Earth Gauge
A National Environmental Education Foundation Program

2010 Atlantic Hurricane Season Wrap-up and Recent Research Developments

The 2010 Atlantic hurricane season is finished. How well did this season correspond to pre-season predictions? What are some recent developments in hurricane research?

Atlantic Hurricane Prediction Basics

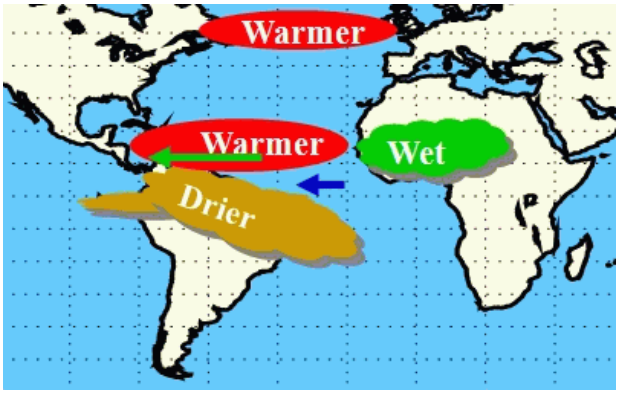
Each May, the National Oceanic and Atmospheric Administration (NOAA) issues an outlook for the Atlantic hurricane season, which runs from June 1 to November 30. The seasonal outlook is formed by analyzing the May climate conditions of the current year and finding past years when similar conditions were present. These past years serve as analogues for the upcoming season and set expectations for tropical cyclone and hurricane counts. NOAA issues an updated seasonal outlook in early August.

As NOAA stresses, their seasonal outlooks do not predict how many hurricanes will make landfall or where hurricanes are likely to make landfall. The weather patterns in place as a hurricane approaches the Caribbean and United States determine hurricane tracks, and these weather patterns can only be predicted a few days before a hurricane makes (or does not make) landfall. NOAA also stresses that it only takes one hurricane or tropical storm to make a disaster. Coastal communities should always be prepared for a hurricane to strike regardless of the seasonal forecast.

There are three key predictive climate factors for Atlantic hurricane season intensity:

- **Sea surface temperatures (SSTs) in the main development region:** Warmer SSTs between 10 and 20 degrees North, from the West Coast of Africa to Central America, mean more energy is available for tropical cyclones.

- **The tropical-multidecadal signal:** Every 20-30 years, a shift in North Atlantic sea surface temperature distributions alters the atmospheric and oceanic conditions that encourage or discourage hurricane formation. Between 1950 and 1970, and since 1995, the “active phase” of the tropical-multidecadal signal, with conditions that promote hurricane formation, has been dominant,



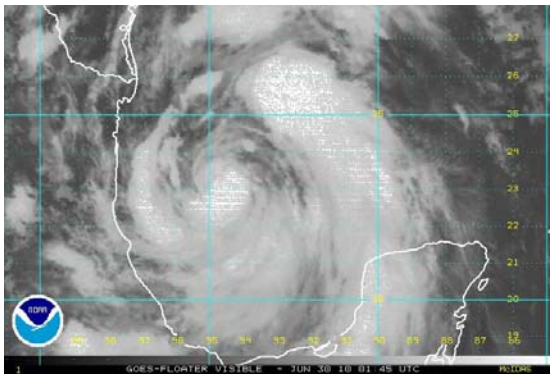
Above: A schematic diagram of the current “active phase” of the tropical-multidecadal signal regime. Image Courtesy of NOAA.

- **The El Niño-Southern Oscillation (ENSO):** Conditions in the tropical Pacific ocean affect the global atmospheric circulation. These effects include regulation of the vertical wind-shear, or how much wind speed and direction changes with altitude, over the Atlantic. Less wind shear allows storm clouds to gather and organize into systems that may become hurricanes. El Niño (warm) conditions in the tropical Pacific mean more vertical wind shear over the Atlantic, while La Niña (cool) conditions mean less. Thus, neutral to La Niña conditions mean more active Atlantic hurricane seasons. El Niño conditions tend to steer hurricanes away from the United States mainland.

Above: How El Niño conditions affect Atlantic hurricane behavior. Image Courtesy of NOAA.

The 2010 Atlantic Hurricane Season

What was predicted: In May, NOAA predicted an 85 percent chance of an above normal season, a 10 percent chance of a near-normal season and only a 5 percent chance of a below-normal season. They predicted a 70 percent probability that there would be between 14 and 23 named storms, eight to 14 hurricanes, three to seven major hurricanes and an accumulated cyclone energy (ACE) index 155-270 percent of the median. ACE takes into account the intensity and duration of the storms, not just their number or whether they reach hurricane strength. This prediction for an above average season was based on developing La Niña conditions, the ongoing active Atlantic phase of the tropical multidecadal signal and very warm SSTs in the main development region.



Above: Hurricane Alex in June 2010 as it blew over the Gulf of Mexico. Image Courtesy of NOAA.

