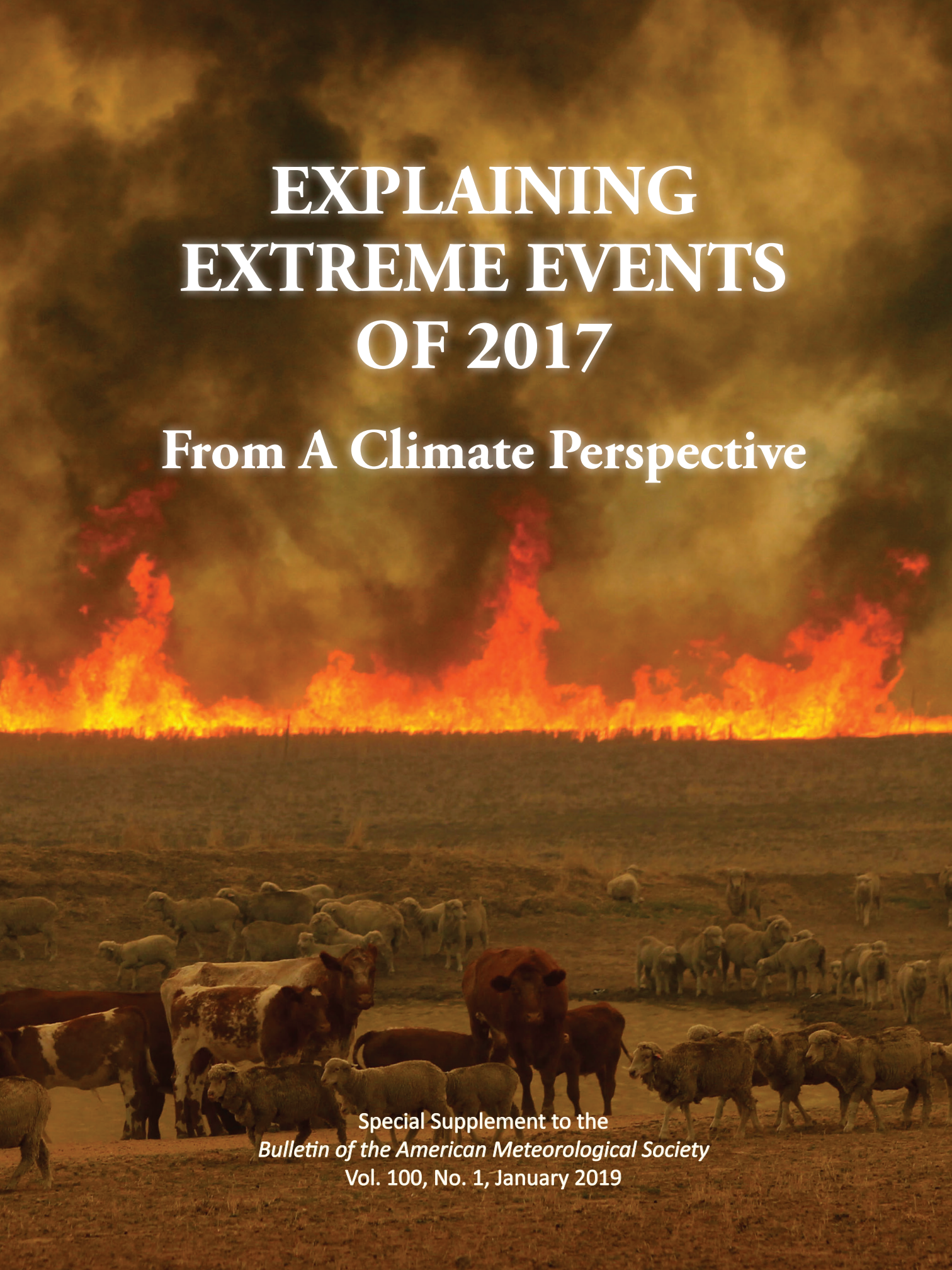

EXPLAINING EXTREME EVENTS OF 2017

From A Climate Perspective

Special Supplement to the
Bulletin of the American Meteorological Society
Vol. 100, No. 1, January 2019

EXPLAINING EXTREME EVENTS OF 2017 FROM A CLIMATE PERSPECTIVE

Editors

Stephanie C. Herring, Nikolaos Christidis, Andrew Hoell,
Martin P. Hoerling, and Peter A. Stott

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Bulletin of the American Meteorological Society

Vol. 100, No. 1, January 2019

American Meteorological Society

Corresponding Editor:

Stephanie C. Herring, PhD
NOAA National Centers for Environmental Information
325 Broadway, E/CC23, Rm 1B-131
Boulder, CO, 80305-3328
E-mail: stephanie.herring@noaa.gov

Cover Credit:

©Dean Sewell/Fairfax Syndication—Sir Ivan Bushfire, February 2017. A bushfire that started near Leadvill, east of Duneedoo in the New South Wales (NSW) Central tablelands, ripped through bush and grasslands in a day that NSW fire authorities classified as catastrophic. Sheep and cattle maneuver around a dam to avoid a fast running bushfire as the fire front moved east. Photograph by Dean Sewell/Oculi.

