CLIMATE COUNCIL

# 2017: ANOTHER RECORD-BREAKING YEAR FOR HEAT AND EXTREME WEATHER

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# Key Findings

## 1

**The four hottest years on record are 2016, 2015, 2017 and 2014, continuing the strong, long-term upswing in global temperatures.**

- The 2013-2017 period has been the hottest five-year period ever recorded.
- 2017 was the third hottest year ever recorded, and was the hottest year where the temperature was not boosted by an El Niño event.
- The world's 10 hottest years on record have all occurred since 1998 and 17 of the 18 hottest years on record have occurred this century.

## 2

**Temperature records toppled across Australia through 2017.**

- 2017 was Australia's third warmest year on record.
- Seven of the ten hottest years on record in Australia have happened since 2005. Five of the seven have occurred the past five years.
- 2017 broke records for hot, dry conditions with more than 260 heat and low rainfall records broken throughout winter.
- Many remarkable records were set across Australia in 2017. In the summer, Moree had 54 consecutive days of 35°C or above. In autumn, Launceston experienced its warmest night on record on 16 March. Queensland, Western Australia and the Northern Territory had their highest winter average maximum temperatures on record. Cape Jaffa in South Australia experienced its highest spring mean daily temperature on record.
- Oceans around Australia also experienced record breaking heatwaves, with high sea surface temperatures contributing to mass coral bleaching on the Great Barrier Reef in early 2017.

3

## The increasing global heat, driven primarily by the burning of fossil fuels, exacerbated extreme weather events around the globe and in Australia in 2017.

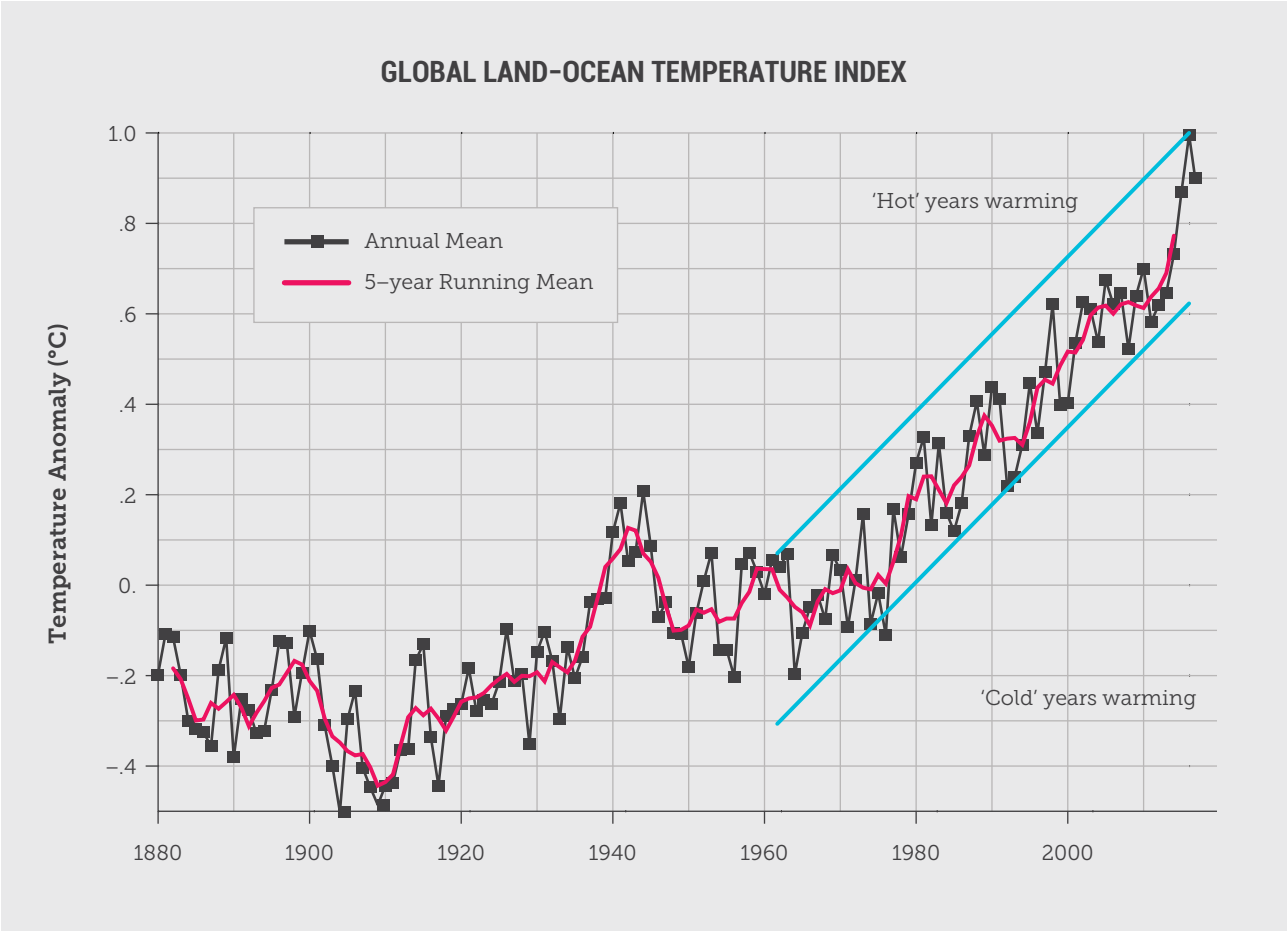
- **Floods:** Massive flooding in South Asia took over a thousand lives.
- **Fires:** Forests across southern Europe and in California were devastated by wildfires. NSW experienced an early start to the bushfire season.
- **Cyclones:** A series of destructive tropical cyclones swept across the Caribbean and southern US with some of the most intense rainfall and winds ever recorded. Tropical Cyclone Debbie struck Queensland and NSW causing power losses to homes and the evacuation of thousands as storms brought heavy rainfall and mass flooding. At least five Australians died, and the damage bill is an estimated $2 billion.
- **Heat:** During a February 2017 heatwave nearly 100 bushfires in New South Wales destroyed at least 30 homes. This same severe heatwave caused problems for the South Australian and New South Wales energy systems.

