I have redacted the phone number and email address of Dr Cornish in the following correspondence, and also the name of the IPA staffer. J.Marohasy, 10 Nov. 2017

INSTITUTE OF PUBLIC AFFAIRS

ATT: redacted

COPIES OF BOM CORRESPONDENCE FOR DR MAROHASY

FROM: DR P. CORNISH

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AUSTRALIA

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17 December 2012

The Director
Bureau of Meteorology
GPO Box 1289
Melbourne
VIC 3001

I am a retired hydrologist who spent more than 25 years recording hydrological and meteorological data in the field, and have published a number of scientific papers in international journals.

For the past 5 years I have been analysing temperatures predicted for, and recorded at, BOM station 066062, Sydney (Observatory Hill). One notable observation has been the rapid temperature fluctuations recorded with the current digital temperature probes. On 16th December 2012 the daily maximum temperature of 30.3°C at Observatory Hill was recorded at 11.59am, while at 12.00pm (1 minute later) the temperature (from the BOM website) was 28.8°C. This is one example of numerous similar rapid fluctuations observed over the period.

I am not questioning the accuracy of the digital temperature probes. Under static equilibrium conditions they most likely register the same temperatures as those recorded on mercury-in-glass and alcohol-in-glass thermometers, equipment used to measure temperatures at this station for many years. What I am questioning is the relative response times of the earlier and current probes. I believe that the thermal capacity of current equipment may be much lower than that of the replaced thermometers, leading to the rapid fluctuations in recorded measurements. I suspect that, under identical rapidly changing conditions in the field, the earlier thermometers would not respond as rapidly as current probes. This is particularly important as all earlier measurements of maximum and minimum temperatures were made with glass thermometers. It follows that maximum temperatures recorded using glass thermometers would probably register lower values than current digital probes under identical fluctuating field conditions. I contend that the use of current digital probes is likely to produce a data set with biased maximum (and probably minimum) values, leading to erroneous comparisons with earlier data sets. As maximum and minimum temperatures are used by the BOM to calculate daily mean temperatures, current observations may lead to incorrect comparisons with earlier mean values as well.

I would appreciate a technical response to my suggestions and comments.

Yours faithfully

Dr P M Cornish

Australian Government
Bureau of Meteorology

Head Office Melbourne
Bureau of Meteorology
GPO Box 1289 Melbourne VIC 3001 Australia

In reply please quote

redacted

6 February 2013

Dear Dr Cornish,

Thank you for your letter of the 17th of December 2012 regarding temperature values returned from the Bureau's Observatory Hill automatic weather station for the 16th of December 2012. The Director of Meteorology, Dr Vertessy, has referred your correspondence to me as the manager with responsibility for the Bureau's observations program.

Firstly, I would like to address your comments about instrument time constants. As you are no doubt aware, the time constant is defined as the time taken for the instrument reading to change to 63 per cent of the applied step change. The electronic temperature probes used in automatic weather stations by the Bureau were designed to have approximately the same time constant as mercury-in-glass thermometers, namely about 40 seconds in moving air when the air speed is greater than 3 m/s. In still air, the time constant for both types of devices is approximately 90 seconds.

To address your question, it is important to note the way the data from an Automatic Weather Station (AWS) is reported in 'real-time' on the external Bureau web page and also the post-collection quality control (QC) checks performed on these data before they are stored in the national archive maintained by the Bureau.

The real-time data displayed on the website has been subject to only the limited QC performed within the AWS. The "air temperature" computed within the AWS is the arithmetic mean of the valid one-second samples within the averaging period (after internal algorithms have checked the one-second samples for very rare but significant anomalies, usually due to electrical interference). The "maximum temperature" in the period is the highest valid one-second sample within the period, and the "minimum" is the lowest valid one-second sample within the period. For the AWS at Observatory Hill, the averaging period is one minute. For older AWSs, or remote locations where communications are less reliable, the averaging period can be either 10 minutes or an hour.

The data transmitted by the AWS are the statistics for the averaging period (mean, minimum, maximum) and the maximum value is reported on the Bureau's web site as the latest temperature. Clearly, the one-second samples will contain both valid signal and noise that passes the internal AWS checks. Once the data are transmitted to the national archive, robust QC and data flagging occurs. One-minute statistics allow for better quality control, by providing more information to the QC algorithms.

As you may be aware, with any electric digitisation system interference can cause spikes. In our examination of the time series from the 16th of December, erroneous spikes were not detected, and the extracted data from the national archive does not suggest any erroneous data for the period in question.

The definitive source of quality controlled data is the national archive and a snapshot of that data for the Observatory Hill dry bulb temperature for 16 December 2012 is provided below. The two values quoted in your letter are highlighted below in grey and green, with the Eastern Standard Time (EST) time stamp.

Time (EST)	*Air Temp*	*Air temp (1-min max)*	*Air temp (1-min min)*
10:57	30.3	30.3	30.0
10:58	29.7	[redacted]	29.7
10:59	28.9	29.7	28.9
11:00	28.6	[redacted]	28.6

The 30.3° C values for Observatory Hill on 16 December occurred between 10:56:01 and 10:58:00 EST (or 11:56 and 11:58 EDST). The quoted value of 28.8° C occurred between 10:59:01 and 11:00:00 EST and represents both the maximum and average of the averaging period.

Examining the time series above, it is likely that the 30.3°C maximum value may have occurred at the start of 10:57 EST and therefore, there could have been as much as 120 seconds between the maximum one-second sample and the maximum air temperature reported at 11:00. From this, it can be seen that the air probe maximum value for the 10:58 EST time stamp was around 3 time constants from the 28.8° C maximum temperature; giving the probe considerable time to change. Also, comparing the maximum and minimum values with their associated average values in the data above does not raise any significant concerns. Hence, the values in the data set represent the likely local screen air temperatures, as would be measured by a mercury-in-glass thermometer.

Changing a measurement process will always impact on a time series. Hence, a significant amount of work has to be done to ensure that the impact of any change is minimal and, ideally, the overall uncertainty in the measurement decreases. This is especially true of our climate reference stations (Observatory Hill is one of those) and the data they collect. The Bureau has taken steps to ensure that the impact of each change to a temperature measurement process reduces the uncertainty.

Some papers on how the Bureau verifies its temperature measurement processes are on the Bureau's web site (www.bom.gov.au/climate/change/acorn-sat/). A specific aspect which was examined as part of the development of the Bureau's Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT) was whether there was any evidence of any systematic biases arising (through changes in response times, or any other reason) from the change from manually-read mercury-in-glass thermometers to electronic temperature probes (http://cawcr.gov.au/publications/technicalreports/CTR_049.pdf, page 70). This analysis found no evidence of any significant systematic change arising from that cause.

The Bureau welcomes queries about our data from keen observers of our data and information. Answering such queries provides the Bureau with an opportunity to re-examine and test our assumptions and methods. Regarding the times series you brought to our attention, we are confident that the real-time data are representative of the local environment at Observatory Hill on 16 December 2012. If you have any further questions on this matter, please contact Bruce Forgan, Superintendent, Data Quality and Improvement (B.Forgan@bom.gov.au).

Yours sincerely,

Dr Sue Barrell

Assistant Director (Observations and Engineering)