Senator the Hon Simon Birmingham

Parliamentary Secretary to the Minister for the Environment

Senator for South Australia

MC14-010861

Dr Jennifer Marohasy
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18 JUL 2014

Dear Dr Marohasy

I refer to your correspondence of 4 March, 5 May 2014 and 10 June 2014, to the Hon Greg Hunt MP, Minister for the Environment, concerning the Bureau of Meteorology and the reliability of temperature statistics and seasonal rainfall forecasts. The Minister has referred your correspondence to me as the matters you've raised fall within my portfolio responsibilities.

I have asked the Bureau of Meteorology to consider the numerous questions you have posed and prepare detailed responses for you. The enclosed package provides their responses, including information previously prepared in response to matters you have already raised with the Bureau and addresses a number of additional points including some specific to your email of 10 June 2014, which were not raised previously.

I have also enclosed a series of links to documents, reports and background information that provide additional detail on the matters you have raised.

It is my view that the Bureau should make their data publicly available wherever possible within their resource constraints. I trust the links and references herein assist your research.

Thank you once again for your correspondence.

Yours sincerely

Simon Birmingham

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RESPONSE TO YOUR LETTER OF 5 MAY 2014

Q1 Could the Bureau explain why it uses 1910 as the start date for the official temperature record, rather than a year such as 1860, given there was a larger amount of reliable temperature data available from the mid 1800s?

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, two years after the Bureau of Meteorology was formed. Secondly, data are more sparse prior to 1910 with very little data for Western Australia and much of central Australia. This creates greater uncertainties when calculating national temperatures before 1910, and precludes the construction of national temperature grids on which the Bureau's annual temperature series is based.

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

Longer records of reasonable quality exist at some sites, and are publicly available through the Bureau's climate data services (see http://www.bom.gov.au/climate/data-services/). The Bureau regularly reports on the longer record for some of those locations, such as Hobart, Melbourne and Sydney.

Q2 Further to 1, if the pre-1910 data is not suitable for official domestic use, can the Bureau explain why it finds it suitable enough to provide data for generation of a global annual mean temperature anomaly back to 1850?

The Bureau provides access to all of its digital data holdings to both domestic and international users. It is not our role to withhold the information, but we are very clear about the reliability and suitability of this data. Global data set providers make their own decisions about which data to include, and undertake their own data homogeneity analyses which are then described in the scientific literature.

The Bureau makes use of international analyses (published by the World Meteorological Organization, WMO) from the US NOAA, NASA and UKMO-University of East Anglia for global and hemispheric temperatures. The use of these data has little relevance to the situation for Australia as the data are almost entirely from other countries and ocean regions.

It is important to note that constructing a global or hemispheric temperature average requires a sparser network density or sampling than that required for a national average. Southern Hemisphere temperature analyses are almost entirely drawn from sea-surface temperatures measured from ships, an approach which can generate useful results on a global or hemispheric scale but is of little use for national or local analyses prior to (around) 1910. This sparse network is reflected in the large uncertainties reported in the data, with the United Kingdom Met Office-University of East Anglia assessing the uncertainty in annual temperature values for the Southern Hemisphere at approximately +/- 0.5°C in 1850, reducing to +/- 0.3°C in 1900. The uncertainty for Australia would be expected to be larger again.

Q3 Could the Bureau please provide a list of the actual stations used to calculate the 2013 average mean temperature anomaly, the specific databases and time intervals applied to each of these stations, as well as the adjustments that have been made to the raw data?

The Bureau of Meteorology has previously provided this information to you in detail. Repeating this previous advice:

> *The stations which are used for the Annual Climate Statement* (2013) *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 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/).*

It should be acknowledged that the record warmth was consistently represented in multiple data sets, further clarification of this is included below.

Q4 Given the potential and actual conflict of interest, could the Australian Bureau of Statistics, (ABS) rather than the Bureau of Meteorology, be tasked with the job of leading the high quality and objective interpretation of historical temperature record for Australia?

Developing and analysing long-period climate records requires a mix of skills covering climatology, physics, mathematics, computer programming, statistics and climate modelling. The Bureau of Meteorology employs staff with these necessary skills. These skills are not present in any other organisation.

An independent international review of the Bureau's temperature analysis processes has highlighted its methods to be best practice and entirely consistent with established international techniques. The Bureau informs me that the responsibilities for the analysis of climate data sits with a Meteorological or Geophysical agency similar to the Bureau across all major comparable countries (for example, all of Europe, Canada, USA, Japan, China, Russia, South Korea, Indonesia, Malaysia, India etc). The Bureau of Meteorology is recognised as a world leading institution in this area, and a knowledge and skill base for the international community.

