

# Another look at Australia's record high temperature

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**The temperature of 53.1°C recorded at Cloncurry on 16 January 1889 has long been recognised as the highest temperature on record in Australia. Comparison of the temperatures at Cloncurry during the summer of 1888-89 with other sites in the region, and inspection of documentary evidence, suggest that this temperature was recorded under instrument and screen conditions not comparable with current standards, and that the thermometers were probably over-exposed to direct sunlight or radiant energy emitted from the structure on which the thermometers were mounted. This provides grounds for the observation's standing as a record to be re-assessed. The most likely alternative candidate for the Australian high-temperature record is an observation of 50.7°C at Oodnadatta in 1960.**

## Introduction

The temperature of 53.1°C recorded at Cloncurry on 16 January 1889 has been generally acknowledged as the highest temperature on record in Australia. In more recent times Australia's hottest days have been recorded in other regions of the continent, giving rise to suspicions about the authenticity of the Cloncurry record. This temperature has not been approached since 1910, which is regarded as the earliest date for which one can have confidence in the full Australian climatological record, because of instrument changes, and the earliest date at which reasonable spatial coverage is available in Australia (Torok and Nicholls 1996; Torok 1996). In the post-1910 period, there have been only two observations of 50°C or greater, the highest being 50.7°C at Oodnadatta on 2 January 1960. If this reduction in the frequency, and change in the location, of extreme high temperatures is real, it represents a potentially significant change in the Australian climate over the last century, particularly in the light of substantial evidence that mean temperatures have warmed since 1910 (Torok and Nicholls 1996).

Reasonably comprehensive national records of daily maximum and minimum temperature are available in digital form since 1957. Figure 1 indicates the sites where temperatures in excess of 48°C have been recorded since then. These are concentrated in two regions, the

**Fig.1 Sites at which temperatures greater than 48°C have been recorded since 1957.**



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central west of Western Australia and a belt extending northeast to southwest from the far southwest of Queensland and northwestern New South Wales to the Nullarbor region of Western Australia and South Australia. The nearest station to Cloncurry to have reached 48°C since the availability of digital daily records is Birdsville, approximately 600 kilometres to the south.

There have been some past investigations of the Cloncurry observation (e.g. Longton 1975). These, however, were confined to checking that the reading was correctly transcribed from the original manuscript, and did not consider the possibility that the observation may not have been a true indication of the temperature on that day. Longton (1975) found no evidence that the observation was incorrect.

## Historical background of Cloncurry and comparison stations

A meteorological station was opened at Cloncurry in January 1888. Many Queensland stations were being opened at the time. The Queensland Meteorological Bureau was established in January 1887 as a branch of the Post and Telegraph Department, and by mid-1888 more than 100 stations were operating (Donaldson 1888). These stations were divided at the time into three categories, these being first, second and third-order stations. Amongst the equipment noted as being supplied to first and second-order stations was a 'Stevenson's double-louvred thermometer screen', while the notes for third-order stations simply specified 'a thermometer screen'. This distinction may or may not have been intentional. The report has been interpreted as meaning that all stations in Queensland were using Stevenson screens by 1888 (e.g. Parker 1994), but the distinction in wording suggests that any implication that Stevenson screens were in use at third-order stations is open to doubt. Cloncurry was a third-order station in 1888, as were the other two stations whose data are used in this paper, Boulia and Winton. By 1892, it had been upgraded to a second-order station (Wragge 1892). The locations of these stations are given in Fig. 2.

The catalogue 'Climatological Stations: Queensland and Tasmania' (unpublished journal: lodged in the National Meteorological Library at the Bureau of Meteorology) notes that a Stevenson screen was installed at Cloncurry on 6 February 1889. It is possible that this could have been a replacement for an existing Stevenson screen but, as the station had only been in existence for 13 months at the time, this seems unlikely. The more probable scenario is that some other kind of stand was in place at Cloncurry from the opening of the station until 6 February 1889. The note for 6 February,

Fig. 2 Location of stations used in this study.



1889 also indicates against the supply of a Stevenson screen: 'old screen presumably useless' and further that the maximum and minimum thermometers were 'defective'. It is not clear for how long prior to 6 February 1889 the instruments or screen (of whatever type it was) had been defective.

