EXPLAINING EXTREME EVENTS OF 2014

From A Climate Perspective

Special Supplement to the
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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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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

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FRONT: ©iStockphotos.com/coleong—Winter snow, Boston, Massachusetts, United States.

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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EDITORIAL AND PRODUCTION TEAM

Riddle, Deborah B., Lead Graphics Production, NOAA/NESDIS National Centers for Environmental Information, Asheville, NC

Love-Brotak, S. Elizabeth, Graphics Support, NOAA/NESDIS National Centers for Environmental Information, Asheville, NC

Veasey, Sara W., Visual Communications Team Lead, NOAA/NESDIS National Centers for Environmental Information, Asheville, NC

Griffin, Jessicca, Graphics Support, Cooperative Institute for Climate and Satellites-NC, North Carolina State University, Asheville, NC

Maycock, Tom, Editorial Support, Cooperative Institute for Climate and Satellites-NC, North Carolina State University, Asheville, NC

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Young, Teresa, Graphics Support, STG, Inc., NOAA/NESDIS National Centers for Environmental Information, Asheville, NC

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

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.

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I. INTRODUCTION TO EXPLAINING EXTREME EVENTS OF 2014 FROM A CLIMATE PERSPECTIVE

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

The field of event attribution faces challenging questions. Can climate change influences on single events be reliably determined given that observations of extremes are limited and implications of model biases for establishing the causes of those events are poorly understood? The scientific developments in this report—now in its fourth year—as well as in the broader scientific literature, suggest that "event attribution" that detects the effects of long-term change on extreme events is possible. However, because of the fundamentally mixed nature of anthropogenic and natural climate variability, as well as technical challenges and methodological uncertainties, results are necessarily probabilistic and not deterministic.

As the science advances, other questions are emerging. For what types of events can event attribution provide scientifically robust explanations of causes? Is near-real-time attribution possible? And, how useful are science-based explanations of extremes for society? We consider these questions in more detail.

The Science. When launched in 2012, an original aim of this report was to encourage the development of the science of event attribution. In this endeavor, we continue to be encouraged by the response from the climate community. The report has grown again and this year includes 32 papers looking at 28 different events from all seven continents (Fig. 1.1).

The exact analysis that goes into each of the attribution statements in this report is dependent on the event in question and the available data and models. Take for example the attribution statement, "High global water vapor content of the atmosphere likely caused the very heavy Pyrenees rainfall event in September." In this case, the science must address the physical processes relating water vapor to heavy precipitation over the Pyrenees in September. Additional extreme event features are also important to explain, including event magnitude and likelihood, against which societal resilience, vulnerability, and preparedness are judged. Magnitude and likelihood are not mutually exclusive characteristics of extremes, though explanations for how long-term change affected one feature can differ from how it affected others (e.g., Dole et al. 2012; Otto et al. 2012).

The sophistication of the contributions continues to develop. For instance, the resources provided by the Weather@home group, which generates regional modeling experiments, have been increasingly employed to study how climate change affects regional-scale weather (e.g., Rosier et al. 2015; Black et al. 2015). The strengths and limitations of Weather@home and other methods are increasingly being scrutinized. With rapid turn-around and space constraints, the possibilities for exhaustive analysis in this report are more limited than in the general literature; the studies here generally rely on well-developed and vetted methodologies.

In addition to an increasing number of submissions, we are also seeing new types of events being examined. In general, temperature and precipitation extremes have dominated event attribution literature since this field emerged in the early 2000s. Confidence in the role of human-caused climate change in temperature extremes remains the highest due to the detectability of a climate change signal. Event types represented for the first time in this year's report include forest fires, tropical cyclones, sea surface temperature, and sea level pressure anomalies. This report is not a random selection of extreme events from the past year, so it does not facilitate broad claims about trends for any extreme event type.