Q5 What is the explanation for the discrepancy between allocated funding for salary and actual salary of climate change modelers employed under the Climate Change Science Program?

The Bureau does not administer the Australian Climate Change Science Program and is unable to account for information released by other agencies. The Bureau releases appropriate information relating to salary levels in its annual report.

Q6 Is the reliance by the Bureau on a General Circulation Model (GCM) to provide monthly and seasonal forecasts justified when methods that use historical patterns have proven to be more accurate?

The Bureau of Meteorology uses a physically based climate model (a "GCM") for seasonal forecasts similar to the models increasingly used in international climate centres. Analyses have shown that these are more accurate, flexible, and useful than the simpler statistical models that you have proposed. Furthermore, GCMs provide physically consistent predictions, i.e. ensuring that the temperature, rainfall, and atmospheric pressure forecasts (etc.) are consistent with each other as is the case in the real world.

The Bureau's model has been shown to be more accurate than the previous statistical methods used for predicting Australian rainfall. As part of our testing, the Bureau compared its new General Circulation Model (POAMA) against the statistical model for the years 1980 to 2010, inclusive. The results of this extensive testing are published on our website at: http://www.bom.gov.au/climate/ahead/rain_ahead.shtml#tabs=Outlook-accuracy.

In terms of research published about neutral networks for seasonal prediction by Dr Abbot and yourself, the appropriate place for such scientific discussion is the scientific literature. The Bureau has concerns about several statements made in that paper and is likely to respond through the standard scientific process.

Q7 Could the Bureau explain why it doesn't publish the actual quantity of rain forecast by the GCM when issuing its monthly and seasonal forecasts, and why it shouldn't establish a publicly available archive showing quantities of rainfall forecast in the past?

It is best practice to provide probabilistic seasonal outlooks, (i.e. forecast the likelihood of an outcome). This characteristic is a result of the chaotic nature of climate prediction and the inevitable limits to predictability. In mathematical terms, a seasonal outlook is both a boundary and initial condition problem, and hence not deterministic in the same context as numerical weather prediction. The Bureau does not publish actual rainfall quantities for publicly issued forecasts because the science, conducted here and overseas, shows such forecasts to be as yet unreliable.

The Bureau assesses the accuracy of every seasonal climate forecast it produces. These data are published periodically in reports, and results are summarised in the Bureau's Annual Report. We also maintain an archive of all issued forecasts which can be found at www.bom.gov.au/climate/ahead. The Bureau's analyses show very clearly that the POAMA model forecasts have skill, the Bureau is engaged in ongoing efforts to further improve forecasts performance including through the use of the Bureau's recently announced Supercomputer upgrade.

RESPONSE TO THE ADDITIONAL QUESTIONS RAISED IN YOUR EMAIL OF 10 JUNE 2014

Further detail in response to the email of 10 June 2014 is provided below.

1. Status of record Australian temperature in 2013

The Bureau of Meteorology reported that 2013 was the warmest year on record for Australia. This conclusion was based on the ACORN-SAT dataset, the documentation for which is available online at http://www.bom.gov.au/climate/change/acorn-sat/index.shtml.

The ACORN-SAT data were subject to a two-step homogenisation procedure, as described in the email. However, the conclusion that 2013 was Australia's warmest year on record is not dependent on homogenisation procedures.

At the level of national annual means, there are negligible differences between the homogenised ACORN-SAT records and non-temporally-homogenised Australian Water Availability Project (AWAP) datasets from about 1960 onwards (although there are substantial differences at some individual stations, which cancel out when averaged nationally). This is illustrated in Figures 7, 8 and 9 of a technical report of the Centre for Australian Weather and Climate Research (CAWCR), which is available at http://cawcr.gov.au/publications/technicalreports/CTR_050.pdf.

In addition to being the warmest year on record for Australia using the homogenised ACORN-SAT data set, 2013 was also clearly the warmest year on record using the unhomogenised AWAP data set. Further evidence of 2013's warmth is provided by the independent Berkeley Earth (BEST) dataset, in which the most recently-available 12-month period, September 2012 to August 2013, is clearly the warmest 12-month period on record in a series extending back into the 1850s.

2. Cooling trends in the last 12 years

Against the background of long-term warming, there is considerable decade-to-decade variability in Australian temperatures, largely as a result of the El Niño-Southern Oscillation (ENSO), with El Niño dominated periods typically being warmer and La Niña dominated periods cooler.

