The Australia Institute
Research that matters.

HeatWatch

Increasing extreme heat in the Whitsundays

Increasing extreme heat will have profound impacts on people, industries and ecosystems in the Whitsundays. CSIRO and Bureau of Meteorology projections estimate that the average number of days over 35 degrees each year could increase fourfold by 2030 and reach over 87 days per year by 2090 without strong climate policies. Hot nights above 25 degrees are projected to rise from an average of 18 per year up to 177 per year by 2090.

Mark Ogge
Bill Browne
Travis Hughes

March 2019

ABOUT THE AUSTRALIA INSTITUTE

The Australia Institute is an independent public policy think tank based in Canberra. It is funded by donations from philanthropic trusts and individuals and commissioned research. We barrack for ideas, not political parties or candidates. Since its launch in 1994, the Institute has carried out highly influential research on a broad range of economic, social and environmental issues.

OUR PHILOSOPHY

As we begin the 21st century, new dilemmas confront our society and our planet. Unprecedented levels of consumption co-exist with extreme poverty. Through new technology we are more connected than we have ever been, yet civic engagement is declining. Environmental neglect continues despite heightened ecological awareness. A better balance is urgently needed.

The Australia Institute's directors, staff and supporters represent a broad range of views and priorities. What unites us is a belief that through a combination of research and creativity we can promote new solutions and ways of thinking.

OUR PURPOSE – 'RESEARCH THAT MATTERS'

The Institute publishes research that contributes to a more just, sustainable and peaceful society. Our goal is to gather, interpret and communicate evidence in order to both diagnose the problems we face and propose new solutions to tackle them.

The Institute is wholly independent and not affiliated with any other organisation. Donations to its Research Fund are tax deductible for the donor. Anyone wishing to donate can do so via the website at https://www.tai.org.au or by calling the Institute on 02 6130 0530. Our secure and user-friendly website allows donors to make either one-off or regular monthly donations and we encourage everyone who can to donate in this way as it assists our research in the most significant manner.

Level 1, Endeavour House, 1 Franklin St
Canberra, ACT 2601
Tel: (02) 61300530
Email: mail@tai.org.au
Website: www.tai.org.au

Summary

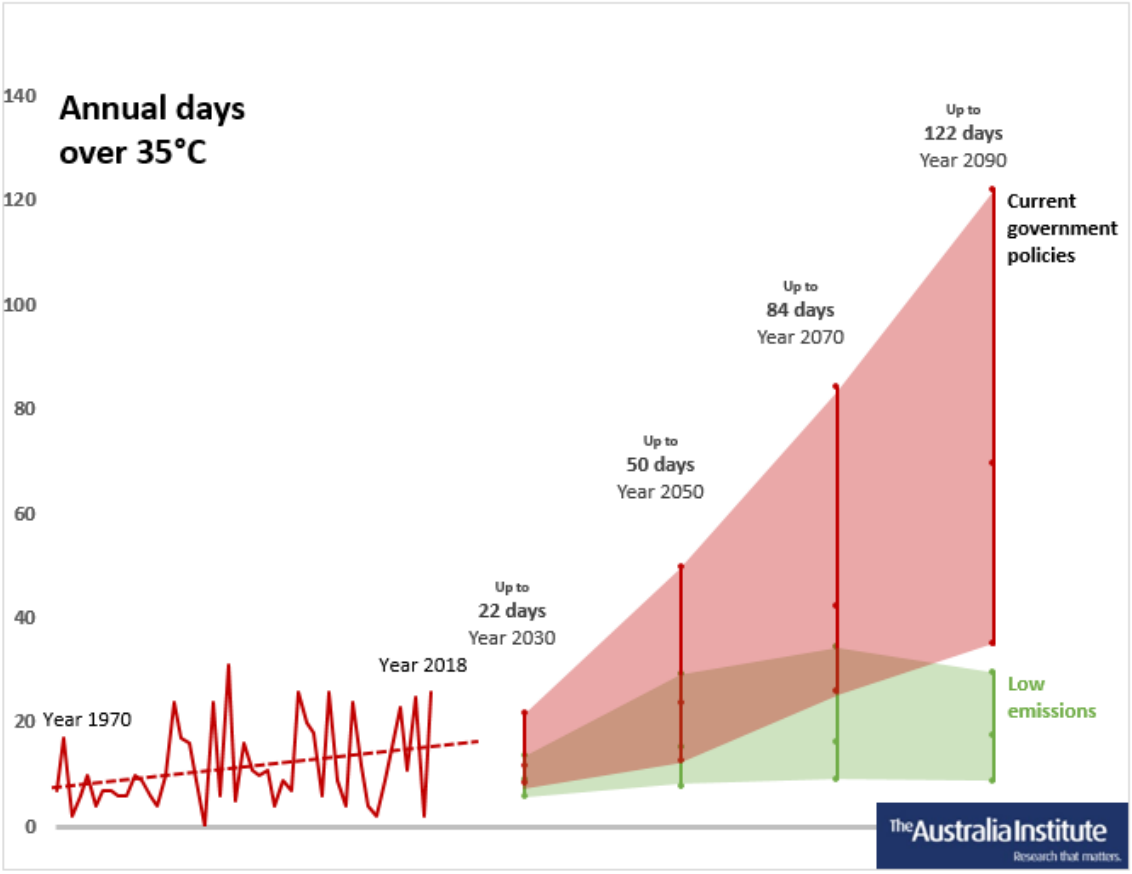
The projected rise in extremely hot days as a result of global warming presents a serious risk to the health and wellbeing of the Whitsundays community.

Proserpine has already experienced a clear increase in extreme heat days, with the amount of days over 35 degree increasing almost 30% from an average of 10 days per year since records began last century (1970-1999) to around 14 days per year this century.

The CSIRO and Bureau of Meteorology (BoM) projects this could rise steeply to up to 22 days per year over 35 degrees by 2030, up to 50 days by 2050 and potentially up to 122 days by 2090.

For Cannonvale, which is closer to the coast, the pleasant climate is at risk with the historic average of 2 days per year over 35 degrees potentially rising fourfold to eight days by 2030, 24 days by 2050 and up to 87 days per year by 2090.

Figure 1: Forecast annual number of days over 35 degrees in Proserpine



Source: Bureau of Meteorology (2019) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml; CSIRO and Bureau of Meteorology (2018) *Climate projections,* provided on request

Exposure to extreme heat can lead to serious illness and death. At temperatures above 35 degrees, the human body's ability to cool itself reduces which can lead to a cascading series of Heat Related Illnesses (HRI) and ultimately heatstroke that can cause organ failure and death. Heatwaves have caused more deaths in Australia since 1890 than cyclones, bushfires, floods, earthquakes and severe storms combined.[1]

The extreme heat risk to the Whitsunday region is exacerbated by its very high humidity, particularly in coastal areas. Over the last year there were 227 days – concentrated in summer – with a relative humidity of 70% or above and 100 days over 80% or above at 3pm on Hamilton Island. Combined with 70% humidity, conditions over 35 degrees are considered "dangerous" by government agencies such as the US Government National Oceanic and Atmospheric Administration (NOAA). Temperatures of 35 degrees combined with 80% humidity is considered "extremely dangerous".

