Scientists' Recent Comments on Global Warming and Hurricanes

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http://www.techcentralstation.com/091605F.html

A scientific team led by Peter Webster of the Georgia Institute of Technology today published findings in *Science* magazine. The team claimed to have found evidence in the historical record of both more tropical cyclones, such as Hurricane Katrina, but also a higher percentage of more intense ones.

This follows on the heels of Massachusetts Institute of Technology's Kerry Emanual proclaiming in the Aug. 4 on-line edition of *Nature* magazine that he had found evidence that global warming in the last 30 years was producing more intense cyclones.

The conclusion many draw from papers such as these is that anthropogenic global warming from the burning of fossil fuels by humans is causing more lethal storms. A closer look, though, reveals not human actions but rather natural cycles are the primary cause.

Much has already been written concerning the findings of Emanuel, and their potential shortcomings, both by myself and others. So, in this article, let's focus on the results this week in *Science*.

Webster and colleagues analyzed the occurrence of tropical systems of all strengths across the principal regions of the world's oceans where they form -- the North Atlantic, the Eastern Pacific, the Western Pacific, the Southwestern Pacific, and the North and South Indian Ocean basins. They limited their analysis to the period since 1970 -- the time since satellites were first used to monitor tropical cyclone development. During this same period, the sea surface temperature (SST) in these basins increased by about 0.5ºC (or just under 1ºF). The researchers sought to determine whether there were any changes in the patterns of hurricanes that could be related to the warmer SSTs.

How Frequent?

They found that the total number of tropical storms (tropical cyclones with maximum winds less than 75 mph) and hurricanes (tropical cyclones with winds equal to or exceeding 75mph) varies a bit from year to year, but over the last 30 years, there has been no trend towards either more or fewer storms. This is interesting because in the North Atlantic Ocean (the primary basin where hurricanes form that effect the United States), storms have become much more frequent since 1995. In other parts of the world, however, such as in the Western and Eastern Pacific, and in the Southern Hemisphere oceans, tropical cyclone frequency has declined since the early

1990s. Such variable behavior in the trends of storm frequency from around the world led the researchers to conclude that:

> *In summary, careful analysis of global hurricane data shows that, against a background of increasing SST, no global trend has yet emerged in the number of tropical storms and hurricanes. Only one region, the North Atlantic, shows a statistically significant increase, which commenced in 1995. However, a simple attribution of the increase in numbers of storms to a warming SST environment is not supported, because of the lack of a comparable correlation in other ocean basins where SST is also increasing.*

How Intense?

But Webster and colleagues did not limit themselves only to the investigation of tropical cyclone frequency. They also examined how tropical cyclone intensity may have changed. Here they found a different result. They report that, globally, since 1970, the annual number of weak (category 1) hurricanes has declined a bit, the number of moderate (categories 2 and 3) hurricanes has fluctuated but the average has remained about the same, and the number of severe (categories 4 and 5) has increased. This same pattern of change is also evident in the annual percentage of the storm types -- in the early 1970s, category 1 storms made up about 45% of all hurricanes, category 2 and 3 storms contributed another 40% and the strong category 4 and 5 storms made up the remaining 15%. By the end of the study period (the early 2000s) the annual contributions were about equal. However, despite this apparent trend towards more intense hurricanes, they found that the highest wind speed observed in the most intense storms has remained remarkably constant. In other words, they found that the strongest storms are not getting stronger, but that there has been a tendency for more of them.

Figure 1 shows Webster et al.'s results.

These results led the researchers to conclude:

> *We conclude that global data indicate a 30-year trend toward more frequent intense tropical cyclones. This trend is not inconsistent with recent climate model simulations that a doubling of CO_2 may increase the frequency of the most intense cyclones, although attribution of the 30-year trends to global warming would require a longer global data record and, especially a deeper understanding of the role of hurricanes in the general circulation of the atmosphere and ocean, even in the present climate state.*

The caveat at the end has implications that likely supercede any attempted attribution of the recent behavior of tropical cyclones to anthropogenic global warming. For example, while Webster et al. chose to begin their analysis in 1970, citing the best available global coverage of hurricanes as their justification, it turns out that in the North Atlantic basin, a full coverage of hurricanes began in the mid to late 1940s when hurricane hunter aircrafts were first used -- this is a full 25 years before satellite monitoring became available. Thus, in the Atlantic, we can peek back a little further to see how the trend since the 1970s fits into a longer-term perspective.

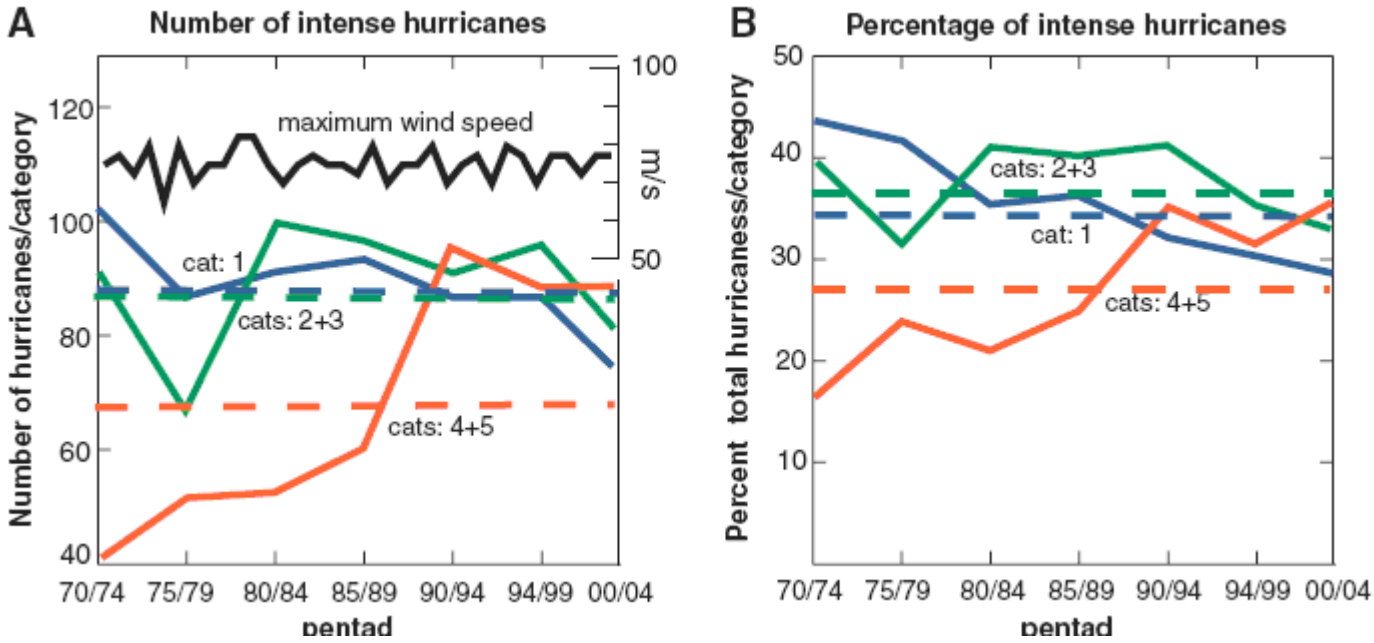

Figure 1. (A) the total number of category 1 storms (blue curve), the sum of categories 2 and 3 (green), and the sum of categories 4 and 5 (red) in 5-year periods. The black curve is the maximum wind speed observed globally. (B) Same as (A), except that the numbers are presented as a percentage of the total annual storm count.

Using data on Atlantic basin tropical cyclones from the National Hurricane Center, the Webster analysis in Figure 1 can be recreated using data that began in 1945. The results for the North Atlantic basin are depicted in **Figure 2**.

