BOOK IT:
2012, THE HOTTEST U.S. YEAR ON RECORD
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Global warming is directly linked to only a few weather events and climate trends. One of them, however, is warming itself, which could make 2012 a watershed climate change year in the U.S. More than superstorms, wildfires, and devastating drought, this year’s record-smashing spring and summer heat waves, with their melted airport runways and warped steel rail lines, are more evidence that climate change is real.

Last week NOAA announced that 2012 was “likely” to be the warmest year on record in the 48 states, based on temperatures through November. At some point, however, likelihood turns into certainty. Does a warm December push the nation to the point where it is impossible for 2012 to be anything but the warmest year ever recorded in the U.S.?

To answer that question Climate Central did the math, and the results are in.

- There is a 99.99999999 percent chance that 2012 will be the hottest year ever recorded in the continental 48 states, based on our analysis of 118 years of temperature records through Dec. 10, 2012.

By taking the top spot as the hottest year, 2012 pushes 1998 into second place, followed by 2006, 1934 and 1999. In line with the global warming trend spurred by steadily rising carbon emissions, seven of the top 10 warmest years ever recorded in the 48 states have occurred in the past 15 years.

Like so much recent record-breaking weather, 2012 isn’t just going to break the previous record, 2012 is looking to smash it, by more than 1°F. Climate Central projects the 2012 average temperature for the continental U.S. at 55.34°F compared to the previous record set in 1998 of 54.32°F. For perspective, 1°F is one quarter of the difference between the coldest and warmest years ever recorded in the continental U.S.
Exactly how cold would it need to be not to break the record? Temperatures would have to average 14.76°F across the continent for the rest of December -- a holiday season colder than any ever recorded.

But that is not going to happen. So far this December the mean temperature in the contiguous U.S. has been 44.13°F. The average temperature for 117 years of previous Decembers is 33.08°F.
The States

Things are a bit different at the state level, where the heat was extreme, but far from every state will set the record. Fully two-thirds of the lower 48 states recorded their first-, second- or third-hottest years through November, and 43 states had one of their top 10 warmest years ever recorded. Even the coolest state, Washington, had a far warmer-than-average year to date.

But while 17 states had recorded their warmest year to date, just 12 have better than a 50-50 chance of continuing this warm weather through the year and having the warmest year on record. (State odds will change as we move toward the end of the year.)

Record-shattering heat has been the norm all year. June-through-August 2012 was just two-tenths of a degree cooler than the Dust Bowl summer of 1936, and July of this year was the hottest month ever recorded in U.S. history.

This scorching summer followed on the heels of a remarkably warm spring in most of the country. March 2012 was the warmest March in U.S. history by a wide margin. In communities across the upper Midwest, daily low temperatures routinely broke previous high temperature records, and daily high records were repeatedly smashed by 20 degrees or more.
Methodology

This analysis was designed to determine the odds that 2012 will or won't be the warmest year for the 48 contiguous states since reliable and comprehensive temperature records began being collected in 1895.

Our analysis is predicated on a number of simplifications, but if anything, we think our simplifications have made our estimates conservative.

We know that the period January-November 2012 was anomalously warmer by 2.735°F than has ever been recorded in the U.S. For December to cancel that out, the average temperature during the month would have to be 24.238°F or colder.

The calculations here are simple. We know the temperature Jan-Nov to be 57.058°F (warmer by 2.735°F than the maximum value thus far, 54.323, recorded in 1998, the warmest year thus far). For December to spoil the party, its temperature would have to be D such that (11/12)*57.058+(1/12)*D<=54.323. Which gives us D<=24.238F.

What is the chance of that happening?

To find out we fit a Normal distribution to the 117 values of average December temperatures, by computing mean and standard deviation from those numbers. The result: the Normal distribution of December temperatures has a mean value of 33.083 and a standard deviation of 2.556. Thus, to determine the odds of 2012 being the warmest on record, we want to know what the probability is of a December recording an average temperature of 24.238°F, according to our Normal distribution.

Elementary calculations show that P(T<=24.238)=0.00027.

Thus, based on a monthly analysis of data through November 30th, the chance that 2012 won't break the record as the warmest year is as small as 0.027 percent.

This analysis does not consider the possibility that what happened so far in the year could be an indicator of December temperature behavior (if anything that would increase the chances that this will be a warm December, rather than an anomalously cold one) and does not take into account the fact that winter temperatures, like yearly temperatures, in the U.S. have seen a significant trend toward warmer values over the past decades, similarly lowering the chances of a colder-than-average December. We are also not taking into account factors like ENSO or other natural sources of natural variability, which could inform our estimates of December temperatures, but here again we think that that kind of predictability would be encapsulated in any dependence of December temperatures on previous months’ anomalies.

Because we are well into December we can use that information to compute updated probabilities as of Monday, December 10.

December temperatures would still need to be as cold or colder than 24.238°F. But now we know that December so far has been averaging 44.138°F. Therefore, the rest of December would have to average R0, such that (10/31)*44.138+(21/31)*R0=24.24, i.e., R0=14.762.

We can then estimate a Normal distribution on the basis of the 117 average temperatures for the last 20 days of December we have in our records, and compute the probability of recording R0. Our computations produce a mean and standard deviation of 32.832 and 3.108, which give a probability of recording 14.762 of 0.000000003071.

This is again assuming that there is no correlation between what happens in the first 10 days of the month and what happens in the next 21 days of the month. But, if anything, the first days of December 2012 saw warm anomalies fairly widespread over the country, lowering the chances of recording a temperature in the next 21 days as low as 14.77°F. (Here we assume that if there is any correlation it is a positive one, obviously).
Finally, to estimate the average temperature for the entire year, we take the 10 observed days, plus the 21 remaining days at the December average, which would result in:

\[
(10 \times 44.138 + 21 \times 32.832)/31 = 36.4791 \text{ for the month.}
\]

We use that value to project the 2012 year-end average of...

\[
(36.4791 + 11 \times 57.05818)/12 = 55.34326
\]

The result is, we break the record by...

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55.34326 - 54.32333 = 1.01993
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