Public availability of ACORN-SAT information

This factsheet provides information on the availability of the Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT) dataset, including:

- Raw and adjusted data – fully available, mostly free
- Adjustments – fully available
- Inputs and outputs of peer review – fully available
- Computer code – available on request
- Metadata – some available
- Ability to reproduce findings – high.

The Bureau of Meteorology holds observational data in several forms. Observational data covers a range of physical fields (for example, rainfall, temperature, humidity and solar radiation) and includes metadata relating to the technical history of the recordings.

Raw temperature data

Current practice sees temperature data from automatic weather stations and manual observations ingested into the national climate database on a near-real-time basis. This data is quality controlled for basic data errors in a process that is described on the public web: www.bom.gov.au/climate/data-services/content/quality-control.html

Raw data on paper manuscripts is retained (as paper and increasingly as scanned images), while electronically transmitted data is stored digitially.

The data in the national climate database is publicly available and accessible through the Bureau's climate data portal, Climate Data Online: www.bom.gov.au/climate/data/. Climate Data Online has been developed as a self-serve website to maximise data availability. However, it is not possible to provide all data in all formats, and some requests are subject to standard government cost-recovery charges. The data available via Climate Data Online is generally considered 'raw', by convention, since it has not been analysed, transformed or adjusted apart from through basic quality control.

A substantial amount of historical paper records have been digitised, and these data are held in the Bureau's national climate database and form the historical climate record. Digitisation of historic paper records is resource intensive and expensive, and has generally proceeded through various projects that have been targeted at particular needs and outcomes. An example of one such project is CLIMARC: www.bom.gov.au/climate/how/climarc.shtml

For temperature data, almost all monthly and annual station data has been digitised, and certainly enough to characterise the main features of climate variability and change for Australia. Daily data has not been entirely digitised, however daily digitisation of historical data has increased over the years to the point of providing a robust national daily dataset back to 1910.

Undigitised paper records also exist in various forms that are not currently within the Bureau's holdings, such as documentary records from various sources that have not been managed by the Bureau. These data are of interest to climate scientists and the Bureau, but require extensive resources to identify, collate and curate. An example of a recent collaborative effort to rehabilitate data from documentary evidence under a joint Australia Research Council project that included the Bureau of Meteorology is the Southeast Australian Climate History (SEARCH): http://climatehistory.com.au/

Analysed temperature data

Restricting ourselves to temperature data, the raw data from the national climate database is analysed in various ways to produce data that is fit for various different research and operational monitoring applications. In this context analysis has a specific meaning, and relates to the process of synthesising the raw data in such a way as to improve its usefulness and application. The two main operational analysed datasets which are produced by the Bureau are:

- the real-time temperature monitor (also known as AWAP, for the Australian Water Availability Project; Jones et al., 2009), and

- the homogenised Australian Climate Observations Network — Surface Air Temperature (ACORN-SAT) dataset (Trewin 2012, 2013).

The real-time monitor is an analysed, gridded surface (three dimensional) that makes use of all available temperature readings on a given day (typically between 700 and 800 sites). The grid is available online at 2pm (AEDT) each day for the previous day's observations. The data are on the web with various interactive tools: www.bom.gov.au/jsp/awap/temp/index.jsp and provided to the user and research communities.

This data is spatially analysed using a method which takes topography and known network changes into account, but is not temporally adjusted in the way undertaken for homogenised datasets. Data has been analysed from 1910 onward, which is the period that coverage across the Australian continent is sufficient enough to produce a reliable national spatial analysis. While this AWAP data has some limitations, it is perhaps the best 'unadjusted' comparison data to the homogeneous datasets.

Adjusted temperature data

The ACORN-SAT dataset uses a subset of the total current and historical temperature network as we seek to maximise coverage across the continent while maintaining consistency through time. This dataset has been developed specifically to account for various changes in the network over time, including changes in coverage of stations and observational practices. Such a reference dataset is required to account for, and remove, non-climatic influences on the data and retain true physical changes in temperature over time. The primary purpose of an adjusted station dataset it to provide quality station level data for users, with areal averages being a secondary product.

ACORN-SAT data has its own quality control and analysis, independently applied, that differs significantly from Climate Data Online and the real-time temperature monitor.

The adjustments are applied using a percentile-matching algorithm applied to daily data in the form of a transformation matrix. These transfer functions are all available on request. In practice, the transfer functions are of little use to those not adept with this level of statistical analysis. Alternatively, the Bureau has provided accumulated annualised adjustments (the impact of the daily adjustments on the annual mean temperature for each observing location) on its website.

