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Hurricane Destructiveness in a Warmer World

Hurricanes have always bedeviled the Gulf Coast states, but global warming is making matters worse. Sea level is rising and will continue to rise as oceans warm and glaciers melt. Rising sea levels means higher storm surges, even from relatively minor storms, causing coastal flooding and erosion and damaging coastal properties. In a distressing new development, scientific evidence now suggests a link between hurricane strength and duration and global warming. Understanding the relationship between hurricanes and global warming is essential if we are to preserve healthy and prosperous coastal communities for ourselves and our children.

More Intense Storms

Recent research has found that storm intensity and duration increases as global warming emissions increase in our atmosphere. Rising sea levels, also caused in part by rising global temperatures, intensify storm damage along coasts. For hurricanes to occur, surface ocean temperatures must exceed 80 degrees Fahrenheit. The warmer the ocean, the greater the potential for stronger storms. More destructive hurricanes not only incur billions of dollars in damage to communities and businesses, but also put thousands of human lives at risk.

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Hurricane Behavior

To understand how global warming can affect ocean storms, it's important to understand how these storms develop in the first place. Seasonal shifts in global wind patterns cause atmospheric disturbances in the tropics, leading to a local drop in pressure at sea level and forcing air to rise over warm ocean waters. As warm, moist air rises, it further lowers air pressure at sea level and draws surrounding air inward and upward in a rotating pattern called a vortex. When the water vapor-laden air rises to higher altitudes, it cools and releases heat as it condenses to rain. This cycle of evaporation and condensation brings the ocean's thermal energy into the vortex, powering the storm. Depending on the severity, meteorologists call these tropical storms or hurricanes in the Atlantic Ocean.

Many factors influence storm behavior, including surface temperatures, humidity, and atmospheric circulation. A sudden change in wind speed or direction (wind shear), for example, may prevent the vortex from forming. But as long as conditions are favorable, the storm will thrive.

Warming Ocean Waters

Natural cycles alone cannot explain recent ocean warming. Because of human activities such as burning fossil fuels and clearing forests, today's carbon dioxide (CO_2) levels in the atmosphere are significantly higher than at any time during the past 400,000 years. CO_2 and other heat-trapping emissions act like insulation in the lower atmosphere, warming land and ocean surface temperatures. Oceans have absorbed most of this excess heat, raising sea temperatures by almost one degree Fahrenheit since 1970. September

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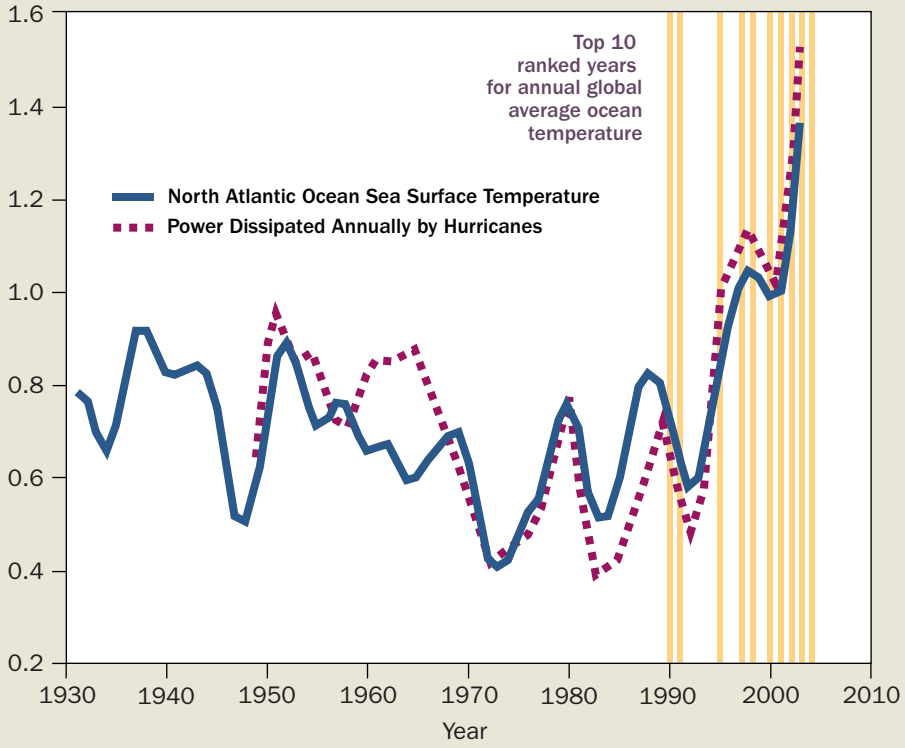
sea surface temperatures in the Atlantic over the past decade have risen far above levels documented since 1930, as shown in the figure at right.

Recent Scientific Developments

A 2004 study published in the peer-reviewed *Journal of Climate* explored the relationship between today's storms compared with simulated storms under conditions with increased atmospheric CO_2 (the primary global warming gas). The study simulated storm behavior under a one percent per year increase in CO_2 over 80 years. Nine different global climate models projected that storms generated under increasing CO_2 conditions were consistently more intense. By the end of the projection, maximum surface wind speeds increased six percent and rainfall increased on average 18 percent over present-day conditions.

