FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY AND LANDFALL STRIKE PROBABILITY FOR 2017

We have increased our forecast and now believe that 2017 will have above-average activity. The odds of a significant El Niño in 2017 have continued to diminish, and most of the tropical and subtropical Atlantic remains anomalously warm. With the increase in our forecast, the probability for major hurricanes making landfall along the United States coastline and in the Caribbean has increased as well. As is the case with all hurricane seasons, coastal residents are reminded that it only takes one hurricane making landfall to make it an active season for them. They should prepare the same for every season, regardless of how much activity is predicted.

(as of 5 July 2017)

By Philip J. Klotzbach[1] and Michael M. Bell[2]

In Memory of William M. Gray[3]

This discussion as well as past forecasts and verifications are available online at http://tropical.colostate.edu

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ATLANTIC BASIN SEASONAL HURRICANE FORECAST FOR 2017*

Forecast Parameter and 1981-2010 Median (in parentheses)	Issue Date 6 April 2017	Issue Date 1 June 2017	Issue Date 5 July 2017	Observed Activity Through June 2017	5 July Forecast for Remainder of 2017
Named Storms (NS) (12.0)	11	14	15	3	12
Named Storm Days (NSD) (60.1)	50	60	70	4	66
Hurricanes (H) (6.5)	4	6	8	0	8
Hurricane Days (HD) (21.3)	16	25	35	0	35
Major Hurricanes (MH) (2.0)	2	2	3	0	3
Major Hurricane Days (MHD) (3.9)	4	5	7	0	7
Accumulated Cyclone Energy (ACE) (92)	75	100	135	3	132
Net Tropical Cyclone Activity (NTC) (103%)	85	110	140	7	133

*Seasonal forecast numbers in the first three forecast columns in the above table include tropical cyclones that formed prior to the date of the forecast release (e.g., Arlene, Bret, and Cindy)

PROBABILITIES FOR AT LEAST ONE MAJOR (CATEGORY 3-4-5) HURRICANE LANDFALL ON EACH OF THE FOLLOWING COASTAL AREAS:

1) Entire U.S. coastline - 62% (average for last century is 52%)

2) U.S. East Coast Including Peninsula Florida - 39% (average for last century is 31%)

3) Gulf Coast from the Florida Panhandle westward to Brownsville - 38% (average for last century is 30%)

PROBABILITY FOR AT LEAST ONE MAJOR (CATEGORY 3-4-5) HURRICANE TRACKING INTO THE CARIBBEAN (10-20°N, 60-88°W)

1) 52% (average for last century is 42%)

ABSTRACT

Information obtained through June 2017 indicates that the 2017 Atlantic hurricane season will have activity above the median 1981-2010 season. This revised prediction is a considerable increase from our early seasonal forecasts issued in April and June. There remains considerable uncertainty with this forecast which we outline in the following paragraphs.

We estimate that 2017 will have an additional 8 hurricanes (median is 6.5), 12 named storms (median is 12.0), 66 named storm days (median is 60.1), 35 hurricane days (median is 21.3), 3 major (Category 3-4-5) hurricanes (median is 2.0) and 7 major hurricane days (median is 3.9). The probability of U.S. major hurricane landfall is estimated to be about 120 percent of the long-period average. We expect Atlantic basin Accumulated Cyclone Energy (ACE) and Net Tropical Cyclone (NTC) activity in 2017 to be approximately 145 percent of their long-term averages for the remainder of the season.

This forecast is based on an extended-range early July statistical prediction scheme that was developed utilizing 34 years of past data. Analog predictors are also utilized. We now anticipate an above-average Atlantic basin hurricane season. The odds of a significant El Niño in 2017 have continued to diminish, and most of the tropical and subtropical Atlantic remains anomalously warm. The lack of El Niño conditions typically leads to a lower shear environment in the tropical Atlantic, while a warmer-than-normal tropical Atlantic provides more fuel for developing tropical cyclones. In addition, a warmer-than-normal tropical Atlantic is generally associated with lower surface pressures, increased mid-level moisture and weaker trade winds, creating a more conducive dynamic and thermodynamic environment for hurricane formation and intensification.

Coastal residents are reminded that it only takes one hurricane making landfall to make it an active season for them, and they need to prepare the same for every season, regardless of how much activity is predicted.

Acknowledgment

These seasonal forecasts were developed by the late Dr. William Gray, who was lead author on these predictions for over 20 years and continued as a co-author until his death last year. In addition to pioneering seasonal Atlantic hurricane prediction, he conducted groundbreaking research in a wide variety of other topics including hurricane genesis, hurricane structure and cumulus convection. His investments in both time and energy to these forecasts cannot be acknowledged enough.

We are grateful for support from Interstate Restoration and Ironshore Insurance that partially support the release of these predictions. We acknowledge a grant from the G. Unger Vetlesen Foundation for additional financial support. We thank the GeoGraphics Laboratory at Bridgewater State University (MA) for their assistance in developing the United States Landfalling Hurricane Probability Webpage (available online at http://www.e-transit.org/hurricane).

Colorado State University's seasonal hurricane forecasts have benefited greatly from a number of individuals that were former graduate students of William Gray. Among these former project members are Chris Landsea, John Knaff and Eric Blake. We have also benefited from meteorological discussions with Carl Schreck, Brian McNoldy, Paul Roundy, Jason Dunion, Mike Ventrice and Amato Evan over the past few years.

