Record warm years almost certainly due to human-made climate change, new study says

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Record-setting temperatures over the past century and a half are extremely unlikely to have occurred without human-caused climate change, but the odds of that happening are not quite as low as previously reported, according to an international team of meteorologists.

"The press reports last year about the unlikely nature of recent global temperature records raised some very interesting questions, but the scientists quoted hadn't done a rigorous calculation," said Michael Mann, distinguished professor of meteorology and director, Earth System Science Center, Penn State. "As a result, the probabilities reported for observing the recent runs of record temperature by chance alone were far lower than what we suspected the true probabilities are. "

Although the new odds of chance producing recent runs of record temperatures are greater than the odds previously reported in the news—between 1 in 27 million and 1 in 650 million—they are still incredibly slim at between 1 in 5 thousand and 1 in 170 thousand. Including the data for 2015, which came in after the study was completed, makes the odds even slimmer.

The reason for the inaccuracy of the previous probability calculations is that the individual yearly temperatures analyzed are not independent of each other.

"Natural climate variability causes temperatures to wax and wane over a period of several years, rather than varying erratically from one year to

the next," said Mann.

In calculating the odds, the previous reports did not take into account that the data did not end simply because December 31 occurred, but that trends overlap into previous and subsequent years. This needs to be taken into account to determine the real probabilities of chance causing the warming events.

"We provided a method for doing this based on combining information from state-of-the-art climate model simulations with the observational temperature record, and we used this method to estimate the probabilities correctly," said Mann.

Using a combination of observations and climate model simulations, the researchers examined temperatures from both the Northern Hemisphere and the entire globe for specific groups of years. They examined scenarios for record warm years of 1998, 2005, 2010 and 2014; for nine of the 10 warmest years occurring since 2000; and for 13 of the warmest 15 years occurring since 2000. They chose the last two scenarios because these are the ones previously reported in news accounts.

The reason that Mann's team found the probability of naturally occurring global warming more likely than previously reported in the news, is that the effective size of their statistical sample was considerably smaller than estimates based simply on the number of years available. This "serial correlation" means that the chance likelihood of runs of warm temperature—nine very warm years over the course of a decade—is much greater than if temperatures were uncorrelated from one year to the next.

The researchers tried a variety of different data sources and statistical approaches and found that in all cases, the odds of the patterns of warming occurring with no human intervention were similarly low.

The researchers note in today's (Jan. XX) issue of Nature *Scientific Reports*, that "while considerably greater than cited in some recent media reports, these odds are low enough to suggest that recent observed runs of record temperatures are extremely unlikely to have occurred in the absence of human-caused global warming.

"2015 is again the warmest year on record, which adds even more weight to our findings," said Stefan Rahmstorf, professor of physics of the oceans, Potsdam University, Germany. "What is more, the anomalous warmth has led to unprecedented local heat waves across the world—sadly resulting in loss of life and aggravating droughts and wildfires. The risk of heat extremes has been multiplied due to human greenhouse-gas emissions, as our data analysis shows."

By contrast, they found that the odds that human activity caused the warming are relatively high. Considering human-caused warming, they find the probabilities of nine of the 10 warmest years and 13 of the warmest 15 years occurring since the beginning of the 21st century, to be 88 percent and 83 percent, respectively, for the Northern Hemisphere.

"It just seemed like it was important to do this right, and address, in a defensible way, the interesting and worthwhile question of how unlikely it is that the recent run of record temperatures might have arisen by chance alone," said Mann.

The recent record temperature years are roughly 600 to 130,000 times more likely to have occurred under human-caused conditions than in their absence, according to the researchers. These findings underscore the impact that human forcing has already had on temperature extremes.

More information: Mann, M.E., Rahmstorf, S., Steinman, B.A., Tingley, M., Miller, S.K. (2016): The Likelihood of Recent Record Warmth. *Scientific Reports*, DOI: 10.1038/srep19831