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HISTORICAL THERMOMETER EXPOSURES IN AUSTRALIA

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ABSTRACT

There is ample contemporary evidence that most meteorological thermometers in Australia were not exposed in Stevenson screens until very late in the nineteenth century, and in many places not until well into the twentieth century. There is also evidence, from a long-running comparison at Adelaide, that mean temperatures in a Stevenson screen are lower than in an open stand in Australian conditions. Thus, there are strong grounds for expecting that nineteenth century, and some early twentieth century, Australian temperatures are biased warm, relative to modern exposures.

KEY WORDS: Australia; temperature; Stevenson screens; climate change.

INTRODUCTION

Parker (1994), in a comprehensive survey of world-wide changes in thermometer exposure, documented some evidence of changes in exposure in Australia, between the late nineteenth century and the early twentieth century. It is generally believed that the Stevenson screen was introduced from the late 1880s in some regions to early this century in others (Torok and Nicholls, 1993), and that prior to this many stations had thermometers exposed on walls or on open ('Greenwich' or 'Glaisher') stands, or in large open 'band-stand' structures. Hughes (1995) argued that the Stevenson screen was in widespread use in Australia in the late nineteenth century, and that there is no need, therefore, for any overall correction to pre-1900 temperatures. Parker (1995), in reply, indicated that precise information about station histories would be more convincing than the circumstantial evidence presented by Hughes. There is, in fact, considerable (although incomplete) information regarding station histories, from original and contemporary sources. These have been examined to produce a more complete picture of dates of general introduction of Stevenson screens across Australia. In the light of the exchange between Parker and Hughes, it seems appropriate to document the information regarding the introduction of Stevenson screens, to assist in the determination of climate trends over the historical period. Distances in the original sources, which are quoted below, are given in feet (sometimes abbreviated to 'ft', and equivalent to 30·5 cm) and inches ('in', equivalent to 25·4 mm).

EVIDENCE OF DATES OF INTRODUCTION OF STEVENSON SCREENS

South Australia and Northern Territory

The journal *Instruments at Outstations, South Australia* (lodged in the National Meteorological Library of the Bureau of Meteorology) indicates that many South Australian stations replaced their Greenwich stands with

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Stevenson screens in 1892 (e.g. Robe, Mt Gambier—although the Greenwich stand was reintroduced here, see below). For some stations the Stevenson screen was introduced earlier (at Port Augusta a screen was used from 1888; prior to this the thermometers hung under a verandah). Not all stations had replaced their stands with screens by the early twentieth century, because Todd (1906) notes that 'Every station, except Fowler's Bay, has dry and wet bulb and maximum and minimum thermometers, mounted on a modified form of the Greenwich stand similar to that at Adelaide, or a Stevenson screen ...'. A 1907 letter from R. Griffiths (Acting Government Meteorologist, South Australia) to H.A. Hunt (Federal Meteorologist) notes that outstations were originally 'supplied with a stand of the Greenwich form ... but from time to time these have been replaced by S. Screens of this size, and now practically every station has a screen of these dimensions'. A few stations still did not have Stevenson screens at this time: at Eucla the Greenwich stand was replaced by a Stevenson screen in 1913, and at Cape Borda in 1909. A station was established at the Roseworthy Agricultural College in 1887, and equipped with a Stevenson screen; but when the station was inspected in 1908 the thermometers were on a Greenwich stand which was 'fixed not revolving', according to *Instruments at Outstations, South Australia*. At Mt Gambier the Stevenson screen had been replaced, sometime before an inspection in 1908, 'by a Greenwich Stand 6ft high (thermometers 4ft) without a movable platform', according to Instrument Inventory books held in the South Australian Regional Office of the Bureau of Meteorology and the Australian Archives.

Hughes (1995) includes a photograph of the Darwin Post Office showing a Stevenson screen, from the late nineteenth century. Hunt (1981), however, notes that 'Prior to 17 March, 1894, the thermometers were exposed in a modified form of the thermometer stand used at Greenwich, and which was similar to that in use at Adelaide, but on the date mentioned an enlarged Stevenson screen of the pattern now adopted by the Commonwealth Meteorological Bureau, was substituted, and is still in use'.

