GEOPHYSICAL RESEARCH LETTERS, VOL. 40, 3705–3709, doi:10.1002/grl.50673, 2013

Anthropogenic contributions to Australia's record summer temperatures of 2013

Sophie C. Lewis[1] and David J. Karoly[1]

Received 15 May 2013; revised 13 June 2013; accepted 16 June 2013; published 23 July 2013.

[1] Anthropogenic contributions to the record hot 2013 Australian summer are investigated using a suite of climate model experiments. This was the hottest Australian summer in the observational record. Australian area-average summer temperatures for simulations with natural forcings only were compared to simulations with anthropogenic and natural forcings for the period 1976–2005 and the RCP8.5 high emission simulation (2006–2020) from nine Coupled Model Intercomparison Project phase 5 models. Using fraction of attributable risk to compare the likelihood of extreme Australian summer temperatures between the experiments, it was very likely (>90% confidence) there was at least a 2.5 times increase in the odds of extreme heat due to human influences using simulations to 2005, and a fivefold increase in this risk using simulations for 2006–2020. The human contribution to the increased odds of Australian summer extremes like 2013 was substantial, while natural climate variations alone, including El Niño Southern Oscillation, are unlikely to explain the record temperature.
Citation: Lewis, S. C., and D. J. Karoly (2013), Anthropogenic contributions to Australia's record summer temperatures of 2013, *Geophys. Res. Lett.*, *40*, 3705–3709, doi:10.1002/grl.50673.

1. Introduction

[2] The Australian summer of December 2012 to February 2013 was the hottest on record (Figure 1a), with average conditions exceeding the observed 1911–1940 mean by 1.32 K (Figure 1b). Summer temperature records were broken on daily through to seasonal timescales: the hottest month on record occurred as well as the hottest day for the entire Australian continent [*Bureau of Meteorology*, 2013a]. By late summer, sustained high temperatures were also coincident with bushfires in south-eastern Australia in Victoria and Tasmania, and severe flooding in north-eastern Australia in Queensland and New South Wales [*Bureau of Meteorology*, 2013b]. Conditions were so severe, it was dubbed the "angry summer" [*Steffen*, 2013].

[3] The observed increase in the intensity, frequency, and duration of heat waves is globally widespread over land [*Perkins et al.*, 2012]. On longer timescales, monthly extremes are increasing at a relatively faster rate than daily extremes [*Coumou and Rahmstorf*, 2012], such that many of the large number of recent record-breaking heat waves and summer extremes have been associated with anthropogenic influences [*Hansen et al.*, 2012]. As changes in climatic means can lead to very large percentage changes in the occurrence of extremes [*Trenberth*, 2012], the extreme seasonal heat is considered in the context of average Australian temperatures having increased by 0.9°C since 1910 [*Bureau of Meteorology*, 2012b]. While changes in Australian average temperatures have been attributed to anthropogenic climate change [*Karoly and Braganza*, 2005; *Stott et al.*, 2010], the possible anthropogenic contribution to extreme seasonal temperatures in Australia has not been considered before.

[4] We cannot categorically ascribe the cause of a particular climate event to anthropogenic climate change; however, the roles of various factors contributing to the change in odds of an event occurring can be identified. The probability of an event occurring is calculated in a large ensemble of climate models and then compared to the equivalent probability in a counterfactual experiment, where only natural climate forcings are imposed [*Allen*, 2003]. Using this conceptual framework, anthropogenic contributions to specific climatic events have been probabilistically estimated [*Stott et al.*, 2004; *Pall et al.*, 2011; *Christidis et al.*, 2013]. Event attribution and climate prediction services are interrelated; attribution studies are necessary for developing meaningful adaptive decisions [*Stott et al.*, 2012].

[5] In this study, we investigate the relative contributions of anthropogenic and natural factors to the record summer temperatures of 2013 averaged across Australia. Utilizing a suite of Coupled Model Intercomparison Project phase 5 (CMIP5) detection and attribution experiments [*Taylor et al.*, 2012], we compare the occurrence of extreme summer temperatures in a series of control simulations and simulations with natural forcings only with those occurring in model experiments including both natural and anthropogenic forcings. Did anthropogenic influences contribute to conditions occurring during the record summer of 2013 and if so, by how much?