The CSIRO also projects large increase in hot nights, considered 25 degrees and above. Alarmingly projections show hot nights could more than triple by 2030 from an historical average of 18 nights per year to up to 60 nights, and up to 177 nights per year by 2090. Cool night time temperatures are essential for good health and allow people to recover from hot days.

None of this is inevitable. CSIRO modelling shows that if emissions are reduced decisively in line with the globally agreed target of limiting the global temperature increase to 1.5 degrees, the number of extreme heat days will be a fraction of those we can expect is we continue the current emissions trajectory. Under a decisive emission reduction scenario, Proserpine will peak at a maximum of 35 days around 2070 before reducing to around 30 days by 2090, ensuring relatively safe temperatures for our children and grandchildren.

A large proportion of Whitsundays region's workforce is employed in agriculture and tourism. Many occupations in these industries are exposed to extreme heat. Similarly, key industries, particularly those related to tourism are directly threatened by increasing extreme heat, as the appeal of the region to tourists is largely dependent on an amenable climate.

[1] McMichael et al (2003) *Climate change and human health, risks and responses,* p 53, https://www.who.int/globalchange/publications/climchange.pdf

Table of Contents

Introduction

The Whitsundays have historically enjoyed a relatively pleasant coastal climate. However, this is at risk as the climate warms and the number of extreme heat events increases.

Last November, Proserpine experienced its most extended heatwave on record, including its hottest day on record, when temperatures reached 44.9 degrees on November 26th. The following two days remained above the previous record of 42.9 degrees. In this period there was a record nine consecutive days over 35 degrees, almost double the previous record of five days. There were four consecutive days over 38 degrees and three over 40 degrees. There had never before been any consecutive days over 38 degrees recorded in Proserpine since records began in 1970.[2]

2018 also saw Australia as a whole post its hottest summer on record, and the first season in which temperatures have exceeded two degrees above the long-term averages.[3]

Beyond the impacts increasing extreme heat itself, there are many other connected impacts including the recent bushfire crisis throughout Queensland which was triggered by the unprecedented heatwave that preceded it. Global warming has also already increased the frequency of rainfall disruptions such as the Queensland floods by 30%, which are projected to increase to 90% by mid-century and 130% by 2100.[4]

EXTREME HEAT

Extreme heat is dangerous for human health, for ecosystems and agriculture. At temperatures above 35 degrees, the human body's main cooling mechanism – sweating – is far less effective. Sweating exchanges heat from the body to the atmosphere, but this heat exchange process diminishes significantly beyond 35

[2] BOM (2018) *Special Climate Statement 67—an extreme heatwave on the tropical Queensland coast*, http://www.bom.gov.au/climate/current/statements/scs67.pdf

[3] Sydney Morning Herald (2019) *'It's been extreme': Australia's summer smashes seasonal heat records,* https://www.smh.com.au/environment/weather/it-s-been-extreme-australia-s-summer-smashes-seasonal-heat-records-20190227-p510od.html

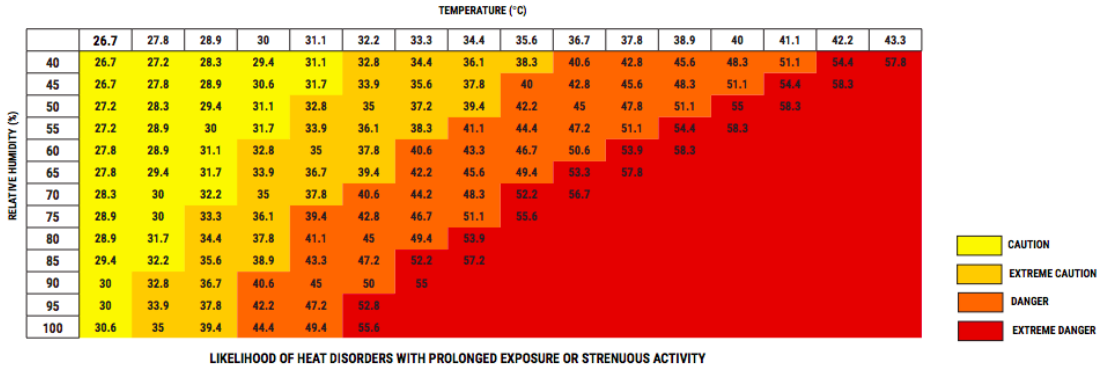
[4] BOM (2017) *Droughts and flooding rains already more likely as climate change plays havoc with Pacific weather*, http://www.bom.gov.au/climate/updates/articles/a023.shtml

degrees, so body temperature rises. This creates discomfort and a range of health impacts, from mild to severe, and can ultimately be fatal without intervention.[5]

Because of this, many regulators and researchers use 35 degrees as an important threshold for safety, work and climatic conditions. 35 degrees is seen as the "limit of high temperature tolerance" by the Occupational Health and Safety Representatives of the Victorian Trades Hall Council and many academic researchers note it as the point where substantial productivity is lost. The CSIRO and Bureau of Meteorology publish 35-degree threshold predictions.[6]

Temperature and humidity are often combined into a heat index figure to provide a simple indicator of the body's ability to cool itself. Of a number of indices available, one of the most important is published by the US Government National Oceanic and Atmospheric Administration (NOAA). As shown in the NOAA heat stress chart in Figure 1 below, the combination of temperatures in the low thirties with high humidity are considered "dangerous" to human health.

Figure 2: NOAA Heat Stress Index



	26.7	27.8	28.9	30	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40	41.1	42.2	43.3
40	26.7	27.2	28.3	29.4	31.1	32.8	34.4	36.1	38.3	40.6	42.8	45.6	48.3	51.1	54.4	57.8
45	26.7	27.8	28.9	30.6	31.7	33.9	35.6	37.8	40	42.8	45.6	48.3	51.1	54.4	58.3	
50	27.2	28.3	29.4	31.1	32.8	35	37.2	39.4	42.2	45	47.8	51.1	55	58.3		
55	27.2	28.9	30	31.7	33.9	36.1	38.3	41.1	44.4	47.2	51.1	54.4	58.3			
60	27.8	28.9	31.1	32.8	35	37.8	40.6	43.3	46.7	50.6	53.9	58.3				
65	27.8	29.4	31.7	33.9	36.7	39.4	42.2	45.6	49.4	53.3	57.8					
70	28.3	30	32.2	35	37.8	40.6	44.2	48.3	52.2	56.7						
75	28.9	30	33.3	36.1	39.4	42.8	46.7	51.1	55.6							
80	28.9	31.7	34.4	37.8	41.1	45	49.4	53.9								
85	29.4	32.2	35.6	38.9	43.3	47.2	52.2	57.2								
90	30	32.8	36.7	40.6	45	50	55									
95	30	33.9	37.8	42.2	47.2	52.8										
100	30.6	35	39.4	44.4	49.4	55.6										

Source: http://www.nws.noaa.gov/os/heat/heat_index.shtml

NOAA's heat stress index rises to "Extreme Danger" at temperatures over 35 degrees combine with 80% humidity.

