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Can public perceptions of Australian climate extremes be reconciled with the statistics of climate change?

Sophie C. Lewis *

Research School of Earth Sciences, The Australian National University, Canberra, ACT, Australia and ARC Centre of Excellence for Climate System Science, Australia

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ABSTRACT

In this study alternative understandings of extreme climate events are examined by focusing on the consecutive spring record-breaking temperatures observed in Australia in 2013 and 2014. Aspects of these extremes have previously been investigated scientifically. However, widely held popular perceptions, such as those epitomised by the public statements of recent Australian Prime Minister Tony Abbott, refute the outcomes of these scientific analyses. Instead, these posit that new temperature records are purely an artefact of natural variability and the longer the period of observations available, the greater possibility of extreme events. Here, I characterise these understandings as alternative mental models of climate change and extremes, with one informed primarily by personal perceptions (The Natural Variability Concept), and the other (The Probabilistic Change Concept) informed by evidence of the physical climate system (i.e., high-quality observed temperatures and a suite of Coupled Model Intercomparison Project phase 5 (CMIP5) climate models). Using these tools, I demonstrate that observed temperature characteristics are irreconcilable with the personal perception-based understanding of extremes as artefacts only of natural climate variability. In addition to showing that the perception-based understanding of climate change and extremes adopted by Abbott (i.e., the Natural Variability Concept) is not fully consistent with the observed time series, I also show that it cannot be internally consistent. The use of these commonly employed statistical properties of temperature time series to examine directly elements of the perception-based conceptualisation of extremes provides insight into the communication of the scientific basis of extreme climate events. I suggest that further quantitative attribution statements are unlikely to explain such extremes more fully than information already available to the public. Directly addressing the misplaced foundational beliefs of the Natural Variability Concept, however, may help accurately communicate aspects of climate extremes more clearly to those open to learning from personal experiences.

1. Introduction

This study explores alternative understandings of extreme climate events by focusing on the example of the consecutive spring record-breaking temperatures experienced in Australia in 2013 and 2014. Over the period of late 2012 to 2015, Australia experienced well above average temperatures. The previous years of 2010–2011 were unusually cool and wet across Australia, in association with strong, consecutive La Niña events (Bureau of Meteorology, 2012). As these exceptional La Niña episodes subsided, sustained high temperatures across Australia were recorded. In 2013, for example, area-mean Australian temperature records were broken for the hottest day, week, month, season and year on record (Bureau of Meteorology, 2014). Temperature records were broken on spatial scales ranging from individual locations through to State- and continent-wide area averages, and on timescales ranging from daily through to annual averages. Notably, a new spring temperature record was set in 2013 for Australia-wide area-average mean temperatures (Tmean; Fig. 1) (Bureau of Meteorology, 2013), which was exceeded again in spring 2014. The 2013 and 2014 spring anomalies were the largest in a high-quality observational record extending back to 1910 (Jones et al., 2009; Trewin, 2012).

Specific aspects of these extreme Australian temperatures have been investigated previously. These studies have explored record temperatures from an attribution framework using climate models to quantify the change in likelihood of extreme temperatures that can be attributed to anthropogenic forcings, such as greenhouse gases (Lewis and Karoly, 2013; 2014). Such model-based attribution approaches provide just one perspective of observed record-breaking Australian temperatures. Personal perceptions of extremes, for example, often provide a differing perspective from

* Corresponding author.
E-mail address: sophie.lewis@anu.edu.au

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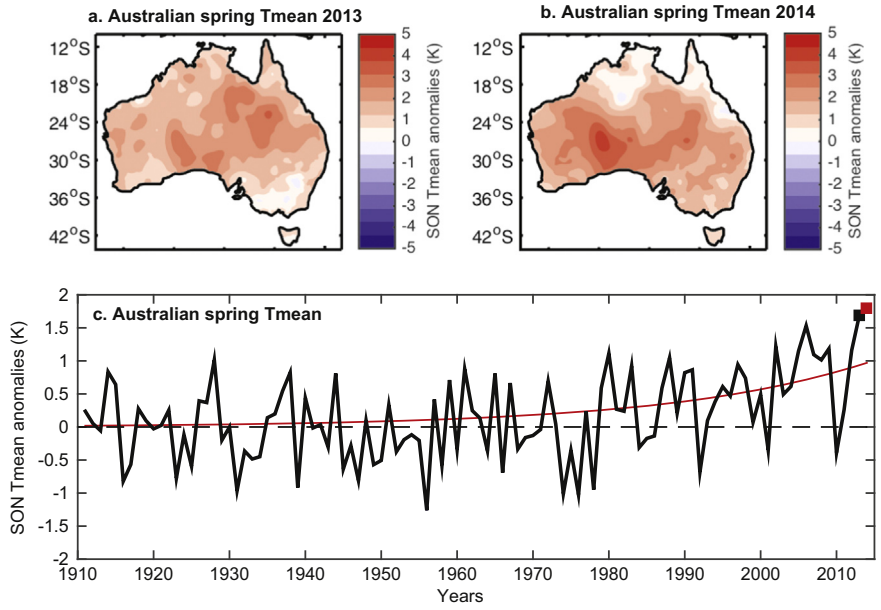