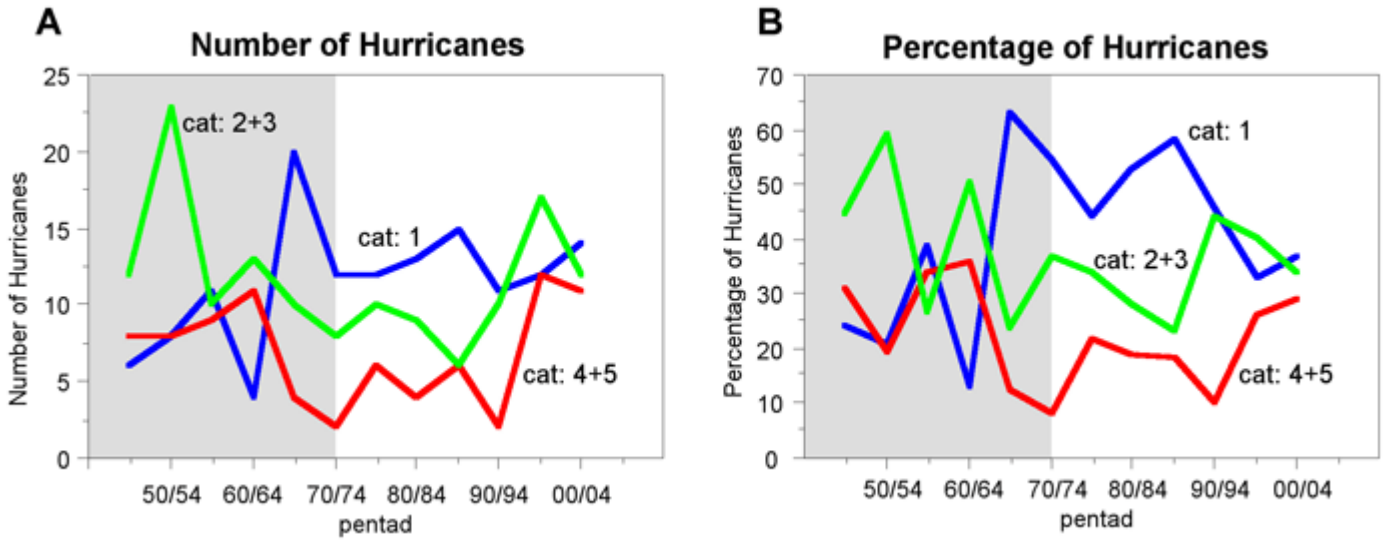

Figure 2. Same as Figure 1, except for the analysis is for only the North Atlantic basin and begins in 1945.

The region shaded in gray is the data from the period prior to that analyzed by Webster's group. Note that the behavior since 1970 (unshaded portion) is pretty

much just as Webster et al. had found (compare with **Figure 1**) -- declines in the weaker category 1 storms and increases in the numbers and percentages of the strong category 4 and 5 storms. However, in the 25 years prior to 1970, *just the opposite occurred* -- the number and percentage of strong hurricanes declined while weak storms became more common. When taken as a whole, the pattern appears to be better characterized as being dominated by active and inactive periods that oscillate through time, rather than being one that indicates a temporal trend. This characterization is one that does not fit so well with the concept that hurricanes are becoming more intense because of increases in atmospheric CO2.

While the impacts of the currently active hurricane period are being felt especially hard in the United States, there remains no scientific proof that human contributions to an enhanced greenhouse effect are the root cause.

References:

Emanuel, K., 2005. Increasing destructiveness of tropical cyclones over the past 30 years. Nature, posted on-line August 4, 2005, doi:10.1038:nature3906

Webster P., et al., 2005. Changes in tropical cyclone number, duration, and intensity in a warming environment. Science, 309, 1844-1846.

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Roger Pielke, Sr.

Comment on Webster et al. September 16, 2005 Science Article "Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment"

http://climatesci.atmos.colostate.edu/?p=53

September 19, 2005

The September 16, 2005 article by Webster et al. in Science concludes that there has been a large increase in the number and proportion of hurricanes reaching Saffir-Simpson category 4 and 5 hurricanes over the past decade. They report that these increases have taken place while the number of tropical cyclones and tropical cyclone days has decreased in all basins except the North Atlantic.

This is a clearly written article by very well-respected scientists. There are, however, several substantive issues with the study. First, an informative figure illustrating the maximum potential for hurricanes as a function of SST was described by a 1988 paper by Robert Merrill entitled "Environmental Influences on Hurricane Intensification" (see Figure 2 in that paper). This research was completed for the Atlantic hurricane region, but the SST thresholds should be the same for the other basins. As presented in that paper, Category 4 and 5 hurricanes require sea surface temperatures (SST) of over 27°Celsius. Thus the criteria that should be examined are anomalies in SST that result in increases of temperatures above the 27°C criteria. Category 5 hurricanes require temperatures 28°C. Has the area of SST above these thresholds increased, for example?

The Webster et al. Science article actually presents a range of SST values during the respective hurricane seasons for the different hurricane basins in Figure 1 of their paper. These range from around 29.5°C for the north Indian Ocean to around 27.5°C for the north Atlantic and eastern Pacific Ocean basins. Such an analysis suggests that regardless of SST temperature trends, the north Indian Ocean should have a greater proportion of Category 4 and 5 hurricanes. Clearly, there are other factors besides SST that determine the ability of the tropical cyclones to attain Category 4 and 5 intensities as we discussed in Pielke, R.A., Jr. and R.A. Pielke, Sr., 1997: Hurricanes: Their nature and impacts on society. John Wiley and Sons, England, 279 pp, and Pielke, R.A., 1990: The hurricane. Routledge Press, London, England, 228 pp. Indeed, it is rare for the hurricane to attain its maximum intensity due to other limitiations. The Science article is silent on the relation between the different SSTs in the different hurricane regions with respect to the proportion that reach category 4 and 5 intensities.

The major limitations that prevent hurricanes from reaching their full potential includes vertical wind shear, dry air intrusion, and less than optimal outflow aloft in the upper portion of the hurricane circulation. In idealized hurricane modeling it is relatively easy to create hurricanes that attain their maximum intensity, since these limitations are not prescribed in the model initialization or boundary conditions. In the real world, however, one or more of these limitations almost always exists (fortunately!). Hurricane Katrina is an example where a particularly effective outflow aloft, moist tropical air, and a lack of vertical wind shear, along with the elevated SSTs, permitted the cyclone to attain a category 5 intensity.

In Nicholls, M.E., and R.A. Pielke, 1995: A numerical investigation of the effect of vertical wind shear on tropical cyclone intensification. 21st Conference on Hurricanes and Tropical Meteorology, AMS, Boston, April 24-28, Miami, Florida, 339-341, we investigated the role of shear on hurricane intensification. In Eastman, J.L., M.E. Nicholls, and R.A. Pielke, 1996: A numerical simulation of Hurricane Andrew. Second International Symposium on Computational Wind Engineering, 4-8 August 1996, Fort Collins, CO , we investigated the skill in the simulation of a Category 4 and 5 hurricane. A clip of our model simulation of Hurricane Georges is available from Video Clip of Hurricane Georges (8 Megabytes). We suggest that the use of high resolution models of hurricane intensification as influenced by SST anomalies should be a high priority in addressing the issue of their role, relative to other influences, on hurricane intensification. It is only with fine-scale hurricane model simulations of real world systems that are able to resolve the eyewall region of the hurricane that we can adequately address the issue of the relative role of the spatial pattern and magnitude of SSTs on the intensity that they attain.

As another issue, why use 5-year running averages? Tropical cyclones respond to the SST that exists when they occur. The analysis should have correlated tropical cyclone intensity with the specific SST values for each event. The conclusions of the authors would be more robust if they evaluated the Category 4 and 5 hurricanes on a case by case basis with respect to the ocean SST temperatures and SST anomalies over which the hurricanes moved.

Finally, the same analysis, as shown by Pat Michaels (Global Warming and Hurricanes: Still No Connection), when applied to an earlier time period (starting in 1945) than in the Webster et al. Science study, indicates that a high proportion of Category 4 and 5 hurricanes also occurred then. Webster et al. is clear as to why

they chose to use the more recent era with the better data coverage. However, coverage for the Atlantic basin, for instance, is quite good since 1945 and should have been assessed against the more recent time period. The Michaels communication ideally should have been submitted to Science as a comment, so that Webster et al. would need to respond. Nonetheless, it highlights an important issue that needs to be resolved as to whether Webster et al. are analyzing the upward portion of a cyclic behavior of hurricane intensities or a real much longer-term trend.

Webster et al. do appear to recognize this issue. The Science article concludes with the statement (referring to the trend towards more frequent and intense hurricanes),

"This trend is not inconsistent with recent climate model simulations that a doubling of CO_2 may increase the frequency of the most intense tropical cyclones, although the attribution of the 30-year trends to global warming would require a longer global data record and, especially, a deeper understanding of the role of hurricanes in the general circulation of the atmosphere and ocean, even in the present climate state".

