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Heatwatch

Extreme heat in Gladstone

The annual average number of days over 35 degrees Celsius in Gladstone has more than doubled since the mid-20th century. CSIRO and the Bureau of Meteorology project further increases, with the number of extreme heat days to triple by 2070 – and these projections appear optimistic. Extreme heat will have profound effects on human health, industries and ecosystems.

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Summary

At temperatures above 35 degrees Celsius the human body's ability to cool itself reduces, making it a common benchmark temperature for occupational health and safety experts, academic and government researchers. Combined with 70% humidity, conditions over 35 degrees are considered 'extremely dangerous' by government agencies such as the US Government National Oceanic and Atmospheric Administration.

The annual number of days over 35 degrees in Gladstone has more than doubled from an average of 2.6 days per year in the mid-20th century to over 6.5 days per year in the last two decades. Combined with the humidity of Gladstone's summer, more days are reaching dangerous heat levels.

CSIRO and Bureau of Meteorology (BoM) project further increases in the number of extreme heat days in Gladstone. Without decisive climate action, CSIRO and BoM project 19 days over 35 degrees per annum in Gladstone by 2070. The projection sees extreme heat days triple from the average of the last two decades.

Alarmingly, the increase experienced in Gladstone so far has already suppassed the projections for extreme heat days for mid-century. CSIRO and BoM project 6 days over 35 degrees each year by 2050. In light of this the 2070 projections appear optimistic: extreme heat could be even worse.

The impacts of more extreme heat are already being seen globally, with Europe, Russia, India and Pakistan all experiencing heat waves resulting in thousands of deaths.[1,2]

The implications of such temperature increases in Gladstone, and the rest of Australia, include increased health impacts and heat-related deaths, reduced productivity in important industries such as agriculture, construction and tourism. Ecosystems would be severely damaged and the standard of living of those at risk in Gladstone would be

[1] Wang, Horten (2015) *Tackling climate change: the greatest opportunity for health The Lancet Climate Change and Human Health Commission*, The Lancet, https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(15)60854-6/fulltext

[2] Hass, et al. (2016) *Heat and Humidity in the City: Neighbourhood Heat Index Variability in a Mid-Sized City in the Southeastern United States,* International Journal of Environmental Research and Public Health.

greatly reduced. These impacts need to be considered and form part of the case for local and national climate action.

Introduction

As the climate warms, the number of extremely hot days is likely to increase. While Gladstone's summer weather is consistently warm, the number of extremely hot days – days over 35 degrees Celsius – has generally been low. The average number of over 35 degree days has, however, more than doubled in recent years and is forecast to increase without a strong policy response to climate change.

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 degrees. This creates discomfort and a range of health impacts, from mild to severe, and can ultimately be fatal without intervention.[3]

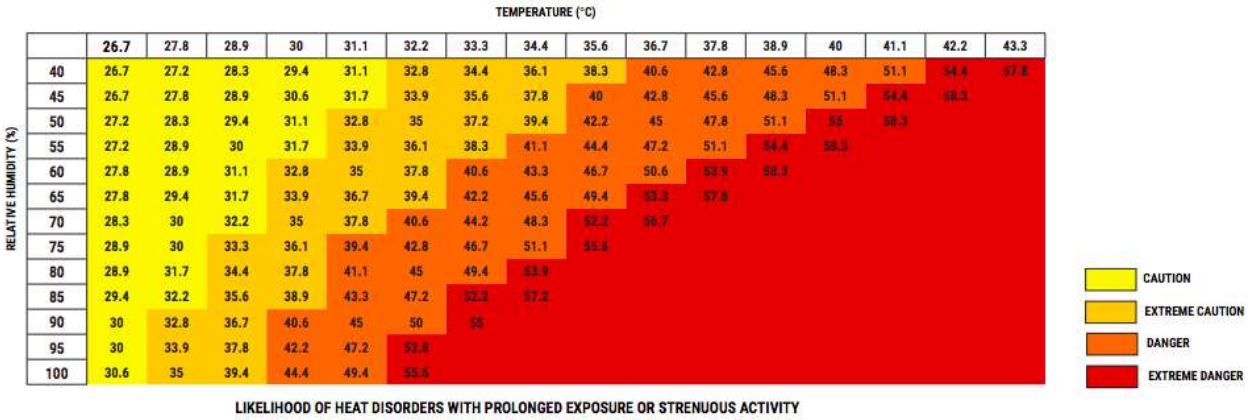
Because of this, many regulators and researchers use 35 degrees as an important threshold for safety, work and climatic conditions. 35 degrees is seen as the "limit of high temperature tolerance" by the Occupational Health and Safety Representatives of the Victorian Trades Hall Council, and academic researchers maintain this temperature leads to substantial productivity loss. The CSIRO and Bureau of Meteorology (BoM) publish 35 degree threshold predictions in their climate modelling.[4]

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.

