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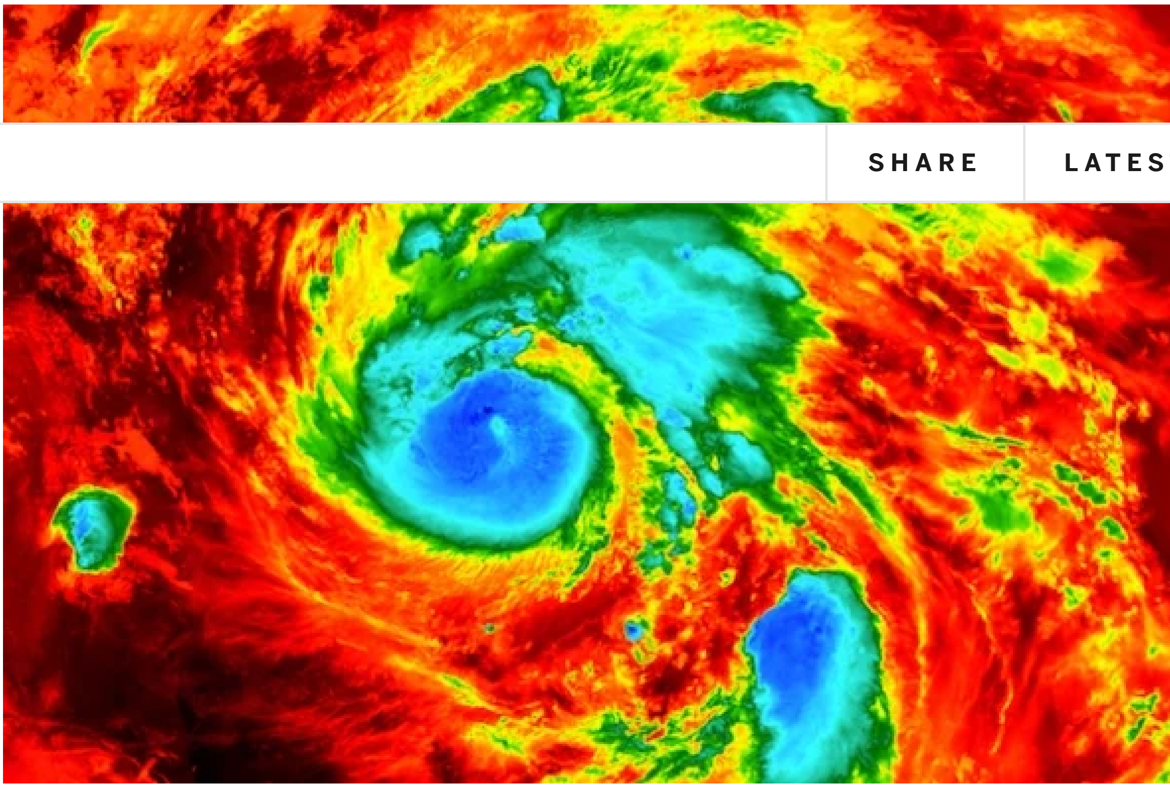
Observations

What We Know about the Climate Change–Hurricane Connection

Some links are indisputable; others are more subtle, but the science is improving all the time

By Michael E. Mann, Thomas C. Peterson, Susan Joy Hassol on September 8, 2017



Hurricane Harvey on August 25, 2017, as seen by the European Space Agency's Copernicus Sentinel-3A weather satellite. *Credit: ESA (CC BY-SA 3.0 IGO)*

With Texas just beginning to recover from the devastation wrought by Hurricane Harvey and the Southeastern U.S. preparing for Hurricane Irma's iminent arrival, people are naturally asking the question: What role might human-caused climate change be playing in all of this?

Scientists have been more than willing to weigh in on this question, but often with different perspectives on the data they should draw from, which has at times led to more confusion than edification. Part of the problem is that there are at least two fundamentally different ways of addressing this problem, and they reflect a different philosophical approach.

The first approach is to account for the simple physical processes at work and what role they may be playing. There are certain indisputable linkages that we can talk about immediately because they have already been vetted in general rather than for any specific storm.

For example, even if we could say nothing else, we can conclude that sea level rise has contributed to the coastal flooding associated with recent major hurricanes: nearly a foot at Battery Park in New York City in the case of 2012 Superstorm Sandy and roughly half a foot in the case of Hurricane Harvey. The seemingly modest 1 foot of sea level rise off the New York City and New Jersey coast made a Sandy-like storm surge of 14 feet far more likely, and led to 25 additional square miles of flooding and several billion extra dollars of damage.

What about the increasing strength of these storms? Here, too, the science is fairly conclusive.

