CLIMATE COUNCIL

THE HEAT MARCHES ON

CLIMATECOUNCIL.ORG.AU

Thank you for supporting the Climate Council.

The Climate Council is an independent, crowd-funded organisation providing quality information on climate change to the Australian public.

Published by the Climate Council of Australia Limited

ISBN: 978-0-9944926-5-4 (web)
978-0-9944926-6-1 (print)

—

Image credit: Cover photo "The Sun behaving strangely" by Flickr user Micolo J under CC BY 2.0.

This report is printed on 100% recycled paper.

Professor Will Steffen
Climate Councillor,
Climate Council

Jacqui Fenwick
Researcher, Climate Council

facebook.com/climatecouncil
info@climatecouncil.org.au
twitter.com/climatecouncil
climatecouncil.org.au

Contents

Key Findings

1 Exceptionally long and hot warm spells in early March in southeastern Australia smashed records, contributing to the escalating number of heat records in Australia and globally as the climate warms rapidly.

- Over the period from 1 to 4 March, maximum temperatures were 4°C or more above average over much of Australia and were 8-12°C above average over most of southeastern Australia.
- Perth has had more 40°C days in the 2015/2016 summer than ever before.
- Sydney experienced a record breaking 39 consecutive days over 26°C, smashing the previous record of 19 days.
- Records are also being broken globally. January and February 2016 were significantly hotter than any other January and February on record.
- Climate change is driving off-the-chart temperature records globally, particularly in the northern high latitudes.

2 These off-the-charts temperatures are driving dramatic and unprecedented climate impacts.

- Record warm sea surface temperatures are threatening the Great Barrier Reef with widespread coral bleaching.
- Arctic sea ice extent is at its lowest on record for this time of year. A rapid decline in sea ice extent is of major concern for both the Arctic and the global climate system.
- Prolonged hot temperatures have contributed to a major algae bloom in the Murray River.
- Hot and dry conditions over the 2015-16 summer contributed to devastating fires in Tasmania.

3 As Australians continue to suffer from more frequent and worsening extreme heat events, the path to tackling climate change is becoming more urgent: no new coal mines can be built, existing coal mines and coal-fired power stations must be phased out and renewable energy must be scaled up rapidly.

- The US has declared a moratorium on new coal mines on federal land and the electricity industry's use of coal fell to record lows in 2015 as renewable energy boomed.
- China has pledged to shut 1000 coal mines this year and their emissions may have already peaked, well ahead of schedule.
- In contrast, Australia's fossil fuel emissions have begun to rise again, particularly in the electricity sector, with electricity emissions increasing by 3% in 2014-2015.

Introduction

Heat records were broken again in early 2016 as the climate sends us yet another disturbing wake-up call.

In Australia, the start of 2016 brought heatwaves and heat spells to most of the continent. Temperature records have been broken from north to south. For the southeast of the country, the duration of unrelenting high temperatures has been exceptional. The arrival of autumn went unnoticed as the high temperatures of summer continued through the first half of March.

The northern hemisphere, in the depths of winter, also saw record warmth. Spells of unseasonably warm temperatures during late 2015 and early 2016 have affected parts of Europe, North America and Asia, and have had severe consequences for sea ice formation in the Arctic Ocean.

Climate change, driven by the ongoing emission of greenhouse gases, is increasing global surface temperatures and worsening extreme heat events. As heatwaves across much of Australia get longer, more frequent and even hotter because of climate change, heat records will continue to be broken and the appearance of summer-like conditions earlier in spring and their persistence well into autumn will become more frequent events.

Despite the record heat, there has been very little action in Australia following the negotiation of the world's first universal climate agreement in Paris late last year. Australia's emissions are likely to continue to rise in the absence of any policies to encourage a rapid reduction in fossil fuel emissions and a transition towards renewable energy. The time frame in which we can avoid many of the most catastrophic impacts of climate change continues to narrow as the carbon budget is rapidly running out. The task is becoming more urgent; every year matters.

1. How Did the Heat Measure Up?

February was warmer than usual across Australia with the national average temperature sitting 0.92°C above the long term average for this time of year (BoM 2016a). A heatwave in the north of the country, in particular, brought extreme temperatures during the end of the month, breaking records across western Queensland (BoM 2016b).

The end of summer came and went unnoticed, as the first half of March continued to bring above-average temperatures.

The daily maximum temperature on 2 March (Figure 1), averaged across the whole country, was 38.14°C, the hottest ever recorded in March, smashing the previous record by 0.98°C. Over the period from 1 to 4 March, maximum temperatures were 4°C or more above average over much of the continent and were 8-12°C above average over most of the southeast.

