Temperature record of the past 1000 years

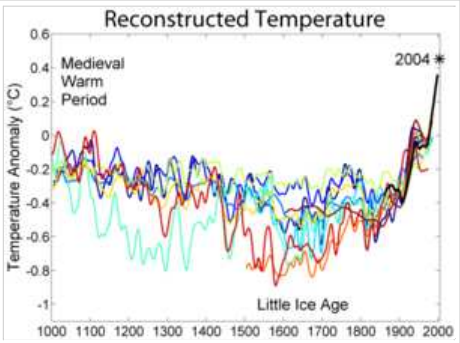
From Wikipedia, the free encyclopedia
(Redirected from Hockey Stick graph)

The **temperature record of the past 1000 years** describes the reconstruction of temperature for the last 1000 years on the Northern Hemisphere. A reconstruction is needed because a reliable surface temperature record exists only since about 1850. Studying past climate is of interest for scientists in order to improve the understanding of current climate variability and, relatedly, providing a better basis for future climate projections. In particular, if the nature and magnitude of natural climate variability can be established, scientists will be better positioned to identify and quantify human generated climate variability (commonly referred to as 'anthropogenic global warming' (AGW)).

The reconstructions of temperature of the last 1000 years vary between:

- ones with significant variability prior to the current century with particular coolness during the Little Ice Age; and,
- ones with minimal variability prior to the current century, generally involving a slight cooling until the 20th century.

In all cases, the increase in temperature in the 20th century, and the temperature in the late 20th century is the highest in the (reconstructed) record. In respect of the best-known reconstruction, that of Mann, Bradley and Hughes, this conclusion has now been strongly reinforced by the National Research Council's report to the U.S. Congress for 1600 onward only (i.e. since near the middle of the Little Ice Age). The panel finds it plausible that the conclusion also holds for the whole millennium, but notes that larger uncertainties reduce the confidence in these long-term comparisons [1] (http://www.nap.edu/catalog/11676.html) .

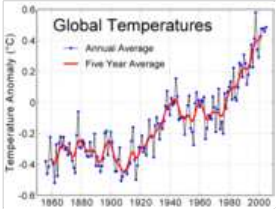


Reconstructions of Northern Hemisphere temperatures for the last 1000 years according to various older articles (bluish lines), newer articles (reddish lines), and instrumental record (black line).

Contents

Instrumental temperature record

The recent instrumental temperature record dates from approximately 1850. These records of thermometer readings show a general warming in global temperatures.



Instrumental temperature record of the last 150 years

For general information about temperature records see the main article: *Temperature record*.

For information on the description of the Medieval Warm Period and Little Ice Age in various reports of the United Nations Intergovernmental Panel on Climate Change, see the main article: *MWP and LIA in IPCC reports*

General techniques

Reconstructions of temperature rely on 'proxy' records. For example, the width of tree rings is related to temperature as is the amount of snowfall over many glacial sites. Further, the isotopic composition of snow, corals, and stalactites can also record temperature changes. Other techniques which have been used include examining the time of crop harvests, the treeline in various locations and other historical records to make inferences about the temperature.

In general, the recent history of the proxy records is calibrated against local temperature records to estimate the relationship between temperature and the proxy. The longer history of the proxy is then used to reconstruct temperature from earlier periods. These records must then be averaged in some fashion if a "global" or "hemispheric" record is desired. Since certain regions contain, for example, a large number of tree ring records, a simple average of all the data would strongly over-weight some small regions - hence data-reduction techniques (PCA) are used to combine some of these regional records before they are globally combined.

An important distinction is between so-called 'multi-proxy' reconstructions, which attempt to obtain a global temperature reconstructions by using multiple proxy records distributed over the globe and more regional reconstructions.

Usually, the data are combined arithmetically, in some weighted average. More recently, Osborn and Briffa used a simpler technique, counting the proportion of records that are positive, negative or neutral

in any time period [2] (http://www.realclimate.org/index.php/archives/2006/02/a-new-take-on-an-old-millennium/) . This produces a result in general agreement with the conventional multi-proxy studies.

Reconstructions with minimal variability

Several reconstructions that suggested there was minimal variability in temperatures prior to the past century were generated by Mann and his co-authors. (See, for example, Mann, Jones and Briffa, Pollack et al. [3] (http://www.grida.no/climate/ipcc_tar/wg1/fig2-19.htm) [4] (http://www.cru.uea.ac.uk/cru/info/milltemp/) .) More recently, they have extended their reconstructions to cover the last 2000 years (Mann and Jones, GRL, 2003 [5] (http://www.ngdc.noaa.gov/paleo/pubs/mann2003b/mann2003b.html)). The work was reproduced by Wahl and Ammann in 2005 [6] (http://www.ucar.edu/news/releases/2005/ammann.shtml) [7] (http://www.cgd.ucar.edu/ccr/ammann/millennium/CODES_MBH.html) [8] (http://www.cgd.ucar.edu/ccr/ammann/millennium/refs/WahlAmmann_ClimChange2006.html) .