A Stevenson screen was installed at Adelaide in January 1887 because of the 'question of thermometer exposure having excited some interest' (Todd, 1906), however, these temperatures did not become official until 1948. The official shade temperatures were from thermometers 'placed on an improved stand, of the Greenwich form' (Todd, 1906), although duplicate thermometers were also 'mounted in an octagon-shaped wooden shed or house ... 10ft. in diameter, having a louvre roof carried by eight stout posts, the eaves of the roof being 7ft. 6in. above the ground. The sides are also louvred to within 5ft. 6in. of the ground, and a dwarf lattice wall is carried up 3ft., leaving a clear open space of 2ft. 6in. between the lattice work and the lowest louvre board. The building is floored, and in the centre the thermometers are fixed, at a height of 5ft. from the floor, on a skeleton revolving frame having a sloping roof like the Greenwich stand, but made of well-oiled and painted canvas. The whole of the building, as well as the stand, is painted white.'

Queensland

Wragge (1886) reported on meteorological observations in Queensland. He noted (regarding exposure of shade thermometers) that 'they hang in many positions ... Some are hung under verandahs and over wooden floors; others are placed against stone walls and fences. Such exposures (not to mention the several remarkable instances of thermometers being placed and observed indoors) give results which are not only not intercomparable and so valueless to meteorology, but which are affected by artificial and secondary conditions, giving misleading values'. Wragge was appointed Government Meteorologist and by the late 1880s Stevenson screens had been installed throughout Queensland (Donaldson, 1888). The journal *Queensland Instrument Book* (lodged in the National Meteorological Library of the Bureau of Meteorology) indicates that most Queensland stations introduced the Stevenson screen in 1889.

Western Australia

Cooke (1906) notes that at Perth 'A set of meteorological instruments was first mounted in a Stevenson screen on 1st January 1897, and observations have been taken regularly at 9 a.m. and 3 p.m. since that time'. This comment refers to a set of observations commenced at the site of the Perth Observatory, which was under construction at that time. From August 1885 to the end of 1896 the official Perth observations were from another site in the Botanical gardens. At that site 'The Thermometer house is of an octagonal form' (Cooke, 1897), 'built from plans supplied by

C. Todd, Esq., C.M.G., Government Astronomer, South Australia, the principle of exposure being similar to that followed in the Adelaide Observatory ... Thermometers for recording the temperature of the air in the shade are placed in the Thermometer house in a revolving stand of Mr. Glaisher's pattern' (Fraser, 1886). Although observations continued at this latter site for some years after 1896, still using the same exposure, the data were not used for official purposes after this date.

There are indications that Western Australian stations opened after 1897 were equipped with a Stevenson screen. It appears likely that stations operating at that date were refitted during 1896 and 1897, including the installation of a Stevenson screen. With the exception of the Perth Botanical gardens, stations operating prior to 1896 were described as having 'Shade Screens ... of the same pattern as those recommended and used by the Board of Trade' (Cooke, 1897). Cooke, the first Government Astronomer of the Colony, was appointed in February 1896 and he or a colleague visited most, if not all, the Western Australian meteorological stations during this year, replacing instruments. Cooke (1898) comments that on this tour he 'found things in a more or less unsatisfactory condition'. This and subsequent annual reports contain a statement which strongly suggests that each out-station was provided with a Stevenson screen before the end of 1897. The term 'Stevenson screen' was not use in the earlier report (Cooke, 1897). The Board of Trade screens were small, single louvred, fully enclosed wall screens (Anonymous, 1877, Scott, 1875, 1907). Thermometers in these screens were found to record higher temperatures than thermometers exposed in a Stevenson screen in open ground (Scott, 1875).

New South Wales

Hughes (1995) notes that there is evidence of an early move from open stand exposure at Sydney. However the thermometer exposure well into the twentieth century was *not* in a Stevenson screen. Hunt (1916) notes that, at Sydney, 'The thermometers have been exposed in a louvred shed 11 feet in length and width, of which the sides are 5ft. 6in. high. The roof is conical, and rises to 13 feet above the ground. As this shelter is gradually falling into decay a duplicate set of observations have been taken from thermometers exposed in an adjacent large Stevenson's screen for the past four or five years'.