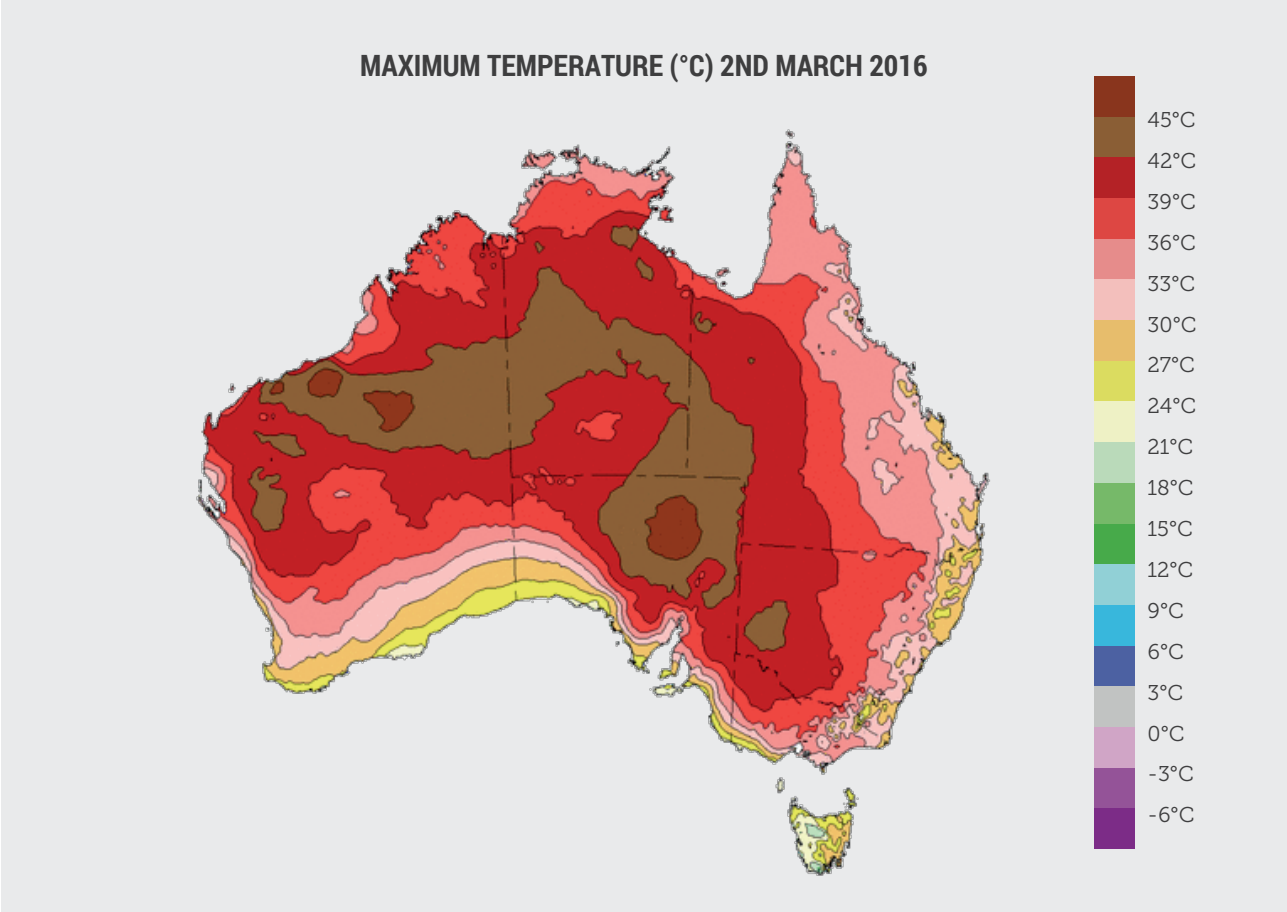


Figure 1: The maximum temperatures for the 2nd of March 2016, averaged across Australia, was 38.14°C - the hottest national temperature ever recorded in March. Figure adapted from BoM 2016d.

Average maximum temperatures from the 1st to the 9th of March were 9.23°C above average in Victoria, and 7.35°C above average in New South Wales, reaching 12°C above average in some regions (BoM 2016b). Minimum temperatures were also 6-8°C above average over a large part of the southeast (BoM 2016b).

Most notable, however, was the duration of high temperatures in early March.

The persistence of the heat in northern Victoria and inland New South Wales exceeded any previous event in March, and in some areas has been approaching record levels for any time of year. Each of the first nine days of the month had maximum temperatures, averaged across the whole state, above 35°C in New South Wales and above 32°C in Victoria, both record-breaking stretches of heat for March (BoM 2016b). The duration of such high temperatures in Victoria was the equal-third longest on record for any month of the year – despite occurring in autumn (BoM 2016b).

Many individual sites in inland Victoria and New South Wales have also set records for the persistence of high temperatures during March, with a few setting records for any time of year. Echuca and Tocumwal, for example, sweltered through eight consecutive days of 38°C or above, breaking records for any month of the year, despite occurring outside of summer (BoM 2016b).

Figure 2: Many inland and rural areas in New South Wales and Victoria set records for the persistence of high temperatures during March.