The Mann, Bradley and Hughes (1998) version of the temperature record has an unofficial name, the "**Hockey Stick**" graph, first coined by Jerry Mahlman, a colleague of Mann's.

The work of Mann et al., Jones et al., Briffa and others [9] (http://www.grida.no/climate/ipcc_tar/wg1/fig2-20.htm) [10] (http://www.grida.no/climate/ipcc_tar/wg1/fig2-21.htm) forms a major part of the IPCC's conclusion that "the rate and magnitude of global or hemispheric surface 20th century warming is likely to have been the largest of the millennium, with the 1990s and 1998 likely to have been the warmest decade and year" [11] (http://www.grida.no/climate/ipcc_tar/wg1/071.htm) . In 2006, a National Academy of Sciences panel concluded that data was too sparse to fully support the decadal and single year conclusions. They did, however, find plausible the more general conclusion that the last 25 years have been the warmest for a millennium. (see below) [12] (http://darwin.nap.edu/books/0309102251/html/4.html) For a comparison of the common temperature plots, see [13] (http://www.ngdc.noaa.gov/paleo/globalwarming/images/revgraph3.gif) .

Reconstructions with greater variability

In the 22 October 2004 issue of *Science*, Hans von Storch and his colleagues claimed that the particular method of Mann et al. probably underestimates the temperature fluctuations in the past by a factor of two or more; however, this conclusion rests at least in part on the reasonableness of the GCM simulation used, which has been questioned. Anders Moberg and his Swedish and Russian collaborators who published their results in Nature on February 10, 2005 [14] (http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v433/n7026/abs/nature03265_fs.html) [15] (http://www.realclimate.org/index.php?p=122) have also generated reconstructions with significantly more variability than the reconstructions of Mann et al.

Scientists such as astrophysicist Sallie Baliunas have argued that these ups and downs correlate with

solar activity and that the number of observed sunspots give us a rough measure of how bright the sun is. Baliunas and others believe that periods of decreased solar radiation are responsible for historically recorded periods of cooling such as the Maunder Minimum and the Little Ice Age. Similarly, they say, periods of increased solar radiation contributed to the Medieval Warm Period, when Greenland's icy coastal areas thawed enough to permit farming and colonization.

Reconciliation of the two approaches

The apparent differences between the statistical and historical approaches are not fully reconciled. One possibility is that the fluctuations recorded in the historical records are regional rather than hemispheric in scale.

The reconstructions mentioned above rely on various assumptions to generate their results. The most fundamental are that the proxy records vary linearly with temperature and that non-temperature factors do not confound the results. If these assumptions do not hold, the reconstructions would be unreliable.

Mann, Bradley and Hughes temperature reconstructions

Although there are many different temperature reconstructions, attention has tended to focus on the work of MBH, which was featured in the 2001 IPCC report. Various claims and counter-claims have been made over the validity of the reconstruction.

Quantitative hemispheric temperature reconstructions (http://www.ngdc.noaa.gov/paleo/recons.html#airtemp) were showing the pattern of slow cooling followed by more rapid warming.

Stephen McIntyre and Ross McKitrick attempted an audit of MBH98 [16] (http://www.uoguelph.ca/~rmckitri/research/trc.html) in Corrections to the Mann et. al. (1998) Proxy Data Base and Northern Hemispheric Average Temperature Series (http://www.multi-science.co.uk/ee_openaccess.htm) . This publication claimed various errors, but M&M offered no explanation as to why their analysis also differs from other reconstructions [17] (http://www.grida.no/climate/ipcc_tar/wg1/fig2-21.htm) .

In turn, Mann (supported by Tim Osborn, Keith Briffa and Phil Jones of the Climatic Research Unit) has disputed the claims made by McIntyre and McKitrick [18] (http://www.cru.uea.ac.uk/~timo/paleo/) [19] (http://holocene.evsc.virginia.edu/Mann/EandEPaperProblem.pdf) , saying "...MM have made critical errors in their analysis that have the effect of grossly distorting the reconstruction of MBH98...". A basic guide to some of these issues is available [20] (http://www.realclimate.org/index.php/archives/2005/02/dummies-guide-to-the-latest-hockey-stick-contro\ . In 2004 Mann, Bradley, and Hughes published a corrigendum to their *Nature* 392, 779-787 (1998) article, correcting a number of mistakes in the online supplementary information that accompanied their article but leaving the actual results unchanged.

