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having doubts about global warming

The rise and fall of the Hockey Stick

The rise of the so called [Hockey Stick graph](#) is pivotal to the story of the rise of the alarm about man made global warming.

The fall of the Hockey Stick graph is pivotal to the rise of scepticism about man made global warming.

Here is the story of the rise and fall of the Hockey Stick.

The Background

A central and critical plank of the alarmist global warming case is that the current phase of warming that started in the late 19th century is unprecedented.

Why is this claim so important?

Because if a similar or greater warming phase has occurred in the *very recent past*, before human CO₂ emissions had caused CO₂ levels to rise, then clearly any such recent warming must have been natural and was not caused by CO₂. And if any recent similar warming phase was natural then clearly the current phase of warming could also be a natural phenomena.

If the current phase of warming could be natural then those arguing that it was primarily caused by human CO₂ emissions would have to prove their hypothesis. *And this is something they cannot do.*

The only “proof” that CO₂ is currently forcing up global temperatures is the claim that the current warming is somehow unusual, unique and unnatural. *That’s the total argument for CO₂ forcing.* Something unprecedented is happening to the climate and CO₂ is the only candidate for what is causing this unique phenomena.

Its certainly true that the well understood physics of CO₂ in the atmosphere demonstrates (see “[CO₂ the basic facts](#)”)that CO₂ is indeed a greenhouse gas and will have a warming impact. No one disputes that. *The issue is what is the scale of impact that this CO₂ warming is having on the overall climate system. Is the effect of the CO₂ so big that it can drive the temperature of the whole planet up in a way that is big enough to actually alter the climate?*

This is a much harder question to answer because no one has a model of the total climate system that actually works and which verifiably produces even remotely accurate forecasts about climate trends.

So without a working model of the total climate system the only way to “prove” that CO₂ is driving climate change is to prove that something truly unique is happening to the climate, that there is unprecedented warming occurring, and and then propose man made CO₂ change as the only candidate as the cause of this ‘unprecedented’ warming.

The “problem” of the Medieval Warm Period

Until the 1990s there were many, many references in scientific and historical literature to a period labelled the [Medieval Warm Period](#) (MWP) lasting from about AD 800–1300. It was followed by a much cooler period termed the [Little Ice Age](#). Based on both temperature reconstructions using proxy measures and voluminous historical references it was accepted that the Medieval Warm Period had been a period when global temperatures were a bit hotter than today’s temperatures. Until about the mid-1990s the Medieval Warm Period was for climate researchers an undisputed fact. The existence of the Medieval Warm Period was accepted without question and noted in the first progress report of the IPCC from 1990. On page 202 of that 1990 IPCC report there was the graphic 7c (see below), in which the Medieval Warm Period was portrayed as clearly warmer than the present.

By the time of the second IPCC report in 1995 where for the first time CO₂ forcing began to be proposed more prominently as a cause of serious alarm, the Medieval Warm Period was sidelined in the text and narrative. An important way that this was done in the report was to alter the diagram of recent climate history by simply shortening the time period it covered so that it now started after the Medieval Warm Period. All that was shown was the long slow recovery from the Little Ice Age to today’s temperatures, i.e. a long period of increasing temperatures. But clearly this was only a short term solution. The way that the Medieval Warm Period dominated the recent climate graph challenged the basic argument for CO₂ forcing which was that the late 20th century climate was some how unique. As Jay Overpeck, an IPCC participant said in his email to Professor Deming, “We have to get rid of the Medieval Warm Period”.