A Stevenson screen was installed at Boulia on 13 March 1896, although, as at Cloncurry, it is not definitely known what type of screen was in use prior to this date. No monthly mean temperature records for Winton appear in the Bureau of Meteorology's archives prior to 1938, but entries in 'Climatological Stations: Queensland and Tasmania' suggest that the station had been open since 1888. A Stevenson screen was supplied there on 4 December 1891. It was a third-order station, which again opens the possibility that the screen in use there in 1888/89 may not have been a Stevenson screen.

Parallel records of monthly mean maximum temperature were obtained from the Bureau of Meteorology's digital archives for the Cloncurry and Boulia sites for the period from January 1888 to the closure of the Cloncurry site in 1975. The Cloncurry site moved from the Post Office to the airport in 1950, but Torok (personal communication) did not find any evidence of a discontinuity in mean maximum temperature arising from this move; nevertheless, post-1950 records have not been used in the comparison of monthly mean temperatures between the two sites. Records of monthly mean maximum temperature for Winton are only available in the Bureau's digital archives from 1938, and are not used in this study. Digital records of daily maximum (and minimum) temperature are only available from 1939 at Cloncurry and 1957 at Winton and Boulia, but copies of original manuscripts were obtained for Cloncurry and Winton covering the period between November 1888 and January 1889.

## Comparison of monthly mean temperatures between Cloncurry and Boulia

Figure 3 shows the difference in anomalies of mean monthly maximum temperature (measured relative to the means from the period of digital daily records) between the two sites over the 1888-89 period. This shows that Cloncurry's mean monthly maxima were anomalously high from November onwards, reaching a peak in December and January. The mean for December 1888 at Cloncurry is cited as 41.1°C in the Bureau of Meteorology records, but the mean of the daily maxima for the month was 44.7°C. This suggests that the mean was identified as suspect and adjusted at some stage, possibly at the time of initial processing. This was not an

Fig. 3 Difference in monthly mean maximum temperature anomalies (Cloncurry - Boulia), 1888-1889.

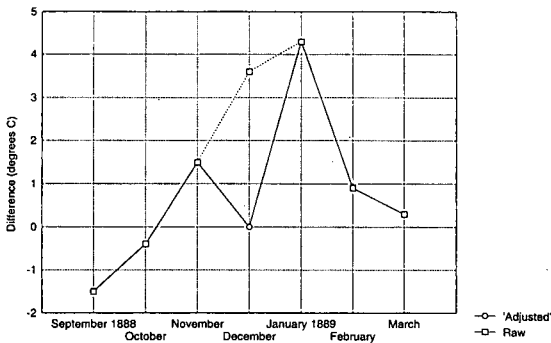
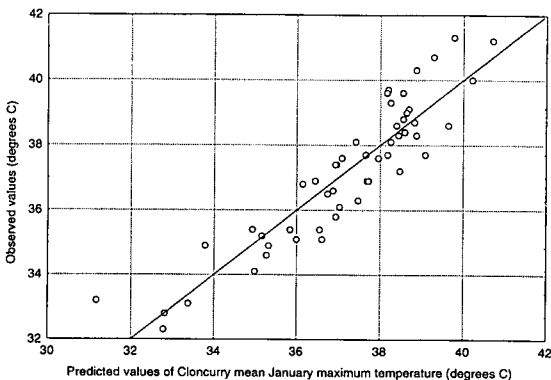


Fig. 4 Cloncurry mean January maximum temperature predicted by multiple regression, using data between 1890 and 1950.



uncommon practice at the time (Torok, personal communication). Despite showing an even larger anomaly relative to Boulia, the January 1889 mean was not adjusted, perhaps because the absolute temperature was lower (42.9°C) and therefore did not arouse suspicion. Furthermore, numerous media reports of heatwaves in the 1920s and 1930s refer to the Australian record high temperature as being 125°F (51.7°C) at Bourke, suggesting that, at the time, the Cloncurry observation may not have been recognised.