2. Data and Methods

[6] We investigate changes in area-mean Australian summer (December to February, DJF) temperature distributions from observational and model sources. We limit the scope of this study to continent-wide, seasonal temperatures, rather than investigating daily or multiday records in particular locations. As sufficiently large, coherent regions exhibit climatic signals above the noise of natural climatic variability [*Stott et al.*, 2004], they are a useful basis for model-observational comparisons. In addition, the statistics of seasonal changes are likely to be more robust than extreme

Additional supporting information may be found in the online version of this article.

[1]School of Earth Sciences and ARC Centre of Excellence for Climate System Science, University of Melbourne, Parkville, Victoria, Australia.

Corresponding author: S. C. Lewis, School of Earth Sciences, University of Melbourne, Parkville, VIC 3010, Australia. (sophie.lewis@unimelb.edu.au)

0094-8276/13/10.1002/grl.50673

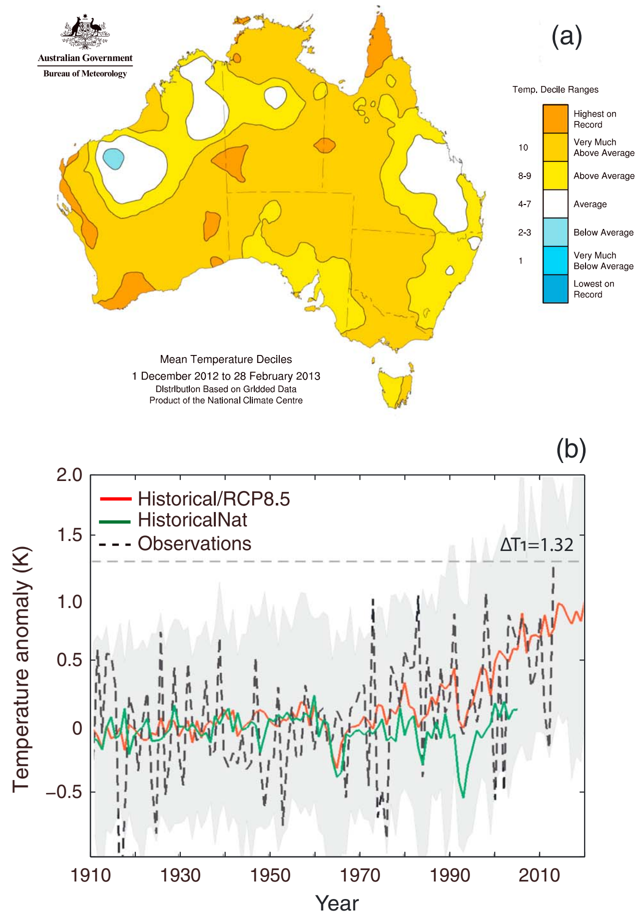

Figure 1. (a) Summer (DJF) Tmean deciles from AWAP gridded data (provided by National Climate Centre, http://www.bom.gov.au/jsp/awap/temp/). (b) Australian summer Tmean anomalies (relative to 1911–1940) for observations (dashed black) and historicalNat (green) simulations. The historical and RPC8.5 multi-model mean is shown (red), and gray plumes indicate the 5th and 95th percentile values across the ensembles. Average Australian conditions during the 2013 summer (ΔT_1) were 1.32 K above the observed 1911–1940 mean (horizontal dashed line).

temperature changes on daily timescales and have been the focus of several previous studies [*Stott et al.*, 2004; *Jones et al.*, 2008; *Hansen et al.*, 2012].

[7] We use observed average monthly mean (Tmean), maximum (Tmax), and minimum (Tmin) temperatures calculated from the Australian Water Availability Project (AWAP) gridded data set [*Jones et al.*, 2009]. Model results are derived from nine climate models participating in CMIP5 [*Taylor et al.*, 2012]. Models were included in this analysis where data were available for all utilized experiments (Table 1) on the Australian node of the Earth System Grid and also based on their skill in capturing observed interannual variability of Australian summer temperatures (see supporting information). Data were regridded onto a common horizontal grid, summer Tmean, Tmax, and Tmin averages calculated and Australian areal averages determined.