This qualification of their work was lost when the news media highlighted in their reports (e.g., see "Experts say global warming is causing stronger hurricanes").

The National Oceanographic and Atmospheric Administration (NOAA) provides a very valuable current assessment of SST anomalies , which can be directly related to the SST temperature anomalies presented in the Webster et al. paper. For example, for the September 17th data, above average SST temperatures in the Atlantic Ocean hurricane region is evident, as is the cooling to below average where the recent hurricanes have traveled. The analysis also shows a complex spatial pattern of SSTs which further supports the need for the Webster et al conclusions to be assessed with respect to the actual SSTs traversed by the hurricanes. The NOAA data also show that the hurricane region exceeds the threshold for Category 4 and 5 hurricanes, even without additional warming.

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HURRICANES AND GLOBAL WARMING: AN INTERVIEW WITH WILLIAM GRAY

Tech Central Station, 12 September 2005
http://www.techcentralstation.com/images/graytranscript.htm

Meteorologist Dr. William Gray may be the world's most famous hurricane expert. More than two decades ago, as professor of atmospheric science and head of the Tropical Meteorology Project at Colorado State University, he pioneered the science of hurricane forecasting. Each December, six months before the start of hurricane season, the now 75-year-old Gray and his team issue a long-range prediction of the number of major tropical storms that will arise in the Atlantic Ocean basin, as well as the number of hurricanes (with sustained winds of 74 miles per hour or more) and intense hurricanes (with winds of at least 111 mph). This year, Gray expects more activity, with 15 named storms, including 8 hurricanes. Four of them, he says, will be intense.

James Glassman: Dr. Gray, in the September issue of Discover Magazine, there's a remarkable interview with you. You're called the world's most famous hurricane...

Dr. William Gray: Well that - you have to talk to my critics about that. I don't think they would agree with you.

Glassman: Well you certainly...

Gray: I've been around a long time, yes. I've been around studying hurricanes over 50 years now, I'm an old guy. Yes.

Glassman: Well, you're in the hurricane forecasting business among other things?

Gray: Well, we're in the seasonal hurricane forecasting business, and monthly. We don't do the short range, you know, one to two day crucial forecasts. That can only be done by one group at the National Hurricane Center. But we certainly do a lot of forecasting for different parts of the globe and the hurricane from a seasonal, monthly point of view. Yes.

Glassman: And from a seasonal, monthly point of view, you had been predicting a growing number of hurricanes. Now, my question is in the wake of Katrina and some of the statements that we've heard immediately afterwards by advocates of the global warming theory - is global warming behind this increase in hurricanes?

Gray: I am very confident that it's not. I mean we have had global warming. That's not a question. The globe has warmed the last 30 years, and the last 10 years in particular. And we've had, at least the last 10 years, we've had a pick up in the Atlantic basin major storms. But in the earlier period, if we go back from 1970 through the middle '90s, that 25 year period - even though the globe was warming slightly, the number of major storms was down, quite a bit down.

Now, another feature of this is that the Atlantic operates differently. The other global storm basins, the Atlantic only has about 12 percent of the global storms. And in the other basins, the last 10 years - even though the Atlantic major storm activity has gone up greatly the last 10 years. In the other global basins, it's slightly gone down. You know, both frequency and strength of storms have not changed in these other basins. If anything, they've slightly gone down. So if this was a global warming thing, you would think, "Well gee, all of the basins should be responding much the same."

Glassman: You're familiar with what your colleagues believe. Do you think many hurricane experts would take a different point of view, and would say, "Oh, it's global warming that's causing hurricanes?"

Gray: No. All my colleagues that have been around a long time - I think if you go to ask the last four or five directors of the national hurricane center - we all don't think this is human-induced global warming. And, the people that say that it is are usually those that know very little about hurricanes. I mean, *there's almost an equation you can write the degree to which you believe global warming is causing major hurricanes to increase is inversely proportional to your knowledge about these storms.*

Now there's a few modelers around who know something about storms, but they would like to have the possibility open that global warming will make for more and intense storms *because there's a lot of money to be made on this*. You know, when governments step in and are saying this - particularly when the Clinton

administration was in - and our Vice President Gore was involved with things there, they were pushing this a lot. You know, most of meteorological research is funded by the federal government. And boy, *if you want to get federal funding, you better not come out and say human-induced global warming is a hoax because you stand the chance of not getting funded.*

Glassman: We thank you very, very much for this interview. Thank you, Dr. Gray.

Gray: Well thank you for asking me.

I am convinced myself that in 15 or 20 years, we're going to look back on this and see how grossly exaggerated it all was. That humans are not that powerful. These greenhouse gases, although they are building up, they cannot cause the type of warming these models say - two to five degrees centigrade with a doubling of the greenhouse gases.

Glassman: Well thank you very much for giving us your time.

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HURRICANES AND GLOBAL WARMING - AN INTERVIEW WITH JAMES J. O'BRIAN

Tech Central Station, 12 September 2005
http://www.techcentralstation.com/images/obrientranscript.htm

Dr. James J. O'Brien is Director of the Center for Ocean-Atmospheric Prediction Studies at Florida State University, where he is the Robert O. Lawton Distinguished Professor of Meteorology and Oceanography.

James Glassman: Dr. O'Brien, in the wake of Hurricane Katrina - in fact, within hours after Katrina hit - we heard a good deal of criticism, mostly from supporters of the Kyoto Protocol that the President and others had not done enough to stop global warming and that this hurricane was, in some way, caused by global warming. You are an expert on hurricanes: do you think that global warming has had an affect on the intensity of hurricanes?

Dr. James O'Brien: Absolutely not. All of the people who are hurricane scientists or teach about hurricanes at the graduate level that I've talked to agree with me.

Glassman: So the notion that the global warming advocates have - which is that there's more carbon dioxide pumped into the atmosphere which warms the surface of the earth, this is a phenomenon that's basically been increasing during the century.

O'Brien: Right.

Glassman: You would expect to have a fairly regular increase in hurricanes.

O'Brien: Well, let me give them some due, OK? Their contention is that the ocean is warming up and if the ocean warms up, we should expect stronger storms, OK? That's a reasonable theory.

Glassman: Right.

O'Brien: The problem is, what I've also looked into, is that if you actually - and they sort of believe that the sea water in the globe has warmed up about a half degree centigrade in the last 50 years or so.

O'Brien: But what's amazing is if you actually looked at the trends in the Atlantic Ocean - the region where hurricanes form from five north to 20 north - from Africa over to the United States, it's actually cooling down. So, I mean yes, there are hotspots in the globe which are warming up, but not in the Atlantic hurricane formation region. So, their theory doesn't really hold water.

Glassman: In fact, is there a cycle of hurricanes?

O'Brien: Yes. There actually is. You know, for the Atlantic region, some scientists have very carefully gone back in time to 1851 and recorded all the hurricanes that hit the United States. Everybody should realize before about 1970, we didn't have adequate satellites. So hurricanes occurred in the Atlantic that nobody knew about and certainly, didn't have measurements on them. But every one that hit the United States, there's certainly newspaper or diaries or other information and so, all of these things have been recorded.

If you take the strength of the hurricanes at landfall from 1851 to 2004 and plot it up, you'll see this remarkable semi-periodic thing come out with about 15 years or so of many storms, strong storms and then 15 years or so with much reduced storms and then 15 years... and it just keeps going like that over the 150 years we have records of. And so if you look at this long record, you'll see that there's *absolutely no evidence of any increase in strength*. Of course, in the periods when we have a lot of storms, you're likely to have stronger storms; and in the periods where you have less storms, you're likely not to have strong storms.

Glassman: Let me just pursue this as far as Katrina is concerned because we certainly heard lots of reports that the reason that Katrina intensified so much when it got into the Gulf of Mexico was that the Gulf itself was very warm, but is that a consequence of global warming?

O'Brien: No, it's really funny.

Glassman: You're laughing.

O'Brien: Yes, I laugh because the entire Gulf of Mexico in the summertime in August is over 90 degrees, OK. In other words, if I take the records from the last 50 years and average it out to get what people think is the normal temperature.

Glassman: Right.

O'Brien: It's always 90 degrees in the summertime, everywhere. So, it was 90 degrees and its always 90 degrees.

