

Table 1. Details of the 1788–1859 southeastern Australia historical climate data sources. Sources marked with an asterisk were obtained in digital form only. In the ‘Frequency’ column, ‘Daily’ indicates that at least one observation was taken each day. ‘Monthly’ means that only monthly summaries or totals are available. In the ‘Variable’ column, P represents atmospheric pressure, T represents temperature, R represents numerical rainfall values and RD represents rainday counts. A number 1 means the variable is available from a source, while a 0 means it is not. In the ‘Metadata availability’ column, a 0 indicates no metadata, a 1 indicates either the observer, instrument location or instrument type is known. A 2 or 3 indicate that two or three of these pieces of information have been determined. Additional metadata are given with the dataset.

No	Source name	Observer Occupation	State	City	Start Date MM YYYY		End date MM YYYY		Frequency	Variable				Metadata availability
										T	P	R	RD	
	<b>1788–1799</b>													
1	Bradley, William (HMS Sirius)	Naval officer	NSW	Sydney	1	1788	9	1788	Daily	1	1	0	0	3
2	Dawes, William	Astronomer	NSW	Sydney	9	1788	12	1791	Daily	1	1	0	1	3
	<b>1800–1820</b>													
3	<i>Sydney Gazette and New South Wales Advertiser</i>	Unknown	NSW	Sydney	3	1803	5	1805	Daily	1	1	0	1	1
	<b>1821–1840</b>													
4	Goulburn, Frederick	Colonial secretary	NSW	Sydney	5	1821	4	1822	Daily	1	1	0	1	1
5	Port Macquarie	Unknown	NSW	Port Macquarie	1	1822	12	1822	Daily	1	1	0	1	0

No	Source name	Observer Occupation	State	City	Start Date MM YYYY		End date MM YYYY		Frequency	Variable				Metadata availability
										T	P	R	RD	
6	Hobart town	Unknown	TAS	Hobart	2	1822	12	1822	Daily	1	1	0	1	0
7	Sydney Hospital	Military officers	NSW	Sydney	4	1822	3	1823	Daily	1	1	0	1	1
8	Macquarie Harbour	Unknown	TAS	Macquarie Harbour	4	1822	1	1823	Daily	1	1	0	1	0
9	Parramatta	NSW Governor, amateur astronomer	NSW	Parramatta	5	1822	3	1823	Daily	1	1	1	1	1
10	Brisbane, Thomas	NSW Governor, amateur astronomer	NSW	Parramatta	5	1822	3	1823	Monthly	1	0	1	0	1
11	<i>Sydney Gazette</i>	Unknown	NSW	Parramatta	4	1823	3	1824	Monthly	0	0	1	0	0
12	<i>Sydney Monitor</i>	Unknown	NSW	Sydney	7	1826	12	1841	Daily	0	1	0	1	0
13	<i>Sydney Herald</i>	Unknown	NSW	Sydney	4	1831	7	1838	Daily	0	1	0	1	0
14	Dunlop, James*	Astronomer	NSW	Parramatta	1	1832	12	1844	Monthly	0	0	1	0	1
15	Milligan, Joseph	Doctor	TAS	Hampshire Hills	1	1835	12	1839	Monthly	0	0	1	0	1
16	Fawkner, John Pascoe	Explorer	VIC	Melbourne	11	1835	7	1836	Daily	0	1	0	1	2
17	Robinson, George Augustus	Chief Protector of Aborigines	TAS	Flinders Island	1	1836	12	1839	Daily	0	1	0	0	1

No	Source name	Observer Occupation	State	City	Start Date MM YYYY		End date MM YYYY		Frequency	Variable				Metadata availability
										T	P	R	RD	
18	Lempriere, Thomas	Public official	TAS	Port Arthur	5	1837	12	1842	Daily	1	1	1	1	2
19	Wyatt, William*	Doctor	SA	Adelaide	1	1838	12	1847	Monthly	1	1	0	1	1
20	Kingston, George Strickland	Surveyor, politician	SA	Adelaide	1	1839	12	1879	Daily	0	0	1	1	2
21	<i>Chronicle</i>	Unknown	NSW	Sydney	12	1839	5	1848	Daily	0	1	0	1	0
22	Wickham, John	Naval officer	QLD	Brisbane	1	1840	12	1850	Monthly	0	0	1	0	3
23	Edward Peacock, Port Jackson <i>Government Gazette*</i>	Trained Convict	NSW	Sydney	4	1840	12	1855	Monthly	1	1	1	1	3
24	Port Phillip <i>Government Gazette</i>	Trained Convict	VIC	Melbourne	7	1840	6	1851	Monthly	1	1	1	1	1
25	Port Macquarie <i>Government Gazette</i>	Trained Convict	NSW	Port Macquarie	8	1840	11	1851	Monthly	1	1	1	1	1
26	Hobarton Observatory	Astronomers	TAS	Hobart	1	1841	12	1848	Hourly	1	0	0	0	2
27	Abbott, Francis	Watchmaker, amateur meteorologist	TAS	Hobart	1	1841	12	1870	Monthly	1	1	1	0	3
	<b>1841–1860</b>													
28	Stevens, Charles	Schoolmaster	NSW	Dooral	11	1841	12	1846	Daily	0	1	1	1	1
29	Purser, Edward	Soldier	NSW	Castle Hill	2	1842	9	1844	Daily	0	1	1	1	1

No	Source name	Observer Occupation	State	City	Start Date MM YYYY		End date MM YYYY		Frequency	Variable				Metadata availability
										T	P	R	RD	
30	King, Phillip Parker	Naval officer, hydrographer	NSW	Port Stephens	1	1843	12	1847	Monthly	1	1	1	0	1
31	Adelaide Survey Office*	Unknown	SA	Adelaide	4	1843	12	1851	Monthly	1	1	0	0	0
32	Waugh, James	Farmer	NSW	Jamberoo	6	1843	6	1847	Daily	0	1	0	1	1
33	Watson, David	Schoolmaster and clerk	NSW	Campbelltown	11	1845	11	1847	Daily	0	1	1	1	1
34	Pugh, William Russ	Doctor	TAS	Launceston	8	1846	12	1849	Daily	1	1	1	1	1
35	<i>Portland Guardian</i>	Unknown	VIC	Portland	3	1849	8	1851	Daily	0	1	0	1	0
36	<i>Cape Otway Government Gazette</i>	Unknown	VIC	Cape Otway	1	1851	12	1851	Monthly	1	1	1	0	0
37	Slade, Edgar	Policeman, horticulturalist	VIC	Alberton	7	1853	1	1857	Daily	1	1	1	1	1
38	<i>Sydney Morning Herald</i>	Trained convict	NSW	Sydney	1	1855	11	1856	Daily	1	1	1	1	3
39	Jevons, William Stanley	Gold assayer, amateur meteorologist	NSW	Sydney	8	1856	4	1858	Daily	1	1	1	1	2



## **Source 1.** The journal of William Bradley onboard the *HMS Sirius*

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**Date:** 26 January 1788–1 October 1788

**Location:** Botany Bay (20 January–25 January) and Sydney Cove, NSW. Sydney Cove coordinates are taken as 33.86°S 151.22°E, 0 m above sea level (ASL).

**Location of original data:** Bradley’s observations are recorded in his journal *A journey to New South Wales 1786–1792* (Bradley, 1969).

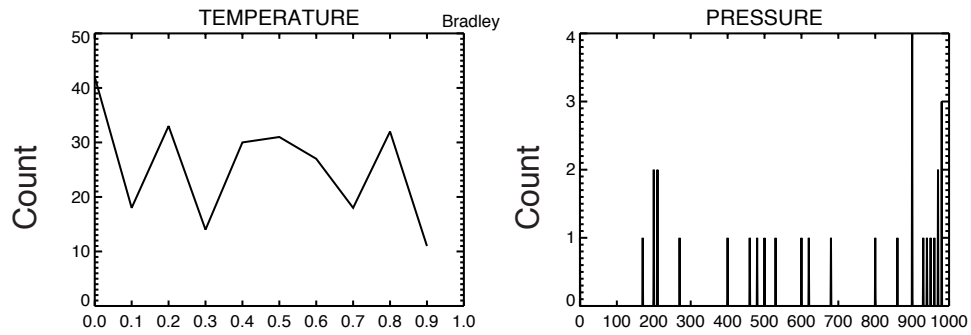
**Observation type:** Daily observations of temperature and pressure at noon. The barometer was unfortunately removed from the *Sirius* on 18 February 1788 (Bradley, 1969).

**Methods of Tmax/Tmin estimation:** Noon temperature observations were taken as Tmax.

**Metadata:** Bradley’s journal reports that the thermometer and barometer were “kept high in the Captain’s cabin, close to the Timekeeper” (Bradley, 1969; Gergis *et al.*, 2009). Bradley’s equipment was provided by the London Board of Longitude (McAfee, 1978). His thermometer was from respected equipment makers Nairne & Blunt, or Ramsden (Knowles Middleton, 1964; 1969; McAfee, 1981a), while the barometer was a mountain (or aneroid) barometer (Bradley, 1969), most likely made by Burton (Dawes, 1791; McAfee, 1981a).

### **Data quality:**

*Observation bias analysis:* Bradley’s temperature observations show a clear preference for values ending in zero, five and even numbers, shown in Figure AI.1. The few surviving pressure readings for Sydney Cove suggest a preference for values rounded to the nearest 100th of an inch. This may be due to the lower accuracy of an aneroid barometer (Holland, 1999; Brohan *et al.*, 2012).



*Figure AI.1.* Frequency distribution of the noon temperature and pressure observations taken by William Bradley. The temperature plot ( left) show the number of temperature observations that end in 0–9. The pressure plot (right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins.

*Temperature seasonal cycle analysis:* There were not enough temperature data to conduct a temperature seasonal cycle analysis.

## Source 2. The meteorological journal of William Dawes

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**Date:** 14 September 1788–6 December 1791

**Location:** Dawes Point, Sydney, NSW, 33.85°S, 151.21°E, 14 m ASL.

**Location of original data:** Dawes' original journal is located in the collection of the Royal Society, London (Dawes, 1791; McAfee, 1981b).

**Observation type:** Dawes took observations of atmospheric pressure and temperature at several times during the day. Observation times vary from before sunrise, 6am, sunrise, after sunrise, 9–10am, Noon, 2–4pm, before sunset, 6pm, sunset, after sunset and 10pm–midnight. Dawes also recorded rainfall, using weight of grain, from September to December 1791.

### Methods of Tmax/Tmin estimation:

*Estimate 1:* Monthly regression based on half hourly temperature data for 1993–2010 from BoM station 66062. Observation times for each day examined separately.

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

*Estimate 3:* As Estimate 1, but observation times put back half an hour.

*Estimate 4:* Monthly mean of maximum and minimum observation recorded each day. At least 60% of monthly data required for a monthly average.

**Metadata:** Dawes took his observations from a small wooden observatory on what is now known as Dawes Point. Dawes Point is at the northern end of central Sydney, and his observatory would have stood about 100 metres from where the southeastern pylon of the Sydney Harbour Bridge now stands (McAfee, 1981a; Gergis *et al.*, 2009). The wooden observatory had two rooms: a rectangular study (where Dawes kept his barometer) and an octagonal room with a conical roof made of canvas that could be rotated on cannon balls (McAfee, 1981a; Kington, 1997). A sketch of the observatory is shown in Figure 3.1.

**Metadata:** The equipment used by Dawes was provided by the Board of Longitude (McAfee, 1978), and Dawes gave detailed information about them in his meteorological journal (McAfee, 1981b; Gergis *et al.*, 2009). Dawes' thermometer was "by Nairne & Blunt, small and divided only to every two degrees [ $^{\circ}\text{F}$ ], the whole scale from 0 to 212 being in length 6.23 inches"(Dawes, 1791; McAfee, 1981b). Dawes stated that the thermometers were exposed outside, away from direct sunlight and about three feet above a stone surface (Dawes, 1791; Kington, 1997). McAfee (1981a,b) suggests that the thermometer was kept in a shady spot in the open air, or inside the well ventilated observatory.

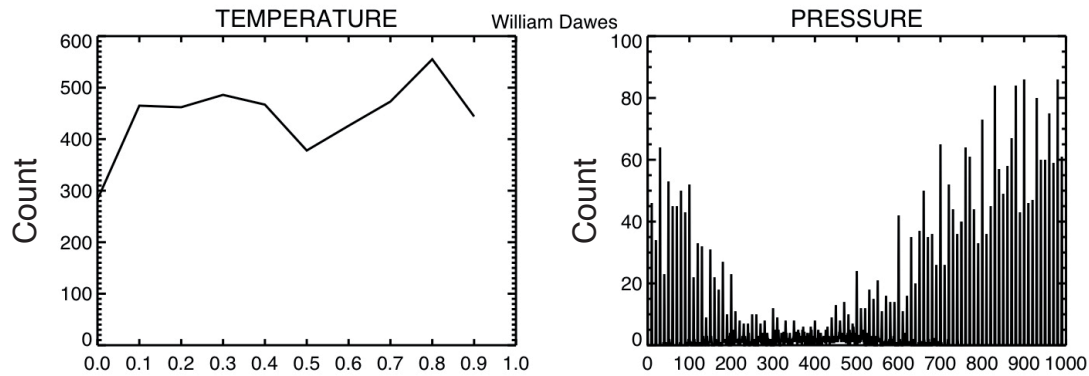
Dawes compared his thermometer to one belonging to Mr Furzer (a quartermaster onboard the *HMS Sirius*) several times during 1791, and found that they gave readings within one degree Fahrenheit of each other (McAfee, 1981a). Dawes used the Board of Longitude's Burton barometer from September 1788 to the start of July 1791 (Dawes, 1791; McAfee, 1981b). From July 1791 until the end of his observations that December, Dawes borrowed a Ramsden barometer from Mr Furzer, owing to the fact that his barometer had a crack in it and was slowly leaking mercury (Dawes, 1791; Gergis *et al.*, 2009). McAfee (1981a) cautioned that the Burton barometer gave low readings due to the leak and Gergis *et al* (2009) found that the Ramsden readings were too low to be considered reliable, possibly due to Dawes' inexperience with the new barometer (McAfee, 1981b).

Dawes recorded also rainfall in grain weight from September–December 1791. The observations are difficult to read in his journal and were not digitised for this project. He also recorded wind speed, wind direction, and general remarks about the weather. Dawes was trained at the Greenwich Observatory (Mander-Jones, 1969) and appears to be a conscientious observer. He recorded details about his instruments (and changes to them) and would have been knowledgeable about the need for standard instrument exposure.

### **Data quality:**

*Observation bias analysis:* Dawes' temperature observations show a slight positive bias towards values ending in eight, and a small negative bias towards values ending

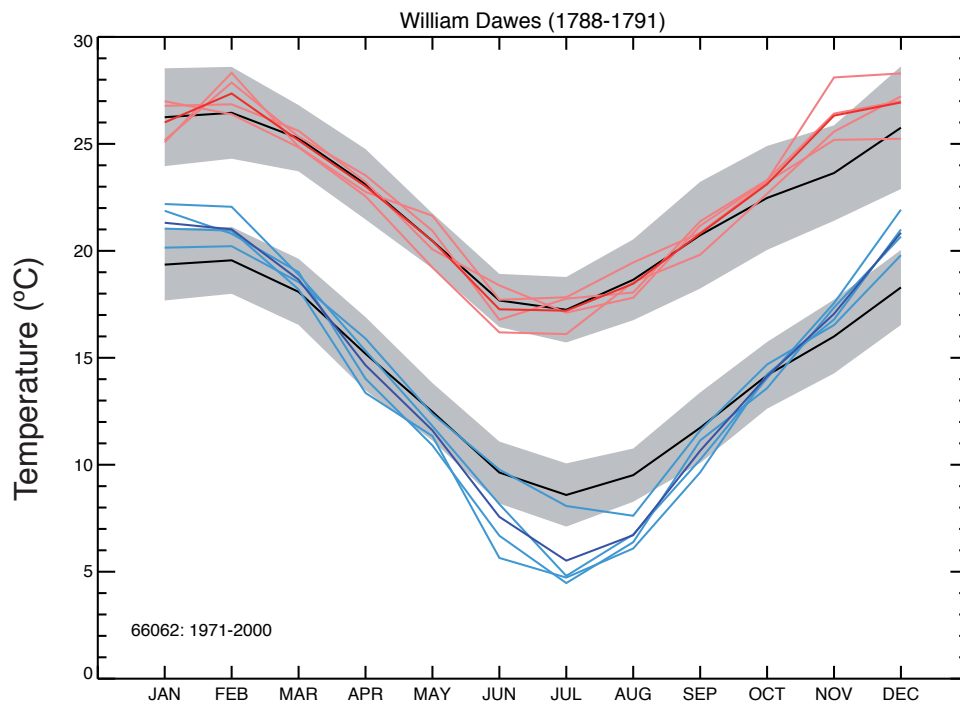
with 0 and 5 shown in Figure AI.2. Considering his thermometer scale was graduated in a scale of 2 °F, this suggests diligent observation practices. His pressure observations also seem to have a slight bias towards observations to the nearest 100th of an inch of mercury (e.g. 29.700, 29.800).



*Figure AI.2.* Frequency distribution of the temperature and pressure observations taken by William Dawes. The temperature plot (left) show the number of temperature observations that end in 0–9. The pressure plot (right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins.

*Temperature seasonal cycle analysis:* Seasonal cycle analysis in Figure AI.3 shows maximum and minimum temperature values that are higher (up to 2 °C) than the modern Sydney temperature cycle during the summer months. Minimum temperatures are also much cooler in austral winter, up to 5 °C lower than the modern seasonal cycle for Sydney. Dawes' maximum temperatures during winter are similar to modern observations. Gergis *et al.* (2009)'s analysis of the seasonal temperature cycle revealed similar results, with slightly warmer temperatures in the summer and cooler temperatures in the winter, when compared to modern observations in Sydney. This is consistent with other comparisons between temperature observations recorded under a non-standard exposure and modern observations taken in a regulation Stevenson Screen (Nicholls *et al.*, 1996).

*Other:* The monthly averages of the observations taken from September–December 1791 were 17.7 hPa lower than the earlier observations. This difference has been added to the September–December monthly means.



*Figure AI.3.* Seasonal cycles of Tmax and Tmin estimates from temperature observations taken by William Dawes. The seasonal cycles of the mean Tmax and Tmin estimates (dark red and blue lines) are compared to seasonal cycles of individual estimates (light red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

### **Source 3.** *The Sydney Gazette and New South Wales Advertiser*

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**Date:** 1 March 1803–30 April 1805

**Location:** Sydney, NSW, 33.86°S, 151.21°E, 21 m ASL.

**Location of original data:** Observations were published as monthly tables in *The Sydney Gazette and New South Wales Advertiser*, available at <http://trove.nla.gov.au/ndp/del/title/3>.

**Observation type:** Fixed hourly temperature and pressure observations. From March 1803–February 1804 daily mean pressure and temperature values were published. From March 1804–April 1805, observations were published for 8 am, noon, 4 pm and 8 pm. Three words describing the weather were also published for each day.

#### **Methods of Tmax/Tmin estimation:**

*Estimate 1:* Monthly regression based on half hourly data for 1993–2010 from 066062 and 8 am, 12 pm, 4 pm and 8 pm observations. Estimates were only calculated for March 1804–April 1805, as only mean temperature data were available for March 1803–February 1804.

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

*Estimate 3:* As Estimate 1, but observation times put back half an hour.

*Estimate 4:* As main estimate, but examining each day separately. Two observations per day were required for an estimate to be made, and at least 60% of monthly data required to calculate a monthly average.

*Other:* Printed mean temperature values for 1803–1804 were also used to examine temperature variability.

**Metadata:** According to some of the published tables, the thermometer and barometer readings were taken “under a shade” at the First Government House in Sydney. The First Government House is now the Sydney Museum, on the corner of William and

College Streets in central Sydney (Proudfoot *et al.*, 1991). There is no record of the instruments used and the original observations have not been located, as discussed in Chapter 3.

In this study, the published mean pressure observations from 1803–1804 were combined with the calculated mean of the four fixed hourly pressure observations from 1804–1805 to examine mean pressure variability.

### Data quality:

*Observation bias analysis:* The temperature observations show a slight negative bias towards values ending in zero and five, as plotted in Figure AI.4. The pressure observations include a number of unrealistically high and low values, with a small bias toward 30.095.

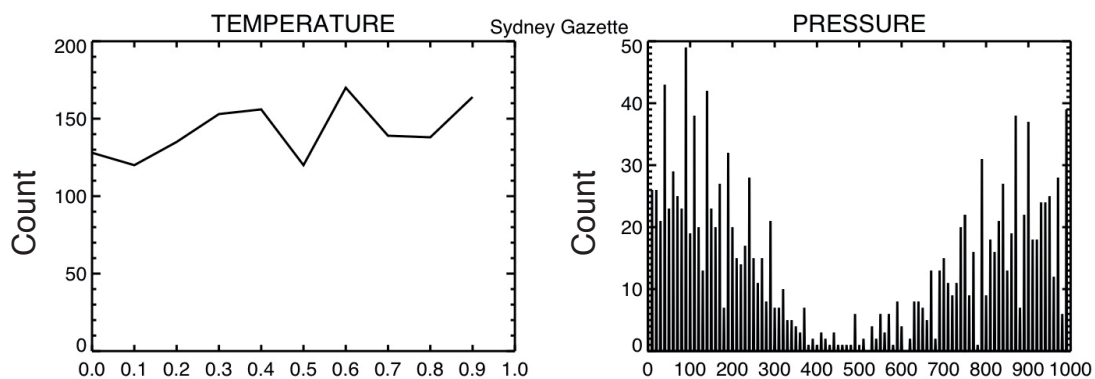
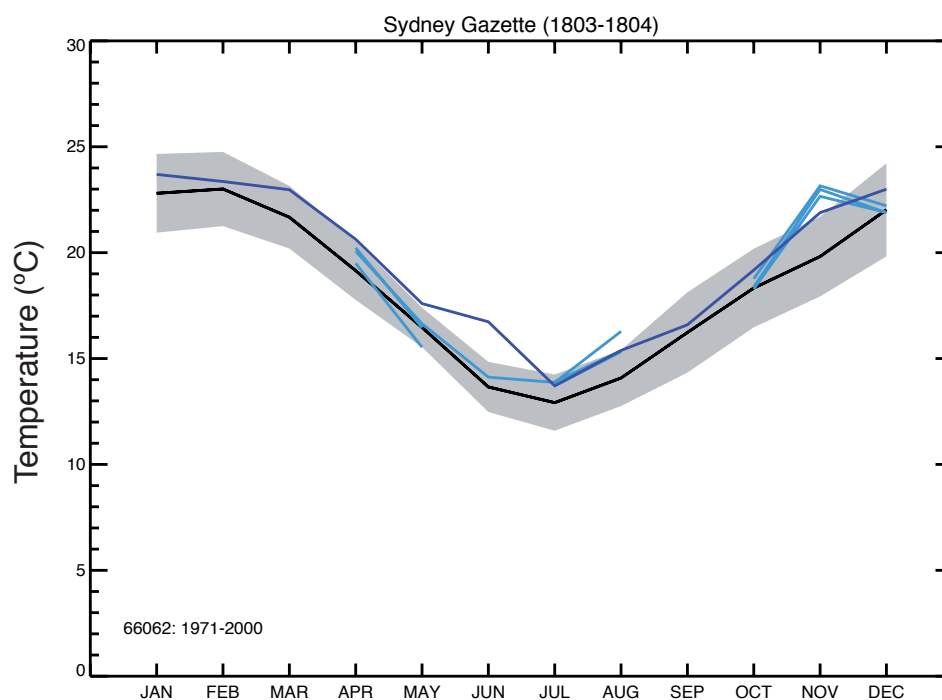


Figure AI.4. Frequency distribution of the temperature and pressure observations published in *The Sydney Gazette and NSW Advertiser*. The temperature plot (left) shows the number of temperature observations that end in 0–9. The pressure plot (right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins.

*Temperature seasonal cycle analysis:* Figure AI.5 shows that the seasonal cycle of the published mean temperatures are higher than the modern mean for all months, but only significantly different during May, June and November. The mean temperatures calculated from Tmax and Tmin estimates are similar to the modern mean temperature seasonal cycle, although warmer in November.





*Figure AI.5.* Seasonal cycles of published mean temperatures and mean temperature calculated from Tmax and Tmin estimates using temperature observations published in *The Sydney Gazette* and *NSW Advertiser*. The seasonal cycle of the published mean temperatures (dark blue line) is compared to seasonal cycles of individual mean temperature estimates (light blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 4. Goulburn, Fredrick

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**Date:** 1 May 1821–30 April 1822

**Location:** Sydney, NSW, 33.86°S, 151.209°E, 32 m ASL.

**Location of original data:** Published in Barron Field's *Geographical Memoirs on New South Wales* (1825), pp 385–396.

**Observation type:** Fixed hourly temperature and pressure observations. The observations were originally taken at 6 am, noon and 8 pm, but from September 182 were recorded as morning, noon and night observations. Three words were also given describing the weather of each day, allowing for the number of raindays to be counted.

### **Methods of Tmax/Tmin estimation:**

*Estimate 1:* Monthly regression based on half hourly data for 1993–2010 from 66062 and 6 am/morning, noon and 8 pm/night observations. Morning and night taken as 6 am and 8 pm.

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

*Estimate 3:* As Estimate 1, but observation times put back half an hour.

*Estimate 4:* As main estimate, but examining each day separately. Two observations per day were required for an estimate to be made, and data were required for at least 60% of a month for a monthly average to be calculated.

**Metadata:** In his summary of early Australian meteorological observations, Loewe (1970) assumed that the observations were taken at Parramatta, just like the observations from Governor Brisbane also published in Barron Field's *Geographical Memoirs on New South Wales* (RON source 10). However, the observations clearly state that they are from Sydney, and in 1821–1822 Sydney and Parramatta were separate towns, not suburbs within the same metropolis as they are today (Proudfoot *et al.*, 1991). Furthermore, while Brisbane was based at the Parramatta Government House for most

of his stint as Governor (King, 1979; Proudfoot *et al.*, 1991), Goulburn conducted the majority of his business from Sydney (King, 1979).

It is likely that the observations came from the vicinity of the Colonial Secretary's Office, which was located to the west of the First Government House in central Sydney (National Library of Australia, 1822). The observations were either taken by Goulburn or one of his staff, as Goulburn himself had a large number of administrative duties (Loewe, 1970; King, 1979). King (1979) additionally states that Goulburn's notes on other topics were "disorganized and unmethodical, and one suspects that these random, hasty notes were never put to coherent use; they point to a lack of method in Goulburn's whole way of working" (pg 235). This description does not make Goulburn out to be an overly reliable observer.

#### Data quality:

*Frequency bias analysis:* Goulburn's temperature observations, analysed in Figure AI.6, show a very small bias towards values ending in four, but in general are fairly randomly distributed. The pressure readings show a bias away from values that end in 0.005, particularly for 30.105 and 30.205.