# 1. Introduction

**More record-breaking heat was experienced around the world in 2017, with the year joining 2014, 2015 and 2016 as the four hottest years ever recorded in the 138-year global temperature archive.**

In fact, 2013-2017 was the hottest five-year period on record (NOAA 2018a; Figure 1). This recent record heat is part of a long-term global warming trend that began most clearly in the mid-20th century and has continued unabated since then. The world's 10 hottest years on record have all occurred since 1998 and 17 of the 18 hottest years on record have occurred this century.

**Figure 1:** Global Land-Ocean Temperature Index, from 1880 to present, using 1951-1980 as a baseline period. The average temperature of both hot and cold years has risen rapidly since the 1970s.




**Source:** Adapted from NASA 2018.

# The last five-year period has been the hottest such period ever recorded.

Australia experienced its third hottest year on record in 2017. The 'Angry Summer' of 2016-17 broke more than 205 climate records across the nation, and included several intense heatwaves in January and February. In winter, over 260 records were broken once again across the country, with the winter of 2017 the hottest on record for maximum temperatures. Low rainfall records were also broken throughout the season, resulting, along with the high temperatures, in an early start to the bushfire season across much of New South Wales. Oceans around Australia recorded temperatures well above average through the year.

The ongoing, long-term trend of record-breaking heat is increasing the frequency and destructiveness of many extreme weather events, with devastating impacts in Australia and elsewhere around the world. Early in 2017, the Great Barrier Reef suffered its second consecutive mass bleaching event as a result of prolonged high sea surface temperatures, while later in the year, Queensland and northern New South Wales experienced record high May-September forest fire danger index values.

Globally, intense monsoonal rains and consequent flooding in South Asia led to more than 1,200 deaths and left 40 million people displaced or affected. Within one month, a series of powerful, damaging hurricanes—Harvey, Irma and Maria – tore through the Caribbean and southern United States, leading to some of the most intense rainfall and winds ever recorded. Heavy rains in Peru led to landslides leaving 75 people dead and making tens of thousands homeless. Meanwhile, wildfires brought on by extreme heat and drought caused devastation across the Mediterranean, with Portugal worst hit. California was also hit by wildfires in October and December, leaving a trail of devastation across the state (Figure 2).

The record-breaking heat and its associated impacts are amongst the most prominent fingerprints of climate change and are primarily caused by the human emission of carbon dioxide from the burning of coal, oil and gas. Carbon dioxide and other greenhouse gases trap additional heat at the Earth's surface and in the lower atmosphere, driving the trends of increasing heat and worsening extreme weather. Human-driven greenhouse gas pollution has been rising strongly since the mid-20$^{th}$ century. Rapid and deep reductions in the level of greenhouse gas pollution is the only way to slow and eventually halt the strong upward trend in global temperature and the trend towards more frequent and intense extreme weather events.

