A photograph of a snowy park path, likely in Central Park, New York. The path is covered in a thick layer of snow, with footprints visible. On either side of the path are ornate blue and gold lampposts. In the background, a large brick building is visible. The sky is overcast and it appears to be snowing.

EXPLAINING EXTREME EVENTS OF 2014

From A Climate Perspective

Special Supplement to the
Bulletin of the American Meteorological Society
Vol. 96, No. 12, December 2015

EXPLAINING EXTREME EVENTS OF 2014 FROM A CLIMATE PERSPECTIVE

Editors

Stephanie C. Herring, Martin P. Hoerling, James P. Kossin, Thomas C. Peterson, and Peter A. Stott

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BACK: ©iStockphotos.com/nathanphoto—Legget, California, United States – August 13, 2014: CAL FIRE helicopter surveys a part of the Lodge Fire, Mendocino County.

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Understanding how long-term global change affects the intensity and likelihood of extreme weather events is a frontier science challenge. This fourth edition of explaining extreme events of the previous year (2014) from a climate perspective is the most extensive yet with 33 different research groups exploring the causes of 29 different events that occurred in 2014. A number of this year's studies indicate that human-caused climate change greatly increased the likelihood and intensity for extreme heat waves in 2014 over various regions. For other types of extreme events, such as droughts, heavy rains, and winter storms, a climate change influence was found in some instances and not in others. This year's report also included many different types of extreme events. The tropical cyclones that impacted Hawaii were made more likely due to human-caused climate change. Climate change also decreased the Antarctic sea ice extent in 2014 and increased the strength and likelihood of high sea surface temperatures in both the Atlantic and Pacific Oceans. For western U.S. wildfires, no link to the individual events in 2014 could be detected, but the overall probability of western U.S. wildfires has increased due to human impacts on the climate.

Challenges that attribution assessments face include the often limited observational record and inability of models to reproduce some extreme events well. In general, when attribution assessments fail to find anthropogenic signals this alone does not prove anthropogenic climate change did not influence the event. The failure to find a human fingerprint could be due to insufficient data or poor models and not the absence of anthropogenic effects.

This year researchers also considered other human-caused drivers of extreme events beyond the usual radiative drivers. For example, flooding in the Canadian prairies was found to be more likely because of human land-use changes that affect drainage mechanisms. Similarly, the Jakarta floods may have been compounded by land-use change via urban development and associated land subsidence. These types of mechanical factors re-emphasize the various pathways beyond climate change by which human activity can increase regional risk of extreme events.

29. THE CONTRIBUTION OF ANTHROPOGENIC FORCING TO THE ADELAIDE AND MELBOURNE, AUSTRALIA, HEAT WAVES OF JANUARY 2014

MITCHELL T. BLACK, DAVID J. KAROLY, AND ANDREW D. KING

Anthropogenic climate change very likely increased the likelihood of prolonged heat waves like that experienced in Adelaide in January 2014 by at least 16%. The influence for Melbourne is less clear.

Introduction. Southeast Australia experienced one of the most significant heat waves on record in January 2014. A near-stationary high pressure system over the Tasman Sea directed very hot air from the interior of the continent to the southeast, where extreme temperatures persisted from 13 to 18 January. Records were broken for extended periods of heat at a number of locations (Australian Bureau of Meteorology 2014), including the major cities of Adelaide and Melbourne. Adelaide recorded five consecutive days above 42°C (13–17 January), while Melbourne recorded four consecutive days above 41°C (14–17 January). The heat wave became a leading news story worldwide when extreme conditions at the Australian Open Tennis Grand Slam in Melbourne resulted in professional tennis players hallucinating and collapsing on court.

This study investigates how the likelihood of prolonged periods of extreme heat, like those experienced in Adelaide and Melbourne in January 2014, has been changed due to human-induced climate change.