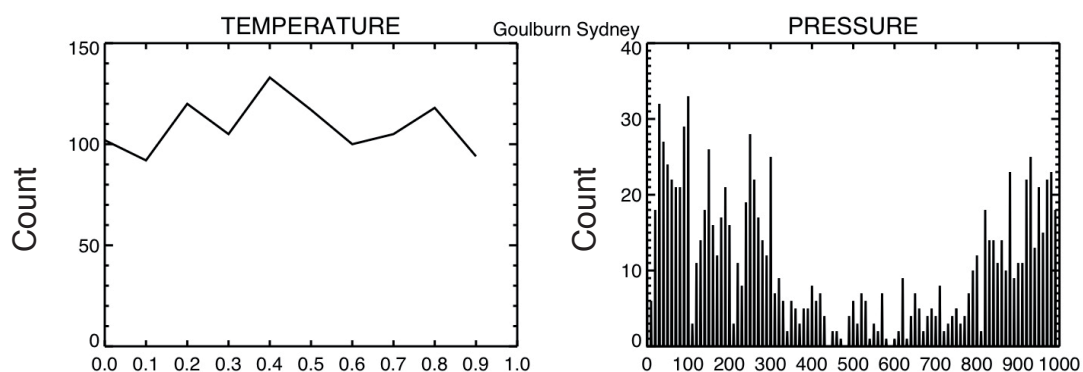
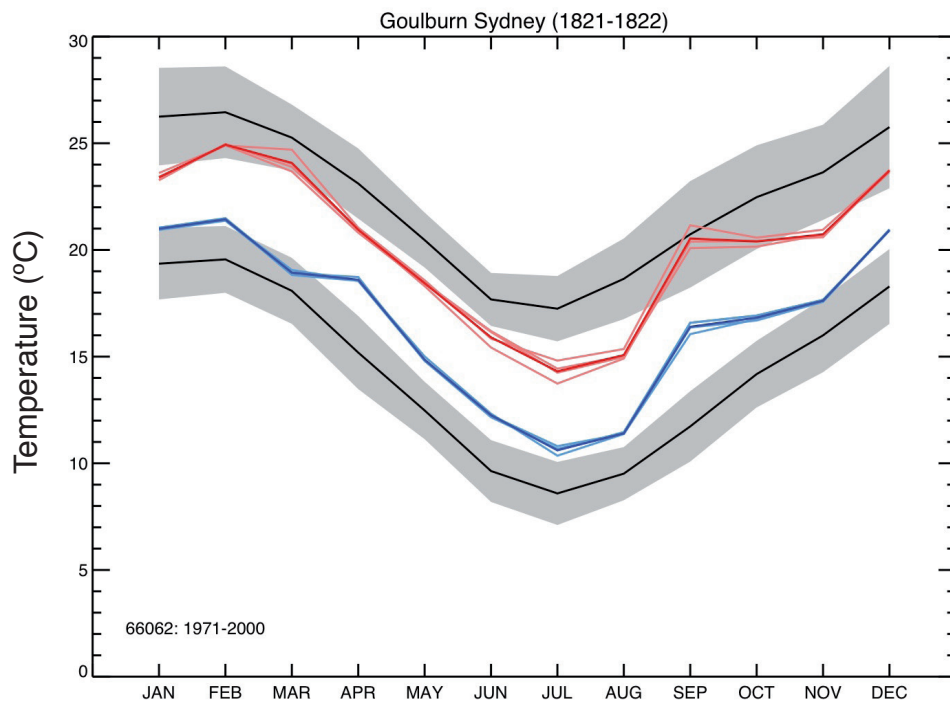


Figure AI.6. Frequency distribution of the temperature and pressure observations taken by Fredrick Goulburn. The temperature plot (left) show the number of temperature observations that end in 0–9. The pressure plot (right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins.

*Temperature seasonal cycle analysis:* Seasonal cycle analysis shows a greatly reduced diurnal temperature range than modern observations. Minimum temperatures are too high in all estimates, while maximum temperatures are too low. This suggests that

the thermometer could have been indoors. There is a strange spike in temperatures for September; as there is only one year of observations this could be an anomalously warm September. Alternatively this could be due to the change in observation times that occurred in September 1822.



*Figure AI.7.* Seasonal cycles of Tmax and Tmin estimates from temperature observations taken by Fredrick Goulburn. The seasonal cycles of the mean Tmax and Tmin estimates (dark red and blue lines) are compared to seasonal cycles of individual estimates (light red and blue lines) and neighbouring BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 5. Port Macquarie

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**Date:** 1 January 1822 – 31 December 1822

**Location:** Port Macquarie, NSW. Location details taken as the same as source 26: 31.43°S, 152.92°E, 16 m ASL.

**Location of original data:** The Royal Society of London Scientific Papers, manuscript number MA60 and MA61. A microfilm copy of the source was obtained from Rob Allan at the United Kingdom Meteorological Office (UK Met Office).

**Observation type:** Fixed hourly temperature and pressure observations with wind directions. Observations were taken at sunrise, 6 am, 9 am, noon, 3 pm, 6 pm and sunset. The sunrise, 6 am, 6 pm and sunset observations are not complete.

**Methods of Tmax/Tmin estimation:**

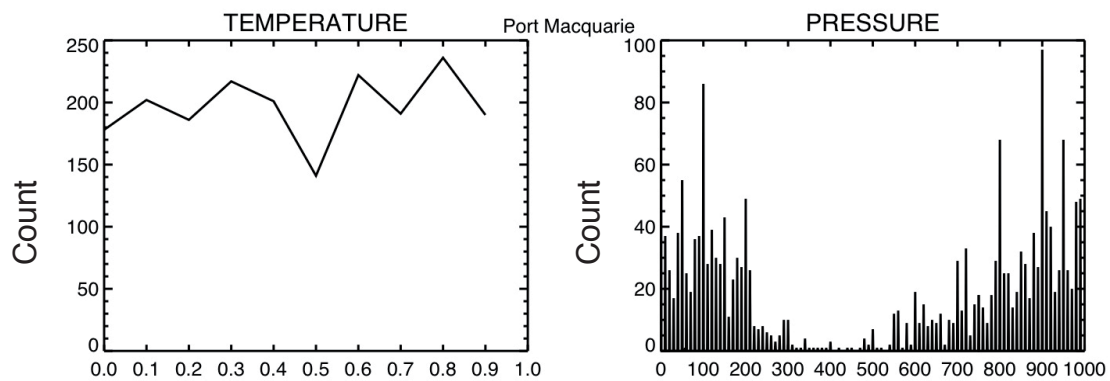
*Estimate 1:* Monthly mean of maximum and minimum temp for each day. Data was required for at least 60% of a month for a monthly average to be calculated.

*Estimate 2:* Monthly regression based on 9 am and 3 pm data from 60026 for 1957–2003 and 9 am and 3 pm observations.

**Metadata:** There is no information about how, who or why these observations were taken, although they were probably ordered by Thomas Brisbane as a part of his early observational network (Moyal, 1986). Port Macquarie was a penal colony in the early 1820s (MacIntyre, 1999), so the observations were most likely taken by officers guarding the prisoners. The observations may have taken near the coast, as understanding the local weather was important for marine transport for much of the 1800s (see chapter 3). There was a signal tower at the mouth of the Hastings river in 1825 as shown in Figure 3.3; the observations may have been taken there. On the other hand, the observations could have been taken at Settlement Point, near the banks of the Hastings River, where the earliest town of Port Macquarie was settled (Port Macquarie–Hastings Council, 2006).

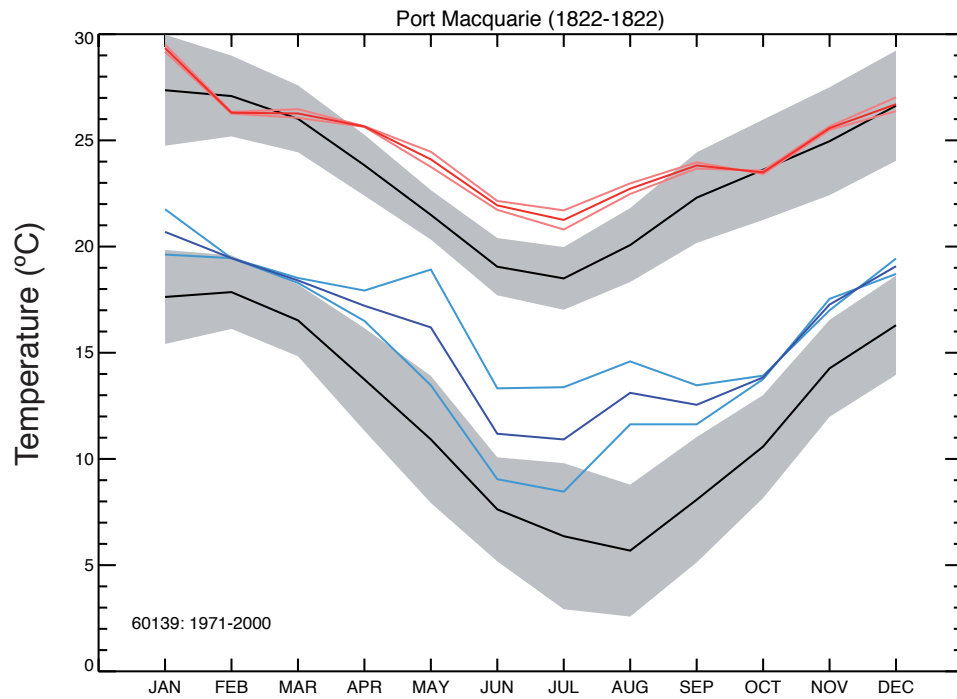
**Data quality:**

*Frequency bias analysis:* As displayed in Figure AI.8, the pressure observations show a clear bias towards values that end in whole hundredths of an inch, particularly .100 and .900. The temperature observations show a bias towards even numbers and against numbers that end in five.



*Figure AI.8.* Frequency distribution of the temperature and pressure observations taken in Port Macquarie in 1822. The temperature plot (left) show the number of temperature observations that end in 0–9. The pressure plot (right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins.

*Temperature seasonal cycle analysis:* The estimated Tmax and Tmin seasonal cycles plotted in Figure AI.9 show reduced seasonal variability, with warmer values during May–September than the modern Port Macquarie seasonal cycle. This could be due to a genuine reduction in seasonal cycle due to coastal conditions at the 1822 station, but is much more likely to be due to exposure and estimate uncertainty.



*Figure AI.9.* Seasonal cycles of Tmax and Tmin estimates from temperature observations taken in Port Macquarie in 1822. The seasonal cycles of the mean Tmax and Tmin estimates (dark red and blue lines) are compared to seasonal cycles of individual estimates (light red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM used is provided in the bottom left corner.

## Source 6. Hobart Town

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**Date:** 1 February 1822 – 31 December 1822

**Location:** Hobart, Tasmania. Location taken from the source: 42.89°S, 147.57°E, 8.7 m (28.5 feet) ASL, or “above mean low water”.

**Location of original data:** The Royal Society of London Scientific Papers, manuscript number MA62. A microfilm copy of the source was obtained from Rob Allan at the UK Met Office.

**Observation type:** Fixed hourly temperature and pressure observations with wind and weather descriptions. Observations were taken at 9 am, noon, 3 pm, 6 pm and 9 pm. The highest, lowest and mean temperature and pressure values for the day were also given, although they seem to be just the maximum, minimum and mean of the five fixed-hourly observations.

### Methods of Tmax/Tmin estimation:

*Estimate 1:* Monthly mean of maximum and minimum temp for each day. Data were required for at least 60% of a month for a monthly average to be calculated.

**Metadata:** Thomas Brisbane most likely organised for these observations to be taken, but there is no other information about observers, instrument exposure or instrument type.

### Data quality:

*Frequency bias analysis:* Figure AI.10 shows a slight bias in the temperature observations ending in zero and eight. Pressure observations are given to the nearest 10th of an inch, suggesting that the barometer may have had a low-resolution.

*Temperature seasonal cycle analysis:* The estimated Tmax and Tmin values shown in Figure AI.11 display greater seasonal variability than modern Hobart temperature observations, with cooler values during austral winter (JJA) and slightly warmer values during December and February, particularly Tmin.



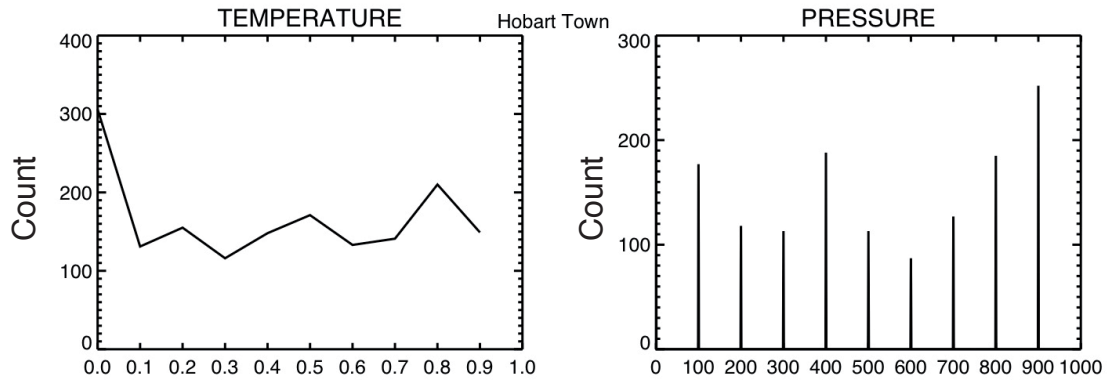


Figure AI.10. Frequency distribution of the temperature and pressure observations taken in Hobart in 1822. The temperature plot (left) show the number of temperature observations that end in 0–9. The pressure plot (right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins.

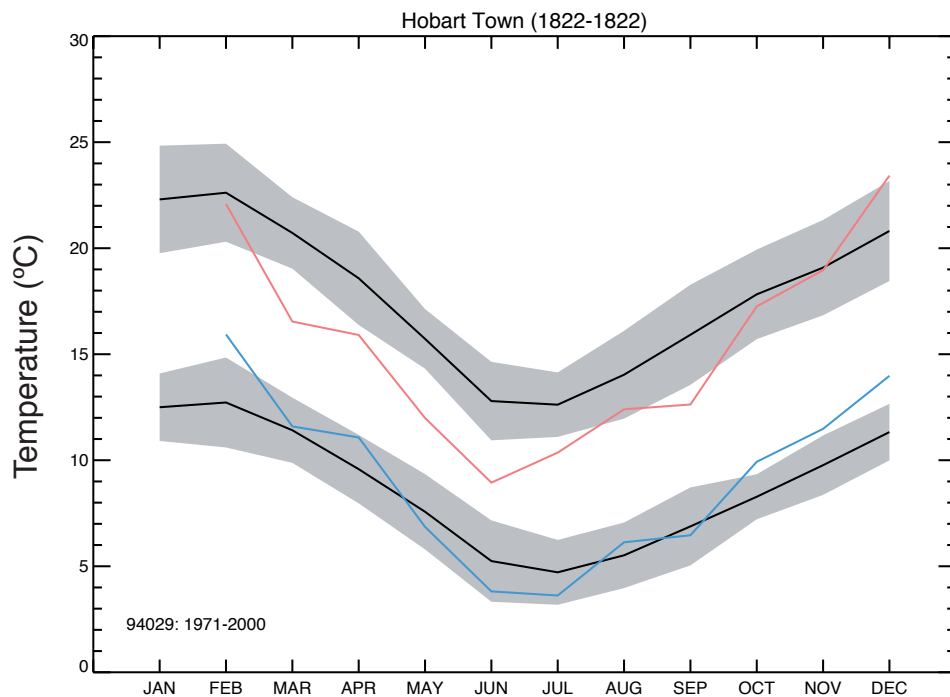


Figure AI.11. Seasonal cycles of Tmax and Tmin estimates from temperature observations taken in Hobart in 1822. The seasonal cycles of the Tmax and Tmin estimates (red and blue lines) are compared to seasonal cycles of nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 7. Sydney Hospital

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**Date:** 7 April 1822–6 April 1823

**Location:** Sydney, NSW, 33.86°S, 151.21°E, height 39 m ASL. Source gives height as 141 feet (43 m) ASL.

**Location of original data:** The original observations are housed at the Royal Society of London, and were obtained on microfilm from Rob Allan from the UK Met Office. Royal Society manuscript number M57.

**Observation type:** Temperature and pressure recorded at 7 am, 1 pm and 7 pm each day, as well as wind and weather descriptions. Attached thermometer readings began in October 1822, but were sporadic.

### Methods of Tmax/Tmin estimation:

*Estimate 1:* Monthly regression based on half hourly data for 1993–2010 from 66062 and 7 am, 1 pm and 7 pm

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

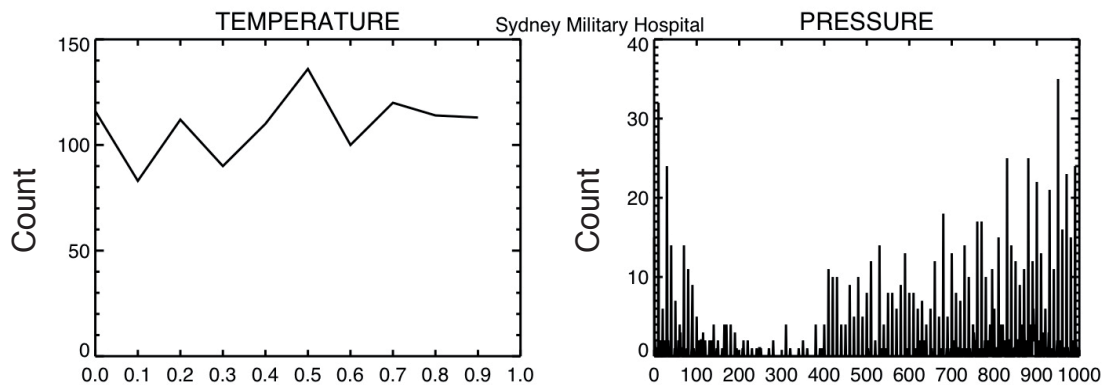
*Estimate 3:* As Estimate 1, but observation times put back half an hour.

*Estimate 4:* As main estimate, but examining each day separately. Two observations per day required for an estimate to be made, and data was required for at least 60% of a month for a monthly average to be calculated.

**Metadata:** Observations were taken at the Regimental Hospital of the 48th Regiment Sydney, which was located on Observatory Hill in central Sydney (Herman, 1970; Macquarie University Library, 2011). The building is still standing and forms part of the Fort Street Public School, the same school that contains the current BoM station for Sydney (Observatory Hill), station number 66062 (Fort Street Public School, 2013). The manuscripts state that the obs were taken 141ft ASL, and that the thermometer was ‘in the shade and exposed to the currents of air’. The modern height calculation of 39 m was used in the conversion of pressure values.

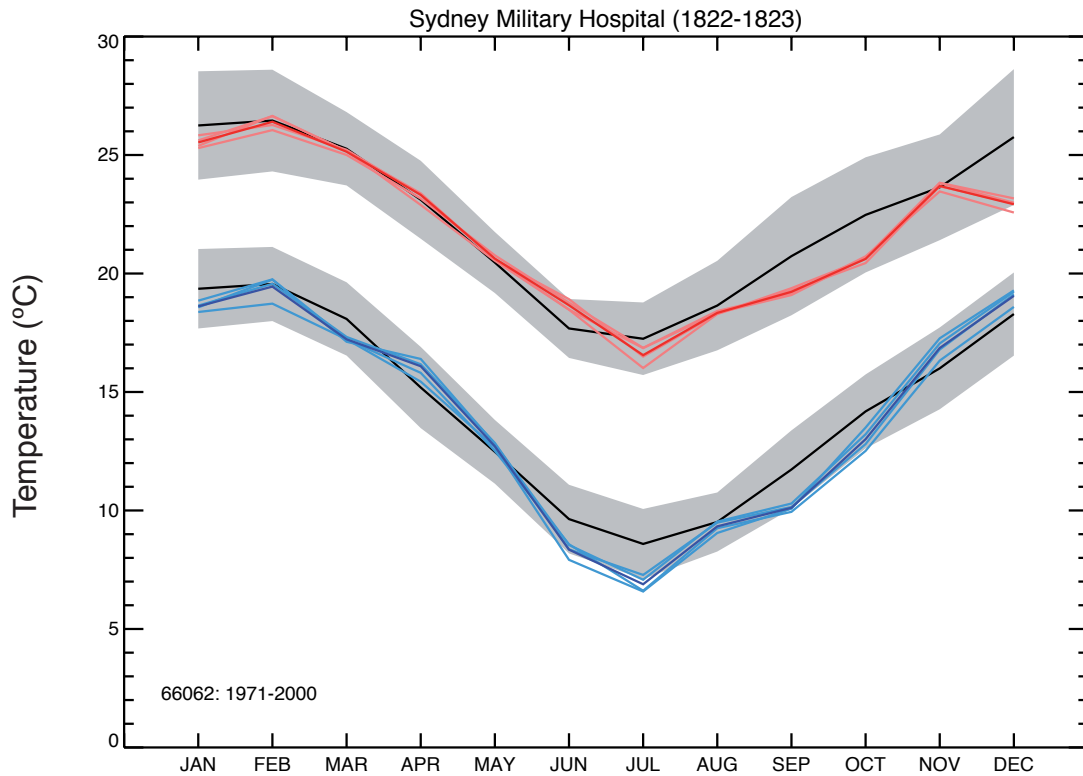
### Data quality:

*Frequency bias analysis:* Figure AI.12 shows a slight bias towards even temperature observations and observations that end in five, as well as pressure observations that end in .950.



*Figure AI.12.* Frequency distribution of the temperature and pressure observations taken in Sydney in 1822. The temperature plot (left) show the number of temperature observations that end in 0–9. The pressure plot (right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins.

*Temperature seasonal cycle analysis:* The estimated Tmax and Tmin values shown in Figure AI.13 display similar seasonal variability to modern Sydney observations, although Tmin estimates are cooler during June–September and Tmax estimates show cooler values during October–January.



*Figure AI.13.* Seasonal cycles of Tmax and Tmin estimates from temperature observations taken in Sydney in 1822. The seasonal cycles of the mean Tmax and Tmin estimates (dark red and blue lines) are compared to seasonal cycles of individual estimates (light red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 8. Macquarie Harbour

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**Date:** 5 April 1822–6 January 1823

**Location:** Macquarie Harbour, TAS, 44.39°S 145.45°E, 0 m ASL.

**Location of original data:** The original observations are housed at the Royal Society of London, and were obtained on microfilm from Rob Allan from the UK Met Office. Royal Society manuscript number M61.

**Observation type:** Pressure and temperature observations taken at 8 am, noon and 8 pm from 5 April 1822 to 22 June 1822, then observations taken at 6 am, 9 am, noon, 3 pm and 6 pm from 25 June 1822 to 6 January 1823. These were accompanied by wind and weather descriptions.

### **Methods of Tmax/Tmin estimation:**

*Estimate 1:* Monthly mean of maximum and minimum temp for each day. Note that observations were taken three times daily during April–June 1822, and six times daily during July 1822–January 1823.

**Metadata:** There is not a lot of information about these observations. Just like the Port Macquarie observations (source 5), Macquarie Harbour in 1822 was a penal settlement established on Sarah Island in the harbour (Lempriere, 1954). Sarah Island is shown in Figure AI.14. Interestingly, the Lieutenant in charge of Sarah Island, Lieutenant Cuthbertson, came from the 48th Regiment in Sydney (Lempriere, 1954), where observations were also taken in 1822 (source 7). He may have taken the observations, although he reportedly drowned on December 22 1822, and the observations continued until January 6 1823 (Lempriere, 1954).

In his summary of the penal settlements of Van Diemen's Land, Thomas Lempriere (1954) wrote about additional observations being taken at Macquarie Harbour: "It is to be regretted that the Meteorological Journals which were kept for several years at Macquarie Harbour by the Commandant's Clerk I. Douglas (a very intelligent man who took pleasure in such pursuits) should have unfortunately either through his removal,



Figure AI.14. Sarah Island, Macquarie Harbour, 1833 by William Buelow Gould. Image: State Library of New South Wales, Call number: V6B/MAC H/2.

the changes and breaking up of the settlement or some other cause, been lost, as they would have afforded much useful information (pg 37)”.

#### **Data quality:**

*Frequency bias analysis:* Pressure observations are given to two decimal places rather than three, suggesting a lack of instrument precision. There is an additional bias towards pressure observations that end in 0.50 and 0.60, as seen in Figure AI.15. Temperature records also show a bias towards observations that end in three and eight.

*Temperature seasonal cycle analysis:* The estimated Tmax and Tmin values displayed in Figure AI.16 show a much greater seasonal cycle than modern observations from the Macquarie Harbour region, with cooler JJA temperatures and much warmer temperatures during austral summer (DJF). This suggests very poor thermometer exposure.

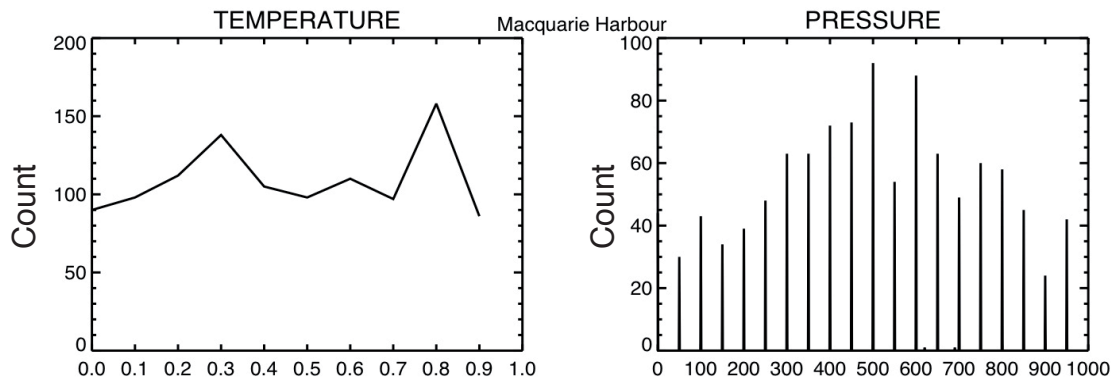


Figure AI.15. Frequency distribution of the temperature and pressure observations taken at Macquarie Harbour in 1822. The temperature plot (left) show the number of temperature observations that end in 0–9. The pressure plot (right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins.

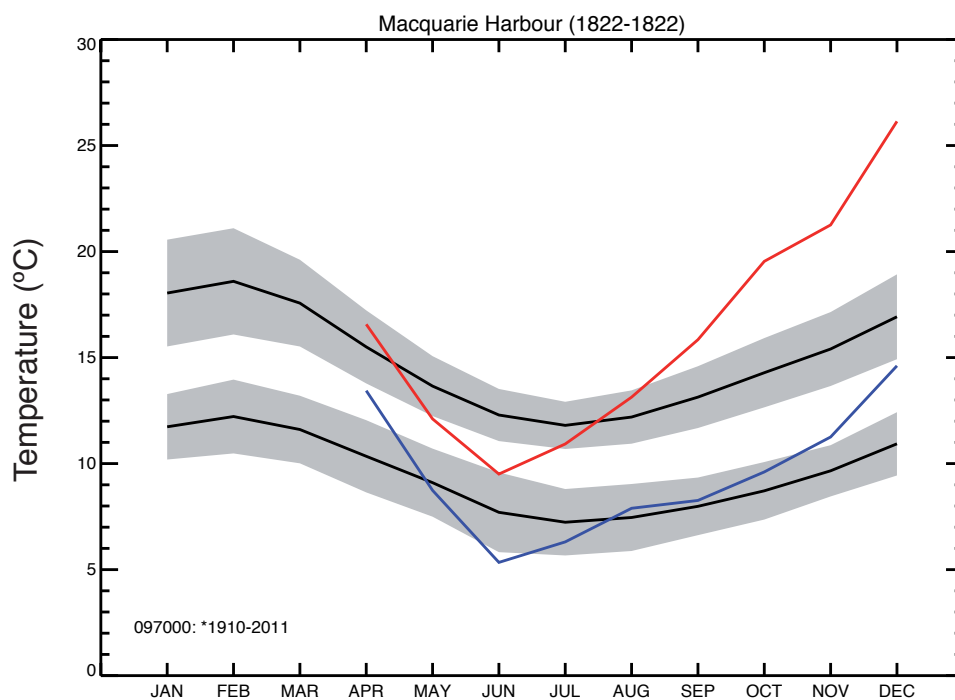


Figure AI.16. Seasonal cycles of Tmax and Tmin estimates from temperature observations taken at Port Macquarie in 1822. The seasonal cycle of the mean Tmax and Tmin estimate (dark red and blue lines) is compared to the seasonal cycle of nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 9. Parramatta

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**Date:** 1 May 1822–31 March 1823 (September missing)

**Location:** Parramatta Observatory at Old Government House, 33.81°S 151.00°E 15.2 m (50 ft) ASL (coordinates taken from Bureau station Parramatta, station number 66046, height taken from the original observations). This is the same location as source 10, 11 and 14 (see Figure 3.8).