**Figure 2**: Santa Rosa, California, devastated by wildfires in October 2017.

# 2. Global Heat Records in 2017

**Global average temperature for 2017 was 0.84°C* warmer than the 20th century average (NOAA 2018a), equivalent to an approximately 1°C temperature rise since the pre-industrial period. It was the third hottest year globally. Together with 2014, 2015 and 2016, 2017 was one of the four hottest years ever recorded in the 138-year global temperature archive. The average global temperature for the 2013-2017 period was the highest recorded for any five-year period (NOAA 2018a). The world's 10 hottest years on record have all occurred since 1998 and 17 of the 18 hottest years on record have occurred this century (NOAA 2018a).**

Although 2017 was the third hottest year globally, it was the hottest year on record in which the temperature was not boosted by an El Niño event (Box 1). Both 2015 and 2016, the only years with higher global average temperature than 2017, were influenced by an exceptionally strong El Niño event that straddled the two years. 2017 was much warmer than the previous non-El Niño year of 2014, and was also much warmer than recent El Niño-boosted years, such as 2010, 2003 and 1998 (Figure 3), reflecting the dominance of the long-term warming trend associated with climate change.

17 of the 18 hottest years have occurred this century.

* Temperature data in this report are based on the National Oceanic and Atmospheric Administration (NOAA) data, from the US. For more information regarding the data, please refer to the official NOAA website: www.noaa.gov

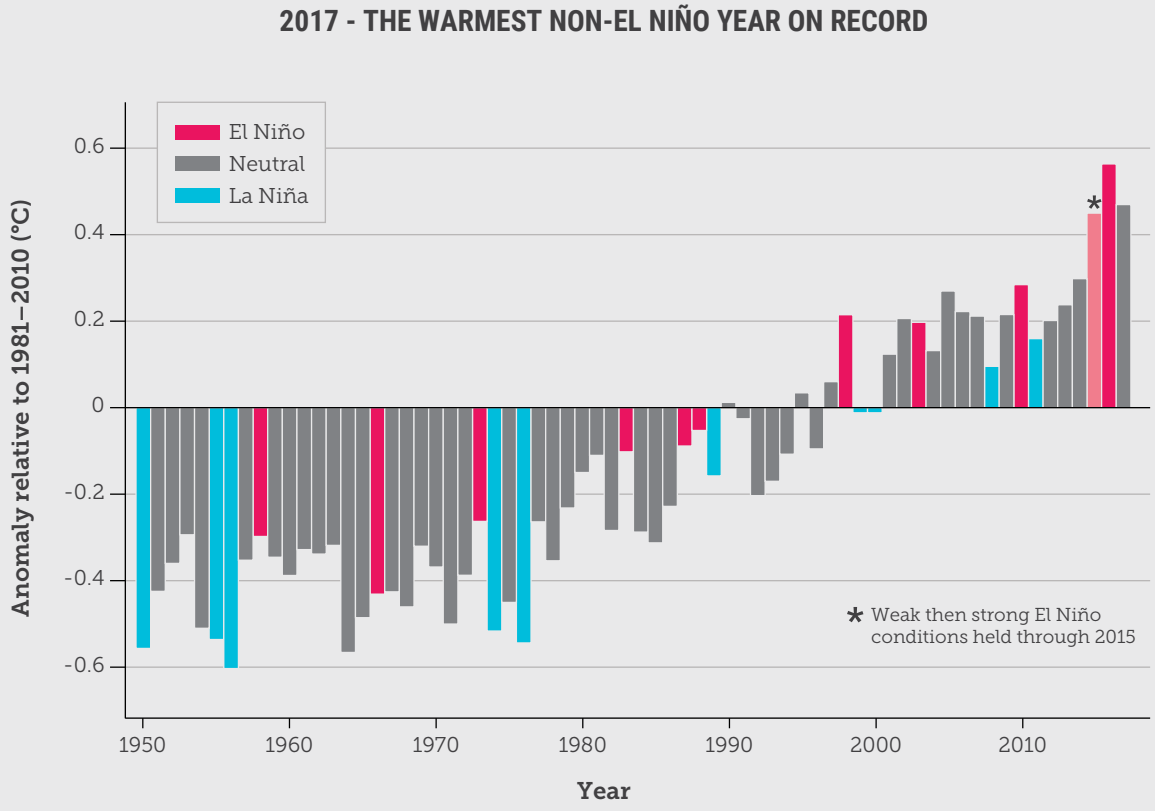
## BOX 1: THE EL NIÑO CONNECTION

**The long-term trend since the mid-20th century of increasing global temperatures is undeniably driven primarily by greenhouse gas pollution from human activities, but from year-to-year, modes of natural variability can add tweaks to the long-term trend. One of the most important modes of variability is the El Niño-Southern Oscillation (ENSO) phenomenon.**

The El Niño phase of ENSO refers to the extensive warming of the central and eastern Pacific Ocean that leads to a major shift in weather patterns across the Pacific. In Australia, particularly eastern Australia, El Niño events are associated with an increased probability of drier conditions (BoM definition, taken from BoM website). In addition to drier conditions in the east, El Niño events usually bring (i) warmer temperatures, (ii) increased fire danger in the southeast and (iii) reduced tropical cyclone numbers to Australia.