[5] Hanna and Tait (2015) *Limitations to thermoregulation and acclimatisation challenges human adaptation to global warming,* Int J Environ Res Public Health, https://academic.oup.com/heapro/article/30/2/239/561863

[6] Victorian Trades Hall Council (2018) *Heat*, http://www.ohsrep.org.au/hazards/workplace-conditions/heat; Singh et al (2015) *Working in Australia's heat: health promotion concerns for health and productivity,* Health Promotion International, https://academic.oup.com/heapro/article/30/2/239/561863; CSIRO and BoM (2015) *Climate change in Australia: Projections for Australia's NRM Regions*, https://www.climatechangeinaustralia.gov.au/en/publications-library/technical-report/

The Whitsundays region experiences very high levels of humidity. There are no humidity records for Airlie Beach and Cannonvale, but the Hamilton Island weather station, which can be used as a proxy for these locations, recorded 226 days per year with humidity of over 70% and 100 days per humidity of over 70% for the year to March 2019.[7]

Proserpine does not have the extremely high levels of humidity of Hamilton Island, but also has high humidity with 67 days over 70% humidity recorded for the same period and 35 days over 80% humidity.[8]

A future of such extreme heat days matched with high humidity represents a serious threat to the wellbeing of people in the Whitsundays region and to Australia's wider population. As well as an increase in heat-related deaths and illness, the rise in extreme heat increases irritability and psychological stress.[9] Hot weather affects patterns in domestic violence,[10] interrupts sleep patterns and reduces capacity and willingness to exercise. All carry broad ramifications, such as increased accident risk, sedentary life style-induced diabetes and cardio vascular disease.[11] Tracking and minimising the way climate change is affecting the number of hot days is of direct interest to the wellbeing of local communities, particularly in areas of high vulnerability to heatwaves like the Whitsundays region.

THE WHITSUNDAYS

The CSIRO and the Bureau of Meteorology (BoM) have produced temperature projections under several climate change scenarios for most of terrestrial Australia. The CSIRO–BoM data is a time series from the Australian Water Availability Project (AWAP) where the average temperature was compiled in roughly five kilometre by five kilometre spatial grids between 1981 and 2010.[12] This time series uses between five

[7] BoM (2019) *Daily Weather Observations*, http://www.bom.gov.au/climate/dwo/201802/html/IDCJDW4078.201802.shtml

[8] BoM (2019) *Daily Weather Observations, Proserpine,* http://www.bom.gov.au/climate/dwo/IDCJDW4096.latest.shtml

[9] Queensland Health (2015) *Heatwave Response Plan* https://www.health.qld.gov.au/__data/assets/pdf_file/0032/628268/heatwave-response-plan.pdf

[10] Auliciems and Di Bartolo (1995) *Domestic violence in a subtropical environment: police calls and weather in Brisbane.* International Journal of Biometeorology 39 (1).

[11] Kjellstrom T et al (2009) *The Direct Impact of Climate Change on Regional Labor Productivity.* Archives of Environmental & Occupational Health 64 (4); World Health Organisation (2017) *Preventing noncommunicable diseases (NCDs) by reducing environmental risk factors*, http://apps.who.int/iris/bitstream/10665/258796/1/WHO-FWC-EPE-17.01-eng.pdf?ua=1

[12] CSIRO and Bureau of Meteorology (2015) *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report*, CSIRO and Bureau of Meteorology.

and eight models to predict days over 35 degrees, over 37 degrees and over 40 degrees in 2030, 2050, 2070 and 2090.[13] It also has a historical average for the years 1981–2010.

The report also employs the IPCC scenarios for global climate action: RCP 2.6 ("low emissions"), RCP 4.5 ("intermediate emissions") and RCP 8.5 ("high emissions/current government policies"). RCP 2.6 equates roughly to what is required to keep the world below 1.5 degrees warming, RCP 4.5 to what is required to keep the world below 2 degrees warming, and RCP 8.5 is the "business as usual" scenario where the world fails to act decisively on climate change. RCP 8.5 is the current trajectory due to the failure of most major polluting governments to implement necessary climate policies.

For the purposes of temperature projections, we have used a 5x5 square kilometre spatial grid square encompassing both Cannonvale and Proserpine to cover both a coastal and more inland location.

For historic temperatures we have used BOM data from Proserpine Airport. Unfortunately, there are no weather station records for Cannonvale or Airlie Beach, however we have used BOM/CSIRO Australian Water Availability Project (AWAP) data where, as mentioned above, the average temperature was compiled in roughly five kilometres by five-kilometre spatial grids between 1981 and 2010.[14]

ABOUT HEATWATCH

The Australia Institute's HeatWatch initiative puts current Australian research about temperature increases due to global warming into context, using data from the Bureau of Meteorology and the CSIRO.

Global temperature increases of 1.5 or 2 degrees above pre-industrial levels will have dramatic impacts on human health, the ecosystem and the economy. The IPCC has found that human-induced warming reached 1 degree above pre-industrial levels in 2017.[15]

Current policy settings would see more extreme warming than 2 degrees above pre-industrial levels. However, temperatures fluctuate by much more than a few degrees

[13] All eight models – ACCESS1.0, CESM1-CAM5, CNRM-CM5, GFDL-ESM2M, HadGEM2-CC, CanESM2, MIROC5 and NorESM1-M – are available for the RCP 4.5 and RCP 8.5 scenarios. Five models – CESM1-CAM5, CNRM-CM5, CanESM2, MIROC5 and NorESM1-M – are available for the RCP 2.6 scenario.

[14] CSIRO and Bureau of Meteorology (2015) *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report*, CSIRO and Bureau of Meteorology.

[15] IPCC (2018) *Global Warming of 1.5 °C,* p 1:4, https://www.ipcc.ch/report/sr15/

every day, meaning that the compounding and extreme effects of temperature increases can be difficult to imagine.

HeatWatch uses extreme heat days (days over 35 degrees) along with other thresholds like 37 degrees and 40 degrees to highlight that the effects of global warming will include a dramatic increase in days where it is uncomfortable or dangerous to operate outside – affecting industries like construction, sport and other outdoor activities.

HeatWatch began with *Cooked with gas: Extreme heat in Darwin,* which highlighted that the Northern Territory's plans to exploit emission-intensive oil and gas reserves will contribute to global warming which could increase the number of days over 35 degrees in Darwin from the current rate of 22 per year to 275 per year in 2070.[16]

Other HeatWatch reports have covered extreme heat in Rockhampton, Gladstone, Roma, the Sunshine Coast, the Gold Coast, Western Sydney and Adelaide. Three Queensland reports were presented alongside Queensland Fire and Emergency Services workshops on extreme heat.

The Australia Institute will continue to focus on additional locations and welcomes interest in collaborating on local versions of the reports.