**Location of original data:** The original observations are housed at the Royal Society of London, and were obtained on microfilm from Rob Allan from the UK Met Office. Royal Society manuscript number M58.

**Observation type:** Pressure and temperature observations are given for morning, noon and night. From October 1822–January 1823 inclusive (September is missing) Tmax and Tmin observations are recorded for each day instead. During this time the temperatures from 30 August 1822 were used as attached temperature values in the calculation of MSLP. For February and March 1823, Tmax, Tmin, morning, noon and night temps were recorded. Rainfall values were also recorded from October 1822 onwards, although the March 1823 values are in an unrecognisable unit. Daily weather descriptions are also given.

### Methods of Tmax/Tmin estimation:

*Estimate 1:* Observed Tmax and Tmin for all but the first four months. Only two of the first four months have more than 60% of data available and so no estimates of Tmax or Tmin were made.

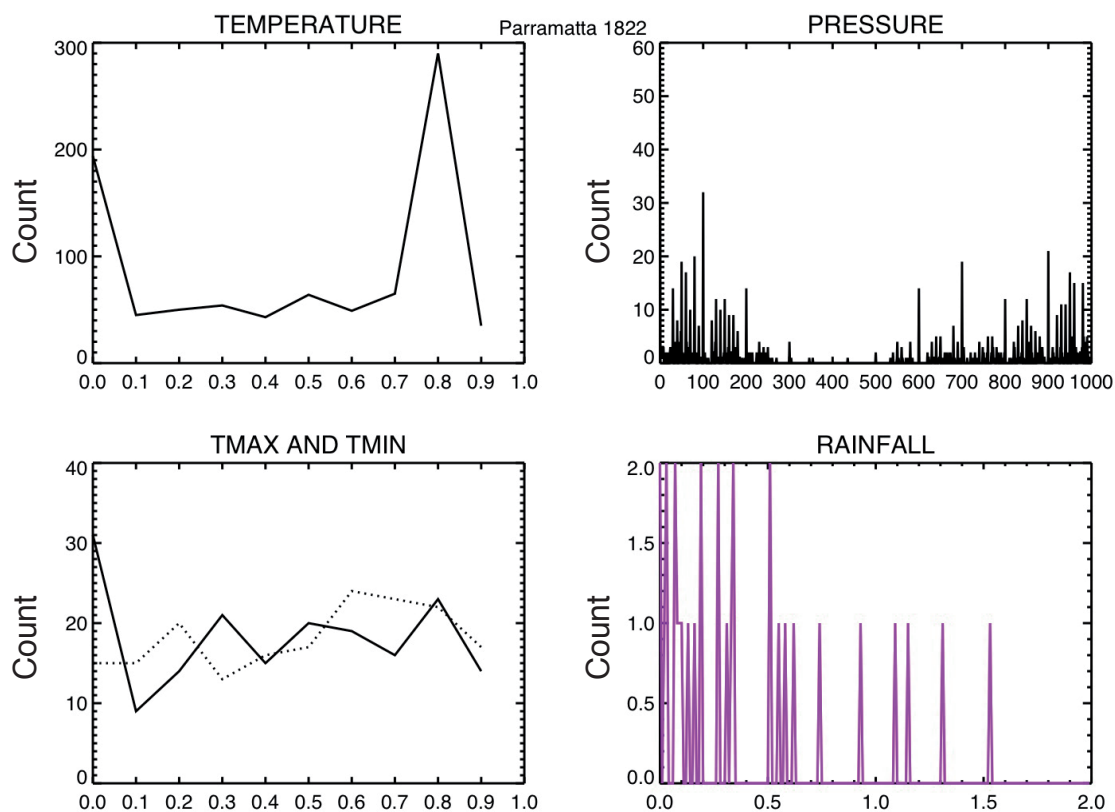
**Metadata:** These observations have most likely come from Governor Thomas Brisbane's Observatory at Old Government House in Parramatta. They were probably taken by Brisbane or his assistants, James Dunlop and Charles Rümker. The monthly mean of these daily observations are in very good agreement with the monthly values from source 10.



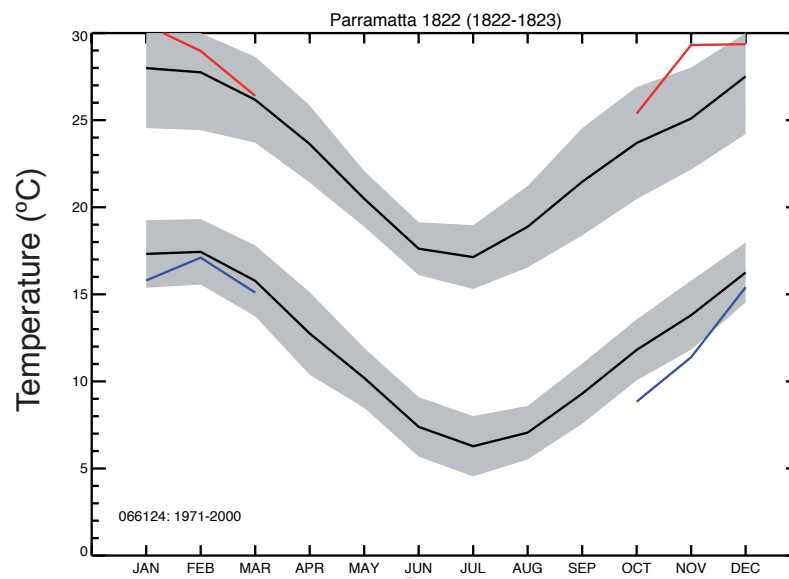
## Data quality:

*Frequency bias analysis:* Temperature observations show a bias towards values ending in zero and eight, while pressure observations show a clear bias towards the nearest whole tenth of an inch, as displayed in Figure AI.17. There are not enough rainfall observations to identify any observer bias in the rainfall record.

*Temperature seasonal cycle analysis:* The six months of published Tmax and Tmin observations, plotted in Figure AI.18 show slightly warmer Tmax values and slightly cooler Tmin values than modern Parramatta temperature observations



*Figure AI.17.* Frequency distribution of the temperature, pressure and rainfall observations taken in Parramatta in 1822. The temperature plot (top left) show the number of temperature observations that end in 0–9. The distributions for Tmax and Tmin observations are plotted similarly (bottom left). The Tmax distribution is plotted in a solid line, and the Tmin distribution in a dotted line. The pressure plot (top right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins. The rainfall plots (bottom right) show the number of rainfall observations in each 0.005-inch bin from 0 to 2 inches.



*Figure AI.18.* Seasonal cycles of Tmax and Tmin observations taken in Parramatta. The seasonal cycle of the published Tmax and Tmin (dark red and blue lines) are compared to the seasonal cycles of nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 10. Brisbane, Thomas

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**Date:** May 1822–May 1823 (September missing)

**Location:** Parramatta Observatory at Old Government House, 33.81°S 151.00°E 18.9 m (62 ft) ASL (coordinates taken from Bureau station Parramatta, station number 66046, height taken from published table). This is the same location as source 9, 11 and 14.

**Location of original data:** This table was published twice: once in Barron Field's *Geographical Memoirs on New South Wales* (Field, 1825) and once in *The Sydney Gazette and New South Wales Advertiser* (17 July 1823, page 3, available at <http://trove.nla.gov.au/ndp/del/title/3>).

**Observation type:** Highest, lowest and mean pressure and temperature value for each month as well as rainfall from September 1822. Only the mean temperature, pressure and rainfall data were used for analysis.

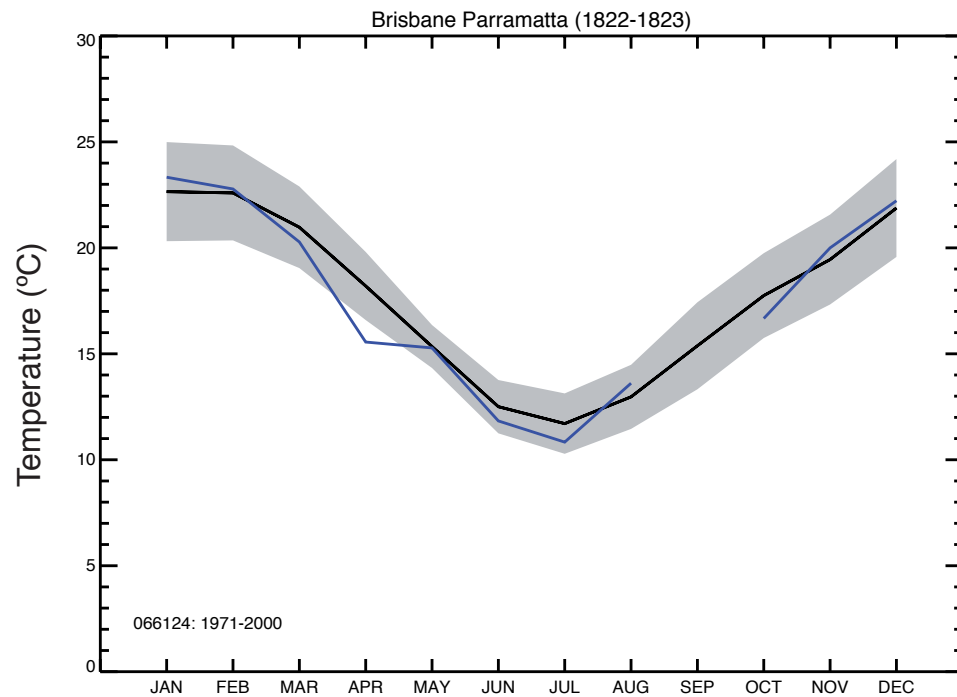
**Methods of Tmax/Tmin estimation:** No attempt was made to estimate Tmax and Tmin, only the mean published temperatures were used.

**Metadata:** As source 9, with the exception that the published table puts the barometer height at 62 feet ASL, rather than 50 feet. The Field (1825) table incorrectly assigned the October 1822 observations to the missing month of September 1822, meaning that each month's observations after this were also assigned to the wrong month.

### Data quality:

*Frequency bias analysis:* As the data are monthly means there is no way to examine observer bias.

*Temperature seasonal cycle analysis:* The seasonal cycle of the Tmean data shown in Figure AI.19 is within the range of modern Parramatta Tmean observations, with the exception of April which is anomalously low.



*Figure AI.19.* Seasonal cycles of published mean temperatures taken by Thomas Brisbane. The seasonal cycle of the published mean temperatures (dark blue line) is compared to the seasonal cycles of nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 11. *Sydney Gazette Parramatta*

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**Date:** April 1823–March 1824

**Location:** Parramatta Observatory at Old Government House, 33.81°S 151.00°E 18.9 m (62 ft) ASL (taken from Bureau station Parramatta, station number 66046). This is the same location as source 9, 10 and 14.

**Location of original data:** This table was published in *The Sydney Gazette and New South Wales Advertiser* (8 April 1824, page 2, available at <http://trove.nla.gov.au/ndp/del/title/3>).

**Observation type:** Absolute highest and lowest pressure, temperature and hygrometer value for each month as well as monthly rainfall totals and prevailing wind direction. These extreme values do not provide much information on mean climate conditions, so only rainfall values used for analysis.

**Methods of Tmax/Tmin estimation:** Only rainfall values were used for analysis

**Metadata:** As source 9 and 10.

### **Data quality:**

*Frequency bias analysis:* As the data are monthly means there is no way to examine observer bias.

*Temperature seasonal cycle analysis:* Only monthly rainfall totals were used, so no temperature seasonal cycle analysis was conducted.

## Source 12. *The Sydney Monitor*

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**Date:** 7 June 1826 (noon temperatures only until 19 July 1826)–19 December 1841

**Location:** Sydney, NSW, 33.86°S 151.21°E, 10 m ASL.

**Location of original data:** Tables were printed in *The Monitor* newspaper, known as *The Monitor* (1826–1828, available at <http://nla.gov.au/nla.news-title76>), *The Sydney Monitor* (1828–1838, available at <http://trove.nla.gov.au/ndp/del/title/95>) and *The Sydney Monitor and Commercial Advertiser* (1838–1841, available at <http://trove.nla.gov.au/ndp/del/title/96>).

**Observation type:** Fixed-hourly temperature values and one word weather descriptions. From 7 June 1826–10 July 1829 observations are given for 7 am, noon and 5 pm. From 11 July 1829–25 December 1838, observations are given for 9 am, noon and 6 pm. From 26 December 1838–19 December 1841, observations are given as morning, noon and evening. There are some small gaps.

### Methods of Tmax/Tmin estimation:

*Estimate 1:* Monthly regression based on half hourly data for 1993–2010 from 66062 and 7 am, 9 am, morning, noon, 5 pm, 6 pm and evening observations. Morning observations were taken at 9 am, evening observations taken as 7 pm.

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

*Estimate 3:* As Estimate 1, but observation times put back half an hour.

*Estimate 4:* As main estimate, but examining each day separately. Two observations per day required for an estimate to be made, and data was required for at least 60% of a month for a monthly average to be calculated.

**Metadata:** According to the article “Public Institutions in Sydney”, published in *The Sydney Herald* (5 July 1841, page 2) *The Sydney Monitor* office was located on the east side of George Street in central Sydney, “opposite the south-east corner of the Old Gaol” (Pickering, 2010). The Old Gaol was on the corner of George and Essex Streets

(Bertie, 2011), meaning that *The Monitor* office was most likely opposite Essex Street (see Figure 3.9).

However, there is no evidence that the observations were actually taken at *The Monitor* office. Nor are there any metadata about who took the observations and how they were taken. The tables simply state that the observations come from “the Sydney area”.

Many overlapping observations between the Sydney newspapers (RON sources 12, 13 and 21) are identical, and one hypothesis could be that the temperature observations came from the same place and were shared by each publication. However, there are also a number of differences between the temperatures reported by each paper, even though they are purported to be at the same time on the same day. The newspaper offices were all within one kilometre of each other in central Sydney (see metadata for sources 13 and 21) so perhaps each office had its own thermometer. This could account for the high level of agreement between the reports but could also explain why they are not identical. A third possibility is that there was one communal thermometer, but it was read at different times by staff from the different papers, and simply printed as being read at an exact hour.

#### **Data quality:**

*Frequency bias analysis:* Figure AI.20 shows a bias towards even values, particularly values that end in zero, suggesting that the thermometer was graded every 2° F.

*Temperature seasonal cycle analysis:* The seasonal cycles of the Tmax and Tmin data are in good agreement with modern Sydney observations, as shown in Figure AI.21. The estimated Tmax and Tmin values during JJA are slightly too low, but DJF values are within the range of modern records.

*Other:* There are a number of typographical errors, including the reprinting of identical data for several weeks; the wrong date and day being assigned to data; and repetition of the same value for day at a time (McAfee, 1981a). The Tmax and Tmin estimates for June 1826–July 1829 have been adjusted after the RHtestsV3 homogenisation program (Wang and Feng, 2010) identified an inhomogeneity in July 1829. This is presumably associated with the change in observation times.

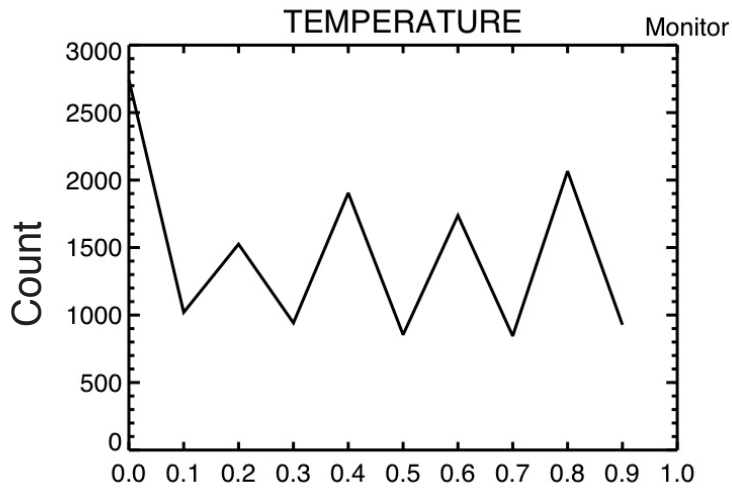


Figure AI.20. Frequency distribution of the temperature observations published in *The Sydney Monitor*, showing the number of temperature observations that end in 0–9.

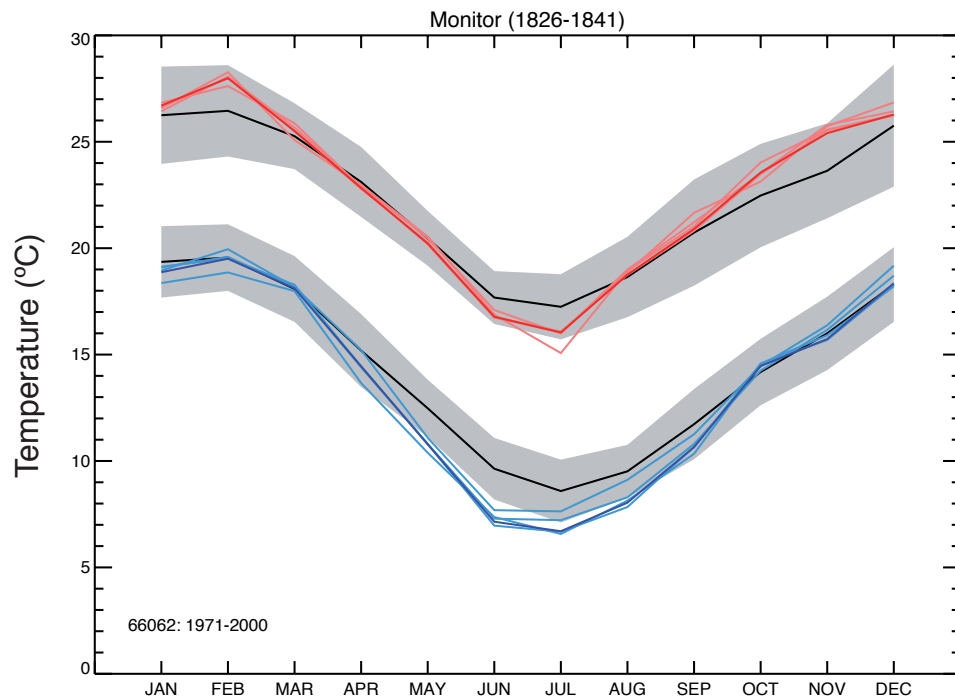


Figure AI.21. Seasonal cycles of Tmax and Tmin estimates from temperature observations published in *The Monitor* newspaper. The seasonal cycles of the mean Tmax and Tmin estimates (dark red and blue lines) are compared to seasonal cycles of individual estimates (light red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.



### Source 13. *The Sydney Herald*

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**Date:** 11 April 1831–20 June 1838

**Location:** Sydney, NSW, 33.86°S 151.21°E, 14 m ASL.

**Location of original data:** Tables were printed in *The Sydney Herald* newspaper, available at <http://trove.nla.gov.au/ndp/del/title/37>.

**Observation type:** Fixed-hourly temperature values and one word weather descriptions. Observations are given for 6 am, noon and 6 pm.

**Methods of Tmax/Tmin estimation:**

*Estimate 1:* Monthly regression based on half hourly data for 1993-2010 from 66062 and 6 am, noon and 6 pm observations.

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

*Estimate 3:* As Estimate 1, but observation times put back half an hour.

*Estimate 4:* As Estimate 1, but examining each day separately. Two observations per day required for an estimate to be made, and data was required for at least 60% of a month for a monthly average to be calculated.

**Metadata:** According to the According to the article “Public Institutions in Sydney”, published in *The Sydney Herald* (5 July 1841, page 2), *The Sydney Herald* office was located on George Street, four doors down from Charlotte Place, now known as Grosvenor Street (Herman, 1970; Pickering, 2010). Again there is no evidence that the observations were actually taken here, and the same hypotheses for *The Monitor* (source 12) data apply.

**Data quality:**

*Frequency bias analysis:* Figure AI.22 shows a bias towards even values, particularly values that end in zero and eight.

*Temperature seasonal cycle analysis:* Seasonal cycles curves of the estimates Tmax and Tmin values, shown in Figure AI.23, display values that are slightly cooler than modern Sydney temperatures in JJA and higher in DJF, similar to source 12. This suggest sub-standard instrument exposure.

*Other:* Just like source 12, there are a number of typographical errors, including the reprinting of identical data for several weeks; the wrong date and day being assigned to data; and repetition of the same value for day at a time (McAfee, 1981a).

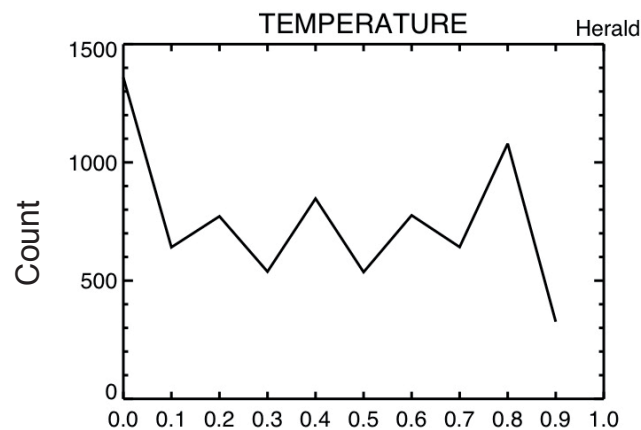


Figure AI.22. Frequency distribution of the temperature observations published in *The Sydney Monitor*, showing the number of temperature observations that end in 0–9.

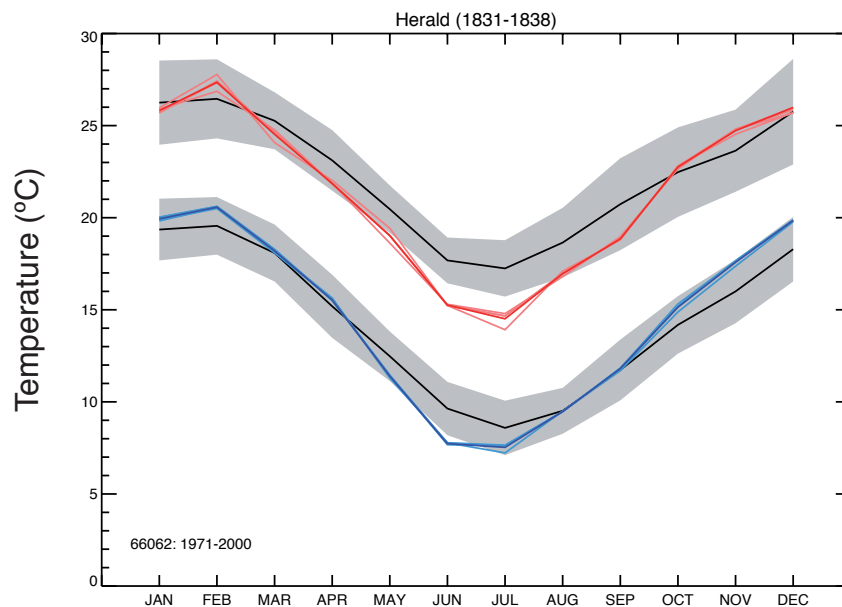


Figure AI.23. Seasonal cycles of Tmax and Tmin estimates from temperature observations published in *The Sydney Herald*. The seasonal cycles of the mean Tmax and Tmin estimates (dark red and blue lines) are compared to seasonal cycles of individual estimates (light red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 14. Dunlop, James

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**Date:** January 1832–April 1876

**Location:** Parramatta Observatory at Old Government House, 33.81°S 151.00°E 15.2 m (50 ft) ASL (taken from Bureau station Parramatta, station number 66046). This is the same location as source 9, 10 and 11.

**Location of original data:** Data came from the Bureau's Parramatta station (number 66046). Some original observations were found in Dunlop's *Astronomical memoranda and observations made with the mural circle at the Parramatta Observatory*, 1832–1840 (Mitchell Library, manuscript number D137–D139) that agree well with the BoM digitised data. Other observations may have come from additional manuscripts, or from the notes of H.C. Russell and Clarke, who communicated frequently with Dunlop (Moyal, 1986).

**Observation type:** Monthly rainfall totals.

**Metadata:** So far no information has been found about the rain gauge used to take these observations. The 1832–1838 observations at least were recorded at the Parramatta Observatory, by James Dunlop who was in charge of the Observatory at the time (Saunders, 2004). The observations in the 1840s were also most likely recorded by Dunlop.

**Data quality:** Monthly data were used and so it was not possible to identify any observer bias. Only rainfall data were analysed so no temperature seasonal cycle analysis was conducted.

**Source 15.** Milligan, Joseph

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**Date:** January 1835–December 1839

**Location:** Hampshire Hills, TAS, 41.26°S 145.78°, 473 m ASL

**Location of original data:** The table of monthly rainfall values was published in *The Tasmanian Journal of Natural Sciences* (1842), Vol 1, pg 78. The journal is available at [http://www.nla.gov.au/ferg/bfull/14400642\\_bfull.html](http://www.nla.gov.au/ferg/bfull/14400642_bfull.html). A monthly table of pressure, temperature and weather descriptions for 1835 was also published (Vol 1, pg 380) but these have not been digitised.

**Observation type:** Monthly rainfall totals.

**Metadata:** Milligan was a surgeon for the Van Diemen's Land Company and was stationed in several places on the north-west of Tasmania (Reynolds, 1926). The table of 1835 data put the location of the observations as 41°18'S, 145°15'E, 1340 ft ASL. It is likely that the observations were taken in the small settlement of Hampshire, and the modern coordinates of this town are used instead.

**Data quality:** Monthly data were used and so it was not possible to identify any observer bias. Only rainfall data were analysed so no temperature seasonal cycle analysis was conducted.

## Source 16. Fawkner, John Pascoe

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**Date:** 8 November 1835–3 August 1836 (sporadic observations from 3 July)

**Location:** Melbourne, VIC, 37.82°S, 144.96°E, 47 m ASL.

**Location of original data:** Observations were written in Fawkner's journal, published by Billot (1982).

**Observation type:** Temperature observations taken several times during the day. Fawkner predominantly recorded at morning, noon and evening, but sometimes ascribed particular times to the morning and evening observations. From 29 April he stopped recording evening observations and began recording at 4 pm. Fawkner also provided small description of the weather conditions, including frost occurrences.

### Methods of Tmax/Tmin estimation:

*Estimate 1:* Monthly regression based on half hourly temperature data for 1997–2012 from BoM station 86071. Observation times for each day examined separately.

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

*Estimate 3:* As Estimate 1, but observation times put back half an hour.

*Estimate 4:* Monthly mean of maximum and minimum value taken at each day. At least 60% of monthly data required for a monthly average.

**Metadata:** Fawkner came on the ship the *Enterprize* in October 1835, the second trip of the ship from Tasmania to Victoria (Anderson, 1966). The *Enterprize* settlers soon made camp on the corner of modern Collins and King Sts (Annear, 2005). The thermometer was kept in a “cool room” (Billot, 1982).

### Data quality:

*Frequency bias analysis:* Figure AI.24 shows a bias towards even temperature values, particularly those ending in 0 and 8.

*Temperature seasonal cycle analysis:* The limited seasonal cycle analysis in Figure AI.25 found much cooler Tmax and Tmin values in the winter. Derek Reid's (1992) analysis found Fawkner's morning observations to be lower and the noon observations to be higher than observations taken at Melbourne's Flagstaff Hill from 1841–1851, all suggesting sub-standard exposure.

