FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY AND LANDFALL STRIKE PROBABILITY FOR 2018

We have decreased our forecast and now believe that 2018 will have below-average activity. The tropical and subtropical Atlantic is currently much colder than normal, and the odds of a weak El Niño developing in the next several months have increased. With the decrease in our forecast, the probability for major hurricanes making landfall along the United States coastline and in the Caribbean has decreased 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 2 July 2018)

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

Anne Manning, Colorado State University media representative, is coordinating media inquiries into this forecast. She can be reached at 970-491-7099 or anne.manning@colostate.edu.

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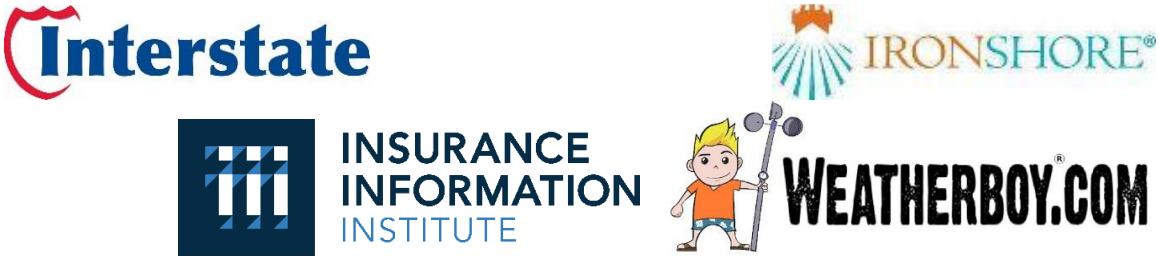

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ATLANTIC BASIN SEASONAL HURRICANE FORECAST FOR 2018*

Forecast Parameter and 1981-2010 Median (in parentheses)	Issue Date 5 April 2018	Issue Date 31 May 2018	Issue Date 2 July 2018	Observed Activity Through June 2018	2 July Forecast for Remainder of 2018
Named Storms (NS) (12.0)	14	14	11	1	10
Named Storm Days (NSD) (60.1)	70	55	45	3.50	41.50
Hurricanes (H) (6.5)	7	6	4	0	4
Hurricane Days (HD) (21.3)	30	20	15	0	15
Major Hurricanes (MH) (2.0)	3	2	1	0	1
Major Hurricane Days (MHD) (3.9)	7	4	2	0	2
Accumulated Cyclone Energy (ACE) (92)	130	90	60	2	58
Net Tropical Cyclone Activity (NTC) (103%)	135	100	70	3	67

*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., Alberto in May).

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

1) Entire U.S. coastline - 39% (average for last century is 52%)

2) U.S. East Coast Including Peninsula Florida - 22% (average for last century is 31%)

3) Gulf Coast from the Florida Panhandle westward to Brownsville - 21% (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) 31% (average for last century is 42%)

ABSTRACT

Information obtained through June 2018 indicates that the 2018 Atlantic hurricane season will have activity below the median 1981-2010 season. This revised prediction is a considerable decrease from our prior seasonal forecasts issued in April and June. There remains some uncertainty with this forecast which we outline in the following paragraphs.

We estimate that 2018 will have an additional 4 hurricanes (median is 6.5), 10 named storms (median is 12.0), 41.50 named storm days (median is 60.1), 15 hurricane days (median is 21.3), 1 major (Category 3-4-5) hurricane (median is 2.0) and 2 major hurricane days (median is 3.9). The probability of U.S. major hurricane landfall is estimated to be about 75 percent of the long-period average. We expect Atlantic basin Accumulated Cyclone Energy (ACE) and Net Tropical Cyclone (NTC) activity for the remainder of the season to be approximately 65 percent of their long-term median values.

This forecast is based on an extended-range early July statistical prediction scheme that was developed utilizing 36 years of past data. Analog predictors are also utilized. We now anticipate a below-average Atlantic basin hurricane season. The tropical Atlantic is much colder than normal. A colder than normal tropical Atlantic provides less fuel for developing tropical cyclones but also tends to be associated with higher pressure and a more stable atmosphere. These conditions tend to suppress Atlantic hurricane activity.