1 Introduction

This is the 34th year in which the CSU Tropical Meteorology Project has made forecasts of the upcoming season's Atlantic basin hurricane activity. We have shown that a sizable portion of the year-to-year variability of Atlantic tropical cyclone (TC) activity can be hindcast with skill exceeding climatology.

2 July Forecast Methodology

Klotzbach (2014) developed a 1 July seasonal forecast model which was utilized for the first time in real time last year. This 1 July forecast is now based on 35 years of historical data since 1982 (Figure 1).

The model has been modified since Klotzbach (2014) to substitute daily NOAA Optimum Interpolation (NOAA OI) SST instead of ERA-Interim 2-meter temperature for the East Atlantic predictor. The primary reason why this was done is daily OI SST is available in real-time, while ERA-Interim is not available in real-time. ERA-Interim is generally preferred over the Climate Forecast System Reanalysis (CFSR) for statistical model development, as most geophysical parameters show slightly better correlations with Accumulated Cyclone Energy (ACE) when using ERA-Interim than they do with CFSR. We utilize the CFSR dataset to estimate the real-time values for our 2nd predictor which is surface pressure in the tropical equatorial Pacific. We have replaced the 2nd predictor in the forecast model this year, as sea level pressure anomalies in the tropical Pacific likely have a stronger physical link with Atlantic hurricane activity than do upper-level winds in the tropical Indian Ocean.

Figure 2 displays the locations of our two 1 July predictors, while Table 1 displays the values of each predictor for the 2017 hurricane season. Table 2 displays the combination of the two predictors as model output for the 2017 Atlantic hurricane season. The May-June SST predictor in the eastern Atlantic is very strongly positive this season, calling for a very active season, while the surface pressure predictor in the tropical eastern Pacific is near its long-term average value.

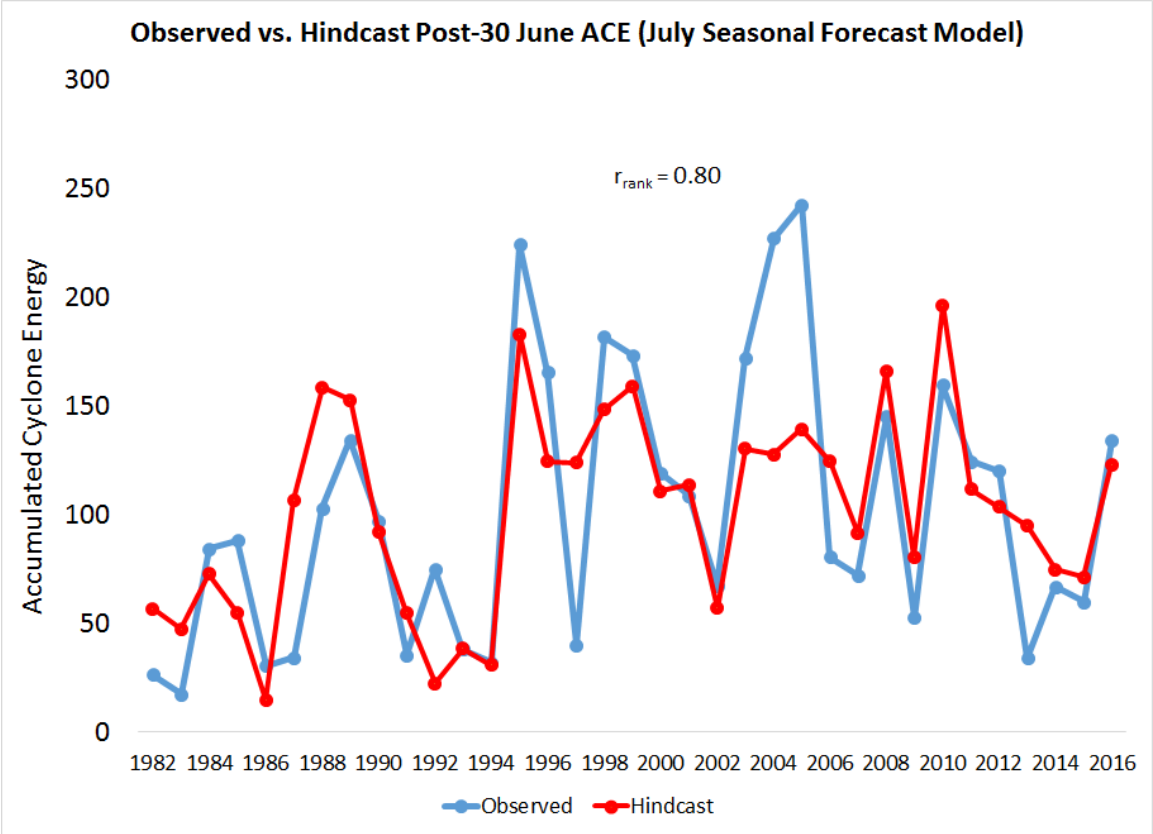

Figure 1: Observed versus early July jackknifed hindcast values of ACE for 1982-2016. The hindcast model explains approximately 65% of the variance from climatology.