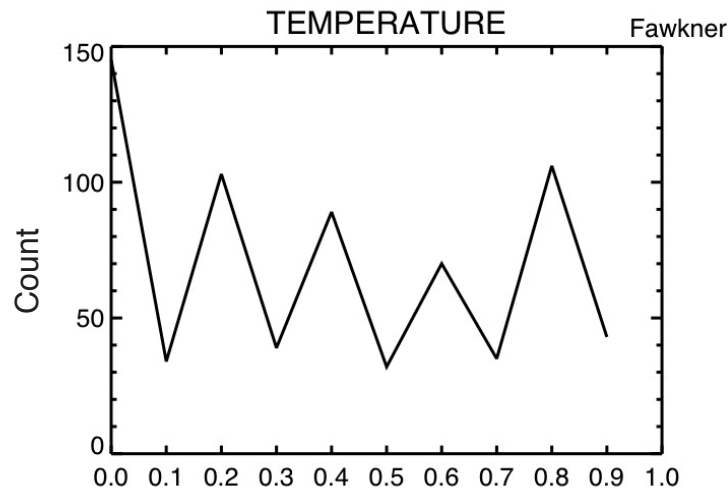


Figure AI.24. Frequency distribution of the temperature observations taken by John Pascoe Fawkner, showing the number of temperature observations that end in 0–9.

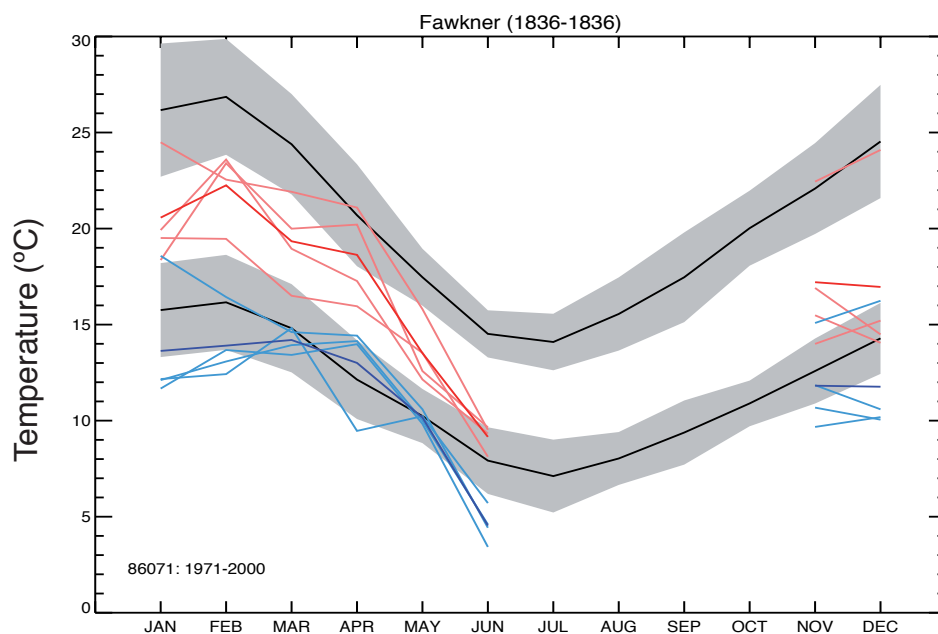


Figure AI.25. Seasonal cycles of Tmax and Tmin estimates from temperature observations taken by John Pascoe Fawkner. The seasonal cycles of the mean Tmax and Tmin estimates (dark red and blue lines) are compared to seasonal cycles of individual estimates (light red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 17. Robinson, George Augustus

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**Date:** 1 January 1836–1 February 1839 (December 1837 missing)

**Location:** Flinders Island, TAS, 40.02°S 147.88°E, 14 m ASL

**Location of original data:** The original observations are in Robinson's papers at the State Library of New South Wales, Volume 52, Part 3 (ML A 7053- A 7084).

**Observation type:** Temperature observations taken at 6 am, 10 am, 2 pm and 6 pm.

### Methods of Tmax/Tmin estimation:

*Estimate 1:* Monthly regression based on hourly data from 99005 for 1993–2012 and data for 6 am, 10 am, 2 pm and 6 pm.

*Estimate 2:* As Estimate 1, but observation times put forward one hour, rather than half an hour, due to modern data availability.

*Estimate 3:* As Estimate 1, but observation times put back one hour, rather than half an hour, due to modern data availability.

*Estimate 4:* As main estimate, but examining each day separately. Two observations per day required for an estimate to be made, and data was required for at least 60% of a month for a monthly average to be calculated.

**Metadata:** Robinson was on Flinders island in the 1830s as “Chief protector of Aborigines” (Australian Dictionary of Biography, 1967). The only settlement during that time was Wybalenna, or Black Man's Land, which was set up in 1834 as a place where Aboriginal people could be kept safe from settlers (Shaw, 2006). Wybalenna is on the western side of Flinders Island, and only the chapel remains (Flinders Island Tourism Association, 2013). The coordinates have been taken from Wybalenna.

### Data quality:

*Frequency bias analysis:* Figure AI.26 shows a bias towards temperature observations ending in zero and six.

*Temperature seasonal cycle analysis:* The estimated seasonal cycle shown in Figure AI.27 is similar modern record for Flinders Island, with slightly higher values in the early summer and lower values in autumn. The modern observations come from about 20km south of Wybalenna, which could explain some of the difference.

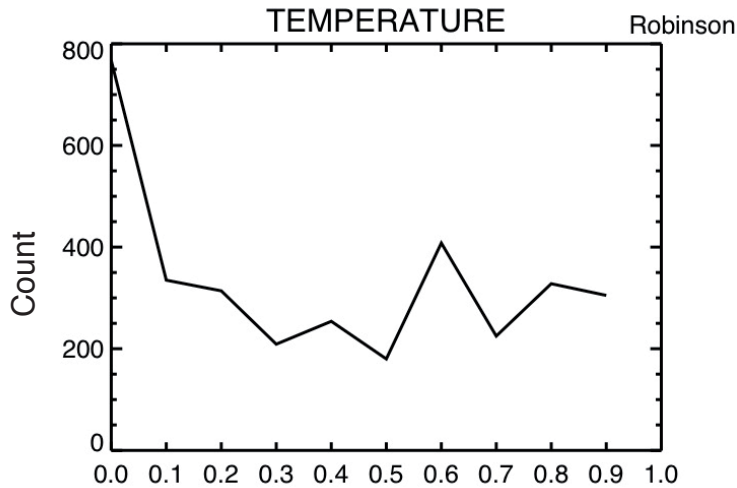


Figure AI.26. Frequency distribution of the temperature observations taken by George Augustus Robinson, showing the number of temperature observations that end in 0–9.

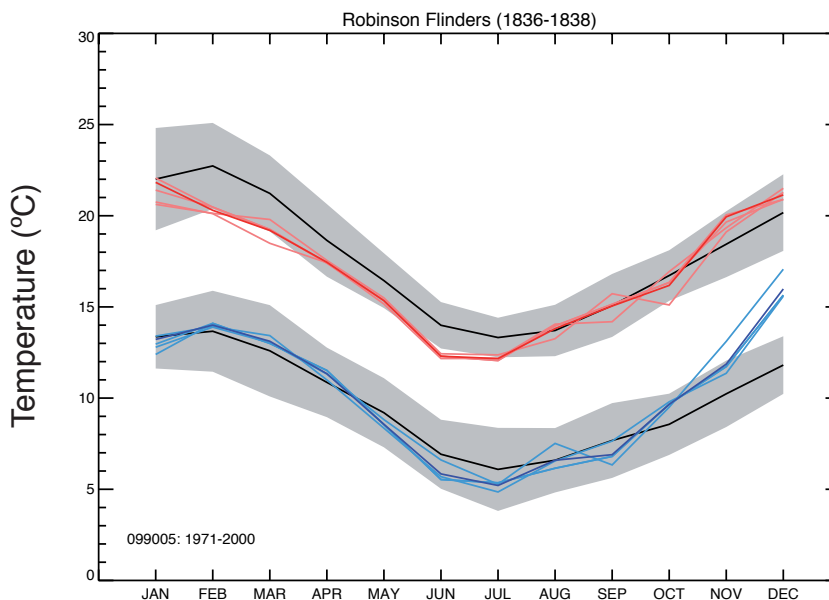


Figure AI.27. Seasonal cycles of Tmax and Tmin estimates from temperature observations taken by George Augustus Robinson. The seasonal cycles of the mean Tmax and Tmin estimates (dark red and blue lines) are compared to seasonal cycles of individual estimates (light red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.



## Source 18. Lempriere, Thomas

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**Date:** 1 May 1837–31 December 1842.

**Location:** Port Arthur, TAS, 43.15°S, 147.85°E, various heights ASL.

**Location of original data:** Original observations housed at the Bureau of Meteorology Head Office Library, Melbourne (manuscript number 32).

**Observation type:** Temperature and pressure observations taken at 8 am, 2 pm and 8 pm, as well as daily rainfall totals and weather descriptions. Hourly observations taken during the solstices.

### **Methods of Tmax/Tmin estimation:**

*Estimate 1:* Monthly mean of maximum and minimum temperature observed each day, as no appropriate modern sources of subdaily temperature could be found for Port Arthur.

*Estimate 2:* Maximum and minimum monthly mean from the 8 am, 2 pm and 8 pm monthly means.

**Metadata:** Observations were taken at the Port Arthur penal settlement by Lempriere or his officers (Lempriere, 1954). The original observations mention a number of instrument moves and give several different heights above sea level, indicating that the job might have been shared. This view is supported by Derek Reid who analysed these data in the early 1990s. He wrote that “while entering the data it was evident that the hand-writing varied, indicating more than one person was involved in copying the results, and that the care and understanding in observing also seemed to change.” (D. Reid, personal communication, 2010).

On the other hand, Lempriere was clearly aware of the contemporary standards of weather observing in the English colonies. Observations were taken at 8 am, 2 pm and 8 pm except for the solstices, when observations were taken hourly. This is the method outlined in the literature of the time (e.g. The Meteorological Committee of

the South African Literary and Philosophical Institution and Institution, 1835). He also took simultaneous observations when replacing barometers, and was in contact with Commander Kay at the Hobarton Observatory, suggesting a keen engagement with the local scientific community.

Some of the noted site moves and other relevant metadata from the original observations include:

May 1837–14 January 1838: Instruments 57.5 feet ASL.

4 September 1837: External thermometer stolen.

15 January 1838: Instruments moved to 27 feet ASL.

26 February 1838: Barometer and thermometer moved to 57  $\frac{7}{12}$  feet ASL.

There are two tables marked April 1838. One gives the instrument height as 52 feet ASL and one gives it as two feet. The observations taken at two feet are taken to be for April 1839, because in 1839 the instruments were around that height.

22 August 1838: Instruments move to two feet ASL. This is supported by Lempriere (1954) which states that the “meteorological registers” were in the Commissariat’s Office, close to the water’s edge.

9 September 1839: Instruments moved to 52.3 feet.

8 December 1839: Received a new chronometer [high precision clock].

25 October 1840: “On comparing the barometer with the standard barometer on the 25th instant an error minus 0.642 has been ascertained. Therefore 0.642 will have to added to each observation to bring it to the standards.”

1 February 1841: New barometer. Height is 65 feet ASL. “It will be observed that since the 7th (of January) the observations of a second barometer have been added, which from the 1st February will be the register. This register barometer has been compared with the Royal Society’s standard at the observatory in Hobarton and requires when

under its neutral point 30.402, an addition of 0.030. On comparing the register and the old barometer the average of the difference of the 25 first observations is 0.706 which less .030 leaves .676, thus increasing the difference between the old barometer from .642 as established by Captain Ross by 0.034. The mean will therefore be 29.801.”

### Data quality:

*Frequency bias analysis:* Observations taken at each height were examined separately, assuming that a different person was responsible for the observations every time the instruments moved. Observation frequency plots for the full dataset are shown in Figure AI.28. Observations at most heights show a bias towards temperature observations ending in three and eight, and pressure observations rounded to the nearest 10th or 50th of an inch. There is a secondary negative bias away from temperature observations

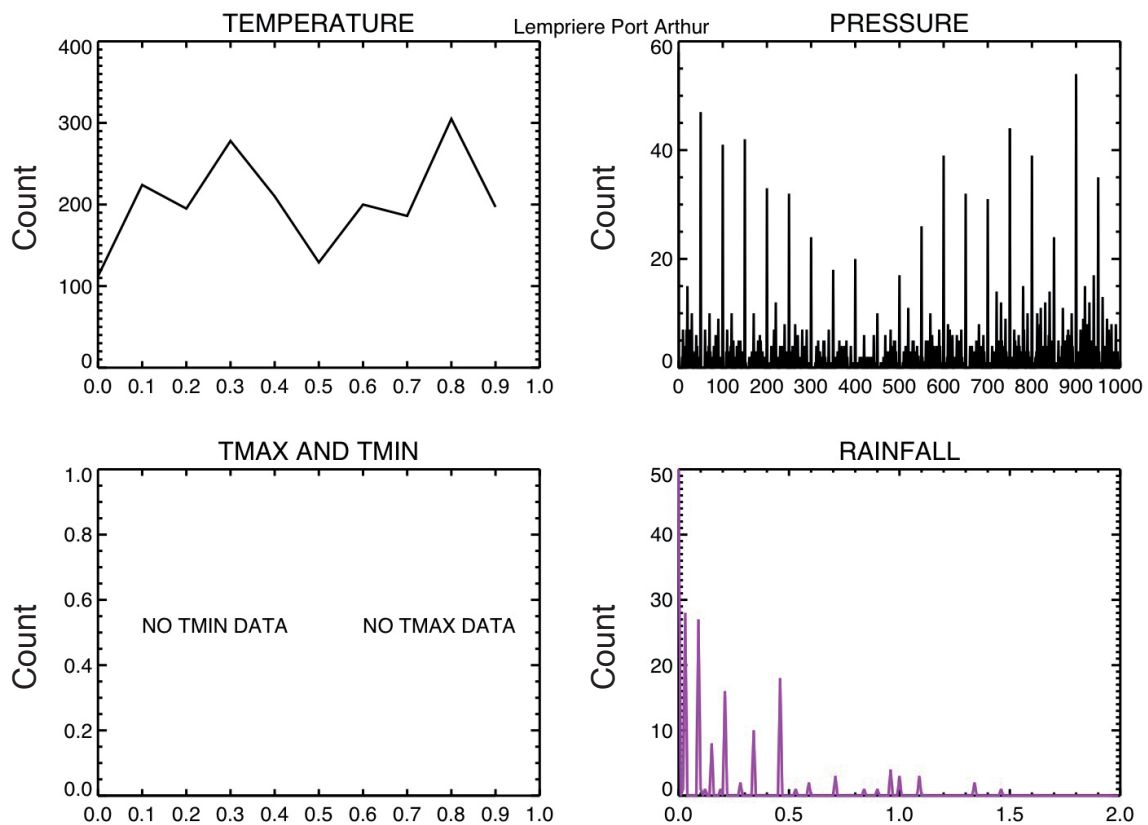
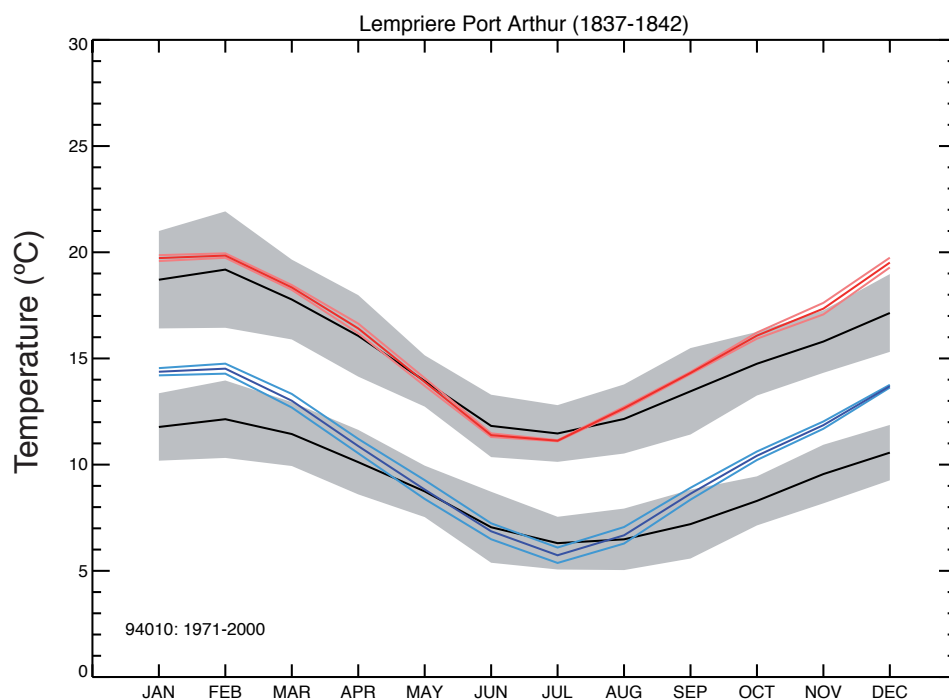


Figure AI.28. Frequency distribution of the Thomas Lempriere temperature, pressure and rainfall observations. The temperature plot (top left) show the number of temperature observations that end in 0–9. The pressure plot (top right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins. The rainfall plots (bottom left) show the number of rainfall observations in each 0.005 inch bin from 0 to 2 inches.

ending in five. This may indicate that the same person (with the same biases) did take all observations, although it could also be due to the design of the thermometer and barometer scale.

*Temperature seasonal cycle analysis:* Seasonal cycle analysis shown in Figure AI.29 reveals slightly warmer than average temperatures from October to May, particularly for Tmin. This is most likely due to sub-standard instrument exposure, but could also be due to difference between the location of the modern BoM station (94010, Cape Bruny Lighthouse) and Port Arthur. Port Arthur is around 40 km north east of Cape Bruny Lighthouse, and may experience a slightly larger seasonal cycle.

*Other:* As discussed in section 5.4, the Lempriere pressure observations were adjusted to account for the change in barometer that occurred in February 1841.



*Figure AI.29.* Seasonal cycles of Tmax and Tmin estimates from temperature observations taken by Thomas Lempriere. The seasonal cycles of the mean Tmax and Tmin estimates (dark red and blue lines) are compared to seasonal cycles of individual estimates (light red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 19. Wyatt, William

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**Date:** 1 January 1838–31 December 1847

**Location:** Adelaide, SA, 34.93°S 138.60°E 47 m ASL.

**Location of original data:** The original observations are located at the State Archives of Adelaide (McAfee, 1981a). Digitised values were obtained from Tony Rogers at the Bureau of Meteorology in Adelaide, December 2011.

**Observation type:** Temperature and pressure observations at 9 am, 3 pm and 9 pm, (pressure observations begin in 1841). From 1841–1844 Wyatt also recorded the daily Tmax and Tmin. Monthly tables of Wyatt’s observations also contain the number of raindays per month.

### Methods of Tmax/Tmin estimation:

*Estimate 1:* Monthly regression based on half hourly data for 1993–2012 from 23090 and 9 am, 3 pm and 9 pm observations.

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

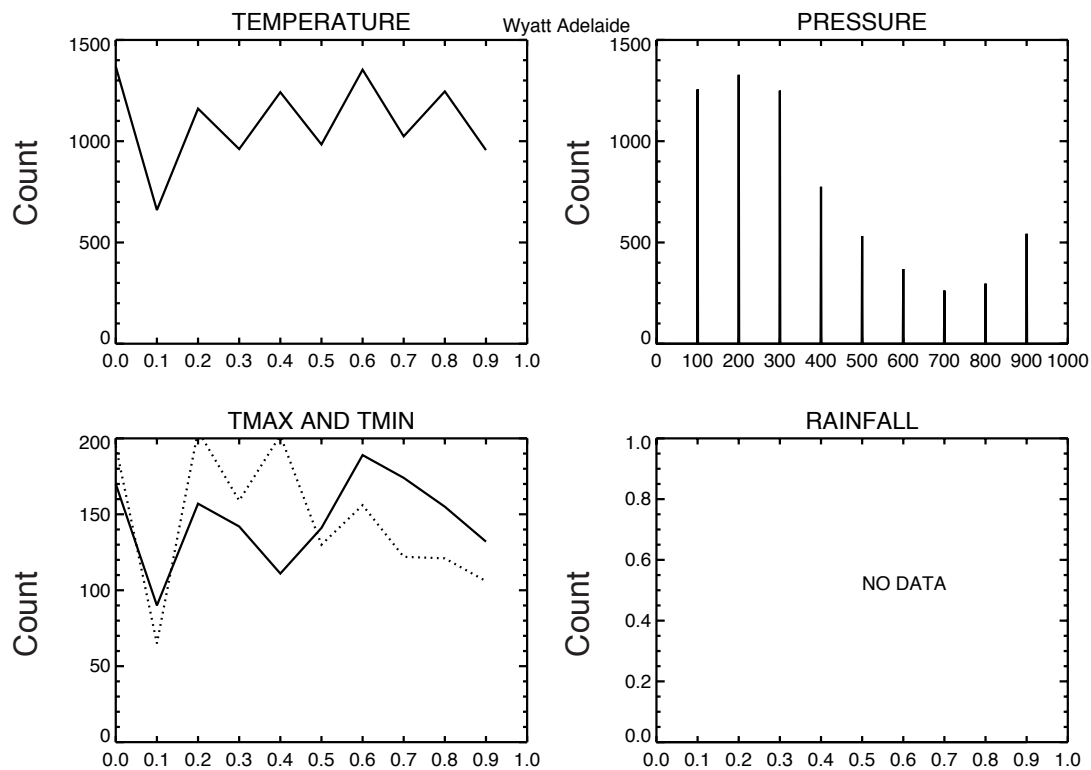
*Estimate 3:* As Estimate 1, but observation times put back half an hour.

*Estimate 4:* Observed maximum and minimum temperatures published for 1841–1844.

**Metadata:** According to Tony Roger’s book *Weather and the Science of Settlement* (2011), William Wyatt lived between Grenfell and Pirie Streets in Adelaide, not far from Hindmarsh Square. There is a street there called Wyatt Street, and this has been taken as the location of the observations.

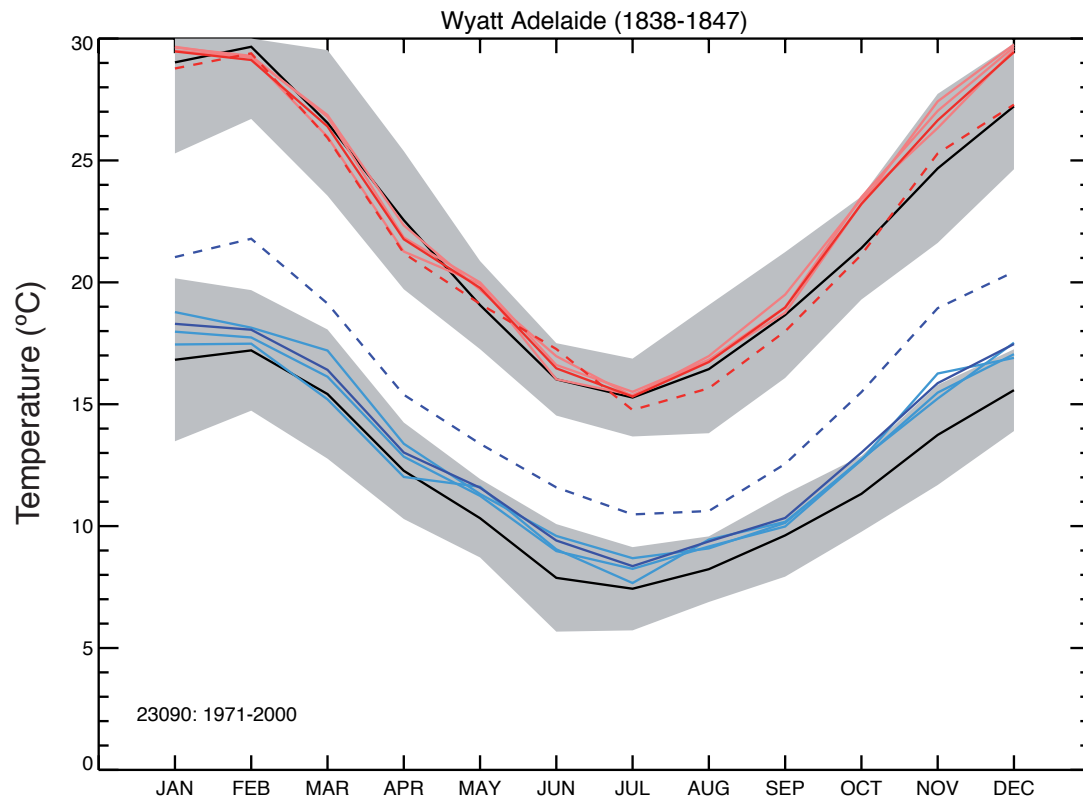
### Data quality:

*Frequency bias analysis:* Figure AI.30 shows that the observations have a positive bias towards even values in the temperature observations, and a bias against observations ending in one. Pressure observations are only given to the nearest 10th of an inch, suggesting that the barometer scale was not of high resolution.



*Figure AI.30.* Frequency distribution of the William Wyatt temperature and pressure observations. The temperature plot (top left) show the number of temperature observations that end in 0–9. The distributions for Tmax and Tmin observations are plotted similarly (bottom left). The Tmax distribution is plotted in a solid line, and the Tmin distribution in a dotted line. The pressure plot (top right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins.

*Temperature seasonal cycle analysis:* There is good agreement between the seasonal cycle of Wyatt’s temperature observations and modern Adelaide observations, as shown in Figure AI.31. The only exception to this is the published Tmin observations from 1841–1844, which are much higher than the estimated Tmin values. This may be due to the Wyatt’s observing times (9 am, 3 am and 9 pm), which are unlikely to capture the minimum temperature of the day.



*Figure AI.31.* Seasonal cycles of Tmax and Tmin estimates from temperature observations taken by William Wyatt. The seasonal cycle of the mean Tmax and Tmin estimates (dark red and blue lines) and the published Tmax and Tmin values (dark red and blue dashed lines) are compared to seasonal cycles of individual estimates (light red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

**Source 20.** Kingston, George Strickland

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**Date:** 1 January 1839–31 December 1879

**Location:** Adelaide, SA, 34.92°S 138.59°E 40 m ASL. Coordinates taken from the BoM station Adelaide (West Terrace), station number 23000.

**Location of original data:** The original observations are published by Kingston (1879). Daily values were obtained from the BoM, station number 23000.

**Observation type:** Daily rainfall observations.

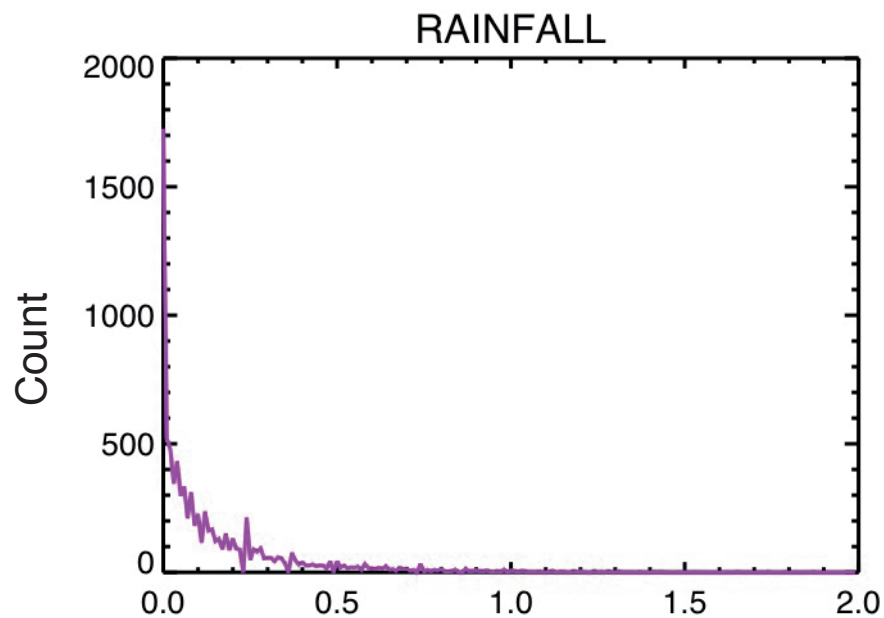
**Metadata:** Kingston lived on Grote Street, near West Terrace in central Adelaide. Kingston's house is shown in Figure AI.32. The BoM assigned Kingston's daily rainfall values on the following day to Kingston, to adhere to their definition of daily rainfall amount as the amount of rain to fall "to 9am of the previous day". This has been reversed in this study, ascribing rainfall amounts to the day given by Kingston to be consistent with the other pre-1859 data sources. There is no information about instrument type, but as discussed in Chapter 3, Kingston was a dedicated observer.