[3] 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

[4] 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/

Figure 1. 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 Celsius with 70% humidity. Gladstone's humidity levels already regularly exceed 70%. From August 2017 to August 2018, there were 50 days with a relative humidity of 70% or above at 3pm in Gladstone.[5]

A future that combines such high humidity levels with an increase in the frequency of days over 35 degrees represents a serious threat to the wellbeing of Gladstone's and Australia's wider community. Irritability and psychological stress increases with heat.[6] There is even growing evidence that hot and humid weather affects patterns in domestic violence,[7] interrupts sleep patterns and reduces capacity and willingness to exercise. Both carry broad ramifications, such as increased accident risk and sedentary life style induced diabetes and cardio vascular disease.[8,9] Tracking and minimising the way climate change is affecting the number of hot days is of direct interest to the wellbeing of local communities and the broader Australian public.

[5] BoM (2018) *Daily Weather Observations*, http://www.bom.gov.au/climate/dwo/201802/html/IDCJDW4048.201802.shtml

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

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

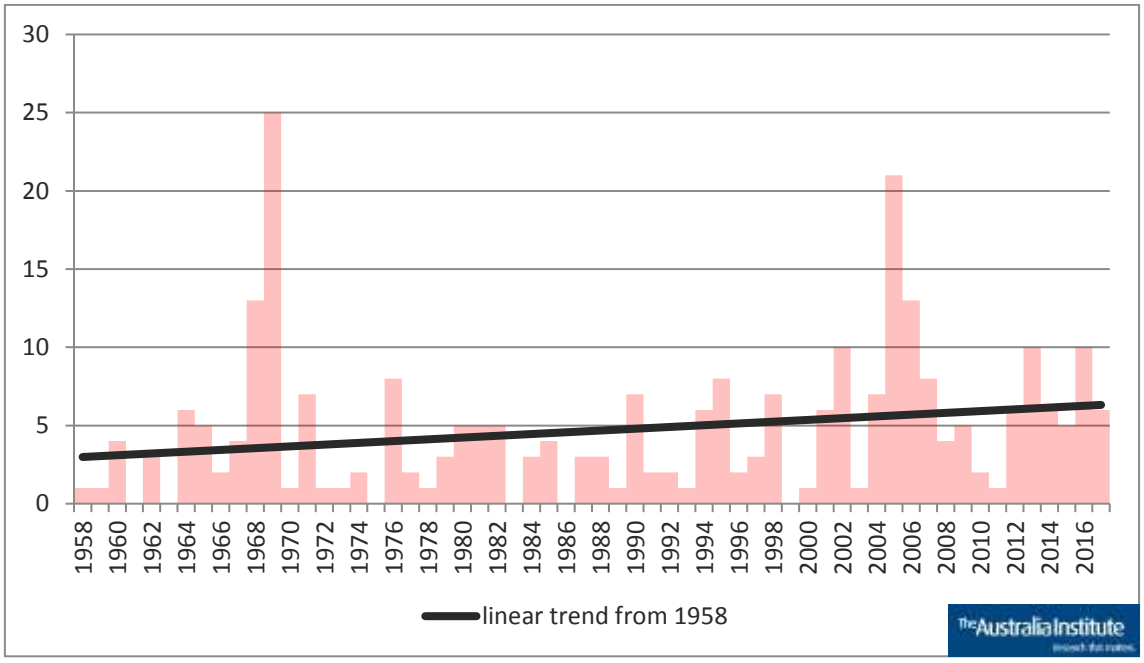
[8] Kjellstrom T et al (2009) *The Direct Impact of Climate Change on Regional Labor Productivity.* Archives of Environmental & Occupational Health 64 (4).

[9] 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

Hot days in Gladstone

The BoM has recorded temperatures in Gladstone since 1958. The number of days over 35 degrees Celsius in each year is shown in Figure 2 below:

Figure 2: Annual number of days over 35 degrees Gladstone, 1958-2017



Source: Bureau of Meteorology http://www.bom.gov.au/climate/data/index.shtml

Figure 2 shows that the trend of over 35 degree days in Gladstone has increased from a base of 2.6 between 1958-1967. The trend in the recorded data is skewed by an extremely hot year in 1969. That year saw a record 25 days over 35 degrees and a historically severe drought in Queensland which was harshest on the central coast where Gladstone is located.[10] Despite this there is a clear trend in increasing numbers of extreme heat days over the recorded period. The trend, summarised in Table 1 below, shows the number of hot days more than doubled between 1998 and 2017.