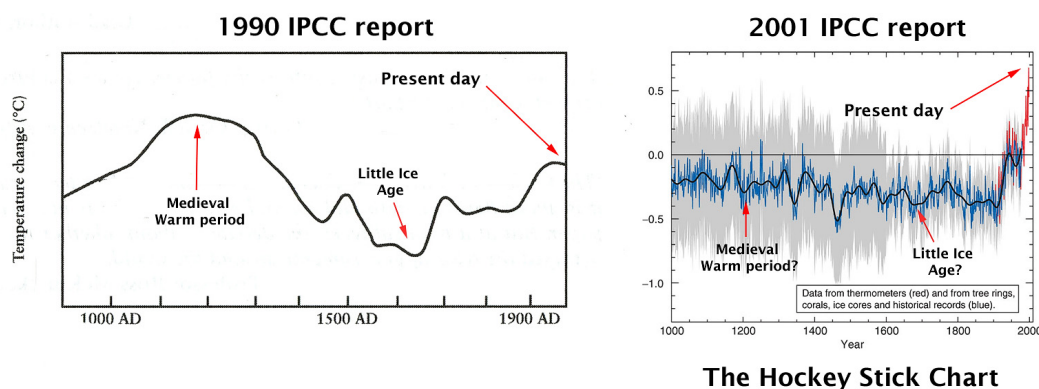
In order to prove CO₂ forcing the Medieval Warm Period had to be eliminated.

The Rise of the Hockey Stick

Between the 1995 second IPCC report and the 2001 third IPCC report there was a complete revision in the way that recent climate history was portrayed. The supporters of the theory that CO₂ changes were driving temperatures up had succeeded in their goal of eliminating the Medieval Warm Period. This rewriting of climate history and the elimination of the Medieval Warm Period was achieved through the famous Hockey Stick graph.

To understand the scale of the revision that had taken place compare the two graphs below. The one on the left is diagram 7c from page 202 of the 1990 IPCC report in which the Medieval Warm Period was portrayed as clearly warmer than the present. On the right is the Hockey Stick graph from [the 2001 IPCC report](#) in which the Medieval Warm Period and the Little Ice Age have all but disappeared and the recent climate history is dominated by a rapid temperature rise in the last 20th century.

Climate change over the past 1000 years as shown by the IPCC



The first blow against the accepted understanding of climate history came in 1995 when the English climatologist [Keith Briffa](#) (based at the Climate Research Unit at East Anglia) published in the journal *Nature* a study with sensational results. According to his studies of tree rings in the Siberian Polar-Ural, there had never been a Medieval Warm Period and the 20th century suddenly appeared as the warmest of the last 1000 years. The most recent part of this study is known as the Yamal study, because of the name of the region it was done in, and it has recently been discredited – see [here](#).

Briffa's work boldly proposed that the 20th Century had experienced the warmest climate of the millennium and this claim was now the central battlefield for the scientific argument about CO2 forcing. This of course ignored the [Climatic Optimum](#) (see [Happy Holocene](#)) between 5000 and 9000 years ago when temperatures were significantly higher than today but most people (and certainly the media and politicians) actually think that 5000 years is a long time ago so there was no need to undermine the Climatic Optimum in order to win wide public support for the CO2 forcing hypothesis. Hottest in the last 1000 years would do.

Briffa's work had an impact and laid the ground work but the real knock out blow that finally succeeded in eliminating the Medieval Warm Period was a paper published in 1998 in *Nature* by Mann, Bradley and Hughes entitled, "Global-scale temperature patterns and climate forcing over the past six centuries" (you can download it [here](#)). This was the original peer reviewed hockey stick article.

[Michael Mann](#) of the Department of Geosciences, University of Massachusetts, who was the primary author of the paper, had in one scientific coup overturned the whole of climate history. Using tree rings as a basis for assessing past temperature changes back to the year 1,000 AD, supplemented by other proxies from more recent centuries, *Mann completely redrew climate history, turning the Medieval Warm Period and Little Ice Age into non-events*. In the new Hockey Stick diagram the Medieval Warm Period and Little Ice Age have disappeared, to be replaced by a largely benign and slightly cooling linear trend in climate until 1900 AD after which the *Mann's new graph showed the temperature shooting up in the 20th century in an apparently anomalous and accelerating fashion*.

In every other science when such a drastic revision of previously accepted knowledge is promulgated, there is considerable debate and initial scepticism, the new theory facing a gauntlet of criticism and intense review. Only if a new idea survives that process does it become broadly accepted by the scientific peer group and the public at large.