All HeatWatch reports are available on our website: http://www.tai.org.au/heatwatch

[16] Hanna and Ogge (2018) *Cooked with gas: Extreme heat in Darwin,* http://www.tai.org.au/content/cooked-gas-extreme-heat-darwin

Increasing hot days in Proserpine

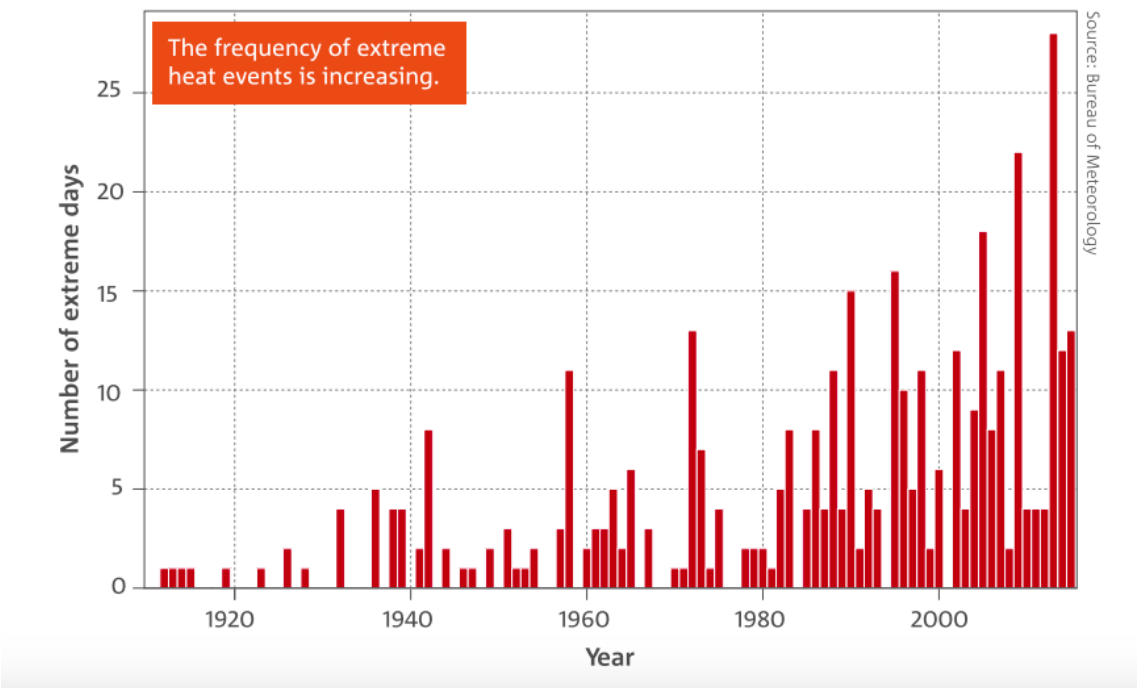
In Australia and globally there has been a clear trend of increasing temperatures and extreme heat events that are attributable to global warming.

The increase in extreme heat events across Australia as a whole is shown in Figure 3 below. This Bureau of Meteorology graph shows the annual number of days exceeding the 99th percentile of each month from 1910–2015.

The Bureau of Meteorology attributes this trend to global warming:

> As the global climate system has warmed, changes have occurred to both the frequency and severity of extreme weather. In Australia, the most obvious change has been an increase in the occurrence of record-breaking heat.[17]

Figure 3: Frequency of extreme heat days, Australia



Source: BoM (2016) *State of the Climate*

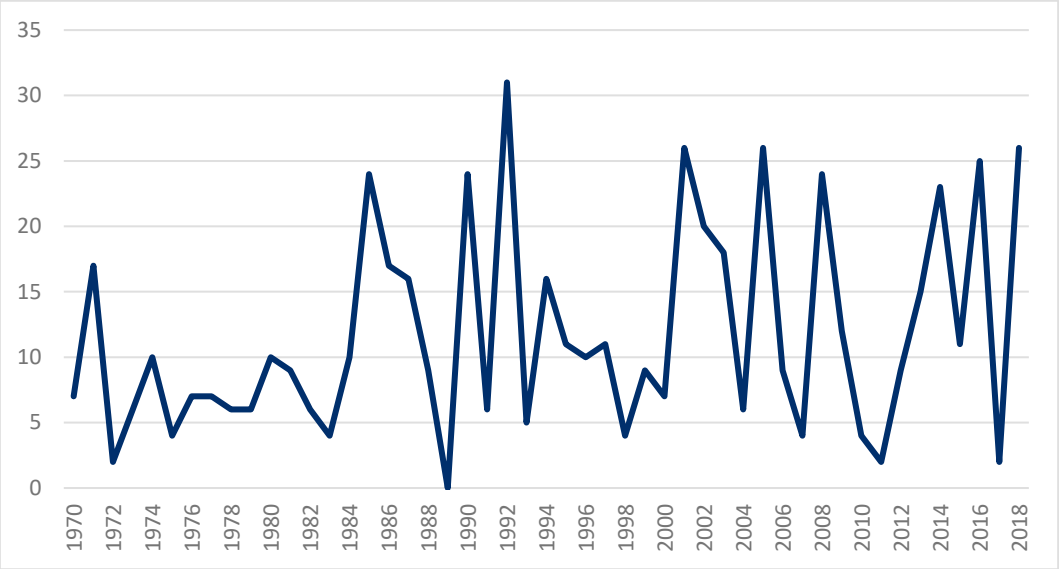
Proserpine Airport is the closest mainland weather station to Airlie Beach with almost 50 years of records going back to 1970. Proserpine is an important agricultural centre

[17] BoM (2016) *State of the Climate*, http://www.bom.gov.au/state-of-the-climate/State-of-the-Climate-2016.pdf

around 26 kilometres by road west of Airlie Beach. Its inland location means it is likely to have hotter overall temperatures with lower humidity.

Figure 4 below shows the number of days over 35 degrees in each year from 1970 onwards at Proserpine Airport weather station.

Figure 4: Annual number of days over 35 degrees Proserpine, 1941–2018



Source: Bureau of Meteorology (2019) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml

Figure 4 and Table 1 below show that the trend of days over 35 degrees in Proserpine has increased since mid-last century.

Table 1: Average days per year above 35 degrees, Proserpine

Decade	Proserpine Airport
1970-1979	7.2
1980–1989	10.5
1990–1999	12.7
2000–2009	15.2
2010–2018	11.7

Source: Bureau of Meteorology (2019) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml

