Are Rising CO_2 Levels And The Increase In Atlantic Major Hurricanes Since 1995 Related?

By Dr. William Gray

The official end of the 2008 Atlantic basin hurricane season occurred last Sunday (November 30). This year was an active and destructive season. My colleague, Phil Klotzbach and I were very happy to see that our forecasts for this year's activity worked out well, as did NOAA's seasonal hurricane forecast. See our website (http://tropical.atmos.colostate.edu) for a 53-page summary of this season's activity. Although this is my 25th year of making these seasonal forecasts, Klotzbach should get most of the credit for the success of this year's forecast.

President-Elect Barack Obama said last week that "storms are growing stronger with each passing hurricane season" (implying that this is due to CO_2 increases). He is repeating what Al Gore has been saying for years and what was implied by thousands of media reports after the damaging Atlantic seasons of 2004-2005. Polls have shown that a relatively high percentage of US citizens think that human-induced global warming has increased hurricane activity.

Yes, the Atlantic has seen a very large increase in major hurricanes during the 14-year period of 1995-2008 (average 3.9 per year) in comparison to the prior 25-year period of 1970-1994 (average 1.5 per year). But, have rises in CO_2 been, in any way, been responsible for the recent large upswing in Atlantic basin major hurricanes since 1995?

I and a number of my colleagues believe that this large increase in Atlantic major hurricanes is primarily due to the multi-decadal increase in the Atlantic Ocean Thermohaline Circulation (THC) that is driven by Atlantic salinity variations. These Atlantic multi-decadal changes have also been termed the Atlantic Multidecadal Oscillation (AMO). These increases are not a result of global surface temperatures or CO_2 increases.

Although global surface temperatures have increased over the last century and over the last 30 years, there are now many observational studies which indicate there has not been any significant long term increase in hurricane frequency or intensity in any of the globe's tropical cyclone basins.

In a global warming world, the atmosphere's upper tropospheric equivalent potential temperatures (θ_e) will warm in unison with the sea surface temperatures. Vertical θ_e lapse rates will not be significantly altered. We have no well founded physical reasons for believing that Atlantic (or other global basin) hurricane frequency or intensity will necessarily change if global ocean temperatures were to continue to rise, although there has been little global temperature rise since 1998. In the quarter-century period from 1945-1969 when the globe was undergoing a weak cooling trend, the Atlantic basin experienced 80 major (Cat 3-4-5) hurricanes and 201 major hurricane days. By contrast, in a similar 25-year period from 1970-1994 when the globe was undergoing a general warming trend, there were only 38 major hurricanes (48% as many) and 63 major hurricane days (31% as many) (Figure 1). Atlantic sea surface temperatures and hurricane activity is related to but does not necessarily follow global mean temperature trends.

