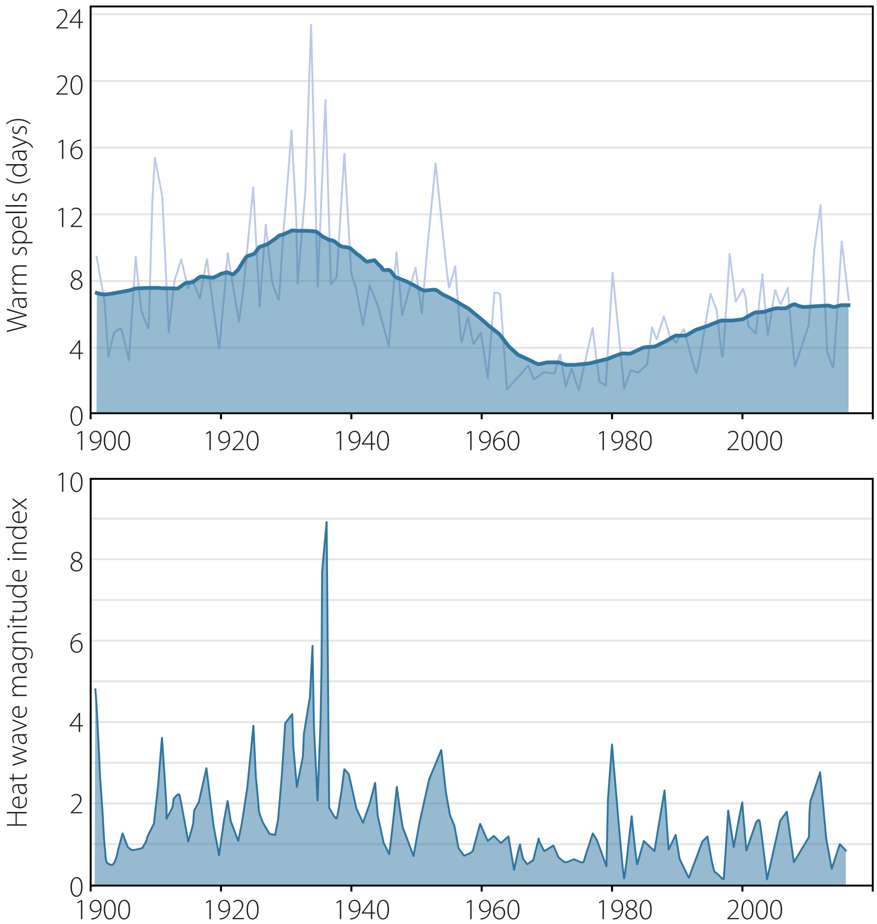


Figure 5: Observed changes in heat waves in the contiguous United States.

The top panel depicts changes in the frequency of heat waves; and the bottom panel depicts changes in the intensity of heat waves.

Figure 6 shows an analysis of part of the official USHCN temperature station network, namely the 725 stations that have data throughout the 1895–2019 period. It shows the average number of days per year when temperatures reached 100°F. Again it shows a pattern of much more severe heatwaves in the 1930s and 1950s, with recent hot weather unexceptional.

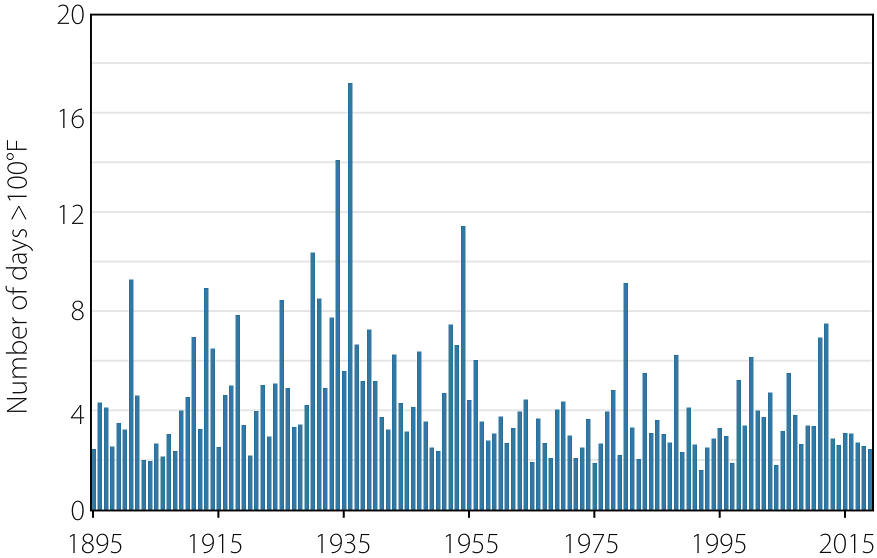
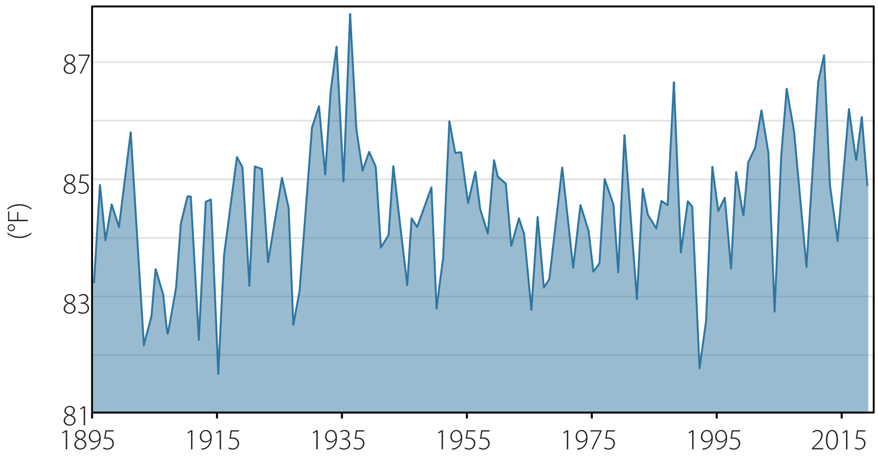


Figure 6: Prevalence of very hot days.

Number of days per year with temperatures above 100°F. Average per USHCN station 1895–2019. Source: J Christy.

However, this very clear evidence of heatwave trends is not borne out by the national summer daily maximum temperature trends (Figure 7), which suggests that maximum temperatures have been rising.

Figure 7: US summer maximum temperatures 1895–2019.