Also, the odds of a weak El Niño for the peak of the Atlantic hurricane season in 2018 have increased somewhat. If El Niño were to develop, it would tend to lead to more vertical wind shear in the Caribbean extending into the tropical Atlantic, tearing apart hurricanes as they are trying to develop and intensify.

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 in 2016. 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, Ironshore Insurance, the Insurance Information Institute and Weatherboy 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 several 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 and Amato Evan over the past few years.

1 Introduction

This is the 35th 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 in 2016. This 1 July forecast is now based on 36 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 replaced the 2nd predictor in the forecast model in 2016, 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 2018 hurricane season. Table 2 displays the combination of the two predictors as model output for the 2018 Atlantic hurricane season. The May-June SST predictor in the eastern Atlantic is strongly negative this season, calling for a below-average season, while the surface pressure predictor in the tropical eastern Pacific is near its long-term average value.

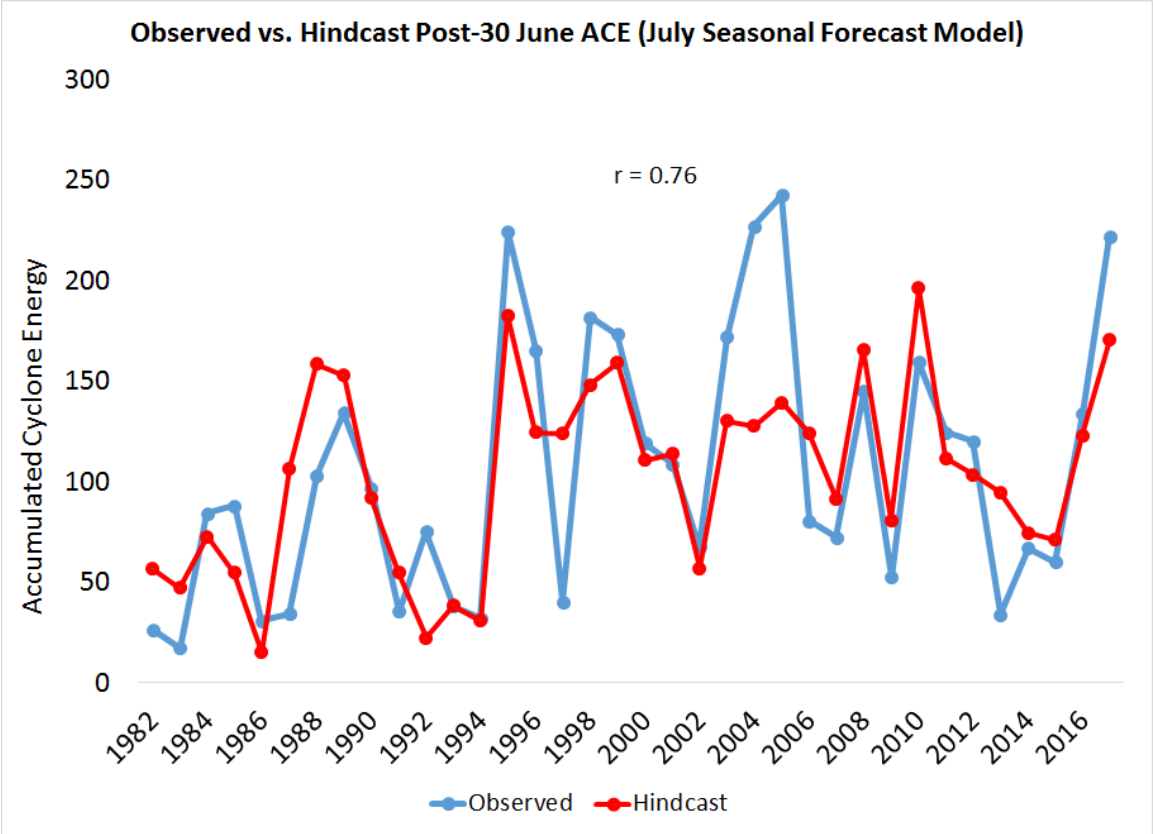

Figure 1: Observed versus early July jackknifed hindcast values of ACE for 1982-2017. The hindcast model explains approximately 60% of the variance from climatology.