[8] We use the standard historical experiment, simulating the climate of 1850 to 2005 with both anthropogenic (well-mixed greenhouse gases, aerosols, and ozone) and natural forcings (volcanic and solar) imposed, and compare these temperature anomalies to those obtained from the historicalNat experiments (with only solar and volcanic forcings from 1850–2005). We also utilize the RCP8.5 experiment (Representative Concentration Pathway with high emissions for the 21st Century), as this is most representative of global CO_2 emissions from 2005 to present [*Peters et al.*, 2012]. In addition, we analyze the long control runs (piControl) provided for each model, as these are long, freely evolving climate simulations with greenhouse gas concentrations appropriate for circa 1850 that permit the analysis of a large number of model years. Both the historicalNat and piControl experiments provide the "world that might have been" counterpart to the anthropogenically-forced experiments, although the control experiment is only an approximation of the natural climate.

[9] We consider historical, historicalNat, and RCP8.5 temperature anomalies relative to the 1911–1940 climatology, providing a common baseline with observations. Anomalies for each piControl model realization are calculated relative to the long-term mean. In order to assess the influence of anthropogenic forcings on summer temperatures, we consider only historical model years 1976–2005 and RCP8.5 model years 2006–2020, while we consider all available quality-checked observational years (1911–2011), all historicalNat model years (1850–2005), and all piControl model years.

3. Anthropogenic Influence on Summer Temperatures

[10] We compare the occurrence of observed Australian average summer Tmean anomalies in the model experiments using probability density functions (Figure 2) estimated using a kernel smoothing function. There is a clear warm shift in the distribution of temperatures between the historical experiment and the historicalNat and observational data sets, for Tmean (Figure 2), Tmax, and Tmin (not shown). Two-sided Kolmogrov-Smirnov tests indicate that the historicalNat and piControl distributions are statistically indistinguishable and could have been derived from the same populations. Conversely, there are significant differences (at the 5% significance level) between the historicalNat and warmer historical distributions, providing evidence for anthropogenic influences on warm summer temperatures. The observational and historical data sets are similar when we consider the common period of 1911–2005 (see Figure 1b). The two probability distributions appear different

Table 1. CMIP5 Model Experiments Analyzed, the Major Differences in Forcings, the Model Years Analyzed, and the Baseline Climatology Used to Calculate Temperature Anomalies

Experiment	Major Forcings	Years Analyzed	Baseline
historicalNat	Solar and volcanics	1850–2005	1911–1940
historical	Anthropogenic (greenhouse gases, aerosols, and ozone) and natural (solar and volcanics)	1976–2005	1911–1940
RCP8.5	Anthropogenic (greenhouse gases, aerosols, and ozone scenarios) and natural (solar)	2006–2020	1911–1940
piControl	Non-evolving preindustrial forcings	All	Long-term mean