July Forecast Predictors

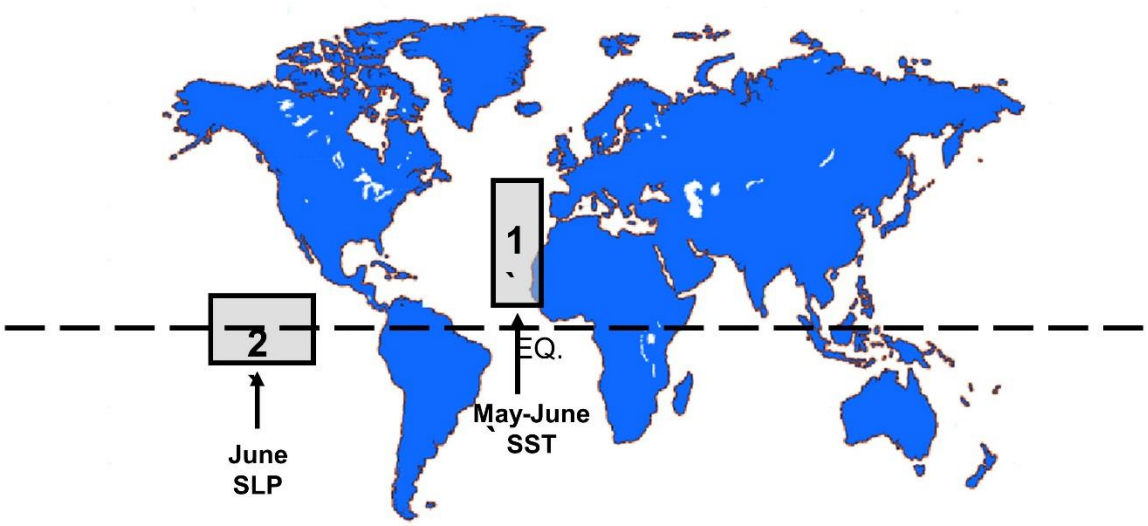

Figure 2: Location of predictors for the early July statistical prediction for the 2017 hurricane season.

Table 1: Listing of 1 July 2017 predictors for the 2017 hurricane season. A plus (+) means that positive values of the parameter indicate increased hurricane activity.

Predictor	2017 Forecast Value	Favorable/Unfavorable for TCs
1) May-June SST (10-50°N, 30-10°W) (+)	+1.3 SD	Favorable
2) June SLP (15°S-15°N, 150-110°W) (+)	-0.1 SD	Neutral

Table 2: 1 July statistical model output for the remainder of the 2017 Atlantic hurricane season.

Forecast Parameter and 1981-2010 Median (in parentheses)	Statistical Forecast
Named Storms (12.0)	13.3
Named Storm Days (60.1)	72.1
Hurricanes (6.5)	8.1
Hurricane Days (21.3)	35.1
Major Hurricanes (2.0)	4.0
Major Hurricane Days (3.9)	10.3
Accumulated Cyclone Energy Index (92)	146
Net Tropical Cyclone Activity (103%)	157

3 Forecast Uncertainty

One of the questions that we are asked regarding our seasonal hurricane predictions is the degree of uncertainty that is involved. Our predictions are our best estimate, but there is with all forecasts an uncertainty as to how well they will verify.

Table 3 provides our early July forecasts, with error bars based on one standard deviation of the 1982-2010 cross-validated hindcast error. We typically expect to see 2/3 of our forecasts verify within one standard deviation of observed values, with 95% of forecasts verifying within two standard deviations of observed values.

Table 3: Model hindcast error and our 2017 hurricane forecast. Uncertainty ranges are given in one standard deviation (SD) increments.

Parameter	Hindcast Error (SD)	2017 Forecast	Uncertainty Range – 1 SD (67% of Forecasts Likely in this Range)
Named Storms (NS)	3	15	12 - 18
Named Storm Days (NSD)	19	70	51 – 89
Hurricanes (H)	2	8	6 – 10
Hurricane Days (HD)	10	35	25 – 45
Major Hurricanes (MH)	1	3	2 – 4
Major Hurricane Days (MHD)	4	7	3 – 11
Accumulated Cyclone Energy (ACE)	42	135	93 – 177
Net Tropical Cyclone (NTC) Activity	41	140	99 – 181

4 Analog-Based Predictors for 2017 Hurricane Activity

Certain years in the historical record have global oceanic and atmospheric trends which are similar to 2017. These years also provide useful clues as to likely trends in activity that the forthcoming 2017 hurricane season may bring. For this early July extended range forecast, we determine which of the prior years in our database have distinct trends in key environmental conditions which are similar to current May-June

2017 conditions as well as what we anticipate to be present during August-October. Table 4 lists our analog selections.

We select prior hurricane seasons since 1950 which have similar atmospheric-oceanic conditions to those currently being experienced. We searched for years that were characterized by neutral ENSO to weak El Niño conditions and generally warm tropical Atlantic SST conditions.

There were six hurricane seasons since 1950 with characteristics most similar to what we expect to see in August-October of 2017. We anticipate that the 2017 hurricane season will have activity near the average of our six analog years. We now believe that this season should experience somewhat above-average activity.

Table 4: Best analog years for 2017 with the associated full-season hurricane activity listed for each year.

Year	NS	NSD	H	HD	MH	MHD	ACE	NTC
1953	14	61.75	7	19.00	3	5.00	99	116
1969	18	92.25	12	40.25	5	6.50	166	182
1979	9	45.75	6	21.75	2	5.75	93	97
2004	15	93.00	9	45.50	6	22.25	227	232
2006	10	52.75	5	21.25	2	2.00	79	85
2012	19	101.25	10	28.50	2	0.50	133	131
Average	14.2	74.5	8.2	29.4	3.3	7.0	133	140
2017 Forecast	**15**	**70**	**8**	**35**	**3**	**7**	**135**	**140**

5 ENSO

The tropical Pacific appears to be locked into ENSO neutral conditions at the present time. There was an increase in ocean heat content during the spring months associated with the transition away from weak La Niña conditions, but this increase has stalled in recent weeks. Upper ocean heat content has been slightly above average for the past several weeks (Figure 3).