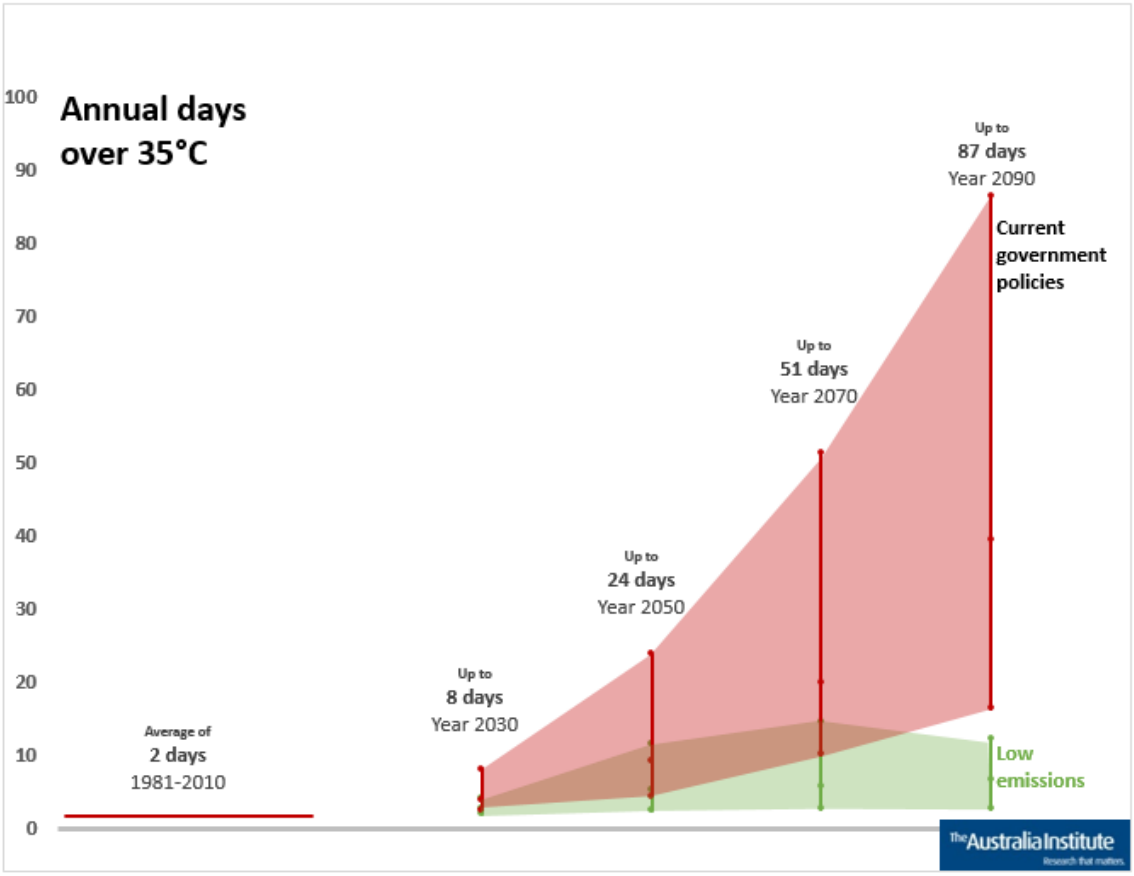
Projected increases in days over 35 degrees

As shown in Figure 5 below, under current government policies, in Cannonvale days over 35 degrees would go from a historical average of 2 days per year (1981-2010) to a maximum of 8 days by 2030, 24 days by 2050, 51 days by 2070 and 87 days by 2090. This would be concentrated in summer, where potentially almost every summer day could be over 35 degrees by 2090.

Proserpine is projected to have even greater increases. As shown in Figure 6 below, under current government policies, in Proserpine days over 35 degrees would go from a historical average of around 10 days per year (1970-1999) to a maximum of 22 days by 2030, 50 days by 2050, 84 days by 2070 and 122 days by 2090. Again, this would be concentrated in summer, where potentially almost every summer day could be over 35 degrees by 2090

The Whitsundays would benefit significantly from climate policies that would keep warming below 1.5 degrees, as represented by the RCP 2.6 scenario. As shown in Table 2 below, climate policies to keep warming below 1.5 degrees keep predicted days over 35 degrees in Cannonvale to below 4.2 days by 2030, increase to a maximum of 11.6 days by 2050 and stabilise at 12.5 days or below by 2090.

Figure 5: Forecast annual number of days over 35 degrees Cannonvale/Airlie Beach



Source: Bureau of Meteorology (2019) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml; CSIRO and Bureau of Meteorology (2018) *Climate projections,* provided on request

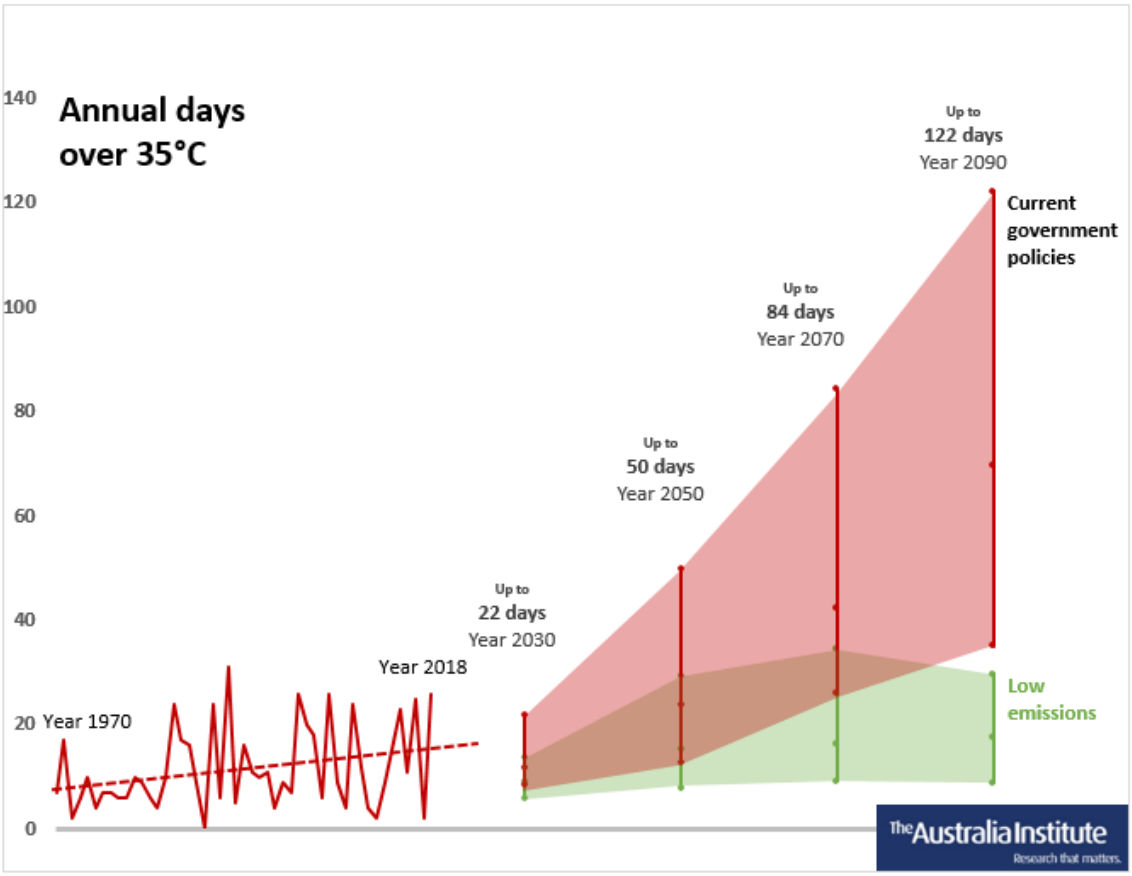
Table 2: Cannonvale/Airlie Beach projected days over 35 degrees

