RMS WHITE PAPER

2014 NORTH ATLANTIC HURRICANE SEASON OUTLOOK

June 2014 - RMS Event Response

2014 SEASON OUTLOOK

The 2013 North Atlantic hurricane season saw the fewest hurricanes in the Atlantic Basin since 1982, and most meteorological forecasts predict that the 2014 season will have similarly low activity rates, with fewer than the long-term and short-term average of tropical storms, hurricanes, and major hurricanes[1] (Table 1). For example, one of the main forecast groups, Colorado State University (CSU), calls for 10 tropical storms, 4 hurricanes, and 1 major hurricane in 2014. All forecast groups predict that the number of tropical storms, hurricanes, and major hurricanes will be less than the average experienced during the more recent period of heightened activity since 1995, which has seen an annual average of 15.2 tropical storms, 7.6 hurricanes, and 3.5 major hurricanes.

The seasonal forecasts are attributing the potential for below-average hurricane activity to a combination of interrelated atmospheric and oceanic conditions, including the likelihood of an El Niño phase of the El Niño-Southern Oscillation (ENSO) and below-average sea surface temperatures (SSTs) in the Atlantic Basin. However, lower activity does not necessarily translate to a decrease in the number of landfalls, although CSU and other groups also predict a below-average probability of hurricane landfall over the U.S. and Caribbean in 2014.

SEASONAL FORECASTS

The North Atlantic hurricane season officially runs from June 1 to November 30. A variety of forecast groups issue seasonal predictions as early as December of the coming year, with the reliability or skill of forecasts improving as the season approaches. Table 1 shows the most recent 2014 seasonal forecasts, including those from the three main forecast groups: Colorado State University (CSU), the National Oceanic and Atmospheric Administration Climate Prediction Center (NOAA CPC), and Tropical Storm Risk (TSR).

Table 1: Summary of the most recent 2014 Atlantic Basin season forecasts, average season activity, and 2013 season storm totals.

FORECAST GROUP	TROPICAL STORMS	HURRICANES	MAJOR HURRICANES	ACE INDEX[2] ($10^4 KT^2$)
CSU[3] (June 2014)	10 (6.3-13.7)	4 (1.9-6.1)	1 (0.0-2.6)	65 (17-113)
NOAA CPC[4] (May 2014)	8-13	3-6	1-2	-
TSR (May 2014)	12 (±4)	5 (±3)	2 (±2)	73(±57)
FSU COAPS[4] (May 2014)	5-9	2-6	-	60
U.K. Met Office[4] (May 2014)	10 (7-13)	6 (3-9)	-	84 (47-121)
Penn State University (May 2014)	9 (±3)	-	-	-
WSI (April 2014)	11	5	2	-
Accuweather (April 2014)	10	5	2	-
1900 – 2013 Average[5]	10	5.5	2.2	91.1
1950 – 2013 Average[5]	11.2	6	2.6	101.8
1995 – 2013 Average[6]	15.2	7.6	3.5	132.7
2013	14	2	0	36

The groups' most recent forecasts for the 2014 North Atlantic hurricane season predict figures most similar to the 1900-2013 average,[5] the lowest of the three seasonal averages (Table 1). Compared to the 2013 season, which closed with 14 tropical storms, 2 hurricanes, and no major hurricanes, forecasters are calling for fewer tropical storms, but more hurricanes and major hurricanes in 2014.

The forecast groups are also calling for accumulated cyclone energy (ACE) values below those of all seasonal averages (Table 1), which suggests that we can expect lower-energy, shorter-lived storms, in accordance with the low number of major hurricanes forecast.

Although forecast groups expect a below-average season, fewer storms do not always translate to proportionally fewer landfalls. Complex factors control the development and direction of storms in the basin, including hurricane steering currents, which form from a large area of high pressure most commonly found in the central Atlantic. As an example, Hurricane Andrew made landfall as a Category 5 storm over Florida in 1992, toward the end of an El Niño phase. The lower-than-expected wind shear and steering currents that steered the storm toward Florida made Andrew the fourth most intense landfalling U.S. hurricane recorded,[7] and the fourth costliest U.S. Atlantic hurricane.[8]

KEY DRIVERS OF THE SEASONAL FORECASTS

The 2014 forecasts anticipate a below-average season in the North Atlantic Basin in relation to the 1950–2013[5] and 1995-2013 averages.[6] This conclusion is attributed to the following interrelated atmospheric and oceanic conditions:

- Below-average sea surface temperatures (SSTs), observed in the Atlantic Main Development Region (MDR)[9] during the first half of 2014, which are expected to continue throughout the 2014 season
- The expected formation of an El Niño phase of the El Niño-Southern Oscillation (ENSO) through the Atlantic hurricane season, which typically inhibits hurricane activity, notably during the August to October peak, with a low likelihood of neutral or La Niña conditions

[1] Category 3 or higher on the Saffir-Simpson Hurricane Wind Scale.

