

ACORN-SAT station adjustment summary—Mackay (as at 24 September 2014)

Mackay is one of 112 ACORN-SAT stations used by the Bureau of Meteorology to assess changes in Australia's climate. Mackay has a complex observation history. The official long-term temperature record for Mackay is predominantly comprised of data from the post office site in the town centre (station number 33046), which closed in 1950, and the Mackay Meteorological Office (station number 33119), near the ocean 5 km north-east of the town centre, which opened in 1959. The gap between these two sites is filled by the Te Kowai research farm (station number 33047), 7 km west of the town centre. There is a further site at Mackay Airport (station number 033045), but this is not used in ACORN-SAT except as a reference station for assessing possible statistical detection of breakpoints.

Observations at Mackay began in 1870, but only limited pre-1910 temperature data have been digitised, and only post-1910 data have been included in the ACORN-SAT dataset. Comparison of the Mackay data with surrounding stations (neighbours), 19 of which have been used at various times, combined with the use of documentary records and periods of parallel data between the three Mackay sites, reveals that there have been six significant breaks in the data and a seventh short-term variation. Three of these, including the two largest, are associated with documented site moves. The raw data series is a combination of several data series that must be adjusted to derive a single, consistent and accurate representation of temperature changes over time.

The ACORN-SAT record contains daily records of minimum (night-time) temperature (Min T) and maximum (daytime) temperature (Max T). The charts in this fact sheet show annual average values of Min T and Max T. The impacts of the daily adjustments on the annual average values are shown in the table below.

The changes that occurred at Mackay and the resulting impacts are summarised as follows:

- 1 January 1914—breakpoint detected by statistical methods.
 - Daytime temperatures started to appear cooler relative to surrounding stations.
 - Max T adjusted by -0.56 °C. No detectable impact on Min T so no adjustments made.
- 1 January 1939 to 1 January 1941—short-term variation detected by statistical methods, prior to a site move in 1941.
 - Daytime temperatures started to appear much warmer relative to surrounding stations.
 - Max T adjusted by -1.67 °C during this period, and $+0.42$ °C after it. No detectable impact on Min T so no adjustments made.
- 1 January 1944—breakpoint detected by statistical methods.
 - Daytime temperatures started to appear warmer relative to surrounding stations.
 - Max T adjusted by $+0.80$ °C. No detectable impact on Min T so no adjustments made.
- 1 January 1948—ACORN-SAT record switches over to Te Kowai (overlap with post office to 1950).
 - Night-time temperatures much cooler, and daytime temperatures slightly cooler, at Te Kowai than in overlapping post office data.
 - Min T adjusted by -2.47 °C. Max T adjusted by -0.31 °C.

- 25 September 1959—ACORN-SAT record switches over to Meteorological Office (overlap with Te Kowai used until 1964).
 - Daytime temperatures much cooler, and night-time temperatures much warmer, at Meteorological Office than in overlapping Te Kowai data.
 - Min T adjusted by $+1.94$ °C. Max T adjusted by -1.50 °C. (Net adjustments from post office site are -0.53 °C for Min T and -1.81 °C for Max T).
- 1 January 1969—breakpoint detected by statistical methods.
 - Night-time temperatures started to appear cooler relative to surrounding stations, especially in summer.
 - Min T adjusted by -0.22 °C (-0.54 °C in summer). No detectable impact on Max T so no adjustments made.
- 1 January 1971. Breakpoint detected by statistical methods.
 - Daytime temperatures started to appear cooler relative to surrounding stations
 - Max T adjusted by -0.33 °C. No detectable impact on Min T so no adjustments made.

Charts 1 and 2 compare raw and adjusted data for annual average Min T and Max T when all relevant factors from 1910 onwards are included.

In Chart 1 the trend lines show that the average Min T is increasing in both the adjusted and raw data. Over the full period of record, the warming trend in the adjusted data is slightly stronger than in the raw data. From 1948-1960 the raw data are much cooler than the adjusted data, and hence for trends which have a starting point within that period (e.g. 1950 to present), the trend in the adjusted data will be much weaker than in the raw data. In this case, the adjustment has increased the artificially small warming trend indicated by the raw data for the period from 1910 to the present, but decreased the artificially large warming trend indicated by the raw data for the period from 1950 to the present.

