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When Will The World Really Be 2 Degrees Hotter Than It Used To Be?

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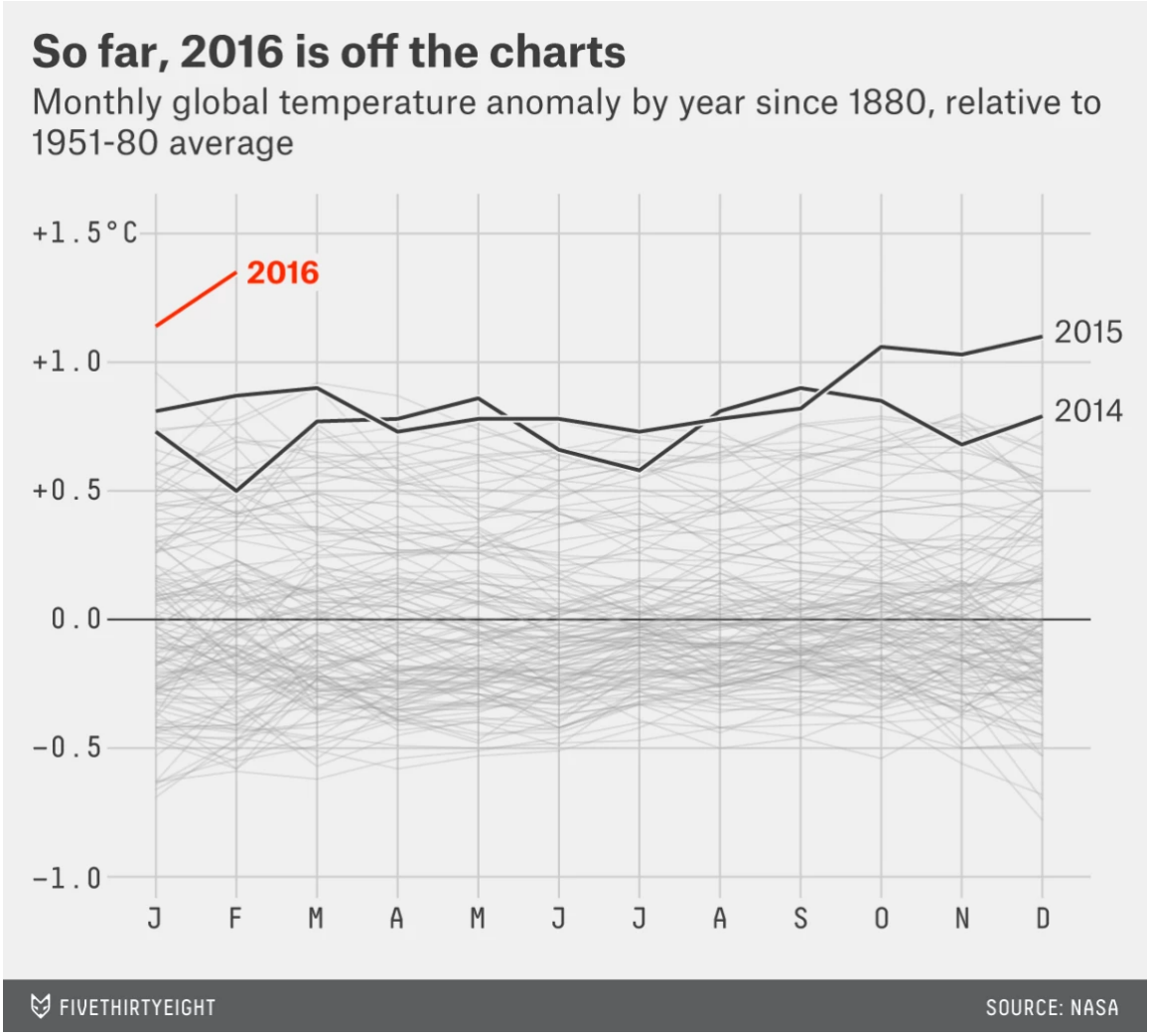
Climate data is a fussy thing, with a bunch of different organizations measuring data against a bunch of different baselines. But all of them agree on one thing: Last month, the Earth endured a heat wave that has had no equal in the hundred-plus years humans have been keeping close track of our home planet's climate. Take data from NASA, which showed that February was (by far) the most unusually warm month since it began keeping records: 1.35 degrees Celsius above the 1951-80 global temperature average and, depending on how you do the math, as much as 2 degrees above pre-industrial levels.



Two degrees Celsius warming above pre-industrial levels is an important milestone — perhaps **the** most important milestone for climate change. For years, global leaders have agreed somewhat arbitrarily that 2 degrees of warming is the point above which "dangerous" climate change will commence. Last December, in Paris, nearly 200 nations agreed to work together to limit global warming to "well below" the 2 degree level and pursue efforts to keep it below 1.5 degrees.

But when will we know that the world has officially crossed the 2 degree mark **for good**?

At a minimum, breaching 2 degrees requires us to be beyond the pre-industrial baseline and to be beyond it for a while. February's record-setting heat may have satisfied only one of those criteria. But it still gives us a sense of what may be to come.