[2] The Accumulated Cyclone Energy (ACE) Index is calculated as the square of the sum of the maximum sustained wind speed (in knots) at 6-hour intervals for the duration of the storm at tropical storm status or greater (sustained wind speeds of 35 knots or higher).

[3] CSU forecast ranges have a 67% probability of occurrence.

[4] Forecast ranges have a 70% probability of occurrence.

[5] The historical database for landfalling hurricanes is generally agreed to be complete since 1900. However, the record of hurricane activity in the Atlantic Basin itself is generally agreed to be complete only from 1950 onward, following increases in aircraft reconnaissance and the onset of satellite technology.

[6] Since 1995, it's widely recognized that the Atlantic Basin has been in a period of elevated activity compared to the long- term historical average of history, driven by a positive phase in the Atlantic Multi-decadal Oscillation (AMO).

[7] National Hurricane Center: Hurricane Research Division (April 1, 2014). "Atlantic hurricane best track (HURDAT version2)" http://www.nhc.noaa.gov/data/hurdat/hurdat2-1851-2013-040114.txt.

[8] Blake, Eric S; Landsea, Christopher W; Gibney, Ethan J; National Climatic Data Center; National Hurricane Center (August 10, 2011). "The deadliest, costliest and most intense United States tropical cyclones from 1851 to 2010" http://www.nhc.noaa.gov/pdf/nws-nhc-6.pdf.

[9] The Main Development Region spans the tropical Atlantic Ocean and the Caribbean Sea between 10-20°N, 20-70°W.

ROLE OF THE ATMOSPHERE AND OCEAN IN THE 2014 NORTH ATLANTIC HURRICANE SEASON

Sea Surface Temperatures

Warm Atlantic sea surface temperatures (SSTs) in combination with low levels of wind shear are essential for hurricane formation and development. SSTs higher than 80°F (26.5°C)[10] are required for hurricane development and for sustained hurricane activity. Since early spring 2014, CSU and TSR have reported significant anomalous cooling across the tropical Atlantic, with the eastern tropical Atlantic exhibiting below-average SSTs.

Forecast groups attribute this anomalous cooling to alterations in the position and intensity of the Atlantic Inter-Tropical Convergence Zone (ITCZ), which brings about changes in tropical vertical and horizontal wind shear patterns, and changes in tropical Atlantic SST patterns. Below-average SSTs in the Atlantic are commonly associated with decreased activity during the Atlantic hurricane season, through increased vertical wind shear, decreased vertical instability, and decreased mid-tropospheric moisture.

Figure 1 shows the SST anomalies (°C) for April to May 2014, highlighting regions where SSTs deviate from the 1981–2010 climatological average. The figure illustrates that SSTs measured over the entire MDR were around 0.25°C below average, with temperatures in the far eastern MDR falling around 0.5°C below average, and in the far northern Gulf of Mexico as much as 1.25°C below average. Conversely, SSTs along the U.S. Atlantic Coast reach slightly above the climatological average, with SST anomalies of up to 0.25°C along the coast.