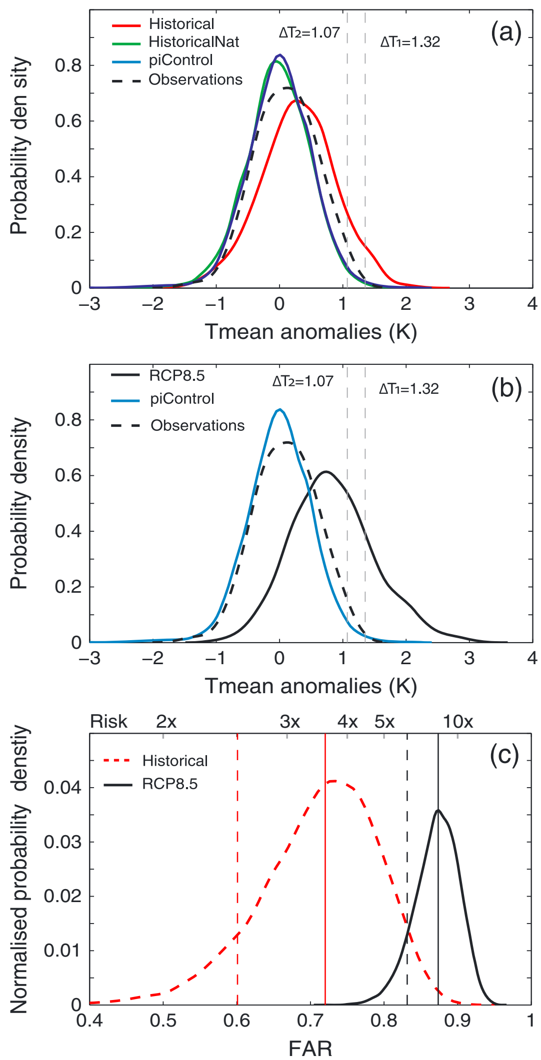

Figure 2. (a) Probability density functions for Australian summer Tmean anomalies (relative to 1911–1940) for observations (dashed black, all years shown), historical (red, 1976–2005 only), historicalNat (green, all years shown), and piControl (dark blue, all years shown relative to long-term mean) simulations. Vertical dashed lines show observed 2013 anomaly (ΔT_1) and threshold of the second hottest summer on record (ΔT_2). (b) As for Figure 2a, but for RCP8.5 experiment (black, 2006–2020 only). (c) The fraction of attributable risk of extreme summer Australian temperatures exceeding ΔT_2 for the historical (red) and RCP8.5 simulations (black). Solid (dashed) vertical lines indicate mean (90th percentile) FAR estimates for each experiment.

in Figure 2, as the observations are shown for 1911–2010 and historical simulations for 1976–2005 only.

[11] Averaged over the Australian continent, 2013 summer temperatures exceeded the observed 1911–1940 mean by 1.32 K. To examine possible changes in the likelihood of extreme summer heat occurring in the models, we defined a threshold (Tmean 1.07 K, Tmax 1.21 K, and Tmin 1.15 K) based on the second hottest observed summer temperatures. Selection of this threshold, rather than the 2012–2013 deviation from the 1911–1940 mean, reduces the selection bias and also provides an inherently conservative analysis [*Stott et al.*, 2004]. The fraction of attributable risk (FAR), the fraction of risk of a particular threshold being exceeded (i.e., an event) that can be attributed to a particular influence, was calculated as

$$\mathrm{FAR} = 1 - \frac{P_{\mathrm{NAT}}}{P_{\mathrm{ALL}}},$$

where P_{NAT} denotes the probability of an event occurring in a reference state and P_{ALL} under a parallel forced state [*Stone and Allen*, 2005]. An assessment of FAR uncertainty was obtained through bootstrap resampling (see supporting information), with the best estimate (mean) and 90th percentile FAR values presented here.

[12] The best estimate Tmean FAR was calculated as 0.72 for the historical experiment, relative to historicalNat. That is, there was a greater than threefold increase in risk of average summer temperatures exceeding those that occurred in Australia during the second hottest summer on record in the historical experiment compared to the parallel historicalNat experiment, with no anthropogenic forcings. The Tmin FAR (0.88) was higher than for Tmax (0.50): there was an eightfold increase in the risk of extreme average summer Tmin attributable to anthropogenic influences and a doubling of Tmax risk. There was a spread in distribution of FAR values across the historical ensembles (Figure 2c), although there it was very likely (>90% confidence) that there was at least a 2.5 times increase in risk associated with extreme mean summer heat due to human influences. A similar FAR value (0.70) was obtained by selecting a threshold based on the third hottest observed summer Tmean.

