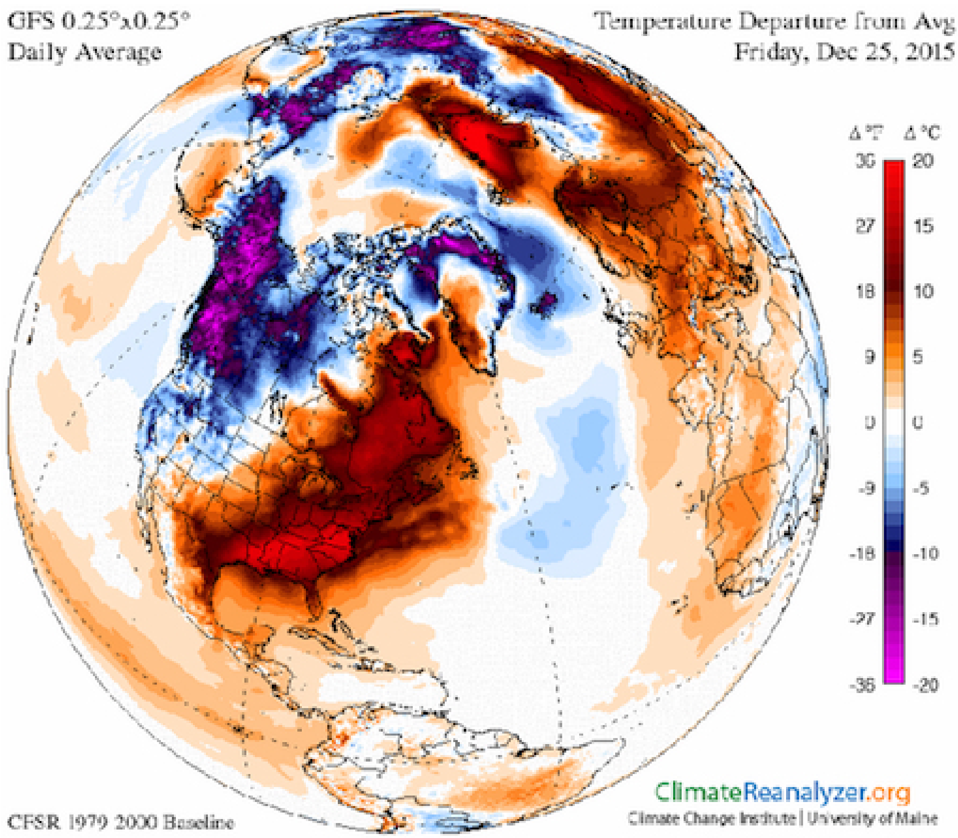
PHYS.ORG

The how and why behind a record-breaking Christmas heatwave

January 11 2016, by Jesse Farmer, Earth Institute, Columbia University



Temperature departure from average for Dec. 25, 2015. Note the swath of red colors across the eastern U.S. indicating much warmer than average temperatures. From University of Maine's Climate Change Institute.

Every Christmas, my family has a routine: wake up early in our eastern North Carolina house, shuffle downstairs in slippers and sweaters, and open presents.

This year? Forget the slippers and sweaters; we spent our Christmas day in t-shirts and shorts, with the windows open and the ceiling fans running.

Much of the eastern two-thirds of the United States was similarly balmy, with high temperatures Christmas Day more than 20°F above average from Texas to Maine. According to NOAA's National Centers for Environmental Information , 789 daily high temperature records were tied or broken on Christmas Eve and Christmas Day in the continental United States.