This never happened with Mann's 'Hockey Stick'. The coup was total, bloodless, and swift as Mann's paper was greeted with a chorus of uncritical approval from the increasingly politically committed supporters of the CO2 greenhouse theory. Within the space of only 12 months, the new theory had become entrenched as a new orthodoxy. The ultimate consummation of the new theory came with the release of the draft of the Third Assessment Report of the IPCC in 2000. Based solely on this new paper from a relatively unknown and young scientist the IPCC could now boldly state:

"It is likely that the rate and duration of the warming of the 20th century is larger than any other time during the last 1,000 years. The 1990s are likely to have been the warmest decade of the millennium in the Northern Hemisphere, and 1998 is likely to have been the warmest year."

Overturning its own previous view in the 1995 report, the IPCC presented the 'Hockey Stick' as the new orthodoxy with hardly an apology or explanation for the abrupt U-turn since its 1995 report. The IPCC could show almost no supporting scientific justification because other than Mann's Hockey Stick paper, and Briffa's Siberian tree ring study there was little in the way of research confirming their new line.

The Hockey Stick graph, the new orthodoxy, was blown up to a wall sized display and used as a back drop for the public launch of the 2001 IPCC report.

Within months of the IPCC draft release, the long-awaited draft U.S. 'National Assessment' Overview document featured the 'Hockey Stick' as the first of many climatic graphs and charts in its report, affirming the crucial importance placed in it by the authors and by the active pro CO2 warming campaign at large. This was now not an esoteric theory about the distant past but rather the core foundation upon which the offensive on global warming was being mounted.

Soon the Hockey Stick was everywhere and with it went the new simple and catchy campaigning slogans "*its hotter now than the last 1000 years!*", "*1998 was the hottest year for a 1000 years!*"

Not long after the 2001 IPCC report the Government of Canada sent the hockey stick to schools across the country, and its famous conclusion about the 1990s being the warmest decade of the millennium was the opening line of a pamphlet sent to every household in Canada to promote the Kyoto Protocol.

Al Gore's Oscar winning and hugely popular film "An Inconvenient Truth" was virtually built around the Hockey Stick (although Gore couldn't resist tweaking it to make it look even more compelling by changing the way the graph data was displayed along the axis so that the temperature trend line it showed looked even steeper and starker).

In the UK the Government announced that the DVD of the "An Inconvenient Truth" would be sent to every school in the country as a teaching aid.

The Hockey Stick seemed to be carrying all before it. Dr Mann was promoted, given a central position in the IPCC and became a star of the media.

And then it all went horribly wrong.

The Fall of the Hockey Stick

In the years immediately after the 2001 IPCC report it seemed as if the sudden adoption of the Hockey Stick model of the earth's recent climate past had created a new orthodoxy which could not be challenged. Even when some scientists quietly worried that the new theory about the past climate had been adopted way too quickly or were unhappy about the way that satellite temperature readings didn't seem to fit the Hockey Stick model or they noticed that new individual proxy studies still seemed to keep showing that the Medieval Warm Period was hotter than today, they mostly stayed silent. They didn't want to be branded as 'deniers' after all.

Then an unlikely hero emerged in the shape of [Stephen McIntyre](#) a retired mineralogist from Toronto. McIntyre is not a scientist or an economist but he does know a lot about statistics, maths and data analysis and he is a curious guy. He didn't start off as a climate sceptic but was just someone interested in the nuts and bolts of these new and apparently exciting ideas about climate change, and he was curious about how the Hockey Stick graph was made and wanted to see if the raw data looked like hockey sticks too. In the Spring of 2003, Stephen McIntyre requested the raw data set used in the Hockey Stick paper from Mann. After some delay Mann arranged provision of a file which he said was the one used in the original 1998 Hockey Stick paper and McIntyre began to look at how Mann had processed all the data from the numerous different proxy studies cited as his source material and how they had been combined to produce the average that was the basis of the famous Hockey Stick shape.