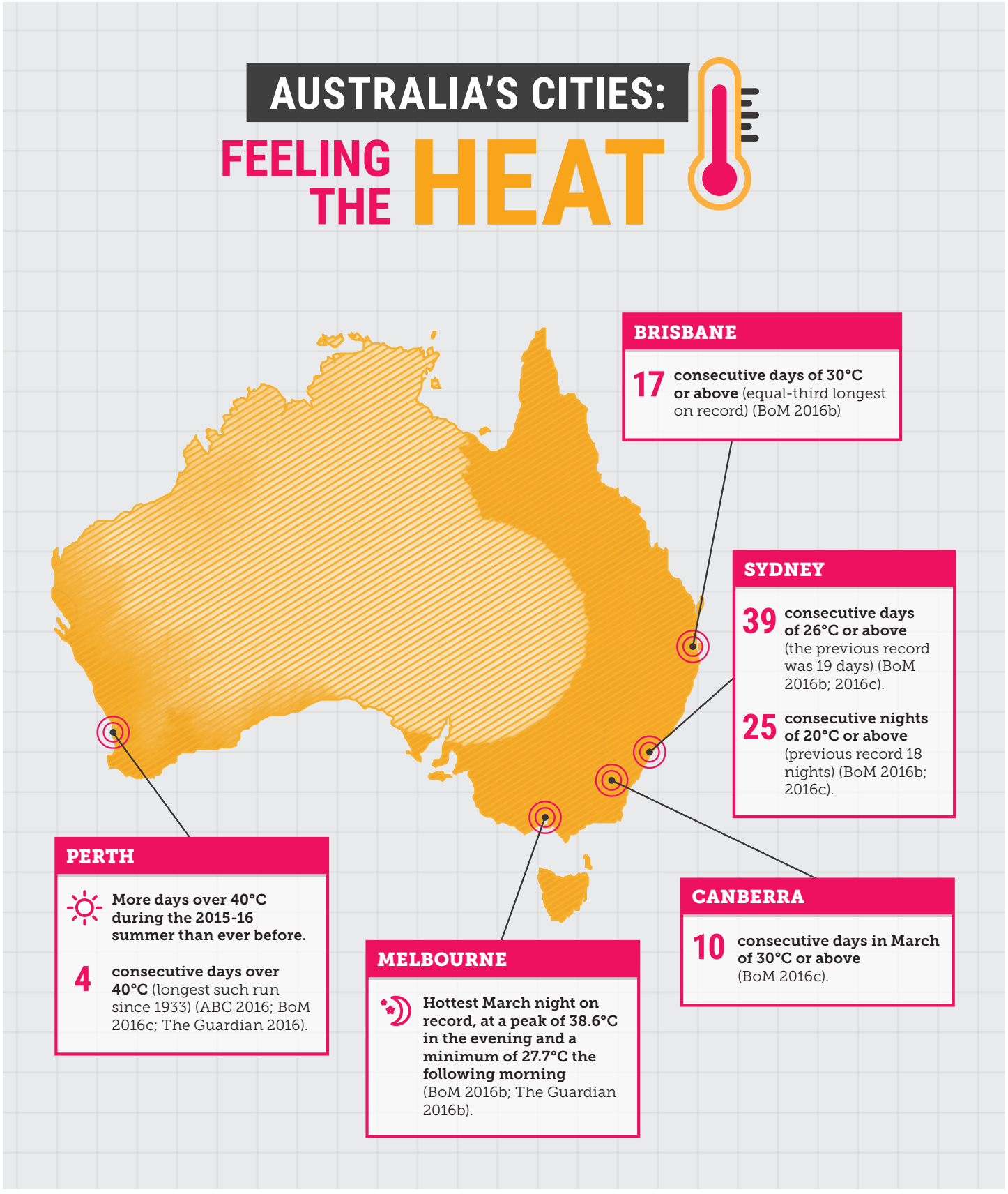


Figure 3: February and March 2016 brought prolonged heat conditions for much of southern and eastern Australia.

Other countries have felt the heat too.

February temperatures in some US states were substantially above the long-term average, including Alaska which had its warmest February on record at 6.8°C above average. The warm February, particularly in the northwest, concluded the warmest winter on record for the US (NOAA 2016c).

In central England, which has the longest temperature record in the world (dating back to 1659), the 2015-16 winter was the second-warmest ever, and only 0.1°C behind the previous record set in 1869 (Met Office 2016).

The average global surface temperature - land and ocean combined - for February 2016 was an astonishing 1.21°C above the 20th century average, the highest February temperature on record and the highest departure from average on record for any month (NOAA 2016d). The temperatures on land were particularly high, with the average land surface temperature 2.31°C above the 20th century average, further above average than any month on record (NOAA 2016d).

2. Putting Early 2016 in the Long-Term Context

When put in the context of the long-term global warming trend, the extreme heat events of early 2016 adds to the overwhelming evidence for human-driven climate change.

February 2016 was the hottest February globally in 137 years of records, at 1.21°C above the 20th century average (NOAA 2016b). This makes February the tenth consecutive month of record-breaking high surface temperatures for the globe (NSIDC 2016).

2015 was the hottest year on record globally (NOAA 2016), marking the fourth time this century that the annual global temperature record has been broken. Fourteen of the fifteen hottest years on record have occurred in the last fifteen years, and it has already been projected that 2016 global annual temperature may well exceed the 2015 record (Met Office 2015).

The record-breaking hot years the world has experienced in the last few decades would have been almost impossible in a world without climate change (King et al. 2016; King and Black 2016). A recent study found a 99.99% likelihood - virtually certain - that the record-breaking global annual temperatures since 2000 were influenced by human activity (Mann et al. 2016).