M&M have published another *Geophysical Research Letters* article [21] (http://www.agu.org/pubs/crossref/2005/2004GL021750.shtml) on February 12, 2005, claiming that the "Hockey Stick" shape was a result of a flawed principal component analysis, and that using the same steps like Mann et al., they were able to obtain the Hockey Stick graph in 99 percent of cases even if red noise was used as input. Mann and his collaborators have responded to the M&M articles via various means, including posts at the blog RealClimate (http://www.realclimate.org/index.php?p=11) .

In 2006, a panel report of the National Academy of Sciences ordered by the U.S. Congress was published. The basic conclusion of Mann et al. (1998, 1999) was that the late 20th century warmth in the Northern Hemisphere was unprecedented during at least the last 1,000 years. The committee reported that there is sufficient evidence from tree rings, boreholes, retreating glaciers, and other "proxies" of past surface temperatures to say with a high level of confidence that the last few decades of the 20th century were warmer than any comparable period in the last 400 years. Less confidence can be placed in proxy-based reconstructions of surface temperatures for A.D. 900 to 1600, although the available proxy evidence does indicate that many locations were warmer during the past 25 years than during any other 25-year period since 900 [22] (http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=11676) .

The report also confirmed some of the points of the criticism by M&M: the bristlecone pines are not a good temperature proxy; the data and the software should have been made available; and the principal component analysis as used by Mann et. al. "tends to bias the shape of the reconstruction", however this "does not appear to unduly influence reconstructions of hemispheric mean temperature" [23] (http://darwin.nap.edu/openbook/0309102251/html/106.html) .

Steve McIntyre has recently been quoted as saying "I'm inclined to agree that, for the most part, the Hockey Stick does not matter to the great issue of the impact of 2xCO2." and this is a point of agreement on both sides. [24] (http://sciencepolicy.colorado.edu/prometheus/archives/climate_change/000641reflections_on_the_c.htm

There is an ongoing debate about the details of the temperature record and the means of its reconstruction.

Other criticisms are directed at the statistical methods employed in creating reconstructions. The methodology of papers by Mann et al (MBH98 and MBH99) have been criticised by Stephen McIntyre and Ross McKitrick (M&M) on various grounds. In the February 11, 2005 issue of *Science*, Richard A. Kerr discusses the *Geophysical Research Letters* paper that appeared on February 12, 2005 [25] (http://www.agu.org/pubs/crossref/2005/2004GL021750.shtml) by McIntyre and McKitrick. This has been reinforced by an independent team of statisticians led by Edward J. Wegman, George Mason University and chair of the National Academy of Sciences' (NAS) Committee on Applied and Theoretical Statistics at the behest of Sen. Joe Barton. [26] (http://energycommerce.house.gov/108/home/07142006_Wegman_Report.pdf)

Mann counters that the criticisms directed at his statistical methodology are purely political and add nothing new to the debate [27] (http://news.mongabay.com/2006/0716-climate.html) .

Uncertainties and limitations

In a letter to Nature (August 10, 2006) Bradley, Hughes and Mann pointed at the original title of their 1998 article: *Northern Hemisphere temperatures during the past millennium: inferences, uncertainties, and limitations* (Geophys. Res. Lett. 26, 759–762; 1999) and explained that they stated in the abstract, *We focus not just on the reconstructions, but on the uncertainties therein, and important caveats*. They affirmed that *expanded uncertainties prevent decisive conclusions for the period prior to AD 1400*. They pointed out *more widespread high-resolution data are needed before more confident conclusions can be reached* and that the uncertainties were *the point of the article*. These points are being made to refute a news story that claimed *that systematic uncertainties in climate records from before 1600 were not communicated as clearly as they could have been*. [1]

Updates

There are ongoing updates and future events related to the MBH work.

- RealClimate (http://www.realclimate.org) - Climate scientists blog, including Mann
- ClimateAudit (http://www.climateaudit.org) - McIntyre blog

National Research Council Report

These are the five conclusions of the NRC report. [28] (http://www.nap.edu/catalog/11676.html)

- *The instrumentally measured warming of about 0.6℃ dur ing the 20th century is also reflected in borehole temperature measurements, the retreat of glaciers, and other observational evidence, and can be simulated with climate models.*
- *Large-scale surface temperature reconstructions yield a generally consistent picture of temperature trends during the preceding millennium, including relatively warm conditions centered around A.D. 1000 (identified by some as the "Medieval Warm Period") and a relatively cold period (or "Little Ice Age") centered around 1700. The existence and extent of a Little Ice Age from roughly 1500 to 1850 is supported by a wide variety of evidence including ice cores, tree rings, borehole temperatures, glacier length records, and historical documents. Evidence for regional warmth during medieval times can be found in a diverse but more limited set of records including ice cores, tree rings, marine sediments, and historical sources from Europe and Asia, but the exact timing and duration of warm periods may have varied from region to region, and the magnitude and geographic extent of the warmth are uncertain.*
- *It can be said with a high level of confidence that global mean surface temperature was higher during the last few decades of the 20th century than during any comparable period during the preceding four centuries. This statement is justified by the consistency of the evidence from a wide*

variety of geographically diverse proxies.