HOW TO CITE THIS DOCUMENT

Citing the complete report:

Herring, S. C., N. Christidis, A. Hoell, M. P. Hoerling, and P. A. Stott, Eds., 2019: Explaining Extreme Events of 2017 from a Climate Perspective. *Bull. Amer. Meteor. Soc.*, **100 (1)**, S1–S117, https://doi.org/10.1175/BAMS-ExplainingExtremeEvents2017.1.

Citing a section (example):

Hope, P., M. T. Black, E.-P. Lim, A. Dowdy, G. Wang, A. S. Pepler, and R. J. B. Fawcett, 2019: On determining the impact of increasing atmospheric CO_2 on the record fire weather in eastern Australia in February 2017 [in "Explaining Extremes of 2017 from a Climate Perspective"]. *Bull. Amer. Meteor. Soc.*, **100 (1)**, S111–S117, https://doi.org/10.1175/BAMS-D-18-0135.1.

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chapter 1

INTRODUCTION TO EXPLAINING EXTREME EVENTS OF 2017 FROM A CLIMATE PERSPECTIVE

Stephanie C. Herring, Nikolaos Christidis, Andrew Hoell, Marty Hoerling, and Peter A. Stott

This year's report includes climate change attribution assessments of seventeen different extreme events from around the world during 2017 (Table S1) and once again illustrates that both terrestrial and oceanic heat events are becoming more frequent and intense as a consequence of human-induced climate change. For example, climate change increased the odds at least threefold since 1950 of a heat wave like the one that impacted southern Europe (Kew et al. 2019). The November 2017/18 Tasman Sea marine heatwave was found to be virtually impossible without anthropogenic influence (Perkins-Kirkpatrick et al. 2019). Ocean heat events have wide-ranging impacts; for example, warm sea surface temperatures in the west Pacific Ocean, which were found to not be possible without human-caused climate change, doubled the probability of African drought, which contributed to food insecurity (Funk et al. 2008). These results continue to build the body of evidence that the oceans experience extreme heat events and the heat events in turn drive extreme events on land.

On land, analyses of drought events continues to illustrate the nuanced way in which climate change can impact the drivers of an extreme event. Two independent studies using different methodological approaches found that the 2017 U.S. northern Great Plains drought was made more intense due to long-term soil moisture decreases resulting from anthropogenically forced increases in evapotranspiration and temperature (Hoell et al. 2019; Wang et al. 2019). Those studies, however, found that climate change has not reduced the overall amount of precipitation during spring and summer over the northern Great Plains, normally the rainiest time of the year in that region.

In addition to the usual analyses of specific events found in this report, the editors also wanted to further explore the relevance of climate change attribution science to decision support. This year, several Perspective pieces illustrate how attribution results are relevant across a broad range of sectors that incorporate information on extreme events. This ranges from those looking to the future to address changing risk exposure, as well as looking towards the past to understand what caused an event and, potentially, to determine who was responsible for it.

In the articles *Actuaries are Paying Attention to Climate Data* (Owen 2019) and *Hydroclimatic Extremes as Challenges for the Water Management Community: Lessons from Oroville Dam and Hurricane Harvey* (Vano et al. 2019), the authors explore how attribution results are relevant in a risk management context. In Owen's article, written from her experience as both a professional actuary and researcher with the Society of Actuaries, Owen notes that "the actuarial profession is responding strongly to the challenges presented with climate change." She points to the Actuaries Climate Index (http://actuariesclimateindex.org/home/), which was the result of the combined effort of the four major actuarial organizations in North America. As the impacts of climate change continue to have financial consequences, actuaries are increasingly asking "What does the future look like for the financial risks associated with climate change?" An interesting point from Owen's article is her observation that for those actuarial decisions that have consequences over long time periods even "small deviations from estimations of future costs have considerable financial consequences." Thus, when considering the impacts of climate change on extremes understanding how that risk might change in the future can significantly impact predicted risk exposure.

Vano and coauthors are members of the AMS Water Resources Committee and author backgrounds

AFFILIATIONS: Herring—NOAA/National Centers for Environmental Information, Boulder, Colorado; Hoell and Hoerling—NOAA/Earth System Research Laboratory, Physical Sciences Division, Boulder, Colorado; Christidis and Stott—Met Office Hadley Centre, Exeter, United Kingdom, and University of Exeter, Exeter, United Kingdom
CORRESPONDING AUTHOR: Stephanie Herring, stephanie.herring@noaa.gov