Data and Methods. We use very large ensembles of simulations with the Met Office HadAM3P global atmospheric circulation model (Pope et al. 2000; 1.25° longitude by 1.875° latitude, 19 levels) with a nested regional model (HadRM3P; 0.44° longitude by 0.44° latitude, 19 levels) over the Australasian Coordinated Regional Climate Downscaling Experiment (CORDEX1) domain. These simulations were undertaken as part of the weather@home distributed computing project (Massey et al. 2015). Using this framework, the

model was run under two distinct climate scenarios: industrial (“all forcings”) and non-industrial (“natural”) realizations of the year 2014. The “all forcings” simulations were driven by observed aerosols and greenhouse gas composition, as well as observed sea surface temperatures (SSTs) and sea ice from the Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) operational analysis (Donlon et al. 2012). The “natural” simulations were driven by preindustrial greenhouse gases and aerosols, sea ice extent corresponding to the year of maximum sea ice extent in each hemisphere of the OSTIA record, and SSTs modified to remove estimates of the warming attributable to historical anthropogenic greenhouse gasses. Estimates of the SST changes due to human influences were separately calculated using 10 available Coupled Model Intercomparison Project Phase 5 models (Taylor et al. 2012; see online supplemental material). Thus, 10 alternative ensembles of the “natural” climate were created. Given this experimental design, the change in likelihood of heat events is conditional upon the main modes of variability represented by the prescribed observed SSTs for 2014. To generate sufficiently large ensembles, the model was run using multiple initial conditions subject to random perturbations. We used all of the ensemble members that were available at the time of writing: 3417 for the “all forcing” scenario and 7998 for the “natural” scenario (constituting at least 780 members for each of the 10 “natural” ensembles).

To ensure that the model is able to reliably represent January daily maximum temperatures at Adelaide and Melbourne (taken as the nearest model land-only grid point values), evaluation was separately performed for each location. Because the model simulations only span the short period from December 2013 to November 2014, we cannot express the temperatures as anomalies relative to a climatological pe-

¹www.cordex.org

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riod. Instead, we compare the combined distribution of January daily maximum temperatures from the “natural” model scenario against the observed 1910–39 station temperatures from the high-quality Australian Climate Observations Reference Network–Surface Air Temperature (ACORN-SAT) dataset (Trewin 2013). The Australian surface temperatures do not show a discernable anthropogenic warming signal prior to 1950 (Karoly and Braganza 2005) and thus the early period of the instrumental records (1910–39) may be treated as a proxy for a “natural” climate baseline. Therefore, we correct for model bias by adjusting the mean of the “natural” daily maximum temperature distribution to equal that of the early observations; this bias adjustment is then applied to the “all forcing” distribution. Using this approach, modeled daily maximum temperatures for Adelaide were adjusted (cooled) by 0.97°C, while Melbourne values were cooled by 0.92°C. The resulting modeled and observed daily maximum temperature distributions are remarkably similar in shape and variance (Fig. 29.1a, b). There is a warm shift in the distributions between the “natural” and “all forcing” scenarios: +0.63°C for Adelaide and +0.54°C for Melbourne.

For this study we define heat waves to be n consecutive January days when the maximum tempera-

FIG. 29.1. (a) Distributions of January daily maximum temperatures for Adelaide as represented by the ACORN-SAT observational dataset (1910–39; shown in gray) and the climate model scenarios—“all forcing” ensemble (red) and “natural” climate ensemble (blue). The model distributions have been bias-corrected. The vertical dashed line identifies the observed temperature threshold used to define heat wave events. (b) January daily maximum temperatures for Melbourne. (c) Composite maximum temperature (shaded; °C) and mean sea level pressure (contour; hPa) for 29 Adelaide heat waves as represented by the climate model. (d) Composite conditions for 21 Melbourne heat waves as represented by the climate model. (e) Observed conditions during the Adelaide heat wave (13–17 Jan 2014). Maximum temperatures are from the Australian Water Availability Project (AWAP) dataset (Jones et al. 2009) while MSLP is from ERA-Interim reanalysis (Dee et al. 2011). (f) Observed conditions during the Melbourne heat wave (14–17 Jan 2014). The locations of Adelaide and Melbourne are identified by the black dots in (c) and (d), respectively.