About this time Steve McIntyre linked up with [Ross McKittrick](#) a Canadian economist specialising in environmental economics and policy analysis. Together McIntyre and McKittrick began to dig down into the data that Mann had used in his paper and the statistical techniques used to create the single blended average used to make the Hockey Stick. *They immediately began to find problems.*

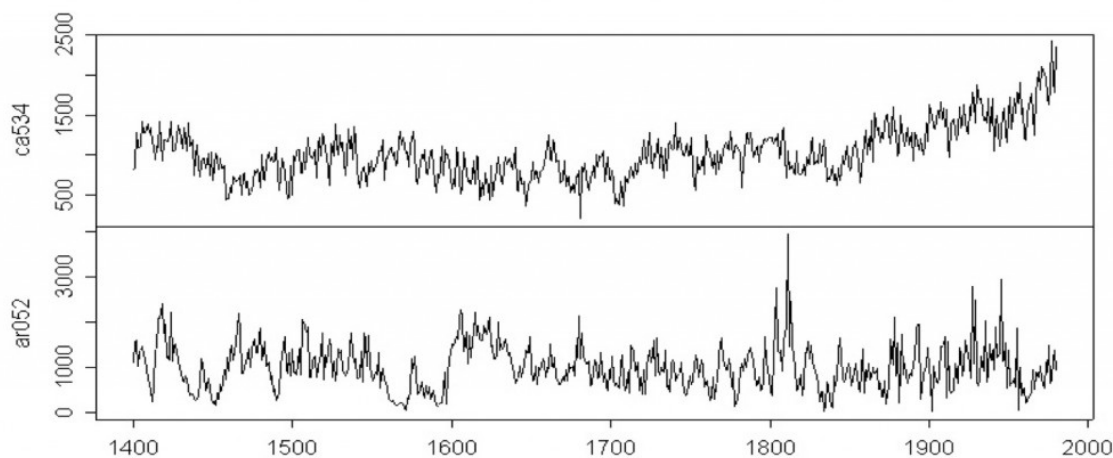
Some of these problems just seemed the sort of errors that are caused by sloppy data handling concerning location

labels, use of obsolete editions, unexplained truncations of available series, etc. Although such errors should have been spotted in the peer review process and they would adversely affect the quality of Mann's conclusions they had a relatively small effect on the final results.

But McIntyre and McKittrick found one major error, an error so big that it invalidated the entire conclusion of the whole paper. *A whopper of an error.*

As we have seen what Mann had done was blend together lots of different proxy studies of the past climate going back a 1000 years and then produced an average of all these studies and a single graph showing the trend. Clearly the validity of the techniques used to blend together and average the different data from the various different studies was absolutely critical as to the validity of the final conclusions reached and the resulting Hockey Stick graph. This sort of blending of data sets is a very common statistical exercise and there are very well established techniques for undertaking such an exercise, these techniques use values that are called 'principal components' (if you want to know a lot more about the technical details then download McKittrick's paper from [here](#)). What McIntyre and McKittrick discovered was that *Mann had used very unusual principal component values and the effect of the choice of value used had drastically skewed the outcome* of the blending and averaging exercise. Effectively what Mann's odd statistical techniques did was to select data that had any sort of Hockey Stick shape and hugely increase its weight in the averaging process. *Using Mann's technique it meant that any data was almost certain to produce a spurious Hockey Stick shape.*

Here is an example of the sort of things Mann was doing to the raw data.