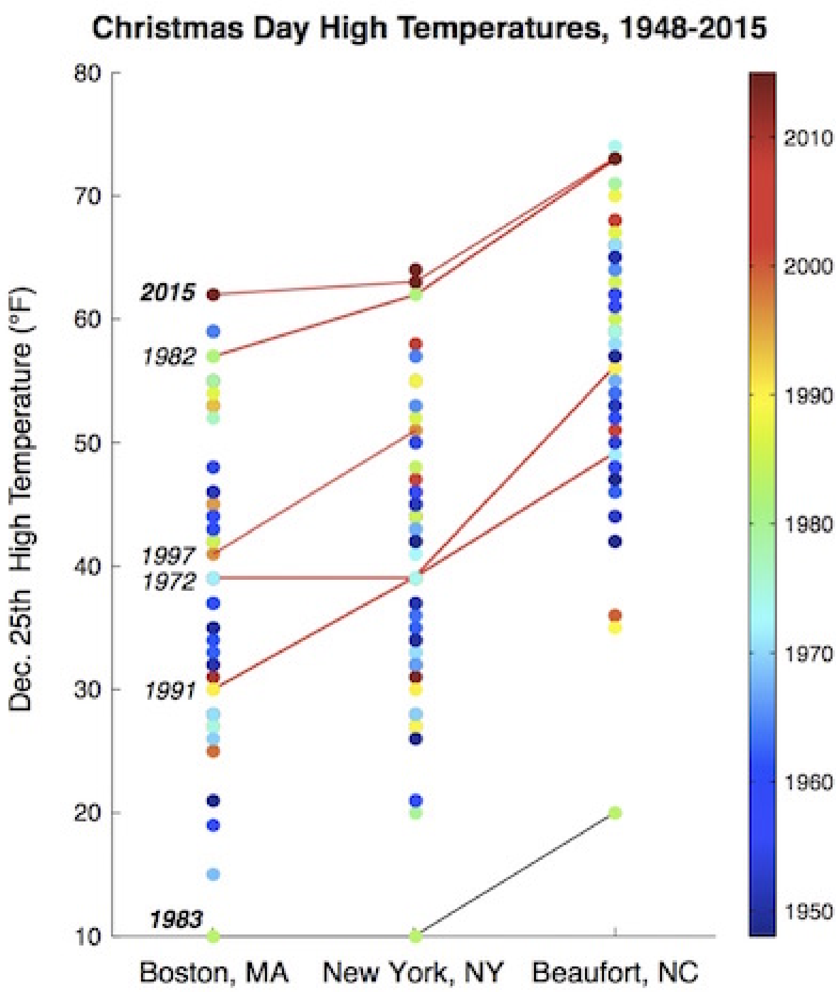
On the heels of a major international climate agreement, and with this year's El Niño event in the media spotlight, one might wonder what lies behind this Christmas warmth. Was it the El Niño? Some sinister anti-Santa combination of El Niño with climate change? Or was it just random?

To get perspective on what caused the Christmas warmth, I spoke with two new faces on the Lamont campus who are experts on climate variability and extreme weather events: Deepti Singh, a postdoctoral fellow at the Lamont-Doherty Earth Observatory, and Justin Mankin, an Earth Institute postdoctoral fellow. Although my question was simple—why was it so warm?—their responses illuminated the challenge of assigning causality to any extreme weather event.

Christmas How

Singh and Mankin both pointed out that in order to understand why it was warm, we first have to know how it was warm. And that requires understanding the weather.

"We live in the mid latitudes, where from year to year there can be huge temperature swings," said Mankin. To this point, consider the high temperatures recorded on Christmas Day over the last seven decades at three locations: New York City, Boston, Mass., and Beaufort, N.C. (close to my hometown).



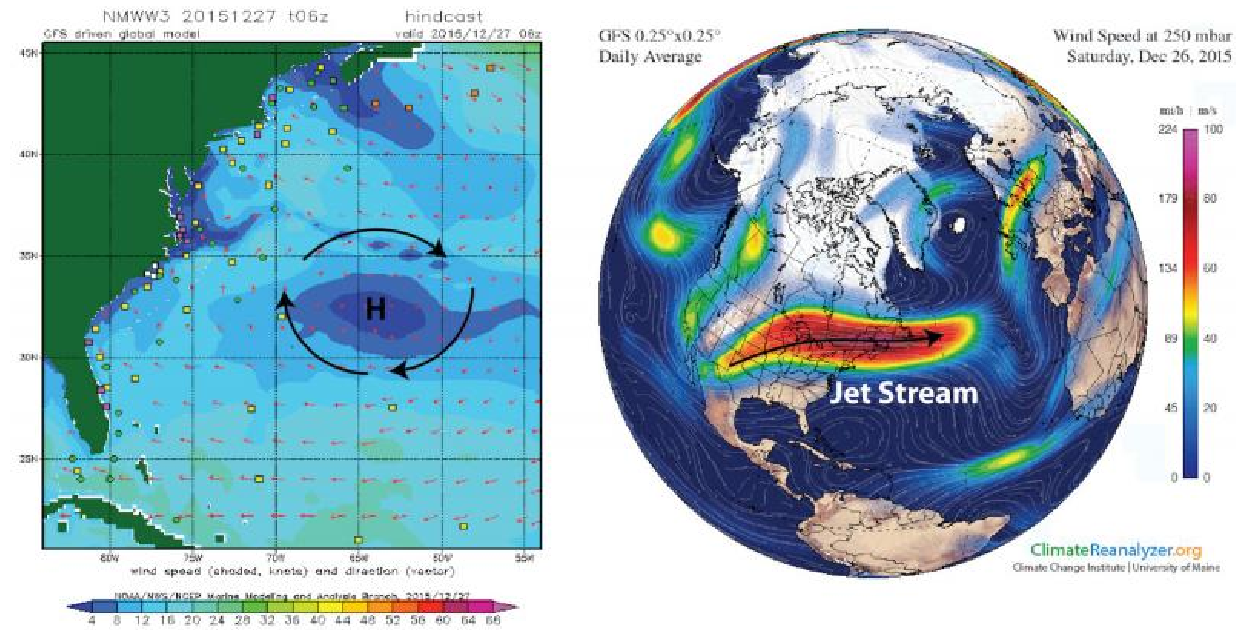
High temperatures on Christmas Day from New York (left), Boston (center), and Beaufort, N.C. (right). Each temperature measurement is color coded by year (color scale on far right). Red lines connect temperatures of Decembers during past major El Niño events (1972, 1982, 1991, 1997 and 2015).