ture exceeds a very high threshold. For Adelaide, this observed threshold is 42°C ($n = 5$ days), while for Melbourne the threshold is 41°C ($n = 4$ days). Heat waves are considered to be non-overlapping events—that is, six consecutive days in Adelaide above 42°C would be counted as a single heat wave event. To test the sensitivity of the results to these temperature and duration thresholds, we also examined heat waves of shorter durations ($n = 1$ to $n = 3$ days) and reduced the

observed temperature thresholds to 40°C for Adelaide and 39°C for Melbourne (see online supplemental material).

To estimate the anthropogenic influence in a quantitative manner, we use the fraction of attributable risk (FAR; Allen 2003; Stott et al. 2004) in which the probability of heat waves occurring is compared in the “all forcing” and “natural” scenarios. Here, we aggregate the 10 “natural” ensembles in order to calculate a *best estimate* of FAR, while we consider each of the “natural” ensembles separately in order to better sample the possible range of FAR values and estimate uncertainties. This latter point was undertaken because there is a greater variation in FAR between the different “natural” ensembles (due to the different underlying SST patterns) than within the ensembles (due to the perturbed initial conditions). To assist with the interpretation of results, FAR values are also presented as *estimated increase in likelihood*.

Results. Within the 3417 simulations comprising the “all forcing” ensemble, we identified 29 heat waves at Adelaide with five or more consecutive days above 42°C (return period of 118 years), and 21 heat waves at Melbourne with four or more consecutive days above 41°C (return period of 163 years). Composite mean sea level pressure (MSLP) and maximum temperature conditions for these modeled heat waves are shown in Figs. 29.1c, d, while conditions for actual case events are shown in Figs. 29.1e, f. The model is seen to be capable of representing the large-scale pressure patterns associated with prolonged heat waves in southeast Australia, adding confidence to the resulting attribution statement.

Next, we compare the frequencies of heat waves in the “all forcing” and “natural” climate ensembles to assess the impact of human influence (see Fig. 29.2; a complete listing of heat wave frequencies is provided as online supplemental material). For heat waves at Adelaide with five consecutive days above 42°C, the best estimate of FAR is 0.65 (with a range of 0.14 to 0.85). This corresponds to a 186% increase in likelihood due to anthropogenic climate change (range from 16% to 567% increase in likelihood). For

heat waves at Melbourne with four consecutive days above 41°C, the best estimate of FAR is 0.47 (ranging from −0.42 to 1.0); within one of the “natural” ensembles the frequency of heat waves is greater than that for the “all forcing” ensemble, while in another “natural” ensemble the heat wave never occurred. This corresponds to a 89% increase in likelihood due to anthropogenic climate change (range from 30% decrease to >1000% increase in likelihood).

Finally, we examine the sensitivity of the FAR results by relaxing the temperature and duration thresholds used to define heat waves. Overall, the results remain relatively robust (see Fig. 29.2 and Supplementary Fig. S29.3). The “best estimates” of FAR maintain similar positive values when considering events of different durations and magnitudes. Across this sampled space, FAR values calculated for the individual “natural” ensembles were consistently positive for Adelaide heat events, while there remained some negative FAR values for Melbourne events. While we can expect some uncertainty in the FAR values for the warmer, longer heat wave events to be due to their low frequency within the modeled distribution, sample size alone cannot explain all of the uncertainty. For example, the single very hot days in Melbourne (Fig. 29.2) still show a large spread in FAR values despite the relatively higher frequency of

FIG. 29.2. Fraction of Attributable Risk (FAR) and corresponding increase in likelihood calculated for Adelaide (blue) and Melbourne (black) heat waves of different durations. The temperature threshold used to define heat waves was 42°C for Adelaide and 41°C for Melbourne.

such events under both the “natural” and “all forcings” climate scenarios. Therefore, the underlying SST patterns driving the “natural” simulations have an important influence on the resulting FAR values. The negative FAR values for Melbourne and the small FAR values for Adelaide are associated with the smaller estimates of anthropogenic SST increases (see online supplemental material).

