Hurricanes and climate: The debate over tropical cyclones and anthropogenic climate change

Pat Fitzpatrick
GeoSystems Research Institute
Mississippi State University at Stennis Space Center

The possible association between tropical cyclones[1] and global climate change has energized much controversy in the last few years. The Atlantic hurricane season in 2005 inflamed this issue. The 2005 Atlantic season set records for: most number of tropical cyclones (27); most hurricanes (14); most Category 5 hurricanes (3); most intense hurricane on record (Hurricane Wilma, 882 mb); most intense storm in the Gulf of Mexico (Hurricane Rita, 897 mb); and the most costly storm on record (Hurricane Katrina, $150-200 billion). Katrina was also the fifth deadliest United States storm on record (1500-1600 fatalities). Indeed, since 1995 most years have witnessed above normal Atlantic hurricane activity. The period from 1970 to 1994 consisted of relatively quiet Atlantic seasons, suggesting that some kind of climate shift has occurred. Other recent high-impact tropical cyclone events around the globe also support this assertion.

It is well-established that water temperatures in most ocean basins have increased by 0.5 to 1.0˚F in the past several decades. Most scientists attribute this to anthropogenic global warming. The genesis and intensification of tropical cyclones is critically influenced by warm oceans. Therefore, some scientists have postulated that global warming has augmented hurricane activity. Several recent studies have provided evidence for this allegation. One analysis shows that the number of Category 4 and 5 hurricanes has increased since 1975. Another study shows that the number of Atlantic tropical cyclones closely parallels the increase of water temperature from the late 1800s.

However, critics point out three main flaws in this proposed global warming relationship. First, tropical cyclones exhibit natural variability in terms of intensity and numbers. Second, the historical record has reliability issues. Both factors insert considerable uncertainty in drawing any relationships between tropical cyclones and anthropogenic climate change. Finally, other factors besides water temperature affect tropical cyclones, and it is unknown how these other influences will change on a warmer planet.

For example, intense tropical cyclones (Category 3 or better) in the Atlantic Ocean exhibit multidecadal variability. It is generally accepted that this oscillatory behavior is due to slow water temperatures cycles in the Atlantic which last 20-30 years. Atlantic

[1] A tropical cyclone is the generic term for a non-frontal low-pressure system over tropical or sub-tropical waters with organized thunderstorm activity and cyclonic surface wind circulation. Tropical cyclones with maximum sustained surface winds less than 39 mph are called *tropical depressions*. Once this wind reaches 39 mph, it is a *tropical storm*. If wind reach 74 mph, they are called a *hurricane* in the Atlantic Ocean, but have different names in other ocean basins (such as a *typhoon* in the West Pacific). Intense tropical cyclones are defined as Category 3 (winds 111-130 mph), Category 4 (131-155 mph), or Category (>155 mph).

hurricane activity tends to be active when this phase has above normal water temperatures (such as 1945-1970 and starting in 1995), while Atlantic activity is relatively quiet during the cooler ocean mode (such as 1970-1994). Intertwined in these long cycles are El Nino phases associated with warmer than average oceans in the central and eastern equatorial Pacific that last 2-7 years; Atlantic activity is dramatically reduced during an El Nino because it creates Atlantic wind patterns that are hostile to tropical cyclones. Likewise, El Nino years also shifts tropical cyclone activity in the Pacific and Indian oceans.

Serious questions about the historical record also exist. Prior to the era of satellites, many tropical cyclones were missed entirely. Therefore, all datasets after 1960 will, on average, contain more storms. The intensity of many tropical cyclones is also unknown. Currently, only the United States performs aircraft reconnaissance flights. Only one other basin ever had aircraft measurements (the west Pacific, from1946 through 1987). When aircraft measurements are missing, all estimates are done primarily using satellite techniques, and are known to contain errors. The combination of intensity uncertainty and missing storms makes extrapolating any trends from this dataset a dubious exercise.

Finally, while water temperature is the most important factor in tropical cyclone dynamics, many other environmental factors affect these storms. These include: the deep warm water; moisture availability; weak wind shear; a source of rotation; and no land interaction/landfall. Only when all these factors exist can a hurricane reach its maximum potential intensity for a given water temperature. In fact, few hurricanes reach their potential because some inhibiting factor exists. Furthermore, global warming could enhance some negative influences regionally; an ensemble of 18 global climate models show that wind shear and dry air will increase in the Atlantic, while in contrast the opposite occurs in the west Pacific where environmental factors favor more hurricanes. Therefore, anthropogenic warmer oceans do not necessarily correlate to increased tropical cyclone activity or stronger hurricanes globally. Climate models give mixed results on whether the average storm intensities will change, but most show evidence for some increase in intensity.

For more information on this topic, the reader is referred to documentation written by the 6th International Workshop on Tropical Cyclones of the World Meteorological Organization (WMO), titled *Statement on Tropical Cyclones and Climate Change*. This publication, released in November 2006, can easily be found by typing the report name and organization in a web search engine. Overall, this report discourages making any firm conclusions on hurricane intensity trends.

It should be pointed out some researchers disagree with the WMO report. Holland and Webster (2007) state the following "with confidence": "*The recent upsurge in…frequency… is due in part to global warming and this is most likely the dominant effect. Earlier variations, such as the sharp increase in the 1930's, were also probably impacted by greenhouse warming. ……We have noted with some concern the contradictory conclusions…..which describe the data as being of high quality sufficient to determine "natural variability" ….but…insufficient ….to determine trends."*