Globally, an El Niño event provides an extra boost to the global average temperature, typically around 0.1 – 0.2°C (Trenberth et al. 2002; Foster and Rahmstorf 2011). El Niño years stand out as being somewhat warmer than the years around them, and, conversely, La Niña years (the opposite phase of ENSO to El Niño) are somewhat cooler (Figure 3), but they do not alter the long-term, multi-decadal global warming trend.

**Figure 3:** Global temperature anomalies relative to the 1981–2010 average, showing El Niño, Neutral and La Niña years.




**Note:** 2017 data point shows global mean temperature for the period January to September 2017 (0.47°±0.08°C warmer than the 1981-2010 average).

**Source:** Adapted from WMO 2017.

Global temperature records tumbled yet again in 2017. Here are some examples:

- Hong Kong experienced its warmest January on record (NOAA 2017a).
- Germany, France and Austria had their warmest March on record (NOAA 2017b).
- May, June and July temperatures were the hottest on record in Africa (NOAA 2017c, 2017d, 2017e).
- Austria recorded a new May national maximum temperature on 30 May 2017, when temperatures reached 35°C (NOAA 2017c).
- The July 2017 global land temperature was the highest on record, 1.2°C above the 20th century average of 14.3°C (NOAA 2017e).
- The Kingdom of Bahrain had its warmest July since records began in 1902, with a national temperature of 36.9°C (3°C above average) (NOAA 2017e).
- Portugal had its highest October temperature on record (NOAA 2017f).
- Alaska had its warmest December on record (NOAA 2018b).

# 3. Australian Heat Records Broken in 2017

**2017 continued a long trend of increasing heat, 'angry summers' and smashed weather records across Australia. The country experienced its third warmest year on record; the annual average temperature across the continent was 0.95°C warmer than the 1961-1990 average (BoM 2018). The maximum temperatures across the country were the second highest on record. Oceans around Australia also recorded temperatures through 2017 that were well above average.**

Rainfall was a somewhat different story through 2017, with very dry conditions through the middle of the year, but wetter conditions during the last quarter of the year. June 2017 was the second driest June on record, while September was the driest on record for the Murray-Darling Basin.

The records listed below are referenced against the 1961–1990 average, and are sourced from BoM's climate archives (http://www.bom.gov.au/climate/current/statement_archives.shtml).

## Summer

- Sydney and Brisbane had their hottest summers on record.
- Canberra experienced its warmest summer on record for daytime temperatures.
- January and February heatwaves caused record hot days and nights for southern Queensland and northern to eastern New South Wales.
- Moree had 54 consecutive days of 35°C or above, a new record for New South Wales.
- On 11 February the state-wide New South Wales average maximum temperature reached 44°C, the hottest February day on record.
- Both Moorabbin and Laverton (outer suburbs of Melbourne) experienced their hottest January night on record on the 8th.

## Autumn

- Mean maximum temperatures were very much above average (+1.21°C) for Australia, the seventh warmest autumn on record.
- March was an exceptionally warm month. The national mean temperature was the third highest on record, 1.66°C above average, while the national mean maximum temperature was 1.87°C above average, the second warmest on record for March.
- Mean maximum temperatures were the warmest on record for autumn for parts of western Queensland and the Northern Territory.
- Launceston (37 years of record) had its warmest night (highest daily minimum temperature) on record on 16 March.
- On 26 March, five locations in South Australia experienced their highest autumn temperature on record - Tarcoola Aero (44°C), Nullarbor (43.4°C), Woomera Aerodrome (43°C), Minnipa Pirsa (42.4°C) and Coulta (Coles Point) (40.6°C).

## Winter

- Australia had its warmest winter on record for average maximum temperatures, reaching nearly 2°C above average.
- Australia had its fifth warmest winter on record for average temperatures.
- Queensland, Western Australia and the Northern Territory had their highest winter average maximum temperatures on record.
- Winter days were the second-warmest on record for South Australia and the third warmest for New South Wales.

## Spring

- Spring was the sixth-warmest on record for national average temperatures.
- 22 September was the hottest September day experienced in Australia since records began, with a temperature of 33.47°C, more than six degrees warmer than the September average.
- High temperature records for September were set in Victoria, New South Wales and Queensland.
- Melbourne had a record 15 days of 30°C or more during spring.
- Cape Jaffa in South Australia experienced its highest spring mean daily temperature on record (37.4 °C).
- Derby Aerodrome in Western Australia had a record high spring temperature of 44.8°C on 30 October.