In terms of Australian temperatures, it is likewise very unlikely that our recent hot summers and years would have occurred without human-induced climate change (King et al. 2016; King and Black 2016). The record heat in Australia during 2013, for example, was virtually impossible without climate change (Lewis and Karoly 2014).

Without serious action on climate change, Sydney, Melbourne, Adelaide and Canberra could all experience a doubling or tripling of days over 35°C by 2070 (BoM 2013; Climate Council 2014; CSIRO and BoM 2007). Heatwaves will continue to get longer, hotter and more frequent over much of the country (Cowan et al. 2014) and heat spells outside of summer are very likely to worsen too.

3. Impacts of the Extreme Heat

Worsening extreme heat events bring severe impacts on our health and well-being. Heatwaves and heat spells in Australia and around the world take their toll on human health, the environment, agriculture, infrastructure and many other facets of society.

The impact of climate change on extreme weather, increasing the number of hot days and heatwaves, is driving up the likelihood of very high fire danger weather. After a record breaking dry spring and a dry, hot summer, in January 2016 bushfires ran rampant across Tasmania's ancient forests and World Heritage wilderness. Tasmania is no stranger to bushfires, especially after the arrival of European settlers, but this year's fires were particularly destructive. They had an impact on vegetation that is unique to Tasmania, including iconic alpine species, and burned up vast tracts of organic soils which the unique Tasmanian vegetation depends on. It is extremely unlikely that burnt areas with alpine flora will ever fully recover because of the slow growth of these species, the increased risk of subsequent fires given the change to more flammable vegetation and the slow accumulation of peat soils, which takes thousands of years (Bowman 2016). In Australia's southeast, it is very likely that an increased incidence of drought - coupled with consecutive hot and dry days - will result in longer fire seasons and an even larger number of days of extreme fire danger (e.g. Clarke et al. 2011).

In the Murray River, prolonged hot temperatures of February and March are believed to have contributed to a major algal bloom, affecting ecosystems as well as domestic, recreational and agricultural water use in the region (The Guardian 2016c). The heat-related outbreak is likely to result in an economic cost from a subsequent downturn in tourism in the region.

Unusually high sea surface temperatures in the tropics during the 2015-16 summer have contributed to a major coral bleaching event affecting the Great Barrier Reef (GBRMPA 2016a). Coral reefs can take many years or even decades to recover after a major bleaching event (GBRMPA 2016b). Repeating bleaching events can cause the death of the corals and the conversion of the reef to an algae-dominated ecosystem (Hoegh-Guldberg et al. 2007).

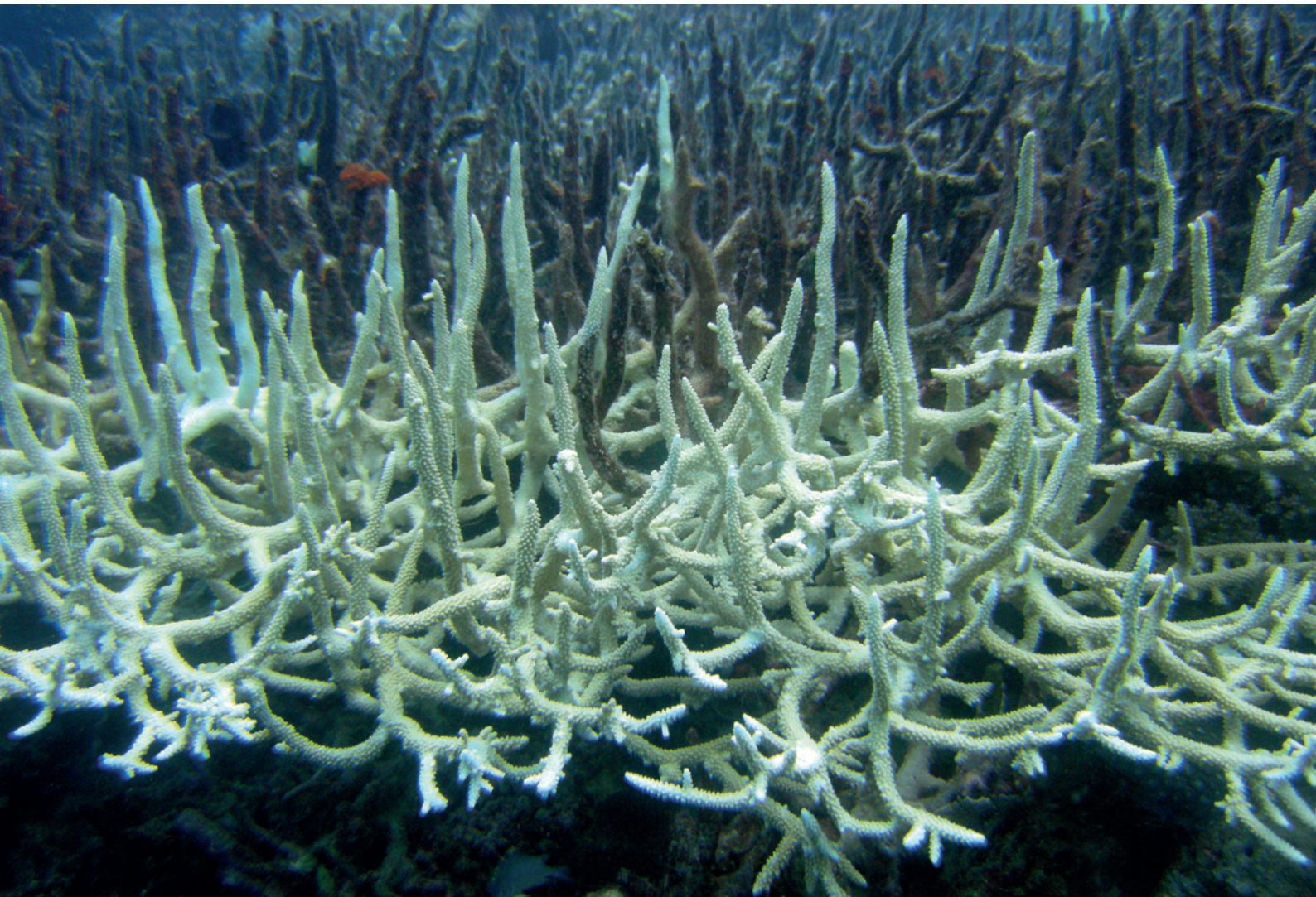
Beyond the catastrophic environmental consequences, the impact of extreme heat on these iconic ecosystems also comes at an economic cost. The Great Barrier Reef and Tasmania's forests, alone, deliver billions of dollars of value-added economic contribution annually (Deloitte Access Economics 2013).