While the overall averages make sense—Boston is slightly colder than New York, and Beaufort quite a bit warmer than both New York and Boston—the high temperature on Christmas Day has varied by almost 50°F at each location over these years. Of these years, 2015 was the hottest or second hottest for all three cities, while the record-breaking Christmas of 1983 was by far the coldest at all three locations.

This enormous range of temperatures for a single calendar day results from weather. And weather creates a huge challenge for attribution: Understanding unusually warm (or cold) temperatures requires understanding the weather patterns associated with them.

"Temperature records don't happen in a vacuum," noted Mankin. "It is imperative to understand the context—to understand physically, how did this event happen?"

Indeed, this year's Christmas heat wave reflected some atypical context. Surface winds showed a Bermuda High pattern more often seen in mid-June than December, while the jet stream lifted far to the north over the U.S.-Canada border. This resulted in severe weather outbreaks and historic flooding in the Midwestern U.S., and even drove formation of a massive storm over the North Atlantic Ocean that thawed the North Pole in the middle of winter!



Surface winds on Dec. 27 from NOAA’s GFS model (left); arrows indicate direction, and colors indicate wind speed. The dark blue area in the middle of the Atlantic is the center of the Bermuda High (right). Upper atmosphere winds on Dec. 26, also from the GFS model. The red region denotes strong high altitude westerly winds of the jet stream, which is usually much farther south during winter.

"Around Christmas, we had record warm temperatures related to an unusual weather pattern affecting large parts of central and eastern North America. By itself, this unusual weather pattern is part of the natural climate variability associated with phenomena like El Niño."

But there are strong indications that more than just El Niño is at play.

"Though we typically expect warmer than average winters in the eastern United States during large El Niño events, this El Niño has set temperature records across the globe in 2015," added Singh. "The fact is that the climate has warmed, the magnitude of wintertime maximum temperatures has increased, hot extremes have become more frequent, and cold extremes have become less frequent. All these observations point to an increased likelihood of unusually warm days like Christmas in today's climate."

Mankin agreed. "On the one hand, it's impossible to say that this Christmas event would not have happened in the absence of climate change, because it probably could have. On the other, this Christmas warmth happened within the context of a number of unusually warm East Coast Decembers (save for the last two years). Warmer winters are certainly something we expect to happen with climate change."

Sleuthing extreme events requires "balancing the idea of the event being entirely congruent with our picture of human-caused climate change, and yet potentially entirely expected in the absence of human-caused climate change. When thinking about why these events occur, you need to keep both these ideas in mind."

Over the last decade, scientists have developed techniques to rigorously test the balance of these two ideas.

"With all these possible affects, saying anything about a specific event requires a lot of detail," noted Singh. The only way to get that level of detail is by using a combination of observations to identify the causes of an event and sophisticated computer models that incorporate scientists' best understanding of the physics that drive global climate and weather. These models allow scientists to simulate earth's climate under different influences, including natural (such as solar and volcanic) and anthropogenic (such as greenhouse gases). Using these models, Singh and her colleagues are developing a framework for understanding the contribution of historical warming to the likelihood and magnitude of specific extreme events, "by seeing how the probability of an event occurring in today's climate compares to the probability of an event occurring in the absence of human-induced climate change."

Professional Opinions

Although Singh and Mankin have not yet analyzed the Christmas heat wave in such a fashion, I asked for their opinions on the Christmas warmth.

For Mankin, "The key question is not whether global climate change caused this event, but to what extent has climate change affected the likelihood or magnitude of such an event? This event happened in a world where more energy is stored because of climate change. But it is not yet clear this extra energy was sufficient or necessary for the event to occur."

Because climate variability is so huge, Mankin thinks internal climate variability is likely the primary culprit for the Christmas warmth, with some expression of global warming tossed in.

Singh agreed. "Climate change did not cause this event. What it most likely did, though, is contribute some fractional amount to the magnitude of the anomalously warm temperatures, account for some percentage of the warm weather. It might have also affected the persistence and the track of the related weather system, but this effect is much harder to tease apart."

Going forward, Singh and Mankin will work on what that percentage contribution actually is. For me, now that the weather has turned cold, I'm returning to a simpler question: Can we get the warmth back, please?

Provided by Earth Institute, Columbia University