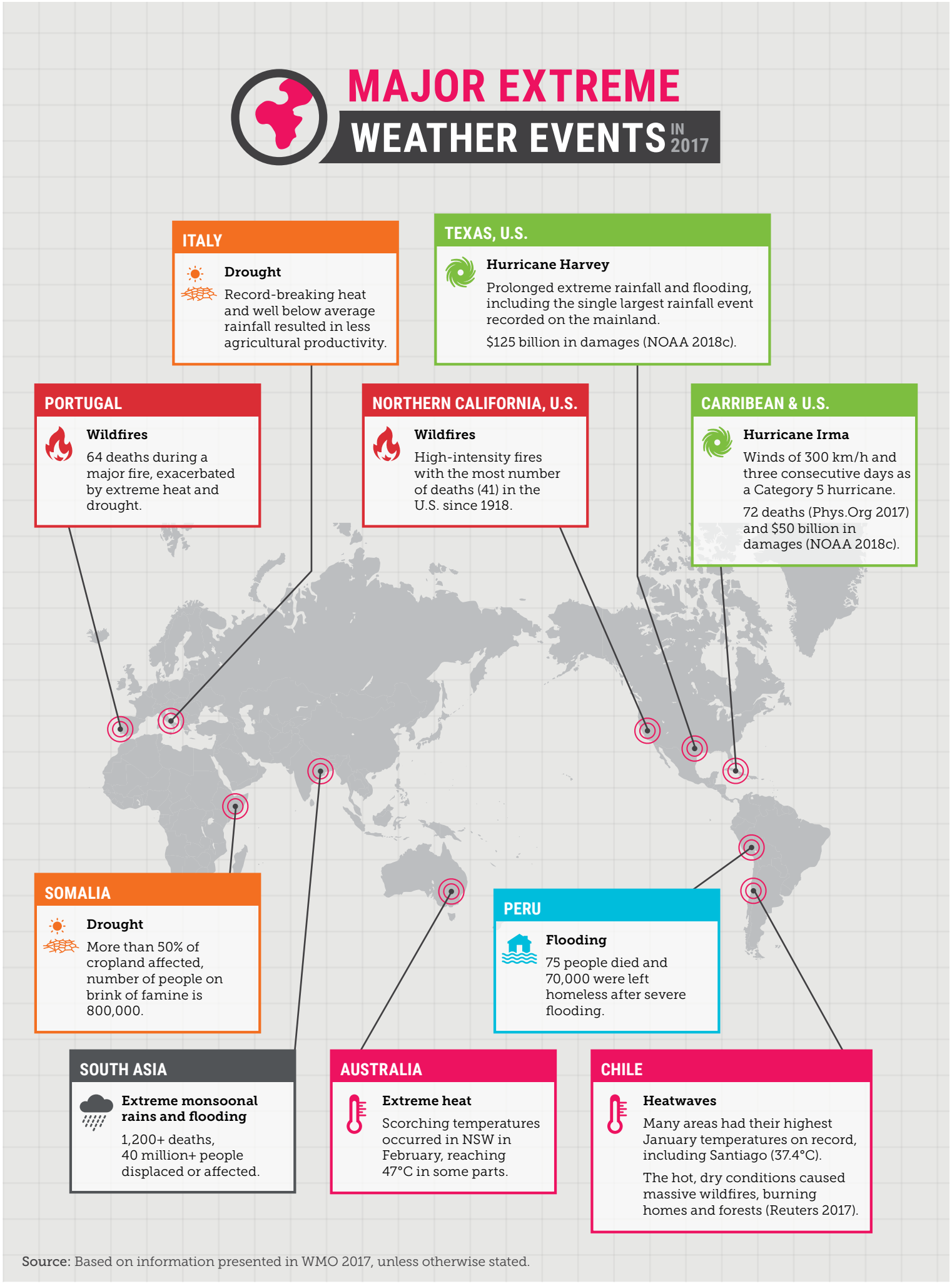
# 4. Consequences of 2017 Record Heat: Impacts of Extreme Weather Globally

**Extreme weather has had devastating impacts across all areas of the world in 2017—from intense monsoonal rains and consequent flooding in South Asia, to powerful hurricanes striking the Caribbean and the southern United States, while wildfires caused numerous fatalities and destruction across southern Europe and California. Figure 4 provides an overview of some of the major extreme weather events of 2017.**

The increasing global heat associated with climate change is now influencing all extreme weather events, because all extreme weather events are now occurring in a more energetic climate system with a hotter, moister atmosphere (Trenberth 2012). Many extreme weather events, such as heatwaves, bushfires and coastal flooding are occurring more frequently and becoming more damaging. 2017 provided more evidence of the increasing impacts and risks that climate change is driving for our health and well-being, our livelihoods and economies, and for the natural world.

Climate change is now influencing all extreme weather events.

Figure 4: Global overview of some of the major extreme weather events of 2017.