In February, during the four consecutive days over 40°C in Perth, hospitals saw an increase in heat related illnesses (ABC 2016, The Guardian 2016). The human health impacts of extreme heat events, detailed in the Climate Council's report 'The Silent Killer', can also come at a significant economic cost, with the loss of productivity due to heat stress potentially costing the Australian economy billions per year (Zander et al. 2015).

At a global scale, the total environmental cost of the warm start to 2016 is not yet known. It is likely that the catastrophic consequences in the Arctic (see Box 1) may have long-term and wide-reaching impacts due to the implications for the broader climate system.

The impacts of extreme heat have significant economic costs.

Figure 4: Coral reefs are very vulnerable to bleaching as the oceans warm because of climate change.



ARCTIC THAW

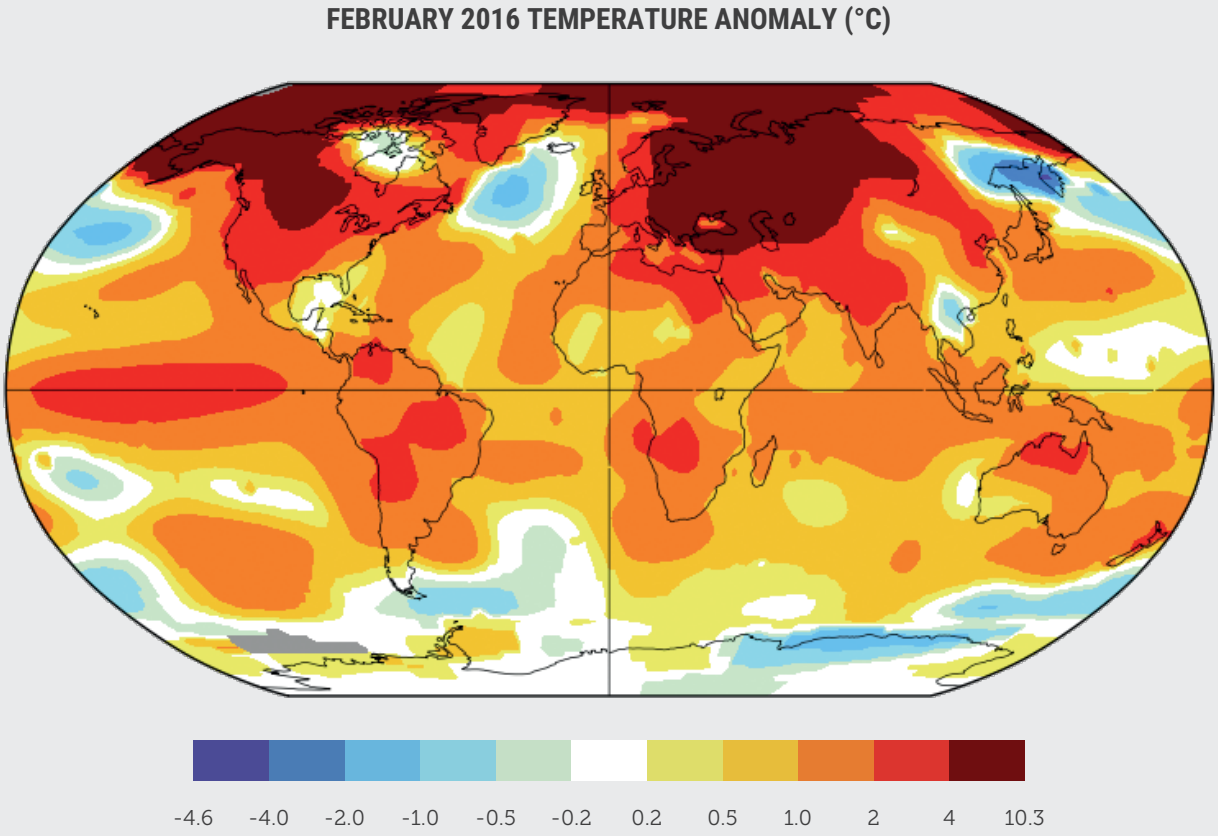


Figure 5: Global temperature data for February 2016, plotted as the difference between this February and average February temperatures for 1900-2000, illustrates the extreme warming in the Arctic during the month (GISTEMP Team 2015; Hansen et al. 2010).