*Figure AI.32.* . George Strickland Kingston's Adelaide residence on section 322 Grote Street circa 1923. Image: State Library of South Australia.



**Data quality:** The rainfall observations do not show any significant biases, shown in Figure AI.33.



*Figure AI.33.* Frequency distribution of the George Strickland Kingston rainfall observations. The plot shows the number of rainfall observations in each 0.005 inch bin from 0 to 2 inches.

## Source 21. *The Chronicle*

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**Date:** 20 December 1839–15 May 1848

**Location:** Sydney, NSW, 33.87°S 151.21°E 20 m ASL.

**Location of original data:** Tables were published weekly in *The Australasian Chronicle* from 20 December 1839 to 3 October 1843, *The Morning Chronicle* from 4 October 1843 to 7 July 1846 and *The Sydney Chronicle* from 8 July 1846 to 15 May 1848. All newspapers are available from the National Library of Australia's Trove database (<http://trove.nla.gov.au/ndp/del/title/48>, <http://trove.nla.gov.au/ndp/del/title/78>, <http://trove.nla.gov.au/ndp/del/title/94>).

**Observation type:** Three times daily temperature observations were published, as well as a one word description of the daily weather. Observations were originally published for 6 am, noon and 6 pm, but from 2 June 1840 were simply given as morning, noon and evening observations.

### Methods of Tmax/Tmin estimation:

*Estimate 1:* Monthly regression based on half hourly data for 1993–2010 from 66062 and 6 am, noon and 6 pm observations. Morning and evening observations were taken as 6 am and 6 pm.

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

*Estimate 3:* As Estimate 1, but observation times put back half an hour.

*Estimate 4:* As Estimate 1, but examining each day separately. Two observations per day required for an estimate to be made, and data was required for at least 60% of a month for a monthly average to be calculated.

**Metadata:** According to the According to the article “Public Institutions in Sydney”, published in *The Sydney Herald* (5 July 1841, page 2), *The Australian Chronicle* office was located on George Street, down the south end near King Street. However, many issues of *The Chronicle* give the office address as 67 Pitt Street, Sydney. These

addresses are about 300 m apart. Coordinates were taken at the George Street address, although there is no evidence that the observations were actually taken at the newspaper office (see source 12).

There is not much information about how the observations were taken (similar to the other Sydney newspapers, sources 12 and 13), but *The Australasian Chronicle* contains a letter from “An Observer” in 1842 with observations matching those published by the newspaper. According to this letter, the thermometer used was “fixed in the shade on the east side of the house, the proper place for it” (*The Australasian Chronicle*, 18 January 1842, page 2).

### Data quality:

*Frequency bias analysis:* Figure AI.34 shows that the temperature observations have a clear bias towards values ending in zero, with a secondary bias towards even numbers.

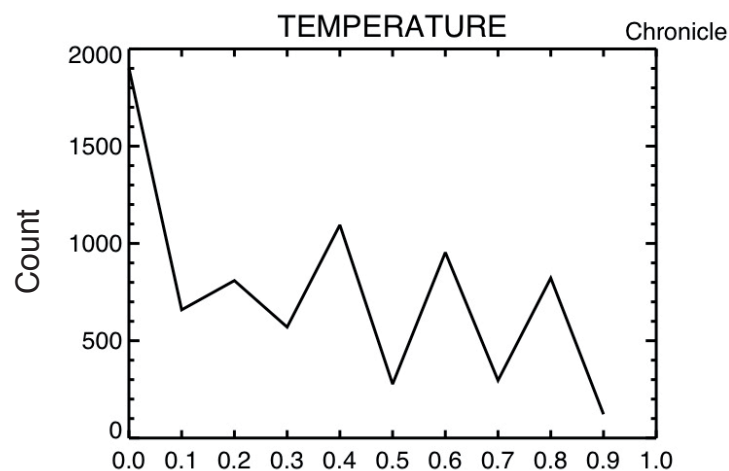
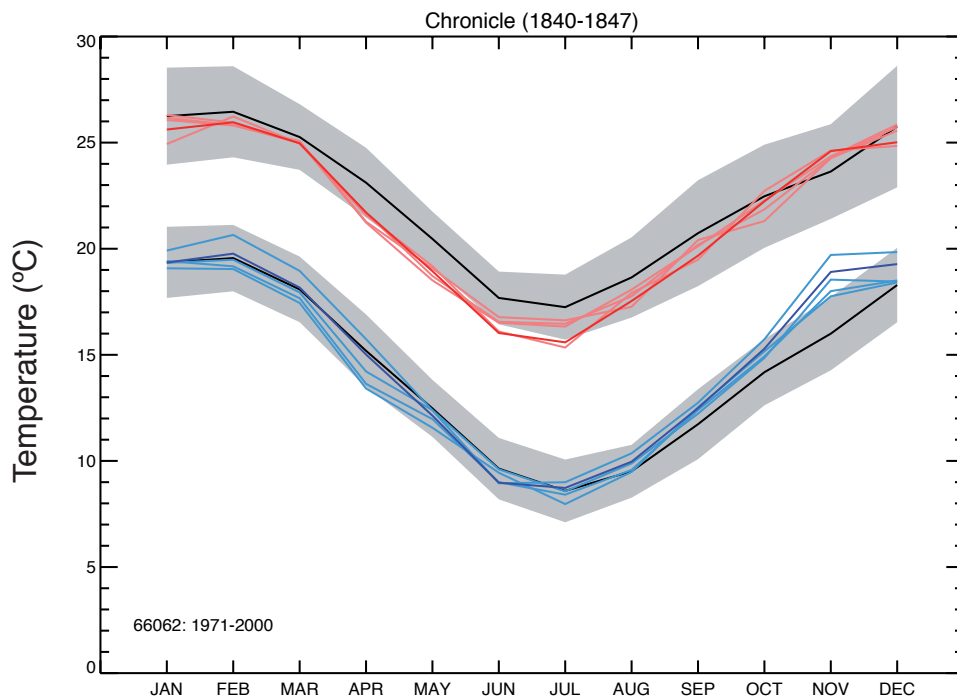


Figure AI.34. Frequency distribution of the temperature observations published in *The Chronicle*, showing the number of temperature observations that end in 0–9.

*Temperature seasonal cycle analysis:* The estimated Tmax seasonal cycles, shown in Figure AI.35, are slightly lower than the modern Sydney seasonal cycle, although generally within the range of uncertainty. Estimated Tmin values are conversely slightly higher than the modern Tmin seasonal cycle, particularly during austral spring (SON).

*Other:* Just like the *Monitor* and *Herald* data, there are a number of typographical errors, including the reprinting of identical data for several weeks; the wrong date and day being assigned to data; and repetition of the same value for day at a time (McAfee, 1981a).



*Figure AI.35.* Seasonal cycles of Tmax and Tmin estimates from temperature observations published in *The Chronicle*. The seasonal cycles of the mean Tmax and Tmin estimates (dark red and blue lines) are compared to seasonal cycles of individual estimates (light red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 22. Wickam, John

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**Date:** January 1840–December 1846

**Location:** Moreton Bay (now known as Brisbane), QLD, 27.42°S 153.02°E 27 m ASL.

**Location of original data:** These observations were published in *The Moreton Bay Courier* on 23 January 1847, page 4 (available at <http://trove.nla.gov.au/ndp/del/title/14>). The rainfall observations are also available from BoM station Brisbane, station number 40214. So far only the published monthly totals for 1840–1846 inclusive have been located.

**Observation type:** Monthly rainfall totals in inches. Ten-day means of temperature were also published from June 1844–December 1846, but these have not been digitised due to time constraints.

**Metadata:** Wickham gives a detailed description of the rain gauge used at the end of the published table:

“I am indebted to Mr Kent for the register of the rain that fell during the years 1840, 1841 and 1842; and as the means used by him are of so simple a nature, and have been used by me throughout the observations, they are described for the benefit of those who may be desirous of establishing rain gauges in different parts of the district:

A small funnel, the bowl of which measures exactly ten superficial inches, is firmly fixed into a cork in the neck of a bottle, and the rain that falls into the bottle, through the funnel, is measured in a phial graduated to ounces—and as an ounce of water is equal to 1.73298 cubic inches, the number of cubic inches of rain that have fallen is determined by multiplying the tenth part of 1.73298, or 1.733, by the number of ounces measured in the phial....A funnel of any known superficies may be used, but ten inches gives the most simple calculation.”

He also gave some information about the temperature readings that were published, saying that “The average temperature is the register of the thermometer at 9 am in the shade, which is taken to be a near approximation to the mean temperature of each

day; the months are divided into three periods of ten days each period is given in the abstract.”

Wickham additionally mentions barometer reading that were taken “during the last six months of 1846”, but were not published in the *The Moreton Bay Courier*. He claims that “during that period the range of mercury has been considerable, being highest with southerly and SE winds, and much depressed with westerly winds. In the middle of July it stood at 30.61 [inHg] with SSE winds, and in the latter part of the same month it fell to 29.72 [inHg], with strong westerly and WNW winds, the thermometer on the later occasion rising to 92 °[F] at 2 pm, whereas with the southerly winds it was not higher than 61 °[F].”

Captain Wickham lived in commandant’s quarters from his arrival in Brisbane in 1843 until 1847. The commandant’s quarters were located near the Commissariat Stores and the Queen’s Wharf in central Brisbane, near where the Government Printing Office was built in 1887 (Drury Clarke, 1984). The Government Printing Office still stands, and is at 84 William St (Brisbane Tourist Information, 2013). The coordinates are taken from that location.

**Data quality:** It was not possible to identify any observer bias as the published data were monthly totals.

## Source 23. Port Jackson *Government Gazette*

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**Date:** April 1840–December 1855

**Location:** Port Jackson (eastern Sydney), NSW, 33.83°S 151.28°E, 89 m ASL.

**Location of original data:** The monthly abstracts were published in the *New South Wales Government Gazette*, available from the State Library of Victoria (<http://gazette.slv.vic.gov.au/>). Original subdaily observations from December 1848 to November 1849 have been located in the Commonwealth Archives in Sydney (Derek Reid, personal communication), but have not been digitised due to time constraints. Observations from Port Jackson continued to be published in *The Sydney Morning Herald* until November 1856 (see source 38).

**Observation type:** From April 1840 to March 1841, mean monthly temperature and pressure observations were published, along with rainfall amounts and number of raindays. From April 1841 to December 1855, monthly means of temperature, attached temperature and pressure at 8:30 am, 2:30 pm, sunset and 9 pm were published, as well as monthly rainfall totals, the number of raindays and the date and amount of the highest rainfall. In this study, the mean pressure values from April 1840–March 1841 were combined with the 8:30 am pressure values from April 1841 onwards to provide a pressure record for the entire period. The highest and lowest values for each week of each variable were also published, but were not digitised due to time constraints. Detailed descriptions of the week's weather were also provided. From June 1847, monthly means of Tmax and Tmin were published as well.

*Estimate 1:* Monthly regression based on half hourly data for 1993–2010 from 66037 and 8:30 am, 2:30 pm, sunset and 9 pm

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

*Estimate 3:* As Estimate 1, but observation times put back half an hour.

*Estimate 4:* Observed maximum and minimum temperatures from 1847–1855.

Note that Tmax and Tmin estimates were only calculated for 1842–1855, as the 1840–1842 data were mean temperature only.

**Metadata:** Observations were most likely taken at the South Head lighthouse or signal station, at the South Head of Sydney's Port Jackson. The observer was George Edwards Peacock, a “white collar” convict who was also a gifted painter (see section 3.2). Station height is given at 254 feet and later 240 feet ASL, although there is no documented site move. In August 1843 a “mountain barometer” replaced the “common barometer” that was being used. Peacock took three months of parallel observations to determine the difference between the two. Russell (1877) provides the following information about the instruments used, “extracted from the observation sheets:

*Barometer:* Is not described, but it appears in the history that it was a good mercurial barometer, and was compared by Mr. Dunlop, the Astronomer, with a Troughton and Simms' [a British instrument maker] standard.

*Internal [attached] thermometer:* Attached to the barometer and has the ball exposed.

*External thermometer:* Is in a southern exposure, five feet above the ground, placed against a stone wall in a small screen of wood, which protects it from direct or indirect radiation, rain etc., and at the same time admits a free circulation of air.

*Rain gauge:* Is cylindrical, ten inches in diameter, with sides two inches deep, then descending to a tubular hole of half an inch diameter, to prevent as much as possible evaporation and other decrease; it is placed on the ground in a perfectly open situation. (The first gauge seems to have been six inches in diameter, and the change from six to ten inches was made between 1845 and 1849)."

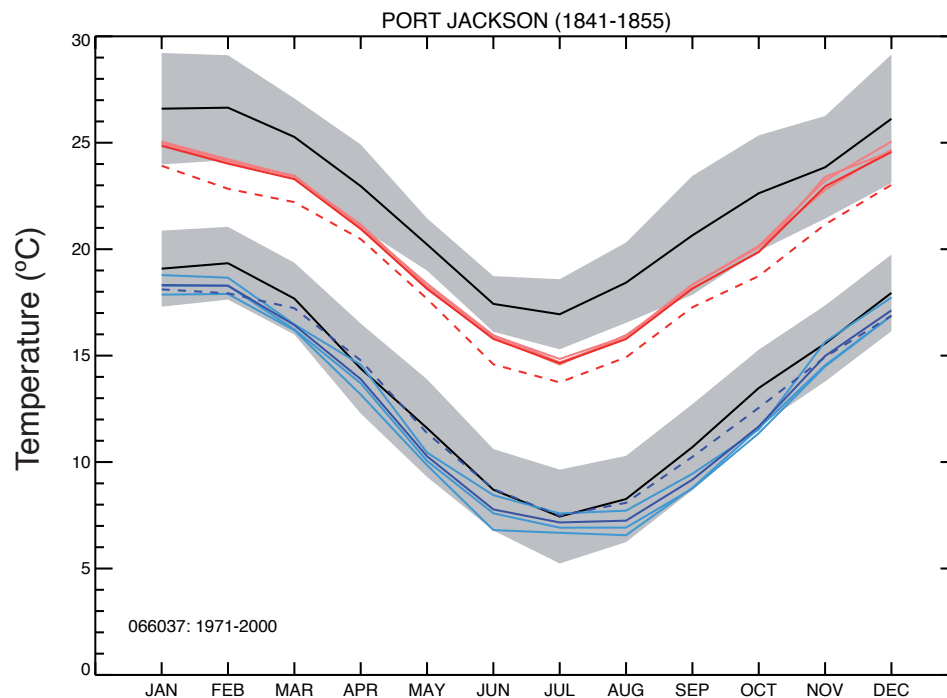
#### **Data quality:**

*Frequency bias analysis:* The data are monthly only, so no observer bias analysis could be conducted.

*Temperature seasonal cycle analysis:* Figure AI.36 shows that the Tmax seasonal cycle (both the values estimated from the fixed hourly observations, and the observed values from 1847–1851) has a similar shape to the modern observations, even though



the 1842–1855 temperatures are cooler. The cooler absolute temperatures might be due to the modern observations coming from the Sydney Airport, which is further inland than the Port Jackson signal station. The estimated and observed Tmin observations are very similar to the modern Tmin seasonal cycle.



*Figure AI.36.* Seasonal cycles of Tmax and Tmin estimates from the Port Jackson temperature observations. The seasonal cycles of the mean Tmax and Tmin estimates (dark red and blue lines) are compared to seasonal cycles of individual estimates (light red and blue lines), the observed Tmax and Tmin values (dashed red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

*Other:* Peacock was trained in taking meteorological observations, and Russell (1877) believed that the observations were well kept. Todd on the other hand, thought that the observations were not taken very well (see Chapter 3 and Todd, 1893). Peacock was definitely engaged in the scientific community of Sydney writing regularly to local newspapers, WB Clarke and other contemporaries (Moyal, 2003).

## Source 24. Port Phillip *Government Gazette*

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**Date:** July 1840–December 1851

**Location:** Melbourne, VIC, 37.81°S 144.95°E 41 m ASL

**Location of original data:** The monthly abstracts were published in the *New South Wales Government Gazette*, available from the State Library of Victoria (<http://gazette.slv.vic.gov.au/>). Original subdaily observations from January–November 1849 have also been located in the Commonwealth Archives in Sydney (Derek Reid, personal communication). Subdaily observations from April 1840– January 1842 have also been located in the Public Records Office of Victoria (Reid, 1992). Neither of these sources have not been digitised due to time constraints.

**Observation type:** From July 1840 to December 1841, mean monthly temperature and pressure observations were published, along with rainfall amounts and number of raindays. Reid's (1992) analysis of the early Port Phillip original observations states that measurements were taken at sunrise, 9 am, noon, 6 pm and 11 pm, so the mean values may have come from an averaging of these observation times. From January 1842 to December 1851, monthly means of temperature, attached temperature and pressure at 8:30 am, 2:30 pm, sunset and 9 pm were published, as well as monthly rainfall totals, the number of raindays and the date and amount of the highest rainfall. The mean pressure values from 1840–1841 were combined with the 8:30 am pressure values from 1842–1851 to provide a pressure record for the entire period. The highest and lowest values for each week of each variable were also published, but were not digitised due to time constraints.

### Methods of Tmax/Tmin estimation:

*Estimate 1:* Monthly regression based on half hourly temperature data for 1997–2012 from BoM station 86071. Observation times for each day examined separately.

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

*Estimate 3:* As Estimate 1, but observation times put back half an hour.

Note that Tmax and Tmin estimates were only made for 1842–1851 as only mean temperature data were available for 1840–1842.

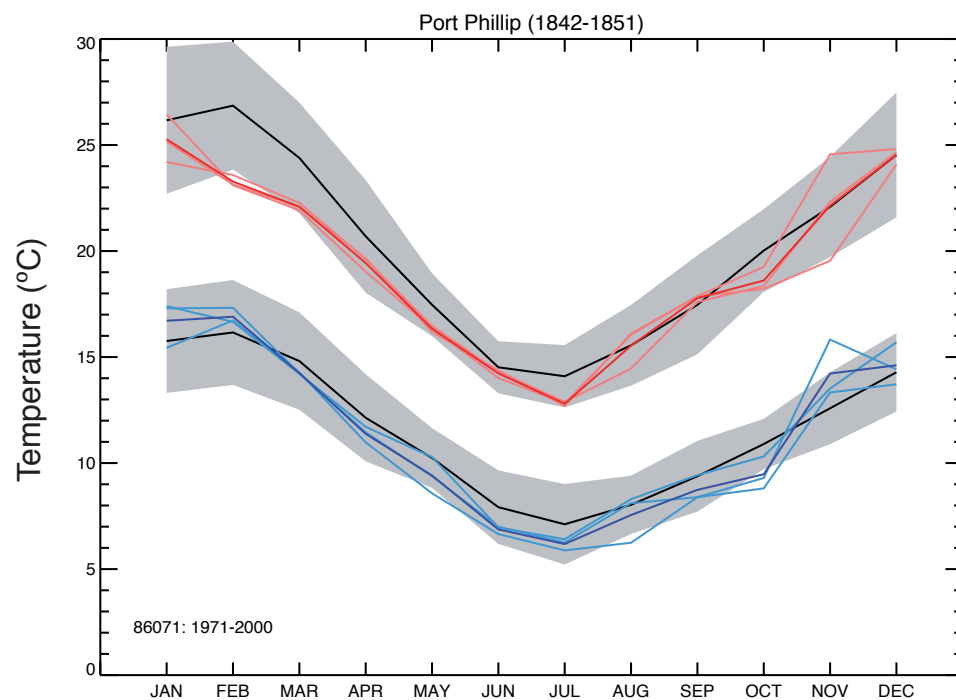
**Metadata:** Observations were taken at the Flagstaff Hill signal station in central Melbourne (Baracchi, 1919; Reid, 1992). The observations were initially taken by a trained convict Philip Hervey (Reid, 1992; Rosel, 2011), although he may not have been the observer for the whole period. In fact, Reid (1992) suggests that he was relieved of his duties in early 1842. In his analysis of the data, Reid (1992) wrote “The impression gained from working with Hervey’s observations is that he approached the job with enthusiasm for the first few months, experimenting and adding new equipment...It seems that he would have been the sole occupant of the Signal Station, responsible also for reporting shipping movements, and that he settled into a routine which varied little.”

A marine barometer belonging to Mr Latrobe was used to record pressure after July 1840 (Reid, 1992), but no information has been found about the external thermometer or rain gauge used. It is logical to assume that the instruments were similar to those used at the Port Jackson station, at least for the first part of the record. Reid (1992) asserts that the external thermometer was “in the shade”.

**Data quality:**

*Frequency bias analysis:* The data are monthly only, so no observer bias analysis could be conducted.

*Temperature seasonal cycle analysis:* The estimated seasonal cycles of Tmax and Tmin, shown in Figure AI.37 are a very similar shape to modern cycles, although Tmax estimates show a slightly reduced seasonal variability. Estimated Tmax and Tmin are cooler than the modern mean, particularly Tmax estimates from January–July.



*Figure AI.37.* Seasonal cycles of Tmax and Tmin estimates from the Port Phillip temperature observations. The seasonal cycles of the mean Tmax and Tmin estimates (dark red and blue lines) are compared to seasonal cycles of individual estimates (light red and blue lines) and neighbouring BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 25. Port Macquarie *Government Gazette*

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**Date:** August 1840–November 1851

**Location:** Port Macquarie, NSW, 31.43°S 152.92°E 16m ASL.

**Location of original data:** The monthly abstracts were published in the *New South Wales Government Gazette*, available from the State Library of Victoria (<http://gazette.slv.vic.gov.au/>). Original subdaily observations from January–November 1849 have also been located in the Commonwealth Archives in Sydney (Derek Reid, personal communication), but have not been digitised due to time constraints.

**Observation type:** From August 1840 to December 1841, mean monthly temperature and pressure observations were published, along with rainfall amounts and number of raindays. From January 1842 to December 1851, monthly means of temperature, attached temperature and pressure at 8:30 am, 2:30 pm, sunset and 9 pm were published, as well as monthly rainfall totals, the number of raindays and the date and amount of the highest rainfall. The mean pressure values from 1840–1841 were combined with the 8:30 am pressure values from 1842–1851 to provide a pressure record for the entire period. The highest and lowest values for each week of each variable were also published, but were not digitised due to time constraints.

### Methods of Tmax/Tmin estimation:

*Estimate 1:* Monthly regression based on 9 am and 3 pm data from 60026 for 1957–2003 and 8:30 am and 2:30 pm data. Note that Tmax and Tmin estimates were only made for 1842–1851 as only mean temperature data were available for 1840–1842.

**Metadata:** Observations were most likely taken at the Port Macquarie signal station. The historic signal station was on Flagstaff Hill, just south of the mouth of the Hastings River (Port Macquarie–Hastings Council, 2009). The published abstracts give the station height at 53 feet (16 m) ASL, and this height is used for analysis, although Google maps puts the height of Flagstaff Hill as 5 m ASL. Figure 3.3 shows the location of the signal station on Flagstaff Hill in 1825, and it is likely that the station was still in this position in 1840. The observations were taken by a trained white-collar convict

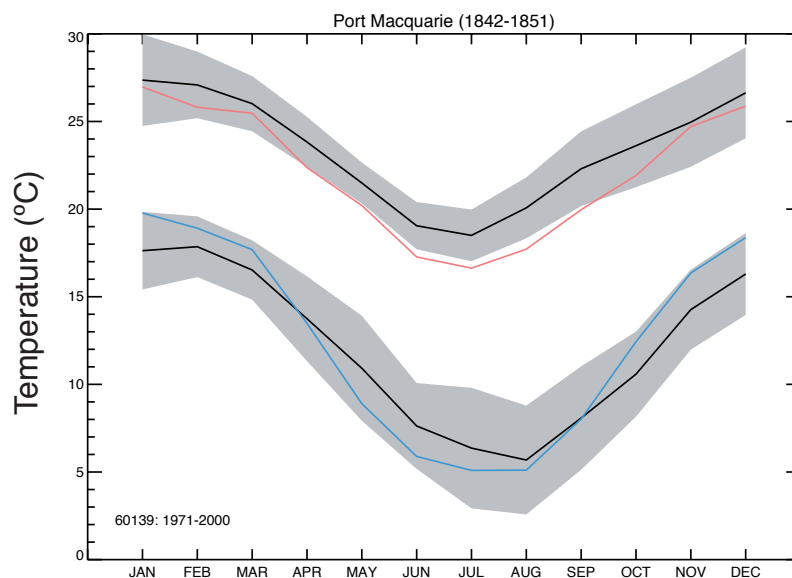
(or “special”) as at Port Jackson and Port Phillip, but there is no written record of who was sent to Port Macquarie (described in section 3.2). There is also no information about the instrumentation used at Port Macquarie, although the instruments may well be similar to those used at Port Jackson, considering that the stations were instigated at around the same time.

### Data quality:

*Frequency bias analysis:* The data are monthly only, so no observer bias analysis could be conducted.

*Temperature seasonal cycle analysis:* As shown in Figure AI.38, the estimated seasonal cycles of Tmax and Tmin display cooler JJA temperatures and warmer DJF temperatures than the modern cycles, indicating poor instrument exposure.

*Other:* This station seems to be the least reliable of the three stations set up by Governor Gipps in the 1840s. As shown in section 5.5, there are clear issues with the pressure data taken in the early period, and they are in poor agreement with neighbouring stations.



*Figure AI.38.* Seasonal cycles of Tmax and Tmin estimates from the Port Macquarie temperature observations (red and blue lines) compared to the seasonal cycles of nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 26. Hobarton Observatory

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**Date:** 1 January 1841–31 December 1848.

**Location:** Hobart, TAS, 42.87°S 147.33°E 29 m ASL.

**Location of original data:** The observations were published in three volumes of *Observations made at the Magnetical and Meteorological observatory at, Hobarton, in Van Diemen Island, and by the Antarctic Naval Expedition*. The volumes are available at several Australia libraries, including the Bureau of Meteorology's National Library (RB 551.582(946)). Monthly summaries of these data have also been published by Francis Abbott (source 27).