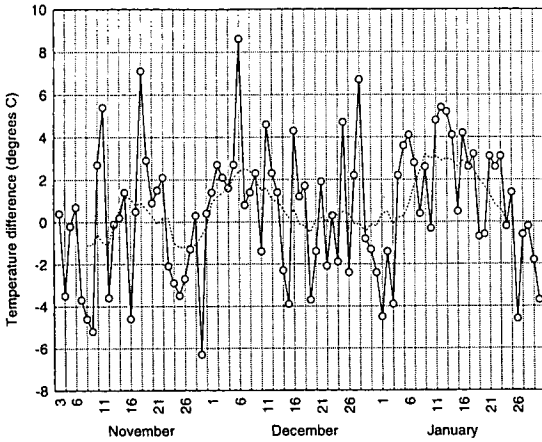
A multiple regression was carried out, using data from the period between 1890 and 1950, to estimate the mean January maximum temperature at Cloncurry using mean January maximum temperature at Boulia (correlation with mean January maximum temperature at Cloncurry,  $r=0.80$ ) and total January monthly rainfall at Boulia ( $r=-0.62$ ) and Cloncurry ( $r=-0.70$ ) as the independent variables. Figure 4 shows this regression, which explained 84 per cent of the variance in the Cloncurry mean maxima. This procedure predicted a January 1889 mean maximum temperature at Cloncurry of 38.4°C, which was 4.5°C, or 3.82 standard deviations, lower than that actually recorded. The residuals for the 1890-1950 period are approximately normally distributed; in a normal distribution, such a value could be expected once in approximately 13,000 observations.

## Daily temperatures at Cloncurry and Winton

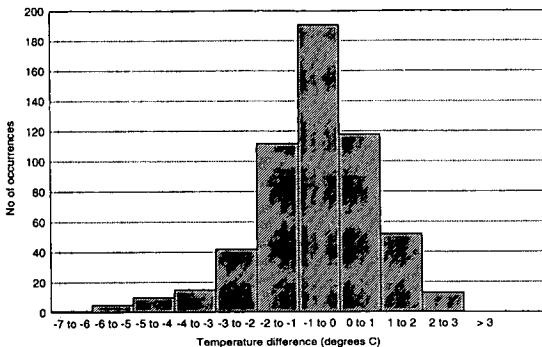
Daily maximum and minimum temperatures were not readily available from Boulia for the period of interest, but they were available from copies of original manuscript records for Cloncurry and Winton for the period from November 1888 to January 1889. Figure 5 shows the difference between the maximum temperatures at these sites over this period. Over most of the three-month period, the 11-day running mean of the temperature difference is near zero, but it exceeds 2°C in early December and mid-January.

Figure 6 shows the frequency distribution of the difference between the daily maximum temperatures of Winton and Cloncurry during the period for which daily records are available for both stations in the Bureau of Meteorology's digital database (1957-1975), on days when the temperature at Winton exceeded 40°C. The mean annual number of such days is 29. The greatest positive difference observed on such a day in this 19-year period was 2.8°C. The 1888-89 summer contained 17 days with temperature differences greater than this, reaching a peak of 8.6°C on 6 December 1888. On 16 January 1889, the maximum temperature at Winton was 49.0°C, 4.1°C lower than that at Cloncurry.

**Fig. 5** Difference in daily maximum temperature (Cloncurry - Winton), November 1888 - January 1889. The dashed line is the 11-day running mean of the difference.



**Fig. 6** Frequency distribution of difference in daily maximum temperature (Cloncurry - Winton) on days when maximum temperature at Winton exceeds 40°C, 1957-1975.



### Possible explanations for the anomalously high temperatures at Cloncurry in the summer of 1888-89

The evidence presented above suggests that the maximum temperatures at Cloncurry were anomalously high during the summer of 1888-89, and in particular in early December 1888 and mid-January, 1889.

The most likely cause of such a discrepancy is that the Cloncurry thermometer was exposed to excessive solar radiation during this period. As noted previously, it is likely that a non-Stevenson shelter was in use at Cloncurry at the time. If a Stevenson screen had been in use at Boulia, it would be expected that anomalously high maximum temperatures would have been recorded

at Cloncurry (relative to Boulia) throughout 1888, but there is no evidence of any such anomalies prior to November. This, together with the documentary evidence of Stevenson screens being installed at all three stations at later dates, suggests that non-Stevenson screens were in use at both Cloncurry and Boulia, and probably at Winton as well.

In particular, the Glaisher stand was in common use in many parts of Australia until about 1910, particularly in South Australia and the Northern Territory (Nicholls et al. 1996; Torok 1996), although other stands and instrument exposures apart from the Glaisher stand were in widespread use in Queensland during the 1880s (Nicholls et al. 1996). The Glaisher stand consisted of a vertical board, shaded from above, on which the thermometers were mounted. It could be rotated to keep the instruments shielded from the direct rays of the sun.