This discrepancy raises questions about the accuracy of the US temperature record. No credible explanation has been offered by NOAA, who are responsible for the database. Two factors may have a bearing:

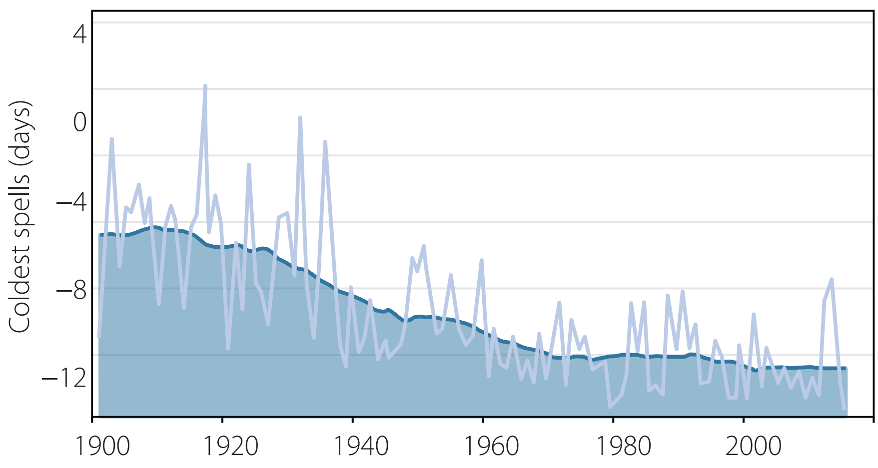
- Large-scale adjustments were made to the US temperature record by NOAA around 1999, which had the effect of reducing temperatures in the 1930s by around 0.9°F.[3]
- The urban heat island effect may have artificially increased national temperature trends.[4]

The National Climate Assessment also analysed cold spells. Figure 8 suggests that there was a marked reduction in extreme cold spells over the course of the 20th century, since when the situation has been relatively stable. This trend has applied throughout most of the US, with the possible exception of parts of the south-east.

The reduction in cold snaps, combined with the decline in heatwaves, makes it clear that US temperatures now tend to be far less extreme than previously.

Figure 8: Cold spells.

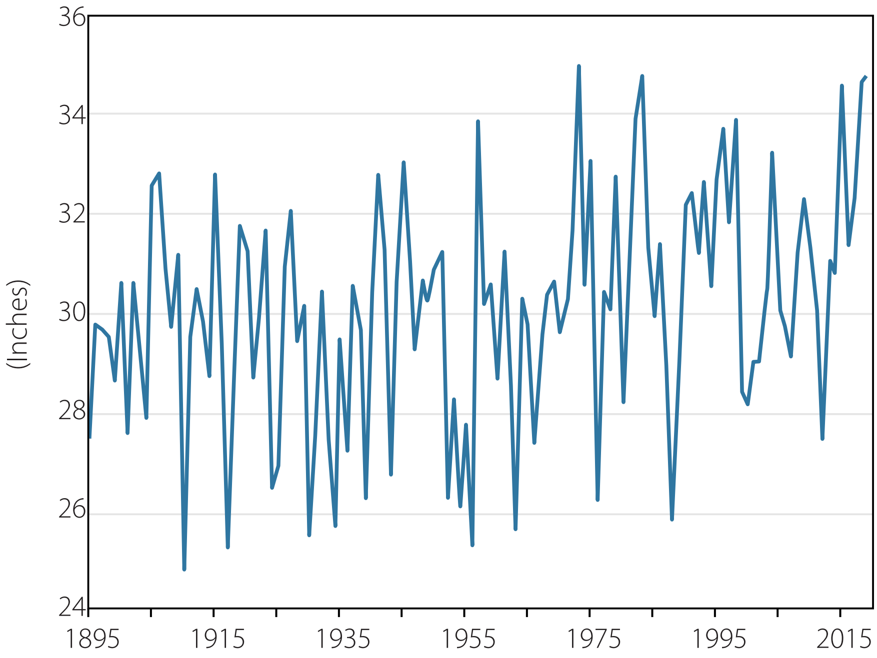
Periods of six days with temperatures below 10th percentile.



Precipitation trends

Annual precipitation in the US has been steadily increasing, having bottomed out in the 1950s (Figure 9). The overall trend since 1895 has been +0.19 in/decade, meaning that average precipitation is now about 10% higher than the beginning of the record. However, this does not mean that peak rainfall is higher, as the wettest year was 1973. What is more relevant is the absence in recent years of extremely dry years, the last being 1988.

Figure 9: US annual precipitation 1895–2019.



The US is, as noted above, a large country with many climatic sub-zones, so national figures and trends can hide regional variations. NOAA produce data that breaks the country into nine separate regions (Figure 10)

Figure 10: US climate regions.

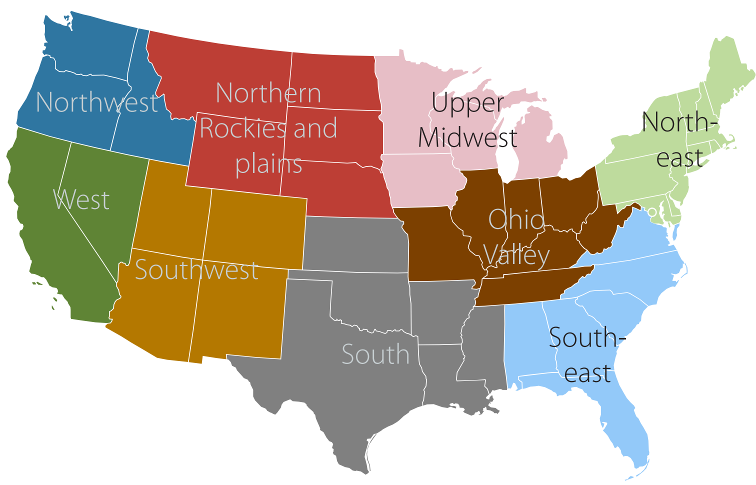
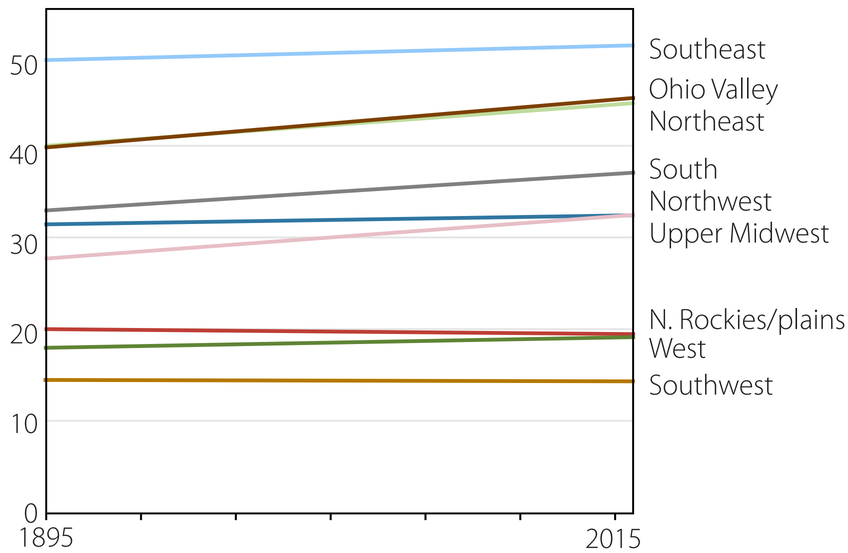


Figure 11 shows the regional precipitation trends since 1895. There is a noticeable split between the western regions, which effectively show no trends at all, and the central and eastern states, where precipitation has been increasing.