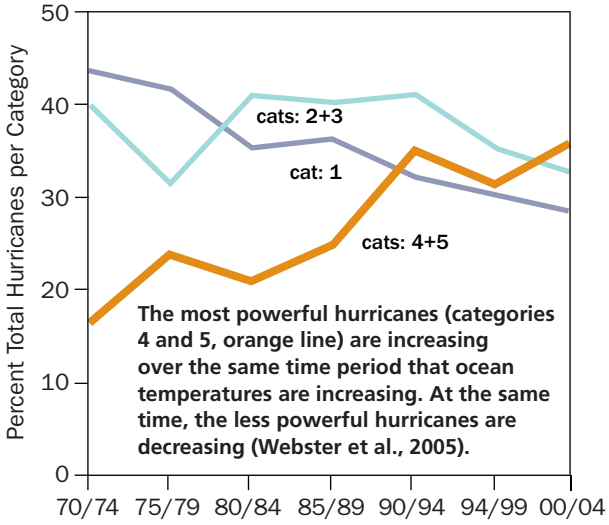
A 2005 study published in the journal *Nature* suggests that storm intensity and duration is linked to the recent ocean warming trends associated with global warming. Scientists tracked measurements of the destructive power of storms, termed the Power Dissipation Index (PDI), since 1950. The study, which combined each storm's maximum wind speeds and storm duration, found that during the last 30 years, the destructive power of storms has doubled in the Atlantic and Pacific.[1] Most of this has occurred during the past 10 years when global average surface ocean temperatures were at record levels. Thus far, scientific evidence does not link worldwide storm *frequency* with global warming. Individual ocean basins have multi-year cycles of storm activity. While the total number of storms in the tropics remained similar through time, the percentage of category 4 and 5 hurricanes have increased over the past 30 years, according to a 2005 paper in the journal of *Science.*

North Atlantic Hurricane Record



The increase in hurricane power and duration (dashed line) closely parallels September sea surface temperature trends (solid line) in the storm generation region of the Atlantic (Emanuel, 2005). The dramatic rise in hurricane intensity occurred during the top 10 ranked years for annual average global ocean temperature (vertical yellow lines).

Higher Percent of Category 4 & 5 Hurricanes Worldwide



The most powerful hurricanes (categories 4 and 5, orange line) are increasing over the same time period that ocean temperatures are increasing. At the same time, the less powerful hurricanes are decreasing (Webster et al., 2005).

Protecting Coastal Communities

Given the huge price tag from the cleanup of recent hurricanes such as Andrew ($43.7 billion)[2], Ivan ($14.2 billion), and Katrina ($125 billion projected), it is essential to do whatever we can to avoid dangerous warming and preserve healthy and prosperous coastal communities for ourselves and our children. Because CO_2 can stay in the atmosphere for 100 years or more, even an aggressive plan to use energy more efficiently and reduce emissions from power plants and vehicles will not stop warming in it tracks. Therefore, it is essential that we combine aggressive emission reduction efforts with improved measures to protect coastal communities. These measures—including building codes, storm drainage plans, and preservation and restoration of wetlands, dunes, and barrier islands—must be designed to cope with increasing sea level rise and storm intensity due to global warming.

1 Tracking of ocean temperatures has been relatively accurate over the past 50 years while storm tracking data have improved significantly in the past 30 years. Both sea surface temperatures and hurricane intensity increased most rapidly over the past 15 years.

2 Inflation adjusted to the year 2004.

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A fully referenced version is available from UCS at *www.ucsusa.org/hurricanepower.*

References

Anikouchine, W. and R.W. Sternberg. 1981. *The World Ocean.* Englewood Cliffs, NJ: Prentice-Hall, Inc.

Barnett, T.P., D.W. Pierce, and R. Schnur. 2001. Detection of Anthropogenic climate change in the world's oceans. *Science* 292: 270–274.

BBC News, September 13, 2005, Big rise in Katrina cost forecast.

Blake, E.S., J.D. Jarrell, M. Mayfield, E.N. Rappaport, and C. W. Landsea, (2005) The costliest U.S. Hurricanes 1900-2004 (adjusted) table derived from NOAA Technical Memorandum NWS TPC-1. Online at http://www.nhc.noaa.gov/pastcost2.shtml?. Accessed September 2005

Committee on the Science of Climate Change, National Research Council. 2001. *Climate Change Science: An Analysis of Some Key Questions.* Washington, DC: National Academy Press.

Emanuel, K. 2005. Increasing destructiveness of tropical cyclones over the past 30 years. *Nature* 436:686-688.

Knutson T.R. and R.E. Tuleya. 2004. Impact of CO_2-induced warming on simulated hurricane intensity and precipitation: Sensitivity to the choice of climate model and convective parameterization. *Journal of Climate* 17: 3477–3495.

NOAA. 2005. Global Surface Temperature Anomalies. Asheville, NC: NOAA/National Climatic Data Center. Online at http:/www.ncdc.noaa.gov/oa/climate/research/anomalies/anomalies.html#index. Accessed July 2005.

Reynolds, R.W. and T.M. Smith. 1995. A high resolution global sea surface temperature climatology. *Journal of Climate* 8: 1571–1583.

Trenberth, K. 2005. Uncertainty in Hurricanes and Global Warming. *Science* 308: 1753–1754.

Webster, P.J., Holland, G.J., Curry, J.A. and H.-R. Chang. 2005. Changes in tropical cyclone number, duration, and intensity in a warming environment. *Science* 309: 1844-1846.

U.S. Department of State. 2002. U.S. Climate Action Report – 2002: Third National Communication of the United States of America under the United Nations Framework Convention on Climate Change. Washington, DC. Online at http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsUSClimateActionReport.html.