Conclusions. This study quantifies the influence of anthropogenic climate change on the likelihood of heat waves like those experienced in Adelaide and Melbourne in January 2014. Using large ensembles of regional climate model simulations of “natural” and “all forcing” scenarios, we find that human influence has increased the likelihood of heat waves in Adelaide (best estimate 186% increase, range from 16% to 567%), while the signal for Melbourne is less clear (best estimate 89% increase, range from 30% decrease to >1000% increase). While the model used in this study is shown to be capable of correctly representing the conditions associated with heat waves in southeast Australia, the overall analysis would benefit from larger ensemble sizes. The results are sensitive to the underlying SST patterns driving the “natural” scenarios, which is not surprising given that we are considering single-model grid cells at locations close to the coastline. Therefore, the study would benefit from further consideration of uncertainties in “natural” SST patterns. This study is an important step towards a comprehensive understanding of the Adelaide and Melbourne heat waves of January 2014.

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REFERENCES

- Allen, M., 2003: Liability for climate change. *Nature*, **421**, 891–892.
- Australian Bureau of Meteorology, 2014: Special climate statement 48: One of southeast Australia’s most significant heatwaves. Bureau of Meteorology, 18 pp. [Available online at www.bom.gov.au/climate/current/statements/scs48.pdf.]
- Dee, D. P., and Coauthors, 2011: The ERA-Interim reanalysis: Configuration and performance of the data assimilation system. *Quart. J. Roy. Meteor. Soc.*, **137**, 553–597, doi:10.1002/gj.828.
- Donlon, C. J., M. Martin, J. Stark, J. Roberts-Jones, E. Fiedler, and W. Wimmer, 2012: The Operational Sea Surface Temperature and Sea Ice Analysis (OS-TIA) system. *Remote Sens. Environ.*, **116**, 140–158, doi:10.1016/j.rse.2010.10.017.
- Jones, D., W. Wang, and R. Fawcett, 2009: High-quality spatial climate data-sets for Australia. *Aust. Meteor. Oceanogr. J.*, **58**, 233–248.
- Karoly, D. J., and K. Braganza, 2005: Attribution of recent temperature changes in the Australian Region. *J. Climate*, **18**, 457–464.
- Massey, N., and Coauthors, 2015: weather@home—development and validation of a very large ensemble modelling system for probabilistic event attribution. *Quart. J. Roy. Meteor. Soc.*, **141**, 1528–1545, doi:10.1002/qj.2455.
- Pope, V. D., M. L. Gallani, P. R. Rowntree, and R. A. Stratton, 2000: The impact of new physical parametrizations in the Hadley Centre climate model: HadAM3. *Climate Dyn.*, **16**, 123–146.
- Stott, P. A., D. A. Stone, and M. R. Allen, 2004: Human contribution to the European heatwave of 2003. *Nature*, **432**, 610–614.
- Taylor, K. E., R. J. Stouffer, and G. A. Meehl, 2012: An overview of CMIP5 and the experiment design. *Bull. Amer. Meteor. Soc.*, **93**, 485–498, doi:10.1175/BAMS-D-11-00094.1.
- Trewin, B., 2013: A daily homogenized temperature data set for Australia. *Int. J. Climatol.*, **33**, 1510–1529, doi:10.1002/joc.3530.

