Scientific integrity and robustness of Australian climate record

This factsheet covers the robustness of the Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT) dataset, including:

- homogenisation and the overall climate trend
- trends in other available datasets and comparison of methods
- progress on improving decision making
- ACORN-SAT as an Essential Statistical Asset.

How homogenisation affects Australia's climate trend

The differences between 'raw' and 'homogenised' datasets are small, and capture the uncertainty in temperature estimates for Australia. The bulk of the uncertainty relates to Australian temperatures from around 1910 to 1940 when the national temperature network was relatively sparser and many sites were reporting from the centre of small towns.

Reference to 'raw' data is in itself a misleading concept as it often implies some pre-adjustment dataset which might be taken as a pure recording at a single station location. For two-thirds of the ACORN-SAT station series there is no raw temperature series, but rather a composited series taken from two or more stations. The often quoted "raw" series is in fact a composite series from different locations.

When compiling long time-series of temperature data from individual locations across Australia, it is demonstrable that non-climatic factors influence apparent changes in the data over time. These factors include changes in the observing network over time and changes in site conditions or observing practices over time, which introduce spurious artefacts (apparent changes that are not associated with actual climate change) into the record.

In Australia, for example, the network has changed from an ad-hoc distribution of non-standard instruments and enclosures across the country prior to 1908, to a network of standard instruments that has progressively covered more of the continent from 1908 onward.

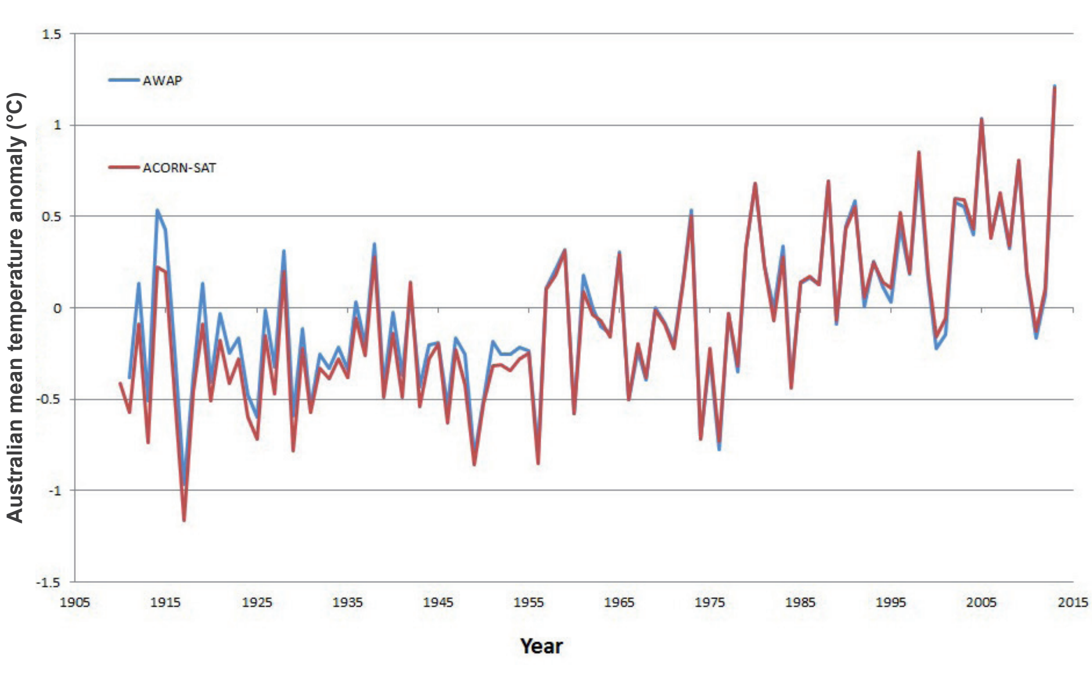

Figure 1: Comparison of two different Bureau of Meteorology temperature records for Australia. The Blue line is the unadjusted (AWAP) gridded Australian average temperature. The red line is the homogenised (ACORN-SAT) temperature for Australia.