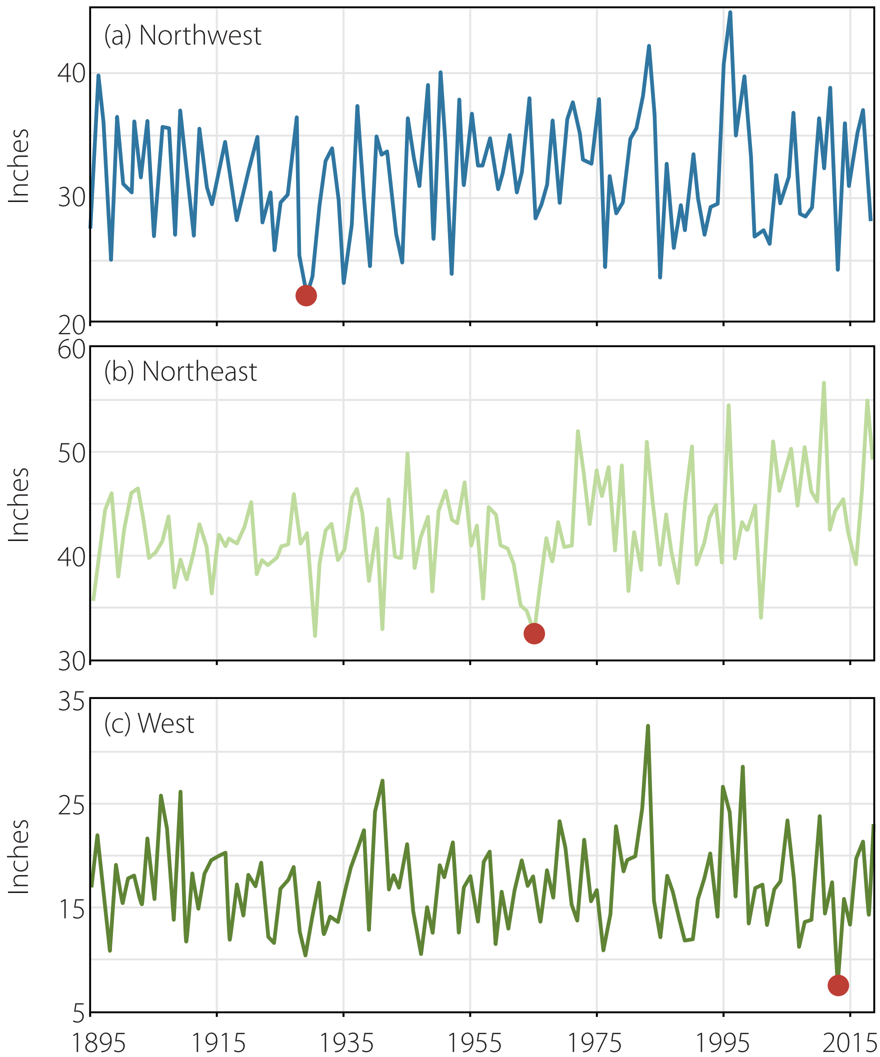
Figure 11: US regional annual precipitation 1895–2019.



What is most significant is the temporal distribution of droughts. In most regions, these were most severe during the 1930s and 50s (Figure 12). In the north-west, the worst period of drought occurred in the 1920s, whilst in the north-east it was in the 1960s. The only region that bucks this trend is the west, where recent droughts have matched earlier ones. There is no evidence, however, that droughts are becoming more frequent or severe in that region.

Figure 12: Droughts were generally worse in the past.

Annual precipitation per region, 1895–2019. The red dot marks the driest year in the record.



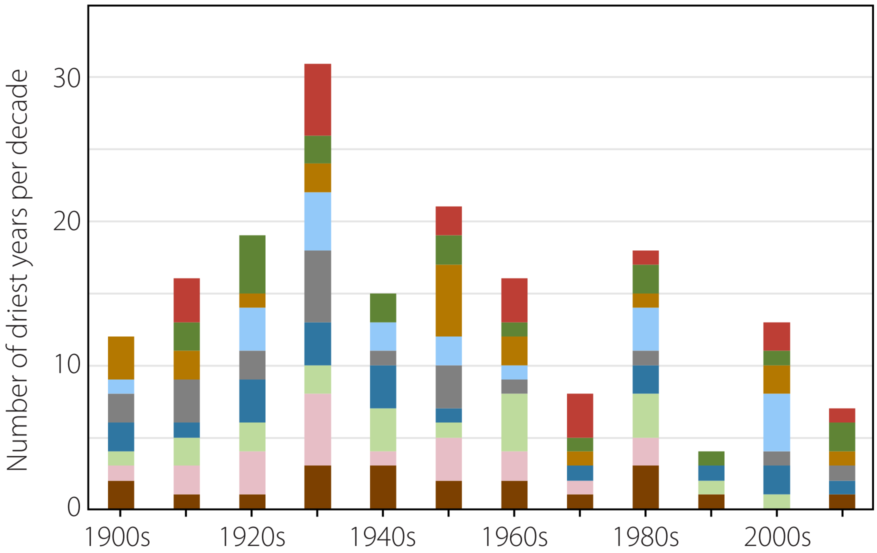
Precipitation extremes

When looking at precipitation extremes, it needs to be recognised that drought and excess rain are two sides of the same coin. Sometimes, extreme rainfall can be the difference between a drought or a no-drought year.

Figure 13 takes the 20 driest years since 1900 for each region, and puts them into decadal 'bins'. In every region there has been a decline in the frequency of these extremely dry years. In most cases a step change occurred around the 1960s and 70s.

Figure 13: Regional analysis of driest years since start of 20th century.

Rockies
West
Southwest
Southeast
South
Northwest
Northeast
Upper Midwest
Ohio Valley

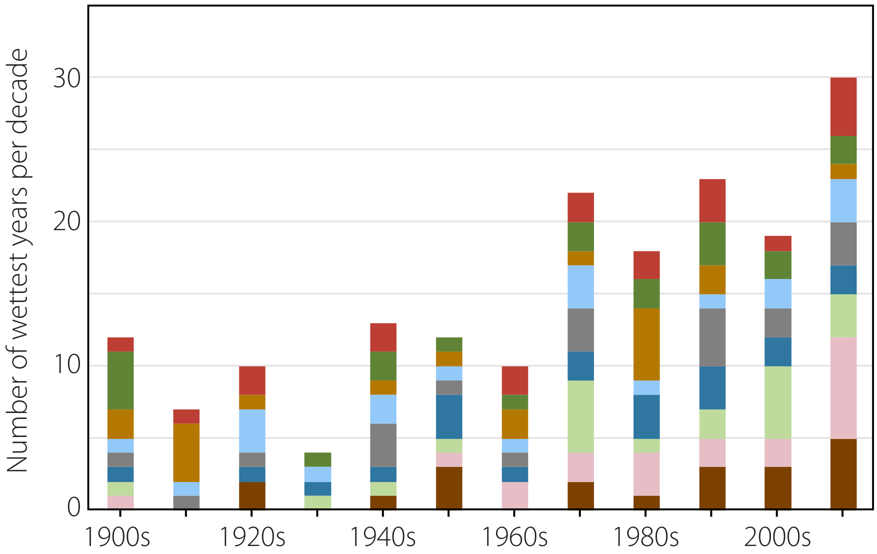


In general terms, there is a mirror image when we look at the wettest years (Figure 14), with the following exceptions:

- In the south-west, both the 1910s and 1980s had a much higher number of wet years than average. Since 1990, however, the climate has returned to the conditions seen in the rest of the period.
- The upper Midwest, northern Rockies and Ohio Valley have all had the highest frequency of extremely wet years in the last decade.