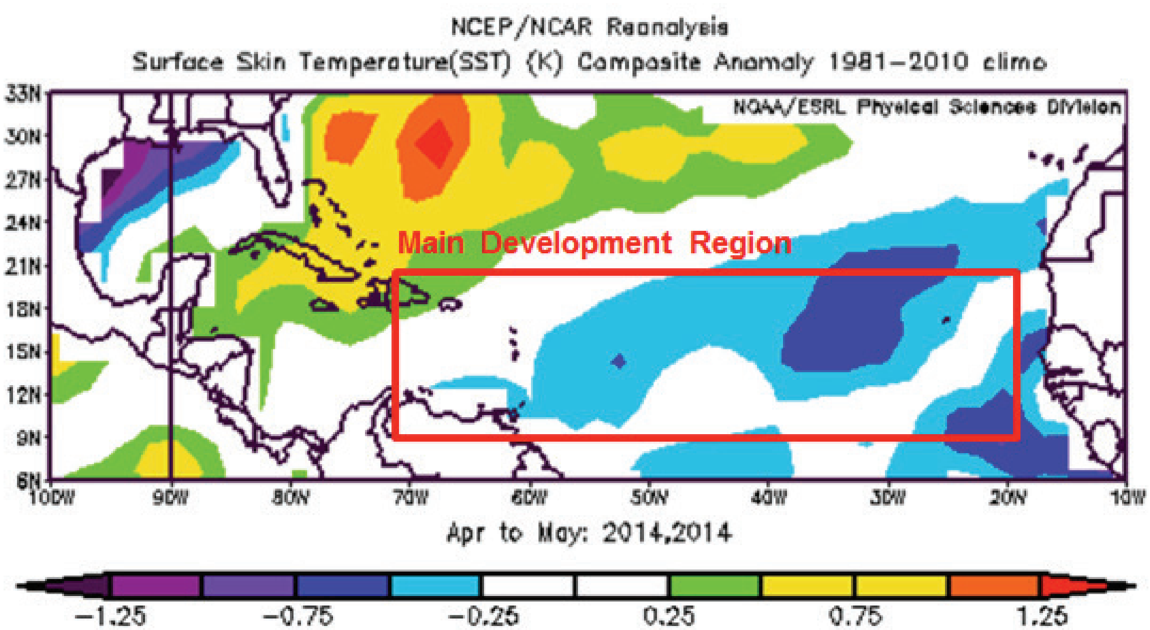

Figure 1: April to May 2014 SST anomalies (°C) in the tropical Atlantic.[11]

[10] As indicated by NOAA Hurricane Research Division http://www.aoml.noaa.gov/hrd/tcfaq/A15.html.

[11] Image from the NOAA/ESRL Physical Sciences Division, Boulder Colorado http://www.esrl.noaa.gov/psd/. Data from Kalnay et al., (2006). Red box denotes the main development region.

For comparison, Figure 2 shows April to May 2013 SSTs, which were at least 0.5°C above the 1981–2010 climatological average across the entire Atlantic MDR, with temperature anomalies in the eastern MDR reaching around 1°C. Conversely, temperatures in and along the Gulf of Mexico were abnormally cool in 2013, with SSTs falling 1°C below the average.

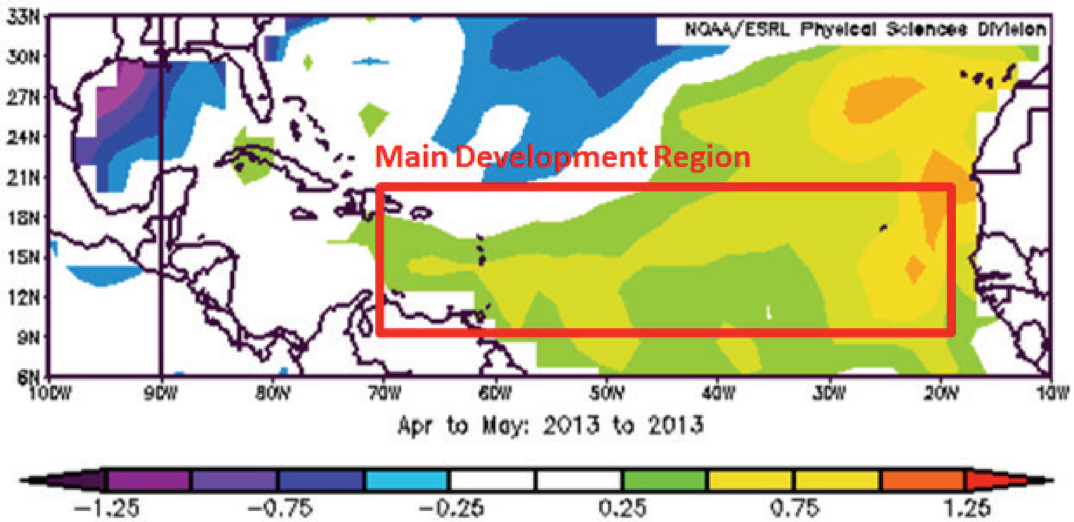

Figure 2: April to May 2013 SST anomalies (°C) in the tropical Atlantic.[11]

Many Atlantic sea-surface temperature forecasting groups[12] predict a continuation of below-average SSTs in the tropical Atlantic through the season, which is anticipated to suppress Atlantic Basin hurricane activity in 2014. Hurricane formation relies on warm SSTs to release heat into the upper atmosphere, which create spiraling winds. Below average SSTs inhibit the release of heat into the upper atmosphere, which is expected to contribute to the low number of hurricanes in 2014. There is, however, uncertainty associated with predicting SSTs at this lead time.

