

**Our Ocean Backyard — *Santa Cruz Sentinel* columns by Gary Griggs, Director, Institute of Marine Sciences, UC Santa Cruz.**

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**Weather on Steroids**



*Rockaway Beach, Queens, NY post-Hurricane Sandy*

There has been considerable speculation, writing and discussion these past several weeks about how the impacts of Hurricane Sandy may have been amplified by climate change. Similar discussions and arguments were made about the drought this past summer that affected about 64% of the United States, as well as the large number of wild fires in the western states.

After our 100-degree weather in early October I wrote a column on the difference between weather and climate. Weather is short-term, day-to-day. Climate is long-term. But over time, there is no question that weather will be influenced by a changing climate. The weather extremes of all sorts we have been experiencing, whether highest average temperatures, driest summers, or smallest Arctic ice coverage, are all observations or trends we ought to be paying attention to.

The question about Hurricane Sandy and its relationship to global climate change echoes the speculation in the sports pages about whether records like those of Lance Armstrong and Barry Bonds were aided by performance enhancing drugs. Both men were clearly exceptional athletes and may have had great careers anyway, but the steroids probably didn't hurt. We may now be experiencing weather on steroids.

There are several different ways climate change might have influenced the strength of Hurricane Sandy: through the effects of sea level rise; through abnormally warm sea surface temperatures; and possibly through an unusual weather pattern that some scientists believe bore the fingerprint of rapidly disappearing Arctic sea ice.

Two major factors affecting water levels are at work along the New York and New Jersey shorelines. First, land rebounding farther north after the removal of the massive weight of Ice Age glaciers has caused the island of Manhattan itself and parts of New Jersey to slowly sink; think of a seesaw or teeter-totter.

Second, at the same time, the oceans have been slowly rising. While the average global rise in sea level over the past century was 7-8 inches, the shoreline of Long Island, Manhattan and New Jersey experienced a rise of 10 to 16 inches. All this simply means that any storm surge will now reach further inland or reach higher elevations. While four to eight inches may not sound like a lot, where the land is very flat, this may allow seawater to flow for blocks. To the Metropolitan Transit Authority or Consolidated Edison, the main electric utility in Manhattan, each additional inch of sea level rise matters a great deal.

Climate change amps up other basic factors that contribute to hurricane strength as well. Higher ocean temperatures lead to increased evaporation and water vapor, which are both fuel for hurricanes. As the Earth's atmosphere has warmed, it retains more moisture, which is drawn into storms and is then dumped on us as rain.

Water temperatures off the East Coast were unusually warm this summer — September had the second highest global ocean and atmospheric temperatures on record- so much so that New England fisheries officials observed significant shifts northward in cold-water fish such as cod. Sea surface temperatures off the Carolinas and Mid-Atlantic remained warm into the fall, offering a perfect energy source for Hurricane Sandy as it moved northward from the Caribbean.

Some scientists, and I realize that there are a lot of scientists out there, believe that about 1°F out of the 5°F East Coast water temperature anomaly may have been due to manmade global warming. Warmer seas provide more water vapor for storms to tap into; this water vapor can later be wrung out as heavy rainfall, resulting in enhanced flooding.

The most damaging aspect of the storm was the massive storm surge that struck the coastline from Maryland to Massachusetts. The added 10 to 16 inches of sea level rise of the last 100 years gave the surge a higher launching pad than it would have had a century ago, making it more damaging than it otherwise would have been. The impacts of storm surges are only going to get worse as sea level rise continues as a result of warming ocean waters and melting polar ice sheets and glaciers.

The storm surge at The Battery in Lower Manhattan was the highest ever recorded at that location. It surpassed even the most pessimistic forecasts, with the maximum water level reaching 13.88 feet above the average of the daily lowest low tide of the month, known as Mean Lower Low Water. The result was a tide that took water from New York harbor, the Hudson River, and the East river and put it right into New York City.

Sandy was also somewhat unprecedented in its pathway. Hurricanes coming up the Atlantic seaboard almost always drift to the northeast and dissipate their energy at sea. Sandy made nearly a 90-degree turn towards the coastline. Why?

Hurricane Sandy crashed into cold air moving south from Canada. This collision increased the storm's energy level and extended its geographical reach. An atmospheric pattern above the Arctic Ocean, known as a blocking high, pushed that cold air into the path of the hurricane. Two climate scientists from Cornell University provided evidence earlier this year that Arctic ice melt linked to global climate change was contributing to the very atmospheric pattern that sent the frigid air down across Canada and into the eastern U.S. All of this put the National Weather Service forecasters in the odd position of having to issue snow advisories for a tropical-hurricane system.