Figure 14: Regional analysis of wettest years since start of 20th century.

Rockies
West
Southwest
Southeast
South
Northwest
Northeast
Upper Midwest
Ohio Valley

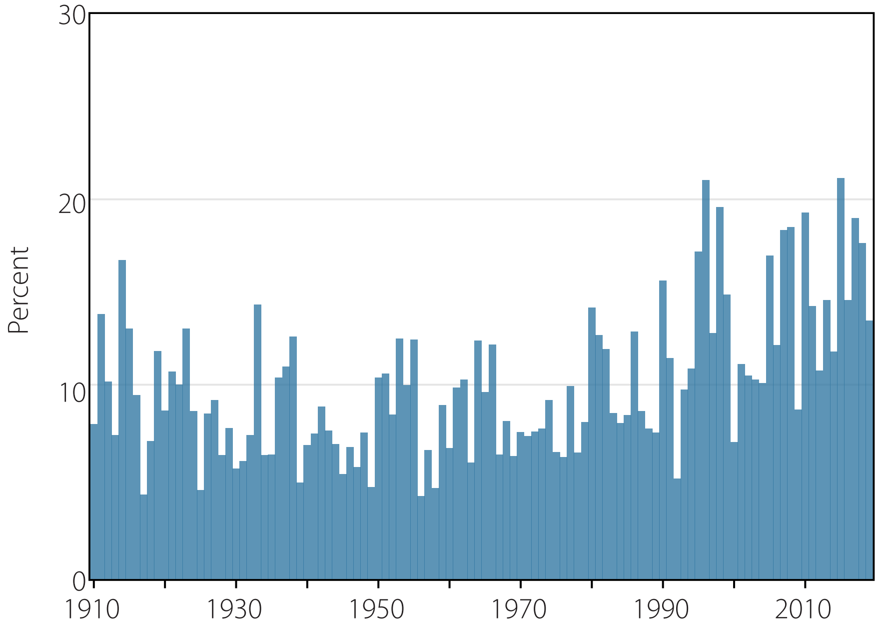


With those exceptions borne in mind, it is still accurate to say that most of the US generally now has a wetter climate than it did in the early 20th century. But despite the unusual levels of rainfall in some areas, the incidence of extremely wet years in the last two decades is not unprecedented.

As well as annual rainfall extremes, NOAA also looks at daily extremes (Figure 15). As would be expected, a greater proportion of precipitation tends to fall as 'extreme daily rain' in recent decades, when drought years have become much less common. What is significant about Figure 15, however, is that the trend in extremes has remained stable since the 1990s.

Figure 15: Extreme daily rainfall in the US, 1910–2019.

Extreme rainfall is defined as twice the value of the percentage of the United States with a much greater than normal proportion of precipitation derived from extreme (equivalent to the highest tenth percentile) 1-day precipitation events.[15]



Floods

Although the US is generally a wetter place than a century ago, has this led to an increase in flooding? A study by the US Geological Survey in 2011 analysed 200 stream gauges in four regions across the US. It found that in none of the regions was there strong statistical evidence for flood magnitudes increasing.

A more recent study in 2017, by Hodgkins et al., assessed trends in major-floods from 1204 sites in North America and Europe. It found the number of significant trends was about the number expected due to chance alone. Changes in the occurrence of major floods were dominated by multidecadal variability, linked in particular to the Atlantic Multidecadal Oscillation, rather than by long-term trends.[5]

US state records

NOAA maintain an official list of meteorological records for each state, including temperatures and 24-hour rainfall.[6] Set up in 2006, the State Climate Extremes Committee not only carefully reviews all potential new records, but also fully reviewed records previously declared. The process is a very detailed one, including site visits.

While these records may not tell us much about averages, they are indicative of extremes. Figure 16 shows the decadal distribution of maximum temperature records. Note that the figures include ties, so from a pure probability point of view, there should be an even distribution. Decades are shown as 1900 to 1909, and so on. The temperature data shows that nearly half of the records were set in the 1930s, with the 1910s also higher than any other decade. Contrary to popular myth, there have only been three records set in the last two decades. One of these, for South Dakota, only tied the record originally set in 1936. Clearly there has been no trend towards higher temperature records in recent years, the 1930s notwithstanding.

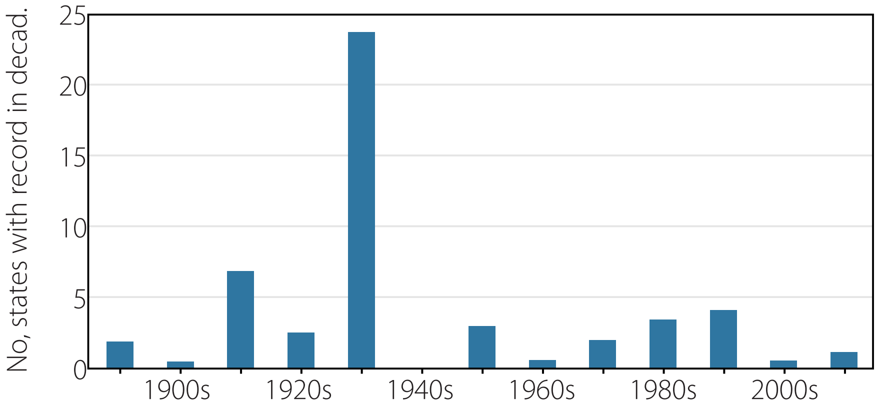


Figure 16: US state temperature records 1890s–2010s (including ties).[6]

The geographical distribution of the 1930s records was wide, ranging from states such as Pennsylvania and Florida in the east to Montana and North Dakota, and even Hawaii. Twenty-three records were set in 1936, but records also fell in 1930, 1931, 1934 and 1937, indicating that this was not just a one-off event. These one off records may not be significant in themselves, but they do support the analyses of heatwaves shown earlier in this paper.