	1981-2010	2030	2050	2070	2090
Historical	1.7				
Low emissions		2.0-4.2	2.5-11.6	2.7-14.7	2.7-12.4
Intermediate emissions		2.3-6.5	3.2-12.4	3.7-16.1	4.2-16.5
Current policies		2.6-8.1	4.5-23.8	10.1-51.3	16.4-86.6

The Australia Institute

Source: CSIRO and Bureau of Meteorology (2018) *Climate projections,* provided on request

Figure 6: Forecast annual number of days over 35 degrees Proserpine/Whitsunday Airport



Source: Bureau of Meteorology (2019) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml; CSIRO and Bureau of Meteorology (2018) *Climate projections,* provided on request

Table 3: Proserpine/Whitsunday Airport projected days over 35 degrees

	1970-1999	2030	2050	2070	2090
Historical	10.3				
Low emissions		5.9-13.7	7.7-29.4	9.2-34.6	8.9-29.7
Intermediate emissions		6.6-18.2	9.7-29.5	10.4-36.5	12.2-38.1
Current policies		8.4-21.9	12.7-49.9	26.0-84.2	35.1-122.2

Source: Bureau of Meteorology (2019) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml; CSIRO and Bureau of Meteorology (2018) *Climate projections,* provided on request

Urban Heat Island effect in Airlie Beach

Much of the Airlie Beach and the surrounding suburbs have become increasingly urbanised as tourism developments have expanded and the population has grown.

Highly urbanised areas create an environment that is divergent from the surrounding rural areas. Research has found that due to urban structures like concrete and skyscrapers - along with roads, pavement, and diminished vegetation cover – cities becomes warmer as more heat is absorbed in the materials during day and then released at night, which increases night-time temperatures.[18]

This creates an Urban Heat Island effect (UHI) not just on these surfaces but also in the atmosphere. This is more prominent during summer as temperatures rise. During the daytime UHI causes exposed surfaces like roofs to heat to temperatures up to 50 degrees hotter than the air while rural areas remain closer to the atmospheric temperatures, creating an 'island' effect in cities.[19]

It is at night though when UHI has its most negative influence on atmospheric heat extremes. Heat absorbed in urban structures during the day is slowly released after sunset compared to heat in vegetated areas. This produces much higher temperature shifts in the air overnight than in equivalent rural areas.[20] On a clear calm night, the US Environmental Protection Agency states that the temperature difference can be as high as 12 degrees between urban and rural areas.[21]

The overnight effects of UHI are consistent across climate zones and scenarios. Coastal cities like Airlie Beach also suffer from UHI despite sea breeze.[22] Studies also raise the concern that night temperature extremes carry the higher risks of mortality as people are unable to recover from daytime heat stress .[23]

---

[18] Sharifi and Soltani (2017) *Daily variation of urban heat island effect and its correlations to urban greenery: A case study of Adelaide,* Frontiers of Architectural Research 6.
[19] United States Environmental Protection Agency, *Learn About Heat Islands,* https://www.epa.gov/heat-islands/learn-about-heat-islands
[20] Argueso et al. (2015) *Effects of City Expansion on Heat Stress under Climate Change Conditions,* PLoS ONE 10.
[21] United States Environmental Protection Agency, *Learn About Heat Islands,* https://www.epa.gov/heat-islands/learn-about-heat-islands
[22] Santamouris et al. (2017) *Urban Heat Island and Overheating Characteristics in Sydney, Australia – an analysis of multiyear measurements,* Sustainability 9.
[23] Zhao et al. (2018) *Interactions between urban heat islands and heat waves,* Environmental Research Letters 13.

Projected increases in nights over 25 degrees

When hot days are combined with hot nights, heat load and stress carry over and the body has no opportunity to cool down and recover. Studies show that there is an association between the mortality of not just stroke patients but also the general population and high night temperatures.[24]

Extreme heat nights also cause increased insomnia and lack of rest. This is exacerbated by the higher relative humidity overnight. As sleep is vital for healthy human functioning, a deficit means more susceptibility to disease, obesity, chronic illness and harm to our psychological and cognitive functioning.[25]

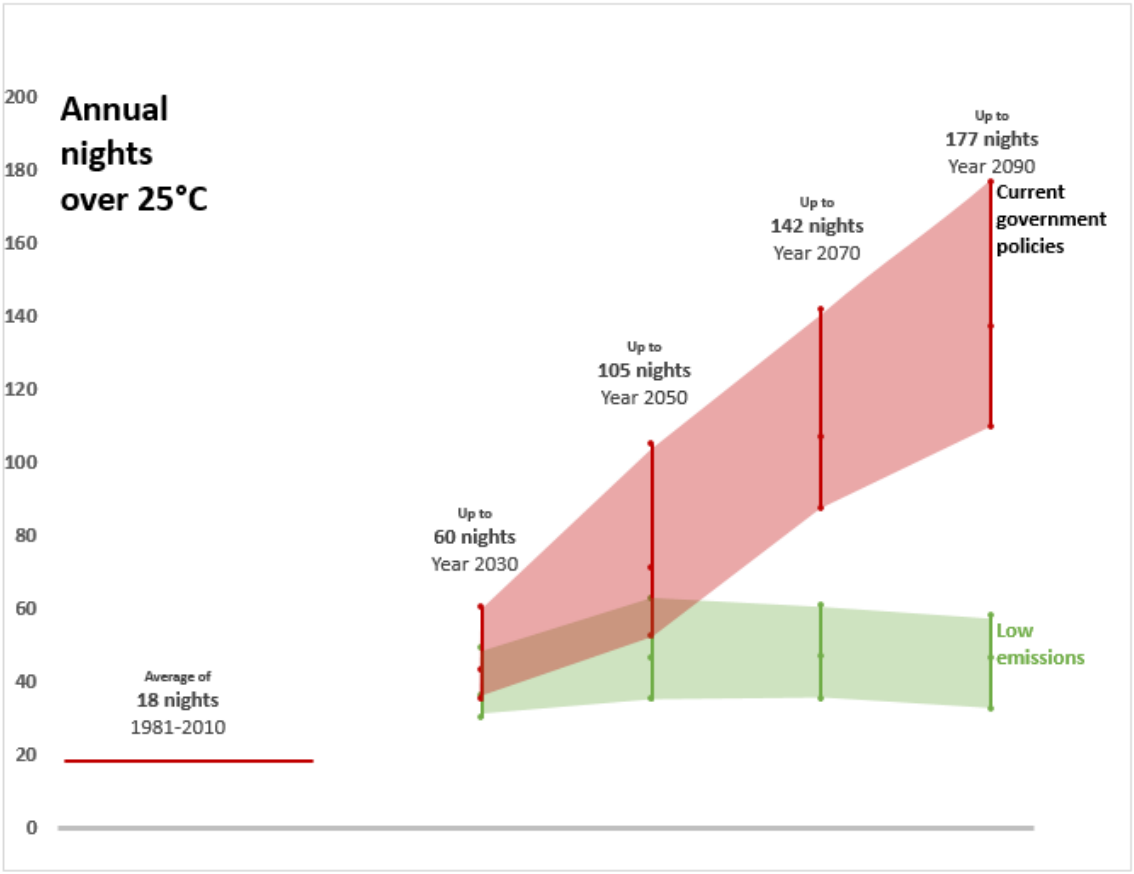
The number of hot days in the Airlie Beach/ Cannonvale area is projected to be accompanied by an even greater increase in the frequency of extreme summer nights. Part of this more rapid warming at night is characteristic of the climate system however, as night-time temperatures are more sensitive to a build-up of greenhouse gases.[26] The BoM classifies nights with "hot nights" as those with a minimum temperature of 25 degrees.