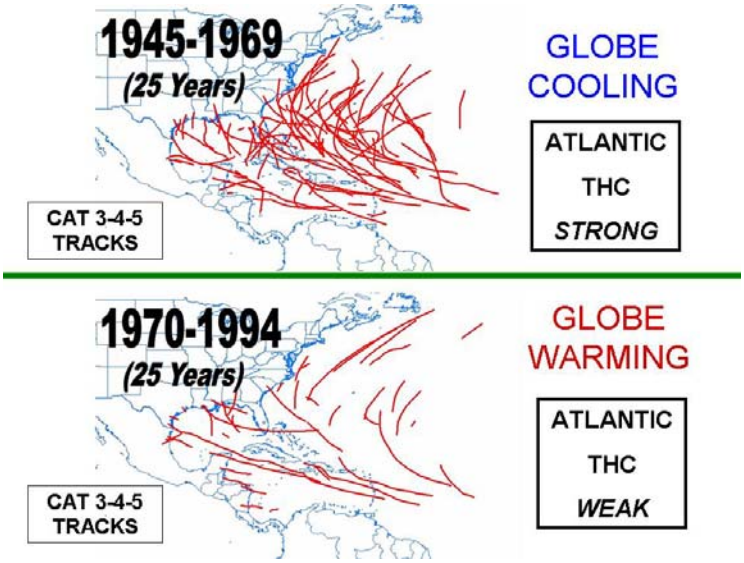

Figure 1: Tracks of major (Category 3-4-5) hurricanes during the 25-year period of 1945-1969 when the globe was undergoing a weak cooling versus the 25-year period of 1970-1994 when the globe was undergoing a modest warming. CO_2 amounts in the later period were approximately 18 percent higher than in the earlier period. Major Atlantic hurricane activity during the later period was only about one third of that of the earlier period despite warmer global temperatures. On a normalized basis major hurricanes cause about 80-85 percent of all tropical cyclone spawned destruction.

Technology developments have rendered long period over-ocean hurricane observations unreliable. The most reliable long-period hurricane records we have are the measurements of US landfalling tropical cyclones since 1900 (Table 1). Although global mean ocean and Atlantic sea surface temperatures have increased by about 0.4^{o}C between the two 50-year periods of 1900-1949 and 1959-2008, the frequency of US landfall numbers actually shows a slight downward trend for the later period even though CO_2 has gone up about 30 percent between these two periods. This downward trend is particularly noticeable for the US East Coast and Florida Peninsula where the difference in landfall of major (Category 3-4-5) hurricanes between the 43-year period of 1923-1965 (24 landfall events) and the 43-year period of 1966-2008 (7 landfall events) was especially large (Figure 2). For the entire United States coastline, 39 major hurricanes made landfall during the earlier 43-year period (1923-1965) compared with only 22 for the latter 43-year period (1966-2008). This downward landfall numbers occurred despite the fact that CO_2 amounts were approximately 20 percent higher during the latter period compared with the earlier period (Figure 3). This figure illustrates that caution must be used when extrapolating trends into the future. Obviously, U.S. major hurricane landfalls will continue after 2050.

Table 1: U.S. landfalling tropical cyclones by intensity during two 50-year periods.

YEARS	Named Storms	Hurricanes	Intense Hurricanes (Cat 3-4-5)	Global Temperature Increase
1900-1949 (50 years)	189	101	39	+0.4°C
1959-2008 (50 years)	167	85	33	

We should not read too much into the very busy two hurricane seasons of 2004 and 2005. The activity of these years was unusually high but well within natural bounds of Atlantic seasonal hurricane variations.

What made the 2004 and 2005 seasons so unusually destructive was not the high frequency of major hurricanes but the high percentage of hurricanes that were steered over the US coastline.

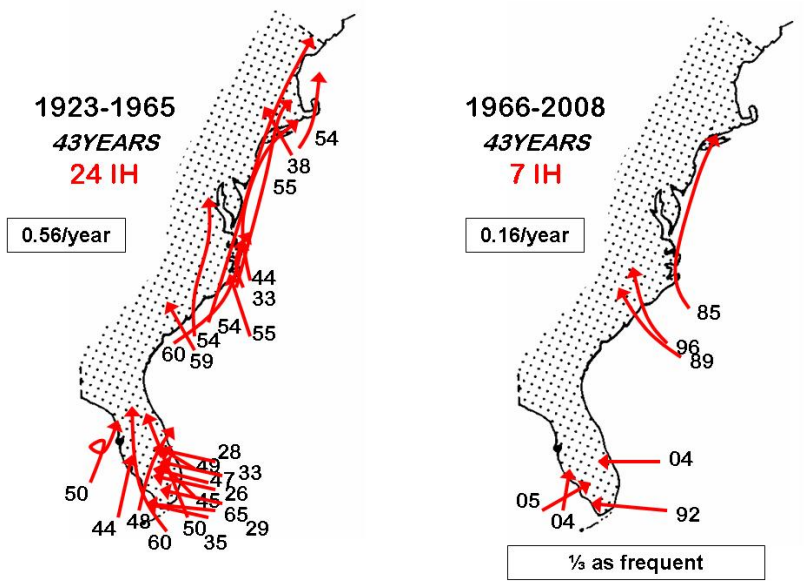

Figure 2: Contrast of the number of tracks of East Coast and Florida Peninsula major landfalling hurricanes during the 43-year period of 1923-1965 versus the most recent 43-year period of 1966-2008.

