

Are heatwaves in Australia becoming more frequent, hotter or lasting longer?

By: Geoffrey H Sherrington
Scientist

The hypothesis tested.

We test this hypothesis:

Heatwaves in Australia are becoming more [frequent, hotter and are lasting longer](#) because of climate change.

(The claim was made in a Climate Council report of Jan 2014. From other publications, it seems to be perceived wisdom among authorities from the Australian Bureau of Meteorology and CSIRO, who help to guide national policy.)

Here, we examine the daily maximum temperatures of 5 State capitals, Perth, Adelaide, Melbourne, Sydney and Hobart. These were chosen because many people live close to these weather stations and because their observations cover many decades. Brisbane has too much missing temperature data and Darwin is already hot.

We use simple algebra and 5 sites only because of limited resources. However, more complicated analysis must still explain the findings of simple tests.

There is no settled [definition of 'heatwave'](#) yet. Australia's Bureau of Meteorology, BOM, is currently creating [more complex definitions](#), commonly in terms of 3 day heatwaves.

Here, for ease of calculation, a heatwave is simply defined as a string of consecutive days whose average of the maximum temperatures is anomalously high. We look at past heatwaves of 4, 5, 6 and 10 consecutive days. We select the Top 20 hottest heatwave years and then rank them in various ways.

There are two relevant data sets, both from the Australian Bureau of Meteorology (BOM) whose compilation of the historical record is acknowledged. The first set is the longer one, called CDO for [Climate Data Online](#). This is essentially raw data as recorded. The second set is the [BOM ACORN-SAT](#), or Acorn for short, which is an adjusted, homogenised set that usually commences in 1910. As time goes by, more announcements are made in Acorn terms, when sometimes it is more appropriate to use raw data, so we test both.

Thus, we [present a bundle of graphs](#), being 5 cities x 2 data sets X 3 heatwave day lengths for a total of 30 graphs. Averaged maximum daily temperatures in degrees C always form the Y axis, years always form the X axis.

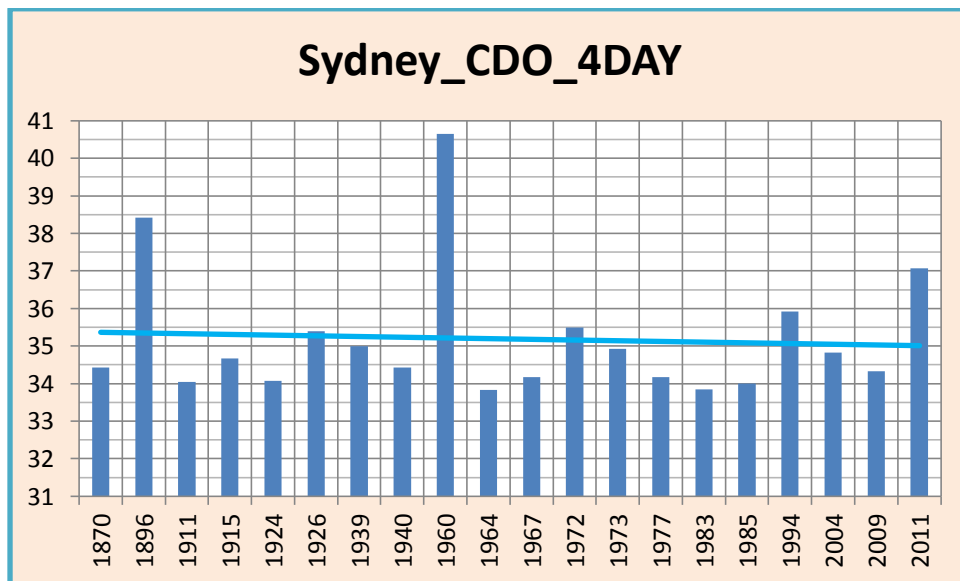
The primary finding:

The hypothesis is falsified for the cities tested.

That is, it is wrong to claim that in these important cities at least, there has been such a change of the characteristics of heatwaves as defined.

Findings in more detail.

Here is one example of the 30 graphs used in the first stage of the analysis. The temperature data are from the BOM CDO for the Sydney Observatory station 66062.



To create this graph, the daily maximum temperature, after some minor infilling of missing data, was searched for every value of the hottest 4 consecutive days. Each 4 day average was ranked from hottest to coldest, then a Top 20 hottest selection was made, with any year appearing only once. (Rarely, some years have 2 Top 20 events, but we used only the hotter).

For most of the graphs, the years are shown in chronologic order of oldest to most recent. The linear regression line has no great mathematical meaning; it is inserted to help the eye to see if there is a discernible trend over the years. The line is coloured blue for a cooling trend, yellow for essentially zero trend and red for a warming trend.

To avoid having to count from the 30 graphs, here is a summary table of trends:

		Trend			
		4 day	5 day	6 day	
Perth	CDO	COOL	COOL	COOL	
	ACORN	cool	cool	cool	
Adelaide	CDO	ZERO	ZERO	WARM	3 cases out of 30 show warm
	ACORN	zero	cool	cool	10 cases out of 30 show zero
Melbourne	CDO	COOL	COOL	ZERO	17 cases out of 30 show cool
	ACORN	zero	zero	zero	
Sydney	CDO	COOL	WARM	ZERO	
	ACORN	zero	warm	warm	
Hobart	CDO	COOL	COOL	COOL	
	ACORN	cool	zero	cool	

Test One: Are heatwaves becoming more frequent?

