



The NIWA “Seven-Station” Temperature Series

9 February 2010

NIWA has previously posted its NZ ‘seven-station’ temperature series data for download here: <https://www.niwa.co.nz/our-science/climate/news/all/nz-temperature-rise-clear/seven-station-series-temperature-data>. Links to this and other related material can be found at <http://www.niwa.co.nz/our-science/climate/news/all/new-zealands-climate-is-warming>. NIWA’s “raw” climate data (as measured, no adjustments) can be downloaded for free from NIWA’s website, <http://www.cliflo.niwa.co.nz>.

There are currently 238 climate stations that routinely report temperatures and other data to the NIWA Climate Database, plus an additional 483 manual rainfall-only stations. Many of these currently-open stations have relatively short records (less than 10 years), but temperature trends can be extended further back in time using data from closed stations. However, a number of the open climate stations have records back to at least 1950, and these long-term records of New Zealand temperature show clear evidence of warming through the 20th century. An example from 11 pristine sites with no significant site changes or environmental changes since the 1930s is shown here: <http://www.niwa.co.nz/our-science/climate/news/all/nz-temperature-rise-clear/temperature-trends-from-raw-data>.

Prior to the 1930s, a lot fewer observations are available. The ‘seven-station’ series are especially valuable because they come from places with very long temperature records, and between them span the country north to south and west to east. Two of the records go back to 1853, and all seven go back to 1908. Unfortunately, none of the individual sites have operated continuously to the present day, so if one wants to assess long-term trends it is necessary to merge temperature records from different sites within the same general area. Table 1 lists the individual sites and the adjustments applied to the raw temperature data.

The longest continuous record in the Climate Database is from Albert Park, Auckland, 1853-1989 (but see footnote 2). The Christchurch Gardens site began measurements in 1863, and is still reporting, but there is a break in the records 1881-1904. Indeed, most of the early climate measurement sites were closed at the end of 1880 due to government financial restrictions (de Lisle, 1986).

Site Changes and Adjustments

There have been various site moves over the century for the individual stations making up the long 7-station series. To analyse these data for long-term national trends in temperature it is necessary to make adjustments for times when the measurement sites were moved significantly, or when other changes are known to have affected the measurements.

Examples are a site movement from near sea level to a significantly higher location where it is naturally cooler (see link: <http://www.niwa.co.nz/news-and-publications/news/all/niwa-confirms-temperature-rise/combining-temperature-data-from-multiple-sites-in-wellington>), or a move to a site which is consistently different in temperature for some other reason. Adjustments are then made, following established procedures, to ensure we are “comparing apples with apples”. These adjustments are only made for the purpose of analysing and plotting the variations and trends – the original “raw” data in the NIWA climate database are not changed.

The most straightforward adjustments to calculate are where the new site has an overlap in its record with the site it is replacing. Unfortunately, all too often such overlaps do not occur; for example, in Wellington, the site of the observatory near Bolton St cemetery was required at very short notice in 1906 for the grave of the Premier, Richard Seddon. In such instances, it is necessary to go to a third site that spans the change-over period. Salinger (1981) provides the results of these three-site inter-comparisons for the 7-station series, up to about 1975. There is also a variety of statistical tests that can be applied to a single record to highlight possible changes in the homogeneity of the data (see Rhoades & Salinger, 1993). See the References below for additional material on site adjustments, and how judgements can be made on the representativeness of sites. A document describing site adjustments for the Hokitika record is available at <http://www.niwa.co.nz/?a=101835>.

The conclusion that New Zealand has warmed since 1900 is not based only on the 7-station data set, or indeed on the additional 11 pristine sites mentioned above. Information from ship measurements of sea-surface temperatures and marine night-time air temperatures over the oceans surrounding New Zealand indicate a warming trend through the twentieth century that is in close agreement with land-based temperature measurements (Folland and Salinger, 1995).

References:

De Lisle, J.F., 1986. Sails to Satellites: A History of Meteorology in New Zealand. Published by the New Zealand Meteorological Service, Wellington, 186p.

Folland, C.K., and M.J. Salinger, 1995. Surface temperature trends and variations in New Zealand and the surrounding ocean, 1871-1993. *International Journal of Climatology*, **15**, 1195-1218.

Fouhy, E., Coutts, L., McGann, R., Collen, B., Salinger, M.J., 1992. South Pacific Historical Climate Network Climate Station Histories. Part 2, New Zealand and Offshore Islands. NZ Meteorological Service, Wellington. ISBN 0-477-01583-2.

Rhoades, D.A., and Salinger, M.J., 1993: Adjustment of temperature and rainfall measurements for site changes. *International Journal of Climatology*, **13**, 899 – 913.

Salinger, M.J., 1977. Dunedin temperatures since 1853. Proceedings of 9th New Zealand Geographical Society Conference, pp.106-109.

Salinger, M.J., 1979. New Zealand temperatures since instrumental records began. Proceedings of 10th New Zealand Geographical Society Conference and 49th ANZAAS Conference, Auckland, pp.13-17.

Salinger, M.J., 1981. Site Assessments on Climatological Stations. Appendix C in: *New Zealand Climate: The instrumental record*. Thesis submitted for the degree of Doctor of Philosophy at the Victoria University of Wellington, January 1981.

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Table 1: Information on NIWA’s “seven-station” temperature series: (1st column) the seven locations, and all individual sites within each location; (2nd column) agent number used by NIWA Climate Database (CliDB) to identify the station; (3rd column) adjustment added to raw data to make temperatures homogeneous with the (usually) latest site; (4th column) period of record for which adjustment applies¹, plus additional remarks on data issues.