Source: Based on information presented in WMO 2017, unless otherwise stated.

# 5. Impacts of Extreme Weather in Australia in 2017

**In Australia, extreme weather events in 2017 drove serious impacts. This section explores these impacts.**


For more details about the influence of climate change on extreme weather events and the escalating impacts and risks, please refer to the Climate Council report: **Cranking Up The Intensity: Climate Change and Extreme Weather Events.**

**Figure 5:** Bushfires in southeast Australia have become more frequent and dangerous due to climate change.

# 5.1 Heat-related Extreme Weather

## 5.1.1 Heatwaves

Extreme heat is a serious health threat for many Australians, often called the silent killer. Major heatwaves have caused more deaths since 1890 than bushfires, cyclones, earthquakes, floods and severe storms combined (DIT 2013; Coates et al. 2014). Longer, hotter and more intense heatwaves in Australia are being driven by climate change. For example, since 1960, the number of record hot days has doubled (Perkins and Alexander 2013; Cowan et al. 2014).

Extreme heat increases the risk of heat-related illness and can also exacerbate pre-existing conditions – children, the elderly and outdoor workers are most at risk (ABS 2015; Watts et al. 2015). Australia's mortality data indicate that over the past four decades there has been a steady increase in the number of deaths in summer compared to those in winter, suggesting that climate change may already be affecting mortality rates (Bennett et al. 2013). Extreme heatwaves led to a 10% increase in both deaths and ambulance callouts in New South Wales from 2005 to 2015 (Jegasothy et al. 2017).

**Figure 6**: Power pylons in southeast Australia – climate change is worsening extreme weather including heatwaves and is increasing the vulnerability of energy systems to blackouts.

The most severe heatwave of last summer was in southeast Australia, which experienced daytime temperatures over 40°C. The highest temperatures recorded were 48.2°C on 9 February at Tarcoola, South Australia, followed by 47.9 °C on 12 February at Walgett, New South Wales (BoM 2017a). This heatwave was made twice as likely to occur because of climate change (Perkins-Kirkpatrick et al. 2017), while the extreme heat in New South Wales over the entire summer season was at least 50 times as likely to occur because of climate change (King et al. 2017).

The same severe heatwave in early February 2017 caused issues for the South Australian and New South Wales energy systems. In South Australia, 40,000 people were left without power for about half an hour in the early evening 8 February while temperatures were over 40°C. The highest temperature in South Australia recorded on 8 February was at Moomba where the daytime maximum reached 46.6°C at Moomba Airport, while Adelaide reached a high of 42.4°C (BoM 2017b, c). This extreme summer heat placed the energy system under great pressure (despite energy supply being available).

Several days later on 10 February, New South Wales experienced the same heatwave with temperatures at Sydney Airport reaching 42.9°C, its hottest February temperature on record (BoM 2017d). With near record all-time peak electricity demand, the state narrowly avoided widespread blackouts. Imports of electricity via three interconnections with Victoria and Queensland ran above design limits, contributing 12% to meeting peak demand (AEMO 2017). Around 3000MW of fossil fuel plant was not available due to: tripping off (400MW), unable to start (760MW), out for maintenance (1000MW) or output limited due to cooling water limits (600MW). At one stage, the Tomago aluminium smelter shed 580 MW of load. It was this, and careful use by consumers, saving 200MW, that allowed New South Wales to avoid widespread blackouts.

This heatwave in February 2017 highlights the vulnerability of our energy systems to extreme weather. Climate change is making heatwaves longer, hotter and more frequent, increasing stresses on Australia's ageing energy infrastructure.

## 5.1.2 Bushfires

Climate change is increasing the likelihood of dangerous bushfire weather, particularly in the southwest and southeast of Australia. As temperatures continue to rise, climate change is lengthening the fire season, which now extends well beyond summer, into October and March, in many regions (Clarke et al. 2013). Analysis of global climate data has shown that the frequency of long fire weather seasons has increased in eastern Australia (VIC, NSW, ACT and QLD) - where around 77% of the population live (ABS 2015; Jolly et al. 2015).

Hot weather, combined with very dry conditions in New South Wales and the Australian Capital Territory, led to tinderbox fire conditions in January and February 2017. During the February heatwave, nearly 100 bushfires were raging simultaneously in New South Wales (BBC 2017), and destroyed at least 30 homes (ABC 2017a). Meanwhile in Victoria, 40 fires were burning in mid-January with temperatures across much of Victoria exceeding 40°C (News Limited 2017).

Dangerous bushfire weather is becoming more common in the south and east of Australia (CSIRO and BoM 2016), and climate change is projected to lead to harsher fire weather in the southeast of Australia over the coming decades (CSIRO and BoM 2015).

Southwest and southeast Australia is facing increasingly dangerous bushfire seasons because of intensifying climate change.