The El Niño-Southern Oscillation (ENSO) and Atlantic Wind Shear

The El Niño-Southern Oscillation (ENSO) is a climate fluctuation over the tropical Pacific Ocean that transitions from a warm phase (El Niño) to a cold phase (La Niña) over a 3–7 year cycle. ENSO can cause large inter-annual fluctuations in Atlantic hurricane activity through its impacts on upper-level atmospheric circulation and vertical wind shear in the Atlantic MDR.[13] El Niño episodes are associated with strong vertical wind shear across the tropical Atlantic, creating conditions that inhibit hurricane activity by spreading the latent heat needed for hurricane development. The reverse is true for La Niña.

The Niño3.4 index, which indicates the departure in monthly SSTs from the long-term mean averaged over the Niño3.4 region (5–5°S, 170–120°W), is commonly used to define an El Niño or La Niña event. ENSO-neutral conditions have persisted since October 2012 and thus the Pacific is currently (as of June 2014) in an ENSO-neutral phase. However, present ENSO conditions favor the development of an El Niño warm phase during the 2014 North Atlantic Basin hurricane season.

[12] Groups include the National Center for Environmental Prediction Coupled Forecast System (NCEP CFS), the European Center for Medium-Range Weather Forecasts (ECMWF), and the International Research Institute for Climate and Society (IRI)

[13] Gray, W.M., 1984: Atlantic seasonal hurricane frequency. Part I: El Niño and the 30 mb quasi-biennial oscillation influences. Monthly Weather Review, 112,1649-1668

Figure 3 illustrates the mid-May ENSO forecasts from various dynamical and statistical models of the likely progression of the Niño3.4 SST anomaly throughout the Atlantic hurricane season, provided by the International Research for Climate and Society (IRI). Most models are calling for the development of El Niño conditions at the start of the season into the Northern Hemisphere winter, although some statistical models call for the continuation of ENSO-neutral conditions during this time.

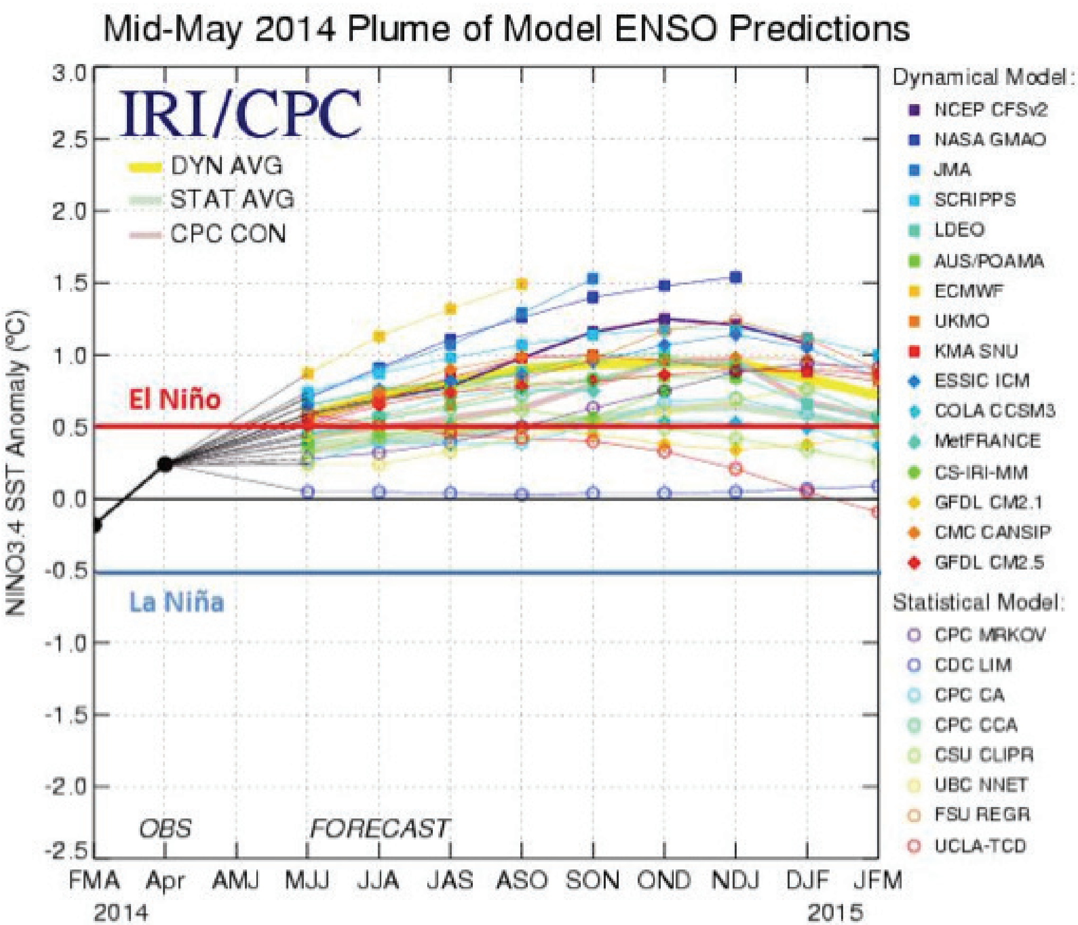

Figure 3: Mid-May 2014 ENSO Model forecasts of three-month SST anomalies in the Niño3.4 region based on the 1971–2000 climatology base period.[14]