- *Less confidence can be placed in large-scale surface temperature reconstructions for the period from A.D. 900 to 1600. Presently available proxy evidence indicates that temperatures at many, but not all, individual locations were higher during the past 25 years than during any period of comparable length since A.D. 900. The uncertainties associated with reconstructing hemispheric mean or global mean temperatures from these data increase substantially backward in time through this period and are not yet fully quantified.*
- *Very little confidence can be assigned to statements concerning the hemispheric mean or global mean surface temperature prior to about A.D. 900 because of sparse data coverage and because the uncertainties associated with proxy data and the methods used to analyze and combine them are larger than during more recent time periods.*

Committee on Energy and Commerce Report

These are the findings of the ad hoc commitee report [29] (http://energycommerce.house.gov/108/home/07142006_Wegman_Report.pdf) authored by Edward J. Wegman, George Mason University, David W. Scott, Rice University, and Yasmin H. Said, The Johns Hopkins University in July 2006:

- MBH98 and MBH99 were found to be somewhat obscure and incomplete and the criticisms of MM03/05a/05b were found to be valid and compelling.
- It is noted that there is no evidence that Dr. Mann or any of the other authors in paleoclimatology studies have had significant interactions with mainstream statisticians.
- A social network of authorships in temperature reconstruction of at least 43 authors having direct ties to Dr. Mann by virtue of coauthored papers with him is described. The findings from this analysis suggest that authors in the area of paleoclimate studies are closely connected and thus 'independent studies' may not be as independent as they might appear on the surface.
- It is important to note the isolation of the paleoclimate community; even though they rely heavily on statistical methods they do not seem to be interacting with the statistical community. Additionally, we judge that the sharing of research materials, data and results was haphazardly and grudgingly done.
- Overall, the committee believes that Mann's assessments that the decade of the 1990s was the hottest decade of the millennium and that 1998 was the hottest year of the millennium cannot be supported by his analysis.

References

1. **^** Bradley, Hughes and Mann (2006): *Authors were clear about hockey-stick uncertainties*, in: Nature 442, 627(10 August 2006) online (http://www.nature.com/nature/journal/v442/n7103/full/442627b.html)

External links

- Mann's home page (http://www.evsc.virginia.edu/faculty/people/mann.shtml)
- A collection of various reconstructions of global and local temperature from centuries on up: (http://www.ngdc.noaa.gov/paleo/recons.html)
- An NOAA collection of individual data records (http://www.ngdc.noaa.gov/paleo/data.html)
- Supplementary information (http://www.nature.com/nature/journal/v430/n6995/suppinfo/nature02478.html) for Mann, M. E. et al. corrigendum: Global-scale temperature patterns and climate forcing over the past six centuries Nature 430, 105(2004) Letters to Nature. http://www.nature.com/nature/journal/v430/n6995/suppinfo/nature02478.html
- Corrections to the Mann et al (1998) Proxy Data Base and Northern Hemisphere Average Temperature Series (http://www.uoguelph.ca/~rmckitri/research/trc.html) . Steven McIntyre, Ross McKitrick. Energy and Environment 14(6) 751-772. http://www.uoguelph.ca/~rmckitri/research/trc.html
- http://www.climate2003.com/ Webpage of Stephen McIntyre
- "A Global Warming Bombshell" (http://www.technologyreview.com/articles/04/10/wo_muller101504.asp?p=1) by Richard A. Muller, *Technology Review* , Oct. 2004; calls into question famous graph by Michael Mann
- What is the 'Hockey Stick' Debate About? (http://www.climatechangeissues.com/files/PDF/conf05mckitrick.pdf) McKitrick reviews the criticisms of the Mann hockey stick for a general scientific audience.
- Myth vs. Fact Regarding the "Hockey Stick" (http://www.realclimate.org/index.php?p=11) — Real Climate
- Was the climate of the 20th century unusual? (http://www.marshall.org/pdf/materials/136.pdf)
- Surface Temperature Reconstructions for the Last 2,000 Years (http://www.nap.edu/catalog/11676.html)
- Ad hoc committee report on the 'Hockey Stick' Global Climate Reconstruction (http://energycommerce.house.gov/108/home/07142006_Wegman_Report.pdf)
- Discussion article about the relevance of the debate to climate policy and climate science policy (http://sciencepolicy.colorado.edu/prometheus/archives/climate_change/000641reflections_on_the_c with contributions from both 'sides'

Retrieved from "http://en.wikipedia.org/wiki/Temperature_record_of_the_past_1000_years"

Categories: Climate change | History of climate
