Mr Grant Hehir
Auditor-General of Australia
Australian National Audit Office
GPO Box 707
Canberra ACT 2601

Dear Mr Hehir

Re: Reliability of methodologies used to construction Australian temperature record

I'm writing in support of a submission made by my colleague Dr Jennifer Marohasy to your office on 11th November, 2015. In particular I'm providing additional information regarding adjustments made to the official historical temperature record for Australia. Dr Marohasy provided Rutherglen as a case study in her submission, I'm providing examples of much larger adjustments. Like Rutherglen, these adjustments cannot be logically justified as I explain in the appendix to this letter.

The following table is a summary of particularly large adjustments of raw temperature measurements by the Bureau in the creation of ACORN-SAT temperatures, which are used to calculate official historical temperatures for Australia. In the case of Dubbo, Carnarvon, Rabbit Flat and Brisbane the adjustments cause increases of more than 2 ^{0}C per hundred years. The detail of the adjustments is given in the following appendix and summarized in the three right columns of this table.

Station	Period		ΔT per 100 years			Adjustments*		
	Years	No. of years	Raw	ACORN-SAT	Increase	Total	Moves	Statistical
Maxima:								
Kyancutta, SA	1930 to 2012	82	0.64	1.84	1.20	3	0	3
Kalgoorlie, WA	1910 to 2012	102	-0.47	0.72	1.19	2	1	1
Nhill, Vic	1932 to 2012	80	0.59	1.53	0.94	7	3	4
Tibooburra, NSW	1912 to 2012	100	0.56	1.53	0.97	7	4	3
Minima:								,
Wilcannia, NSW	1955 to 2012	57	-0.21	1.65	1.86	3	1	2
Dubbo, NSW	1912 to 2012	100	-0.16	2.26	2.42	11	6	0
Carnarvon, WA	1912 to 2012	100	0.18	2.20	2.02	7	0	4
Rabbit Flat, NT	1970 to 2012	42	-1.06	1.73	2.79	6	0	4
Brisbane, QLD	1950 to 2012	62	-0.68	1.57	2.25	6	1	1
Cunderdin, WA	1950 to 2012	62	-0.96	0.53	1.49	2	1	1

***** Other adjustments are merge, screen change and observation time change in Tables A1 and A2

By way of background, I'm trained as a nuclear physicist. I have been a Fellow of three Oxford Colleges and have worked in the United States and Europe. I have published papers on atmospheric methane, ocean interaction with atmospheric CO2, wind power and the nuclear fuel cycle. I am currently a Visiting Fellow of Deakin University (Centre of Rural and Regional Futures).

Yours Sincerely

Dr Tom Quirk
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19th January, 2015

Appendix

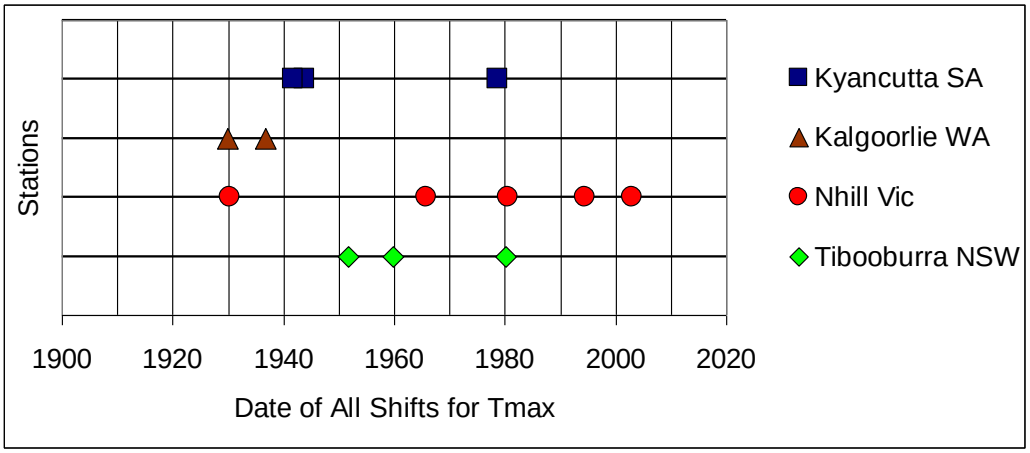
The causes for the adjustments in the above table are defined by the Bureau as follows:

O merge - data from two different station numbers are being merged with overlap,
O move - a documented move (this is restricted to changes at the site that are firmly documented)
O move (n) - a documented move together with a change of station number
O screen - indicates a change or repair to the screen
O obs time - indicates a change in observation time (most often the 1964 change at some stations from a midnight to 9am observation time),
O site env - a change has occurred in the local site environment (e.g. addition/removal of building nearby, change in vegetation),
O statistical - a change found by statistical methods without specific metadata support
*O statistical** - indicates some kind of metadata support which may be imprecise or subject to interpretation

The times at which the adjustments are made are shown in Figure 1 below.

