## AIRCURRENTS

## THE 2009 ATLANTIC HURRICANE SEASON IN PERSPECTIVE

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EDITOR'S NOTE: November 30 marked the official end of the Atlantic hurricane season. With nine named storms, including three hurricanes, and no U.S. landfalling hurricanes, this season was the second quietest since 1995, the year the present period of above-average sea surface temperatures (SSTs) began. This year's relative inactivity stands in sharp contrast to the 2008 season, during which Hurricanes Dolly, Gustav, and Ike battered the Gulf Coast, causing well over 10 billion USD in insured losses. With no U.S. landfalling hurricanes in 2009, but a near miss in the Northeast, 2009 reminds us yet again of the dramatic short term variability in hurricane landfalls, regardless of whether SSTs are above or below average.

By Dr. Peter S. Dailey

## HOW DOES ACTIVITY IN 2009 COMPARE TO LONG-TERM AVERAGES?

By all standard measures, the 2009 Atlantic hurricane season was below average. Figure 1 shows the evolution of a "typical" season, which reflects the long-term climatological average over many decades of activity. Tropical storms, which produce winds of at least 39 mph, occur rather frequently. By the end of the typical season, about 11 tropical storms are observed in the Atlantic.



tropical storms reach hurricane strength in a typical year, with an average of six hurricanes by year end. Major hurricanes, with winds of 111 mph or more, are even rarer, with only about three expected in the typical year. Note the sharp increase in activity during the core of the season-the months of August and September, in particular—when environmental conditions are most favorable for storm development. By comparison, nine tropical cyclones formed in the 2009 season. Of those, only three reached hurricane strength, and two of those further intensified into major hurricanes. Figure 2 shows the evolution of the 2009 season compared with the long-term average. After a very late start (the first named storm, Ana, formed in August, about a month later than average), tropical storms formed roughly on schedule up until Fred, when activity slowed down through to season end. Late-season Ida, which briefly reached hurricane strength, was the ninth and final storm, wrapping up 2009 with a rather weak and uneventful finish.

Hurricanes are much more intense than tropical storms,

producing winds of at least 74 mph. Only about half of

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Figure 1. Progression of a typical Atlantic hurricane season. Source: AIR



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Figure 2. Progression of the 2009 Atlantic hurricane season compared to long-term averages. Source: AIR

Hurricane formation fell far short of climatological expectation, with three storms reaching hurricane strength compared to six in an average season. Interestingly, although Hurricane Bill, ultimately the strongest of the season, formed only a bit later than expected, it was actually slightly early for the formation of a major hurricane. The second hurricane, Fred, formed in September at which time four hurricanes are expected to have developed. Both these storms reached major hurricane strength, bringing major hurricane formation slightly below the long-term average.

Most significantly, however, is that among the hurricanes and major hurricanes that developed this year, none was able to reach the U.S. coastline at hurricane strength. On average, one or two hurricanes are expected to make U.S. landfall. Only about 20% of historical seasons failed to produce a single U.S. landfall.

While reduced storm counts are clearly indicative of a relatively inactive season, another way to evaluate seasonal activity—and one that considers both the strength and duration of storms—is the Accumulated Cyclone Energy (ACE) index. ACE is a measure of the kinetic energy of each individual storm over the entire life cycle of the storm, which is then added together with the corresponding values of all storms in the course of the season. The long-term average ACE in the Atlantic basin is about 102 per season.

Because wind speeds are squared in calculating ACE values, very intense and very long-lasting storms contribute much more to ACE than do weak storms, thus 2004 and 2005 saw ACE values well above the long-term average (Figure 3). In 2006 and 2007, ACE values were significantly below average. In 2008, Hurricanes Gustav and Ike brought the seasonal ACE back above average, although not nearly to the levels of 2004 and 2005. In 2009, the ACE value is less than half the long-term average, with Hurricane Bill alone



accounting for more than half the season's total ACE. Figure 3. Accumulated Cyclone Energy index values for 2004–2009. Source: NOAA/AIR

Compared to the long-term average, the last six years are evenly split, with three exceeding average ACE and three falling short. This again illustrates the importance of considering activity over an extended period of time, and highlights the danger of extrapolating from a short-term history, which if done from 2004 and 2005 would have led to a gross overestimation of risk in the following years.

#### WHY WAS THIS SEASON'S ACTIVITY SO LOW?

In every hurricane season since 1995, the Atlantic Ocean has been warmer than the long-term climatological average. While many believe this to be a symptom of global warming, these sea surface temperature anomalies have also been attributed to the so-called Atlantic Multidecadal Oscillation (AMO), a climate signal theorized to result in long-duration warm and cool phases in the North Atlantic Ocean. Regardless of the underlying cause, warmer ocean temperatures provide more heat to fuel tropical cyclone activity, and undoubtedly contributed strongly to the activity in seasons like 2004 and 2005. Anomalies observed this year, however, were significantly lower than those in 2004 and 2005.