Fig. 1. Observed mean Australian spring (Spring-November; SON) temperature anomalies (K, relative to 1911–1940) for 2013 (a) and 2014 (b) and for the observed period 1910–2014 (c), with the record anomalies of 2013 (black) and 2014 (red) shown. Data are from AWAP (Jones et al., 2009).

scientific results. After an extreme climate event it is common for the public, media and research community to ask, what caused this event (Trenberth, 2012; Hulme, 2014)? Is it linked to global warming? Do recent record-breaking temperatures reveal aspects of climate change? Here I propose two simplified mental models widely used to address these questions and ultimately understand climate extremes. These mental models based on these alternative understandings, namely i) the Probabilistic Change Concept and ii) the Natural Variability Concept, which are outlined below.

1.1. *Alternative understandings of extremes*

The Probabilistic Change Concept refers to an understanding of climate extremes based around the quantification of the probability of occurrence. These approaches typically utilise data from climate models to determine the change in likelihood of a defined extreme event that can be attributed to a specific forcing. For example, the Lewis and Karoly (2013; 2014) analyses utilise data from global climate models that contributed detection and attribution experiments to phase five of the Coupled Model Intercomparison Project (CMIP5) (Taylor et al., 2012) and demonstrate, for example, that anthropogenic influences substantially increase the risk of extreme spring temperatures occurring in Australia (Lewis and Karoly, 2014). The repeated spring records of 2013 and 2014 have also been investigated using these analysis tools showing such extremes are very unlikely to occur due to natural climate variations alone but have a significant chance of occurring under greenhouse gas forcing (*Gallant and Lewis*, submitted).

Such attribution studies using this fraction of attributable risk (FAR) framework (Stott et al., 2004) are considered useful for understanding the risks of future extreme temperatures and impacts, which has implications for adaptive decision-making (Stott et al., 2010). Through this Probabilistic Change understanding of extremes, record climate events potentially represent an important diagnostic of change in the climate system. A changing climate can lead to changes in the frequency, intensity, spatial extent, duration and timing of extremes, and furthermore, can result in unprecedented events (IPCC, 2012). An end member viewpoint of this model is Trenberth's (2012) statements that the "answer to the oft-asked question of whether an event is caused by climate change is that it is the wrong question. All weather events are affected by climate change because the environment in which they occur is warmer and moister than it used to be."

Alternatively, in the second mental model of understanding (the Natural Variability Concept), climate extremes are considered artefacts of natural climate variability, and should not be linked to climate change. Under this conceptualisation, recent record-breaking is indicative of natural climate variability and the ever-greater length of observational record keeping available. The Natural Variability mental model based on a personal perspective of climate change and extreme climate events is a widely held understanding of extreme events, with many people understanding anthropogenic climate change as a future problem that does not currently impacts their locality (Myers et al., 2012). This understanding is readily demonstrated by public comments by the recent Australian Prime Minister Tony Abbott. During the record-breaking spring temperatures in Australia in 2013, Abbott said, "… the thing is that at some point in the future, every record will be broken, but that doesn't prove anything about climate change. It just proves that the longer the period of time, the more possibility of extreme events". Other public comments by Prime Minister Abbott about climate change and variability include that the argument behind human-caused climate change is "absolute crap", that "there doesn't appear to have been any appreciable warming since the late 1990s" and that the link between climate change and extreme Australian climate events is "complete hogwash" (Readfearn, 2014). Former Prime Minister Abbott's understandings of climate change and variability are not unique. Rather, these provide an encapsulation of a widely help view that the longer the period of time under consideration, the greater the possibility of extreme events. Abbott's comments are selected here for exploration as they demonstrate a widespread mental model of understanding and are capable of being highly influential.

These personal understandings of climate change arise from several causes. First, the manifestation of climate change in weather and climate is typically poorly understood (Trenberth, 2011). In general, people have difficulty perceiving changes in the physicals climate system above the natural variability of local climate (Myers et al., 2012). Hansen et al., 2012 ask, "[h]ow can a person discern long-term climate change, given the notorious