Stevenson screens progressively replaced other types of shelters through the period prior to 1910. This process took place earlier in Queensland than in most other States (or colonies as they were then), as the then Government Meteorologist, Clement Wragge, was a keen proponent of the Stevenson screen (Parker 1994).

Thermometers in a Glaisher stand were shielded from the direct rays of the sun, but were still open to radiation from the ground, part of the sky and surrounding objects, and hence higher mean maximum and lower mean minimum temperatures were recorded on them than on those in a Stevenson screen, even when the stand was operated correctly (Laing 1977; Parker 1994). The difference in mean temperatures over 61 years of parallel observations at Adelaide was approximately 0.2°C throughout the year for minima, and ranged from 0.2°C in winter to 1.0°C in summer for maxima (Nicholls et al. 1996). Furthermore, if the stand was not rotated as required, the instruments could be exposed to direct sunlight. In temperate latitudes this was most commonly a problem in the morning and evening, but in the tropics the seasonal reversal of the direction of direct sunlight also had to be taken into account. There have been no similar comparisons done over such periods between the Stevenson screen and other types of shelters used in Australia, but it is reasonable to believe that any change of instrument shelter may involve a bias in recorded temperatures.

The sun is south of overhead at Cloncurry (latitude 20°43' S) at local noon for the approximate period 28 November to 18 January, and at Winton (latitude 22°24' S) for the period 6 December to 8 January. This makes the period from 8 to 18 January, during which the record occurred, of particular interest, as the sun is south of overhead at Cloncurry during this period, but not at Winton. If both stations were incorrectly exposed to the south, it would be expected that they would observe anomalously high temperatures for the periods when the

sun was south of overhead, with the possible exception of a few days at either end of the period when the sun was approximately directly overhead at local noon. Hence, Cloncurry would be expected to be too warm from late November or early December to mid-January, and Winton from mid-December to early January. It follows from this that the greatest temperature difference between the sites would be expected in the period when the sun is south of Cloncurry but north of Winton, in early December and mid-January, and that little difference between the two would be expected when both are too hot, around the time of the summer solstice. This is entirely consistent with the results observed in Fig. 5. If Winton was also incorrectly exposed to the south, as the minimal temperature differences in late December suggest, it also brings into question the Winton observation of 50.6°C on 14 December 1888.

There are a number of possible explanations for the thermometers being incorrectly exposed to the south. As previously noted, the effectiveness of the Glaisher stand was dependent on the conscientiousness of the observer in turning it to keep the thermometers out of the sun's direct rays. Observers needed to be particularly diligent at tropical sites, where the sun is south of overhead (in the southern hemisphere) for a period during summer and the stand would therefore have to be turned in the opposite direction to that in which it was turned for the rest of the year. If Glaisher stands were in use at the two sites, it is possible that the stand was not turned at either site to take the reversed direction of direct sunlight into account and that the thermometers were subject to direct solar radiation in mid-summer, or to excessive radiant energy from the shelter structure. This would also be the case if the thermometers were mounted on a south-facing wall, a practice which Nicholls et al. (1996) suggest was not unknown in Queensland at the time. It is even possible that problems could arise in a Stevenson screen if the door is facing south (as is the usual practice in Australia) and the door is left open for long enough while observations are made for direct solar radiation to affect the instruments. This has been noted as a problem in recent times (Bate, personal communication), but there is no evidence of it causing discrepancies of the magnitude of those observed between Cloncurry and Winton in 1888/89.

## Implications for the Australian record high temperature

All known daily maximum temperatures in excess of 50°C in Australia are listed in Table 1. Of these, the 1877 Bourke and the Mildura and Eucla observations are known to have been taken using non-standard instrumentation (Crowder 1995), and the Cloncurry and

**Table 1. Daily maximum temperatures of 50°C or greater in Australia**

<i>Temperature (°C)</i>	<i>Station</i>	<i>Month</i>
53.1	Cloncurry	January 1889
52.8*	Bourke	January 1877
51.9	Cloncurry	December 1888
51.7	Bourke	January 1909
50.8*	Mildura	January 1906
50.7*	Eucla	January 1906
50.7	Oodnadatta	January 1960
50.6**	Winton	December 1888
50.0	Wilcannia	January 1939

\* Observations previously known to have been taken with non-standard instrumentation.