[13] This is a conservative estimate of Australian summer temperature changes associated with anthropogenic climate change. Beyond selecting a threshold based on the second warmest recorded Australian summer temperatures, we also compared the historicalNat experiment to historical model years 1976–2005 only. When the same approach is extended through to 2020, using model simulations forced with the RCP8.5 scenario, the FAR (determined relative to the pre-industrial control experiment) is larger again. Data from RCP8.5 simulations were used for the period 2006–2020, as this is centered on the 2013 summer of interest. First, the warm shift in Tmean distributions for the RCP8.5 experiment is larger than for the historical experiment (Figure 2b). The RCP8.5 ensemble average Tmean anomaly for 2006–2020 is 0.84 K (relative to 1911–1940), which is above the 90th percentile of observed summer temperature anomalies occurring over Australia from 1911–2010.

[14] In the RCP8.5 simulations, the best estimate Tmean FAR value was calculated as 0.87 (Tmax 0.72; Tmin 0.95), indicating a greater than sevenfold increase in the risk of summer mean temperatures as severe or worse than 1997–1998 resulting from anthropogenic forcings. In this high emissions scenario with strong concomitant warming trends, the occurrence of high Australian summer temperatures at least as warm as the 2013 record summer is substantially more likely than in the control and historicalNat simulations. In addition to the increase in risk between the historical (1976–2005) and RCP8.5 (2006–2020) experiments, the uncertainties associated with FAR values using RPC8.5 simulations are substantially reduced. The FAR values for the analyzed RCP8.5 ensembles (compared to historicalNat) were tightly clustered around the ensemble mean. Using anthropogenically-forced simulations for 2006–2020, it is very likely (>90% confidence) that human influences increased the risk of extreme summer mean temperatures by at least fivefold, maximum temperatures by

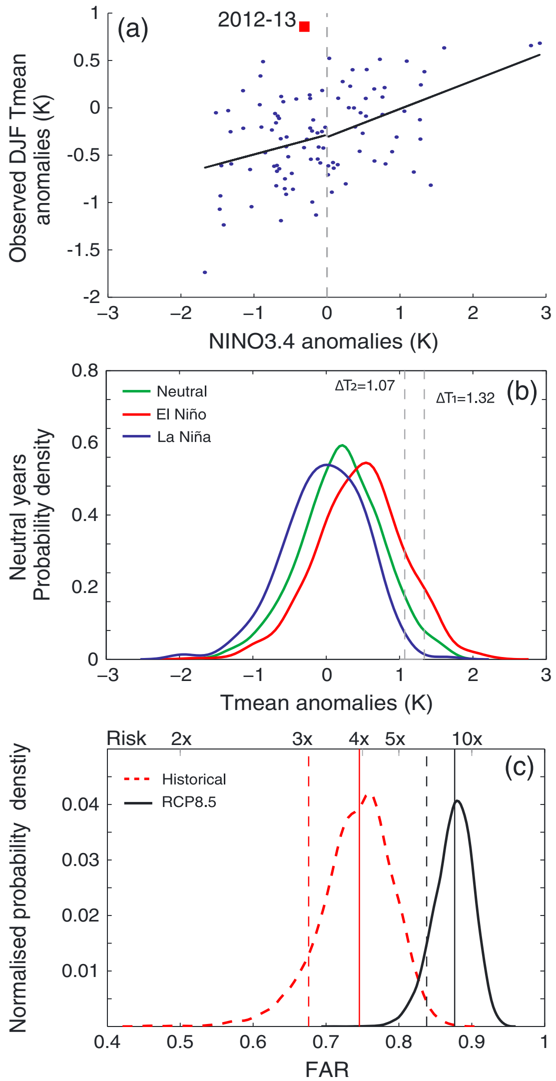

Figure 3. (a) Scatter plot of DJF average observed Tmean anomalies in the NINO3.4 region against area-averaged Australian summer Tmean anomalies (relative to 1981–2010). Conditions during summer 2013 are shown (red square). Lines of best fit for warm and cool NINO3.4 anomalies are calculated using ordinary least squares regression. (b) PDFs of Tmean anomalies for neutral (green), El Niño (red), and La Niña (blue) years only from the historical simulation. El Niño (La Niña) years were determined where average modeled summer NINO3.4 anomalies were >0.5 K (<−0.5 K) from the running 30 year mean. Vertical dashed lines show observed 2013 anomaly (ΔT_1) and threshold from the second hottest summer on record (ΔT_2). (c) The fraction of attributable risk of extreme summer Australian temperatures exceeding ΔT_2 for the historical (red) and RCP8.5 (black) simulations for NINO3.4 neutral years only. Solid (dashed) vertical lines indicate mean (90th percentile) FAR estimates for each experiment.