[10] Queensland Office of Economic and Statistical Research (2009) *Queensland Past and Present: 100 Years of Statistics, 1896–1996*, http://www.qgso.qld.gov.au/products/reports/qld-past-present/qld-past-present-1896-1996-ch02-sec-02.pdf

Table 1: Average number of days per year above 35 degrees Gladstone

Year	Average days over 35 degrees
1958-1967	2.6
1958-1977	4.3
1978-1997	3.2
1998-2017	6.5
2013-2017	7.4

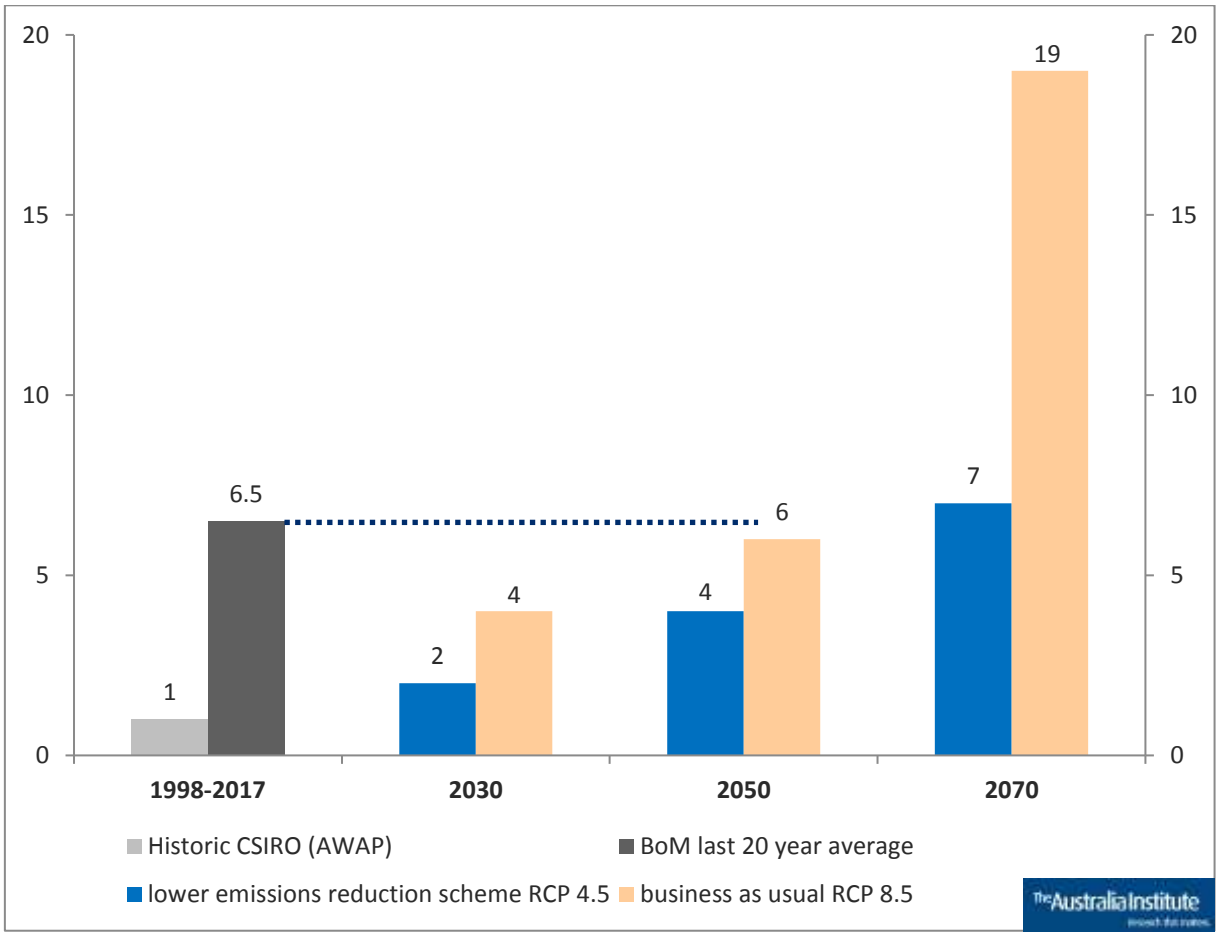
Source: Bureau of Meteorology http://www.bom.gov.au/climate/data/index.shtml

As shown in Table 1 above in last 5 years the number of days over 35 degrees have reached 7.4 days per annum. This represents a near threefold increase since the middle of the 20th century. More worrying still, the following decades are likely to exacerbate these challenges.