Another significant challenge is near-real-time event attribution. One reason this is important is that extreme events often elicit immediate public policy responses, such as building code modifications (Peterson et al. 2008). In these cases, near-real-time attribution can help science inform discussion about

AFFILIATIONS: Herring—NOAA/National Centers for Environmental Information, Boulder, Colorado; Hoerling—NOAA/Earth System Research Laboratory, Boulder, Colorado; Kossin—NOAA/National Centers for Environmental Information, Madison, Wisconsin; Peterson—NOAA/National Centers for Environmental Information, Asheville, North Carolina; Stott—Met Office Hadley Centre, Exeter, United Kingdom

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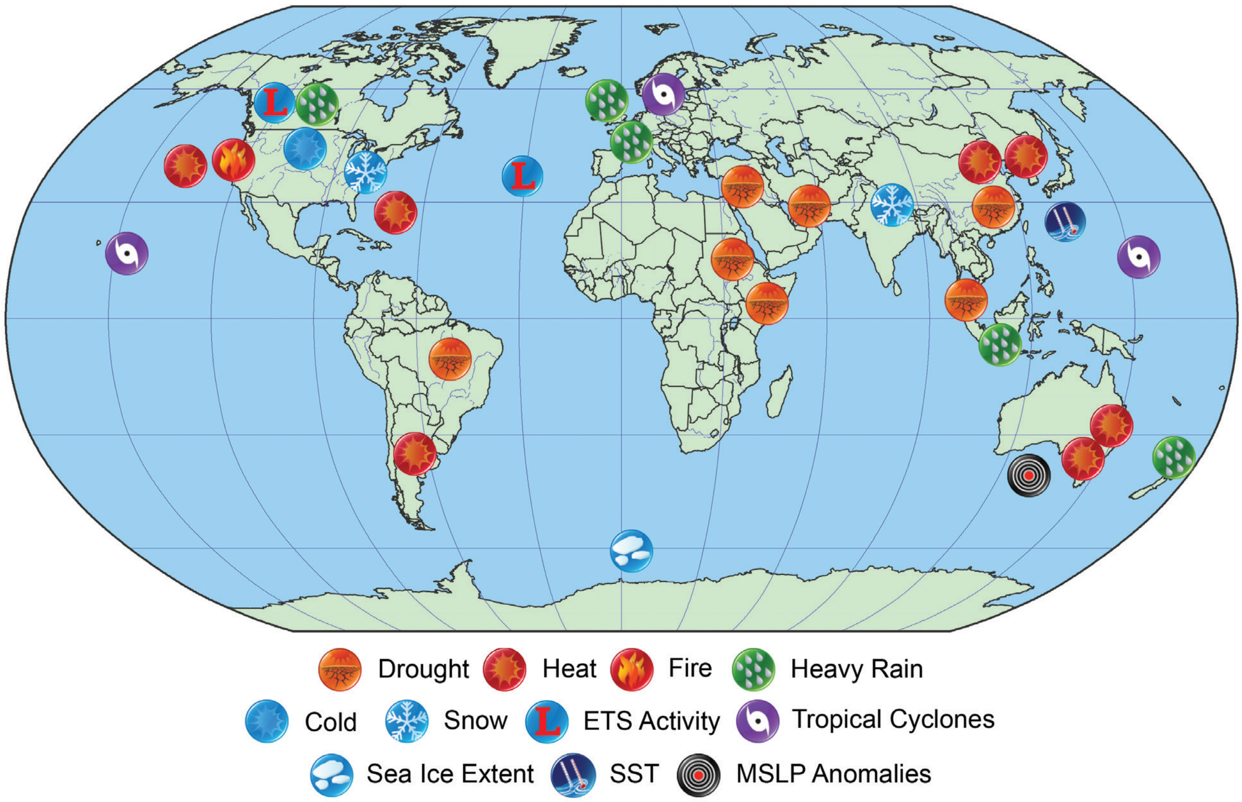

Fig. 1.1. Location and types of events analyzed in this publication.

about policy. Major efforts in real-time event attribution include the World Weather Attribution (WWA; www.climatecentral.org/what-we-do/our-programs/climate-science#wwa) project based in the United States and led by Climate Central as well as the European Climate and Weather Events: Interpretation and Attribution (EUCLEIA; www.eucleia.eu) project based in Europe and led by the UK Met Office.