# 5.2 Impacts on Ecosystems

Ecosystems suffer severe impacts from heat-related extreme weather.

The Great Barrier Reef experienced its worst ever bleaching event in 2016 (Figure 7) resulting in the mortality of two-thirds of the coral in the pristine, northern sector. Warmer than average sea surface temperatures off the Queensland east coast again triggered another bleaching event in 2017, with further consequences for the reef's health. The Great Barrier Reef employs around 70,000 people (Deloitte Access Economics 2013) and contributes around $7 billion to the national economy annually (Jacobs 2016), so the loss in tourism as a result of coral bleaching could be dire for the region.

The severe summer heat in 2017 has also affected terrestrial wildlife such as flying foxes, which are particularly susceptible to extreme heat events. Exposure to air temperatures over 40°C can lead to heat stress and death from dehydration, especially when very hot conditions are accompanied by dry weather (Climate Council 2017a). The February 2017 heatwave caused thousands of flying fox deaths across southeast Australia. The worst affected areas were in northern New South Wales, where more than 2,000 flying foxes died (ABC 2017b).

**Figure 7:** After the Great Barrier Reef's worst mass bleaching event in its history in 2016, above-average sea surface temperatures in summer 2017 triggered a second year of bleaching (photo of bleaching near Port Douglas).

# 5.3 Tropical Cyclones

Category-four Tropical Cyclone Debbie struck Northern Queensland in late March 2017 before tracking slowly down into southern Queensland and northern NSW as an ex-tropical cyclone. This event caused the loss of power to tens of thousands of homes and the evacuation of thousands as powerful storms brought heavy rainfall and mass flooding. At least five Australians died and damages are estimated at $2 billion (The Guardian 2017).

Trends in tropical cyclone frequency and intensity are difficult to discern for the Australian region due to the short observational records, as well as high year-to-year variability. However, where a long record of reliable data exists, some trends have been identified in tropical cyclone activity in the past few decades, such as a statistically significant increase in intense cyclone activity in the North Atlantic region since the 1970s (Kossin et al. 2007; IPCC 2013).

The most direct influence of climate change on the impacts of tropical cyclones is via coastal flooding. Typically, the damage from tropical cyclones comes from: (i) excessively high winds that directly damage built infrastructure and the natural environment; and (ii) coastal flooding caused by a storm surge and by the heavy rainfall that often accompanies the storm (Climate Council 2017b).

Cyclone Debbie is a tragic reminder of how extreme weather events place lives, property and critical infrastructure at risk. Climate change is intensifying many extreme weather events in an atmosphere that is warmer and wetter because of increasing greenhouse gas emissions from human activities, primarily the burning of fossil fuels – coal, oil and gas.

Climate change is worsening many extreme weather events, risking the lives and livelihoods of Australians.

# 6. The Window of Opportunity to Tackle Climate Change is Closing

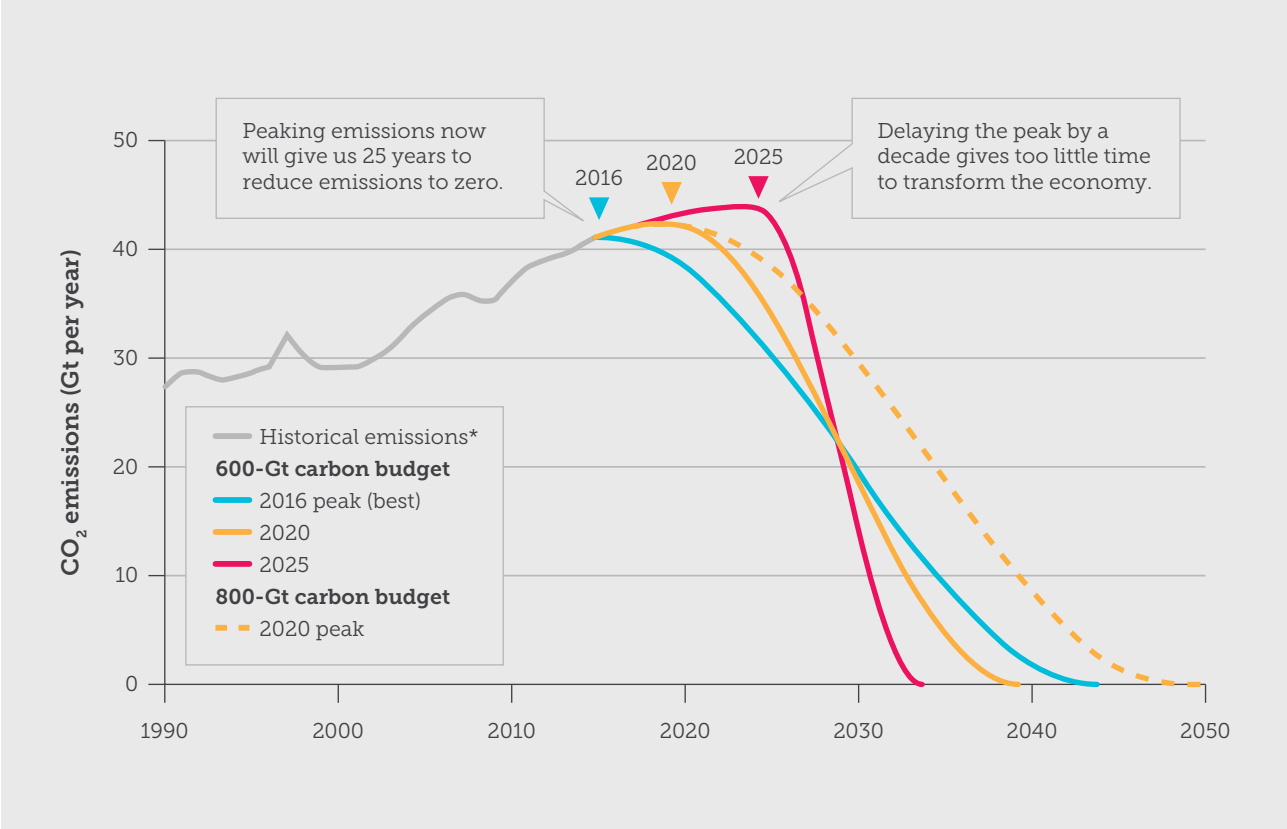
**The 2017 global heat and its associated impacts are yet another reminder of the urgency of the challenge to reduce emissions. Furthermore, 2018 started with more climate disruption.**