Projected increases in days over 35

The number of days over 35 degrees in Gladstone is expected to increase in the coming decades, according to climate modelling presented by CSIRO and BoM. Under a business-as-usual (BAU) scenario on greenhouse emissions, CSIRO-BoM estimates Gladstone could experience four days over 35 degrees per year in 2030, six days per year by 2050 and 19 days per year in 2070. Figure 3 below lays out the CSIRO-BoM predictions out to 2070 under this business-as-usual scenario and another scenario that includes greater action on climate change:

Figure 3: Forecast annual number of days over 35 degrees Gladstone



Source: CSIRO and Bureau of Meteorology (2015) Climate projections: Climate threshold calculator, https://www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/threshold-calculator/

The projections in Figure 3 above are based on the United Nations Intergovernmental Panel on Climate Change (IPCC) Representative Concentration Pathways (RCPs), which

are scenarios of various levels of concentrations of greenhouse gases in the atmosphere. Figure 3 features the scenario RCP 8.5, which is the highest of the four scenarios of global emissions outlined by the IPCC in their 2014 Fifth Assessment. It reflects the BAU scenario, as it most closely resembles the current global trajectory of increasing emissions.[11]

Figure 3 also shows the projected number of days over 35 degrees under the RCP 4.5 scenario where strong emission reduction is achieved. The RCP 4.5 pathway requires drastic reduction in emissions. If this is achieved, the CSIRO expects the number of days over 35 degrees per year for Gladstone to be significantly lower than in the BAU trajectory, with 2 days over 35 degrees per year in 2030, 4 days per year in 2040 and 7 days per year in 2070. While these figures carry significant risks, substantial additional harm could be avoided.

An obvious problem arises when the projections in Figure 3 are compared to the historic data in Figure 2 - projections have already been exceeded. The historic data used by the CSIRO is a time-series from the Australian Water Availability Project (AWAP) where the average temperature was compiled in 5x5km spatial grids between 1981-2010.[12] This model, and the projections built off it, observed only one day a year over 35 degrees in this period. This compares to the 6.5 days per year average as observed at the Gladstone Radar over the last twenty years.

Whatever the reason for the discrepancy between the two historical averages, Figure 3 shows that the CSIRO projection of six days a year over 35 degrees by 2050 has already been surpassed according to the Bureau of Meteorology.

This raises the further potential that the projection of 19 days a year over 35 degrees by 2070 is low. It appears that CSIRO and BoM's most pessimistic projections have already proven to be too optimistic.

[11] Le Quere et al (2017) *Global carbon budget 2017*. Earth Syst Sci Data 8. https://www.earth-syst-sci-data.net/10/405/2018/essd-10-405-2018-discussion.html

[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, Australia. https://www.climatechangeinaustralia.gov.au/en/publications-library/technical-report/

Conclusion

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

Given the vulnerability of Gladstone and the rest of the Queensland to climate change, strong emissions reduction policies are in the state's interests.

Fortunately, Queensland is in a strong position to reduce, implement, and benefit from strong climate and energy emissions reduction policies. The Queensland Government's renewable energy target will drive renewable energy development to reduce emissions, create jobs and bring other economic benefits.

Locally, Gladstone Power Station is nearing the end of its operating life and is due for replacement. If the region develops renewable energy projects to replace the coal-fired power station in a timely manner, the city and region stand to gain.

Increasing gas and coal exports are incompatible with Australia's carbon budget and commitments under the Paris agreement to limit warming to less than 2 degrees. It has been calculated that two thirds of existing fossil fuel reserves need to remain in the ground in order to have even a 50% chance to avoid 2 degrees of warming.[13] In line with this, further expansions of Gladstone's coal and gas export infrastructure should be ruled out.

Strong action on climate change by reducing Australia's emissions, fossil fuel exports and supporting global action are in Gladstone's and Australia's best interests.

[13] McGlade and Ekins (2015) *The geographical distribution of fossil fuels unused when limiting global warming to 2 °C*, https://www.nature.com/articles/nature14016