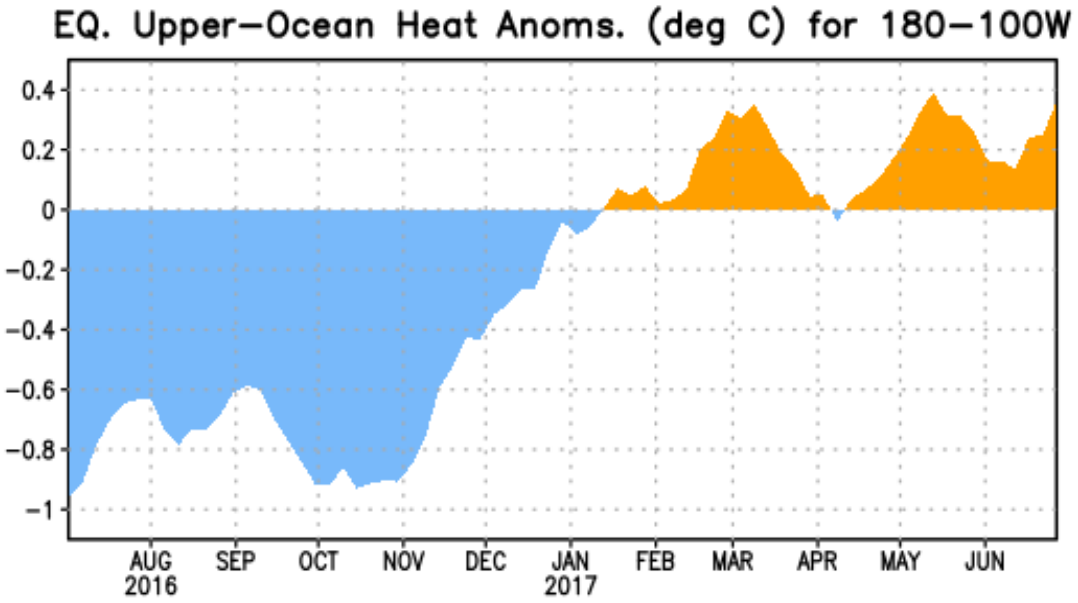

Figure 3: Central and eastern tropical Pacific upper ocean (0-300 meters) heat content anomalies over the past year. Anomalies have been slightly above normal since mid-April 2017. Figure courtesy of the Climate Prediction Center.

Currently, SSTs are running near to slightly above average across the eastern tropical Pacific with above-average SSTs persisting in the central tropical Pacific. Table 5 displays the May and June SST anomalies across the tropical Pacific. There has generally been a modest cooling across the tropical eastern Pacific and a modest warming over the tropical central Pacific over the past month.

Table 5: May and June SST anomalies for Nino 1+2, Nino 3, Nino 3.4, and Nino 4, respectively. June minus May SST anomaly differences are also provided.

Region	May SST Anomaly (°C)	June SST Anomaly (°C)	June minus May SST Anomaly (°C)
Nino 1+2	+0.8	+0.2	-0.6
Nino 3	+0.5	+0.3	-0.2
Nino 3.4	+0.5	+0.6	+0.1
Nino 4	+0.3	+0.6	+0.3

There is a fairly wide spread amongst the various dynamical and statistical models as to what is likely to occur with ENSO over the next few months, but many of the models have considerably backed off on the potential for a weak to moderate El Niño event. The likely lack of El Niño and its associated increase in vertical wind shear across the Caribbean and tropical Atlantic is one of the primary reasons why we have significantly increased our forecast with this update (Figure 4).

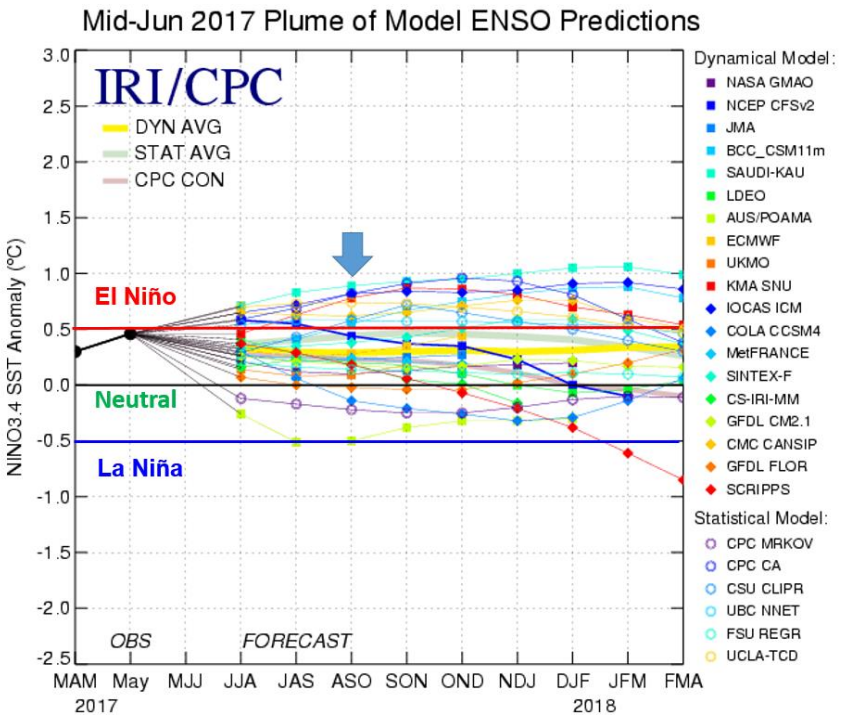

Figure 4: ENSO forecasts from a wide variety of dynamical and statistical models. Figure courtesy of International Research Institute/Climate Prediction Center. The blue arrow highlights the peak of the Atlantic hurricane season (August-October).