The Stakeholders. Both the EUCLEIA and WWA initiatives reflect a growing interest in connecting attribution science to decision making. In a European context, stakeholders involved in decision making that could be affected by climate variability and change have shown a strong interest in the science of event attribution (Stott and Walton 2013). There is also some literature emerging that illustrates how attribution work is being applied by stakeholders, including a case study using the hot and dry summer of 2012 in southeast Europe (Sippel et al. 2015). However, interest from a wide variety of sectors including policy making, litigation, regional planning, and public communication does not mean that the requirements from the different groups are the same, and tailored approaches to communication between scientists and stakeholders are likely to be required (Stott and Walton 2013). We are looking forward to the results of efforts such as WWA and EUCLEIA over the next several years.

In the absence of robust literature exploring decision-maker needs for event attribution information, we have taken an anecdotal look at how the science in these reports could be relevant beyond the research community. From our initial look, it is clear that event attribution is more than just a tool to communicate the impacts of the changing climate to the public. Some decision makers do value knowing how specific events were impacted by the changing climate and what this means for their future (e.g., Hoerling et al. 2013). The science of event attribution can thus be viewed as critical progress toward building a "situational awareness" that supports informed decision making. From the science perspective, this involves providing information about global environmental elements and explaining their connections to regional conditions. From a stakeholder perspective, a robust and reliable situational awareness informs risk reduction. The science is evolving, but the vision is to provide users with an improved understanding of how changes in extremes can be relevant and applied to improved decision making.

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Certain sectors appear to have a greater interest in event attribution than others do. For example, we asked several contacts in the reinsurance sector about how they might use event attribution. While the attribution of changing trends in extreme events was relevant to their business and bottom line, our contacts all indicated they do not currently find great value in the attribution of specific events. This is primarily because relatively short time scales are of greatest relevance to them, and these tend to be dominated by year-to-year variability and persistence rather than climate change on longer time scales.

In contrast, discussions with participants of the National Integrated Drought Information Service (NIDIS; www.drought.gov) revealed that water resource managers and others dealing with drought in the U.S. West find event attribution work useful. The attribution work helps show why long-term planning should account for changing climate. Also, since all droughts are different, decision makers are interested in what ingredients went into any particular drought, how it evolved, and whether it could have been predicted. This is especially beneficial for improving early warning for drought. Attribution science provides situational awareness of our weather and climate system, which can lead to informed planning decisions. Decision makers have also shown interest in attribution for floods. For example, NOAA was asked by the U.S. Army Corps of Engineers to do an in-depth assessment of the 2011 Missouri River Basin flood to inform their planning (Hoerling et al. 2013).

Stakeholder perspectives will undoubtedly vary around the world depending on the specific local contexts in which event attribution science is applied. The extent to which hazardous weather and climate extremes affect people depends on their exposure and vulnerability as well as the meteorology (e.g., Peduzzi et al. 2012). Therefore, much more work needs to be done on attribution of the impacts of extreme events (Stott 2015). A continuing ambition for this report is to increase the geographical coverage of regions examined and geographical representation of authors contributing their regional expertise as we'd like this report to serve stakeholders throughout the world.

Conclusions. As attribution science continues to mature, effectively communicating the results becomes increasingly important. So this year, authors have been asked to try and clearly state whether climate change influenced the event's intensity, frequency, or both. These distinctions are important because changes in intensity versus frequency have very different implications for communities, businesses, and governments trying to adapt to the impacts of a changing climate.

Looking to the future, it will be important to continue to assess whether and how effectively decision makers apply attribution science. Expectations about what will have value needs to be developed by the user community in collaboration with scientists. Close interactions between attribution scientists and the user community will be essential to fully exploit the value of this research to society.

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Table 34.1. 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.

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	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.

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