A brief look at September temperatures 1956 – 2023

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The September 2023 temperatures recorded in a many Australian regions were widely reported as being above average and, in some cases, setting records. This brief note analyses historical data at one location.

Media reports often focus on the state capital cities as thay are the major population centres. However, due to urban spread over many years, comparison of temperature data can be problematic. This is due to vegetation being removed and farmland taken over to be replaced by roads and concrete buildings that retain heat. For this reason, data used in this analysis were obtained for the weather station at Nowra Naval Air Station (station number 068072) as it is located in an area that has seen minimal development over the period of observations and also data are available for a sufficiently long timeframe.

There are many weather-related websites but it is important to find one that provides the required data in an easily accessible format. All that is required are the daily maximum temperatures over a long period. Fortunately, the daily minimum and maximum temperatures are available at

[Long-term temperature record: Australian Climate Observations Reference Network – Surface Air Temperature (bom.gov.au)](bom.gov.au)

The observations at Nowra (068072) commenced on 1 December 1955 and the final entry was recorded on 31 December 2022. The data downloaded simply consisted of the date and maximum temperature, as shown in Figure 1.

maxtemp =	date	maxtemp
	01 Dec 1955	24.9
	02 Dec 1955	29.1
	03 Dec 1955	21.1
	04 Dec 1955	19.4
	05 Dec 1955	19.4
	06 Dec 1955	21.9
	07 Dec 1955	25.6
	08 Dec 1955	24.5
	09 Dec 1955	23.8
	10 Dec 1955	23.6
	11 Dec 1955	24.9
	12 Dec 1955	25.6
	13 Dec 1955	23.8
	14 Dec 1955	21.3
	15 Dec 1955	24.9
	16 Dec 1955	32.9
	⋮ 24 487	
	2 levels │ 49 006 elements	

Figure 1: The first 16 lines of downloaded data

While this is a simple collection of data to work with it is necessary to extract the September temperatures in the most efficient manner. I used *Mathematica* for this part of the analysis. The line number location of 1 September in each year is found using the DayCount function, counting from the initial date (1 December 1955). The temperature at that location and the next twenty-nine temperatures are extracted for each year. The coding is provided in Figure 2.

```
In[4]:=  Do[
    dc[j_] := dc[j] = DayCount[{1955, 12, 1}, {1955 + j, 9, 1}];
    tabmt = Table[maxtempdata[[n, 2]],
      {n, dc[j] + 2, dc[j] + 31}];
    mt[j] = Max[DeleteCases[tabmt, ""]];
    n30plus[j] =
      BinCounts[tabmt, {-0.001, 39.999, 10}][[4]];
    nmiss[j] = 30 - Length[DeleteCases[tabmt, ""]];
    meant[j] = Mean[DeleteCases[tabmt, ""]], {j, 1, 67}]
```

Figure 2: *Mathematica* coding for the analysis

The variable 'tabmt' stores the September temperatures for the year indicated by the loop. Four variables are obtained from the table:

(1) Maximum temperature (mt), after first deleting any missing data.
(2) The number of days with maximum temperature 30℃ or more (n30plus). The temperatures are placed in bins of width 10 and the frequency of temperatures in the range (29.999, 39.999) recorded.
(3) The number of missing values in each September (nmiss). Fifty-four years had complete data, ten years had one missing value, two and three missing values occurred once only. An outlier was 1989 with sixteen missing values.
(4) The mean monthly temperature (meant), again calculated after deleting any missing data.

Corresponding values for 2023 were added after obtaining the data from a Bureau of Meteorology website (Nowra, NSW - September 2023 - Daily Weather Observations (bom.gov.au)).

R statistical software was used to plot the results in Figure 3, together with the 30℃ reference line.
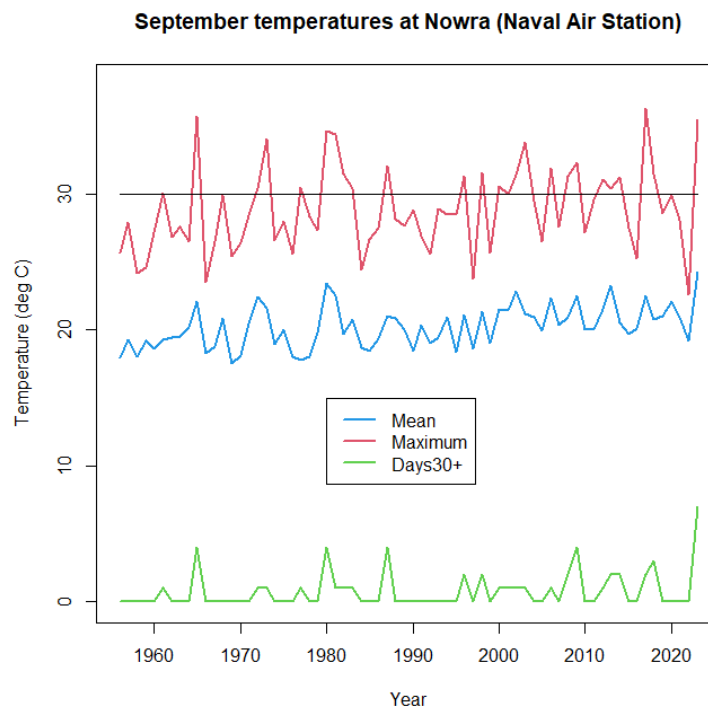

Figure 3: Temperature data for Nowra Naval Air Station 1955 – 2023

Figure 3 shows

(1) Of the sixty-eight years analysed twenty-five had at least one maximum September temperature 30℃ or more with fifty-one occurrences in total.

(2) The frequency of maximum temperature 30℃ or more appears to be increasing. Of the twenty-five years mentioned in (1) ten occurred in the first forty years and fifteen in the last twenty-eight years.

(3) There were four years when there were four occasions during the month that the September maximum temperature was 30℃ or more (1965, 1980, 1987 and 2009). There were seven occasions in September 2023 when the maximum temperature was 30℃ or more and these occurred primarily in six consecutive days commencing on the fifteenth day (range 30.7 ℃ - 35.5℃). Previously, only in 1987 was there a run of more than two consecutive days when the maximum temperature exceeded 30℃ (25th – 28th).

(4) The September maximum temperature in 2023 (35.5℃) compares with 35.7℃ in 1965 and 36.3℃ in 2017.

(5) The average maximum September temperature for 1956 – 2023 was 20.2℃ while the average daily maximum for September 2023 was 24.1℃. Removing the six consecutive readings greater than 30℃ reduced the average maximum to 22.0℃.

(6) The variability in the mean monthly temperature was higher in the period 1960 – 1980 before reducing in the 1990s. Table 1 shows the changes that have occurred between each (approximate) third of the period of observation.

Period	Mean monthly maximum ℃	Standard deviation ℃
1956 – 1980	19.5	1.57
1981 – 2000	20.0	1.23
2001 – 2022	21.1	1.11

Table 1: Means and standard deviations of September maximum temperatures

Conclusion

Some media outlets seemed to suggest that the maximum temperatures recorded in September 2023 were record-breaking. However, analysis of long-term data for Nowra show that maximums exceeding 30℃ are not unusual for September. What was unusual in 2023 was a run of six days with maximums exceeding 30℃. The previous longest run since 1956 was four days and that had occurred only once.

10 October 2023