threefold, and minimum temperature by 10-fold. We also calculate a substantial decrease in Tmean return times of this type of event (second hottest Australian summer temperatures) associated with anthropogenic influences. The event is expected to occur 1-in-16 years without anthropogenic influences, but we estimate it occurs in 1-in-6 years in the historical experiment and 1-in-2 years in the RCP8.5 experiment.

4. ENSO Influence on Summer Temperatures

[15] In addition to the longer term anthropogenic warming trend, El Niño Southern Oscillation (ENSO) is the main driver of internal climate variability in the Pacific [*Philander*, 1990]. Australian interannual rainfall and surface temperature variations are strongly linked to ENSO phases [*Power et al.*, 1999], with El Niño conditions generally associated with warmer than average Australian summer temperatures (Figure 3a). As such, we also consider the extreme 2012–2013 conditions in relation to this large-scale mode of variability. The 2013 summer occurred following 2 years of exceptionally heavy rainfall associated with an extended La Niña event [*Bureau of Meteorology*, 2012a]. During October 2012, sea surface temperatures in the NINO3.4 region returned to neutral, and December 2012 to February 2013 was characterized by cool-neutral conditions, with an average NINO3.4 anomaly of −0.31°C (relative to the 1981–2010 baseline) [*International Research Institute*, 2013]. Conversely, previous extremely warm Australian summers (e.g., 1997–1998, 1925–1926) occurred during dry conditions associated with El Niño events, when potential soil-moisture feedbacks may have been important [*Timbal et al.*, 2002].

[16] We define El Niño (La Niña) influenced summers in the historical experiment as those where the average, Tmean anomaly (calculated relative to a 30 year running mean) in the NINO3.4 region was greater (less) than 0.5 K (−0.5 K). The distribution of modeled Australian average temperature anomalies was compared for El Niño (n = 907), La Niña (n = 249), and neutral (n = 856) summers (Figure 3b). Modeled El Niño summers are characterized by generally warmer Australian average temperatures than La Niña summers. Again using the temperature anomaly threshold of 1.07 K (determined from the second hottest Australian summer on record), we determine that summers of this severity are at least three times more likely under El Niño conditions than under La Niña conditions. We also explicitly compare summer temperatures in the historical and historicalNat experiments for years characterized by neutral ENSO conditions (Figure 3c). The increase in risk is similar to that when considering all ENSO conditions: a best estimate sevenfold increase in risk is calculated for extreme summers for the RCP8.5 scenario, with 90% confidence of at least a fivefold increase in risk. Hence, the ENSO neutral conditions during the 2013 summer do not appear to have been a factor in the record Australian summer temperatures.

5. Summary

[17] This study was motivated by the recent 2012–2013 record Australian summer temperatures. Comparison of the distribution of Australian area-average temperature anomalies from various CMIP5 experiments from nine models shows a significant change in the probability of extreme warm summer temperatures in model experiments forced with increasing human influences, compared with the equivalent naturally forced experiments. Given both the weakly La Niña-neutral conditions prevailing during 2012–2013, and the modeled strong increase in risk associated with this type of seasonal extreme in the anthropogenically-forced experiments, natural climatic variations alone are unlikely to have caused the record Australian 'angry' summer of 2013. These results support a clear conclusion that anthropogenic

climate change had a substantial influence on the extreme summer heat over Australia and that natural climate variations alone are unlikely to explain the recent record summer temperature.