It sounds easy enough to measure global warming: see how hot it was, compare it to how hot it used to be. But climate scientists have several ways of measuring how hot it used to be. NASA's base period, as I mentioned above, is an average of 1951-80 global temperatures, mostly because that was the most recently available 30-year period when the data set was first created. By chance, it's also pretty representative of the world's 20th-century climate and can help us understand how much warmer the world has become while many of us have been alive.

Other organizations go further back. The Intergovernmental Panel on Climate Change, the body of climate scientists that was formed to provide assessments to the United Nations, bases its temperature calculations on an 1850-1900 global average. There was about 0.4 degrees of warming between that time period and the NASA base period.

Climate scientists often refer to that 1850-1900 timespan as "pre-industrial" because we don't have comprehensive temperature data from the 1700s. But meteorologist Michael Mann, director of Penn State University's Earth System Science Center, has argued that an additional 0.25 degrees of warming occurred between the start of the Industrial Revolution (around 1750) and 1850.[1] Including Mann's adjustment would bring February 2016 global temperatures at or very near 2 degrees above the "pre-industrial" average.[2]

All of this to say: It was hot in February and very possibly hot enough to cross that important 2-degree line. But "only" for February. It's obviously not yet known exactly how the rest of 2016 will progress, though odds are that a waning El Niño will keep the annual average above that of 2015, which currently ranks as the hottest year in history.

The current warming surge amounts to what's called a step change — a practically instantaneous shift in our planet's climate. In the Arctic, it's kicked off fresh concern about melting permafrost — which could further exacerbate global warming through the release of vast quantities of carbon dioxide and methane and induce permanent changes in the region's ecosystem. This sudden shift in temperature has arrived because of a

confluence of events: Long-term global warming, the multiyear effect of El Niño, and extreme weather — including persistent heat waves at the regional scale.

The major cause of February's exceptional warmth is global warming, and we know that because it fits the pattern that's long been expected: Among other indicators, the Arctic is warming at a faster rate than the rest of the planet, and land areas are warming faster than the oceans.

We're also in the midst of a particularly strong El Niño, which tends to increase global temperatures, although El Niño can't explain all or even most of the current warming spike — especially the warmth in the Arctic. Mark Serreze, director of the National Snow and Ice Data Center at the University of Colorado, told the Guardian that he'd "never seen anything like this before" in the 35 years that he has been studying the Arctic climate. El Niño warming probably explains about 0.2 degrees Celsius of the current global surge, according to a modeling study from the Met Office (the U.K.'s national meteorological service).

Even if we did temporarily breach 2 degrees in February, climate-focused scientists I spoke to said we won't have truly reached that notorious milestone until we're on the other side of it for a while. Meteorologist Bob Henson doesn't think there's a universally accepted benchmark for just how long we'd need to wait to know for sure we're there. For his own work, Henson would prefer to wait until the data included a year without an El Niño, or better yet a decade-long average. "That would imply that it might be mid-century before we get to 2 degrees," Henson told me.

Based on the Met Office's estimates and my calculations, 2016 will probably be around 1.1 to 1.5 degrees above the 1850-1900 average. An annual breach of 2 degrees could happen as soon as 2030, according to climate model simulations, although there's always the chance that climate models are slightly underestimating or overestimating how close we are to that date. Writing with fellow meteorologist Jeff Masters for Weather Underground, Henson said the current spike means "we are now hurtling at a frightening pace toward the globally agreed maximum of 2.0°C warming over pre-industrial levels."

Henson and other scientists I interviewed for this article all struck a similar theme: When we've **really** hit 2 degrees — averaged over an entire decade — the impacts on ecosystems and extreme weather will be substantially worse than what's happening this year.

Stefan Rahmstorf, a climate scientist at the Potsdam Institute for Climate Impact Research in Germany, was less sanguine. He told The Sydney Morning Herald that temperatures "are clearly more than 1.5 degrees above pre-industrial levels. ... We are in a kind of climate emergency now."

According to a five-year prediction from the Met Office, global temperatures may fall slightly over the next year or two, as the El Niño wanes and temporarily cooler ocean temperatures associated with La Niña take hold. But global warming will make that respite brief: 2018, 2019 and 2020 will likely be warmer than 2015, and the warming trend is expected to continue long after that. Sixteen of the 18 years that followed the last big El Niño (1997-98) were warmer than 1997.

That means our near-term planetary future appears to be partly locked-in. Even if atmospheric carbon dioxide levels were immediately stabilized at around 400 parts per million, we're committed to another 0.4 to 0.6 degrees Celsius of warming because of an inherent 40-year lag in the climate system that delays the full effect of greenhouse gases on the oceans and atmosphere. (But, of course, we haven't stabilized global carbon dioxide levels. In 2015, they rose at the fastest rate ever measured.)

No matter how quickly global temperatures rise over the coming years, the February record has added fresh relevance to the Paris climate deal. We're very likely locked in to a 2 degree warmer world — even though last month was only a preview.

Footnotes

1. Mann's adjustment is debated because it's based partly on model estimates.
2. Here's how that math works: February was 1.35 degrees above the 1951-80 average, according to NASA. Add the difference between the 1951-80 average and the 1850-1900 global average from the IPCC (0.4 degrees), and you get to 1.75 degrees. Then if you add Mann's 0.25 adjustment, you get to somewhere around 2.0 degrees.