New Years Eve in the Arctic should be dark and cold, and sea ice should be expanding and thickening after the previous year's melt. In the final days of 2015, however, surface temperatures at the North Pole exceeded zero degrees, a whopping 23°C above average (NSIDC 2016b).

This extreme heat event came amidst an ongoing trend of warming Arctic temperatures, driven by climate change, which are increasing at a far greater rate in the Arctic than the global average. Global maps of monthly temperature anomalies (the difference between the measured and the long term average temperatures) illustrate just how dramatic this Arctic warming is, as shown in Figure 5.

The consequences of this climate change-driven dramatic warming are dire. The Arctic sea ice extent for February was the lowest February extent in the satellite record, at 1.16 million square kilometers below the 1981-2010 average (NSIDC 2016; Figure 6). To put this in perspective, the ice extent this February was smaller than the long-term February average by an area the size of NSW, VIC, TAS and the ACT combined. This followed a record low sea ice extent observed for January (NSIDC 2016).

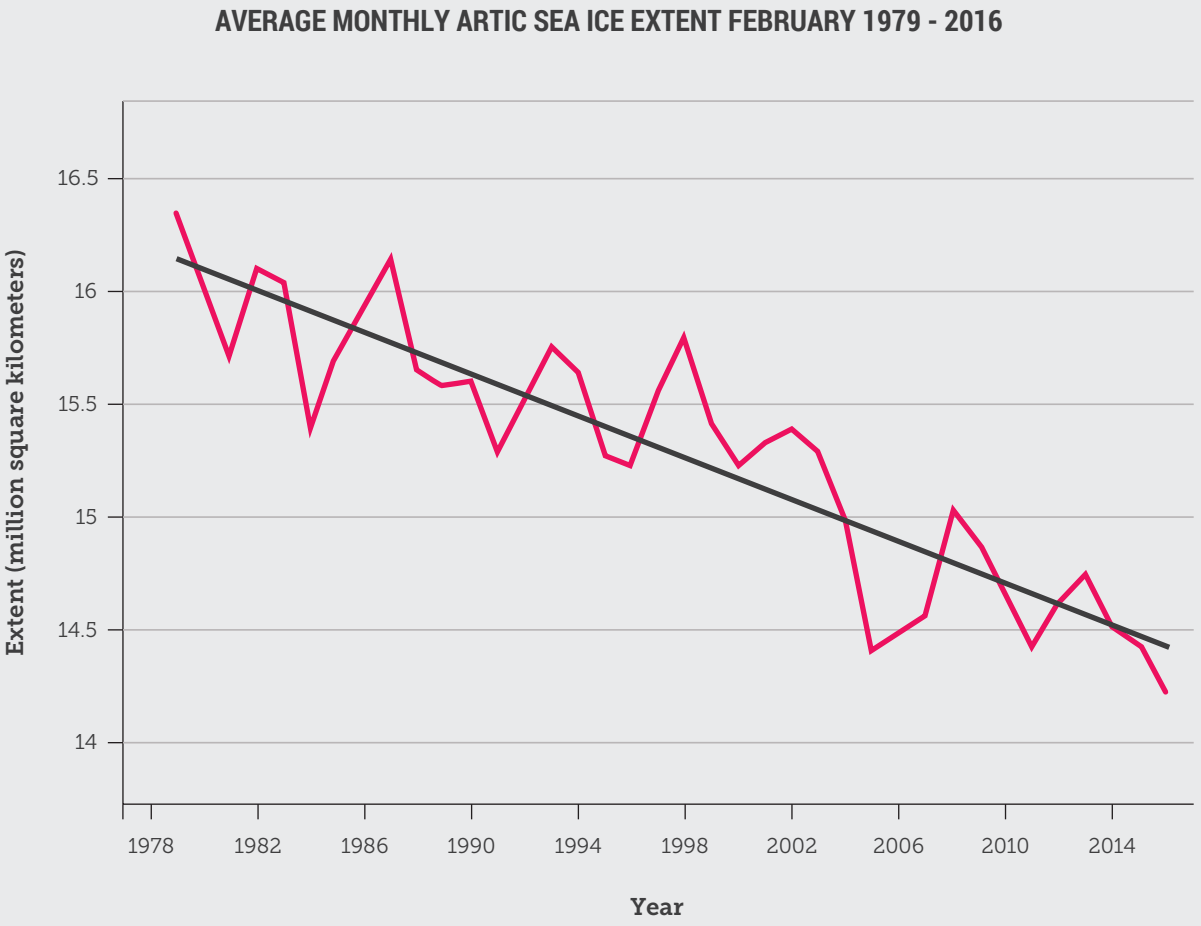


Figure 6: Graph of the Arctic sea ice extent in February each year from 1979 shows that February 2016 sea ice extent was the lowest on record. The linear rate of decline for February is now 3.0% per decade (NSIDC 2016).