[18] We conservatively estimate that the extreme summer heat was at least 2.5 times more likely (>90% confidence) due to anthropogenic influences in the simulations up to 2005. However, using simulations centered on 2013, it is very likely (>90% confidence) that human influences increased this risk by at least fivefold. The best estimate anthropogenic mean temperature change for 2013 (0.84 K, determined from the RCP8.5 ensemble mean for years 2006–2020) was applied to the observational record (for the period 1911–1940 of minimal anthropogenic warming), and the calculated FAR value of 0.90 was found to be close to the equivalent RCP8.5 FAR value of 0.87. That is, the increase in risk for this type of event could be accurately estimated simply from the observational record and modeled mean temperature changes. In this instance, an assessment of risk could potentially occur in near-real time. Previous studies also show that precomputing changes in the likelihood of exceeding a temperature threshold over a suite of thresholds enables a near real-time assessment of the anthropogenic influences on the observed temperatures for some regions [*Christidis et al*., 2011].

[19] There was also a substantial decrease in the return times (increase in the frequency) of extreme summers between the historical (1976–2005) and RCP8.5 (2006–2020) model years. Beyond the 2020 cut-off utilized in our study, there is likely a marked increase in the occurrence of extreme hot seasons under the RCP8.5 scenario. Other studies show that by 2080–2099 in the RCP8.5 simulations, at least 65% of seasons are projected to be extremely hot over all land areas, with frequent heat likely to have severe implications for human and natural systems [*Diffenbaugh and Giorgi*, 2012]. An increase in the frequency of extreme summer heat in the future is very likely. In the bushfire prone, highly populated areas of eastern Australia, understanding the risk of extreme summer temperatures and likely changes to the frequency of summer extremes has implications for making adaptive decisions. Extending this analysis to particular heat waves, such as those that occurred throughout the 2013 Australian summer would be useful. Beyond the anthropogenically-driven increase in seasonal temperatures, there has been a general lengthening of summer-like conditions, with spring and autumn shortened in many places [*Hansen et al*., 2012]. Investigating human influences on out-of-season heat waves, such as the record November 2012 and March 2013 heat waves in south-eastern Australia would also be valuable for understanding potential future changes in heat wave intensity and frequency.

[20] **Acknowledgments.** This research was supported by the ARC Centre of Excellence for Climate System Science (grant CE 110001028) and the NCI National Facility. We thank the Bureau of Meteorology, the Bureau of Rural Sciences, and CSIRO for providing AWAP data. We acknowledge the WCRP's Working Group on Coupled Modelling, which is responsible for CMIP. The U.S. Department of Energy's PCMDI provides CMIP5 coordinating support.

[21] The Editor thanks Peter Stott and Nikolaos Christidis for their assistance in evaluating this paper.