The 24-hour rainfall records (Figure 17) certainly show a clear increase in frequency, peaking in the 1990s. Significantly though, the number of state records in the last two decades has fallen back to the level of the 1960s and 70s. There are no ties within the precipitation records, and the chart does not include Kansas, where the record is under review. The rainfall records may be skewed by the growth in the number of recording stations from the 1950s, which has increased the chance of recording an extreme event.

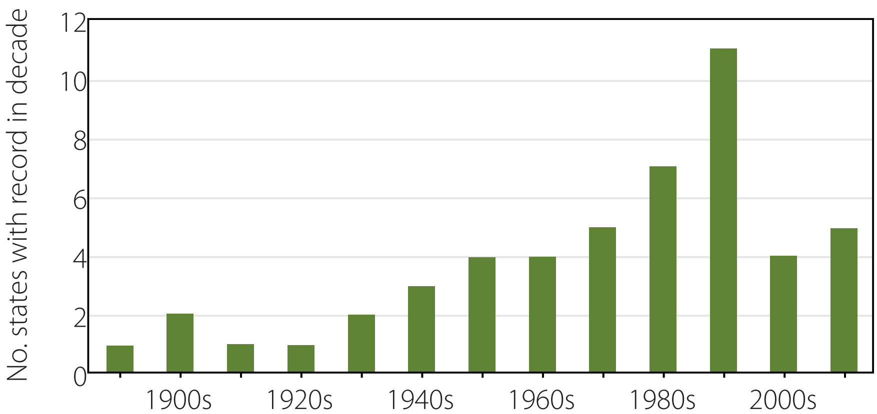


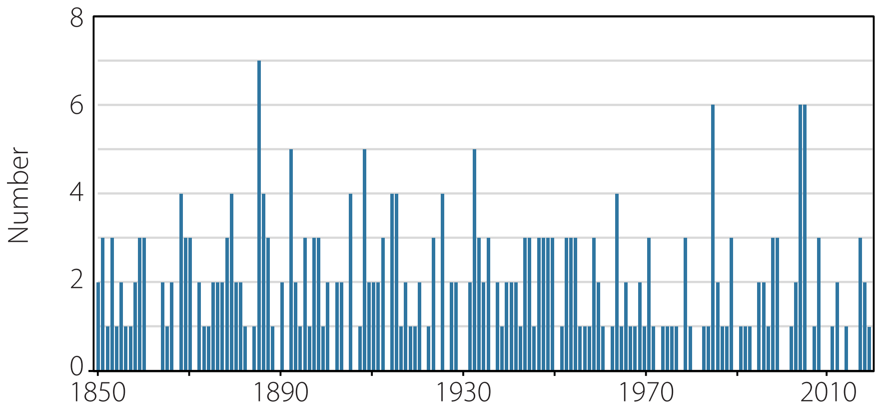
Figure 17: US state 24-hour precipitation records 1890s–2010s (including ties).[6]

Hurricanes

The Hurricane Research Division (HRD), which is part of NOAA, has compiled comprehensive data for Atlantic hurricanes that have made landfall in the US mainland. The data list goes back to 1851. Because methods for recording and measuring hurricanes have changed over the years, HRD have re-analysed the data and reports submitted originally, taking into account, for instance, atmospheric pressure measurements and damage. This process allows consistent long-term comparisons to be made, with the possible significant exception of the Civil War period, when no hurricanes were recorded at all, presumably for reasons of war.

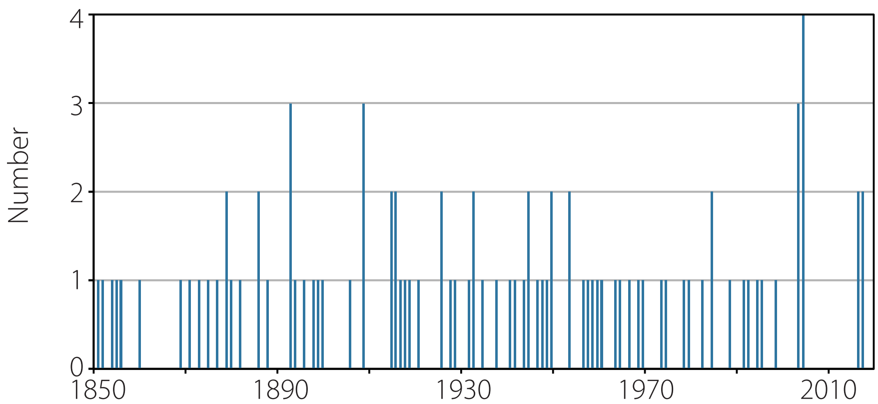
Since 1851 there have been 294 hurricanes, an average of 1.7 per year (Figure 18). In the last decade there have been 10, well below average. The record is, however, marked by considerable year-on-year variability – many years see no hurricanes, and there was a record seven in 1886 – so little can be inferred from short-term trends. Nevertheless, there is clearly nothing to suggest that hurricanes are becoming more frequent.

Figure 18: Number of US landfalling hurricanes 1851–2019.[16]



Hurricanes are graded according to their wind speeds via the Saffir-Simpson scale, from Category 1, the weakest, to Category 5, the strongest. Major hurricanes are defined as Category 3 and above. Analysis of these major landfalling hurricanes again shows year-on-year variability, with 2004 and 2005 seeing seven in total, but the following 11 years having none at all, a record (Figure 19). The data is inevitability limited, due to the rarity of these events, but again there is no evidence that major hurricanes are becoming more frequent.

Figure 19: Category 4–5 landfalling hurricanes in the US, 1851–2019.[16]



There have only been four landfalling Category 5 hurricanes on record in the US (Table 1).

Table 1: Category 5 hurricanes in the US.

Name	Year	Knots
Labor Day	1935	160
Camille	1969	150
Andrew	1992	145
Michael	2018	140

It is noticeable that they are roughly evenly distributed in time, and that the storm strength has progressively declined. Again, the small number of events make such trends insignificant.

There have also been 18 Category 4 hurricanes since 1900, with the busiest period being the 1940s and 50s. Taken together with the Category 5s, the data shows the strongest hurricanes to be declining in both frequency and strength during recent decades (Figure 20).