On 7 January 2018, Sydney was the hottest city on Earth over a 24-hour period with the temperature at the western suburb of Penrith reaching 47.3°C (ABC 2018). In the northern hemisphere, the ongoing exceptional heating around the north pole – twice the global average – is breaking down circumpolar air flows that normally keep the cold air around the north pole and more temperate air to the south (Mann 2017; Mann 2018). As Sydney was sweltering, icy polar air was penetrating as far south as Florida while unusually warm conditions were experienced north of Finland (SMH 2018).

Tackling climate change is urgent. There is no time to lose if we are to meet the Paris Agreement goal of limiting global temperature rise to no more than 2°C above pre-industrial levels, and prevent worsening extreme weather and other escalating risks of climate change. To meet the 2°C target, global greenhouse gas pollution must have peaked by 2020 and we need to reach net-zero emissions in about 25 years (Figure 8). Delaying peak emissions to 2025 would leave too little time to transform the economy; the world would be locked into a very dangerous future (Figueres et al. 2017; Rockström et al. 2017).

While the greenhouse gas pollution from most of our closest allies'—the United States, European Union and the United Kingdom—are trending downwards, Australia's emissions have been rising steadily since March 2015 (Australia Government 2017a). We have rapidly become the global laggard on climate change. Indeed, Australia holds the embarrassing title of being the fourth worst country out of 57 ranked nations on tackling climate change, only ahead of Iran, the Republic of Korea and Saudi Arabia (Germanwatch 2017). Furthermore, without a policy to reduce emissions and a pathway to do so, it is unlikely that Australia will meet its 2030 emission reduction target (UNEP 2017; Australian Government 2017b), which is already well below what is necessary to tackle climate change (CCA 2015).

**Figure 8:** Emission reduction trajectories for meeting the Paris target(s). The year of peak emissions has an enormous effect on the steepness of the subsequent trajectory. Delaying peak emissions to 2025 is too late for any achievable emission reduction trajectory.




**Source:** Figueres et al. 2017.

But there is hope. States, territories, local councils and individuals are taking the lead. Australia is a world leader in the uptake of household solar with nearly 1.7 million systems installed, and industrial-scale solar systems are being rolled out at an increasing rate. Wind energy is becoming a major source of electricity in Australia's populous southeast. South Australia already generates nearly 50% of its electricity from renewables (Climate Council 2017b), and is moving forward on solar thermal and energy storage technologies, including the commissioning of the world's largest lithium-ion battery in December 2017. The Australian Capital Territory will be 100% renewable by 2020, and aims to reach net-zero emissions in its entire economy by 2050 at the latest (Climate Council 2017b). Such action at the state level shows that meeting the climate change challenge is possible.

The many heat-related records of 2017 are yet another reminder that the task of dealing effectively with climate change is urgent. The solutions to the challenge are appearing rapidly and the pathway to a prosperous, carbon-neutral society is becoming clearer. What we now need at the national level is leadership, a clear vision for tackling climate change, and coherent policies for getting the job done.

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