Based on the above information, our best estimate is that we will have warm neutral ENSO conditions in place for the peak of the 2017 Atlantic hurricane season. Additional discussion of ENSO will be included with the 4 August update.

6 Current Atlantic Basin Conditions

Tropical Atlantic SSTs are currently warmer than normal, while the far North Atlantic is quite cold (Figure 5). Strong positive warm anomalies also dominate the eastern tropical and especially subtropical Atlantic. In general, the current SST anomaly pattern in the tropical Atlantic correlates well with the June SST correlation associated with active Atlantic hurricane seasons (Figure 6). However, the cold far North Atlantic looks more similar to what is expected with negative AMO periods.

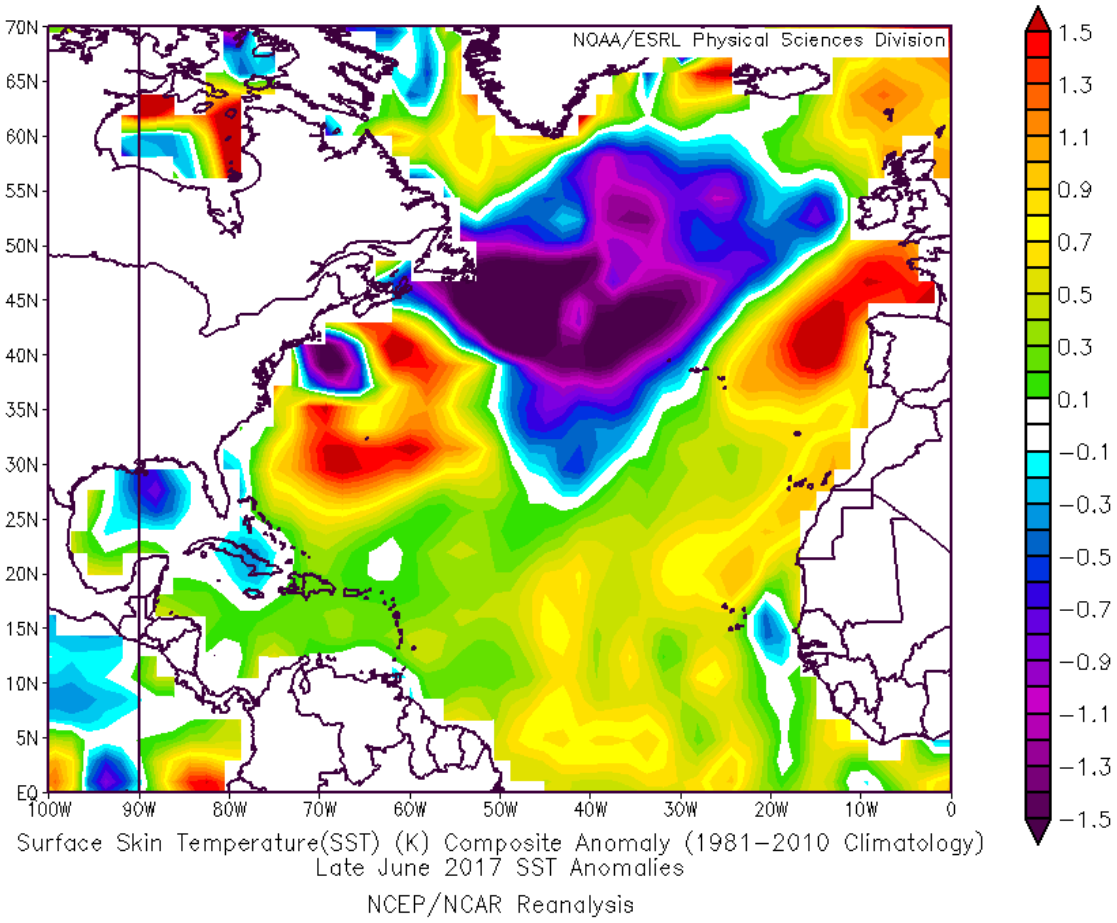

Figure 5: Late June SST anomalies across the Atlantic.