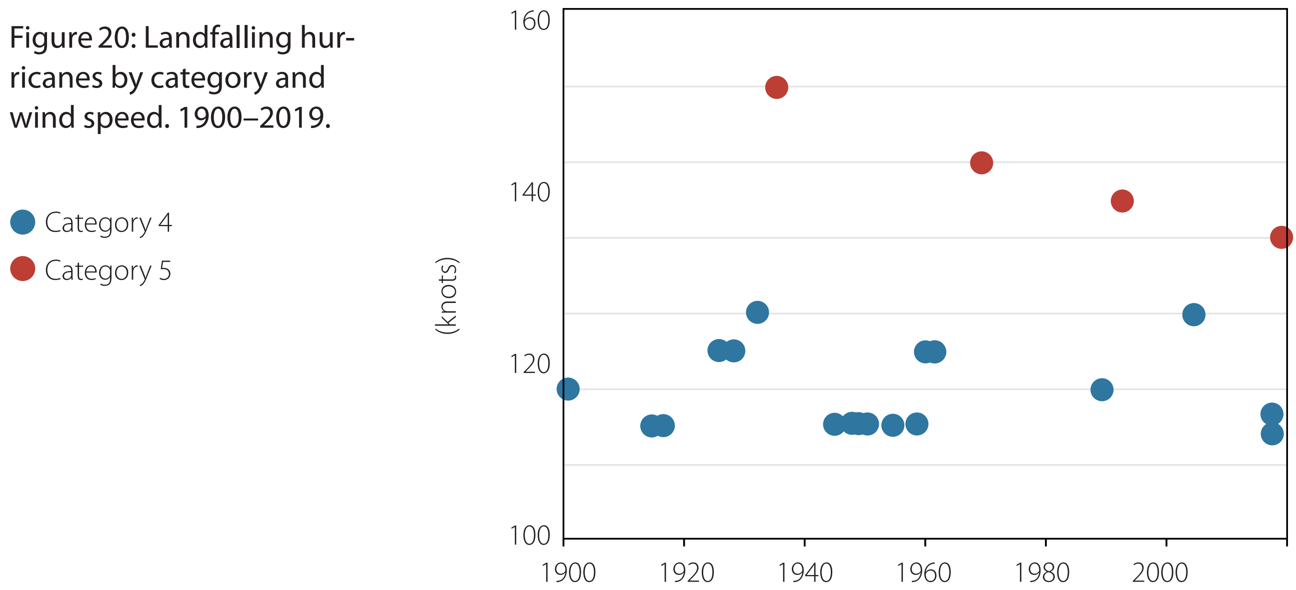


Figure 20: Landfalling hurricanes by category and wind speed. 1900–2019.

Tornadoes

Official records of tornadoes in the US date back to 1950. However, it is generally accepted that these records were unreliable prior to 1970. Since 1970, however, there have been a number of significant changes that have affected how tornadoes are reported and recorded, such as Doppler radar, the advent of mobile phones, the development of spotter networks by National Weather Service (NWS) offices, local emergency management officials and media, and population shifts.[7]

Nowadays, even when a tornado has not actually been observed, damage assessments are carried out after the event by NWS teams. As a result, tornadoes that would have gone unrecorded in the past are now being logged. Most of these tend to be the weaker storms.[8]

Tornadoes are categorised according to wind speeds on the Fujita Scale, from EF-0 to EF-5, with the latter being the strongest. Figure 21 shows how the proportion of the weakest EF-0 tornadoes has dramatically increased over the years, finally stabilising in the late 1990s when Doppler radar was widely rolled out. Similar trends have been found with the ratio of EF-1 tornadoes.[8]

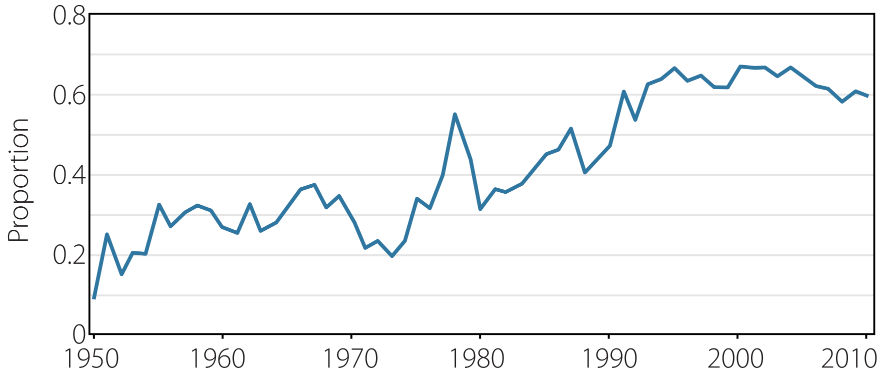


Figure 21: EF-0 tornadoes as a proportion of total, 1950–2010.

As a consequence, NOAA advise that:

> To compare tornado counts before Doppler radars, we have to either adjust historical trends statistically to account for the unreported weak tornadoes of before, or look only at strong to violent (EF2-EF5) tornadoes, whose records are much better documented and more stable.[7]

Figure 22a shows that since 1970, the number of stronger tornadoes – EF-2 and above – has been falling. In addition, the frequency of the most powerful tornadoes – EF-4s and EF-5s – has sharply declined (Figure 22b). Indeed, there has not been an EF-5 tornado in the US since May 2013, the second longest such period on record. This compares to a total of 36 EF-5s since 1970.

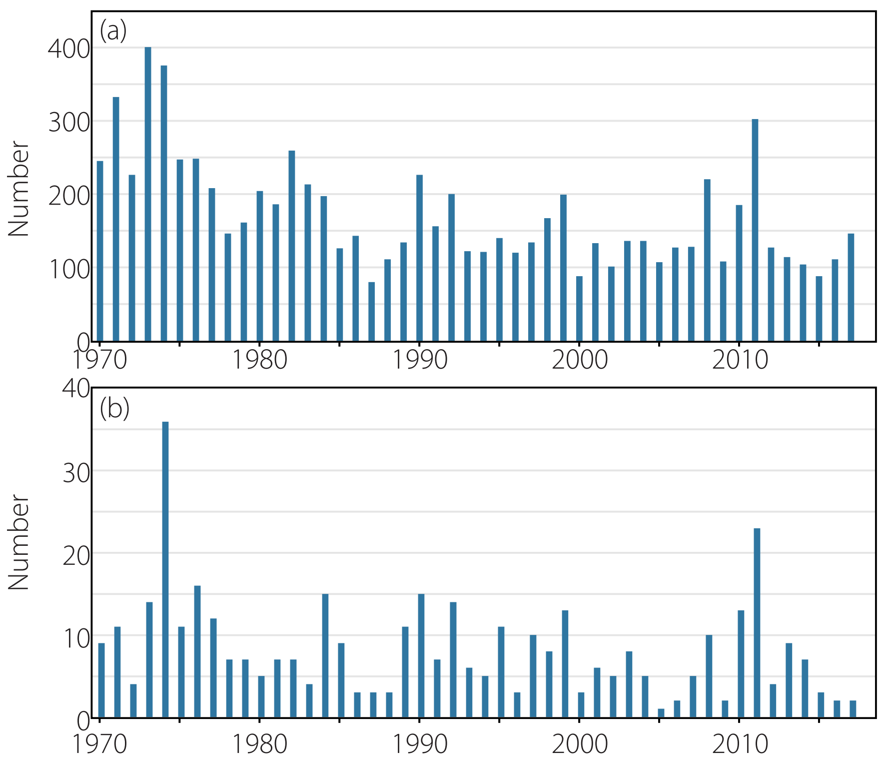


Figure 22: Annual tornado counts, 1970–2018.