Glassman: So, the real problem here was that Katrina was really timing. I mean Katrina was a storm that, unfortunately, spent time in the Gulf of Mexico during the time when the water was hot.

O'Brien: Yes. I don't know the steering, but however it got disturbed going over the peninsula of Florida. What surprised everybody was when it came out into the Gulf of Mexico; it did this jog to the south. If you remember, it was going southwest for a while and that allowed it to get so far away from land that it had a long way to go before it was going to come back on shore.

Glassman: Sort of a running start.

O'Brien: So yes, it had a - you know, it's a long distance. It was going about 10 to 15 miles an hour. So it had a long time to gather up, from long distances, all this moisture from this hot water.

Glassman: Now, are you saying that people who study hurricanes do not feel that the reason that Katrina, or any other recent hurricanes, have been so intense is that the surface temperature of the earth has been increasing?

O'Brien: *With regard to people who work on hurricanes or are knowledgeable about the tropics - I don't know of anybody who would think that global warming is causing Katrina.*

Glassman: Thank you very much Dr. O'Brien.

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General comments: Benny Peiser

16 September 2005

What strikes me about the latest Science study on hurricane intensity (Webster, et al) is the apparent failure to assess whether similar periods of storm intensity were observed in the past. This question is, of course, relevant for anyone who wishes to associate the rise in hurricane intensity with global warming. After all, if similar periods of 'intense' cyclone and hurricane activity occurred when global mean temperatures were significantly lower than today, the alleged correlation between the current warming and storm intensity would be highly questionable. I had a look at NOAA's historical hurricane statistics and found that the late 19th century appears to be a period of higher hurricane intensity (as measured by "Accumulated Cyclone Energy") compared to the late 20th century.

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Pielke, Jr. and Emanuel statements on hurricane science to date.

Pielke:

"It is critically important to distinguish what has appeared in the peer-reviewed literature, from what a few vocal scientists say in the media. In the peer reviewed literature there are 3 important papers out this year. These papers are Emanual (Nature), Webster et al. (Science, to be published 9/16) and Pielke et al. (BAMS, December). Across these papers is a clear consensus on the science of climate change and hurricanes. Statements to the media by some other scientists, on

different sides of the issue, reflect what they expect future research to reveal, not what can be presently found in the literature." -- Personal communication, 9-7-05

"To summarize, claims of linkages between global warming and hurricane impacts are premature for three reasons. First, no connection has been established between greenhouse gas emissions and the observed behavior of hurricanes (IPCC 2001; Walsh 2004). Emanuel (2005) is suggestive of such a connection, but is by no means definitive. In the future, such a connection may be established (e.g., in the case of the observations of Emanuel 2005 or the projections of Knutson and Tuleya 2004) or made in the context of other metrics of tropical cyclone intensity and duration that remain to be closely examined. Second, the peer-reviewed literature reflects a scientific consensus exists that any future changes in hurricane intensities will likely be small in the context of observed variability (Knutson and Tuleya 2004, Henderson-Sellers et al 1998), while the scientific problem of tropical cyclogenesis is so far from being solved that little can be said about possible changes in frequency. And third, under the assumptions of the IPCC, expected future damages to society of its projected changes in the behavior of hurricanes are dwarfed by the influence of its own projections of growing wealth and population (Pielke at al. 2000). While future research or experience may yet overturn these conclusions, the state of knowledge today is such that while there are good reasons to expect that any conclusive connection between global warming and hurricanes or their impacts will not be made in the near term."

http://sciencepolicy.colorado.edu/prometheus/archives/climate_change/000558correction_of_misquo.html

Emanuel:

Here is what Emanuel himself says of his study:

Q. "How can you assert that the upswing [in hurricane intensity] in the last 50 years is a consequence of global warming?

A: We cannot say for sure. What we can say is that everywhere we have looked, the change in hurricane energy consumption follows very closely the change in tropical sea surface temperature.

Q: Does this mean that we are seeing more hurricane-caused damage in the U.S. and elsewhere?

A: There is a huge upward trend in hurricane damage in the U.S., but all or almost all of this is due to increasing coastal population and building in hurricane-prone areas. When this increase in population and wealth is accounted for, there is no discernible trend left in the hurricane damage data. ...While we can already detect trends in data for global hurricane activity considering the whole life of each storm, we estimate that it would take at least another 50 years to detect any long-term trend in U.S. land falling hurricane statistics, so powerful is the role of chance in these numbers.

Q: I gather from this last discussion that it would be absurd to attribute the Katrina disaster to global warming?

A: Yes, it would be absurd.

http://wind.mit.edu/~emanuel/anthro2.htm

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Hurricanes and Global Warming
Revised 18 August 2005
Accepted 27 August 2005
Pielke, Jr., R. A., C. Landsea, M. Mayfield, J. Laver and R. Pasch, in press, 2005. December. Hurricanes and global warming, *Bulletin of the American Meteorological Society*.

http://sciencepolicy.colorado.edu/admin/publication_files/resourse-1766-2005.36.pdf

Abstract
This paper reviews recent research on tropical cyclones and climate change from the perspective of event risk – the physical behavior of storms, vulnerability – the characteristics of a system that create the potential for impacts, but independent of event risk, and also outcome risk – the integration of considerations of vulnerability with event risk to characterize an event that causes losses. The paper concludes that with no trend identified in various metrics of hurricane damage over the 20th century, it is exceedingly unlikely that scientists will identify large changes in historical storm behavior that have significant societal implications, though scientists may identify discernible changes in storm behavior. Looking to the future, until scientists conclude (a) that there will be changes to storms that are significantly larger than observed in the past, (b) that such changes are correlated to measures of societal impact, and (c) that the effects of such changes are significant in the context of inexorable growth in population and property at risk, then *it is reasonable to conclude that the significance of any connection of human caused climate change to hurricane impacts necessarily has been and will continue to be exceedingly small*.

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Comments on "Increasing destructiveness of tropical cyclones over the past 30 years"

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Letter to *Nature*, concerning Emanuel's paper.

Sir—The strongest observed linkage reported to date between increases in global temperature and increases in tropical cyclone intensity was made recently by Emanuel[1], who examined the temporal behavior of the power dissipation index (PDI), the annual sum of the cube of the maximum wind speed for each tropical cyclone observation made in the North Atlantic and Western Pacific basins. In these tropical cyclone basins, the PDI appeared to increase rapidly during the past several decades. However, a closer examination of the underlying data indicates that the long-term trend in the Atlantic basin is largely the result of the exceptionally active tropical cyclone seasons of 2003 and 2004 rather than a gradual build-up during the recent era of global temperature increases.

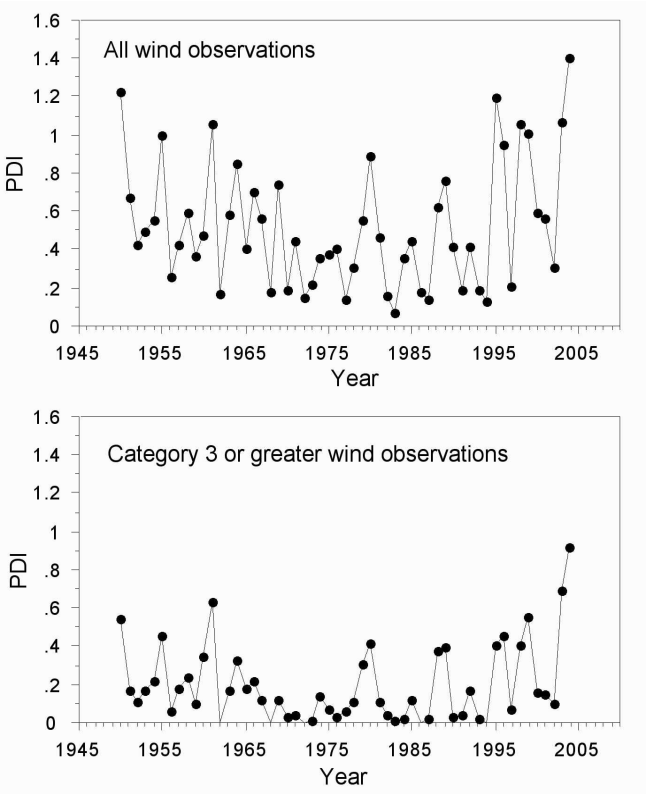

Figure 1a (top). Unfiltered, annual PDI values for the North Atlantic basin, 1950-2004, calculated according to Emanuel[1] and multiplied by 2.1 X 10^{-12} as in Emanuel[1]. **Figure 1b** (bottom). Unfiltered, annual PDI values calculated using only those wind observations greater than 95 kts (greater than category 2 on the Saffir-Simpson scale).