In Chart 2 the trend lines show that the adjusted average Max T is increasing whereas the raw data is decreasing. In this case, the adjustment has corrected the artificial cooling trend created by combining the various raw data sets.

Chart 3 shows a comparison of the temperatures at the three Mackay sites during the years when they overlap, between 1940 and 1965. It can be seen that maximum temperatures at the post office and Te Kowai sites are similar, but that the Meteorological Office site is significantly cooler than Te Kowai (and hence cooler than the post office). Minimum temperatures at Te Kowai are significantly cooler than at either the Meteorological Office or the post office, indicating that minimum temperatures at the Meteorological Office and post office are broadly similar.

Chart 1: Mackay annual average minimum temperatures (1910–2013)

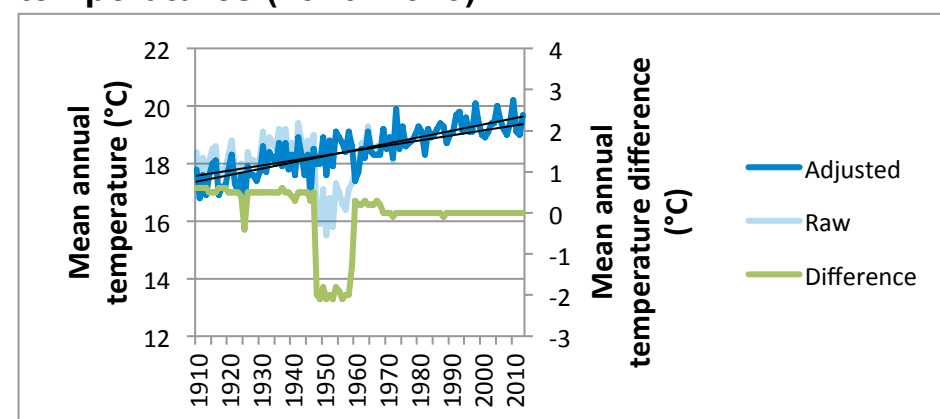


Chart 2: Mackay annual average maximum temperatures (1910–2013)

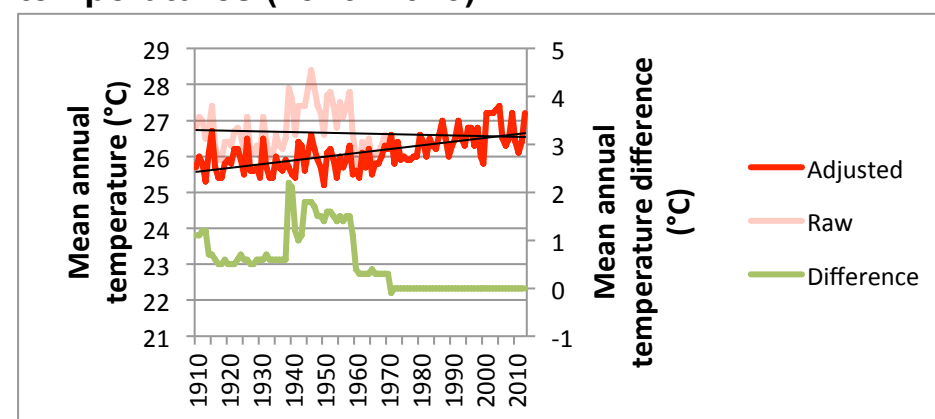
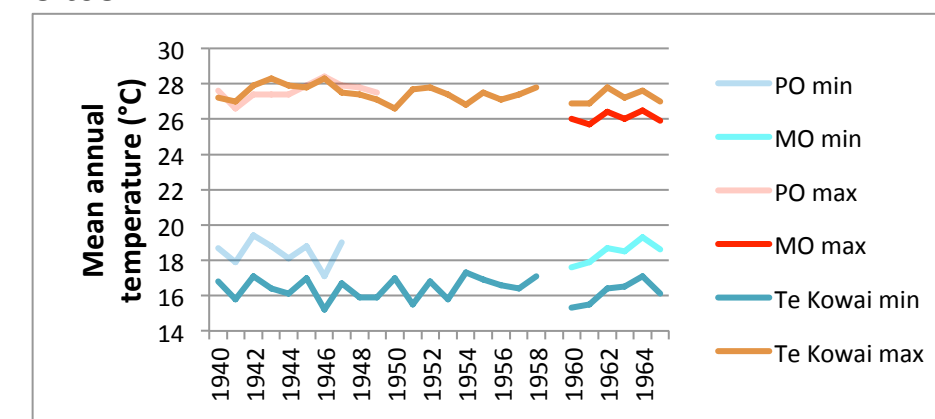