The journal *N.S.W. Instrument Book* (lodged in the National Meteorological Library of the Bureau of Meteorology) indicates that some country stations received thermometer screens in 1898. Another group were supplied with screens in 1901, and a further group in 1906–1908. Earlier descriptions of thermometer exposure referred to thermometer 'stands'. Thus Moruya Heads was supplied with a 'stand' in 1876 and no further mention is made of exposure at this station until a 'thermometer screen' was supplied in 1908. Hunt (1907a) noted that even in 1907 'various forms of exposure screens are in use', across the State.

Victoria

Baracchi (1919) noted that by 1907 all Victorian stations had ' ... maximum, and minimum thermometers, and a Stevenson screen or other appropriate structure for their exposure'. This indicates that Stevenson screens were not in place at all stations, even by this late date. Baracchi introduced a 'Thermometer Shed' as the standard exposure around 1898. There are numerous indication of such sheds being erected at stations, in a handwritten journal recording correspondence about outstations at this time, and a three volume handwritten journal of instrumentation at all Victorian stations (these are lodged in the Commonwealth Government Archives). New stations were promised maximum and minimum thermometers only once they had erected a shed. There is evidence that the sheds were not Stevenson screens. There is an annotation on the pages of the journal relating to Gabo Island that indicates that a 'Thermometer Shed' is used. This has then been crossed out and, in a different hand and ink, 'Stevenson's Screen July 1901' has been added. Many other stations have similar annotations, and for many the 'Shed' was replaced in 1906–1908. For instance the entry for St Arnaud, which opened in 1880, reads 'Thermometer Shed replaced by small therm. screen 11/9/08'. Further confirmation that sheds and screens were not synonymous comes from the Stradbrook entry for 6 February 1899: 'Mr Easteby cannot induce his Company to erect a Therm. Shed. Mr Baracchi is willing to supply him with a Stevenson's screen for £3.10.0' (Editor–this is £3.50 in present currency). Six months later there is a note that the 'Stevenson's Therm. Screen' had been sent by mail. Baracchi (1919) describes the shed in use at 'the older stations, and at a few others of more recent date' as 'a double roof with a 10-in. free air-

space between, supported by four posts, enclosing an area of 5 by 6 feet, three sides of the shed being louvred from the roof down to a sufficient extent to exclude the direct rays of the sun'.

Tasmania

Wragge (1896) toured Tasmania in 1895 to report on the Meteorological Service. Only one station (Low Head) had a Stevenson screen, and this was improperly placed. At Hobart and several other stations the thermometers were exposed in a 'shelter' or 'shed' with a double iron roof that allowed early morning sunshine in summer to fall on the thermometers. At Corinna the thermometers were installed within the post office. Wragge had Stevenson screens built and installed at several stations including Hobart, and recommended their installation at all other stations. Hunt (1907a) noted, however, that by 1907 the 'screens are in a state of decay'.

Summary

Examination of primary sources regarding instrumentation at Australian meteorological stations indicates the following dates for the general introduction of Stevenson screens:

South Australia and Northern Territory: generally 1892, but some exceptions (e.g. Port Augusta 1888, Darwin 1894, Eucla 1913). Some Stevenson screens were replaced on unknown dates by a Greenwich stand, with the screen reintroduced in 1908.
Queensland: 1888/89.
Western Australia: 1896/97.
New South Wales: 1898–1908.
Victoria: generally 1906–08, although some were introduced earlier.
Tasmania: not earlier than 1895.

Even as late as 1907, by which time most stations had Stevenson screens, the situation regarding exposure of thermometers was less than perfect. Hunt, the recently appointed Commonwealth meteorologist, hosted a Meteorological Conference in Melbourne in May 1907. In his address to the Conference he noted that 'In different States various methods of exposure and types of equipment obtain. Some of the screens in use—in fact the majority—are of the dimensions of the British Stevenson pattern, and many that we have had the opportunity of seeing have been made without due consideration to the choice of wood in their construction, with the result, when subjected to our extremes of climate, have warped and cracked in all directions, arousing suspicion that the direct rays of the sun may occasionally reach the thermometers through the roof' (Hunt, 1907b). Hunt's appointment led rapidly to the standardization of exposures, with most of the remaining non-standard exposures being replaced by Stevenson screens from 1908. Only a few stations (e.g. Daly Waters in the Northern Territory) used non-standard exposure thereafter.