Annual PDI values were not depicted by Emanuel[1]. Instead values were shown that were double filtered using a 1-2-1 smoother than tends to emphasize groupings of two to three years. This is particularly evident in the Atlantic basin, where 2003 and 2004 are the consecutive years with the highest combined PDI value and consequently the greatest value in Emanuel[1] Figure 1. However, using the technique described by Emanuel[1], a filtered value for 2004 cannot be produced without knowledge of the conditions in 2005—knowledge which will not be available until the end of the 2005 hurricane season. In fact, it is not even possible to produce a correctly filtered value for 2003 without the 2005 value, if the filter is applied twice in succession as described. Had the analysis in Emanuel[1] properly ended in 2002, the conclusions would have been radically different, clearly indicating the well-known tropical cyclone periodicity in the Atlantic basin, and little else.

Alternatively, actual, unfiltered values of the PDI could have been presented. We calculated our own PDI values applying the methodology described by Emanuel[1], and present them in Figure 1a. Aside from 2004, the PDI values since the beginning of the active tropical cyclone period in 1995[2] are not historically unprecedented. Additionally, we have taken the analysis one step further and calculated the PDI values for only those tropical cyclone observations in the North Atlantic basin that exceeded 95 kts—the threshold for a category 3 storm on the Saffir-Simpson scale—a storm which, according to the National Hurricane Center, contains winds of sufficient magnitude to begin to cause some structural damage to small buildings. Since the PDI was created as an indicator for storm damage, it seems that it would have its greatest usefulness when applied to conditions which yield significant wind-related impacts. Figure 1b shows our results for category 3 observations and stronger. Again, the PDI values for the years 2003 and 2004 stand out as historically significant, but otherwise, there seems to be little to indicate conditions during the current active tropical cyclone period are different than those during the previous active period during the 1950s and 1960s.

Therefore, we find it difficult to reach the conclusion that there exists a clear association between global temperature increases and increases in tropical cyclone intensity as this conclusion is highly dependent on just two years worth of observations—observations taken during a time when Atlantic basin tropical cyclone activity is known to be enhanced for other reasons[2]. We therefore would suggest that the declaration of an observable relationship between rising global temperature and tropical cyclone activity is premature.

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There's no shame in good hurricane science

http://www.reason.com/hod/pm081705.shtml

August 17, 2005
Patrick J. Michaels

Given the recent claims that hurricanes are getting dramatically worse because of global warming, it's too bad we've already exhausted the letter "G" for this hurricane season. "Gasbag" would have been a pretty good moniker for the next storm. In case you've missed the hype, MIT's Kerry Emanuel has a paper in the online version of *Nature* magazine saying that hurricanes are becoming dramatically more powerful as a result of global warming.

Merely venturing into the discussion of hurricanes and global warming is more dangerous than most tropical cyclones. About Emanuel's article, William Gray of Colorado State University—the guy who issues the annual hurricane forecast that grabs headlines every summer—told the *Boston Globe*, "It's a terrible paper, one of the worst I've ever looked at."

There's also nastiness if you say hurricanes aren't getting worse. A month ago, University of Colorado's Roger Pielke, Jr., posted a paper that was accepted in the *Bulletin of The American Meteorological Society* concluding there is little if any sign of global warming in hurricane patterns. In a pre-emptive strike, Kevin Trenberth from the federally funded National Center for Atmospheric Research in Boulder, Colorado, told the local newspaper, "I think he [Pielke] should withdraw his article. This is a shameful article."

Six months earlier, Christopher Landsea of the National Hurricane Research Laboratory, another federal entity, quit the United Nations' Intergovernmental Panel on Climate Change. Landsea is probably the world's most respected hurricane scientist. He was furious that Rajenda Pauchari, director of the panel, condoned Trenberth's statements that hurricanes were worsening because of global warming. What is going on here? Nothing unusual. Behavior like this takes place every day at faculty meetings across academia. But global warming and hurricanes are hot topics right now, so the bickering spills over into the press.

What is unusual is the especially shoddy nature of the current scientific review process on global warming papers.

Consider the recent *Nature* article. If hurricanes had doubled in power in the last few decades as Emanuel claims, the change would be obvious; you wouldn't need a weatherman to know which way this wind was blowing. All of these feuding scientists would have agreed on the facts long ago.

Damages caused by doubling the strength of hurricanes would be massive and increasing dramatically. Figures on this are pretty easy to come by, at least in the United States. The insured value of property from Brownsville, Texas to Eastport, Maine—our hurricane prone Atlantic Coast—is greater than a year of our Gross Domestic Product. If hurricanes had actually doubled in power, the losses in the insurance industry would be catastrophic.

Pielke has studied this, and his work is well known. Hurricanes are causing greater dollar damages because more and more people are building increasingly expensive beachfront monstrosities that have financially appreciated during the recent real-estate bubble. Account for these and there is no significant change in hurricane expenses along our coast. Illinois climatologist Stanley Changnon has also studied this for non-hurricane weather damage over the entire country with similar results. Pielke told me that, "analysis of hurricane damage over the past century shows no trend in hurricane destructiveness, once the data are adjusted to account for the dramatic growth along the nation's coasts."

You would think that reviewers of Emanuel's paper at *Nature* would have thought to ask whether, in fact, there was evidence for increasingly powerful storms.
But they didn't. There is just no incentive in the scientific community to kill the remarkably fertile global warming goose, a beast that feeds on public fears.
The federal outlay on climate research is now $4.2 billion per year, roughly the same amount given to the National Cancer Institute. The climate research community sees a grave threat when research shows there's no threat from the climate. So papers that hawk climate disaster get superficial reviews and uncritical headlines, while those that argue otherwise are "shameful."
Patrick J. Michaels is Cato Institute senior fellow for environmental studies and author of Meltdown: The Predictable Distortion of Global Warming by Scientists, Politicians, and the Media.

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HURRICANES AND GLOBAL WARMING - IS THERE A LINK?

Tech Central Station, 14 September 2005
http://www.techcentralstation.com/091404D.html

By **George Taylor**

I could see this one coming.

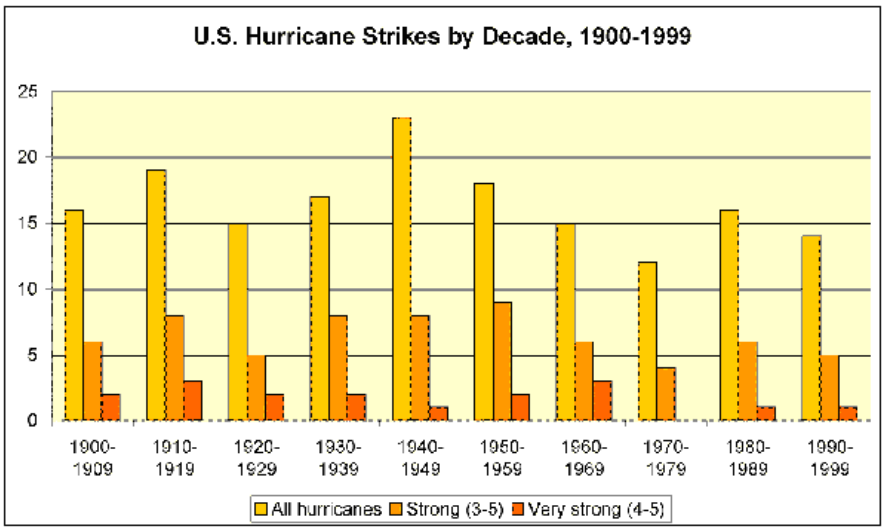
The other day a lady in my department saw me and said, "Well, George, with all these hurricanes it's pretty clear that global warming is happening, right?" I think Jane was just being playful, because she's heard me talk about global warming and knows of my "politically incorrect" viewpoint on this issue, Yet she raises a question that a lot of people have been asking: does the busy hurricane year in the Atlantic have anything to do with global warming?

The short answer: no.