Chart 3: Comparison between the three Mackay sites



Mackay station temperature adjustments

Station name	Station number	Temperatures adjusted	Date (adjustment applied to all data prior to this date, unless stated)	Cause	Impact of adjustment (°C)	Seasonal (if applicable)	Comparative stations										Merged stations	Notes
							33047	33058	39023	33013	39083	32005	33007	32078	39122	32037		
Mackay	33119	Max	1/1/1971	Statistical	-0.33		33047	33058	39023	33013	39083	32005	33007	32078	39122	32037		
Mackay	33119	Min	1/1/1969	Statistical	-0.22	Summer -0.54	33047	39083	33065	33002	35019	32040	33013	34002	39069	32004		
Mackay	33119	Min	25/9/1959	Move (with overlap)	1.94												33047	1959–1964 data used in overlap
Mackay	33119	Max	25/9/1959	Move (with overlap)	-1.50												33047	1959–1964 data used in overlap
Mackay	33119	Min	1/1/1948	Move (with overlap)	-2.47												33046	1948–1950 data used in overlap
Mackay	33119	Max	1/1/1948	Move (with overlap)	-0.31												33046	1948–1950 data used in overlap
Mackay	33119	Max	1/1/1944	Statistical	0.80		33047	39083	34002	33001	32040							
Mackay	33119	Max	1/1/1941	Move	0.42		33047	34002	33001									
Mackay	33119	Max	1/1/1939–31/12/1940	Statistical	-1.67		33047	34002	33001	32005	33007	39069	35019	39023				
Mackay	33119	Max	1/1/1914	Statistical	-0.56		33047	34002	33001									

Comparative and merged stations

Station number	Station name
32004	Cardwell
32005	Cape Cleveland
32037	South Johnstone Experimental Station
32040	Townsville
32078	Ingham
33001	Ayr
33002	Ayr DPI Research Station
33007	Bowen
33013	Collinsville
33046	Mackay Post Office.
33047	Te Kowai
33058	Pine Islet
33065	St. Lawrence
33077	Pacific Heights
34002	Charters Towers
35019	Clermont
39023	Cape Capricorn
39069	Walterhall
39083	Rockhampton Airport
39122	Heron Island

Station temperature adjustment table legend

- Station name: name used in the national climate record
- Station number: the active ACORN-SAT station number as at 31 December 2011.
- Temperatures adjusted: this describes which aspect of the temperature record was adjusted—Max for daily maximum temperature; Min for daily minimum temperature.
- Date: all data prior to this date was adjusted for the reason (cause) cited.
- Cause: this describes why an adjustment was required.
 - Merge: data from two different station numbers are being merged, with overlap.
 - Move: a documented site move.
 - Move (n): a documented site move, together with a change of station number.
 - Screen: indicates a change or repair to the Stevenson screen.
 - Obs time: indicates a change in observation time (most often the 1964 change at some stations from a midnight to 9 am observation time).
 - Site env: a change has occurred in the local site environment (e.g. addition/removal of building nearby, change in vegetation).
 - Statistical: a change found by statistical methods without specific documentary support.
 - Statistical*: indicates some kind of documentary support which may be imprecise or subject to interpretation. This is further explained in the notes field.
 - AWS: installation of an automatic weather station; if there was an associated site move this is shown as 'move'.
- Impact of adjustment: the overall impact of the daily adjustments made for the particular reason (cause) cited.
- Seasonal (if applicable): this applies where the adjustment was made on the basis of seasonal, rather than annual, criteria. In general the minimum threshold for adjustment is a 0.3 °C difference in the annual mean. Exceptions include:
 - where seasonal criteria are met (0.3 °C in two seasons, or 0.5 °C in a single season), in which case details are given; or
 - for the 1964 observation time change, which standardised the time for taking all observations at 9.00 am.
- Comparative stations: stations against which the station's data was compared statistically.
- Merged stations: stations from which data was sourced and merged to enable adjustment (see Notes above)
- Notes: provides additional explanatory information.