Peer review inputs and findings

An extensive, dedicated ACORN-SAT website was developed in 2011. Frequently asked questions on ACORN-SAT are publically available at www.bom.gov.au/climate/change/acorn-sat/

This ACORN-SAT website also includes:

a. Data and network: www.bom.gov.au/climate/change/acorn-sat/#tabs=Data-and-network

b. An extensive description of data and methods, including links to various relevant research papers: www.bom.gov.au/climate/change/acorn-sat/#tabs=Methods

c. Information on the international expert review of ACORN-SAT conducted in 2011 including the findings: www.bom.gov.au/climate/change/acorn-sat/#tabs=Expert-review

d. A summary of the adjustments applied to the data: www.bom.gov.au/climate/change/acorn-sat/#tabs=Adjustments

Computer Code

As with all operational data at the Bureau, ACORN-SAT is dependent on software and code that is linked to our systems architecture. The Bureau has prepared portable versions of the analysis code in PYTHON that is available to researchers or members of the public upon request.

The Bureau holds large quantities of analysis code written across a range of programming platforms. This code tends to sit in two categories: production grade, which is code designed to work reliably under operational conditions with minimal human intervention, and research code which might be designed to investigate a specific once off issue.

Metadata

The metadata supporting the climate data held by the Bureau is extensive and in various forms. In this context, metadata is information about "climate data", which describes such things as the location of instruments at weather stations, updates to practices etc. This information is an important input into the preparation of adjusted datasets such as ACORN-SAT.

Some is digitised within the Bureau's internal metadata database known as SitesDB. However, the complete history of papers records for all sites, are not digitised. While this information is available to the public on request on a case-by-case basis

(such as a request for all metadata for an individual location), there is no practical way that the information can be made available to the general public en masse. An issue here is that much of the paper records are held by National Archives of Australia, with additional paper records stored by the Bureau in both Head Office (Melbourne) and in each of the seven regional offices.

Reproducing ACORN-SAT

All of the data described above is publicly available, and much of it for free. The methodologies have been published in both Bureau of Meteorology research papers (which are internally reviewed according to normal scientific peer-review conventions) and in the international scientific literature. In this way, researchers have the necessary components to work with the data in their own capacity to reproduce the ACORN-SAT dataset. Noting the availability of raw data, adjustments, metadata and code there are no obstacles to the reproduction of the ACORN-SAT datasets to a high degree.

Producing analyses such as ACORN-SAT involves much work, and typically takes scientists at the Bureau of Meteorology several years to complete. Historically, the homogenised datasets at the Bureau have been entirely redeveloped every ten years or so, with incremental updates occurring more frequently. The ACORN-SAT dataset superseded an earlier dataset which had been in operational use since the late 1990s (Della-Marta et al, 2004; Torok and Nicholls, 1996). The scientific practice of preparing temporally homogenised data is relatively straight-forward with a number of software packages available and supported by the World Meteorological Organization and other agencies (e.g., RHtests see http://etccdi. pacificclimate.org/software.shtml). The main obstacle to reproducibility relates to the quantity of data, and the inability to automate all steps in the process.

Reproduction in climate science tends to have a broader meaning, and relates to the robustness of results. The most practical independent checks of the robustness of the data take the form of alternative analyses using similar base data. Such analyses have been performed from time to time for various climate fields and by various research groups in universities and other agencies. The base data are also accessed by four major international climate agencies (NASA and NOAA in the United States, the UK Meteorological Office, and the Japan Meteorological Agency),

which use their own independent methods to produce their own analyses, as do non-government groups such as the Berkeley Earth initiative. The Bureau of Meteorology welcomes and encourages contributions from the research community. The Bureau's data are also used extensively in meteorological and climate studies, many of which involve a range of processing or reanalysing the data to fit particular research needs. The Bureau has traditionally kept some involvement with those efforts since they act to improve our data and methods.

References

Della-Marta, P., Collins, D. and Braganza, K. 2004. Updating Australia's high-quality annual temperature dataset. Aust. Met. Mag., 53, 75–93.

Jones, D.A., Wang, W. and Fawcett, R. 2009. High-quality spatial climate data-sets for Australia. Aust. Met. Oceanogr. J., 58, 233–248.

Torok, S.J. and Nicholls, N. 1996. A historical annual temperature dataset for Australia. Aust. Met. Mag., 45, 251–260.

Trewin, B. 2012. Techniques involved in developing the Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT) dataset. CAWCR Technical Report 49, Bureau of Meteorology, Melbourne.

Trewin, B.C. 2013. A daily homogenised temperature data set for Australia. Int. J. Climatol., 33, 1510–1529.

Other resources of relevance

The 2011 report of the Independent Review Panel www.bom.gov.au/climate/change/acorn-sat/ documents/ACORN-SAT_IPR_Panel_Report_WEB. pdf

ACORN-SAT fact sheet www.bom.gov.au/climate/ change/acorn-sat/documents/ACORN-SAT-Fact-Sheet-WEB.pdf