

Dear Dr Marohasy

Thank you for your letter of 9 January 2014, regarding temperature measurement seeking information to verify our claim that 2013 was the hottest year on record in Australia. I also welcome your interest and detailed questions on the data.

The Bureau places a great deal of importance on the quality of its observations and analyses. The impacts of climate are significant and our data and projections, and those from meteorological institutions from across the world, show strong evidence for a changing climate.

The Bureau has produced a very large volume of documentation of its methods and data, with a summary of the information provided in this response. We refer you particularly to our climate webpages (<http://www.bom.gov.au/climate/change/>) which provide extensive scientific literature as well as data for individual locations.

You raise a number of points regarding the nature of the Bureau's climate data, and the recent Annual Climate Statement 2013 (available at <http://www.bom.gov.au/climate/current/annual/aus/>). To assist with clarity in the response, we have repeated your questions, shown here in italics.

*... why does the Bureau only use data after 1909, all the while claiming that 2013 is the hottest year on record? Indeed it is well documented that the 1890s and early 1900s, years corresponding to the Federation drought, were exceptionally hot.*

There are two reasons why national analyses for temperature currently date back to 1910, which relate to the quality and availability of temperature data prior to this time. First, and most importantly, national standardisation of instrumentation did not occur until 1910, some two years after the formation of the Bureau of Meteorology. Data prior to this time is often fragmented, of uncertain or low quality, and in many cases no data exists about the nature of instruments and instrument enclosures. Secondly, data are more sparse prior to 1910 with very little data for Western Australia. This creates greater uncertainties when calculating national temperatures before 1910.

Detail on the early data and the choice of 1910 is provided in the ACORN-SAT publications at <http://www.bom.gov.au/climate/change/acorn-sat/#tabs=Methods>. In summary this states:

Unfortunately for modern-day scientists, there was no common standard for observing equipment during the colonial period. Any number of instrument configurations were used, including— perhaps iconically— thermometers housed in beer crates on outback verandas. By 1910, however, the newly formed Australian Bureau of Meteorology had established standardised equipment in many parts of the country.

The nature of the difficulties with early data is highlighted by the descriptions of practices by the NSW Government Meteorologist, Henry Russell (from the late 19<sup>th</sup> Century)... that *many rural NSW sites used thermometers on building walls, hung in the open air under verandahs, or even indoors*. In some cases it has been possible to determine the nature of instruments and exposure – for example it is well established that the Cloncurry 53.1°C in 1889 was taken in a modified beer crate on a south facing wall exposed to the sun.

The decision not to use the pre-Stevenson Screen data for ACORN-SAT was made to avoid the use of such unreliable information.

In response to your statement that “the 1890s and early 1900s, years corresponding to the Federation drought were exceptionally hot”, there is a recent, peer reviewed scientific paper which explored this period using the available data and found this not to be the case. The paper describes the curation of pre 1910 data for southeast Australia that was performed at the University of Melbourne in conjunction with the Bureau of Meteorology.

Ashcroft L, Karoly D., and Gergis J. 2012. Temperature variations in southeastern Australia, 1860-2011, Australian Meteorological and Oceanographic Journal 62 (2012) 227–245 (<http://www.bom.gov.au/amoj/docs/2012/ashcroft.pdf>)

While these data are limited to the southeast Australian region, the paper shows no evidence of abnormally high temperatures during the Federation Drought or the wetter decades before this.

#### *The specific stations used to calculate this statistic*

The stations which are used for the Annual Climate Statement are those in the homogenous ACORN-SAT dataset. Eight urban stations, including Melbourne, Sydney, Hobart and Adelaide are excluded from the calculation of the national mean temperature, because of the heat island effect.

The ACORN-SAT stations are described at <http://www.bom.gov.au/climate/change/acorn-sat/index.shtml#tabs=Data-&-network>. This extensive document contains a short site history, and recent photos where available. The link also provides access to all annual station data up to and including 2013 for each day for which a temperature observation is available.

#### *The specific databases and time intervals used for each of these stations*

The ACORN-SAT dataset is based on electronic data held by the Bureau of Meteorology and available through the Australian Data Archive for Meteorology (ADAM). Daily maximum and minimum temperatures are used for the purposes of this analysis, so for complete station records there were 365 daily maximum and 365 daily minimum temperatures contributing data.

You can also obtain data for the full network (approximately 750 stations) – either on line through “Climate Data Online” (<http://www.bom.gov.au/climate/data/>) or through a manual data request (<http://www.bom.gov.au/climate/data-services/>).

#### *The history of the use of Stevenson screens at each of these stations*

Details of data from the 112 locations are provided in the ACORN-SAT Station Catalogue at <http://www.bom.gov.au/climate/change/acorn-sat/index.shtml#tabs=Data-&-network>. The ACORN-SAT data comes entirely from Stevenson Screens. As we note previously, station records prior to this date are incomplete, and it is known that a wide variety of instruments and enclosures were used.

The best available published description of the early history of Australian temperatures at stations is contained in the PhD study by Dr Simon Torok.

Torok, S.J. 1996. The development of a high quality historical temperature data base for Australia. PhD Thesis, School of Earth Sciences, Faculty of Science, University of Melbourne, Australia.

#### *How the yearly average temperature is defined*

The process of defining yearly average temperatures consists of analysing observed temperatures at the ACORN-SAT station locations to a grid, and forming an area weight average of the data. There are two papers which describe this process in some detail which are provided below.