Failure to account for the non-stationarity in the network, for example an increase in the number of site in inland and northern areas, or a systematic shift of observing sites from post offices to airports, leads to apparent and spurious trends in the data.

Trends in temperature rendered from absolute raw data are in no way a physical baseline for the comparison of properly analysed trends. As an example, the increase in sites in northern and inland locations results in a very large and spurious warming trend in absolute raw data. Conversely, a systematic shift from locations in the centre of towns or near the coast to inland rural locations which has been commonplace with the development of aviation leads to a spurious (smaller) cooling trend.

Comparing specifically homogenised temperature records with those that are simply spatially analysed (the real-time monitor described in the 'Public availability of ACORN-SAT' factsheet) shows a very high level of agreement in temperature variability and trends since 1960 onward (see Figure 1). This corresponds to the period in which the warming trend is largest for Australia. The trend since 1961 in ACORN-SAT is +0.76 °C ; the trend in an older version of the homogenised dataset, using different methods and based on monthly data, puts the trend at +0.75 °C, while the trend in the unadjusted gridded data is +0.71 °C.

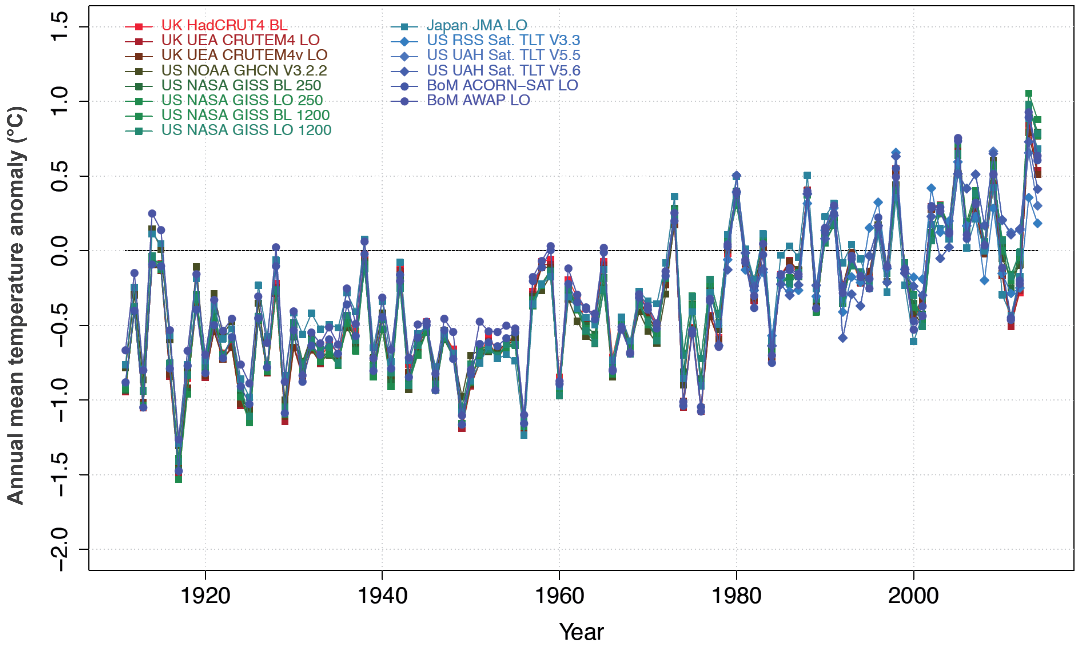

Figure 2: Annual mean temperature anomaly for continental Australia (1911–2014)—a comparison of local and international datasets, comprising 'land only' (LO) surface air temperature (SAT) datasets, blended land-ocean datasets (BL) and satellite lower tropospheric datasets (TLT). Datasets from the Bureau of Meteorology (BoM) include the operational whole-network (unhomogenised) dataset (Australian Water Availability Project, AWAP) and the ACORN-SAT dataset. Datasets from the United Kingdom (UK) are obtained from the University of East Anglia's Climatic Research Unit. Their LO datasets are merged with the UK Met Office Hadley Centre's sea-surface temperature (SST) analyses to create the HadCRU BL datasets. Dataset versions 3 and 4 are shown, with (v) and without variance adjustment. Datasets from the United States (US) National Aeronautics and Space Administration (NASA) Goddard Institute for Space Studies (GISS) are available in two analysis scales (250 km and 1200 km), courtesy of the US National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory's (ESRL) Physical Sciences Division (PSD). The Global Historical Climatology Network (GHCN) version 3.2.2 dataset was obtained from the NOAA National Climatic Data Center (NCDC). The Berkeley Earth Surface Temperature (BEST) dataset was obtained from Berkeley Earth, at Berkeley University in the US. The TLT datasets (1979–2013 only) were obtained from the University of Alabama in Huntsville's (UAH) National Space Science and Technology Centre (NSSTC) and Remote Sensing Systems (RSS).