July Forecast Predictors

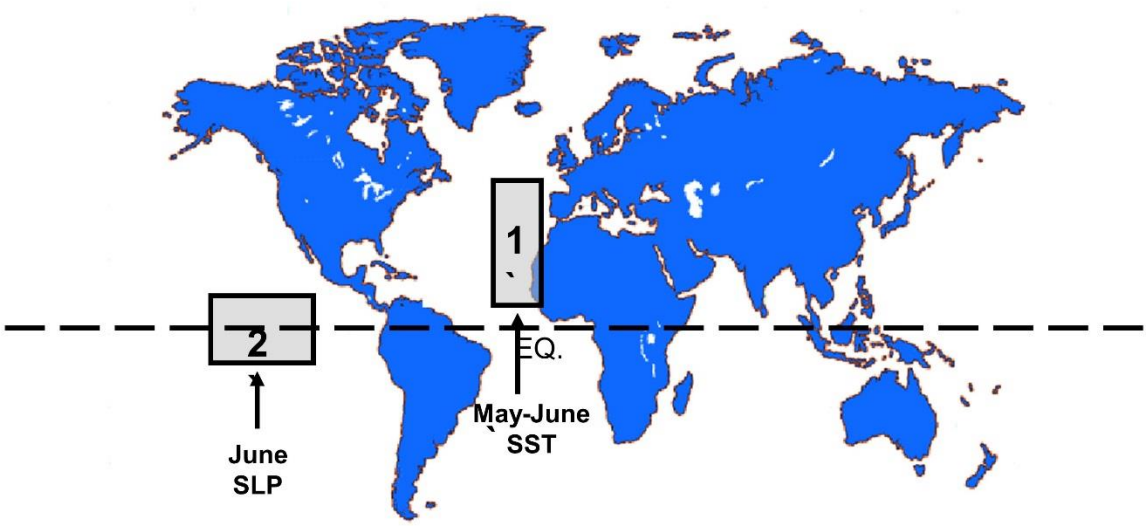

Figure 2: Location of predictors for the early July statistical prediction for the 2018 hurricane season.

Table 1: Listing of 1 July 2018 predictors for the 2018 hurricane season. A plus (+) means that positive values of the parameter indicate increased hurricane activity.

Predictor	2018 Forecast Value	Favorable/Unfavorable for TCs
1) May-June SST (10-50°N, 30-10°W) (+)	-1.2 SD	Unfavorable
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 2018 Atlantic hurricane season.

Forecast Parameter and 1981-2010 Median (in parentheses)	Statistical Forecast
Named Storms (12.0)	8.4
Named Storm Days (60.1)	35.8
Hurricanes (6.5)	4.3
Hurricane Days (21.3)	13.6
Major Hurricanes (2.0)	1.3
Major Hurricane Days (3.9)	2.1
Accumulated Cyclone Energy Index (92)	56
Net Tropical Cyclone Activity (103%)	64

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 2018 hurricane forecast (including Alberto). Uncertainty ranges are given in one standard deviation (SD) increments.

Parameter	Hindcast Error (SD)	2018 Forecast	Uncertainty Range – 1 SD (67% of Forecasts Likely in this Range)
Named Storms (NS)	3	11	8 – 14
Named Storm Days (NSD)	19	45	26 – 64
Hurricanes (H)	2	4	2 – 6
Hurricane Days (HD)	10	15	5 – 25
Major Hurricanes (MH)	1	1	0 – 2
Major Hurricane Days (MHD)	4	2	0 – 6
Accumulated Cyclone Energy (ACE)	42	60	18 – 102
Net Tropical Cyclone (NTC) Activity	41	70	29 - 111

4 Analog-Based Predictors for 2018 Hurricane Activity

Certain years in the historical record have global oceanic and atmospheric trends which are similar to 2018. These years also provide useful clues as to likely trends in activity that the forthcoming 2018 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

2018 conditions as well as what we anticipate will 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 generally characterized by neutral to weak El Niño conditions and below-normal 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 2018. We anticipate that the 2018 hurricane season will have activity near the average of our five analog years. We now believe that this season should experience below-average activity.