[14] Image provided by the International Research for Climate and Society (IRI) http://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/.

The May probabilistic ENSO forecasts for the Niño3.4 region, also provided by IRI, are shown in Table 2. The May forecast for August-September-October, which represents the climatological peak of the hurricane season, indicates a 67% probability of El Niño, a 31% probability of ENSO-neutral conditions, and a 2% probability of La Niña.

The 2014 forecasts for the development of El Niño conditions indicate that enhanced vertical wind shear, which acts to inhibit hurricane activity, is likely to play a major role in suppressing hurricane activity in the Atlantic Basin. However, if ENSO-neutral conditions continue, strong vertical wind shear is not expected to occur over the tropical Atlantic, increasing the potential for elevated hurricane activity in the Atlantic Basin.

Table 2: The IRI probabilistic ENSO forecast for the Niño3.4 region as released in May 2014.[15]

SEASON	LA NIÑA (%)	NEUTRAL (%)	EL NIÑO (%)
May-June-July 2014	~0%	50%	50%
June-July-August 2014	1%	40%	59%
July-August-September 2014	2%	36%	62%
August-September-October 2014	2%	31%	67%
September-October-November 2014	2%	29%	69%
October-November-December 2014	1%	29%	70%
November-December-January 2015	1%	27%	72%
December-January-February 2015	1%	33%	66%
January-February-March 2015	2%	40%	58%

UNDERSTANDING THE SKILL LEVEL OF SEASONAL FORECASTS

Seasonal Forecast implications

Many uncertainties are associated with seasonal forecasts, which are based on the status of a variety of atmospheric and oceanic factors that are challenging to quantify and predict. For example, the success of seasonal hurricane forecasts depends on the successful prediction of relevant climatological factors such as ENSO and the relationship between such factors and hurricane activity. For this reason, RMS recommends treating seasonal hurricane activity forecasts with a level of caution.

Forecast skill for predicting the number of North Atlantic hurricanes is relatively low in the months prior to the season's start. The 2013 seasonal forecasts released in May and June overestimated the number of tropical storms and major hurricanes that occurred in the season. For example, the June 2013 CSU forecast predicted 18 tropical storms, 9 hurricanes, and 4 major hurricanes, when in fact the season ended with 14 tropical storms, 2 hurricanes, and no major hurricanes. As the hurricane season progresses, however, statistical and dynamical models incorporate information about the ocean's observed subsurface thermal structure, which generally increases the accuracy and predictive skill of subsequent forecasts.

[15] Data provided by the IRI http://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/.

Landfalling Hurricanes

Forecast groups, including Colorado State University (CSU) and Tropical Storm Risk (TSR), predict a below-average probability of hurricane landfall over the U.S. and Caribbean in 2014, in comparison to the long-term mean annual probability of hurricane landfall over the last century. The June CSU forecast gives a 40% probability of one or more major hurricanes making landfall along the entire U.S. coastline, well below the 52% average over the last century. The CSU forecast gives a 32% probability of one or more major hurricanes making landfall along the Caribbean coastline, compared to the average for the last century of 42%. In comparison to 2013, the June 2013 CSU forecast called for a 72% probability of a major hurricane landfall along the U.S. coastline and a 61% probability of a major hurricane landfall along the Caribbean coastline. The CSU landfall probability is calculated based on the overall Atlantic Basin Net Tropical Cyclone Activity (NTC).

There is greater uncertainty associated with forecasting hurricane landfalls than forecasting hurricane development in the Atlantic Basin. Landfall forecasts are difficult to predict more than a few weeks in advance, due to the forecast uncertainty of steering currents (or steering winds) that influence storm direction. Steering currents are synoptic scale systems (large-scale weather systems) that can be highly changeable and difficult to predict far in advance. Steering current patterns observed during the 2011 and 2012 Atlantic hurricane seasons played a role in keeping storms away from the U.S., while in 2004 and to a lesser extent in 2005, steering currents were influential in directing a number of storms toward the United States.