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Global Warming Bombshell

By Richard Muller October 15, 2004

Progress in science is sometimes made by great discoveries. But science also advances when we learn that something we believed to be true isnt. When solving a jigsaw puzzle, the solution can sometimes be stymied by the fact that a wrong piece has been wedged in a key place.

In the scientific and political debate over global warming, the latest wrong piece may be the hockey stick, the famous plot (shown below), published by University of Massachusetts geoscientist Michael Mann and colleagues. This plot purports to show that we are now experiencing the warmest climate in a millennium, and that the earth, after remaining cool for centuries during the medieval era, suddenly began to heat up about 100 years ago--just at the time that the burning of coal and oil led to an increase in atmospheric levels of carbon dioxide.

I talked about this at length in my December 2003 column. Unfortunately, discussion of this plot has been so polluted by political and activist frenzy that it is hard to dig into it to reach the science. My earlier column was largely a plea to let science proceed unmolested. Unfortunately, the very importance of the issue has made careful science difficult to pursue.

But now a shock: Canadian scientists Stephen McIntyre and Ross McKitrick have uncovered a fundamental mathematical flaw in the computer program that was used to produce the hockey stick. In his original publications of the stick, Mann purported to use a standard method known as principal component analysis, or PCA, to find the dominant features in a set of more than 70 different climate records.

But it wasnt so. McIntyre and McKitrick obtained part of the program that Mann used, and they found serious problems. Not only does the program not do conventional PCA, but it handles data normalization in a way that can only be described as mistaken.

Now comes the real shocker. This improper normalization procedure tends to emphasize any data that do have the hockey stick shape, and to suppress all data that do not. To demonstrate this effect, McIntyre and McKitrick created some meaningless test data that had, on average, no trends. This method of generating random data is called Monte Carlo analysis, after the famous casino, and it is widely used in statistical analysis to test procedures. When McIntyre and McKitrick fed these random data into the Mann procedure, out popped a hockey stick shape!

That discovery hit me like a bombshell, and I suspect it is having the same effect on many others. Suddenly the hockey stick, the poster-child of the global warming community, turns out to be an artifact of poor mathematics. How could it happen? What is going on? Let me digress into a short technical

discussion of how this incredible error took place.

In PCA and similar techniques, each of the (in this case, typically 70) different data sets have their averages subtracted (so they have a mean of zero), and then are multiplied by a number to make their average variation around that mean to be equal to one; in technical jargon, we say that each data set is normalized to zero mean and unit variance. In standard PCA, each data set is normalized over its complete data period; for key climate data sets that Mann used to create his hockey stick graph, this was the interval 1400-1980. But the computer program Mann used did not do that. Instead, it forced each data set to have zero mean for the time period 1902-1980, and to match the historical records for this interval. This is the time when the historical temperature is well known, so this procedure does guarantee the most accurate temperature scale. But it completely screws up PCA. PCA is mostly concerned with the data sets that have high variance, and the Mann normalization procedure tends to give very high variance to any data set with a hockey stick shape. (Such data sets have zero mean only over the 1902-1980 period, not over the longer 1400-1980 period.)

The net result: the principal component will have a hockey stick shape even if most of the data do not.

McIntyre and McKitrick sent their detailed analysis to *Nature* magazine for publication, and it was extensively refereed. But their paper was finally rejected. In frustration, McIntyre and McKitrick put the entire record of their submission and the referee reports on a Web page for all to see. If you look, youll see that McIntyre and McKitrick have found numerous other problems with the Mann analysis. I emphasize the bug in their PCA program simply because it is so blatant and so easy to understand. Apparently, Mann and his colleagues never tested their program with the standard Monte Carlo approach, or they would have discovered the error themselves. Other and different criticisms of the hockey stick are emerging (see, for example, the paper by Hans von Storch and colleagues in the September 30 issue of *Science*).

Some people may complain that McIntyre and McKitrick did not publish their results in a refereed journal. That is true--but not for lack of trying. Moreover, the paper was refereed--and even better, the referee reports are there for us to read. McIntyre and McKitricks only failure was in not convincing *Nature* that the paper was important enough to publish.

How does this bombshell affect what we think about global warming?

It certainly does not negate the threat of a long-term global temperature increase. In fact, McIntyre and McKitrick are careful to point out that it is hard to draw conclusions from these data, even with their corrections. Did medieval global warming take place? Last month the consensus was that it did not; now the correct answer is that nobody really knows. Uncovering errors in the Mann analysis doesnt settle the debate; it just reopens it. We now know less about the history of climate, and its natural fluctuations over century-scale time frames, than we thought we knew.

If you are concerned about global warming (as I am) and think that human-created carbon dioxide may contribute (as I do), then you still should agree that we are much better off having broken the hockey stick. Misinformation can do real harm, because it distorts predictions. Suppose, for example, that future measurements in the years 2005-2015 show a clear and distinct global *cooling* trend. (It could happen.) If we mistakenly took the hockey stick seriously--that is, if we believed that natural fluctuations in climate are small--then we might conclude (mistakenly) that the cooling could not be just a random fluctuation on top of a long-term warming trend, since according to the hockey stick, such fluctuations are negligible. And that might lead in turn to the mistaken conclusion that global warming predictions are a lot of hooey. If, on the other hand, we reject the hockey stick, and recognize that natural fluctuations can be large, then we will not be misled by a few years of random cooling.

A phony hockey stick is more dangerous than a broken one--if we know it is broken. It is our responsibility as scientists to look at the data in an unbiased way, and draw whatever conclusions follow. When we discover a mistake, we admit it, learn from it, and perhaps discover once again the value of caution.

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