Table 4: Best analog years for 2018 with the associated full-season hurricane activity listed for each year.

Year	NS	NSD	H	HD	MH	MHD	ACE	NTC
1986	6	23.25	4	10.50	0	0.00	36	37
1990	14	72.25	8	26.75	1	1.00	97	100
1994	7	28.75	3	7.25	0	0.00	32	35
2009	9	30.00	3	12.00	2	3.50	53	70
2014	8	35.00	6	17.75	2	3.75	67	82
Average	9.0	39.5	5.1	16.5	1.3	2.0	63	71
2018 Forecast	**11**	**45**	**4**	**15**	**1**	**2**	**60**	**70**

5 ENSO

The tropical Pacific currently is characterized by warm neutral ENSO conditions. There has been an increase in upper ocean heat content over the past several months, with current values of upper ocean heat content supportive of El Niño development (Figure 3). Despite the upper ocean heat content warming, there remains some question as to how much of this warming will reach the ocean surface in the next couple of months.

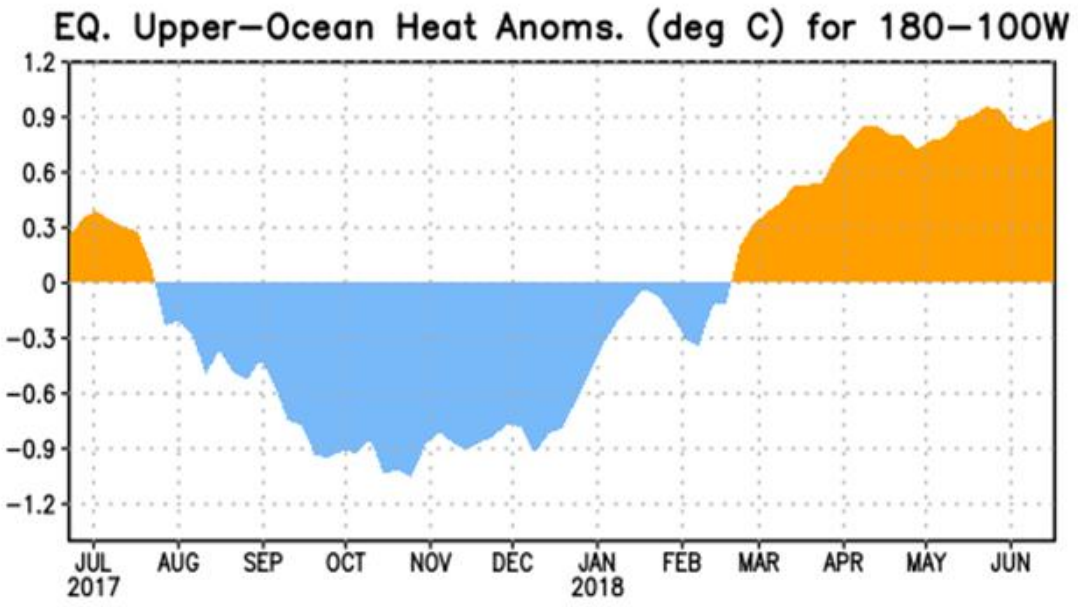

Figure 3: Central and eastern tropical Pacific upper ocean (0-300 meters) heat content anomalies over the past year. Anomalies have been trending upwards since late last year and are currently near 0.9°C. Figure courtesy of the Climate Prediction Center.