Prior to 1940, there is no significant trend in Australian temperatures, with variability dominated by the alternation between drought and wet periods. There is some difference in the baseline climatology of the homogenised and spatially analysed datasets during this time, with the homogenised data around 0.2 degrees Celsius cooler than the unadjusted data when averaged over the entire country. Changes since 1910 show increases in temperature of +0.96 °C for ACORN-SAT, +0.96 °C for the preceding version of the homogenised data and +0.73 °C for the real-time temperature monitor. The ACORN-SAT trend over the entire record is consistent with previous studies, and closely aligns with independent analysis by international authorities for Australia as will be described below.

ACORN-SAT trends compared to other datasets

A comparison of trends using 18 different methods of data selection, preparation and analysis are provided below. This is an extension of work originally reported at the time of the 2012 ACORN-SAT dataset release (Fawcett et al., 2012).

It should be noted that the differences described between the spatially analysed trend and those with specific temporal homogenisation, over the period 1910 to 1940, are not due simply to the adjustment of the trend. These differences are due to a number of factors, including the uncertainty introduced by a sparser observing network and the greater difficulty in obtaining an estimate of an Australian annual mean temperature.

A much sparser network prior to 1940 increases the 'spatial footprint' of individual sites in their contribution to the national average. Research indicates that it is even more important to remove artefacts from the data when the network is sparse, since errors may be propagated by the subsequent spatial analysis. When the network is large enough, a properly constructed spatial surface largely accounts for discontinuities apparent in individual site records.

Warming in the Australian region is also evident in local sea-surface temperatures. Sea-surface temperatures are monitored and analysed in very different ways to temperatures over land.

Observations of warming in the oceans around Australia show trends very similar to those for the Australian continent itself.

Bureau's methods compared to international methods

In 2011, the Bureau subjected its data collection and methods of analysis to an international peer review, with invited experts from the US, Canada and New Zealand. This review was asked to assess the Bureau's methods against those internationally. The review panel found that the Bureau of Meteorology's practices were amongst the best in the world.

