Stanford WOODS INSTITUTE for the ENVIRONMENT

Research Brief

FALL 2017

Global Warming's Influence on Extreme Weather Events

Introduction

As extreme weather events have increased in frequency in many regions around the world, so too have efforts in the scientific community to quantify the impact of global warming on individual events. The ability to determine the extent to which global warming is influencing the severity and probability of these events will allow public and private sector decision-makers to more effectively manage climate-related risks, including resilient infrastructure, sustainable supply chains, and secure communities.

About the Researchers

This research was led by **Noah Diffenbaugh**, a Professor in Stanford University's School of Earth, Energy & Environmental Sciences and Senior Fellow at the Stanford Woods Institute for the Environment; in partnership with **Deepti Singh**, a former Stanford Earth System Science graduate student; former members of Diffenbaugh's research group **Justin Mankin**, **Daniel Horton**, **Daniel Swain**; and Assistant Professor of Statistics and Earth System Sciences at Stanford University and affiliate of the Stanford Woods Institute for the Environment **Bala Rajaratnam**.

This brief is based on new research from Stanford University that provides a framework for understanding the influence of global warming on four types of extreme climate events:

- 1) The hottest month
- 2) The hottest day
- 3) The driest year
- 4) The wettest 5-day period

Extreme Event Attribution Framework

This new study developed a four-step framework that combines observational data and climate model analysis. The four attribution metrics were evaluated at points all over the world where sufficient data were available. The data availability varies depending on the extreme climate metric, but generally includes information from all six inhabited continents, with North America, Europe and East Asia having the most consistent coverage.

The study found that human-caused global warming has already increased the severity and probability of the hottest monthly and daily temperatures at more than

80 percent of the observed area, with areas in the tropics experiencing the strongest effects. In addition, the study found that global warming has increased the probability of the driest and wettest events at approximately half of the observed area. Tropical North and South America, tropical and southern Africa, and Southeast and East Asia showed the strongest increase for extreme dry years.

Points for Policy-makers

The new study increases the degree of certainty with which extremely hot, wet, and dry weather events can be attributed to human-caused climate change. This type of information has important implications for policy decisions on such issues as public health and security, infrastructure replacement and siting, emergency management and preparedness, and a host of other national-, state- and community-level planning issues. Of particular note for policy-makers are the following considerations:

- **This new framework can be applied to other extreme events.** The researchers demonstrated that their framework is effective for examining other climate extremes beyond temperature and precipitation, such as sea ice, snowpack, high winds and storm surges.

In addition to precipitation and temperature, the researchers also analyzed other types of extreme climate events, such as the record-low Arctic sea ice levels seen in September 2012. The framework demonstrates that global warming influenced both the severity and probability of the record-low sea ice.

- **The framework could be used to predict the probability of extreme events at different levels of global warming.** The framework could be used to quantify the probability of unprecedented events at higher levels of forcing (should greenhouse gas emissions continue to rise), or at lower levels of forcing (should the UN Paris targets be met), to demonstrate the cost- and life-saving benefits of reducing the greenhouse gases causing increases in the frequency and severity of these extreme weather events.
- **The framework can assist policy-makers in developing risk management systems by providing calculations of probability and severity of extreme weather events at various levels of global warming.** This information can help in planning for events that might otherwise be discounted as worst-

The framework can also assess atmospheric pressure patterns and atmospheric water vapor, which can be viewed as two of the key "ingredients" in the recipe for an extreme weather event. When applied to the 2010 Russian heat wave, the framework shows that global warming contributed substantially to the occurrence of the dominant atmospheric pressure pattern, which was one of the key factors that caused the heat wave.

case scenario by demonstrating how likely they are to occur. For instance, planners can use this information in infrastructure design, resource management practices, and disaster risk management systems. Likewise, the successful implementation of programs such as the National Flood Insurance Program, which is up for reauthorization in September 2017, depend in part upon the availability of accurate data.

- **The framework can also be used in determining an appropriate social cost of carbon.** To determine the feasibility and recommended price of a carbon tax, policy-makers must be aware of the degree to which the global warming that has already happened has contributed to costly disasters, and how the reduction of greenhouse gas emissions—and thus global warming—could reduce catastrophic losses by avoiding future disasters.

Conclusions

The framework developed in the study effectively demonstrates that human-caused climate change has already increased the probability and severity of extreme weather events. This framework can be an important tool in creating adaptation and mitigation strategies to prepare for catastrophic events in both the current and future climate. For decision-makers who must craft policies for an uncertain future, being able to accurately assess the likelihood—and uncertainty—of extreme weather events will have life- and cost-saving benefits.

This brief is based on findings from the paper "Quantifying the influence of global warming on unprecedented extreme climate events" published by Noah Diffenbaugh in Proceedings of the National Academy of Sciences in May 2017.