The Bureau of Meteorology's analysis broadly concurs with the material presented in your email of 10 June 2014 on temperature trends at selected Queensland stations for the period 2002–2013. More generally, the 2002–2013 period shows short-term cooling over much of northern and eastern Australia, and warming in the west and south. The relative cooling over the 2002–2013 period is largely consistent with increases in monsoonal rainfall, and in particular the widespread heavy rainfall associated with the strong La Niña event of 2010–11.

A period of 10 years is far too short to determine that a long-term trend has been established, and the relatively cooler temperatures have certainly not reversed the accumulated warming since 1910. When all possible 12-year periods within the 1951–2013 window are considered (Table 1, below) using those stations from your email of 10 June that have sufficient data for the full 1951–2013 period, as well as selected stations from elsewhere in Australia, it may be seen that there is considerable volatility in 12-year trends at all stations, but that positive 12-year trends predominate over negative 12-year trends at all stations analysed. Such a result is consistent with a dominant warming trend overlaid by shorter-term variability. The fact that this short period does not constitute a clear trend is illustrated by the fact that 2013 was Queensland's hottest year on record.

Over longer periods, the influence of this volatility is reduced, as longer time periods are less able to be influenced by a single major El Niño or La Niña near the start or end of the period. An analysis of 30-year trends at the five Queensland stations (Table 1) found that none of the five stations showed a negative 30-year trend for maximum temperature for 1957–1986 or for any later 30-year period up to and including 2013. This indicates that over time periods sufficiently long for ENSO-related variability to be smoothed out, there is a clear and sustained warming signal from the 1950s onwards.

3. *Reconciliation of increasing carbon dioxide concentrations with falling temperature trend*

The influence of increasing greenhouse gases on global mean surface temperature is not instantaneous. For example, in response to current greenhouse gas levels, the climate system will continue to warm toward a radiative equilibrium for centuries. Additionally, global mean-surface temperature responds to other factors as well as greenhouse gas concentrations, and these cause short-term volatility in that index. The amount of heat accumulated in the climate system is better appreciated by looking across multiple climate indices. For example, around 90 per cent of the additional energy from the enhanced greenhouse effect has warmed the global oceans, with both sea-level and ocean heat content showing increases in recent decades. As described above, the falling temperatures observed over parts of Australia in the 2002–13 period are a relatively short-term and local phenomenon that is consistent with normal patterns of decadal climate variability, mostly related to ENSO, superimposed on longer-term sustained regional warming.

There is currently no evidence of longer-term cooling in Australia, as illustrated by the evidence presented in the 2014 State of the Climate report (see reference provided below). The 21st Century has seen Australia's and the Globe's hottest decade and year on record.

Station number	Location	Number of 12-year periods with trends which are		Largest 12-year trends between 1951 and 2013 (°C/year)	
		Positive	Negative	Positive	Negative
Queensland stations in email of 10 June 2014					
31011	Cairns	27	17	+0.08 (1979-1990)	-0.05 (1968-1979)
32040	Townsville	36	10	+0.07 (1977-1988)	-0.13 (2001-2012)
39083	Rockhampton	34	15	+0.09 (1994-2005)	-0.14 (2001-2012)
40004	Amberley	32	19	+0.10 (1982-1993)	-0.12 (2001-2012)
44021	Charleville	33	18	+0.15 (1995-2006)	-0.16 (2001-2012)
Selected other Australian stations					
4032	Port Hedland	31	17	+0.13 (1999-2010)	-0.12 (1990-2001)
12038	Kalgoorlie	31	19	+0.11 (1998-2009)	-0.08 (1979-1990)
14015	Darwin	30	11	+0.06 (1999-2010)	-0.03 (1958-1969)
15590	Alice Springs	31	18	+0.14 (1974-1985)	-0.11 (1957-1968)
18012	Ceduna	35	14	+0.10 (1997-2008)	-0.08 (1979-1990)
26021	Mount Gambier	36	11	+0.10 (1952-1963)	-0.06 (1967-1978)
46037	Tibooburra	32	16	+0.14 (1954-1965)	-0.12 (2001-2012)
58012	Yamba	30	19	+0.09 (1982-1993)	-0.08 (1952-1963)
72150	Wagga Wagga	33	15	+0.19 (1995-2006)	-0.08 (1979-1990)
76031	Mildura	28	20	+0.13 (1992-2003)	-0.07 (1959-1970)
94029	Hobart	36	10	+0.09 (1963-1974)	-0.08 (1987-1998)

Table 1. 12-year maximum temperature trends, summarised for all 12-year periods within the 1951-2013 window. Periods with zero trends are not included.

ADDITIONAL INFORMATION

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 2014 report, jointly prepared by the Bureau of Meteorology and CSIRO can be found at http://www.bom.gov.au/state-of-the-climate/

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 the Environment 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/