Arctic sea ice typically reaches its maximum extent for the year in mid to late March, from which point it will begin to melt. The ice cover on the Arctic Ocean has a major influence on the broader climate system and on regional warming, through a strong reinforcing feedback effect.

As the area of summer ice melt increases, more dark ocean water is exposed, which absorbs rather than reflects incoming sunlight and warms the region even further. For this reason, a rapid decline in sea ice extent is of major concern for both the Arctic and the global climate system.

4. Conclusion

Australia, and the rest of the world, are in uncharted territory when it comes to the warming of the world's climate. February obliterated the global temperature record set just the previous month, reaching 1.21°C above the long-term average for the first time in February.

The rest of the world is getting on with the job of rapidly reducing fossil fuel emissions. The US has declared a moratorium on new coal mines on federal land and the electricity industry's use of coal fell to record lows in 2015 as renewable energy boomed. Emissions from the electricity sector fell by almost 18% on 2005 levels (BNEF 2016). China has pledged to shut 1000 coal mines this year and modelling shows their emissions may have already peaked- well ahead of schedule (Green and Stern 2016).

In contrast, Australia's fossil fuel emissions have begun to rise again - particularly in the electricity sector, with emissions increasing by 3% in 2014-15 (DoE 2015). In the absence of any substantive policy announcements since the Paris talks, it is unclear how we will meet even the low emissions reduction targets we committed to in Paris.

In the meantime, Australians are being harmed by more frequent and more intense extreme heat and we are closer than ever to crossing catastrophic tipping points in our climate system.

The path to tackling climate change is clear: no new coal mines can be built, existing coal mines and coal-fired power stations must be phased out and renewable energy must be scaled up rapidly.

We must get on with the job and join the global transition to a clean energy world.

References

ABC (Australian Broadcasting Corporation). 2016. Perth Swelters in heatwave, breaking 50-year-old weather record. 10 February. Accessed at http://www.abc.net.au/news/2016-02-09/hot-weather-record-for-perth/7153994

BNEF (Bloomberg New Energy Finance). 2016. Sustainable Energy in America Factbook: Executive Summary. Accessed at http://www.bcse.org/wp-content/uploads/BCSE-2016-Sustainable-Energy-in-America-Factbook_Executive-Summary.pdf

BoM (Bureau of Meteorology). 2013. ACORN-SAT station data and network maximum temperature data. Accessed at: www.bom.gov.au/climate/change/acorn-sat/#TABS=1.

BoM. 2016a. Australia in February. Accessed at: http://www.bom.gov.au/climate/current/month/aus/summary.shtml

BoM. 2016b. Special Climate Statement 55: Prolonged March heatwave affects many parts of Australia. 11 March. Accessed at: http://www.bom.gov.au/climate/current/statements/scs55.pdf

BoM. 2016c. Climate Data Online. Accessed at: http://www.bom.gov.au/climate/data/index.shtml?bookmark=201

BoM. 2016d. Daily Maximum Temperature for Australia. Accessed at http://www.bom.gov.au/jsp/awap/temp/index.jsp

Bowman D. 2016. Fires in Tasmania's ancient forests are a warning for all of us. The Conversation, 29 January 2016. Accessed at https://theconversation.com/fires-in-tasmanias-ancient-forests-are-awarning-for-all-of-us-53806.

Clarke H, Smith P and Pitman, A. 2011. Regional signatures of future fire weather over eastern Australia from global climate models. *International Journal of Wildland Fire* 20: 550-562.

Climate Council. 2014. Heatwaves: Hotter, Longer, More Often. Will Steffen, Lesley Hughes and Sarah Perkins. Accessed at http://www.climatecouncil.org.au/heatwaves-report.

Cowan T, Purich A, Perkins S, Pezza A, Boschat G, and Sadler K. 2014. More Frequent, Longer, and Hotter Heat Waves for Australia in the Twenty-First Century. *Journal of Climate.* 27: 5851–5871.

CSIRO and BoM. 2007. Climate change in Australia: technical report 2007. CSIRO, Australian Bureau of Meteorology. 148 pp.

Deloitte Access Economics. 2013. Economic contribution of the Great Barrier Reef, March 2013, Great Barrier Reef Marine Park Authority, Townsville. Accessed at https://www.environment.gov.au/system/files/resources/a3ef2e3f-37fc-4c6f-ab1b-3b54ffc3f449/files/gbr-economic-contribution.pdf.

DoE (Department of Environment). 2015. Quarterly Update of Australia's National Greenhouse Gas Inventory: June 2015. Accessed at http://www.environment.gov.au/system/files/resources/cb14abbb-3a4b-406f-a22d-86f565674c3e/files/nggi-quarterly-update-jun-2015.pdf

GISTEMP Team. 2015. GISS Surface Temperature Analysis (GISTEMP). NASA Goddard Institute for Space Studies. Dataset accessed on 16/03/2016 at http://data.giss.nasa.gov/gistemp/.