There have been other years with comparable hurricane activity to 2005. For instance, 1933 had 21 named storms in a year when there was no satellite or aircraft data. Records of 1933 show all 21 named storm had tracks west of 60°W where surface observations were plentiful enough for detection. If we eliminate all the named storms of 2005 whose tracks were entirely east of 60°W and therefore would have likely been missed given the technology available in 1933, we reduce the 2005 named storm total by seven (to 21) – the same number as was observed to occur in 1933.

The active hurricane season in 2008 lends further support to the belief that the Atlantic basin remains in an active hurricane cycle associated with a strong thermohaline circulation and an active phase of the Atlantic Multidecadal Oscillation (AMO). This active cycle is expected to continue for another decade or two at which time we should enter a quieter Atlantic major hurricane period like we experienced during the quarter-century periods of 1970-1994 and 1901-1925. Atlantic hurricanes (particularly major hurricanes) go through multi-decadal cycles. Cycles in Atlantic major hurricanes have been observationally traced back to the mid-19th century, and changes in the AMO have been inferred from Greenland paleo ice-core temperature measurements going back thousand of years.

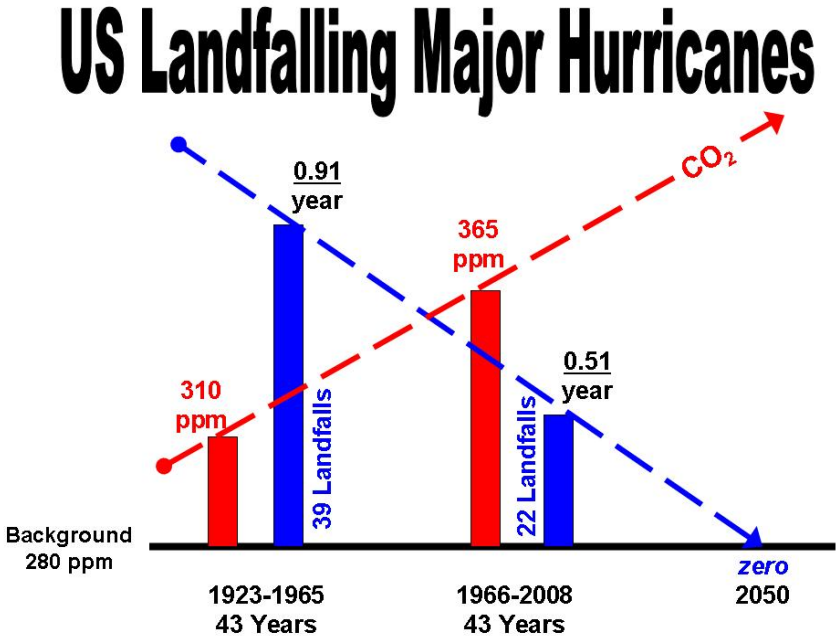

Figure 3: Portrayal of decreasing US total major hurricane landfalls over the last two 43 year periods despite a mean rise in atmospheric CO_2. This figure illustrates that caution must be used when extrapolating trends into the future. Nobody should think that U.S. major hurricane landfalls will not continue after 2050.

The influence of rises in atmospheric CO_2 on hurricane activities is likely to be very small and within the noise level of our measurement capability or of any reliable numerical model output. There is no way of telling whether CO_2 rises might have a miniscule positive or a miniscule negative effect on hurricane frequency or intensity. It would be unwise for our society to reduce atmospheric CO_2 gases under the naïve belief that we would in any way be reducing the damage from these storms.