

News Front Page



Africa

Americas

Asia-Pacific

Europe

Middle East

South Asia

UK

Business

Health

Science/Nature

Technology

Entertainment

Have Your Say

In Pictures

Week at a Glance

Country Profiles

In Depth

Programmes

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Climate legacy of 'hockey stick'

There are few more provocative symbols in the debate over global warming than the "hockey stick".

The hockey stick was a term coined for a chart of temperature variation over the last 1,000 years, which suggested a recent sharp rise in temperature caused by human activities.

The chart is relatively flat from the period AD 1000 to 1900, indicating that temperatures were relatively stable for this period of time. The flat part forms the stick's "shaft".

But after 1900, temperatures appear to shoot up, forming the hockey stick's "blade".

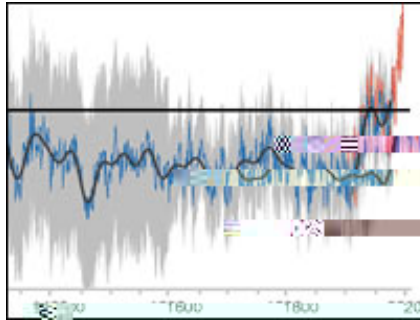
The temperature chart originates from two seminal research papers published in *Nature* in 1998 and *Geophysical Research Letters* in 1999 by Michael Mann of the University of Virginia, Ray Bradley of the University of Massachusetts at Amherst and Malcolm Hughes of the University of Arizona.

The high-profile publication of the data led to the "hockey stick" being used as a key piece of supporting evidence in the third assessment report by the United Nations' Intergovernmental Panel on Climate Change (IPCC) in 2001, which offered a stark warning to policymakers of the urgency for action on reducing greenhouse emissions.

The authors drew on a variety of sources that give information on past climate to reconstruct their temperature patterns.

These included tree rings, ice cores, coral, instrumental data and historical records.

The data led the researchers to the inevitable conclusion that greenhouse gas emissions were the dominant factor influencing climate variability in the 20th Century, a standpoint that remains hotly contested by some scientists.



The IPCC's version showed temperature variation over 1,000 years

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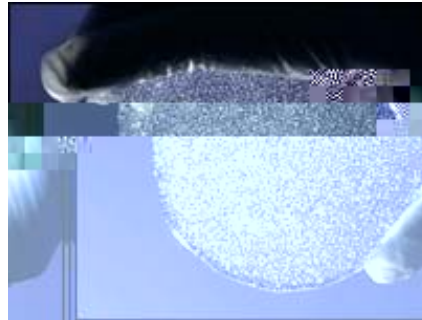
Potent symbol

Over the years, the chart has gradually become a potent symbol of man's impact on global climate in the post-industrial age.

Ever since the publication of Mann, Bradley and Hughes' data, global warming sceptics have tried to chip away at this record. And in a recent article published by the National Center for Policy Analysis think tank one scientist even claimed that the hockey stick had been "broken".

Professor David R. Legates of the University of Delaware claims flaws in the data and methods used to fashion the hockey stick mean it can no longer be viewed as valid.

"There is an exaggeration of recent trends, suggesting that 1998 was the warmest year, and that the 1990s were the warmest decade of the millennium," Dr Legates told BBC News Online.



The temperature record uses data from many sources including ice cores

"There is an underestimation of the uncertainty, because they did not take into account other errors associated with estimating large-scale trends and temperature from observational data."

The central thrust of Legates' article is rejected by other climate scientists, who claim that the sudden upsurge in temperatures since 1900 is all too real.

"This isn't a scientific paper, it's absolutely awful," said Professor Phil Jones, director of the Climate Research Unit at the University of East Anglia in Norwich, UK.

Professor Jones and Mann extended the 1,000-year temperature record back to AD 200 for a research paper published in 2003. But the sharp warming trend in the post-industrial age was still clear.

Future warning

Jones says that all the evidence points to temperatures rising by about two tenths of a degree C per decade for the foreseeable future.

In an article in the publication *Energy and Environment*, Legates and fellow climate scientists Willie Soon and Sallie Baliunas criticised Mann and Jones' chart for leaving out the so-called Medieval Warm Period (AD 800 to 1400) and the Little Ice Age (AD 1600 to 1850).

But other researchers, such as Dr Joyce Penner of the University of Michigan said they were not convinced by the case they made.

Some scientists believe that the timing of these cold and warm periods varied geographically over the globe in a considerable way.

There have been other criticisms. This year, David Chapman, Marshall Bartlett and Robert Harris criticised the decision to exclude borehole data from one version of the temperature chart devised by Mann and Gavin Schmidt.



Professor Jones wants to look for long-lived trees in areas such as Alaska

By measuring temperatures in holes drilled in the ground scientists can construct a pattern of underground temperature variation to calculate the extent to which Earth's climate has warmed or cooled over hundreds of years.

But Professor Jones explains that there were valid reasons for excluding this data; namely that boreholes produce fewer data points to study than some of the other evidence included in the study.

In addition, borehole data can be influenced by changes in vegetation at the surface, Jones explains:

"If an area was forested in the 17th Century, then that surface is denuded, then that will go into the borehole and the signal will change."

Ongoing search

For Professor Jones, the priority now is obtaining as much data as he can to reduce the error bars in the chart.

He is working to obtain so-called dendroclimatic, or tree-ring, data from long-lived trees in Russia, Argentina, Chile, New Zealand, Tasmania and North America. He also wants to obtain more data from corals as well as documentary evidence from China and Japan.

Dr Legates says he has preliminary calculations that indicate the uncertainty in Mann and Jones' record is probably twice as large as they indicate.

This, he suggests, means that recent temperature trends do not show unprecedented global warming. Professor Legates adds that he plans to work on his analysis for publication in a scientific journal.

But Joyce Penner thinks the signs are that the analysis behind the chart of temperature variation is sound:

"Even if more data is added, I would be surprised if it changed the shape of that curve much. There is such a strong difference between pre-industrial behaviour and the growth during the last 100 years or so," she said.

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