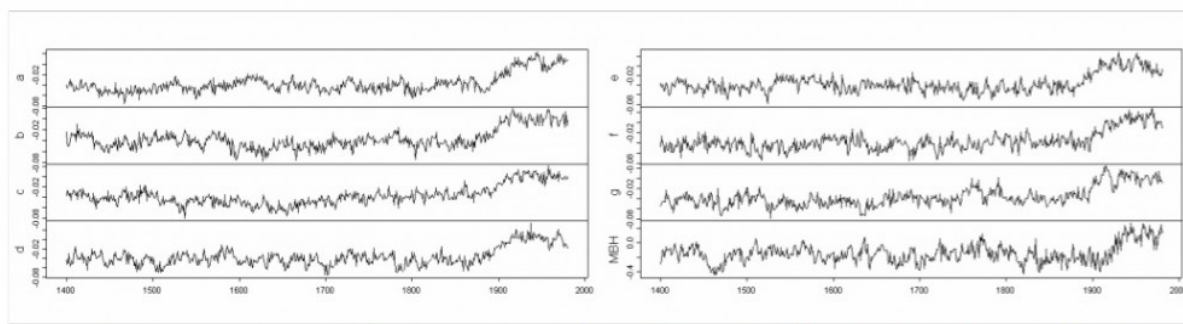
Above are two separate temperature reconstructions running from 1400AD, both use tree rings, one is from California and one is from Arizona. Both were part of the data used by Mann and included in the Hockey Stick average. The top one shows a temperature up tick at the end in the 20th century like the final Hockey Stick, the other shows a relatively flat temperature for the 20th century. *Mann's statistical trick gives the top series, the one with the desired Hockey Stick shape a weighting in the data that is 390 times that of the bottom series just because it has a Hockey Stick bend at the end.* This means that whatever data is fed into Mann's statistical manipulations is almost bound to produce a Hockey Stick shape whether it is actually in the data or not.

McIntyre and McKittrick then took their critical analysis a step further. When you apply a statistical manipulation to a set of data it is important to make sure that what you doing is not actually distorting the data so much that you are really just creating something new, spurious and false in the numbers. One way to do this is to take the statistical manipulation in question and apply it to several examples of random numbers (sometimes this is called a Red Noise test). To simplify, you use random numbers as input data, then apply the statistical technique you are testing to the

random numbers then if the techniques are sound you should get a set of random numbers coming out the other end of the calculations. There should be no false shape imparted to the random noise by the statistical techniques themselves, if what you get out is random numbers then this would prove that the techniques you were testing were not adding anything artificial to the numbers. This is what McIntyre and McKittrick did using the techniques that Mann had used in the Hockey Stick paper. *And the results were staggering.*

What they found was that 99% of the time you could process random data using Mann's techniques and it would generate a Hockey Stick shape. This meant that Mann's claim that the Hockey Stick graph represented an accurate reconstruction of the past climate was in tatters.

Here are some examples. Below are eight graphs. Seven were made by processing random numbers using Mann's techniques. The eighth is the actual Hockey Stick chart from Mann's paper. *See if you can spot which is which.*