Under current government policies, in Airlie Beach/Cannonvale, nights over 25 degrees would go from a historical average of 18 nights per year to a maximum of 60 nights by 2030, 105 nights by 2050, 142 nights by 2070 and 177 nights by 2090. Virtually all summer nights, and much of autumn and spring are likely to be over 25 degrees by 2090.

However, with strong climate policies limiting global average temperatures to 1.5 degrees as recommended by the IPCC, rises in nightime temperature are projected to be a fraction of this. Under this scenario shown in green in Figure 7 below, hot nights in Cannonvale peak at a maximum of 63 nights per year over 25 degrees in 2050 and lower to a maximum of 58 nights by 2090.

[24] Murage et al (2017) *Effect of night-time temperatures on cause and age-specific mortality in London,* Environmental Epidemiology 1; Roye (2017) *The effects of hot nights on mortality in Barcelona, Spain,* International Journal of Biometeorology 61.
[25] Obradovich et al (2017) *Nighttime temperature and human sleep loss in a changing climate,* Science Advances 3.
[26] Davy et al. (2016) *Diurnal asymmetry to the observed global warming*. *International Journal of Climatology*.

Figure 7: Forecast annual number of nights over 25 degrees Cannonvale/Airlie Beach



Source: Bureau of Meteorology (2019) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml; CSIRO and Bureau of Meteorology (2019) *Climate projections,* https://www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/threshold-calculator/

Health and productivity impacts of extreme heat

The impact of extreme heat on human health, particularly over extended periods, is severe. Although people living in hot areas do acclimatise to help cope with extreme temperatures, there are limits.[27] A large increase in days over 35 degrees will push past those limits.

The health impacts of increasing extreme heat can include both direct heat illnesses such as heat exhaustion and indirect illnesses such as heart failure and even death.[28]

WorkSafe Queensland lists a range of illnesses arising directly from extreme temperatures from mild cramps, rashes, and dehydration to severe injuries such as heat stroke, exhaustion and even death if treatment is delayed.[29] As climate change worsens this can be expected to put people that are more vulnerable at increasingly greater risk.

The groups most vulnerable to heat impacts include the elderly, the very young, and those with pre-existing health conditions. Illnesses such as angina, kidney disease, and diabetes are at higher risk of being triggered or exacerbated when people are unable to maintain a safe body temperature.[30]

People suffering from mental disorders are also vulnerable. This vulnerability to extreme heat can result from altered behavioral responses to high temperatures or the impact of medications.

As stated earlier, irritability and psychological stress also increase in heat. When hot days are combined with hot nights, heat load and stress carry over and the body has no opportunity to cool down and recover. Studies show that there is an association between the mortality of not just stroke patients but also the general population and

[27] Hanna and Tait (2015) *Limitations to thermoregulation and acclimatisation challenges human adaptation to global warming,* Int J Environ Res Public Health 12.

[28] NSW Government (2017) Heat-related illness including heat stroke, https://www.health.nsw.gov.au/environment/factsheets/Pages/heat-related-illness.aspx

[29] WorkSafe Queensland (n.d.) *Health effects,* https://www.worksafe.qld.gov.au/injury-prevention-safety/hazardous-exposures/heat-stress/health-effects

[30] Hanna et al (2016) *The silent killer: Climate Change and the Health Impacts of Extreme Heat,* The Climate Council, https://research-management.mq.edu.au/ws/portalfiles/portal/72578140/72578105.pdf

high night temperatures.[31] The 'synergistic effect' of night humidity, increased temperatures, and urban heat island effects in heatwaves has been estimated in some studies to double general mortality risk by the end of the century under RCP 8.5.[32] Often underrated, major heatwaves have been dubbed the 'silent killer', causing more deaths in the last century in Australia than all natural disasters put together.[33]

Extreme heat nights also cause increased insomnia and lack of rest. This is exacerbated by the higher relative humidity overnight. As sleep is vital for healthy human functioning, a deficit means more susceptibility to disease, obesity, chronic illness and harm to our psychological and cognitive functioning.[34]

Productivity decreases significantly under these stresses as people are affected with the consequences of extreme heat. Workplace safety and the ability to work declines. This can also be displayed in economic terms as costs rise to account for the lack of labour productivity and changes needed in workplaces.[35]

Like most parts of Australia, a significant proportion of the local workforce is exposed to the heat.

Construction and manufacturing are also both significant employers in Queensland and are particularly exposed to extreme heat events.

The cost of lost productivity because of extreme heat in Australia has been estimated at almost $7 billon in 2013-14 alone.[36]

[31] Murage et al (2017) *Effect of night-time temperatures on cause and age-specific mortality in London,* Environmental Epidemiology 1; Roye (2017) *The effects of hot nights on mortality in Barcelona, Spain,* International Journal of Biometeorology 61.

[32] Zhao et al (2018) *Interactions between urban heat islands and heat waves,* Environmental Research Letters 13.

[33] Hanna et al (2016) *The silent killer: Climate Change and the Health Impacts of Extreme Heat,* The Climate Council

[34] Obradovich et al (2017) *Nighttime temperature and human sleep loss in a changing climate,* Science Advances 3.

[35] Climate Council (2014) *Heatwaves: Hotter, Longer, More Often,* https://www.climatecouncil.org.au/uploads/9901f6614a2cac7b2b888f55b4dff9cc.pdf

[36] Zander, Opperman and Garnet (2015) *Extreme heat poses a billion-dollar threat to Australia's economy,* https://theconversation.com/extreme-heat-poses-a-billion-dollar-threat-to-australias-economy-41153

HEAT STRESS AND THE WHITSUNDAYS WORKFORCE

Increasing extreme heat will have serious consequences for the health and safety of many of the region's workforce.

A significant proportion of the Whitsundays workforce is particularly vulnerable to the dangers of increasing extreme heat.

The 2016 Census lists 366 people working in agriculture, 425 in manufacturing, 650 in construction. These are all industries that regularly require strenuous activity outdoors, or in un-airconditioned indoor spaces which can often be hotter than outdoors.

Tourism directly employs 3720 people in the Whitsundays region.[37] A significant proportion of tourism jobs are also likely to require sustained and sometimes strenuous outdoor activity given tourism in the region is based on outdoor activities. As tourism is not classified as industry within the census classification, there may be overlap with categories referred to above.