(a) EF-2 and above; (b) EF-4 and EF-5.[17]

Sea-level trends

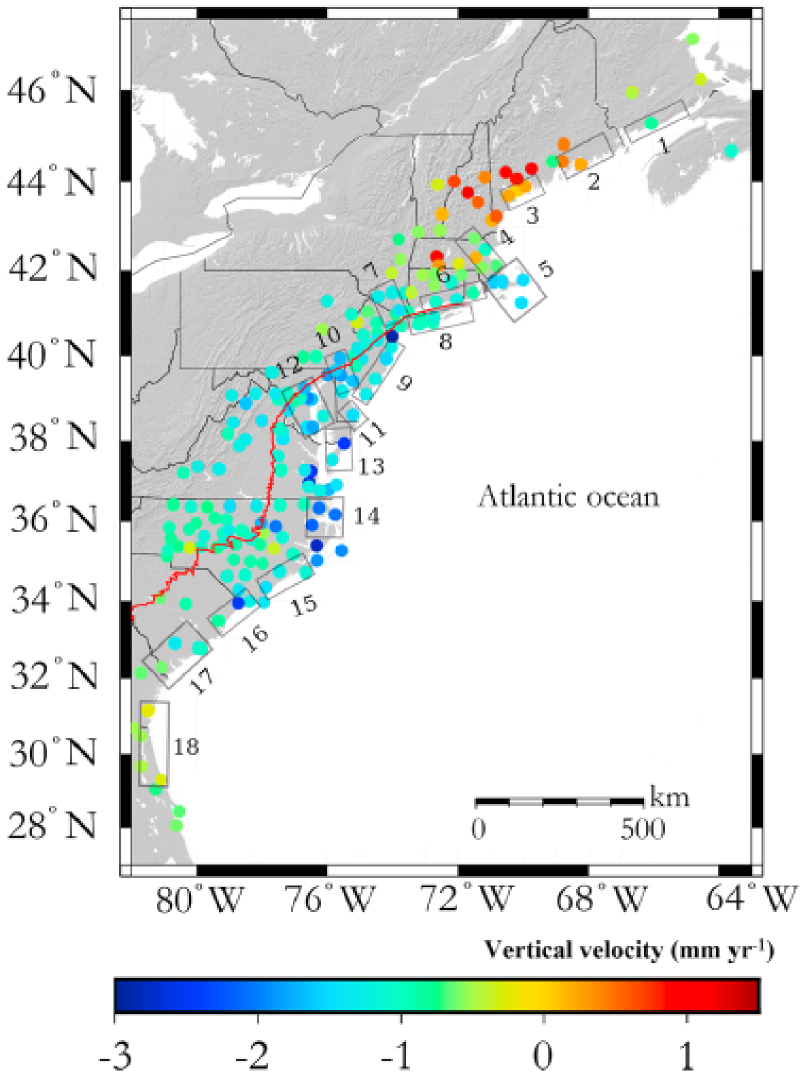
When looking at sea-level rise, we need to understand the difference between relative sea level and absolute sea level. The relative sea level is the mean sea level related to a local reference land level, and is consequently a function of land movement as well as absolute sea level, which is the height of the ocean relative to the centre of the Earth.

In the US, the major cause of land movement is isostatic; that is, the rising or sinking of landmass as the result of the melting of the great ice age glaciers. In simple terms, the area previously covered by glaciers has rebounded without the weight of the ice. Simultaneously, the area to the south has tilted downwards to maintain equilibrium.

This tilting is particularly noticeable on the Atlantic coast. As Figure 23 indicates, while the land is rising in the northeast, from New York to Florida the coast is sinking by between about 0.5 and 3 mm per year.

There are also more localised factors at play, such as land subsidence due to water extraction and construction.[9] Chesapeake Bay is the site of an old comet or meteor crater about 35 million

Figure 23: Vertical land movement of US Atlantic coast.[18]

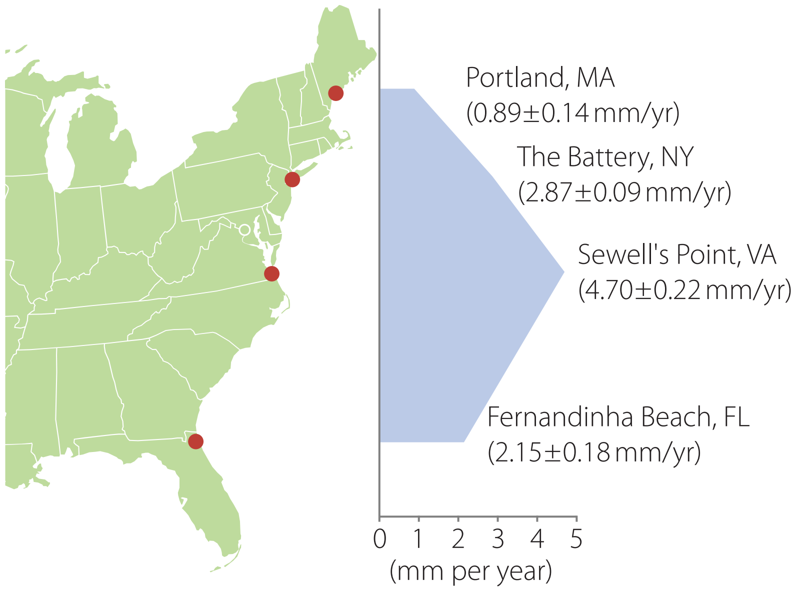


years old. As a result, the land is still sinking, at an overall rate of up to 4 mm per year.[10]

The Mississippi Delta is another area where land is subsiding rapidly due to local factors, such as dredging of channels and destruction of wetland flora, which have led to erosion and the prevention of silt build up, both critical to delta development.

Figure 24 shows the wide range of sea-level rise along the east coast, from 1.89 mm a year in Maine to as much as 4.7 mm at Sewell's Point, which is in the heart of Chesapeake Bay.

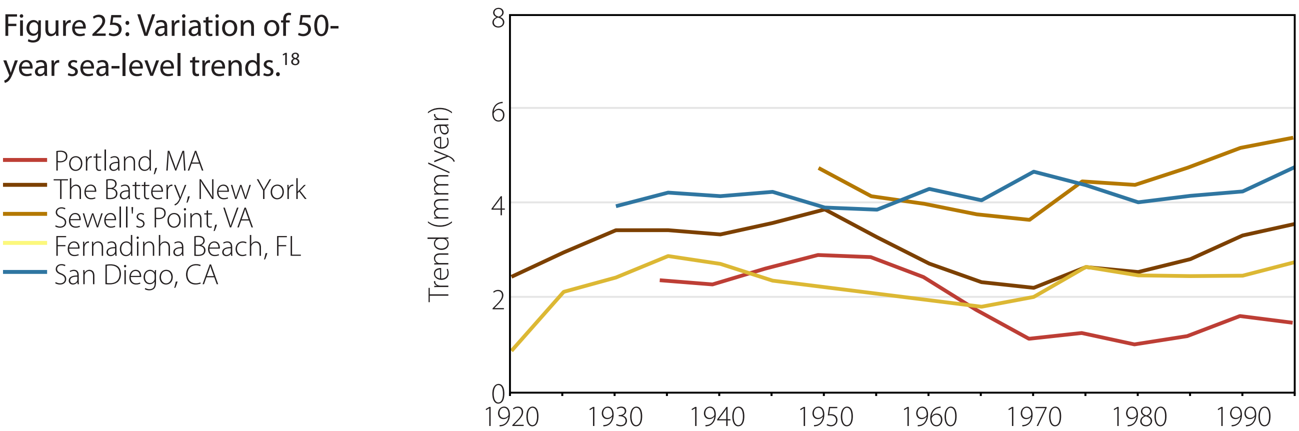
Figure 24: Sea-level trends at selected long running US sites[18]