This is also described at <http://www.bom.gov.au/climate/change/#tabs=About-climate-change> . Further information is available in the ACORN-SAT publications also available at this site.

*Clarify what if any interpolation, area weighting, and/or adjustments for UHI bias, may have been applied to the data in the calculation of the annual mean values*

The methodology for preparing the ACORN-SAT data are described in the paper referred in the above link: *Techniques used in the development of the ACORN-SAT dataset*. The impact of data homogenisation on analysed trends is described in a separate paper *On the sensitivity of Australian temperature trends and variability to analysis methods and observation networks*. Both of these papers can be found at the following link.

<http://www.bom.gov.au/climate/change/acorn-sat/#tabs=Methods>

Importantly, homogenised data is assessed by the Bureau, US National Climatic Data Centre and UK Hadley Centre as providing the most accurate representation of actual temperature changes. The process of adjustment for station moves ensures historical data are consistent. Nonetheless, the trends in temperature for Australia are largely insensitive to the data preparation technique, including whether or not temporal homogenisation is applied to the data, with the warming since 1950 being consistent in all temperature analyses. This is the period when almost all of the warming has occurred in Australia.

Further, the ranks of individual warm years are also largely unaffected by temperature adjustments. 2013 was the warmest year on record for Australia in both the ACORN-SAT temperature data, as well as the Bureau's real-time temperature monitoring database <http://www.bom.gov.au/jsp/awap/temp/index.jsp>, which is spatially interpolated without temporal adjustments.

It is also important to clarify that homogenisation cannot be applied in real time. The 2013 ACORN-SAT data is unadjusted data taken directly from the Bureau's climate database (ADAM). It is correct in stating that eight sites are characterised as having anomalous warming due to the UHI, and these have not been included in the calculation of national and state averages. Only those stations assessed as having minimal or no urban signal are used for the 2013 statement. For example, data from the Melbourne site (86071) at the corner of Latrobe Street and Victoria Parade, is not used for the Australian average.

The method of interpolation is described in two significant scientific reports: [http://www.bom.gov.au/climate/change/acorn-sat/documents/ACORN-SAT\\_Report\\_No\\_3b\\_WEB.pdf](http://www.bom.gov.au/climate/change/acorn-sat/documents/ACORN-SAT_Report_No_3b_WEB.pdf)

<http://www.bom.gov.au/amm/docs/2009/jones.pdf>

In concluding, the Bureau of Meteorology takes a great deal of care with the climate record, and understands the importance of scientific integrity and the provision of data, products and services. We share our observations daily with the world and our research is peer reviewed and published in high quality international journals. Our research and analyses confirming a warming climate is consistent with research from many international organisations.

In the event you wish further information not covered in this email, we refer you to the significant body of information contained in the links provided in the attachment to this letter. I hope this information is of assistance to you, and wish you well with your own investigations.

Yours sincerely

Mr Neil Plummer  
Assistant Director, Climate Information Services  
Bureau of Meteorology

## **Attachment**

### **Suggested web links for further information on Climate Change**

See the Bureau's website at <http://www.bom.gov.au/climate/change>

The recent *State of the Climate 2012* report, jointly prepared by the Bureau of Meteorology and CSIRO can be found at <http://www.csiro.au/Outcomes/Climate/Understanding/State-of-the-Climate-2012.aspx>

The Bureau of Meteorology's recent update to the national climate record can be found at <http://www.bom.gov.au/climate/change/acorn-sat/>

Since 1976 the Bureau has been taking greenhouse gas concentration measurements at Cape Grim <http://www.bom.gov.au/inside/cgbaps>

CSIRO has been analysing these measurements and this information is available at <http://www.csiro.au/greenhouse-gases/>

Together with CSIRO the Bureau has been researching how climate will change in Australia in the future. The climate projections are at <http://www.climatechangeinaustralia.gov.au>

The Australian Government's Department of Climate Change and Energy Efficiency (DCCEE) has published answers to a range of frequently asked questions. These can be found at <http://www.climatechange.gov.au/en/climate-change/understanding-climate-change.aspx>

CSIRO has produced an extensive range of materials and published these on their website. Listed below are links for a number of informative websites:

<http://www.csiro.au/resources/Climate-Change-Book>

<http://www.csiro.au/resources/Climate-questions-science-facts.html>

<http://www.csiro.au/science/the-science-of-climate-change.html>

<http://www.csiro.au/resources/pfxh.html>

<http://www.csiro.au/resources/ps3cw.html>

<http://www.csiro.au/resources/psrs.html>

<http://www.csiro.au/news/ps398.html>

<http://www.csiro.au/news/ps38x.html>

<http://www.csiro.au/news/ps38w.html>

Other sites that you may find useful are:

*The Intergovernmental Panel on Climate Change* <http://www.ipcc.ch>

*The Australian Academy of Science* <http://www.science.org.au/policy/climatechange.html>

*The Royal Society* <http://royalsociety.org/Climate-change-controversies-a-simple-guide/>

There are some excellent sites that are explicitly aimed at answering common questions on climate change. Some of these take significant contributions from working climate scientists, and have been internationally recognised for the work they do in communicating science. Two notable examples in this category, that are updated regularly, are:

*Real Climate* <http://www.realclimate.org/index.php/archives/2007/05/start-here>

*Skeptical Science* <http://www.skepticalscience.com/>