The long answer: Long-term statistics on hurricanes are quite good, so we can have some confidence in the trends we see in hurricane counts. There are two reasons for this: (1) hurricanes are big, powerful storms and very hard to miss; (2) they are well-defined. The Saffir-Simpson scale uses wind speed (one-minute average) to define a hurricane's strength, starting at 74 mph (Category 1) and ending at speeds above 155 mph (Category 5). Other rating systems use central pressure as a criterion.

Figure 1, obtained from data provided by the National Hurricane Center, shows hurricane strikes (landfalls) by decade in the U.S. since 1900. The 1940s were rather busy, the 70s the quietest, and the 1990s pretty close to the long-term average. A simple linear fit suggests a decrease over time. This is a result echoed by Easterling, et al (2000), who said, "the number of intense and landfalling Atlantic hurricanes has declined." In the Gulf of Mexico there is "no sign of an increase in hurricane frequency or intensity," according to Bove, et al (1998). For the North Atlantic as a whole, according to the United Nations Environment Programme of the World Meteorological Organization, "Reliable data ... since the 1940s indicate that the peak strength of the strongest hurricanes has not changed, and the mean maximum intensity of all hurricanes has decreased."

Granted, there has been an upswing in the Atlantic since 1995, and this year's bumper crop of storms has struck Florida in numbers and intensities seldom occurring before. A sign of things to come, especially in a warmer world? Not according to Bill Gray's Tropical Forecast group at Colorado State University. Gray, who has developed successful methods for predicting hurricane activity, said, "Various groups and individuals have suggested that the recent large upswing in Atlantic hurricane activity (since 1995) may be in some way related to the effects of increased man-made greenhouse gases such as carbon dioxide (CO2). There is no reasonable scientific way that such an interpretation of this recent upward shift in Atlantic hurricane activity can be made."



And there is no reason to expect increases in hurricanes due to greenhouse warming. Climate models, for all their problems, are unanimous in at least one respect: they predict that most of the future warming will be in high latitudes, in the polar regions. This will reduce the north-south temperature gradient and make poleward transfer of heat less vigorous -- a task in which tropical storms play a major role. All other things being equal, a warmer world should have fewer, not more, hurricanes.

The same effect should reduce the overall intensity of mid-latitude storms as well. Does it? Let's examine the evidence.

Schwartz and Schmidlin (2002) analyzed frequencies of blizzards in the US since 1959. Defining a blizzard as a storm with falling or blowing snow, visibilities less than 400 meters and winds over 16 m/sec, they concluded that there have been increasing numbers of blizzards reported, while the area affected by all blizzards has not changed significantly. This would indicate that blizzards are becoming smaller. It is also possible that "NWS is recording smaller, weaker blizzards in recent years that

went unrecorded earlier in the period, as occurred also in the official record of tornadoes in the United States," which would suggest that blizzard frequency increases may be overstated.

Changnon and Changnon (2000) studied hail frequencies in the US over the last century. They found that "the national average based on all hail values formed a bell-shaped 100year distribution with hail occurrences peaking in mid-century." Thunderstorm distributions were similar to the hail results. Further, the authors found that hail insurance loss values have declined since the 1950s, in agreement with the hail results.

Zhang, et al (2000) examined storm activity along the US East Coast over the twentieth century. After stating, "it has been speculated that future global warming will change the frequency and severity of tropical and extratropical storms," the authors used historical data in an attempt to help predict future trends. Using a variety of indices, including storm surge water levels, the authors found "no significant trend in storm activity during this century along the East Coast." The real problem along the coastline, they say, is not changing climate but changing land use, as more and more development occurs along the shorelines, creating greater susceptibility to storm damage.

Gulev, et al (2000) employed NCEP/NCAR reanalysis data since 1958 to study the occurrence of winter storms over the northern hemisphere. They found a statistically significant (at the 95% level) decline of 1.2 cyclones per year for the period, during which temperatures reportedly rose in much of the hemisphere.

"Global warming causes increased storminess" makes for interesting headlines. It also violates fundamental scientific truth and the lessons of history.

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Katrina and history

Montreal Gazette
Thursday, September 1, 2005
Page: A21
Section: Editorial / Op-Ed
By **TAD MURTY**

From time immemorial, people have worried about the weather. And for very good reason. From the thunderstorm that contributed to the slaughter of three Roman legions in Germany and the brutal cold that demolished the armies of Napoleon and Hitler to the cool, rainy summer that resulted in Ireland's potato famine, weather has had a massive impact on human history.

Weather affects us today as well, as Hurricane Katrina's devastation of New Orleans and the Gulf Coast of Mississippi this week demonstrated all too clearly.

However, it is only recently that it has become fashionable for governments, environmental activists and many in the media to also worry about the weather 30, 50 or even 100 years in the future.

"Altering climate patterns will cause more frequent and severe extreme weather events ... threatening the health and safety of Canadians and people around the globe," exclaims Environment Canada in Project Green.

Natural Resources Canada's posters are distributed to schools with claims that, "Experts anticipate more severe thunderstorms, which can cause injury and property damage, ... [and] more frequent freezing-rain events."

Environmental groups seem to be competing with each other for the most terrifying forecasts. While the David Suzuki Foundation warns of increasingly "bizarre weather" and the impact of "new weather patterns" that "will generate unexpected new types of disasters," the Sierra Club asserts that "Canada can expect increased persistent droughts, retreating glaciers, more floods, more sudden deluges of rain washing contaminants to watercourses, a warming and melting Arctic, dropping Great Lakes levels, loss of water quality, more ice storms, more forest fires, more severe coastal storm surges and more extremely hot days, and thus, more smog days in summer."

All this would be quite worrisome if it were true. Fortunately, there is no significant scientific data to back up these claims.

Even a cursory check of the websites of prominent meteorological

services clearly shows that neither the frequency nor the intensity of natural disasters has increased. Observational evidence, based on real, measured data, shows nothing unusual is happening.

In one of the recent special issues of the Netherlands-based International Journal of Natural Hazards, we had several peer-reviewed papers on extreme weather events in different parts of the world - windstorms over the Canadian Prairies, floods in North Carolina, global monsoons, etc. No support was demonstrated for the global warming/extreme weather hypothesis whatsoever.

The impact of natural hazards is much worse, but that's because population is growing and coastal infrastructure is getting ever bigger and more complex. However, out of the 2,000 or so manuscripts that crossed my desk in my 18 years as editor of Natural Hazards, I can't recall a single one based on actual observations that claimed that global warming has anything to do with extreme weather events.

Yes, many papers based on computer models tell a different story. But after being associated with such simulations for the past 45 years, I have little faith in their predictions. With a very slight "tweaking" of one single parameter (low cloud amount) in the model, forecasts can change abruptly from global warming to an ice age. Before coming to any conclusions about extreme weather trends, we must examine measurements of what is really happening in the world.

Hurricanes, or "severe cyclones" as they are referred to in India, can be especially devastating. I have examined about 20 different atmospheric and oceanographic parameters associated with hurricanes around the globe using all available historical data up to the end of 2004. Not a single record was set after October 1979.

The two basins in the world most affected by hurricanes are the Bay of Bengal in South Asia and the Gulf of Mexico. Since 1995, there has been an increase in the annual number of tropical cyclones in the Gulf of Mexico. However, no new records have been set and nothing that cannot be attributed to natural variability is happening.

But how about the Bay of Bengal, a region sociologists refer to as the mother of all hazard-prone areas?

My colleagues in India and I put together a 200-year database and found that the total number of cyclones in the 20th century is about half of that in the 19th. For the state of Orissa, which is the most affected in India, there were 72 storm surges in the 19th century and 56 in the 20th. There were three super cyclones in the 19th century and only one in the 20th. The most intense hurricane in history occurred in this region in 1876, creating a storm surge with a maximum height of 13.6 metres.

In the Indian state of Andhra, the second-most affected in the country, the last time there was a cyclone of any consequence was in 1996. This lack of activity is making it very difficult for state disaster managers

to keep the public, media and politicians interested in cyclones. If indeed climate change is increasing the frequency and intensity of hurricanes and other extreme weather, it is not at all obvious in the observational records.

Extreme weather events have always been with us and they will always be with us in future. We cannot do very much about them, except to try to adapt to them in the best way we can.

-- *Tad Murty*, formerly senior research scientist with Fisheries and Oceans Canada, teaches civil engineering at the University of Ottawa and edits the international scientific journal Natural Hazards.