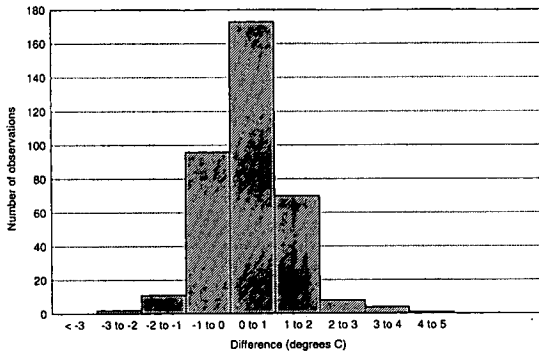
\*\* The Winton observation has been cited as being higher in other sources, but these failed to take an index correction into account.

Winton observations are discussed earlier in this paper. The Oodnadatta and Wilcannia observations are known to have been taken in Stevenson screens. The Oodnadatta observation is consistent with other observations throughout the region. Four other stations exceeded 48°C on this day; Finke (48.3°C, a Northern Territory record), Port Augusta (48.3°C), Whyalla (49.4°C) and Marree (49.4°C). Its authenticity is not in serious doubt. The Wilcannia observation is also consistent with other observations in the region (such as 49.7°C at Menindee and 47.8°C at Cobar), and took place during a period of exceptionally high temperatures in southeastern Australia, which saw records set at many centres, including Adelaide, Melbourne and Sydney.

This leaves the Bourke observation of 3 January 1909 remaining for consideration. The catalogue 'Climatological Stations: New South Wales' (unpublished journal: lodged in the National Meteorological Library at the Bureau of Meteorology) indicates that a Stevenson screen was installed at Bourke in August 1908. However, no other station in New South Wales or southern Queensland is known to have exceeded 47.2°C on this day.

The original manuscript record for Bourke shows temperatures of 125°F (51.7°C) observed on both 2 and 3 January. The observation on 2 January has been corrected on the manuscript to 112°F (44.4°C), which is consistent with the temperatures over the region, and with the 1500 LST temperature of 110°F (43.3°C). The 3 January observation was not corrected. However, 3 January was a Sunday, and no other observations were made on this day (as was the usual practice at Bourke, and many other stations, at the time). It is therefore likely that the observation is actually the maximum temperature for the 48 hours to 0900, 4 January, and therefore it would be affected by the same error which was corrected in the case of the 2 January observation. Reports

**Fig. 7** Frequency distribution of difference in daily maximum temperature (Bourke - (Walgett + Thargomindah + Coonamble)/3) on days when maximum temperature at Bourke exceeded 40°C, 1959-1995.



from those stations in the region which did take observations on both days suggest that temperatures in the region on 3 January were similar to those of 2 January.

Figure 7 compares the temperature at Bourke with the mean of temperatures observed at Thargomindah, Walgett and Coonamble on days when the daily maximum temperature at Bourke exceeds 40°C during the period 1959-95. The mean difference is 0.5°C, and the largest difference observed during this 37-year period is 4.1°C, while the difference on 3 January 1909 was 6.9°C. This difference is sufficiently large to render the observation suspect. As the screen and instrumentation are known to be standard, a possible cause of any error would be clerical or observational. Nicholls et al. (1996) note that many Stevenson screens used at this time were in poor condition, and some had split wood on top which allowed direct sunlight to enter the screen through the cracks, although the fact that the screen was only a few months old makes this unlikely in the case of Bourke, and the remainder of the month was not exceptionally hot compared with other stations in the region. An observational error is more likely.

## Conclusion

It is likely that the temperature presently recognised as the highest observed in Australia was not recorded under conditions comparable with current standards. The most

plausible cause of the irregular observation appears to be a failure to adequately shelter the instruments from incoming solar radiation during the period of the year when the sun is south of overhead. If this was a widespread occurrence, it has potential implications for the accuracy of climatic records throughout the tropics prior to the introduction of the Stevenson screen.

The highest temperature in Australia known to have been taken under standard conditions, and consistent with supporting observations from other sites, is 50.7°C, recorded at Oodnadatta, South Australia, on 2 January 1960.

## Acknowledgments

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