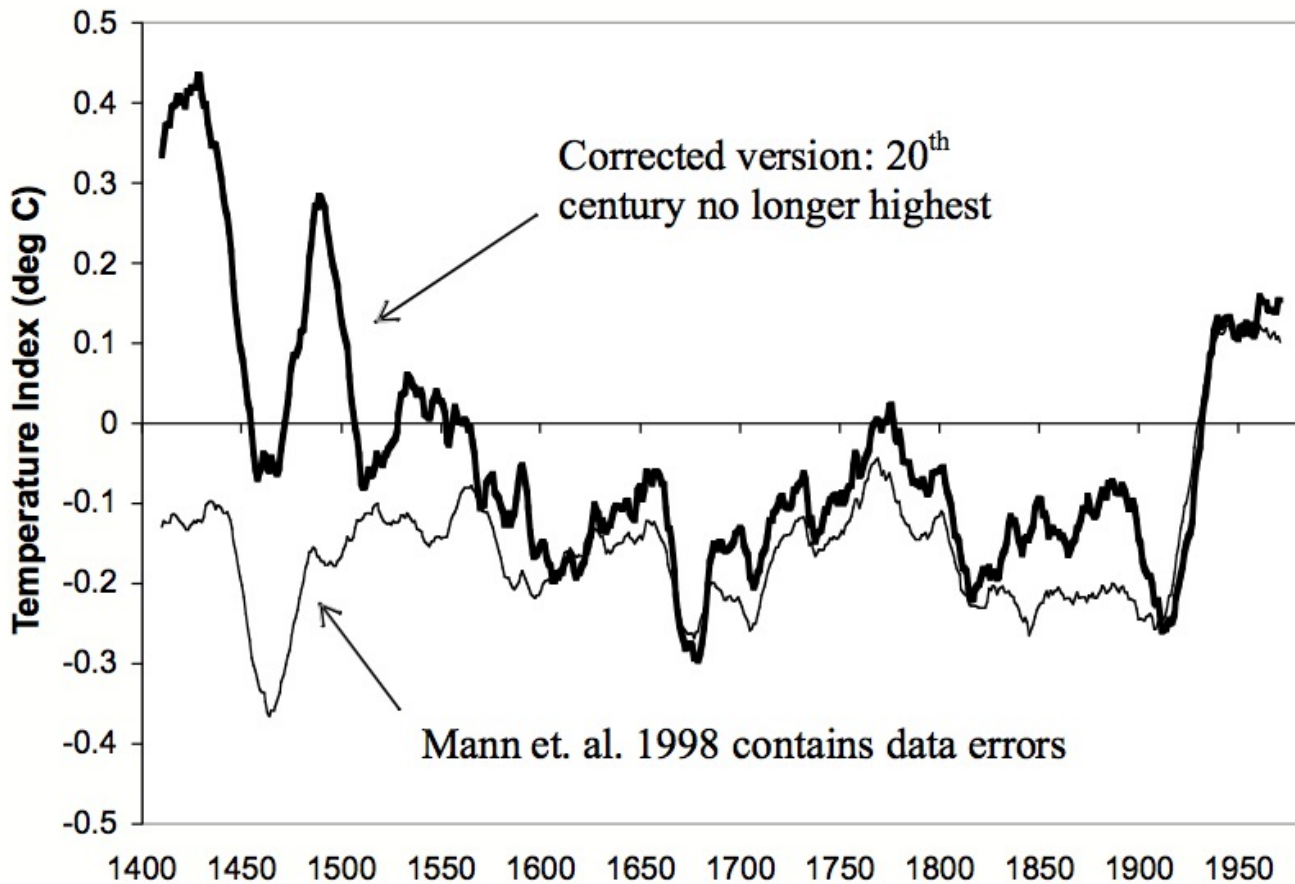
McIntyre and McKittrick submitted a letter to Nature about the serious flaws they had uncovered in the methodology used in the Hockey Stick paper. After a long (8-month) reviewing process Nature notified them that they would not publish it. They concluded it could not be explained in the 500-word limit they were prepared to give McIntyre and McKittrick, and one of the referees said he found the material was quite technical and unlikely to be of interest to the general readers!

Instead of publishing anything from McIntyre and McKittrick explaining the serious errors that they had found Nature allowed Mann to make a coy correction in an on-line Supplement (but not in the printed text itself) where he revealed the nonstandard method he had used, and added the unsupported claim that it did not affect the results.

Eventually in 2003, McIntyre and McKittrick published an article entitled "[Corrections to the Mann et al. \(1998\) Proxy Data Base and Northern Hemisphere Average Temperature Series](#)" in the journal Energy and Environment raising concerns about what they had found in Mann's Hockey Stick paper. By this point following further work analysing Mann's paper McIntyre and McKittrick showed that the data mining procedure did not just pull out a random group of proxies, instead it pulled out a single eccentric group of bristlecone pine chronologies published by Graybill and Idso in 1993 called the Sheep Mountain series. The original authors of the bristlecone study have always stressed that these trees are not proper climate proxies, their study was not trying to do a climate reconstruction and that they were surprised that Mann included it in the Hockey Stick data set. McIntyre and McKittrick had discovered that just removing this odd series from Mann's proxy set and then applying Mann's own eccentric statistical averaging caused the Hockey Stick shape to disappear. *This revolutionary new model of the recent climate past was that fragile and it revealed the Hockey Stick graph as just a carefully worked artificial creation.*

In the graph below the dotted line is the original Hockey Stick chart as published by Mann and as adopted and promoted by the IPCC. The solid line shows the past temperature reconstruction if the data used by Mann is averaged using the correct statistical analysis techniques rather than Mann's unconventional ones. *As can be seen the familiar Medieval Warm Period re-emerges and the 1990s cease to be the hottest of the millennium, that title*

is now claimed by the early 1400s.