It is clear that many Australian stations installed Stevenson screens in the last few years of the nineteenth century, although some stations (notably in New South Wales and Victoria) did not receive screens until well into the twentieth century. So, around the start of the twentieth century there was a mixture of exposures of thermometers for the recording of shade temperatures: some were in Stevenson screens (many in a poor state of repair), some in Glaisher/Greenwich stands, and others in 'Thermometer houses or sheds'. The gradual introduction of screens means that comparisons between temperatures at various stations could be used to correct for biases resulting from the introduction of screens. Some idea of possible biases in temperatures in the late nineteenth century arising from the lack of Stevenson screens at many stations can be gained from contemporary measurements of temperatures in the different exposures.

STEVENSON SCREENS VERSUS GREENWICH/GLAISHER STANDS IN AUSTRALIAN CONDITIONS

Stevenson screens and a Glaisher stand were operated continuously at Adelaide Australia, from 1887 until 1948. This period of comparison far exceeds other comparisons between stands and screens, as reported in Parker (1994). The maximum and minimum temperatures in the Stevenson screen and the Glaisher stand have been compared

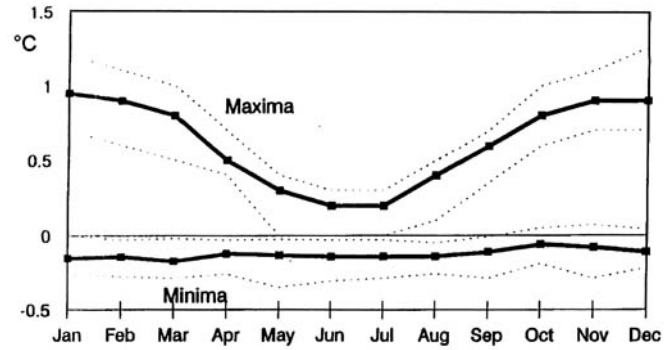

Figure 1. The median and upper and lower quartiles of the mean monthly differences between temperatures measured at Adelaide in the Stevenson screen and on the Glaisher/Greenwich stand (Glaisher/Greenwich temperatures minus Stevenson temperatures). Data used were the 61 complete years of record (1887–1947)

using the 61 complete years (1887–1947) of record (Richards *et al.*, 1992, 1993). Figure 1 shows the median differences in the mean monthly maximum and minimum temperatures (Glaisher/Greenwich minus Stevenson), and the upper and lower quartiles of the differences. The minima measured in the two exposures are similar throughout the year, with Stevenson screen minima being about 0·2°C warmer. The maxima measured in the Stevenson screen are cooler than those in the Glaisher stand and the difference varies seasonally. The difference is only about 0·2°C in winter, but reaches nearly 1°C in summer. These differences, and the annual cycle in the mean differences can be compared with the situation in England, as summarized by Parker (1994). At Adelaide the differences in the minima were smaller, whereas the differences in the maxima were larger. The median difference in temperatures at Adelaide was considerably larger than the differences noted by Parker (1994) at higher latitude stations. Over the year, the mean temperatures were about 0·2°C warmer in the Glaisher stand, relative to the Stevenson screen.

If the conditions at Adelaide were representative of other stations, the progressive introduction of Stevenson screens across Australia between the late 1880s and about 1908 would have introduced an artificial drop in temperature. The magnitude of this drop would have depended on the number of screens originally exposed on Glaisher/Greenwich stands or a similar 'open' environment, prior to their replacement by Stevenson screens. The artificial drop would have occurred at different times in the different colonies, because each colony introduced Stevenson screens at different times. As noted above, the progressive replacement of the earlier exposure methods should enable a careful, objective site-by-site comparison to calculate the biases due to various exposure methods.

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