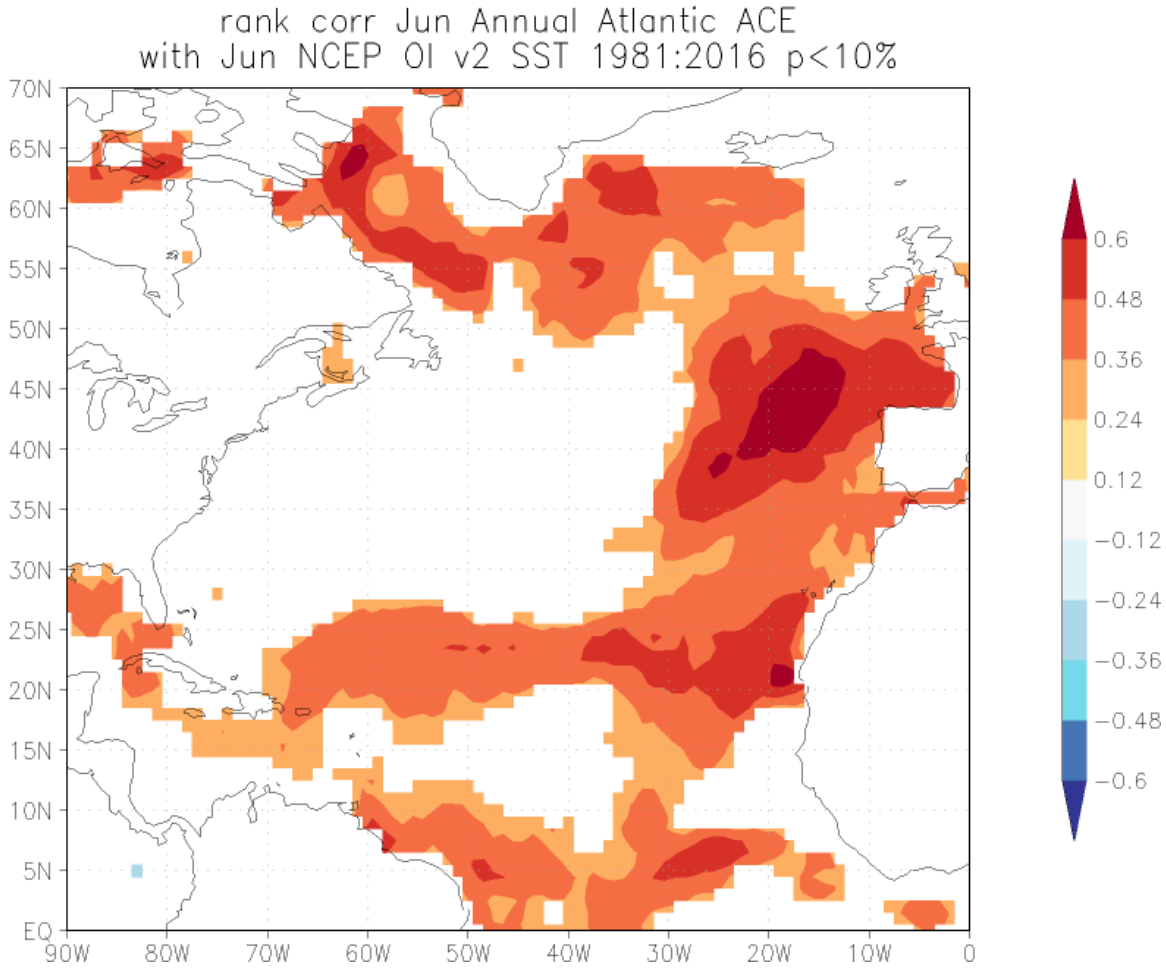

Figure 6: Rank correlation map between June SSTs and annual Atlantic ACE.

Sea level pressure anomalies have been running well below average since the beginning of June in the Main Development Region (MDR) (10-20°N, 60-20°W) (Figure 7). While the importance of this predictor increases in July compared with June, low sea level pressure anomalies in June tend to be associated with active seasons (Figure 8).

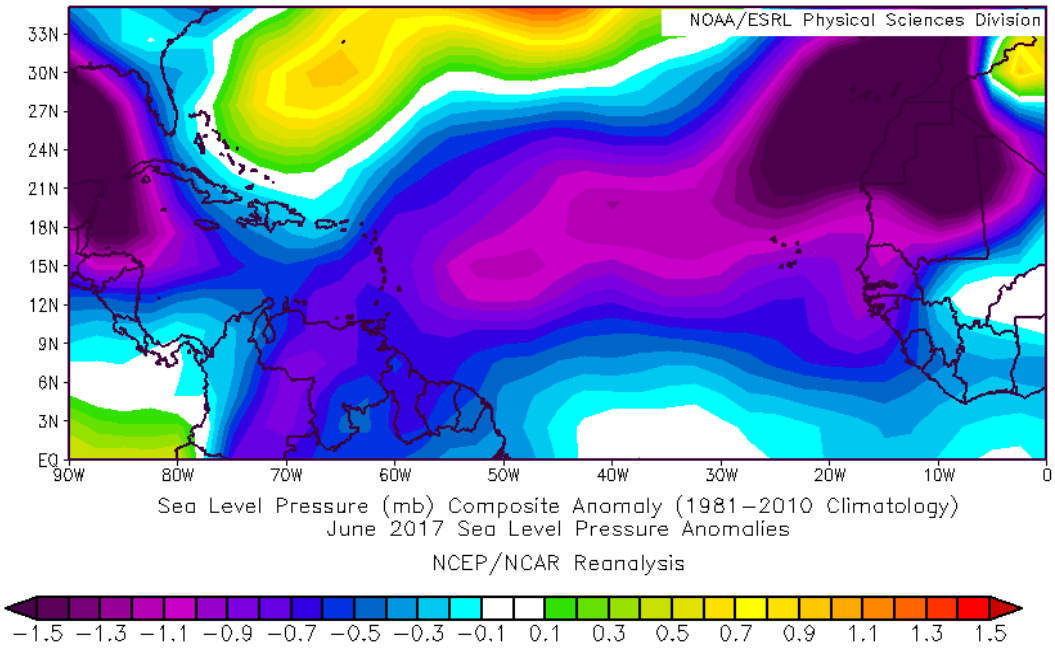

Figure 7: Sea level pressure anomalies across the tropical Atlantic during June 2017. Sea level pressure anomalies are running well below average this month.