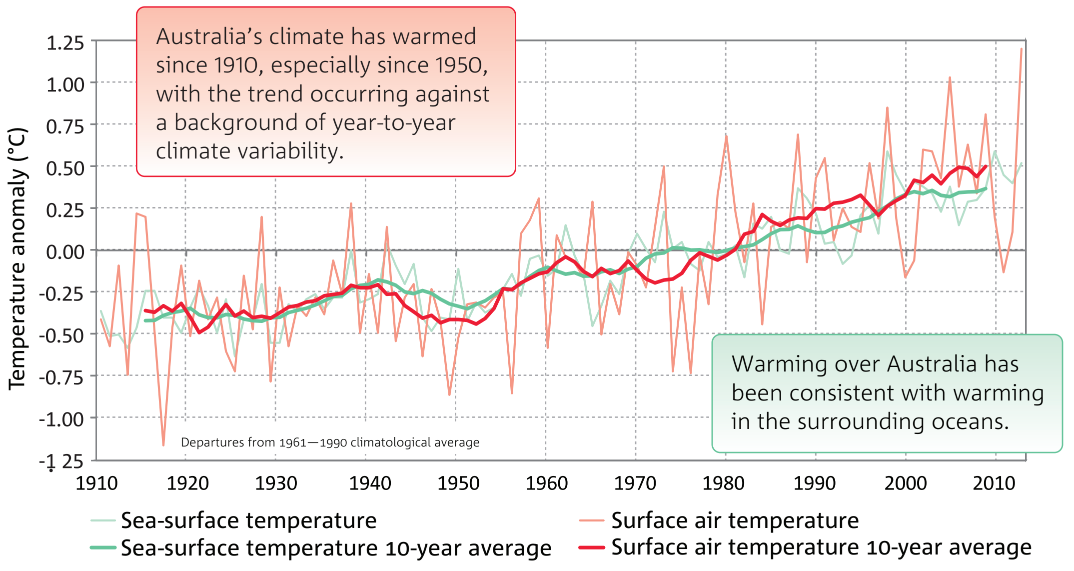

Figure 3: Comparison between Australian surface air temperature and surrounding sea surface temperatures since 1910 showing similar variation and trends.

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Further, ACORN-SAT is the first continent-wide homogenised daily dataset, with most other centres currently restricted to homogenised monthly or annual temperatures (e.g. Menne and Williams, 2009). There are a number of alternative methods which have been developed (e.g. Della-Marta and Wanner, 2006; Mestre et al., 2011) but have not yet been implemented operationally in a national or continental-scale dataset. This indicates that the Bureau remains at the forefront of the science, which is also reflected in the Bureau's involvement on World Meteorological Organization expert teams in this area of research.

Consistent selection of data periods, stations and adjustment methods

In terms of supporting information, transparency and accessibility of the science, the Bureau of Meteorology's ACORN-SAT webpages are perhaps the most comprehensive in the world at present.

ACORN-SAT has been developed as a 'live' dataset, with regular updates to improve the analysis in a heuristic process building on the use of the data in the research community. As such, two updates to the data have already been applied since its release in 2012. Maintaining stable observational networks continues to be a significant challenge to meteorological agencies around the world, as changing infrastructure requirements place pressure on the location of observing sites. Implementing a robust method for preserving the network requirements is an ongoing process at the Bureau of Meteorology.

ACORN-SAT as an Essential Statistical Asset for Australia

In 2014 the Australian Bureau of Statistics, for the Essential Statistical Assets for Australia, assessed three of the Bureau of Meteorology's climate datasets, including ACORN-SAT. They reported that for all quality indicators selected, the Bureau's climate datasets meet an acceptable standard and that appropriate quality practices and processes are in place. These indicators are institutional environment, relevance, timeliness, accuracy, coherence, interpretability and, accessibility.

References

Della-Marta, P.M. and Wanner, H. 2006. A method of homogenizing the extremes and mean of daily temperature measurements. J. Clim., 19, 4179–4197.

Fawcett, R.J.B. et al., 2012. On the sensitivity of Australian temperature trends and variability to analysis methods and observation networks. CAWCR Technical Report 50. Bureau of Meteorology, Melbourne.

Menne, M.J. and Williams, C.N. 2009. Homogenization of temperature series via pairwise comparisons. J. Clim., 22, 1700–1717.

Mestre O, Gruber C, Prieur C, Caussinus H, Jourdain S. 2011. SPLIDHOM : a method for homogenization of daily temperature observations. J. Appl. Met. Climatol. 50: 2343–2358.