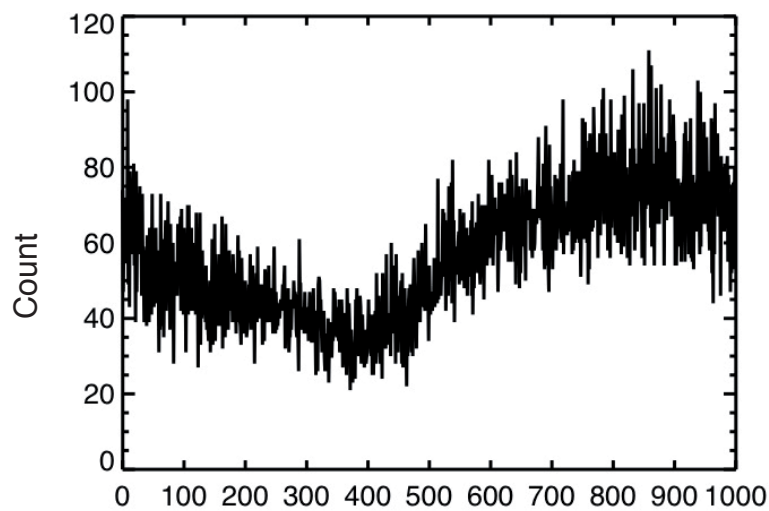
**Observation type:** Hourly atmospheric pressure observations reduced to 30 °F. Temperature observations were also recorded every hour for the eight years, but these have not been digitised due to time constraints.

**Metadata:** The observations were taken at the Hobart Observatory, just like the early observations from source 27. These observations were taken as part of a global magnetic survey instigated by the Royal Society (Savours and McConnell, 1982). Similar observatories were also set up in Toronto in Canada, the island of St Helena, and Cape of Good Hope in South Africa (Savours and McConnell, 1982). The instruments used in Hobarton were recorded as “standard”, the same as those used in the St Helena and Toronto observatories (Magnetical and Meteorological Observatory, 1850). The published observations also mentioned that the observations were taken “a little after” the specified times given. This was due to the method being used by the Royal Society:

“The instructions of the Royal Society directed that the times of observation should be “hours of mean time at Göttingen. The difference of meridians between Göttingen and Hobarton is 9h 10m, Hobarton being east; if therefore it had been possible that all the instruments to be observed at any particular hour could have been attended to at the same instant, that instant would have been would have been 10 minutes after the occurrence of an exact hour of mean time at Hobarton. But as this was not possible, the meteorological instruments were first observed, and were completed before the

occurrence of the exact Göttingen hour, and consequently within 10 minutes after the occurrence of an exact hour at Hobarton.”

**Data quality:** Frequency analysis of the pressure observations, shown in Figure AI.39, does not display any observer bias. The observations were reduced to 30 °F before being published which may mask biases in the original observations. The agreement between the mean of these hourly observations and the monthly means given by source 27 is very high ( $r = 0.98$ ).



*Figure AI.39.* Frequency distribution of the pressure observations taken at the Hobarton Observatory, showing the number of observations that end in 0.000–0.995, in 0.005-sized bins



## Source 27. Abbott, Francis

---

**Date:** January 1841–December 1870

**Location:** Hobart, TAS, 42.87°S 147.33°E 29 m and 14 m ASL.

**Location of original data:** The tables were published by Francis Abbott in two publications: *Results of twenty-five years' meteorological observations for Hobart Town* (Abbott, 1866), and *Results of five years' meteorological observations for Hobart Town* (Abbott, 1872). The first publication is available at several libraries across Australia, including the Bureau of Meteorology national library (Call number RB 551.582(946)). The second publication is available online at <http://www.archive.org/stream/resultsfiveyear00tasmgoog#page/n5/mode/1up>.

**Observation type:** Monthly tables of mean pressure, mean temperature, mean diurnal temperature and rainfall totals. The pressure observations have been reduced to a temperature of 30 °F, so this was used as the attached thermometer value when converting the pressure observations to hPa. The highest and lowest temperatures for each month were also published, but were not digitised due to time constraints.

**Methods of Tmax/Tmin estimation:** The relationship between the published diurnal temperature range (DTR) and mean temperature values were used to estimate mean maximum and minimum temperature values for each month.

Tmax and Tmin can be approximated from the DTR and mean temperature by assuming that

$$T_{mean} = \frac{(T_{max} + T_{min})}{2} \quad (AI.1)$$

and

$$DTR = T_{max} - T_{min} \quad (AI.2)$$

then Tmax and Tmin can be approximated by

$$T_{max} \approx \frac{(2 \times T_{mean}) + DTR}{2} \quad (AI.3)$$

$$T_{min} \approx \frac{DTR - (2 \times T_{mean})}{2} \quad (AI.4)$$

Daily maximum and minimum temperature data for 1858 were published in Abbott (1866), so monthly Tmax and Tmin values were calculated from these daily observations to verify the estimated values for 1858. The difference was found to be greatest in DJF (up to 1 °C for Tmax) and smallest in MAM. The average difference between the observed and estimated Tmax and Tmin values for 1858 was 0.44 °C for Tmax and 0.52 °C for Tmin.

The 1841–1854 data are monthly summaries of the observations kept at the Hobart Observatory run by Lieutenant Kay. Monthly means from 1841–1848 are actually means from hourly observations taken at the observatory (source 26), while the 1849–1854 mean were calculated from observations taken at 7 am, 1 pm and sunset.

The 1855–1870 observations were taken by Abbott at his home at 78 Murray Street in Hobart, where there is now a clothing store (Gibbs, 1998; McIntyre and Rabbus, 2008). Abbott's home is about 1.8 km away from the observatory (away from the water) and around seven metres lower. Here he continued to record the temperature three times a day, with the exception of January 1855 to January 1856, when observations seem to have been taken at 10 am and 1 pm only. The coordinates of the observatory have been used as the location for all of the observations.

In his summary of the data from 1841–1865, Abbott (1866) wrote:

“From January 1st 1841, until December 31st 1848, the meteorological observations were made at the Magnetic Observatory. From January 1st, 1855 until December 31st, 1865, the registers, reductions and discussions relating to diurnal inequalities of meteorological elements have been performed by myself.

Through the kindness of Captain Kay I had free access to the Hobart Town Observatory, and the mode of registering and reducing was communicated to me. The same system therefore that was carried on at the Government Observatory until the year 1854 has been adopted in computing these abstracts, with this difference, that instead of hourly

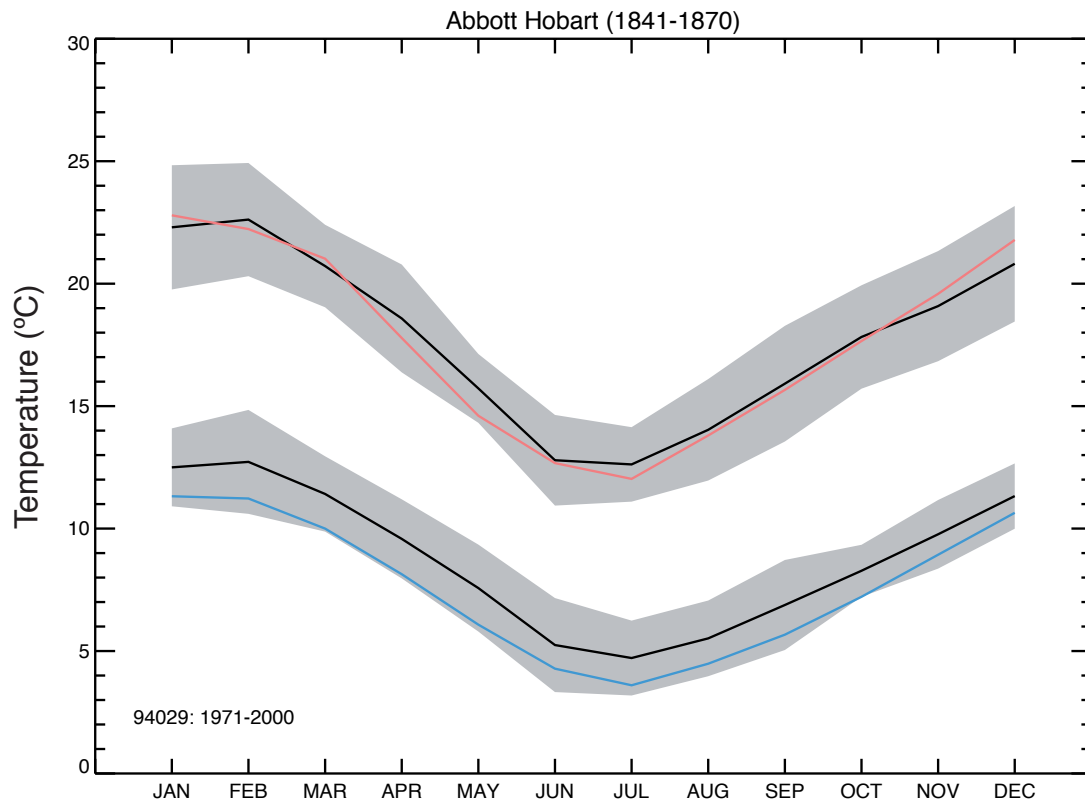
observations the registers have been made only three times a day [7 am, 1 pm and sunset, and for January 1856, 10 am and 1 pm only], but that regularly and without one single omission.”

### **Data quality:**

*Frequency bias analysis:* Only monthly data were examined, so no observer bias analysis could be conducted.

*Temperature seasonal cycle analysis:* As mentioned above, the estimated monthly mean Tmax and Tmin values are likely to be around 0.5 °C warmer than observed values. Comparing the estimated seasonal cycle with the modern temperature cycle in Figure AI.40 shows the estimated Tmax values to be consistently warmer than modern observations by up to 2 °C, while the estimated Tmin values are cooler by around 1 °C. The shape of the estimated seasonal cycle is however similar to the modern cycle, suggesting that the observations can capture seasonal variability.

*Other:* Francis Abbott was well regarded as a meticulous man and observer (Rimmer, 1969), and his frequent communication with the Hobart Observatory would have ensured his scientific literacy, making him a reliable observer. The movement of the observations from the observatory to Abbott’s home was detected as an inhomogeneity in both Tmax and Tmin observations (see Chapter 5). The period of 1855–1856 when observations were only being taken at 10 am and 1 pm was also found as an additional inhomogeneous period in the Tmin record.



*Figure AI.40.* Seasonal cycles of Tmax and Tmin estimates from Francis Abbott's temperature observations (red and blue lines) compared to the seasonal cycles of nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 28. Stevens, Charles

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**Date:** 29 November 1841–7 April 1846

**Location:** Dural (formally Dooral), NSW, 33.68°S, 151.03°E, 190 m ASL

**Location of original data:** The observations are hand-written records held in W.B. Clarke's paper at the State Library of New South Wales's Mitchell Library (manuscript number ML MSS 139/80–81). They were sent to Clarke as letters, and are likely to be transcribed from the original observations.

**Observation type:** Temperature observations taken at 8.30 am, 11 am, noon, 2.30 pm, sunset and 9 pm (noon observations cease in September 1842). Rainfall amounts and weather descriptions, including rainfall occurrences, were also recorded.

### **Methods of Tmax/Tmin estimation:**

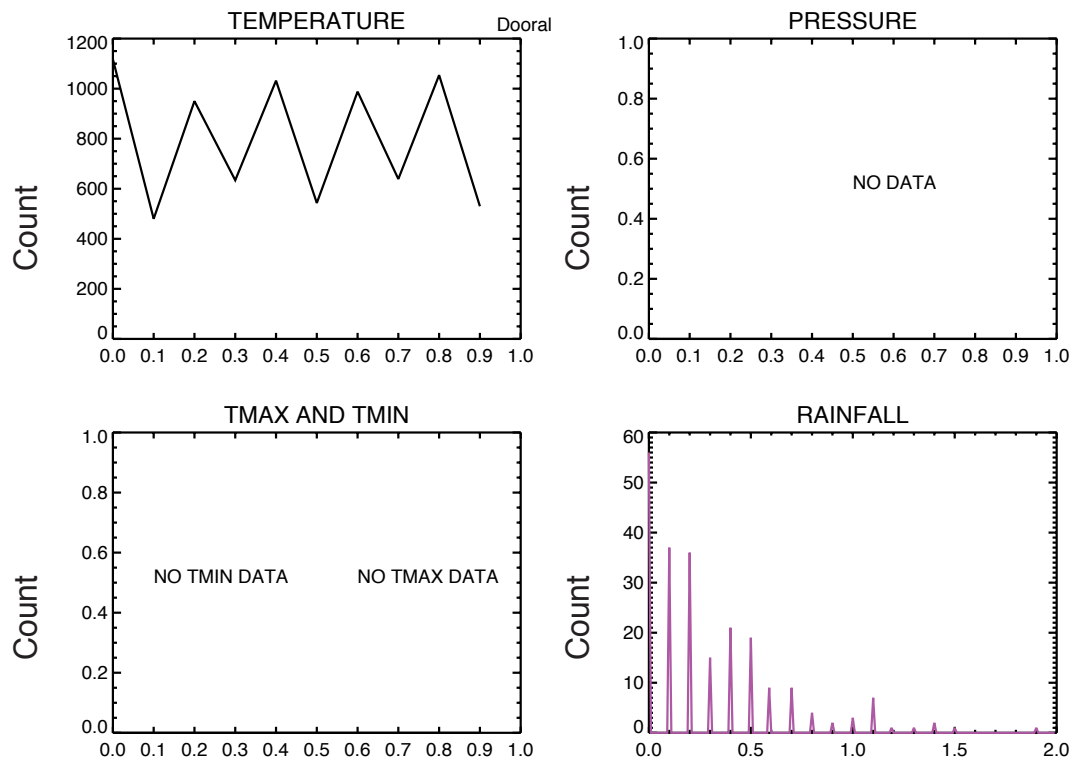
*Estimate 1:* Monthly mean of maximum and minimum temperature recorded each day, as no suitable neighbouring modern subdaily temperature could be found to calculate a regression. Data were required for at least 60% of the month for a monthly average to be calculated.

**Metadata:** Temperature, rainfall and remarks were taken by Charles Steven at the schoolhouse in Dural and regularly sent to Clarke. A Church of England denominational school existed in Dural in 1839, which was held in a “small and inconvenient” building a little way down the hill from where the historic St Jude's church would be built in 1846 (Sutherland-Harris, 2007). The latitude and longitude are taken as slightly downhill from St Jude's church, which still stands. An advertisement for a sermon in 1840 mentioned that the building was big enough as a school but not big enough to be a church.

Clarke was the pastor of Dural, and he would have likely requested that the observations be made. No information has been found about the precise location or nature of the instruments used. Nothing could be found about Charles Stevens either, although his regular delivery of observations to Clarke suggests that he took the job seriously.

**Data quality:**

*Frequency bias analysis:* Figure AI.41 shows that the temperature observations have a bias towards even numbers. Rainfall readings are given to the nearest 10th of an inch.

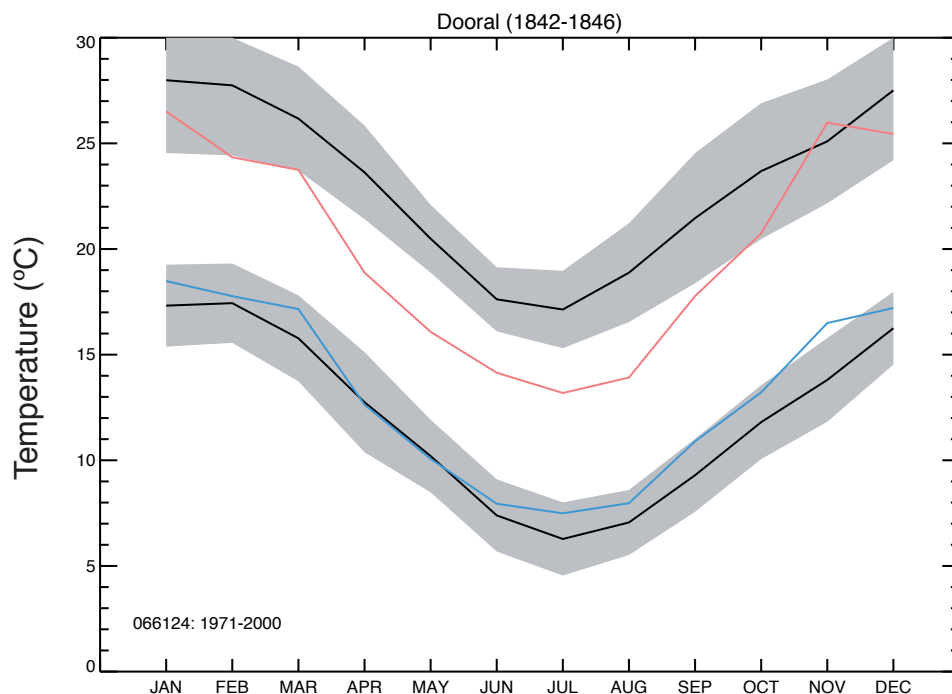


*Figure AI.41.* Frequency distribution of the Charles Stevens temperature and rainfall observations. The temperature plot (top left) show the number of temperature observations that end in 0–9. The rainfall plot (bottom right) shows the number of rainfall observations in each 0.005 inch bin from 0 to 2 inches.

*Temperature seasonal cycle analysis:* Tmax and Tmin estimates had to be calculated by simply taking the highest and lowest recorded observation for each day, due to a lack of suitable modern subdaily temperature data to develop a regression. As a result of this, and possibly substandard exposure, the monthly mean Tmax values are lower than modern means, and the Tmin seasonal cycle is slightly higher, as shown in Figure AI.42.

*Other:* There are some discrepancies between the mention of rainfall in the weather remarks and the amount of rainfall recorded for each day. Rain days were therefore

taken as the highest number between the number of raindays recorded in each month  
OR the number of days with a numerical rainfall amount in each month.



*Figure AI.42.* Seasonal cycles of Tmax and Tmin estimates from Charles Stevens' temperature observations (red and blue lines) compared to the seasonal cycles of nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 29. Purser, Edward

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**Date:** 27 February 1842–7 September 1844

**Location:** Castle Hill, NSW, 33.725°S, 151.01°E, 126 m ASL.

**Location of original data:** W.B. Clarke's papers at the State Library of New South Wales (manuscript number ML MSS 139/82).

**Observation type:** Temperature observations taken at sunrise, 8.30 am, noon, 2.30 pm, sunset and 9 pm. The maximum temperature of each day was also recorded for the first three months, but the values are generally the same as the 3 pm observations. One-word weather descriptions were also provided, and rainfall amount were recorded from February 1843.

### Methods of Tmax/Tmin estimation:

*Estimate 1:* Monthly mean of maximum and minimum temperature recorded each day. Data were required for at least 60% of the month for a monthly average to be calculated.

*Estimate 2:* Monthly regression based on 9 am and 3 pm observations from 66124 (Parramatta North) for 1967–2012 and the 8:30 am and 2:30 pm historical data.

**Metadata:** These observations were most likely taken by former soldier Edward Purser who came to Australia in 1832 (Barker and Hawkins, 1983). His signature is on the bottom of all the tables sent to Clarke, and he lived in Castle Hill. A history of early settlement in the Hornsby Shire provides the following description of Edward's house, which was used to determine the latitude and longitude of the observations:

“[In 1835] Edward and his family settled on a property of 20–30 acres on Old Castle Hill Road. Edward built a timber house with lath and plaster lining, and a shingled roof; the kitchen was separate from the house but connected by a covered wooden landing. Steps off one side of this landing led to the garden. The house was gradually enlarged over the years, and an iron roof was put on top of the shingles when they



deteriorated. An old camphor laurel tree, still standing in 1981, marked the site of the house, near the junction of Old Castle Hill Road and the present Tuckwell Road. The first planting of an orchard was of 100 orange trees, which flourished and so further plantings were made and stone fruits tried.” (Barker and Hawkins, 1983)

There is no information about the instruments used or the precise location of the thermometer and rain gauge.

### Data quality:

*Frequency bias analysis:* Frequency analysis plots in Figure AI.43 show a slight bias towards even temperature values, although the bias is not as large as other sources. Rainfall observations show a bias against very small rainfall readings: Purser appears to have recorded most trace rainfall amounts as 0.1 inches.

*Temperature seasonal cycle analysis:* The seasonal cycle of estimated Tmax and Tmin values shown in Figure AI.44 are in relatively good agreement with modern values, although JJA estimates are somewhat lower and November estimates are higher.

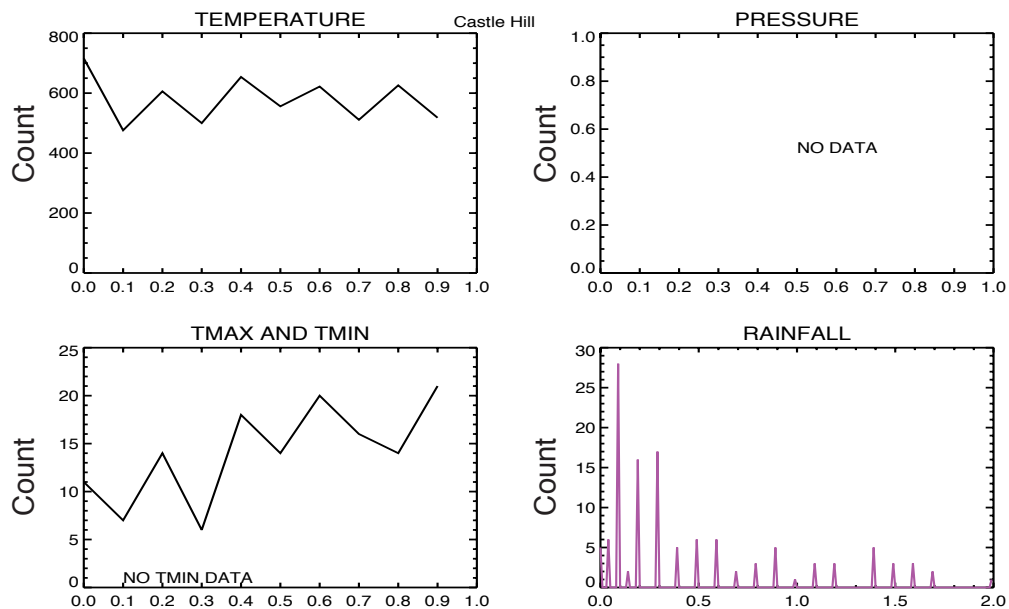
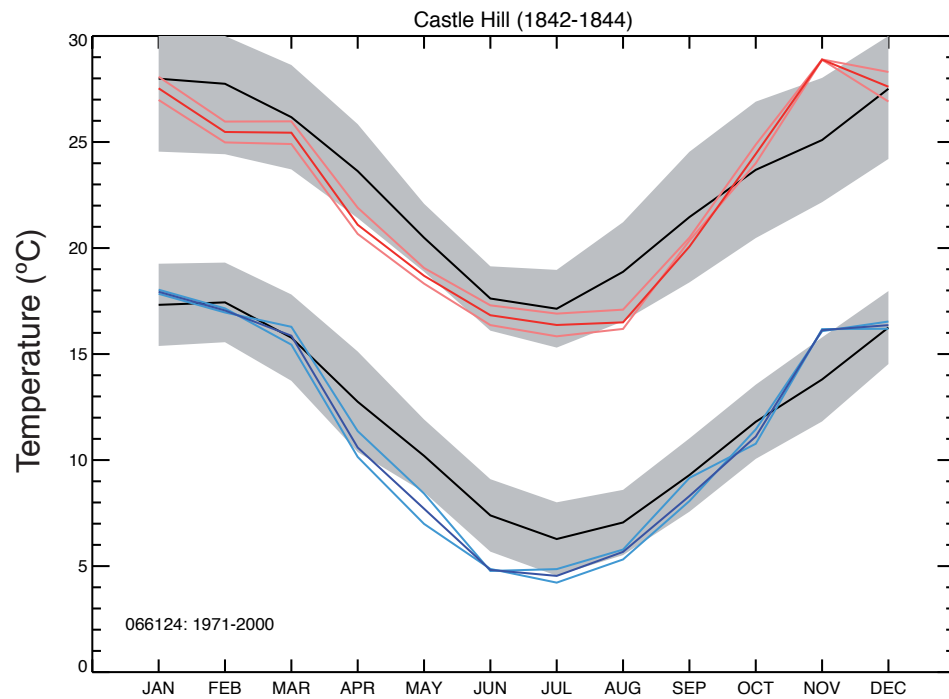


Figure AI.43. Frequency distribution of the Edward Purser temperature and rainfall observations. The temperature plot (top left) shows the number of temperature observations that end in 0–9. The distribution of Tmax observations is plotted similarly (bottom left). The rainfall plots (bottom right) show the number of rainfall observations in each 0.005 inch bin from 0 to 2 inches.



*Figure AI.44.* Seasonal cycles of Tmax and Tmin estimates from Edward Purser's temperature observations (dark red and blue lines) compared to seasonal cycles of individual estimates (light red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 30. King, Phillip Parker

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**Date:** January 1843–December 1847

**Location:** Port Stephens, NSW, 32.67 °S 152.0 °E, 10 m ASL.

**Location of original data:** The large abstract of monthly means and totals was published in *The Tasmanian Journal of Natural Science* (1846, volume 3, page 465–468).

**Observation type:** Monthly means of Tmax, Tmin, 9 am, noon and 3 pm pressure and air temperature, as well as monthly rainfall totals

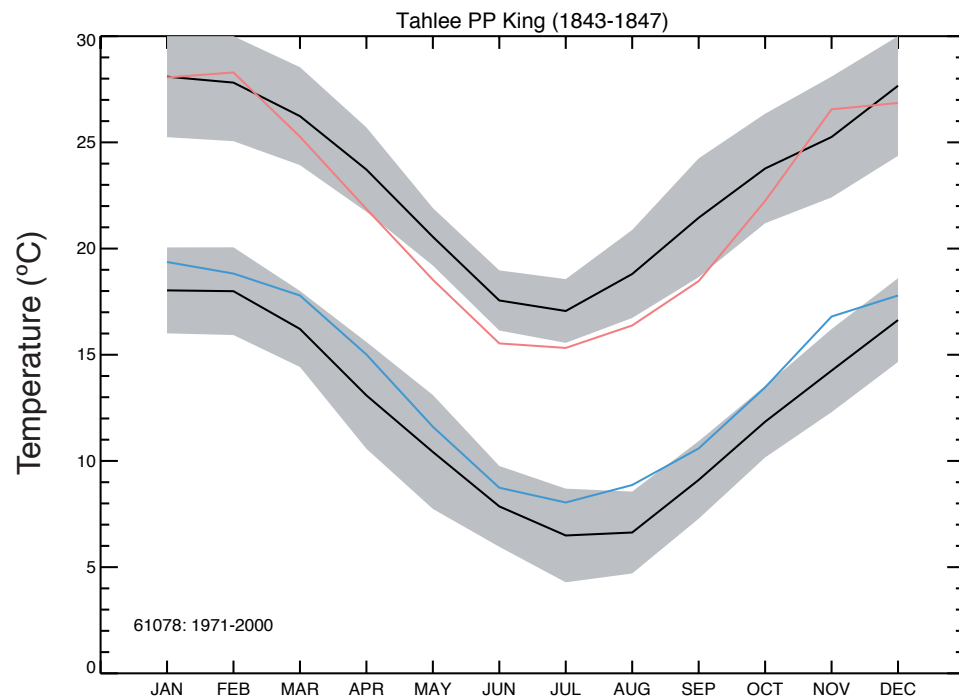
**Methods of Tmax/Tmin estimation:** Published monthly Tmax and Tmin values

**Metadata:** King took the observations while he was the commissioner of the Australian Agricultural Company (AAC). The original headquarters of the AAC was Tahlee, a homestead on the northern shores of Port Stephens, around 30 km north of Newcastle (Tahlee Ministries, 2013). King was a scientific man who regularly took meteorological observations at his other properties and often wrote to contemporaries Clarke and Mitchell discussing meteorological theories and records (Mitchell, 1848; Moyal, 2003). His observations are therefore expected to be reliable.

### Data quality:

*Frequency bias analysis:* The data are monthly, so no frequency analysis could be conducted.

*Temperature seasonal cycle analysis:* The seasonal cycles in Figure AI.45 show JJA Tmax values to be lower than modern observations, and Tmin values to be higher year-round, although the Tmin seasonal curve has a very similar shape to that of modern data. The modern comparison data come from Williamtown (BoM number 61078), which is around 20 km south of Tahlee and around 2 km inland. Tahlee on the other hand back directly onto Port Stephens. This proximity to water may explain the higher Tmin observations.