The Battery in New York and Fernandinha Beach in Florida are more typical of the coast, with long-term rises of 2.87 mm and 2.15 mm per year respectively. For comparison, the trend in San Diego, on the west coast, is 2.20±0.18 mm/yr. After allowing for land subsidence of approximately 1 mm and 0.5 mm per year respectively, absolute sea-level rise can be estimated at about 1.8 mm per year, which would be in line with global estimates.

None of the underlying data shows any evidence of an acceleration of sea-level rise, and this is confirmed by comparison of 50-year trends (Figure 25).

Figure 25: Variation of 50-year sea-level trends.[18]



All stations exhibit a similar pattern of sea-level rise, peaking around the mid-20th century, before slowing and rising again to current rates, which are similar to, or lower than, the earlier peak. This also corresponds to global trends.

Wildfires

Wildfires are not weather events, but are often claimed to be made worse by climate change. However, official data shows that the acreage lost to wildfire has in fact declined substantially since before the Second World War (Figure 26):

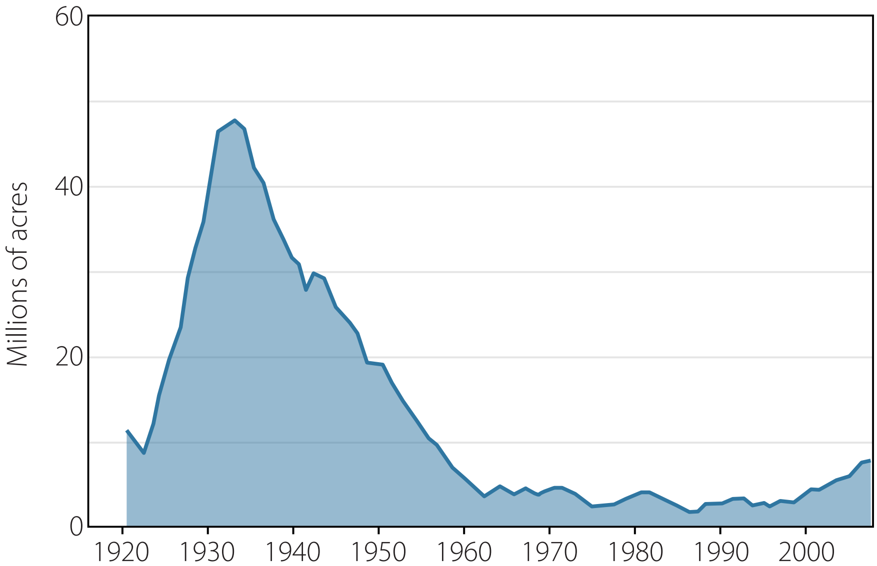


Figure 26: Area lost to wildfire in the US.[19]

Five-year moving average.

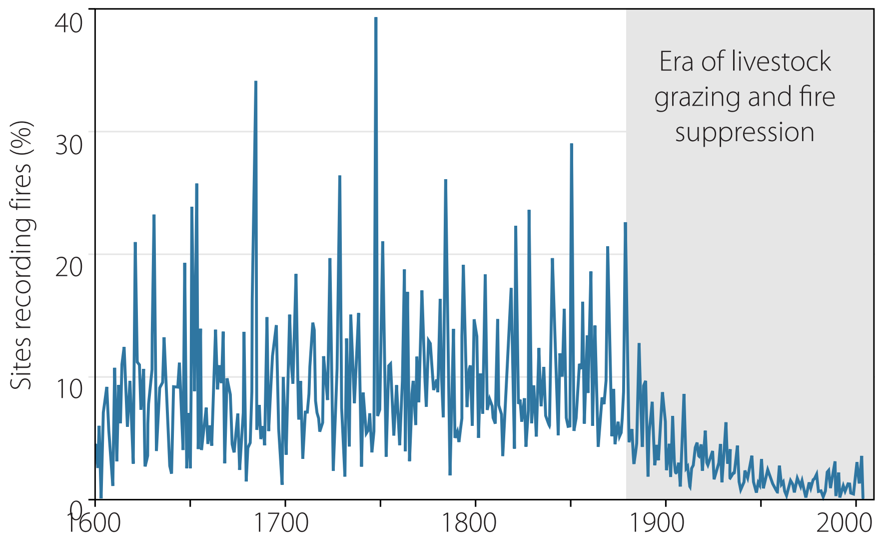
There are a number of reasons for this decline, notably livestock grazing and forestry management practices. In particular, fire suppression, which began in earnest after the war, reduced the wildfire acreage significantly. This effort was helped by newly available mechanisation and aircraft, and was motivated by increasing urbanisation. However, decades of fire suppression and other forest management practices have left a legacy of increased fuel loads and ecosystems dense with an understory of shade-tolerant, late-succession plant species.[11] This fuel load enhances the potential for bigger fires and, as a result, there has been an uptick in wildfire acreage in the last three decades.

Attention is often focussed on California and the northwest, largely because of recent urban development there in forested – and therefore fire-prone – areas. However, long-term comparisons again show that wildfire occurrence is tiny nowadays compared to the past (Figure 27).

Contrary to popular belief, fire is actually a natural event, which helps maintain a mosaic of habitat conditions in the landscape and preserve biodiversity. It increases forest health by consuming fuels, thereby making forests less susceptible to unnatural fire severity, pests, diseases, drought, and pollutant stresses. It has been said that much of California used to be an open park-like forest in pre-European settlement days.[12]

Figure 27: Western North America wildfire occurrence.

Based on 800 sites, 1600–2000.[12]



Unfortunately, decades of fire suppression and poor forest management have changed all that. The Little Hoover Commission in 2018 found that California's forests were suffering from neglect and mismanagement, resulting in overcrowding that leaves them susceptible to disease, insects and wildfire.[13]

To summarise, there have been so many environmental changes that have had major effects on wildfire trends in the US, it simply is not possible to quantify the effect, if any, that climate change has had.

This report will be updated as new evidence emerges. Please contact the GWPF with any new data or information.

Notes

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15. https://www.ncdc.noaa.gov/extremes/cei/graph.

16. https://www.aoml.noaa.gov/hrd/hurdat/All_U.S._Hurricanes.html.

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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.

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