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On the other hand, SSTs have been anomalously warm in the Pacific Ocean since early 2009. This is attributed to El Niño, a quasi-periodic phase of the El Niño Southern Oscillation (ENSO) that is observed approximately every six to eight years. El Niño is associated with increased wind shear in the Atlantic Ocean, which is destructive to hurricanes and inhibits their formation and ability to intensify.

During the early part of the season, however, when the El Niño was not yet mature—the Atlantic was also not nearly as warm as in mid-season. In fact, parts of the tropical Atlantic were actually cooler than average, as indicated by the green regions in Figure 4.



Figure 4. Sea surface temperatures anomalies in June. Reds and yellows indicate warmer than average temperatures, while blues and greens indicate cooler than average temperatures. Source: IRI

As the season progressed, the Atlantic warmed, but by then El Niño had matured, inducing higher levels of Atlantic wind shear (Figure 5) and counteracting the influence of warmer sea surfaceAtlantic temperatures. Note also, a wide swath of the tropical Atlantic was only slightly warmer than average or near average. Thus the lack of abundant fuel (heat) coupled with elevated wind shear limited activity in what would normally be the most active part of the season.



September. Blue colors indicate higher than average shear, and yellows and reds indicate lower than average shear. (Note that the yellow is primarily located over the Caribbean Islands, where hurricanes don't normally form.) Source: NOAA/CPC

#### HURRICANE BILL AND NORTHEAST HURRICANE RISK

While there were no hurricane landfalls in the U.S. this season, Hurricane Bill—the strongest storm of the season—was a near-miss for the Northeast U.S. Hurricane landfalls in the Northeast are relatively rare, occurring approximately once every ten years. The last two were Hurricane Gloria in 1985 and Hurricane Bob in 1991, and the last major hurricane landfall in the Northeast was the Great New England Hurricane of 1938 (also known as the Long Island Express) which. AIR estimates that were the 1938 storm to recur today, it would cost the industry \$38 billion.

The left panel in Figure 6 shows the National Hurricane Center's forecast cone of uncertainty issued for Hurricane Bill on August 20, a few days before the storm moved into the middle latitudes. The most westerly of the potential tracks (as represented by the left side of the cone) corresponded to a forecast intensity of 115 mph at landfall at Cape Cod, as shown in the right panel. Had the left side of NHC's forecast been realized, Bill would have been the first major hurricane landfall in the Northeast in more than 70 years.



Figure 6. NHC's cone of uncertainty for Hurricane Bill issued on 8/20 (left); left-side track and associated intensity forecast (right). Source: NOAA/NHC and AIR

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Ongoing discussion in the industry about Northeast hurricane risk has focused on how the windfield in these more northerly storms differ from those remaining in tropical latitudes. Hurricanes that move into the midlatitudes (not just in the Northeast, but in the Midwest U.S. and even the mid-Atlantic states) often undergo a process called transitioning, whereby the cloud field and wind structure expand and take on the appearance of an extratropical cyclone. About half of transitioning hurricanes do not experience substantial changes in intensity, while the ones that do are roughly evenly split between those that decay and those that intensify. In some cases, the remnants of hurricanes combine with pre-existing mid-latitude cyclones to cause significant damage, as was the case with Hurricane lke last year as it moved through the Midwest.

It is important to note that not all storms transition as they move into the Northeast. Some storms, including Hurricane Bill, are so intense and fast-moving that they do not have time to adjust to the mid-latitude environment. One of the key signs of transitioning is a slow shift of the wind structure to the right of the track; Bill, however, maintained a conventional hurricane structure with a roughly symmetrical wind distribution (Figure 7). Had it followed the track of the 1938 hurricane, Bill could have produced a wide swath of hurricane-force winds at landfall along the New York, Connecticut, and Rhode Island coastline, and a wide footprint of damage from Pennsylvania to Maine. For a more thorough discussion of Hurricane Bill and Northeast hurricane risk, see the AIR Currents article This Season's Reminder of Northeast Hurricane Risk.



Figure 7. Hurricane Bill's wind field as it passed the Northeast. Source: NOAA/NHC

#### CONCLUSION

The 2009 Atlantic hurricane season uniformly fell short of expectations. While many pre-season forecasts called for a roughly average season, the complex feedback mechanisms that govern climate signals and the global distribution of ocean temperatures worked to inhibit hurricane activity this year.

Most notably, despite the current warm regime of sea surface temperatures in the Atlantic, not a single storm made landfall in the United States at hurricane strength, although Hurricane Bill did provide a timely reminder of latent hurricane risk in the Northeast. This year once again demonstrates the uncertainty and year-to-year variability in hurricane activity and the importance of considering multiple long-term views of risk.

Editor's Note: In the next issue of AIR Currents, Dr. Dailey takes a step back from the 2009 season and reconsiders hurricane models conditioned on warm SSTs.

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