Whether or not we see more tropical storms (a matter of continuing research by the scientific community), we know that the strongest storms are getting stronger, with roughly eight meters per second increase in wind speed per degree Celsius of warming. And so it is not likely to be a coincidence that almost all of the strongest hurricanes on record (as measured by sustained wind speeds) for the globe, the Northern Hemisphere, the Southern Hemisphere, the Pacific, and now, with Irma, in the open Atlantic, have occurred over the past two years. A stronger storm means not only more damaging winds, but a bigger storm surge as well, adding to the coastal flooding impact of sea level rise.

fundamental rule of atmospheric thermodynamics known as the Clausius-Clapeyron equation indicates an increase of roughly 7 percent more moisture in the air for each degree Celsius of increase in sea surface temperature (SST). Global SSTs have risen now the better part of a degree C and conditions in which SSTs are several degrees C above normal are now more common as a result. Unusually warm SSTs contributed to the flooding power of both Hurricane Harvey and Hurricane Irene in 2011.

Other connections are more subtle. Part of what yielded the record flooding associated with Harvey and Irene was the slow-moving nature of the storms, which allowed for persistent rainfall over eastern Texas and New England respectively. The slow movement of these storms was favored by an expanded sub-tropical region of high pressure over the southern U.S. and a far northward-shifted jet stream, something that climate model simulations predict as a result of human-caused climate change. There is also some tentative evidence that the warming of the Arctic may favor the stalling of mid-latitude weather systems, though this is at the cutting edge of the science and still being studied.

The second approach to understanding the linkage between human activity and extreme weather involves a sort of climatological "CSI"—running simulations of a

to those increases. As recently as a decade ago, climate scientists had a motto that "you can't attribute any single extreme event to global warming."

By the time politicians and journalists started repeating that line, however, the science had moved on, so that we now *can* attribute individual events in a probabilistic sense. For example, if a baseball player on steroids is hitting 20 percent more home runs, we can't attribute a particular home run to steroids. But we can say steroids made it 20 percent more likely to have occurred. For some of the physical processes discussed here, one can view increasing carbon dioxide in the atmosphere as steroids for the storms.

Scientists now routinely assess how global warming has affected extreme events. While these studies use a variety of approaches, they all consider two worlds: one, our current world with human-caused increases in greenhouse gases and resulting warming, and another world without current levels of greenhouse-gas-induced warming. Most use complex computer models, but some simply compare conditions today to those experienced years ago, when greenhouse gas levels were lower. Some assess changes in probabilities and others assess changes in strength, which can at times make comparisons of the results difficult. Another drawback is that rigorous scientific assessment of global warming's impact on a specific event takes months to determine—although some research groups are trying to address this drawback.

These approaches are not incompatible or mutually exclusive—indeed they are complementary from a philosophical standpoint. Reasoning from simple physics may miss some subtle complications and "feedbacks." For example, while the Clausius-Clapeyron equation suggests about 7 percent more moisture in the air for each degree Celsius of increase in SST, this misses some other possible amplifying factors. More moisture in the storm means more latent heating, a potentially stronger storm, with more convection and stronger updrafts, resulting in even more rainfall.

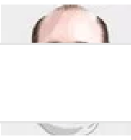
Meanwhile, attribution approaches rely upon climate models' ability to resolve all of the physical processes that may link climate change and extreme weather events, some of which are potentially quite subtle and which may not be fully captured in current generation models (e.g., the physics linking changing behavior

the failure to "attribute" a particular event to the impact of climate change—may simply reflect the insufficiency of the approach rather than the lack of an actual physical connection.

We need to use all of the tools in the toolbox to address these scientific questions. It would be imprudent, however, to conclude that we must wait for the results of formal detection and attribution studies before we can say anything about the effects of climate change on hurricanes as they are happening. There is much that we know based on physics, and we should state those things clearly and immediately, as they can provide insights that can help guide people as they begin to recover and plan for the future.

The views expressed are those of the author(s) and are not necessarily those of Scientific American.

ABOUT THE AUTHOR(S)



Michael E. Mann

University. His most recent book, with Tom Toles, is *The Madhouse Effect: How Climate Change Denial Is Threatening Our Planet, Destroying Our Politics, and Driving Us Crazy* (Columbia University Press, 2016).

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Thomas C. Peterson is President of the Commission for Climatology of the World Meteorological Organization. He was formerly Principal Scientist at NOAA's National Climatic Data Center and National Centers for Environmental Information, and was the lead editor of the first annual report on extreme event attribution published in the Bulletin of the American Meteorological Society.

Susan Joy Hassol

Susan Joy Hassol is director of the nonprofit Climate Communication LLC. She recently co-authored "(Un)Natural Disasters: Communicating Linkages between Extreme Events and Climate Change," in the World Meteorological Organization's *Bulletin*.

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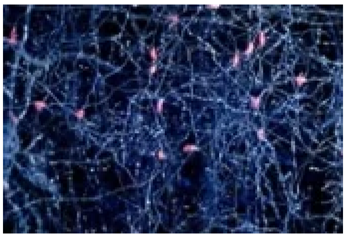

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