As discussed above, at temperatures above 35 degrees, the human body's main cooling mechanism – sweating – is far less effective. Sweating exchanges heat from the body to the atmosphere, but this heat exchange process diminishes significantly beyond 35 degrees, so body temperature rises. There is a range of health impacts, from mild to severe. Heat stroke can cause permanent damage to the brain and other vital organs and can even result in death.[38] The US Army Research Institute of Environmental Medicine advises that all outdoor work with physical exertion be cancelled when the WGTB temperature exceeds 32 degrees.[39]

As discussed above, coastal areas of the Whitsundays have very high levels of humidity, with 227 days with over 70% humidity and 100 days over 80%humidity

[37] Jobs Queensland (2018) *Whitsundays Regional Tourism Workforce Plan 2018–2020,* https://jobsqueensland.qld.gov.au/wp-content/uploads/2018/10/whitsundays-tourism-plan.pdf

[38] Hanna and Tait (2015) *Limitations to thermoregulation and acclimatisation challenges human adaptation to global warming,* Int J Environ Res Public Health, https://academic.oup.com/heapro/article/30/2/239/561863

Australian Mining Review (November 2017) WA miners urged to guard against heat stress, https://www.miningreview.com.au/wa-miners-urged-guard-heat-stress/

[39] Hanna (2016) Microclimates and heat islands: Climate change exacerbates occupational heat exposures, http://greenhouse.asnevents.com.au/assets/Greenhouse/Presentations/1420HannaMR2Wed.pdf

recorded last year on Hamilton Island. The combination of temperatures over 35 degrees and humidity levels over 80% are considered “extremely dangerous”. combination of increasing extreme temperatures and very high humidity, particularly in the coastal areas is a significant risk to the health and safety of many people in the Whitsundays workforce.

IMPACTS ON TOURISM

Tourism is a very important industry in the Whitsunday region. There are over 600 tourism businesses in the Whitsunday region and tourism is estimated to directly and indirectly employ 4500 people.[40]

Tourism in the region is based firmly on outdoor attraction, particularly exploring the Great Barrier Reef. The attractiveness of destinations to tourists is largely dependent on the climate. Historically the Whitsundays have enjoyed at relatively pleasant climate with only 2 days a year on average above 35 degrees in coastal areas.

If the dramatic rise in extreme temperature days projected to occur on our current emissions trajectory occur, the attractiveness of the Whitsunday region as a destination is likely to be significantly diminished. This will have flow on effect to the many businesses and workers in the regions’ tourism industry whether or not they are directly exposed to the heat.

Increasing heat will also reduce workforce productivity among many industries, particularly in construction and agriculture which are important industries in the region.

[40] Jobs Queensland (2018) *Whitsundays Regional Tourism Workforce Plan 2018–2020,* https://jobsqueensland.qld.gov.au/wp-content/uploads/2018/10/whitsundays-tourism-plan.pdf

Impacts on infrastructure and industry

Extreme heat can cause failures to critical infrastructure, particularly transport and electricity supply. Coal and gas power stations in particular are highly vulnerable to extreme heat, experiencing both reduced output and an increased level of breakdowns. This is exacerbated by high electricity demand as a result increased use of air-conditioning during extreme heat conditions. During the February 2017 heatwave in South Australia, 17% of gas generation (438 MW) failed to deliver during the peak demand period on the heatwave day (8th of February),[41] leading to widespread blackouts.[42]

In an urbanised environment like Airlie Beach, air-conditioning can be critical to people's wellbeing during extreme heat. Electricity blackouts during heatwaves lead to the loss of air-conditioning when it is most essential. During the 2009 Heatwave in Melbourne on the evening of the 30th of January, 500,000 people were left without power on a day that reached 44 degrees. There were 374 deaths recorded as a result of this heatwave overall. The estimated economic cost of the heatwave was $800 million.[43]

Extreme heat can also affect transport including airports[44], roads can melt[45] and rail. [46] which are vital to region's economy.

[41] Ogge and Aulby (2017) *Can't stand the heat; The energy security risk of Australia's reliance on coal and gas generators in an era of increasing heatwaves*, http://www.tai.org.au/sites/defualt/files/P454%20Can%27t%20stand%20the%20heat%20FINAL%202.31.pdf

[42] Harvey and Shepherd (February 2017) *Rolling blackouts ordered as Adelaide swelters in heatwave,* https://www.news.com.au/national/south-australia/rolling-blackouts-ordered-as-adelaide-swelters-in-heatwave/news-story/13394f19db1ee94a59f4036fccdc1ba7

[43] NCCARF (2010) *Impacts and adaptation responses of infrastructure communities to heatwaves,* https://www.nccarf.edu.au/business/sites/www.nccarf.edu.au.business/files/attached_files_publications/Pub%2013_10%20Southern%20Cities%20Heatwaves%20-%20Complete%20Findings.pdf

[44] Coffel et al (2014) Climate Change and the Impact of Extreme Temperatures on Aviation, https://journals.ametsoc.org/doi/10.1175/WCAS-D-14-00026.1

[45] Cheer (January 2018) *Traffic delays after 10 kilometers of Victoria's Hume Freeway melts,* https://www.sbs.com.au/news/traffic-delays-after-10-kilometres-of-victoria-s-hume-freeway-melts

[46] Lauder (2009) *Melbourne railway buckles under heat,* http://www.abc.net.au/worldtoday/content/2008/s2477350.htm

Conclusion

An increase in days of temperature over 35 degrees will have severe impacts on human health, including increased rates of heat-related deaths.

The Whitsunday region is already experiencing an increase in extreme heat events, affecting every aspect of people's lives and wellbeing including work, recreation and the local economy. These impacts will increase dramatically if emissions continue to increase.

Fortunately, none of this this inevitable. The CSIRO projections clearly show that if emissions are reduced in line with the Paris target of limiting global temperature increases to below 1.5 degrees, the increase in extreme temperature days will be a small fraction of the increase projected for our current emissions trajectory.

Australia makes a vastly disproportionate contribution to global warming. We are one of the lowest ranked countries in the world on climate action. As well as having one of the highest rates of domestic greenhouse gas emissions per person in the world, we have a staggering 44 tonnes per person of exported greenhouse gas emissions each, even greater then Saudi Arabia (35.5 tonnes per person) and around sixty times higher than the US.[47] Even worse, there are plans for huge expansions in gas exports from the Northern Territory and Western Australia that could add a billion tonnes more of greenhouse gases to the atmosphere.[48]

Stopping any further expansion of Australia's coal and gas exports, reducing coal and gas exports and emissions produced at home are all essential to the global effort required to prevent increases in extreme heat that will have such a devastating effect on the Whitsundays region and Australia as a whole.

[47] Thwaites and Kestin (July 2018) *Australia ranked worst in world on climate action,* https://reneweconomy.com.au/australia-ranked-worst-world-climate-action-49472/

[48] Climate Analytics (2018) *Western Australia's gas gamble, Implications of exploiting Canning Basin and other unconventional gas resources for achieving climate targets,* https://climateanalytics.org/media/climateanalytics-report-westernaustraliasgasgamble-2018.pdf