*Figure AI.45.* Seasonal cycles of monthly Tmax and Tmin values taken by Phillip Parker King (red and blue lines) compared to the seasonal cycles of nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 31. Adelaide Survey Office

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**Date:** April 1843–Feb 1851

**Location:** Adelaide, SA, 34.93°S, 138.6°E, 45 m ASL.

**Location of original data:** The original daily observations are in the Adelaide office of the National Archives of Australia, Series number AP810/58, Agency CA 5167-Adelaide Observatory. The observations used in this study are digitised monthly means from Derek Reid, formerly of CSIRO.

**Observation type:** Monthly means of temperature taken at 10 am, noon, 2 pm and 4 pm and atmospheric pressure taken at 10 am and 4 pm.

**Methods of Tmax/Tmin estimation:**

*Estimate 1:* Monthly regression based on half hourly data from 23090 for 1993–2012 and 10 am, noon, 2 pm and 4 pm observations.

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

*Estimate 3:* As Estimate 1, but observation times put back half an hour.

*Estimate 4:* As Estimate 1, but excluding the 10 am observations, to obtain an estimate for 1846 when some 10 am data are missing.

**Metadata:** The original observations apparently contain data from 1843 to 1856, but only the 1843–1851 data have been recovered in this study. Derek Reid attached the following comments to the digitised values:

“There are no observations between February 1851 and March 1852, and the procedures changed somewhat after that interval, so it is necessary to consider the observations as comprising two separate blocks. In the first period observations [1843–1851] were made at 1000,1200,1400 and 1600 hours, except for Sundays and Public Holidays. Air temperature, wind direction and descriptions of wind force were given, together with ‘State of the atmosphere’, under which heading ‘cumulus’ was a frequent entry.

Pressure readings commenced in August 1844, and for the bulk of the period these were given at 1000 and 1600 hours only, with no attached thermometer values.

Up to late 1849, the readings appear to have been taken mostly by a single very conscientious observer, who read the thermometer to 1/2 degrees, and recorded wind direction to minor points of the compass. Up to about 1846 he often described the weather on Sundays and holidays in general terms. Towards the end of 1850 observations increasingly tended to be missed and the record ceased in February 1851.

In March 1852 the record started again, with observations taken only at 1030 and 1530 hours local time. Readings of the attached thermometer were given until February 1855. The impression gained while keying data into the computer is of an observer of low intelligence working doggedly to rule. He almost invariably recorded the wind as 'S', possibly due to relying on an unbalanced vane on an off-vertical mast, and made no entries concerning weather or cloudiness. Temperatures are given to the nearest whole degree. However very few observations were missed, and the numerical results seem reasonable."

According to Todd (1893, page 3), the observations were made at the Adelaide Survey Office. A map of Adelaide from 1842 (Kingston and Stephens, 1842) puts the Survey Office as the corner of King William and Franklin Streets in central Adelaide. This is taken as the observation location. No information on instrumentation or instrument exposure could be located.

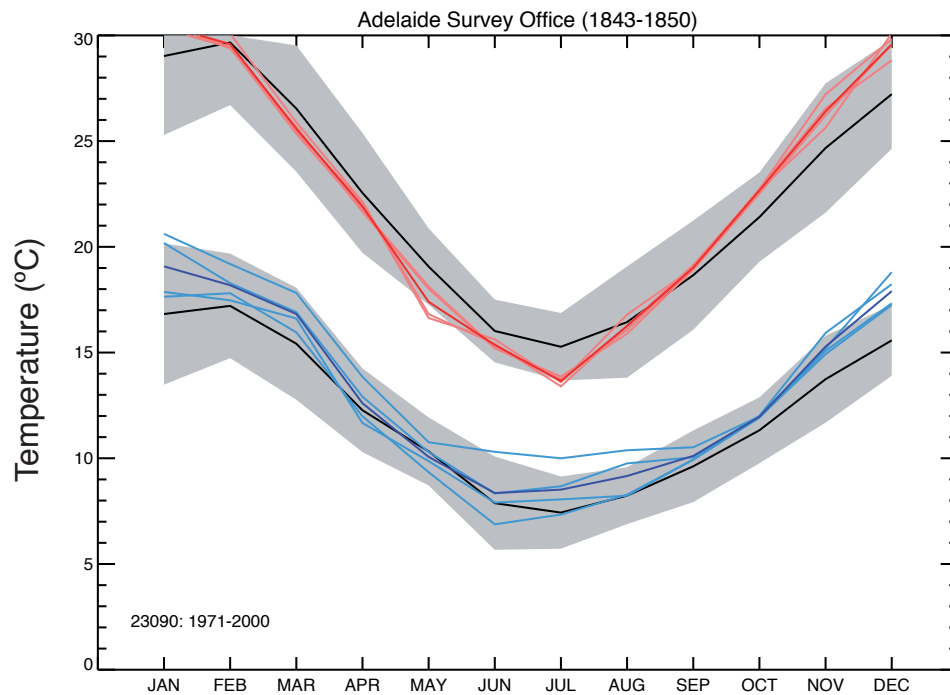
### **Data quality:**

*Frequency bias analysis:* The data are monthly, so no frequency analysis could be conducted.

*Temperature seasonal cycle analysis:* Seasonal cycle comparisons plotted in Figure AI.46 shows DJF Tmax and Tmin estimates to be higher than modern values, and JJA Tmax estimates to be lower than modern values, suggesting substandard thermometer exposure.

*Other:* The comments from Derek Reid indicate that the observer from 1843–1851 was conscientious, but the observer from 1851 to 1856 was less reliable. The pressure

observations are very highly correlated with MSLP data from William Wyatt also in Adelaide (source number 19), indicating that the pressure readings are generally reliable.



*Figure AI.46.* Seasonal cycles of Tmax and Tmin estimates from the Adelaide Survey Office temperature observations (dark red and blue lines) compared to seasonal cycles of individual estimates (light red and blue lines) and nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

## Source 32. Waugh, James

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**Date:** 1 January 1843–31 December 1847 (7 November 1845–27 December 1845 missing)

**Location:** Jamberoo, NSW, 34.65°S, 150.79°E, 23 m ASL.

**Location of original data:** James Waugh’s diary “Weather and Crops, Jamberoo” is held at the State Library of New South Wales, call number B59 (Mitchell Library card catalogue).

**Observation type:** Temperature observations taken at sunrise, 10 pm and at the time of “greatest heat”. Weather descriptions are also provided, as well as detailed agricultural and phenological information.

**Methods of Tmax/Tmin estimation:**

*Estimate 1:* Maximum temperatures taken from Waugh’s observations at the time of “greatest heat”. Minimum temperatures taken as the monthly mean of the minimum temperature recorded each day. Data were required for at least 60% of the month for a monthly average to be calculated.

**Metadata:** Observations were taken by farmer James Waugh on his farm “Waugh Hope” in Jamberoo, near Kiama in central NSW. A sketch of Waugh Hope is shown in Figure AI.47. The sketch is annotated “the house of Mr J.M. Waugh built of mud, plastered within & stuccoed without—about 4 miles from Kiama township”. Waugh Hope is located at 619 Jamberoo Road, Jamberoo (S. Jones, personal communication, 2012). No information could be found about the thermometer type or location, although the original thermometer broke in November 1845 and was replaced in December 1845.



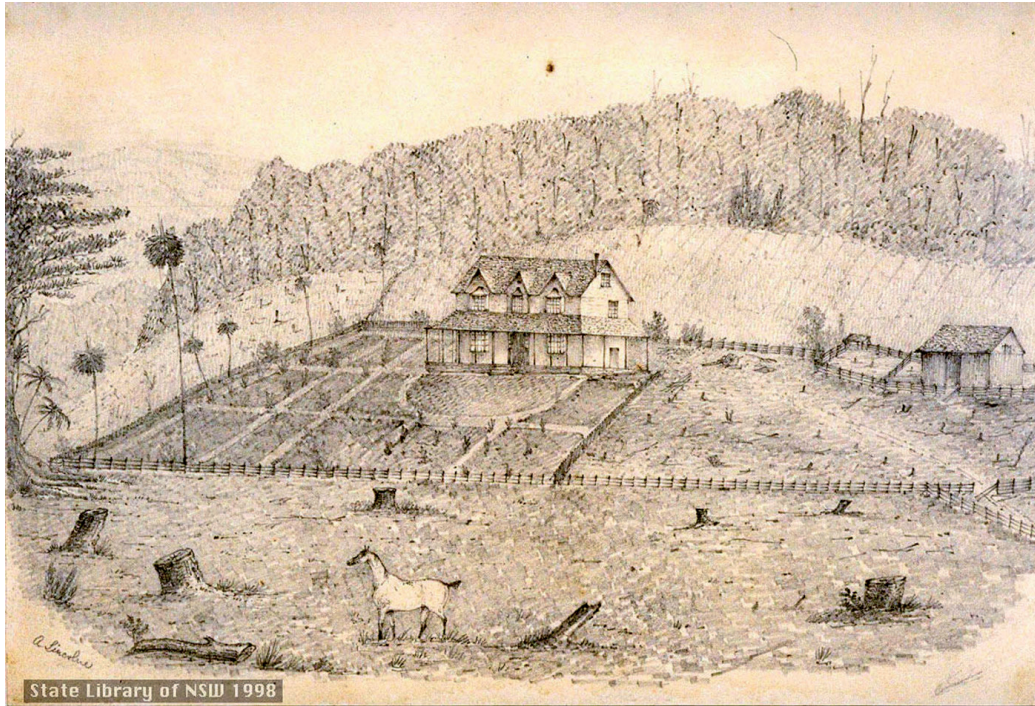


Figure AI.47. Waugh-hope/Jamberoo by Abraham Lincoln, 1840–1845. Image: State Library of New South Wales, call number: PXC 305, digital order number 62725.

#### **Data quality:**

*Frequency bias analysis:* Figure AI.48 shows a clear bias towards even temperature readings, with a secondary bias towards values ending in zero and five for Tmax values.

*Temperature seasonal cycle analysis:* The Tmax seasonal cycle shown in Figure AI.49 is warmer than modern data for DJF and cooler than modern data for JJA, suggesting substandard exposure. The Tmin estimates are much cooler than the modern observations. This may reflect local cooling, or substandard instrument exposure.

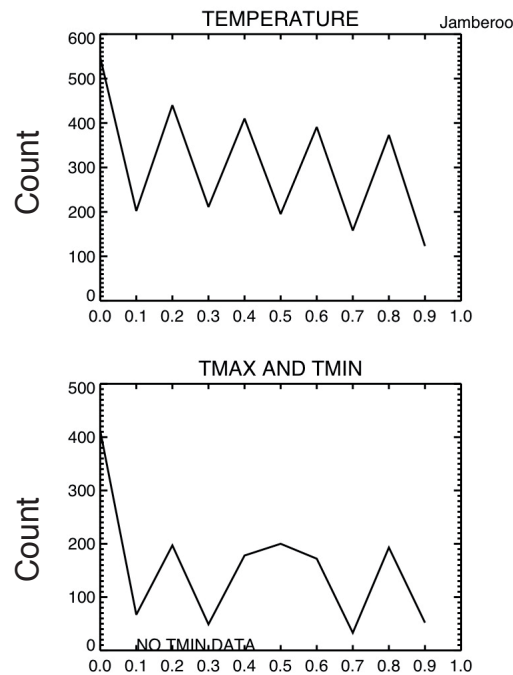


Figure AI.48. Frequency distribution of James Waugh's temperature observations. The temperature plot (top) shows the number of temperature observations that end in 0–9. The distribution of Tmax observations is plotted similarly (bottom).

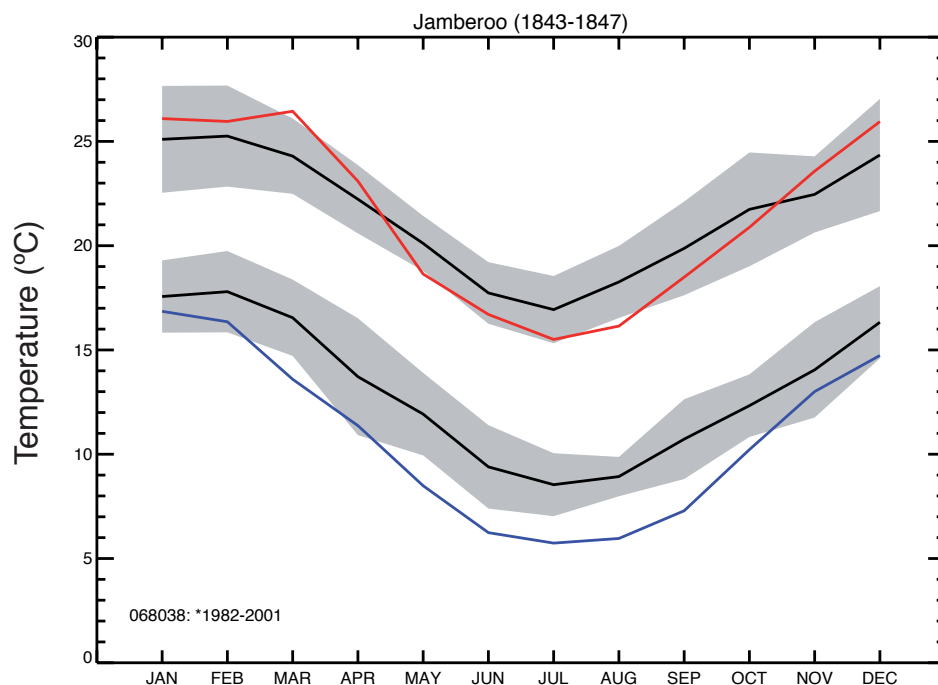


Figure AI.49. Seasonal cycles of Tmax and Tmin estimates from James Waugh's temperature observations (red and blue lines) compared to nearby BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

### Source 33. Watson, David

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**Date:** 14 December 1845–6 November 1847

**Location:** Campbelltown, NSW, 34.07°S, 150.12°E, 85 m ASL.

**Location of original data:** The observations are hand-written records held in W.B. Clarke's paper at the State Library of New South Wales's Mitchell Library (manuscript number ML MSS 139/85). They were sent to Clarke as letters, and are likely to be transcribed from the original observations.

**Observation type:** Temperature at 8:30 am, 11 am, 2:30 pm, 3:30 pm, sunset and 9 pm, rainfall amounts and weather comments. Occasional temperature observations were also taken at sunrise.

**Methods of Tmax/Tmin estimation:**

*Estimate 1:* Monthly mean of maximum and minimum temperature recorded each day. Data were required for at least 60% of the month for a monthly average to be calculated.

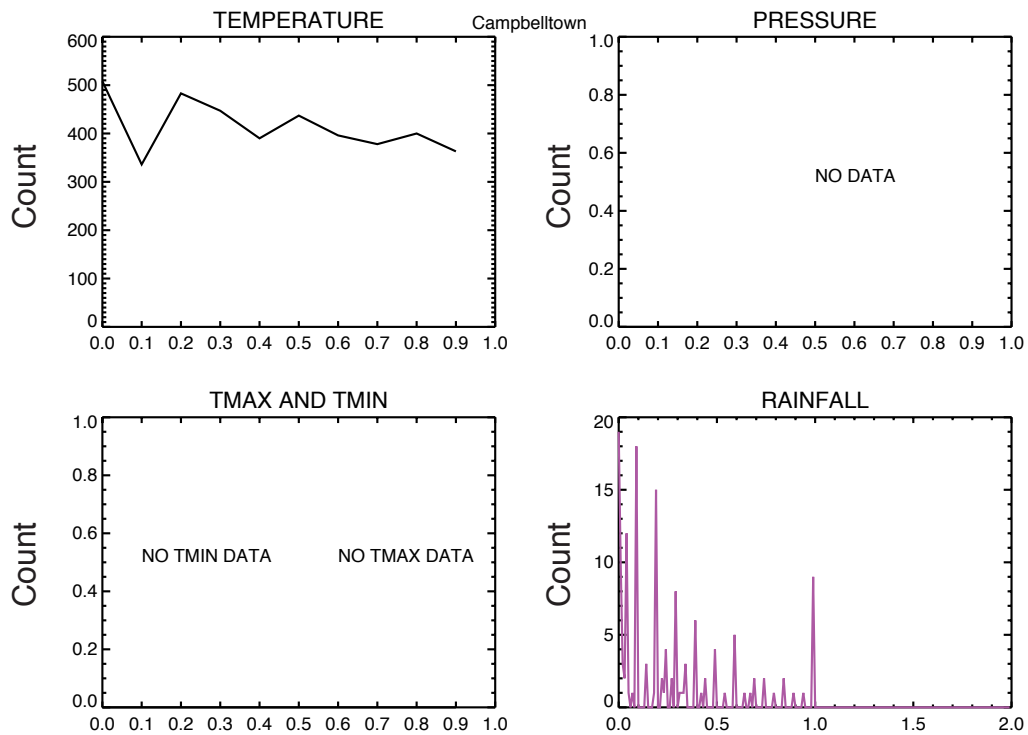
*Estimate 2:* Monthly regression based on 9 am and 3 pm observations from 1962–1981 and the 8:30 am and 2:30 pm historical data.

*Estimate 3:* As Estimate 2, but using the 3:30 pm temperature observations rather than those from 2:30 pm.

**Metadata:** The observations were taken by David Watson, who, according to his obituary, was the schoolmaster and clerk of St Peter's church in Campbelltown ("Family Notices", *The Sydney Morning Herald*, 8 June 1858, page 1). The location of the observations is taken as the location of the church in Campbelltown. No information could be found about instrument type or exposure.

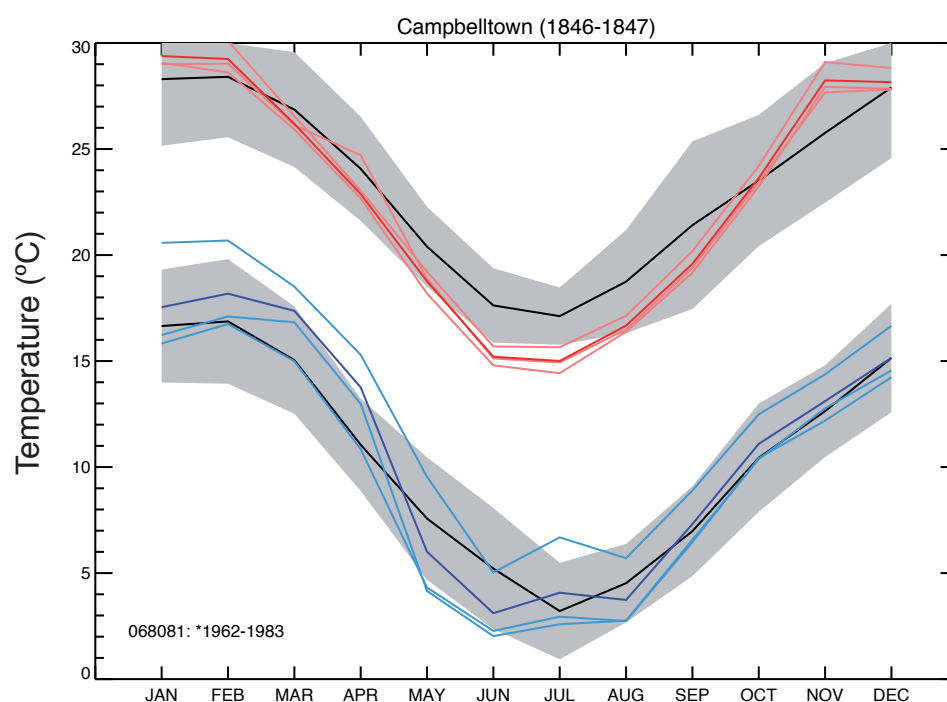
**Data quality:**

*Frequency bias analysis:* Figure AI.50 shows a small bias towards temperature observations that end in zero and two. There is also a clear bias towards rainfall observations to the nearest 10th of an inch.



*Figure AI.50.* Frequency distribution of David Watson's temperature and rainfall observations. The temperature plot (top left) shows the number of temperature observations that end in 0–9. The rainfall plots (bottom right) show the number of rainfall observations in each 0.005 inch bin from 0 to 2 inches.

*Temperature seasonal cycle analysis:* Seasonal cycles of the Tmax and Tmin estimates shown in Figure AI.51 display higher Tmax values than modern seasonal cycles in DJF and generally lower Tmax and Tmin values in JJA.



*Figure AI.51.* Seasonal cycles of the mean Tmax and Tmin estimates from David Watson's temperature observations (dark red and blue lines) compared to seasonal cycles of individual estimates (light red and blue lines) and neighbouring BoM station data over 1962–1983 (the only time period with data available, black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

### Source 34. Pugh, William Russ

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**Date:** 1 January 1846–31 December 1849 (December 1848 missing)

**Location:** Launceston, TAS, 41.44°S, 147.14°E. 28 m ASL.

**Location of original data:** Data from August 1846–June 1848 were published in *The Tasmanian Journal of Natural Sciences*, available at [http://www.nla.gov.au/ferg/bfull/14400642\\_bfull.html](http://www.nla.gov.au/ferg/bfull/14400642_bfull.html). Data from July 1848–December 1849 published in *The Launceston Examiner*, available at <http://trove.nla.gov.au/ndp/del/title/74>.

**Observation type:** Temperature (external and attached thermometer) and pressure observations at 9 am and 3 pm, as well as daily maximum and minimum temperature values and rainfall.

**Methods of Tmax/Tmin estimation:** Observed maximum and minimum temperatures

**Metadata:** Observations were taken by Dr William Russ Pugh at his house on the corner of St John and Frederick Sts in Launceston (Paull, 2011). The house still stands, and there is now a statue of Dr Pugh in the nearby public garden, shown in Figure AI.52. Dr Pugh was a “scientific gentlemen” who was interested in many scientific fields, including the natural environment and anaesthetics (Paull, 2011 and personal communication, 2012). He was also friends with Count Paweł Strzelecki, who may have helped him set up his meteorological station (Paull, personal communication, 2012).

#### Data quality:

*Frequency bias analysis:* Figure AI.53 shows generally unbiased observations. There is a small bias against temperature values that end in one in the Tmax, Tmin and attached temperature data, and a small preference for pressure readings rounded to the nearest 10th of an inch of mercury. There is no obvious bias in the rainfall observations.

*Temperature seasonal cycle analysis:* The seasonal temperature cycle for Pugh’s observed Tmax values is lower than modern observations, particularly in the cooler months, as shown in Figure AI.54. The Tmin seasonal cycle is warmer than the modern

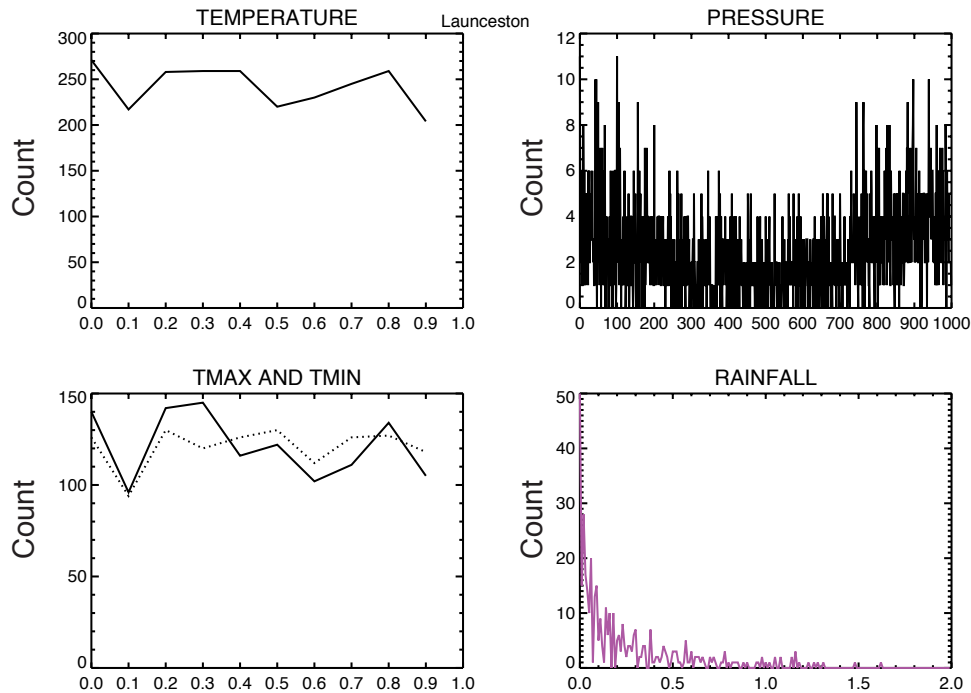




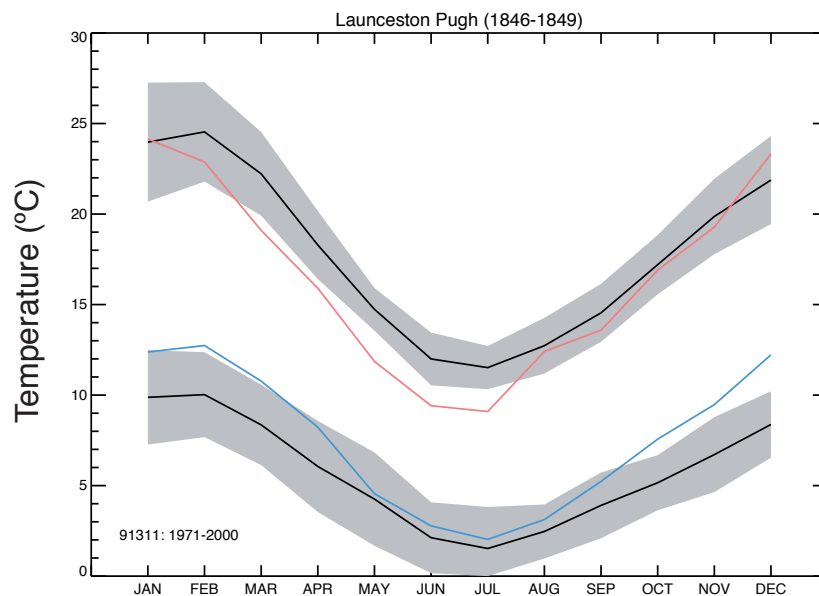
*Figure AI.52.* A statue of Dr William Russ Pugh in Princes Square, Launceston. Dr Pugh's house can be seen in the background. Image: Thomas Sutton via flickr, <http://www.flickr.com/photos/thssutton/1035805303/>.

observations, especially in the warmer months. These differences suggest that Pugh determined his  $T_{\max}$  and  $T_{\min}$  values from subdaily observations, rather than using a self registering maximum and minimum thermometer.

*Other:* The attached thermometer values are much lower than the external thermometer values from October 1847 to November 1848, before a month of missing data. This could indicate a move of instrument or issues with the barometer and attached thermometer.



*Figure AI.53.* Frequency distribution of the William Russ Pugh temperature, pressure and rainfall observations. The temperature plot (top left) show the number of temperature observations that end in 0–9. The distributions for Tmax and Tmin observations are plotted similarly (bottom left). The Tmax distribution is plotted in a solid line, and the Tmin distribution in a dotted line. The pressure plot (top right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins. The rainfall plots (bottom right) show the number of rainfall observations in each 0.005-inch bin from 0 to 2 inches.



*Figure AI.54.* Seasonal cycles of Tmax and Tmin observations from William Russ Pugh's (red and blue lines) compared to neighbouring BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.



## Source 35. *Portland Guardian*

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**Date:** 4 March 1849–28 August 1851

**Location:** Portland, VIC, -38.33°S 141.6°E, 14 m ASL.

**Location of original data:** The meteorological tables were published in *The Portland Guardian and Normanby General Advertiser*, available on microfilm at the State Library of Victoria (ISSN 0813-6149).