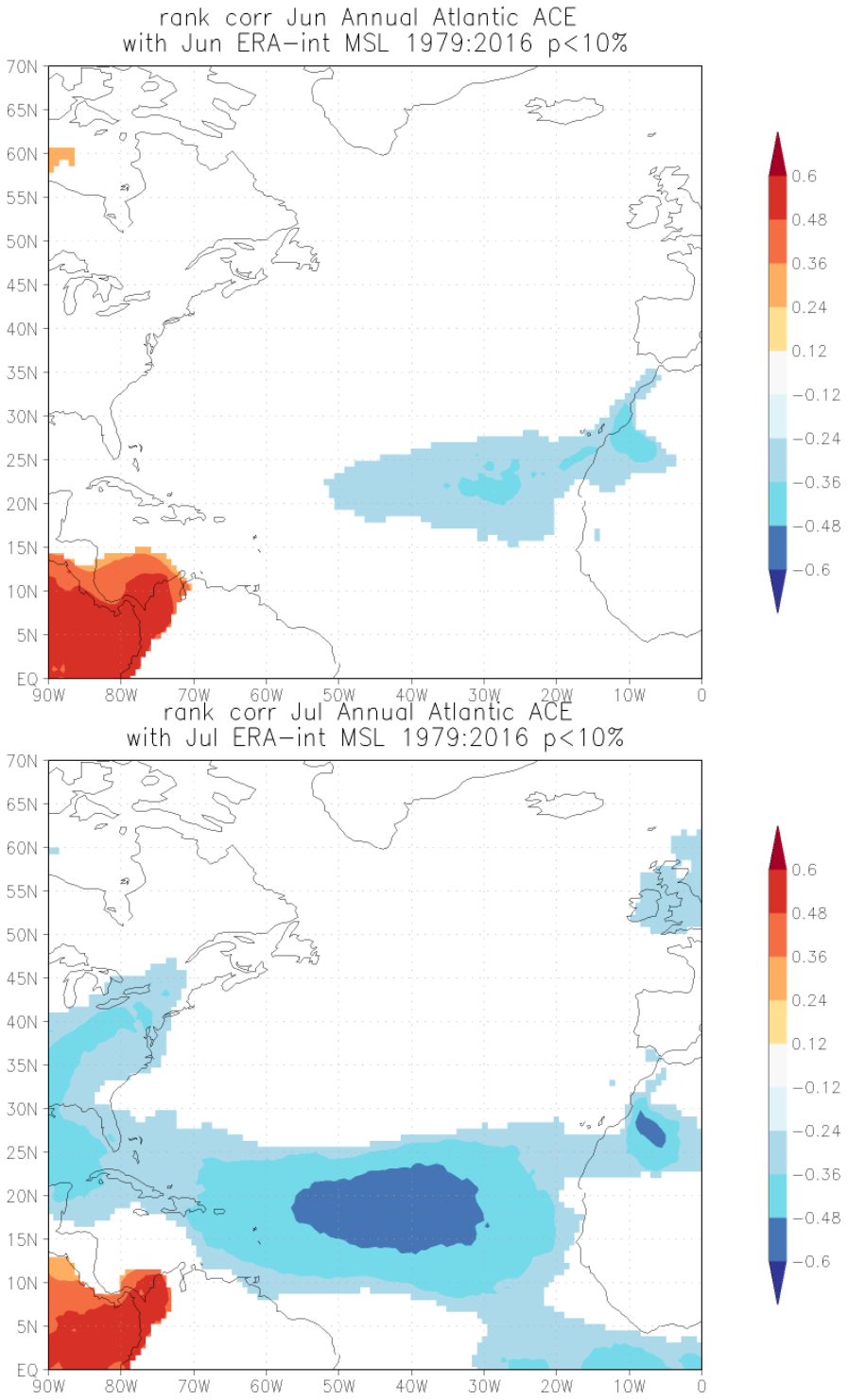

Figure 8: (top panel) Correlation map between June sea level pressure and Atlantic ACE, (bottom panel): Correlation map between July sea level pressure and Atlantic ACE.

Levels of vertical wind shear across the tropical Atlantic and western Caribbean have been somewhat below average while they were a bit above average across the eastern Caribbean over the past 30 days (Figure 9).