Location/Site	Agent	Adjustment	Period of Record
		°C	** Remarks
Auckland			
Albert Park ²	1427	-0.4	Jan-1853 to Aug-1868 ** Months missing 1853-54 so no annual value possible. ** 1861-62 temperatures unreliable.
		-0.5	Sep-1868 to Dec-1950
		-0.6	Jan-1951 to Dec-1975 ³

¹ Please note that all adjustments can only ever be estimates, made in good faith and using scientifically accepted methodologies.

² Although this site is designated as “Albert Park” in the Climate Database, there were actually several early site moves: temperature measurements were taken at Albert Barracks by the Royal Engineers 1853-1869, the Government domain 1868-1883, and the Museum 1883-1909, before Albert Park proper was established in September 1909 (Fouhy et al., 1992).

Mangere	1945	0.0	Jan-1976 to Jul-1998
Auckland Aero	1962	0.0	Aug-1998 to Apr-2002
Mangere EWS	22719	0.0	May-2002 to present
Masterton			
Waingawa	2473	-0.5 -0.2 0.0	Jan-1906 to Apr-1920 Jun-1920 to Sep-1942 Oct-1942 to Dec-1990
East Taratahi AWS	2612	0.0	Jan-1991 to Oct-2009
Martinborough EWS	21938	-0.3	Nov-2009 to present ** Provisional replacement site, adjustment varies seasonally
Wellington			
Knowles Observatory	3383	-0.5	Mar-1862 to Oct-1868
Bowen St	3389	-0.5	Nov-1868 to Oct-1869
Bolton St Cemetery	3390	-0.5	Nov-1869 to May-1906
Buckle St	3431	-0.6	Jun-1906 to Jun-1912
Thorndon	3391	-0.8	Jul-1912 to Dec-1927
Kelburn	3385	0.0	Jan-1928 to Aug-2005
Kelburn AWS	25354	0.0	Sep-2005 to present
Nelson			
Nelson City	4244	-0.6	Jul-1862 to Dec-1880 ** 1863 data not on CliDB ** Jan-1881 to Sep-1907 missing
Nelson, Nile St East	4244	-0.9	Oct-1907 to Nov-1920 ⁴
Cawthron Institute	4244	-0.1	Dec-1920 to Dec-1931 ⁵
Appleby	4239	0.0	Jan-1932 to Nov-1996
Appleby EWS	12755	+0.2	Dec-1996 to May-2000
Nelson Aero	4241	+0.2	Jun-2000 to Mar-2001
Appleby 2 EWS	21937	+1.0	Apr-2001 to present ** Adjustment under review
Hokitika			
Hokitika South (actually in township)	3907	-0.5 -1.3	Jan-1867 to Dec-1880 ** No data 1881-1893 Jan-1894 to Aug-1912 ** Raw data incorrect ⁶

³ Note that the adjustments are increasing with time, a possible indication of urban warming. This is a key reason for moving to a less built-up site (Mangere) as the station representing the “Auckland” location in the composite temperature series.

⁴ The Nile St Vicarage data has not been entered on the Climate Database, but is being digitised as resources permit.

⁵ Note the same station name and agent number are retained through two site changes,

⁶ See this page (<http://www.niwa.co.nz/?a=101835>) for further clarification. CliDB holds the original data as recorded, even though it was recognised back in 1912 to be in error because the meteorological enclosure containing the instruments was too small (daily maximum temperatures noted as being approximately 3°F too high). Rather than delete this data permanently from the records, the period 1894-1912 is flagged, and it is up to the analyst to decide whether to use the data or not, and if so how

		-0.3	Sep-1912 to Jul-1943 ** Township site closed Dec-1945
Hokitika South (old Aerodrome)	3907	+0.3	Aug-1943 to Dec-1964 ** New site opened without name change in Aug-1943 ⁷
Hokitika Aero	3909	0.0	Jan-1965 to present
Christchurch			
Christchurch Gardens	4858	-0.7	Jan-1864 to Dec-1880
Lincoln	4881	-0.5 -1.0 -0.8 -0.3 +0.4 +0.2 0.0	Jan-1881 to Dec-1904 Jan-1905 to Jun-1915 Jul-1915 to May-1929 Jun-1929 to Dec-1943 Jan-1944 to Jan-1965 Mar-1965 to Dec-1975 Jan-1976 to May-1987 ** See Rhoades & Salinger (1993) for discussion of adjustments
Lincoln Broadfield EDL	4882	0.0	Jun-1987 to Dec-1999
Lincoln Broadfield EWS	17603	0.0	Jan-2000 to present
Dunedin			
Exchange, Princes St	22645	+0.5	Jan-1853 to Dec-1863
Observatory, Roslyn	5378	0.0	Jan-1864 to Apr-1886
Leith Valley	5380	+0.3	May-1886 to Jan-1913
Botanical Gardens	5375	-0.1	Feb-1913 to Sep-1940
Beta St Reservoir	5379	+1.3 +0.6	Oct-1940 to Nov-1942 Dec-1942 to May-1947
Musselburgh	5402	-0.2 0.0	Jun-1947 to Dec-1959 Jan-1960 to Aug-1997
Musselburgh EWS	15752	0.0	Sep-1997 to present

to correct it in a way that can be scientifically justified. This has long been the philosophy of the climate section at NIWA and its predecessor the New Zealand Meteorological Service.

⁷ Temperature data for the overlap period 1943-45 between the Township and Aerodrome sites are not yet on CliDB, but the Southside site is 0.6 to 0.7°C colder than the Township during the overlap period. NIWA still holds the original paper records, and is getting the information digitised as resources permit. It will be necessary to generate a new agent number and split the current Hokitika South 1867-1964 data into two parts, Hokitika Township 1867-1945 and Hokitika Southside 1943-1964.