There are a significant number of "moves" where the location of the thermometers has been moved. One would expect that any shift would be accompanied by an overlap period. However it is clear that for most sites there is little or no overlap measurements. In fact the detailed information shows that up to 10 nearby sites have been used for the adjustment. This procedure does not give the temperature adjustment at the site but rather a possibly unrelated adjustment. A check on this would be to see what these same sites would give when compared to the old location before the move.

The most extraordinary adjustment is "obs time". Brisbane Airport location is an example and is listed in Table A2. This is when the reading time of the 24 hour maximum and minimum measurement thermometers was changed from a midnight reading to a 9 am reading. The 9 am reading generally gives the maximum for the previous day as the maximum temperature usually occurs in mid afternoon while the minimum usually occurs before sunrise in the early morning of the day of the reading. So the description of this adjustment makes no sense.



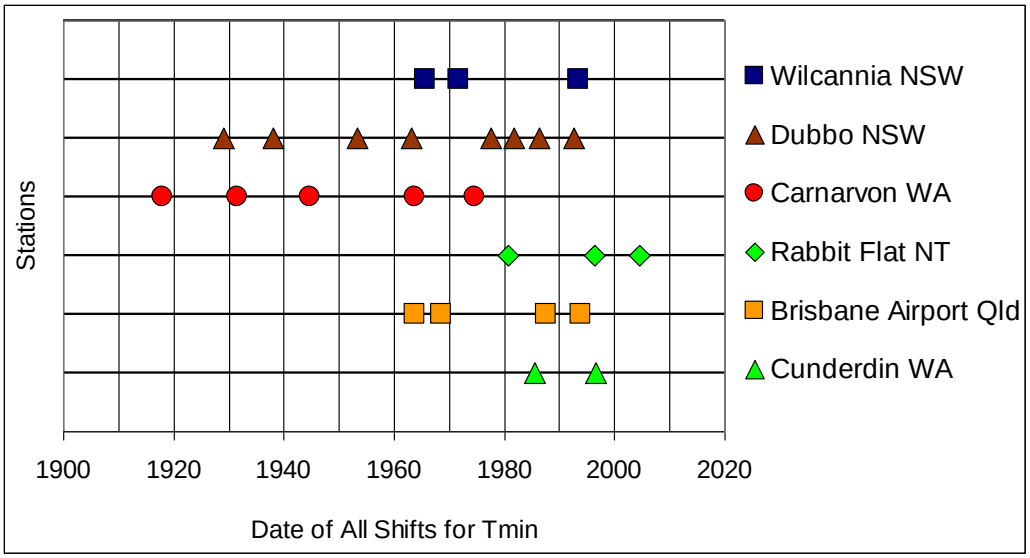
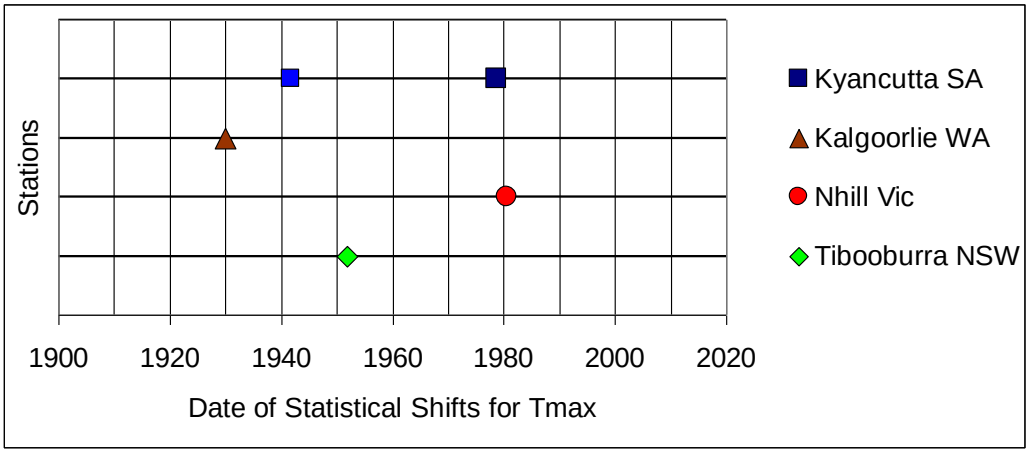


Figure 1: *Timing of all adjustments for* ***Top)*** *Tmax and* ***Bottom)*** *Tmin*

Finally the statistical adjustments are made without any supporting evidence. The timing of these adjustments is shown in Figure 2.

Any adjustment that is derived from a statistical approach should not only give values but also the uncertainty in the magnitude of the shift and most importantly the timing when the shift occurred. Further the nearby stations used to identify statistical shifts may be 10s to 100s of kilometres away from the chosen station. The degree of correlation of remote sites from the chosen station may vary as a function of distance and this should be measured and considered before its use in the analysis. This is a well known approach in mineral ore body evaluation.