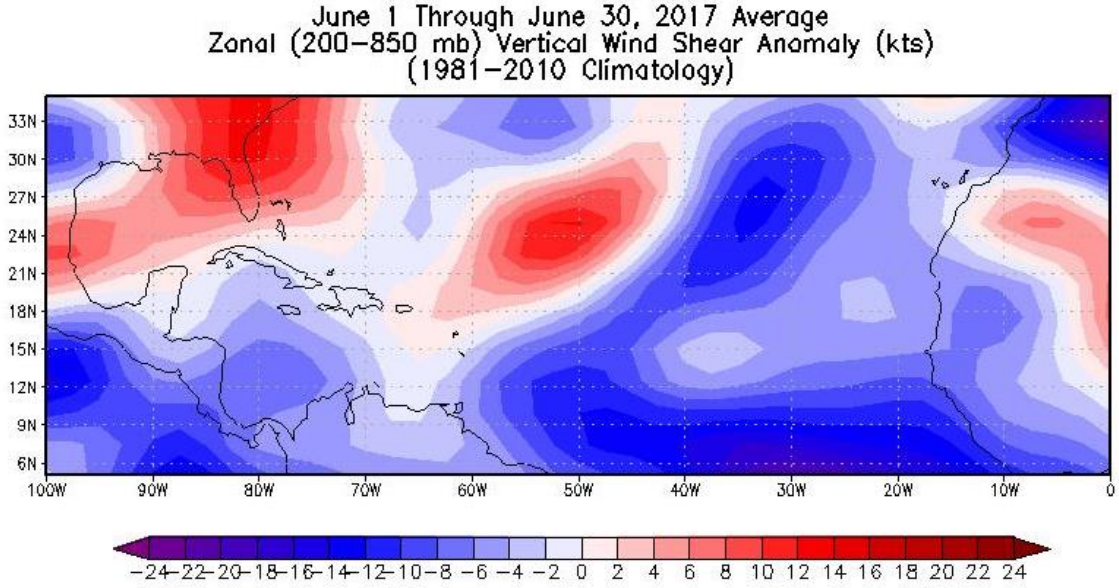

Figure 9: Recent 30-day anomalies of zonal vertical wind shear across the tropical Atlantic and Caribbean differenced from the 1981-2010 climatology.

The latest forecast from the CFS model is calling for slightly below-normal vertical wind shear across the Main Development Region and portions of the Caribbean during the peak of the Atlantic hurricane season from August-October (Figure 10). If this forecast verifies, we could potentially see a much more active Main Development Region than what has been observed over the past few years.

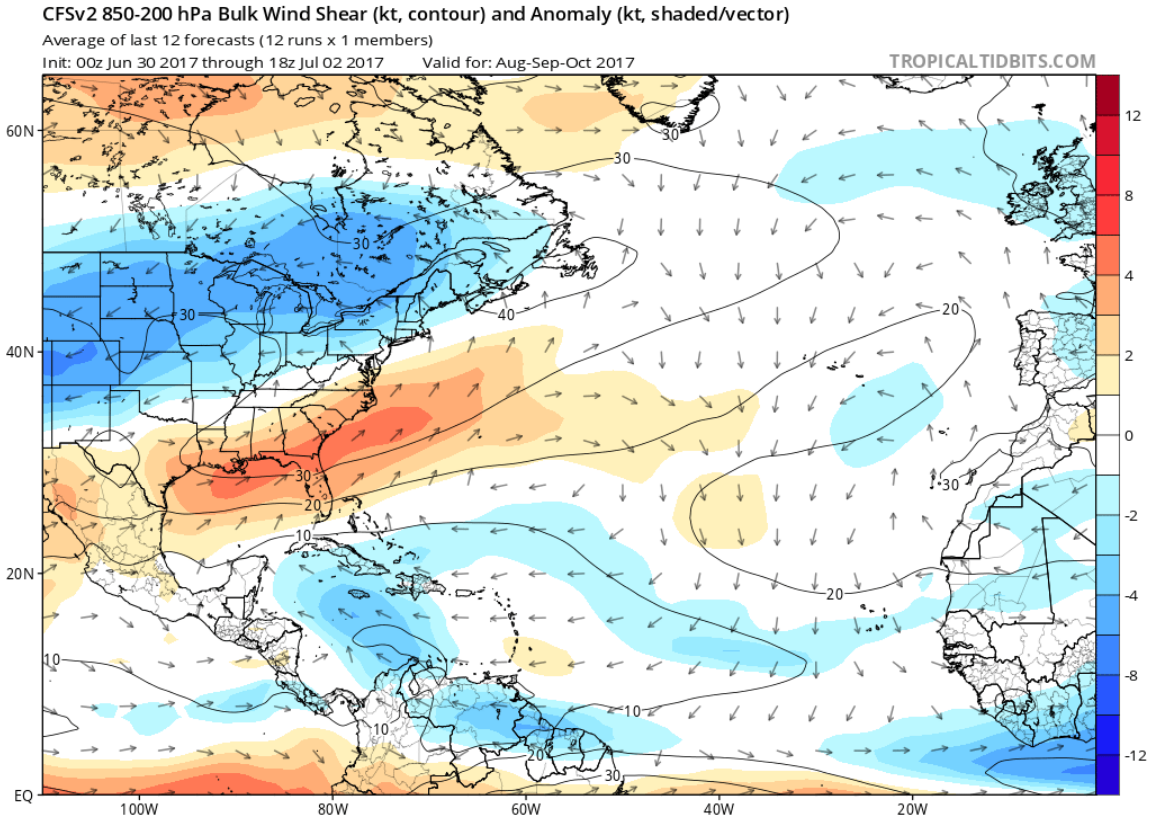

Figure 10: Most recent forecast from the Climate Forecast System for bulk wind shear across the North Atlantic for August-October. Figure courtesy of Tropical Tidbits.

7 Forthcoming Updated Forecasts of 2017 Hurricane Activity

We will be issuing a final seasonal update of our 2017 Atlantic basin hurricane forecasts on Friday**, 4 August**. We will also be releasing two-week forecasts for Atlantic TC activity during the climatological peak of the season from August-October. A verification and discussion of all 2017 forecasts will be issued in late November 2017. All of these forecasts are available online.