References

Allen, M. (2003), Liability for climate change, *Nature*, *421*(6926), 891–892.
Bureau of Meteorology (2012a), Australia's wettest two-year period on record; 2010–2011, *Spec. Clim. Statement*, *38*, Melbourne.
Bureau of Meteorology (2012b), State of the Climate 2012, Melbourne.
Bureau of Meteorology (2013a), Extreme heat in January 2013, *Spec. Clim. Statement*, *43*, Melbourne.
Bureau of Meteorology (2013b), Extreme rainfall and flooding in coastal Queensland and New South Wales, *Spec. Clim. Statement*, *44*, Melbourne.
Christidis, N., P. A. Stott, F. W. Zwiers, H. Shiogama, and T. Nozawa (2011), The contribution of anthropogenic forcings to regional changes in temperature during the last decade, *Clim. Dyn.*, *39*(6), 1259–1274, doi:10.1007/s00382-011-1184-0.
Christidis, N., P. A. Stott, A. A. Scaife, A. Arribas, G. S. Jones, D. Copsey, J. R. Knight, and W. J. Tennant (2013), A new HadGEM3-A-based system for attribution of weather- and climate-related extreme events, *J. Clim.*, *26*(9), 2756–2783, doi:10.1175/JCLI-D-12-00169.1.
Coumou, D., and S. Rahmstorf (2012), A decade of weather extremes, *Nat. Clim. Change*, *2*(7), 1–6, doi:10.1038/nclimate1452.
Diffenbaugh, N. S., and F. Giorgi (2012), Climate change hotspots in the CMIP5 global climate model ensemble, *Clim. Change*, *114*(3–4), 813–822, doi:10.1007/s10584-012-0570-x.
Hansen, J., M. Sato, and R. Ruedy (2012), Perception of climate change, *Proc. Natl. Acad. Sci. U. S. A.*, *109*(37), E2415–E2423, doi:10.1073/pnas.1205276109.
International Research Institute (2013), Technical ENSO update. [Available from http://iri.columbia.edu/climate/ENSO/currentinfo/technical.html.]
Jones, G. S., P. A. Stott, and N. Christidis (2008), Human contribution to rapidly increasing frequency of very warm Northern Hemisphere summers, *J. Geophys. Res.*, *113*, D02109, doi:10.1029/2007JD008914.
Jones, D. A., W. Wang, and R. Fawcett (2009), High-quality spatial climate data-sets for Australia, *Aust. Meteorol. Oceanogr. J.*, *58*(4), 233.
Karoly, D. J., and K. Braganza (2005), Attribution of recent temperature changes in the Australian region, *J. Clim.*, *18*(3), 457–464.
Pall, P., T. Aina, D. A. Stone, P. A. Stott, T. Nozawa, A. G. J. Hilberts, D. Lohmann, and M. R. Allen (2011), Anthropogenic greenhouse gas contribution to flood risk in England and Wales in autumn 2000, *Nature*, *470*(7334), 382–385, doi:10.1038/nature09762.
Perkins, S. E., L. V. Alexander, and J. R. Nairn (2012), Increasing frequency, intensity and duration of observed global heatwaves and warm spells, *Geophys. Res. Lett.*, *39*, L20714, doi:10.1029/2012GL053361.
Peters, G. P., R. M. Andrew, T. Boden, J. G. Canadell, P. Ciais, C. Le Quéré, G. Marland, M. R. Raupach, and C. Wilson (2012), The challenge to keep global warming below 2°C, *Nat. Clim. Change*, *3*(1), 4–6, doi:10.1038/nclimate1783.
Philander, S. G. (1990), *El Nino, La Nina, and the Southern Oscillation*, Academic Press, San Diego.
Power, S., T. Casey, C. Folland, A. Colman, and V. Mehta (1999), Inter-decadal modulation of the impact of ENSO on Australia, *Clim. Dyn.*, *15*(5), 319–324.
Steffen, W. (2013), The Angry Summer, pp. 1–12, Climate Commission, Canberra.
Stone, D. A., and M. R. Allen (2005), The end-to-end attribution problem: From emissions to impacts, *Clim. Change*, *71*(3), 303–318, doi:10.1007/s10584-005-6778-2.
Stott, P. A., D. A. Stone, and M. R. Allen (2004), Human contribution to the European heatwave of 2003, *Nature*, *432*(7017), 610–614, doi:10.1038/nature03089.
Stott, P. A., N. P. Gillett, G. C. Hegerl, D. J. Karoly, D. A. Stone, X. Zhang, and F. Zwiers (2010), Detection and attribution of climate change: A regional perspective, *WIREs Clim. Change*, *1*(2), pp. 192–211, doi:10.1002/wcc.34.
Stott, P. A., M. Allen, N. Christidis, R. Dole, M. Hoerling, C. Huntingford, P. Pall, J. Perlwitz, and D. Stone (2012), Attribution of weather and climate-related extreme events, *WCRP Position Paper on ACE*. [Available at http://library.wmo.int/pmb_ged/wcrp_2011-stott.pdf.]
Taylor, K. E., R. J. Stouffer, and G. A. Meehl (2012), An overview of CMIP5 and the experiment design, *Bull. Am. Meteorol. Soc.*, *93*(4), 485–498, doi:10.1175/BAMS-D-11-00094.1.
Timbal, B., S. Power, R. Colman, J. Viviand, and S. Lirola (2002), Does soil moisture influence climate variability and predictability over Australia?, *J. Clim.*, *15*(10), 1230–1238.
Trenberth, K. E. (2012), Framing the way to relate climate extremes to climate change, *Clim. Change*, *115*(2), 283–290, doi:10.1007/s10584-012-0441-5.