Table 34.I. ANTHROPOGENIC INFLUENCE

ON EVENT STRENGTH †

	INCREASE	DECREASE	NOT FOUND OR UNCERTAIN
Heat	Australia (Ch. 31) Europe (Ch.13) S. Korea (Ch. 19)		Australia, Adelaide & Melbourne (Ch. 29) Australia, Brisbane (Ch.28)
Cold		Upper Midwest (Ch.3)	
Winter Storms and Snow			Eastern U.S. (Ch. 4) N. America (Ch. 6) N. Atlantic (Ch. 7)
Heavy Precipitation	Canada** (Ch. 5)		Jakarta**** (Ch. 26) United Kingdom*** (Ch. 10) New Zealand (Ch. 27)
Drought	E. Africa (Ch. 16) E. Africa* (Ch. 17) S. Levant (Ch. 14)		Middle East and S.W. Asia (Ch. 15) N.E. Asia (Ch. 21) Singapore (Ch. 25)
Tropical Cyclones			Gonzalo (Ch. 11) W. Pacific (Ch. 24)
Wildfires			California (Ch. 2)
Sea Surface Temperature	W. Tropical & N.E. Pacific (Ch. 20) N.W. Atlantic & N.E. Pacific (Ch. 13)		
Sea Level Pressure	S. Australia (Ch. 32)		
Sea Ice Extent			Antarctica (Ch. 33)

† Papers that did not investigate strength are not listed.

†† Papers that did not investigate likelihood are not listed.

* No influence on the likelihood of low rainfall, but human influences did result in higher temperatures and increased net incoming radiation at the surface over the region most affected by the drought.

** An increase in spring rainfall as well as extensive artificial pond drainage increased the risk of more frequent severe floods from the enhanced rainfall.

*** Evidence for human influence was found for greater risk of UK extreme rainfall during winter 2013/14 with time scales of 10 days

**** The study of Jakarta rainfall event of 2014 found a statistically significant increase in the probability of such rains over the last 115 years, though the study did not establish a cause.

	ON EVENT LIKELIHOOD ††			Total Number of Papers
	INCREASE	DECREASE	NOT FOUND OR UNCERTAIN	
Heat	Argentina (Ch. 9) Australia (Ch. 30, Ch. 31) Australia, Adelaide (Ch. 29) Australia, Brisbane (Ch. 28) Europe (Ch. 13) S. Korea (Ch. 19) China (Ch. 22)		Melbourne, Australia (Ch. 29)	7
Cold		Upper Midwest (Ch.3)		1
Winter Storms and Snow	Nepal (Ch. 18)		Eastern U.S. (Ch. 4) N. America (Ch. 6) N. Atlantic (Ch. 7)	4
Heavy Precipitation	Canada** (Ch. 5) New Zealand (Ch. 27)		Jakarta**** (Ch. 26) United Kingdom*** (Ch. 10) S. France (Ch. 12)	5
Drought	E. Africa (Ch. 16) S. Levant (Ch. 14)		Middle East and S.W. Asia (Ch. 15) E. Africa* (Ch. 17) N.E. Asia (Ch. 21) S. E. Brazil (Ch. 8) Singapore (Ch. 25)	7
Tropical Cyclones	Hawaii (Ch. 23)		Gonzalo (Ch. 11) W. Pacific (Ch. 24)	3
Wildfires	California (Ch. 2)			1
Sea Surface Temperature	W. Tropical & N.E. Pacific (Ch. 20) N.W. Atlantic & N.E. Pacific (Ch. 13)			2
Sea Level Pressure	S. Australia (Ch. 32)			1
Sea Ice Extent			Antarctica (Ch. 33)	1
TOTAL				32

† Papers that did not investigate strength are not listed.

†† Papers that did not investigate likelihood are not listed.

* No influence on the likelihood of low rainfall, but human influences did result in higher temperatures and increased net incoming radiation at the surface over the region most affected by the drought.

** An increase in spring rainfall as well as extensive artificial pond drainage increased the risk of more frequent severe floods from the enhanced rainfall.

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