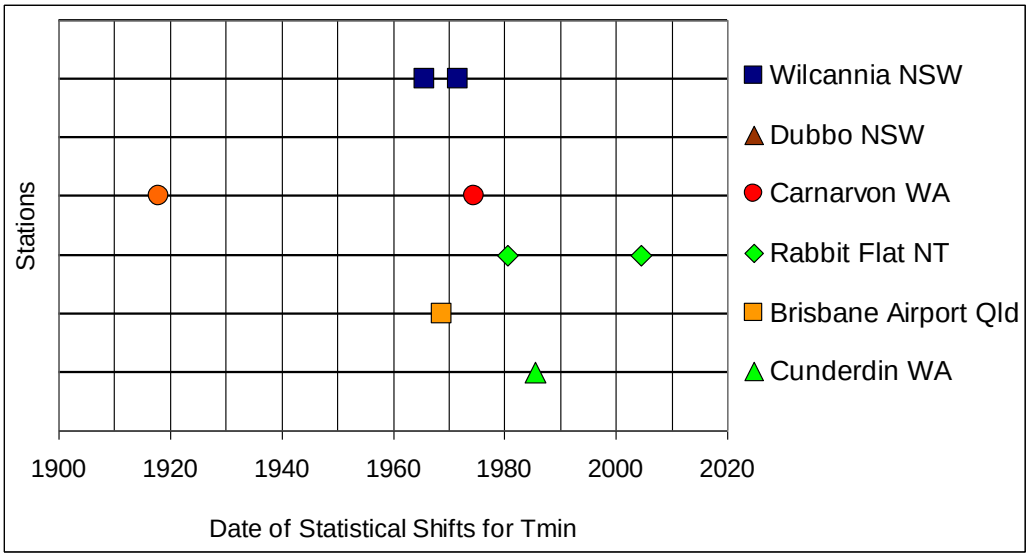


Figure 2: *Timing of statistical adjustments for* ***Top)*** *Tmax and* ***Bottom)*** *Tmin*

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The conclusion to be drawn from these examples is that ACORN-Sat adjustments are changes resulting from a not very rigorous analysis. The time series at stated locations are scrambled by adjustments derived from other locations. Further the explanation of the procedure followed would be helped by making the procedures used in the computer analysis available for external validation.

Further details of the ACORN-SAT adjustments are shown in Tables A1 and A2.

Table A1

Maximum	Date	Cause	ΔT ^{0}C					Sites used
Kyancutta SA	1-Jan-79	Statistical period	-0.42					10
Kyancutta	1-Jan-44	Statistical	0.77					10
Kyancutta	1-Jan-42	Statistical	-0.56					10
Kalgoorlie WA	1-Dec-36	Move	-0.54					9
Kalgoorlie	1-Jan-30	Statistical	-0.62					8
Nhill Vic	1-Jun-03	Merge	0.35					1
Nhill	1-Jan-95	Move	0.36					10
Nhill	1-Jan-81	Statistical	-0.31					10
Nhill	1-Mar-66	Move	-0.17	Summer	-0.54			10
Nhill	1-Jul-30	Move	-0.23	Summer	-0.57			10
Tibooburra NSW	2-Aug-80	Move	-0.29	Spring	-0.54			10
Tibooburra	1-Jan-60	Move	-0.34	Spring	0.37			10
Tibooburra	1-Jan-52	Statistical	-0.02	Winter	-0.38	Summer	0.44	9

Table A2

Minimum	Date	Cause	ΔT ^{0}C					Sites used
Wilcannia NSW	1-Dec-93	Move	-0.86					10
Wilcannia	1-Jan-72	Statistical	0.6					10
Wilcannia	1-Jan-66	Statistical	-0.5					10
Dubbo NSW	16-Jan-93	Merge	-0.17	Autumn	-0.44	Summer	-0.37	
Dubbo	22-Oct-86	Move	-0.71					10

Dubbo	1-Feb-82	Move	-0.33					10
Dubbo	1-Jan-78	Move	0.3					10
Dubbo	1-Jul-63	Move	0.75					10
Dubbo	1-Jul-53	Move	-1.05					10
Dubbo	1-Apr-38	Screen	-0.13	Summer	-0.53			10
Dubbo	1-Apr-29	Move	0.99					10
Carnarvon WA	1-Jan-75	Statistical*	-0.53					10
Carnarvon	1-Jan-64	Obs time	-0.26					10
Carnarvon	10-Jan-45	Merge	-1.04					1
Carnarvon	1-Sep-31	Screen	-0.44					9
Carnarvon	1-Jan-18	Statistical	-0.29	Autumn	-0.5	Winter	-0.33	6
Rabbit Flat NT	1-Jan-05	Statistical	-0.18	Spring	-0.46	Summer	-0.35	10
Rabbit Flat	15-Nov-96	Merge	0.21	Winter	0.59			1
Rabbit Flat	1-Jan-81	Statistical	-0.87					10
Brisbane Airport Qld	1-Apr-94	Merge	0.25	Spring	0.54	Summer	0.37	1
Brisbane Airport	30-Nov-87	Move	-0.61					10
Brisbane Airport	1-Jan-69	Statistical	-0.69					10
Brisbane Airport	1-Jan-64	Obs time	0.47					10
Cunderdin WA	1-Jan-97	Move (n)	-0.66					10
Cunderdin	1-Jan-86	Statistical	-0.47					10

Ends.