**Observation type:** Temperature observations at 8 am, noon (in the shade and in the sun) and at sunset. Short daily weather descriptions were also published.

### **Methods of Tmax/Tmin estimation:**

*Estimate 1:* Monthly regression based on half hourly data from 90015 for 1994–2012 and 8 am, noon and sunset observations. Note that 90015 is the BoM station at Cape Otway, rather than Portland, because the modern Portland subdaily temperature data and Tmax/Tmin data do not overlap and could not be used to develop a regression.

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

*Estimate 3:* As Estimate 1, but observation times put back half an hour.

*Estimate 4:* As Estimate 1, but an estimate was calculated for each day separately using the monthly regression and then averaged to obtain a monthly mean. Data were required for at least 60% of a month for a monthly average to be calculated.

**Metadata:** There is no information about where or how the observations were taken. The tables simply state that the observations were taken “the township of Portland”. The location is taken as the position of central Portland.

### **Data quality:**

*Frequency bias analysis:* Figure AI.55 shows that the temperature observations have a small bias towards even values.

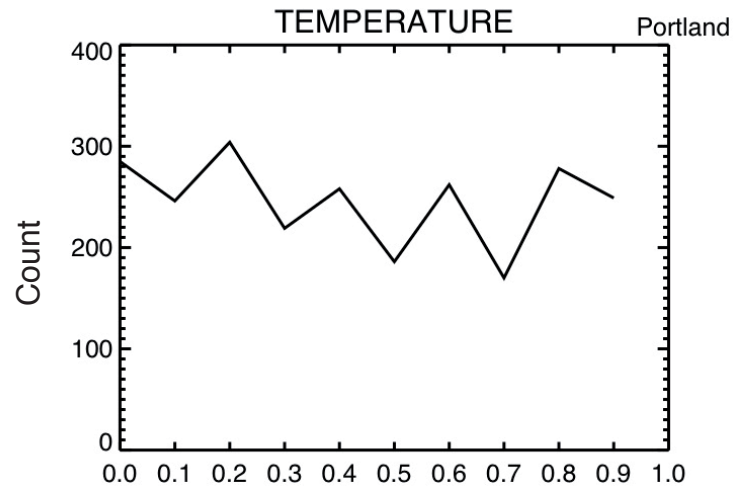


Figure AI.55. Frequency distribution of the Portland temperature observations, showing the number of temperature observations that end in 0–9.

*Temperature seasonal cycle analysis:* The estimated temperature seasonal cycles shown in Figure AI.56 are in good agreement with the modern Portland seasonal cycle, particularly Tmin. Tmax estimates are warmer than the modern cycle during November and December.

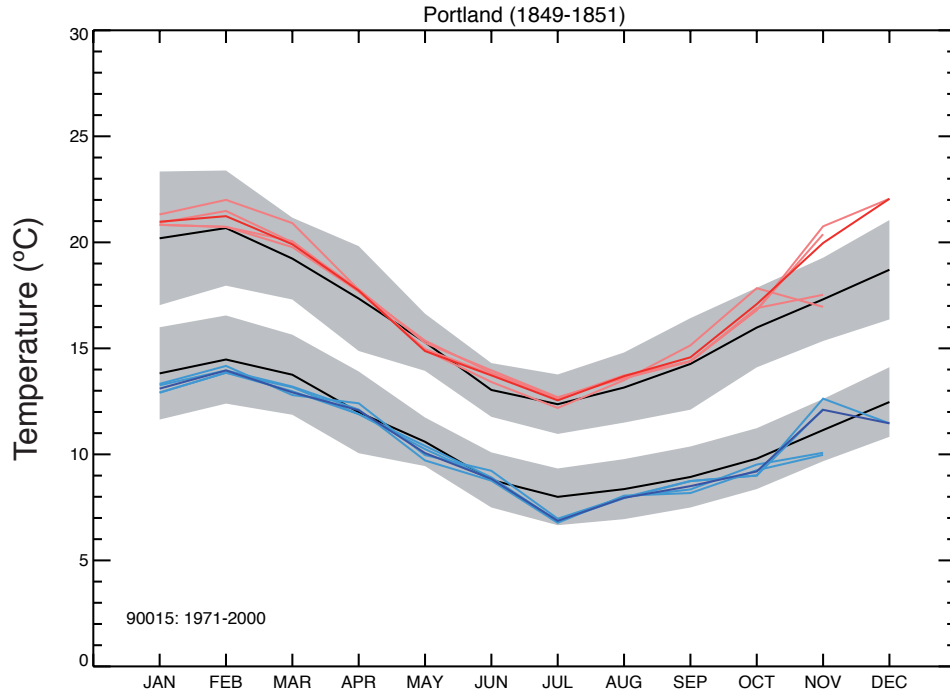


Figure AI.56. Seasonal cycles of Tmax and Tmin estimates from the Portland temperature observations (dark red and blue lines) compared to seasonal cycles of individual estimates (light red and blue lines) and neighbouring BoM station data over 1962–1983 (the only time period with data available, black line, grey shading shows two standard deviations above and below the mean). The number of the BoM used is provided in the bottom left corner.

### Source 36. Cape Otway Government Gazette

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**Date:** January–December 1851

**Location:** Cape Otway, VIC, 38.85°S, 143.51°E, 78 m ASL

**Location of original data:** These records are monthly abstracts from the *Victorian Government Gazette* available at the State Library of Victoria (<http://gazette.slv.vic.gov.au/archive/1840-1859/1851>). Only the abstracts from 1851 have been located, and no original observations have been found.

**Observation type:** Monthly means of attached temperature and pressure at 8:30 am, 2:30 pm, sunset and 9 pm were published, as well as monthly rainfall totals, the number of raindays and the date and amount of the highest rainfall.

**Methods of Tmax/Tmin estimation:**

*Estimate 1:* Monthly regression based on half hourly data from 90015 for 1994–2012 and 8:30 am, 2:30 pm, sunset and 9 pm.

*Estimate 2:* As Estimate 1, but observation times put forward half an hour.

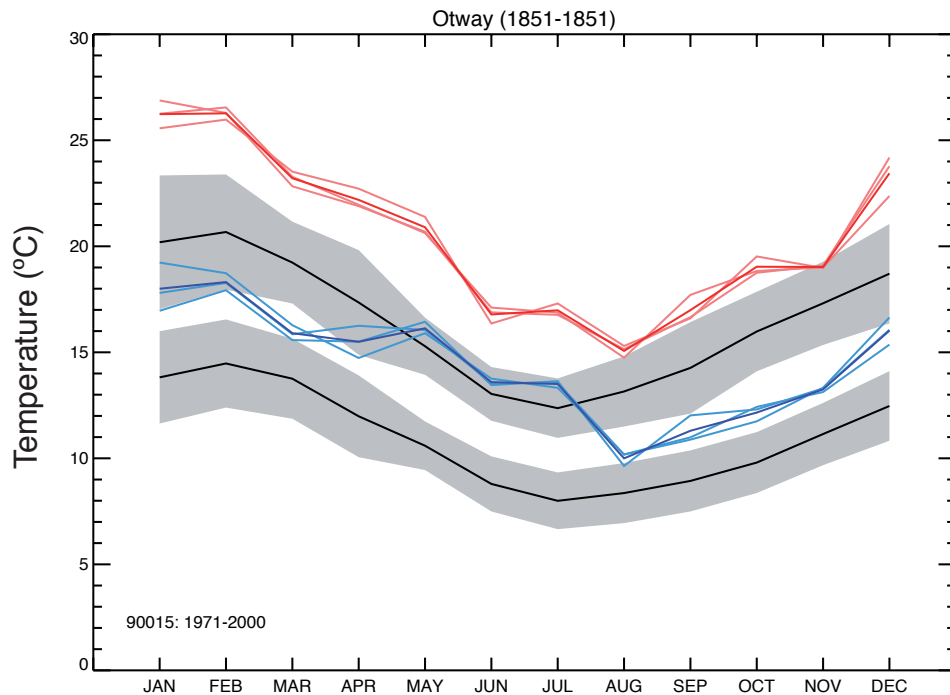
*Estimate 3:* As Estimate 1, but observation times put back half an hour.

**Metadata:** The monthly abstracts give the height of the observations as 300 feet above sea level. This is close to the height of the signal station near the at the Cape Otway lighthouse but twice as high as the location of the Cape Otway lighthouse, according to Google Earth. The location of the observatory is therefore taken to be the Cape Otway signal station. No information could be found about the instrument type or exposure, or the observer.

**Data quality:**

*Frequency bias analysis:* No frequency analysis could be conducted as the data are monthly.

*Temperature seasonal cycle analysis:* The temperature observations come from an attached thermometer, presumably located inside next to the barometer. The seasonal cycles of Tmax and Tmin estimates are therefore much warmer and less variable than the modern Cape Otway seasonal cycles, as shown in Figure AI.57.



*Figure AI.57.* Seasonal cycles of Tmax and Tmin estimates from the Cape Otway temperature observations (dark red and blue lines) compared to seasonal cycles of individual estimates (light red and blue lines) and neighbouring BoM station data over 1962–1983 (the only time period with data available, black line, grey shading shows two standard deviations above and below the mean). The number of the BoM used is provided in the bottom left corner.

## Source 37. Slade, Edgar

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**Date:** 1 June 1853–31 January 1857

**Location:** Alberton, VIC, 38.62°S, 146.67°E, 9.1m (June 1853–October 1855) and 15.5 m (November 1855–January 1857) ASL.

**Location of original data:** These records are monthly abstracts from the *Victorian Government Gazette* available at the State Library of Victoria (<http://gazette.slv.vic.gov.au/archive/1840-1859>).

**Observation type:** From 1 June 1853–31 August 1853, thermometer and barometer readings at 8 am and 4 pm were published, as well as maximum and minimum daily temperatures and a daily weather description. From 1 September 1853–31 October 1855, barometer, attached thermometer and “thermometer in shade” readings were published for 8:30 am, 2:30 pm, sunset and 9 pm, as well as maximum and minimum daily temperatures and daily weather descriptions. From 1 November 1855–31 January 1857, barometer and attached thermometer readings were published for 9 am, 3 pm and 9 pm, as well as maximum and minimum daily temperatures, daily weather descriptions and daily numerical rainfall totals.

**Methods of Tmax/Tmin estimation:** Observed Tmax and Tmin values

**Metadata:** The published observations were attributed to Edgar Slade, who was a police officer in the Alberton region. From the diary of a fellow police officer, John Sadleir, who took over from Slade in 1867 (Sadleir, 1913):

“The officer whose place I took in Gippsland was Captain Edgar Slade, R.N. Like most sailors he was a poor horseman, and, on that account, had seldom been able to visit the more remote stations in his district. He had established his headquarters at Alberton, at the southern extremity of Gippsland.

It cannot be said that Slade was a very efficient police officer. Yet it was remarkable how well his subordinates carried out their duties. These happened to be a good class of

men who seldom abused the freedom allowed them; and when questions of discipline did crop up, Slade dealt with them fairly and judiciously enough.”

These comments suggest that Slade may not have been the most diligent man. However, he was also very keen horticulturist, and was a member of several scientific societies, including the Royal Society of Victoria, the Philosophical Society of Victoria and the Victorian Institute for the Advancement of Science (Haldane, 2012). This indicates that Slade would have been aware of the meteorological practices being used in the colony at the time.

No information could be found on the instrument types or exposure. There was a change in height above sea level from 30 feet to 51 feet in November 1855, possibly a change in location or a re-measurement. External temperatures are not recorded after the height change, suggesting that the external thermometer may have broken in the move.

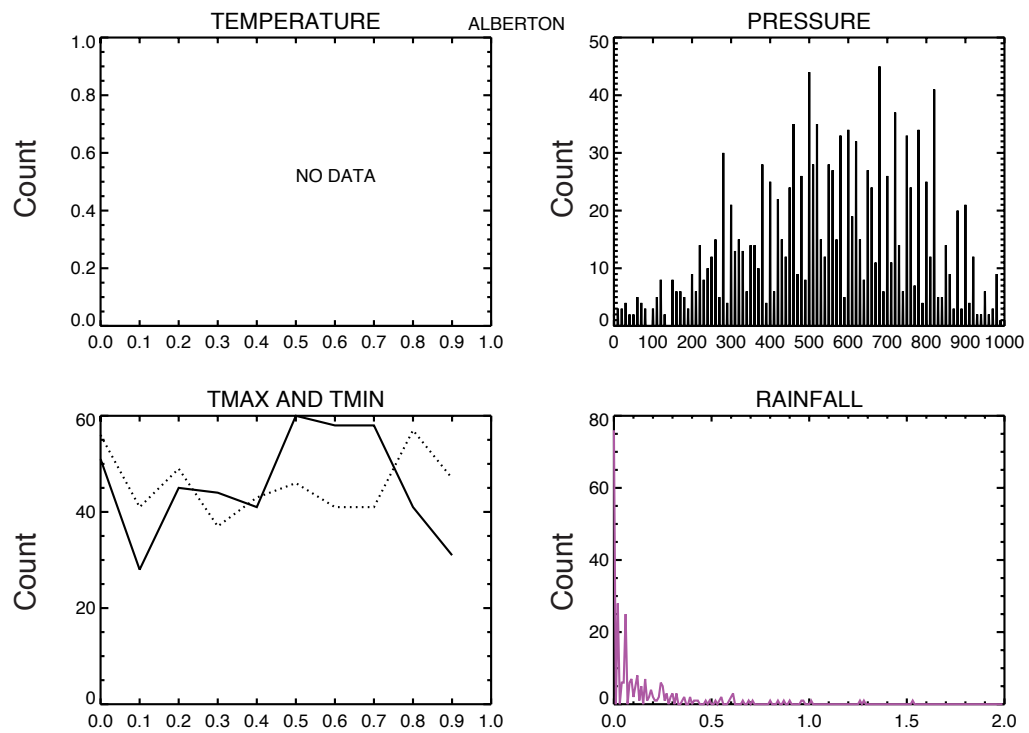
#### **Data quality:**

*Frequency bias analysis:* Frequency plots in Figure AI.58 indicate that Slade had a bias towards rounding to the nearest 5 or 10 °F for temperature, particularly for maximum temperature and the daily regular observations. The pressure observations also display a bias towards values to the nearest 10th of an inch.

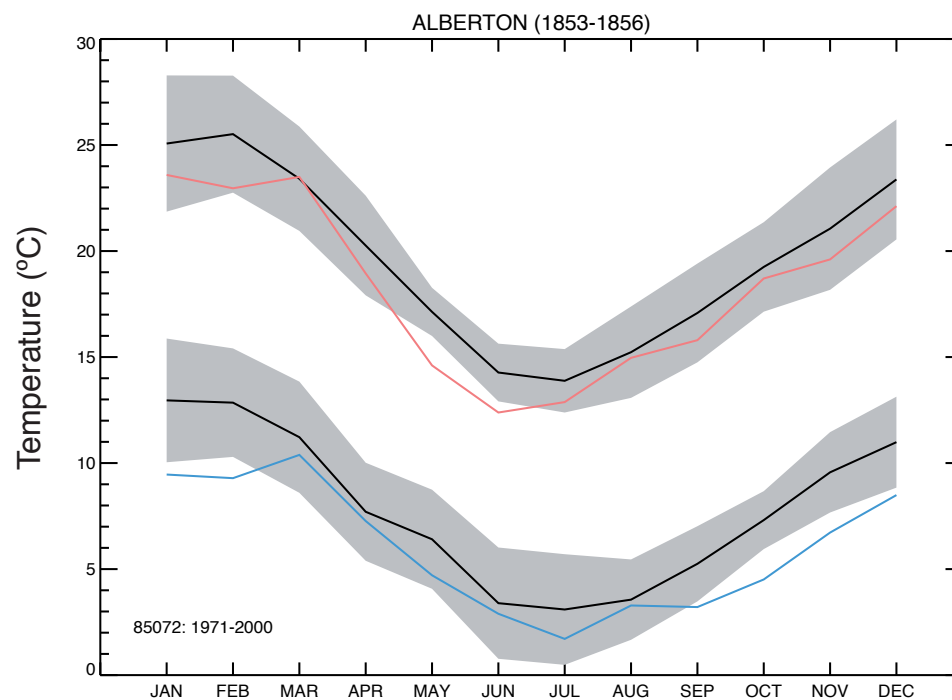
*Temperature seasonal cycle analysis:* The seasonal cycle of the maximum temperature data shows similar characteristics to the modern seasonal cycle for Alberton, although the historical temperatures are cooler during May–July. The minimum temperature seasonal cycle is flatter than the modern cycle, with cooler conditions recorded from October–February. The modern and historical seasonal cycles are plotted in Figure AI.59.

*Other:* During November 1855 and January 1857, when rainfall observations and weather descriptions were being made, there are over 37 days when a rainfall amount was recorded but rainfall was not mentioned in the weather description. This suggests that the weather descriptions are not an overly reliable source of rainday information,

or could indicate that accumulated dew was recorded as rainfall. Either way, the rainfall and rainday information must be treated with caution.



*Figure AI.58.* Frequency distribution of Edgar Slade's temperature, pressure and rainfall observations. The pressure plot (top right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins. The Tmax and Tmin plot shows the number of temperature observations that end in 0–9: the Tmax distribution is plotted in a solid line, and the Tmin distribution in a dotted line. The rainfall plots (bottom right) show the number of rainfall observations in each 0.005 inch bin from 0 to 2 inches.



*Figure AI.59.* Seasonal cycles of Edgar Slade's Tmax and Tmin observations (red and blue lines) compared to neighbouring BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.



### Source 38. *Sydney Morning Herald*

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**Date:** 9 January 1855–3 November 1856 (March 1855 and January 1856 missing)

**Location:** Port Jackson (eastern Sydney), NSW, 33.83°S 151.28°E, 89 m ASL.

**Location of original data:** Weekly tables were published in *The Sydney Morning Herald*, available at <http://trove.nla.gov.au/ndp/del/title/35>.

**Observation type:** Daily temperature, attached temperature and pressure at 8:30 am, 2:30 pm, 9 pm, as well as daily maximum and minimum temperatures, rainfall totals and weather descriptions.

**Methods of Tmax/Tmin estimation:** Observed Tmax and Tmin values.

**Metadata:** These observations are a continuation of the monthly summaries for Port Jackson published in the *Government Gazette* (source 23). Detailed metadata are provided in the description for source 23.

#### **Data quality:**

*Frequency bias analysis:* Figure AI.60 shows that the temperature observations have a bias towards values ending in 5–7, while the pressure observations display a clear bias towards values ending in nine.

*Temperature seasonal cycle analysis:* The published Tmax values display a seasonal cycle that is much cooler than the modern observations, although the curve is similar in shape to the modern observations. The lower Tmax values might be due to the modern observations coming from the Sydney Airport, which is further inland than the Port Jackson signal station. Published Tmin values are very similar to the modern seasonal cycle. The modern and historical seasonal cycles are plotted in Figure AI.61.

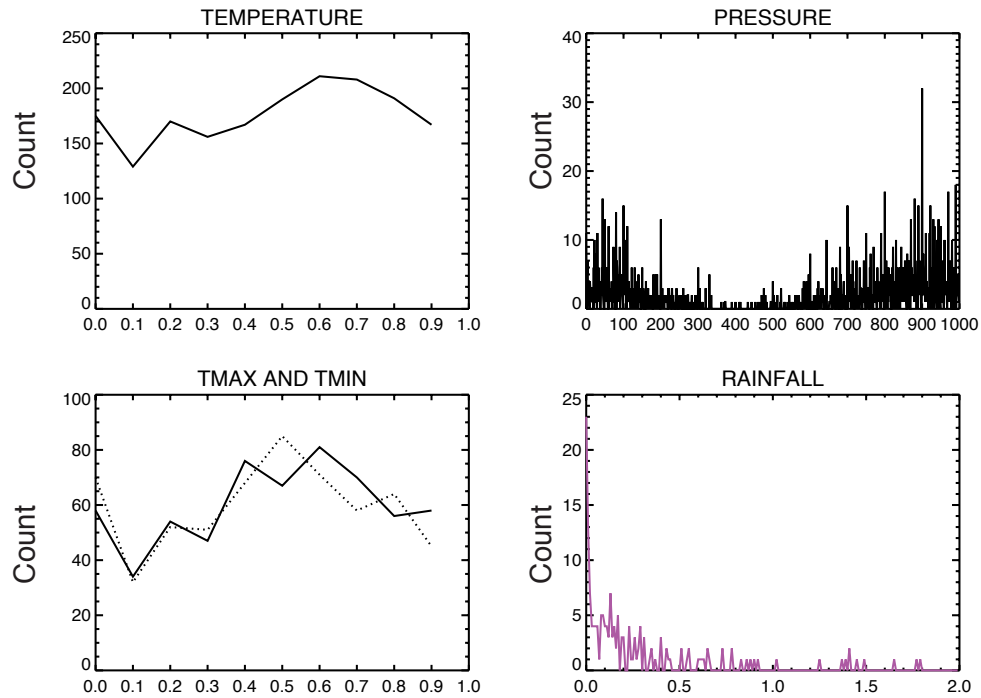


Figure AI.60. Frequency distribution of *The Sydney Morning Herald* temperature, pressure and rainfall observations. The temperature plot (top left) shown the number of temperature observations that end in 0–9. The distributions for Tmax and Tmin observations are plotted similarly (bottom left). The Tmax distribution is plotted in a solid line, and the Tmin distribution in a dotted line. The pressure plot (top right) shows the number of observations that end in 0.000–0.995, in 0.005-sized bins. The rainfall plot (bottom right) show the number of rainfall observations in each 0.005 inch bin from 0 to 2 inches.

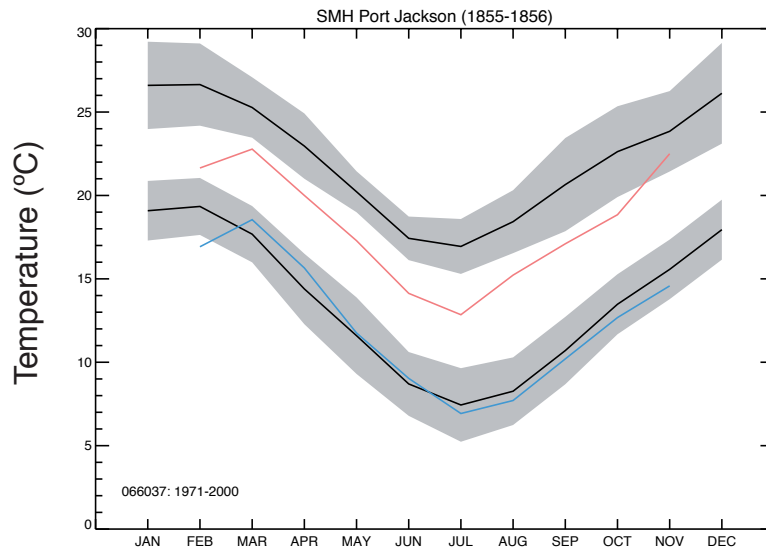


Figure AI.61. Seasonal cycles of *The Sydney Morning Herald* Tmax and Tmin observations (red and blue lines) compared to neighbouring BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM used is provided in the bottom left corner.

## Source 39. Jevons, William Stanley

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**Date:** July 1855–June 1858.

**Location:** Sydney suburbs of Petersham and Double Bay, NSW. Coordinates taken from the second location, 33.87°S 151.24°E, 3.4 m ASL.

**Location of original data:** Tables were published in *The Sydney Magazine of Science and Art*. Most issues are available online at <https://www.google.com.au/search?tbm=bks&hl=en&q=sydney+magazine+of+science+and+art>.

**Observation type:** Monthly means of pressure, temperature, maximum temperature and minimum temperature, as well as monthly rainfall totals. Mean daily barometer and temperature readings were calculated from observations taken at 9 am and 9 pm, and monthly means determined from these daily averages. Several tables of daily data for 1857–1858 have also been located, but only monthly means have been digitised.

**Methods of Tmax/Tmin estimation:** Observed Tmax and Tmin values.

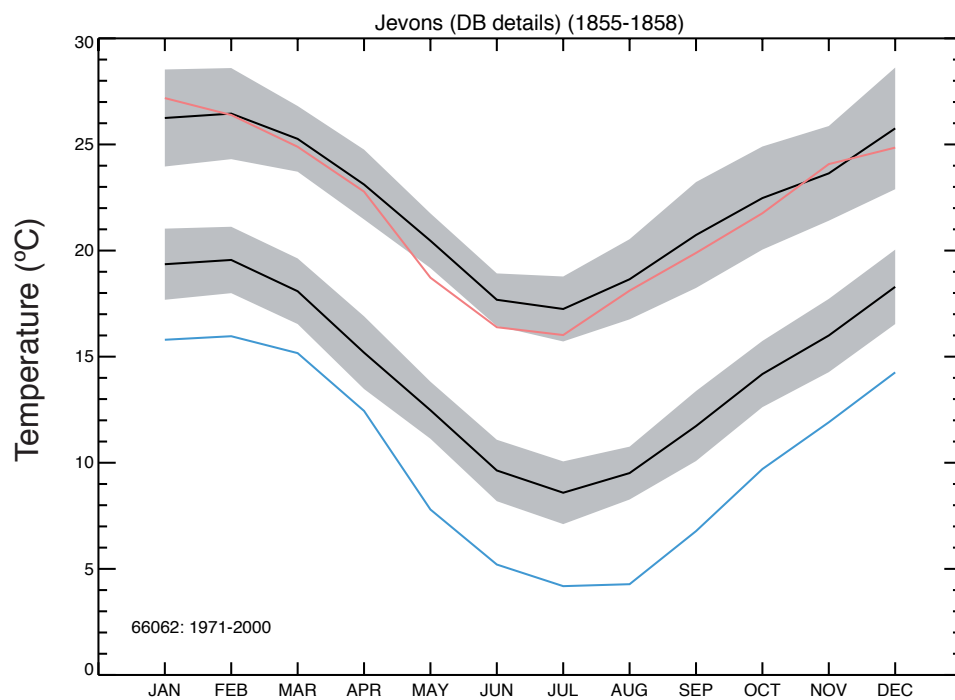
**Metadata:** Observations were taken by William Stanley Jevons, a gold assayer who moved to Sydney in 1854 (Nicholls, 1998; Powerhouse Museum, 2004). Jevons was interested in many fields of research, including meteorology, sociology, economics and chemistry. Jevons returned to England in 1859, where he became one of England's leading economists.

When Jevons first arrived in Sydney to work at the Royal Mint, he lived in Petersham, a central Sydney suburb. He lived with a Mr Miller, who also worked at the Mint (Martin, 2003). The cottage in Petersham was on Parramatta Road (Martin, 2003), although the precise address could not be found. In March 1857 Mr Miller and his wife bought a “Tueila”, large house at 73 Bay St in Double Bay, and Jevons moved with them (Martin, 2003; Woolahra Municipal Council, 2013). Petersham and Double Bay are about 10 km apart. Jevons was a meticulous man who was actively involved in scientific societies in Sydney (Nicholls, 1998), and so his observations are considered to be reliable. Jevons reported that his instruments had been compared with those at Greenwich and “observations [had] been reduced accordingly”.

**Data quality:**

*Temperature seasonal cycle analysis:* No observation frequency analysis was conducted because only monthly data were used.

*Temperature seasonal cycle analysis:* Seasonal temperature cycles plotted in Figure AI.62 show that Jevons' maximum temperatures are in very good agreement with the modern observations from Sydney's Observatory Hill, but the minimum temperatures are much lower, although they do display a similar seasonal progression. The lower seasonal cycles may be due to the slightly more inland location of Petersham compared to Observatory Hill.



*Figure AI.62.* Seasonal cycles of William Stanley Jevons' Tmax and Tmin observations (red and blue lines) compared to neighbouring BoM station data over 1971–2000 (black line, grey shading shows two standard deviations above and below the mean). The number of the BoM station used is provided in the bottom left corner.

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