DOI:10.1175/BAMS-D-18-0307.1

	ANTHROPOGENIC INFLUENCE ON EVENT			METHOD USED	
	INCREASE	DECREASE	NOT FOUND or UNCERTAIN		Total Events
Heat	Ch11: Southern Europe Ch 18: China Ch 19: China			Ch 11: weather@ home, EC-Earth, HadGEM-3A, and EURO-CORDEX Ch 18: HadGEM3-GA6-N216 Ch 19: CMIP5	**3**
Heat & Dryness	Ch 17: China			Ch 17: CMIP5	**1**
Marine Heat	Ch 20: Tasman Sea Ch 12: East Africa			Ch 20: CESM1, CMIP5 Ch 12: CESM1, CMIP5	**2**
Heavy Precipitation	Ch 8: Peru Ch 9: Uruguay Ch 10: Western Europe Ch 13: Bangladesh Ch 16: China			Ch 8: HadGEM3-A Ch 9: HadGEM3-A Ch 10: EC-Earth3 in forecast mode Ch 13: weather@ home HadRM3P RCM nested in the global atmosphere-only HadAM3P Ch 16: CanESM2	**5**
Drought	Ch 6: U.S. Northern Plains Ch 7: U.S. Northern Plains Ch 12: East Africa			Ch 6: CESM Ch 7: AMIP GEOS-5 Ch 12: CESM 1, CMIP5	**3**
Fire Season	Ch 15: South Korea		Ch 21: Australia	Ch 21: McArthur Forest Fire Danger Index (FFDI) and seasonal forecast model, POAMA2	**1**
Seasonal Changes				Ch 15: weather@home East Asia project, CMIP5	**1**
Poor Sunshine	Ch 14: Japan			Ch 14: MIROC5, CMIP5	**1**
Total Events	16		1		**17**

Acronyms:

AMIP: Atmospheric Model Intercomparison Project
CAM: Community Atmosphere Model
CanESM: Canadian Earth System Model
CESM: Community Earth System Model, www.cesm.ucar.edu/
CMIP: Coupled Model Intercomparison Project
EURO-CORDEX: Coordinated Downscaling Experiment—European Domain
GEOS: Goddard Earth Observing System Model
HadAM: Hadley Center Atmospheric General Circulation Model
HadGEM: Hadley Centre Global Environmental Model
MIROC: Model for Interdisciplinary Research on Climate
POAMA: Predictive Ocean Atmosphere Model for Australia
Weather@Home: www.climateprediction.net/weatherathome/

include government and academic researchers and consulting and municipal engineers. They used case studies of the Oroville Dam and New Don Pedro incidents and flooding from Hurricane Harvey to explore concerns and questions water managers confronted, and then "list some lessons those experiences offered about framing attribution studies to serve management needs." One lesson they identified as important is to more clearly address the duration characteristics of precipitation events. For example, most attribution papers tend to deal with the amount of rain that has fallen over a particular period, and less frequently explore whether the duration of rain events is changing. Vano and colleagues are encouraging the attribution community to explore this duration question because of the relevance to water resource managers.

Also, Marjanac et al. (2018) assess the role attribution science could play in a range of legal challenges that could be classed as 'climate change litigation'. They conclude that attribution scientists need to communicate probabilistic findings in a way that is accessible for decision-makers who work to differing standards of proof. They also highlight a need for the insurance industry to take account of changing climate when drawing up their catastrophe models for commercial use.

LOOKING AHEAD. This annual special edition of the *Bulletin of the American Meteorological Society* is now in its seventh year, and over this time has seen explosive growth in the field of event attribution. In the first year the editors managed to recruit six papers, which at the time seemed like an extraordinary success (Peterson et al. 2012). All the papers either dealt with temperature or precipitation, or the combination of the two factors in impacting drought. Today, the report is being published in a new landscape of attribution research that involves a much broader range of scientists, methodologies, and event types. In addition, numerous attribution papers are now being published much closer to the occurrence of the event itself, especially for high-impact events such as Hurricane Harvey (Emanuel 2017; van Oldenborgh et al. 2017; Risser and Wehner 2017). Increasingly attribution research is being done using initialized forecast systems, and there is a move toward real-time release of attribution results (www.nature.com/articles/d41586-018-05849-9). This leads to the question of the role this report has within the attribution community going forward.

The original motivation of this report was twofold. One goal was to support the attribution research community by providing a place to look across event types and methodological approaches and explore what works, and where improvements can be made. It was always meant as a tool to advance the science and increase its relevancy, with a mission larger than the examination of any single event. The second driver was to improve communication and understanding of attribution results not only to the public, but to other sectors that will hopefully integrate attribution results into their decision making. This communication driver was the motivation behind making these reports 1,500 words and "readable" to an external audience. These two original reasons remain the primary focus of this report, and in next year's report we will continue to look for papers on individual events while using this platform to advance the overall research. For example, we will continue to include Perspective pieces that provide the attribution community with feedback from other sectors to help shape and drive research relevancy. In addition, the editors will be looking to synthesize research from across events and methodological approaches to assess broader human-caused changes in the earth system that drive extreme events. At the same time, the outreach and communication effort will continue as we work to not only expand the scope of who and how attribution research is utilized, but also promote informed discourse around how human-caused climate change is impacting extreme events. The editors welcome comments and feedback from both readers and contributors on how this report can continue to advance the science and adaptation response to climate change impacts on extremes. We look forward to embarking on this in partnership with the attribution community, and with those who use the results of attribution research.

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