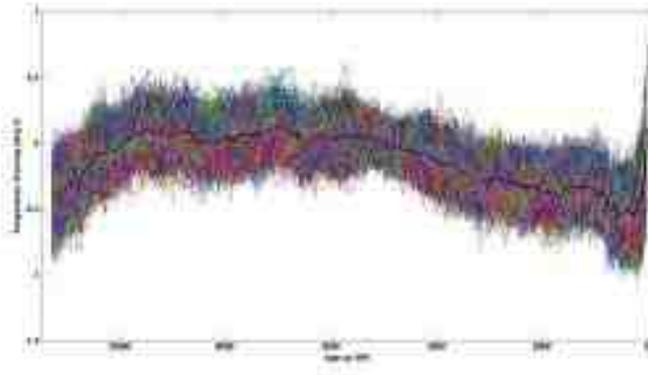


True face of climate's hockey stick graph revealed

- 19:00 07 March 2013 by [Michael Marshall](#)
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The new hockey stick (*Image: Shaun A. Marcott et al./Science*)

Earth's temperature is changing faster now than at any time since the last ice age, according to a new analysis of global temperatures spanning the last 11,300 years.

The study has produced the first extension of the notorious "hockey stick" temperature graph all the way back to the end of the last ice age.

It suggests that we are not quite out of the natural range of temperature variation yet, but will be by the end of the century.

Thermometre measurements only exist back to around 1860, so when climatologists reconstruct historical temperatures, they must use proxies. Tree rings, for instance, are useful because they are thicker during warm years when trees can grow faster.

[Shaun Marcott](#) of Oregon State University in Corvallis and colleagues have compiled 73 such proxies from around the world, all of which reach back to the end of the [last glacial period](#), 11,300 years ago. During this period, known as the Holocene, the climate has been relatively warm – and civilisation has flourished.

"Most global temperature reconstructions have only spanned the past 2000 years," says Marcott.

Marcott's graph shows temperatures rising slowly after the ice age, until they peaked 9500 years ago. The total rise over that period was about 0.6 °C. They then held steady until around 5500 years ago, when they began slowly falling again until around 1850. The drop was 0.7 °C, roughly reversing the previous rise.

Then, in the late 19th century, the graph shows temperatures shooting up, driven by humanity's greenhouse gas emissions.

Unprecedented warming

The rate of warming in the last 150 years is unlike anything that happened in at least 11,000 years, says [Michael Mann](#) of the Pennsylvania State University in University Park, who was not involved in Marcott's study. It was Mann who created the original [hockey stick graph \(see upper graph here\)](#), which showed the change in global temperatures over [the last 1000 years](#).

Over the Holocene, temperatures rose and fell less than 1 °C, and they did so over thousands of years, says Marcott. "It took 8000 years to go from warm to cold." Agriculture, communal life and forms of government all arose during this relatively stable period, he adds. Then in 100 years, global temperatures suddenly shot up again to very close to the previous maximum.

How fast temperatures change is the real issue of climate change, says Mann. "That's what challenges our adaptive capacity." Rapid change means farming practices must alter quickly, and preparations for extreme weather events must also be rapidly put in place.

Wobbly planet

The gradual changes through the Holocene were driven by changes in Earth's rotation, says Marcott. The planet is tilted about 23° relative to the plane of its orbit, and this tilt increased early in the Holocene before decreasing again. "It sort of wobbles," Marcott says. A greater tilt increases the amount of sunlight at the poles during summer, and this keeps the planet warmer.

If humans had not begun warming the planet by releasing greenhouse gases, Earth would eventually return to an ice age. "If we were following the orbital trend we'd still be cooling," Marcott says.

Marcott's data suggests that the planet is now nearly – but not quite – as warm as at its warmest point in the last 11,000 years. [Some climatologists have suggested](#) that it is already hotter, but it is difficult to say for sure due to uncertainties in the data.

Mann says it should be possible to find out. He points out that, according to Marcott's data, the tropics are currently hotter than at any point during the Holocene. The poles, on the other hand, appear to have been unusually warm in the past. But Marcott's data set contains a lot of data from the far north, and Mann thinks it might be slightly exaggerating past warmth.

"It's possible, given the potential bias, that there is in fact no precedent over the past 11,000 years," says Mann says.

Even if we are not yet hotter than the entire Holocene, we will soon be. Marcott examined the latest climate models' temperature predictions for this century, and found that by 2100 they were all outside the Holocene range. "The projections for 2100 will be very clearly outside the entire distribution of the data," Marcott says.

Journal reference: *Science*, DOI: 10.1126/science.1228026