GBRMPA (Great Barrier Reef Marine Park Authority). 2016a. Visit the Reef: Latest overview of current conditions. Accessed at http://www.gbrmpa.gov.au/visit-the-reef/current-conditions-on-the-great-barrier-reef/latest-overview-of-current-conditions-on-the-reef.

GBRMPA. 2016b. Managing the Reef: Coral bleaching. Accessed at http://www.gbrmpa.gov.au/managing-the-reef/threats-to-the-reef/climate-change/what-does-this-mean-for-species/corals/what-is-coral-bleaching.

Green F and Stern N. 2016. China's changing economy: implications for its carbon dioxide emissions. Climate Policy, March 2016.

Hansen J, Ruedy R, Sato M, and Lo K. 2010. Global surface temperature change, *Reviews of Geophysics.* 48, RG4004, doi:10.1029/2010RG000345.

Hoegh-Guldberg O, Mumbym P, Hoten A, Steneck R, Greenfield P, Gomez E, Harvell C, Sale P, Edwards A, Caldeira K, Knowlton N, Eakin C, Iglesias-Prieto R, Muthiga N, Bradbury R, Dubi A and Hatziolos M. 2007. Coral reefs under rapid climate change and ocean acidification. Science 318: 1737-1742.

King A, Black M, Min S, Fischer E, Mitchell D, Harrington L, and Perkins-Kirkpatrick S. 2016. Emergence of heat extremes attributable to anthropogenic influences. *Geophysical Research Letters.* 42, doi: 10.1002/2015GL067448.

King A and Black M. 2016. We traced the human fingerprint on record-breaking temperatures back to the 1930s. The Conversation. 8 March. Accessed at: https://theconversation.com/we-traced-the-human-fingerprint-on-record-breaking-temperatures-back-to-the-1930s-55438.

Lewis S and Karoly D. 2014. The role of anthropogenic forcing in the record 2013 Australia-wide annual and spring temperatures. *Bulletin of the American Meteorological Society* 95: S31-S34.

Mann M, Rahmstorf S, Steinman B, Tingley M and Miller S. 2016. The likelihood of Recent Record Warmth. *Scientific Reports.* 6: 19831.

Met Office. 2015. Met Office forecasts 2016 to be hottest year on record. Accessed at http://www.metoffice.gov.uk/news/releases/archive/2015/global-temperature

Met Office. 2016. Record breaking winter for England and Wales. Accessed at: http://www.metoffice.gov.uk/news/releases/2016/winter-statistics

NOAA. 2016. State of the Climate: Global Analysis for Annual 2015. National Centers for Environmental Information. Accessed at http://www.ncdc.noaa.gov/sotc/global/201513

NOAA. 2016b. Global Analysis – January 2016, Accessed at https://www.ncdc.noaa.gov/sotc/global/201601

NOAA. 2016c. National Overview – February 2016, Accessed at https://www.ncdc.noaa.gov/sotc/national/201602

NOAA. 2016d. Global Analysis - February 2016. Accessed at https://www.ncdc.noaa.gov/sotc/global/201602

NSIDC. 2016. February continues the streak of record low Arctic sea ice extent. Accessed at https://nsidc.org/arcticseaicenews/

NSIDC. 2016b. 2015 in Review. Accessed at https://nsidc.org/arcticseaicenews/2016/01/2015-in-review/

The Guardian. 2016. Perth heatwave: temperatures climb above 40C for fourth day in a row. Wednesday 10 February. Accessed at: http://www.theguardian.com/australia-news/2016/feb/10/perth-heatwave-temperatures-climb-above-40c-for-fourth-day-in-a-row

The Guardian. 2016b. Melbourne records its hottest March night since records began. Wednesday 9 March, Accessed at: http://www.theguardian.com/weather/2016/mar/09/melbourne-records-its-hottest-march-night-since-records-began?CMP=soc_567

The Guardian. 2016c. Businesses fear tourist drop-off as blue-green algae clogs Murray river. Thursday 10 March. Accessed at: http://www.theguardian.com/environment/2016/mar/10/businesses-fear-tourist-drop-off-as-blue-green-algae-clogs-murray-river

Zander K, Botzen W, Oppermann E, Kjellstrom T and Garnett S. 2015. Heat stress causes substantial labour productivity loss in Australia. *Nature Climate Change.* 5: 647-651.

Image Credits

Cover photo: “The Sun behaving strangely” by Flickr user Micolo J under CC BY2.0.

Page 3: Figure 2: “Farm, Foxhow” by Flickr user Rhondaa licensed under CC BY-NC 2.0.

Page 8: Figure 4: “Bleached Staghorn Coral” by Flickr user Matt Kieffer licensed under CC BY-SA 2.0.

Thank you for supporting the Climate Council.

The Climate Council is an independent, crowd-funded organisation providing quality information on climate change to the Australian public.

CLIMATE COUNCIL

facebook.com/climatecouncil

twitter.com/climatecouncil

info@climatecouncil.org.au

climatecouncil.org.au

The Climate Council is a not-for-profit organisation and does not receive any money from the Federal Government. We rely upon donations from the public. We really appreciate your contributions.

DONATE climatecouncil.org.au/donate