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Correction of Errors in Fortune Story

http://sciencepolicy.colorado.edu/prometheus/archives/environment/000554correction_of_errors.html

September 3, 2005

Post co-authored by **Roger Pielke, Jr.** (RP) and **Kerry Emanuel** (KE)
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Over this past week as the horrific disaster along the Gulf coast has developed in the aftermath of Hurricane Katrina, we have both been quoted extensively in the media based on our various work on hurricanes. For the most part the reporting of our views has been accurate and responsible. With this short post, we'd like to correct some significant mischaracterizations and errors in a Fortune news story. We address them below.

1. The Fortune story states, "But Emanuel and other experts have warned for over a decade that global warming may be creating an environment prone to more violent storms, droughts and other weather extremes ... " This may be true of "other experts" but it is not an accurate characterization of KE's statements over the past decade.

2. The Fortune story states, "A forthcoming paper co-authored by University of Colorado researcher Roger Pielke Jr. argues that by 2050, hurricane losses due to both coastal population growth and the rising value of coastal property will be 22 to 60 times greater than those that are potentially caused by global warming's effects. Ironically, MIT's Professor Emanuel was a co-author of that paper. But after compiling the startling data on intensifying hurricanes, he says, "I changed my mind" and struck his name from the authors' list."

The reason that KE decided to withdraw amicably from co-authorship had nothing to do with the paper's summary of research on the societal impacts of hurricanes, as implied here, but instead, a change in KE's views on the significance of global warming in observed and projected hurricane behavior. It is misleading to use KE's withdraw to dismiss the entire paper. Here is how KE characterized his withdrawal to RP in an email:

> "The awkward situation we find ourselves in is bound to occur when research is in rapid flux. Working with both data and models, I see a large global warming signal in hurricanes. But it remains for me to persuade you and other of my colleagues of this, and it is entirely reasonable for you all to be skeptical...it is, after all, very new. It is not surprising, therefore, that what I have come to believe is at odds with any reasonable consensus. The problem for me is that I cannot sign on to a paper which makes statements I no longer believe are true, even though the consensus is comfortable with them."

We remain close, collegial colleagues who are seeking to advance science by challenging each others ideas in the traditional fora of scientific discourse. We hope that the media will recognize that science is complex and legitimate, differing perspectives often co-exist simultaneously. This diversity of perspective is one feature that motivates the advancement of knowledge.

3. The Fortune story states, "Emanuel found that since 1949, the average peak wind speeds of hurricanes over the North Atlantic and the western and eastern North Pacific has increased by a whopping 50%... Meanwhile the duration of the storms, in terms of the total number of days they lasted on an annual basis, rose by roughly 60%." This is a mischaracterization of the recent research conducted by KE, which instead found an increase in the power dissipation of hurricanes, an integrated measure of peak wind speeds and storm duration; it is the cube of the wind speed that has increased by about 50%, not the wind speed itself.

4. Finally, the story misuses the term "hypercanes" which refers to theoretical research conducted by KE and colleagues in the mid-1990s. The term has nothing to do with the present or near-term future. Hypercanes require ocean temperatures of at least 50 C and may have formed shortly after collisions of large extraterrestrial bodies, such as asteroids, with the earth; they will not arise as a consequence of global warming.

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Manufactured Controversy - Comments on Today's Chronicle Article

http://sciencepolicy.colorado.edu/prometheus/archives/climate_change/000560manufactured_controv.html#comments

Posted to **Author: Pielke Jr., R**

Richard Monastersky has a lengthy article in the Chronicle of Higher Education that discusses at length our forthcoming paper in BAMS on hurricanes and global warming. Monasterky's article includes some very good reporting, particularly at the end, but it also contains some very significant errors and mischaracterizations in the early sections that I address below. The article is most accurate beginning with the Section titled "Hot Air." My main complaint with the article is that it seeks to create the appearance of a conflict where, at least from the text of our BAMS paper, one does not exist.

1. Monastersky starts the article by saying, "When it came to global warming and hurricanes, Kerry A. Emanuel used to be a skeptic." This is an odd choice of words. Emanuel, in his own words is outside the current scientific consensus on this subject,

writing of his recent study, "It is not surprising, therefore, that what I have come to believe is at odds with any reasonable consensus." It seems to me that the term "skeptic" should be reserved for those who are challenging a current consensus, rather than as Monastersky would have it, anyone who doesn't believe that global warming affects (fill in the blank). Otherwise, the term "skeptic" becomes a political label. On hurricanes and global warming it is Emanuel who has described himself skeptical of the current consensus.

2. Monastersky characterizes our BAMS paper as "dismissing the idea that climate change would make hurricanes significantly more dangerous." This is a significant misrepresentation of our paper. Our abstract is considerably more nuanced than this, "Looking to the future, until scientists conclude (a) that there will be changes to storms that are significantly larger than observed in the past, (b) that such changes are correlated to measures of societal impact, and (c) that the effects of such changes are significant in the context of inexorable growth in population and property at risk, then it is reasonable to conclude that the significance of any connection of human-caused climate change to hurricane impacts necessarily has been and will continue to be exceedingly small." This is not a dismissal but a frank acknowledgement of the conditions under which we would expect to see a larger significance of the connections of hurricanes and climate change. Monastersky has grossly misrepresented our paper.

3. Monastersky writes, "He withdrew his name from the forthcoming paper that plays down global warming's influence on hurricanes. Then he published a new study in Nature last month, proclaiming the opposite conclusion." No. No. No. Emanuel's paper is not "opposite" of our BAMS paper. We acknowledge the Emanuel paper in our paper and write that Emanuel (2005) is "suggestive" of a connection between hurricanes and global warming. That is hardly opposite. Monasterky is creating a conflict where none exists. Our paper does not "play down" the effect of global warming and hurricanes; it is an accurate assessment of the current literature. Monastersky is creating a straw man.

4. Monastersky contradicts himself in trying to create a conflict where none exists. He writes,

> "On one side stand Mr. Emanuel and other researchers who use computer models to predict storm behavior. They see signs that a hotter climate will brew more-damaging storms. On the other side, Mr. Emanuel's former co-authors argue that global warming will have little or no influence on storms. "It seems pretty clear, looking back in time from the perspective of damages, we're not going to find a large change in the behavior of storms," says Roger A. Pielke Jr., an associate professor of environmental studies at the University of Colorado at Boulder and the lead author of the paper that Mr. Emanuel had once supported."

There are two points here. One is that our paper does not (!) say that global warming will have "little or no influence on storms". Again this is a gross mischaracterization of what we have written. We cite the exact same literature that Emanuel does to describe current projections for future effects of climate change on storms (e.g., Knutson and Tuleya). There is agreement on this point. Second, on the relative effects of climate changes versus societal changes on future damages Emanuel agrees completely with our assessment. Here is what Monasterky writes

later in the article, "Nonetheless, [Emanuel] agrees with his former co-authors that the most important factor for increased damage in the near term is coastal development, along with related societal forces."

Also, here is what Emanuel says on his WWW page, "There is a huge upward trend in hurricane damage in the U.S., but all or almost all of this is due to increasing coastal population and building in hurricane-prone areas. When this increase in population and wealth is accounted for, there is no discernible trend left in the hurricane damage data." Monastersky is trying to play "one side" against the "other side" but this is simply inaccurate. Both "sides," such as they are, agree that climate change may affect hurricanes and also that societal changes will continue to dominate the damage record decades into the future. This represents a consensus, not conflict. (Also, a small error, I am a full professor, not associate professor.) Emanuel and Landsea may disagree with the merits of Emanuel (2005) and they can play that out in the peer-reviewed literature in the future. None of their disagreement appears in our BAMS paper, because it doesn't appear in the peer-reviewed literature.
5. We submitted the paper originally Nature, not Science as Monastersky reports, and the paper was not sent out for review as being "too specialized" and more appropriate for the disciplinary literature.

Overall, I am disappointed by this piece because it reports this issue in terms of a conflict that doesn't exist. The real story here is one of consensus on important issues. But I guess that just isn't as sexy a story.

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THE METEOROLOGIST'S ROLE IN SOCIETY

Breeze, Newsletter of the Indian Meteorological Society, Chennai Chapter, Vol. 8, No. 1, May 2005

S. Raghavan[1]

Science was once considered as purely the pursuit of knowledge. One scientist is quoted as saying "May it be of no use to anyone"! Application of science for practical benefit came later. Michael Faraday is said to have apprised the then British Prime Minister of his discovery of electromagnetic induction. The PM asked "What use is it, Mr. Faraday?" Faraday is reported as replying "You may be able to tax it some day". It was perhaps Faraday's view that tax was the only thing a politician would understand. But Faraday's words were prophetic. Latter day politicians and administrators are reluctant in funding research in pure science and appreciate only the applications.