We answer this by counting the number of heatwaves in the first half and second half of the years of each chronological Top 20 data set. The longer, CDO data set is used. Here is a table to summarise the findings.

			NUMBER OF HEATWAVES, CDO DATA SET		
			4 day	5 day	6 day
Perth	1897-1955	EARLY	4	1	1
	1956-2013	LATER	16	19	19
Adelaide	1887-1950	EARLY	13	14	15
	1951-2013	LATER	7	6	5
Melbourne	1856-1935	EARLY	8	10	10
	1936-2013	LATER	12	10	10
Sydney	1859-1936	EARLY	6	8	8
	1937-2013	LATER	14	12	12
Hobart	1882-1956	EARLY	11	10	10
	1957-2013	LATER	9	10	10

Findings: There is a mixture of results depending on site location. Perth has more heatwaves since 1956, than before then. Adelaide has the opposite, with many more heatwaves before 1950, than after 1950.

There is not a strong pattern for Melbourne, Sydney, or Hobart.

The hypothesis that heatwaves are becoming more frequent is then supported by one city only of the 5 tested, Perth. Note that the results for Perth and indeed all stations, can vary if a different selection of local weather stations is chosen.

Test Two: Are heatwaves becoming hotter?

This is answered by [trends of the heat wave Top 20 in chronological order](#).

Each chronological list was divided into the earliest 10 of the Top 20 years and the later 10 years. The average temperature of each early set of 10 was compared with the average of each later set of 10. This later number, for each of the 5 sites, was subtracted from the earlier number to show a temperature rise or fall over the history. A positive number is taken to mean that there is cooling over the years.

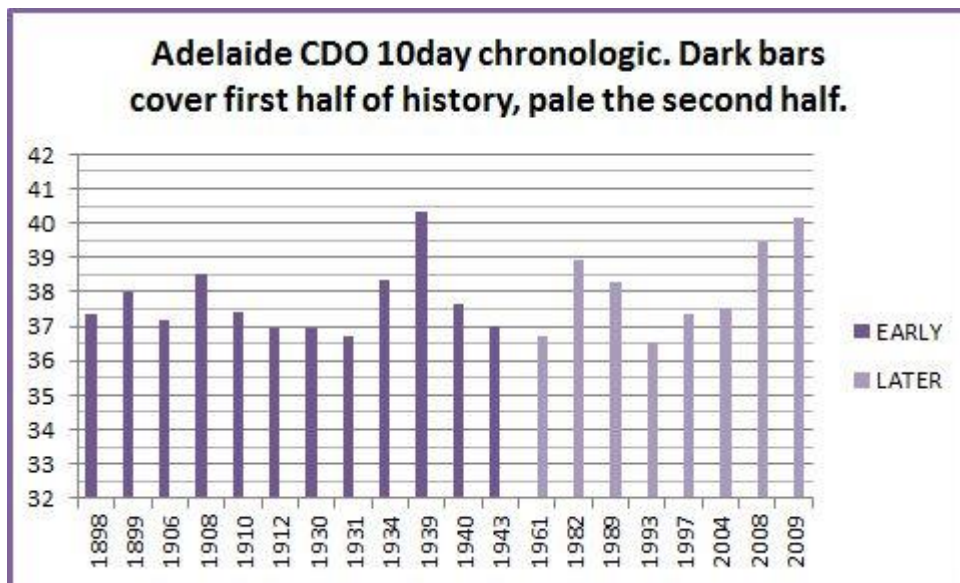
The outcome is shown in this table. In all but one case out of 15, (Sydney, Acorn, 5 day) these data show heatwaves are getting cooler with the passing of time.

Heating of Top 20
from early to late

SITE	4 DAY	5 DAY	6 DAY
PERTH Acorn	0.27	0.60	0.87
ADELAIDE Acorn	0.12	0.34	0.53
MELBOURNE Acorn	0.34	0.02	0.46
SYDNEY Acorn	0.66	-0.46	0.01
HOBART Acorn	0.40	0.25	0.47

Test Three: Are heatwaves becoming longer?

We introduce [10 day heatwave calculations through graphs](#) such as this one for Adelaide.



In this example, it can be seen that the long, 10 day heatwaves are no more prevalent in the second half of the history than the first half, 1887 to 1950. It is concluded for this case that heat waves are not becoming longer. The following table summarises all 15 CDO cases calculated.

SITE	NUMBER OF TOP 20 CASES	
	EARLY HALF	LATER HALF
Perth	1	19
Adelaide	12	8
Melbourne	6	14
Sydney	7	13
Hobart	20	0

The result is a mixed bag. This method of analysis suggests that later heatwaves have been dominantly longer in Perth, because only 1 case appears before the half-way point. Conversely, early heatwaves are dominant in Hobart, with not a strong signal in Adelaide, Melbourne or Sydney.

The hypothesis that heatwaves are becoming longer is not supported by this analysis of these 5 important cities.

CONCLUSIONS.

It is easy to raise objections to the methodology of this analysis.

It is not easy to explain why perceived wisdom supports the opening hypothesis of longer, hotter and more frequent heatwaves, when this simple exercise falsifies it in the first instance.

SUPPLEMENTARY DATA.

Excel spread sheets are available on request.