In doing this research McIntyre and McKittrick had legitimately accessed Mann's public college web site server in order to get a lot of the source material, and whilst doing this they found the data that provoked them to look at the bristlecone series *in a folder entitled "Censored"*. It seems that Mann had done this very experiment himself and discovered that the climate graph loses its hockey stick shape when the bristlecone series are removed. In so doing he discovered that the hockey stick was not an accurate chart of the recent global climate pattern, it is an artificial creation that hinges on a flawed group of US proxies that are not even valid climate indicators. But Mann did not disclose this fatal weakness of his results, and it only came to light because of McIntyre and McKittrick's laborious efforts.

You can download McKittrick's own account of the whole Hockey Stick saga [here](#) and this [web page](#) compiled by McIntyre and McKittrick has a list of links and documents relating to the Hockey Stick controversy.

Following the publication of McIntyre and McKittrick's critique of Mann's work there was an immediate counter attack by some climatologists who had worked closely with Mann in the past. The attack on McIntyre and McKittrick's critique of Mann's work really boiled down to saying that of course the Hockey Stick disappeared if you stopped using Mann's techniques and that you should carry on using Mann's techniques and then you could get the Hockey Stick back!

Eventually a US senate committee of inquiry was set up under the chairmanship of [Edward Wegman](#) a highly respected Professor of mathematics and statistics and in 2006 his report was published. You can download it [here](#).

The report examined the background to Mann's Hockey Stick paper, the paper itself, the critique of it by McIntyre

and McKittrick and took evidence from all the key players. Interestingly Wegman's committee commissioned some original research into how the small world of climatology actually worked. The study of the social networking of the paleoclimatology world showed how closed it was and how often a small group of scientists both co-wrote and peer reviewed each others papers. For work that depended so much on making statistical claims about trends it was noted that it was surprising that no statisticians ever seemed to be involved in either the research work itself or its peer review.

The key finding in the Wegman Report was that "Our committee believes that the assessments that the decade of the 1990s was the hottest decade in a millennium and that 1998 was the hottest year in a millennium cannot be supported by the MBH98/99 [*the technical name of Mann's original Hockey Stick paper*]"

The other conclusions of the Wegman Report are also very interesting; It listed the following conclusions:

Conclusion 1. *The politicization of academic scholarly work leads to confusing public debates. Scholarly papers published in peer reviewed journals are considered the archival record of research. There is usually no requirement to archive supplemental material such as code and data. Consequently, the supplementary material for academic work is often poorly documented and archived and is not sufficiently robust to withstand intense public debate. In the present example there was too much reliance on peer review, which seemed not to be sufficiently independent.*

Conclusion 2. *Sharing of research materials, data, and results is haphazard and often grudgingly done. We were especially struck by Dr. Mann's insistence that the code he developed was his intellectual property and that he could legally hold it personally without disclosing it to peers. When code and data are not shared and methodology is not fully disclosed, peers do not have the ability to replicate the work and thus independent verification is impossible.*

Conclusion 3. *As statisticians, we were struck by the isolation of communities such as the paleoclimate community that rely heavily on statistical methods, yet do not seem to be interacting with the mainstream statistical community. The public policy implications of this debate are financially staggering and yet apparently no independent statistical expertise was sought or used.*

Conclusion 4. *While the paleoclimate reconstruction has gathered much publicity because it reinforces a policy agenda, it does not provide insight and understanding of the physical mechanisms of climate change except to the extent that tree ring, ice cores and such give physical evidence such as the prevalence of greenhouse gases. What is needed is deeper understanding of the physical mechanisms of climate change.*

Generally the response of the IPCC, the supporters of the CO2 hypothesis and the broader coalition of climate campaigners to all this was a cross between a sneer and a yawn, and the Hockey Stick continued to be used widely as a campaigning and propaganda tool.

It is still being used today.

In 2008 the BBC paid for a large truck to tour central London displaying a giant version of Mann's Hockey Stick as part of the promotion of its very pro CO2 warming mini series called "Climate Wars".

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