Coming to Meteorology, a few decades ago, the meteorologist was content with practising his/her science. For example, if a cyclone was detected in the Bay of Bengal the job of the meteorologist was just to issue forecasts and warnings. It was for the recipients of the warnings to think of the consequences and take action to mitigate the disaster. Seeing that this did not work well, the India Meteorological Department under the leadership of Dr. P. Koteswaram, initiated a coordination between the meteorologists and various other organisations. This has helped disaster managers and the public to a considerable extent to appreciate the nature of a cyclone, and prepare for it rather than lament after the event. More remains to be done in this area.

But apart from cyclone disasters there are several other aspects of weather and climate which impact on us in terms of health, quality of life, and economic development. Floods, water scarcity, air pollution, wind and solar energy and the much talked about climate change are all issues where meteorology is an important factor. On the positive side, weather and climate are resources which when properly exploited can yield large economic benefits. By choosing not to load additional fuel for possible diversions whenever a reliable terminal aerodrome forecast (TAF) indicated fair weather, an Australian airline saved Australian $16 million in a year (Anaman et al., 1998). A fertiliser firm plans its distribution based on weather and climate information. The impact of air pollution can be minimised by locating industries considering the meteorological factors determining pollutant distribution. A knowledge of the wind distribution is obviously necessary for planning location of wind mills.

The impact of any meteorological phenomenon or event on society depends on various factors, natural, social, economic and political. For example scarcity of water gets often attributed to lack of rain, while actually the scarcity may be due to various other factors, such as increasing demand, overexploitation of ground water and lack of storage facilities (Raghavan, 2003). The increasing damage in all countries due to tropical cyclones is often attributed to an increase in frequency or intensity of cyclones perhaps due to global warming, but it has been shown that this is not true (IPCC, 2001); the increased damage is due to increased economic activity and population increase in coastal areas (Pielke and Landsea, 1998; Raghavan and Rajesh, 2003). Thus it is necessary to distinguish between the phenomenon and its impact. Politicians and administrators as well as the public have to evaluate the impact on society of the various phenomena and take decisions in the face of uncertainties. Apparently scientific but incorrect or sensational information is often fed to them. The meteorologist has therefore a responsibility in bringing about a correct appreciation of the nature of the meteorological phenomena and the factors which determine their impact, on the part of politicians, administrators and society in general and in removing misconceptions.

To give a seemingly trivial example, there was an agitation against wind power generators in Maharashtra recently because of a belief that the wind mills were driving away the clouds and causing drought. One is reminded of the belief some decades ago (now taken as a joke) that hydroelectric power stations were taking away electricity from the water, which was rendered unfit for irrigation! But the agitation had to be taken seriously as it became a convenient stick for the opposition parties to beat the government with.

A much misunderstood phenomenon is "global climate change". There is a widespread impression that

(1) the world is getting warmer and this is due to increase of greenhouse gases emitted by human activities and

(2) that because of this there will be dire consequences such as rise in sea level, flooding of low lands, melting of glaciers, heat waves, increase of floods, droughts and tropical cyclones, changes in biota and so on in many parts of the world.

This has been dramatised recently in an American movie "The Day After Tomorrow". How much of this is really true?

There is a preponderance of scientific opinion (see e.g. IPCC, 2001) that temperatures in most parts of the world are increasing and that much of the increase is probably anthropogenic i.e. due to human activities. Some scientists disagree

about the existence of global warming and others think that there are causes other than greenhouse gases. Therein lies the scientific method. Unlike in matters of faith, scientific inferences are based on experiment and inquiry. Any scientific hypothesis is subject to overthrow if new findings are made, which are not explicable by the theory.

The science behind global warming is complicated by several phenomena working at cross purposes and the play of several negative and positive feedback mechanisms. To mention only a few, increase of greenhouse gases may cause warming, but will also increase clouding which may reduce the warming. Melting of sea ice will lead to more warming. Aerosols are also generated by human activities and some of these cool the atmosphere. Changes in different regions may be different. Changes in regional or even global temperatures can be brought about by changes in land use processes e.g. conversion of forests into farms (see e.g. Pielke et al., 2002). It may not be safe to extrapolate the warming over the future. A single catastrophic event e.g. a major volcanic eruption, can cause cooling for several years, partially neutralising the warming. Temperature changes can occur due to astronomical causes e.g. variation in solar radiation or changes in earth's orbital parameters (Clement et al., 2001). Though astronomical changes are very slow, there can be sudden switches in a time frame of a few decades. On a shorter time scale there is a recent finding relating low sunspot activity to low crop yield! (New Scientist, 18 November 2004). Glaciers in Switzerland and in the Himalayas are said to be melting (New Scientist News Service, 16 April 2002). This is an expected result of global warming. But it is also found that evaporation (measured by pan evaporimeters) and potential evapotranspiration are decreasing over the years (Chattopadhyay and Hulme, 1997; Roderick and Farquhar, 2002). This is contrary to the expectation that air will become drier but can be explained in terms of decreases in sunlight resulting from increasing cloud coverage and aerosol concentration.

Impact of floods and probably floods themselves are increasing not because of global warming but because of other human activities, e.g. land use changes, deforestation and occupation of flood plains due to population pressures.

Another whipping boy is the El Niño, which is supposedly the cause of all the ills of the world. There are some who claim to forecast weather for long periods using the El Niño as the sole input. Such simplistic predictions often boomerang badly. In 1997, when a major El Niño developed, widespread fears of a major drought in southern Africa were generated. This did not materialise. People made decisions based on the likelihood of drought, such as not planting, that ultimately hurt them (Dilley, 2002). There are numerous other examples of simplistic wrong predictions.

Based on findings of the INDOEX programme of the late nineties, a report appeared of an "Asian Brown Cloud" (ABC) in the form of pollution from the Asian mainland spreading over south Asia and the adjacent Indian Ocean, and it was claimed that it would have serious adverse effects on the monsoon and agriculture. However, Srinivasan and Gadgil (2002) have pointed out that such sensational claims have no scientific basis. Similar pollution occurs over other parts of the globe but that is being underplayed. Also the ABC occurs in the period January to March and has little relevance to the monsoon.

We are also frequently told that the monsoon rains have decreased over the years and there is consequent drought. Examination of rainfall data over various regions of India shows that while there are large year-to-year variations, there is no trend of decreasing rainfall. It is however true that water has become scarcer. The

reason for this is not failure of rainfall but our inability to plan for water storage, conservation and augmentation of resources and even our deliberate destruction of existing resources in the name of development (Raghavan, 2003).

Several remedies for water scarcity are suggested e.g. linking of rivers, desalination of sea water and rain enhancement by seeding of clouds. We see many desperate crisis management programmes of cloud seeding in times of drought, which are not likely to succeed and only result in expenditure. Since weather modification is not a proven technology, it is necessary to gain a scientific understanding of cloud processes and plan seeding programmes carefully and evaluate them objectively (NAS, 2003). A scientific programme is being planned in India.

Unfortunately some of the misconceptions mentioned above are not born solely out of a lack of appreciation of meteorological science. Misinformation is often deliberately propagated. If water scarcity is attributed to lack of rainfall, that becomes an act of God and the authority responsible for water management is absolved of failure. If the impact of drought is exaggerated, more funds can be obtained from the authorities concerned. If adverse consequences are predicted from climate change, funding can be obtained ostensibly for their mitigation. Business interests have an obvious advantage in denying or down-playing the effects of air pollution or green house gas emissions. Conflict of interest between different sections of the population is often generated. Political considerations may often lead to exaggeration of some phenomena such as the ABC or the role of methane generated by cattle of India and China.

Wrong or pseudo-scientific inferences often lead to wrong solutions and diversion of resources to misguided programmes. It is therefore appropriate for meteorologists to present balanced scientific evidence on such issues to governments and the public. They should also create an awareness of how to benefit from weather and climate as resources. This will enable society to gain the maximum benefits and mitigate adverse consequences. It is necessary to build up credible mechanisms such that the voice of meteorologists will be heard with attention at all fora. The Indian Meteorological Society should organise itself to do this.

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