What we got: There were 19 named storms this year (the third most on record), 12 hurricanes, five major hurricanes and an ACE index 190 percent of the median; all of these numbers are within the range NOAA set down in May. A few items of note:

- This is the first year, since at least 1900, that 10 or more hurricanes have formed without any striking the United States mainland. On average, if 10 hurricanes form, two strike the U.S. mainland.
- Five hurricane seasons have now gone by without a major storm striking the United States mainland; there have never been six consecutive seasons where this has been the case.
- 1973 was the last year where there was a La Niña event of similar magnitude to this year's event without any hurricanes hitting the United States mainland.

Developments in Hurricane Research

Modeling Improvements

As global climate models have become more sophisticated, they have become more important for NOAA's seasonal forecasts. NOAA now uses new high-resolution climate models to better predict upcoming climate patterns such as ENSO and Atlantic SSTs, which means more accurate seasonal hurricane forecasts. NOAA also employs global climate model output from other national and international research centers. One promising new forecast model is the Florida State University Center for Ocean-Atmospheric Prediction Studies (COAPS) model, which made reasonably accurate hindcasts of the 1986-2005 seasons. The COAPS model used the May 2009 conditions to forecast the 2009 season. For 2009, the model predicted a mean of eight tropical systems, four hurricanes and an ACE of 65. The actual counts were nine named storms, three hurricanes and an ACE of 52. In May 2010, the same model predicted 17 named storms with 10 of them developing into hurricanes. Compare this to 19 named storms and 12 hurricanes for the 2010 season.

El Niño Modoki

While the two-phase El Niño and La Niña ENSO model has been useful, a closer analysis of tropical Pacific SST records reveals that not all events that have been classified as El Niños had the same temperature distributions. During some El Niño events, the warmest waters were directly off the West Coast of South America, which is the classic El Niño, referred to as an eastern Pacific warming (EPW). During other El Niño events, however, the warmest waters were instead concentrated in the central Pacific, a central Pacific warming (CPW). CPW events have also been called *El Niño Modoki* events; *modoki* is a Japanese term for "same, but different." Some studies suggest that unlike EPW events, CPW events do not inhibit North Atlantic tropical cyclone development and instead appear to have corresponding affects more similar to La Niña phases. CPW events may also tend to steer storms onto more southerly tracks towards the U.S. Gulf Coast and Central America. CPW events are becoming more frequent; 80 percent of the CPW events that have occurred since 1950 have happened in the last 20 years.

Pliocene Epoch Hurricane Behavior

The last time Earth had atmospheric carbon dioxide levels close to 400 parts per million was the Pliocene epoch, five to three million years ago. Best estimates suggest that during this time, there were many more hurricanes in both the Atlantic and Pacific Basins. While today there are no such storms in the South Atlantic and far fewer storms in the South Pacific and South Indian Oceans, during the Pliocene both hemispheres experienced frequent hurricanes. Part of the explanation for this increased activity is the permanent or semi-permanent El Niño conditions that were believed to have existed during this time. In contrast to the Atlantic, El Niño conditions stimulate hurricanes in the Pacific. Hurricanes in the Pacific tend to warm shallow water parcels that travel towards the equator from both hemispheres. This water parcel warming leads to a warmer eastern equatorial Pacific, warmer tropics in general and more hurricanes. This cycle of hurricanes promoting conditions that make more hurricanes more likely is an example of a *positive feedback cycle*.

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Sources:

Fedorov, AV. "Tropical cyclones and permanent El Niño in the early Pliocene epoch." Nature 463 (2010): 1066-1070.

Holland, GJ. "Predicting El Niño's Impacts." Science 325 (2009): 47.

Kim, HM et al. "Impact of Shifting Patterns of Pacific Ocean Warming on North Atlantic Tropical Cyclones." Science 325 (2009): 77-80.

LaRow, TE et al. "Seasonal Atlantic tropical cyclone hindcasting/forecasting using two new sea surface temperature datasets." Geophysical Research Letters 37 (2010): L02804.

Leontiou, Andrea. "Surprisingly, Hurricanes Avoid U.S. Landfall in 2010." OurAmazingPlanet 26 October 2010. Accessed Online 12 November 2010 <http://www.ouramazingplanet.com/2010-hurricane-season-tropical-storms-0671/>

National Oceanic and Atmospheric Administration. "NOAA: 2010 Atlantic Hurricane Season Outlook." 27 May 2010. Accessed Online 9 November 2010 <http://www.cpc.noaa.gov/products/outlooks/hurricane2010/May/hurricane.shtml>

"Unique Computer Model Used to Predict Active 2010 Hurricane Season." ScienceDaily 2 June 2010. Accessed Online 9 November 2010 <http://www.sciencedaily.com/releases/2010/06/100601162322.htm>

Zhao, M et al. "Retrospective Forecasts of the Hurricane Season Using a Global Atmospheric Model Assuming Persistence of SST Anomalies." Monthly Weather Review 138 (2010): 3858-3868.