Currently, SSTs are running slightly above-average across most of the eastern and central tropical Pacific, with below-average SSTs right along the west coast of South American in the Nino 1+2 region. Table 5 displays the May and June SST anomalies across the tropical Pacific. There has generally been warming over the tropical central Pacific and cooling over the far eastern tropical 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	-0.5	-0.8	-0.3
Nino 3	-0.2	+0.3	+0.5
Nino 3.4	-0.1	+0.3	+0.4
Nino 4	+0.2	+0.3	+0.1

The models are about evenly split whether we will have a weak El Niño event (0.5 - 1°C) or a neutral ENSO event (-0.5 - 0.5°C) during the peak of the Atlantic hurricane season from August-October (Figure 4). While a weak El Niño event could make conditions more detrimental for Atlantic hurricane activity, the primary reason why we have significantly reduced our forecast is due to the persistence of anomalous cooling in the tropical Atlantic (discussed in the next section).

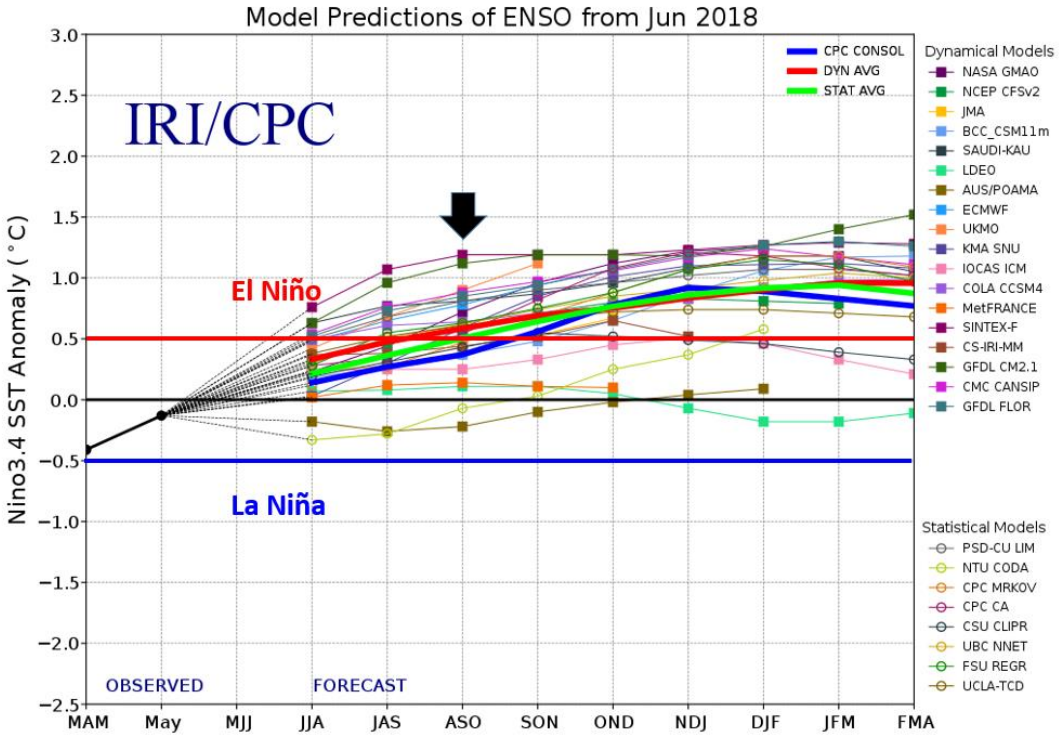

Figure 4: ENSO forecasts from a variety of dynamical and statistical models. Figure courtesy of International Research Institute/Climate Prediction Center. The black arrow highlights the peak of the Atlantic hurricane season (August-October).

Based on the above information, our best estimate is that we will have borderline weak El Niño conditions in place for the peak of the 2018 Atlantic hurricane season. Additional discussion of ENSO will be included with the 2 August update.

6 Current Atlantic Basin Conditions

Tropical Atlantic SSTs and far North Atlantic SSTs are currently much colder than normal (Figure 5). In general, the current SST anomaly pattern in the tropical Atlantic and the far North Atlantic correlates well with the June SST correlation associated with inactive Atlantic hurricane seasons (Figure 6). An extensive discussion as to how North Atlantic SSTs got as anomalously cold as they are now is available in a blog post for the Washington Post's Capital Weather Gang.

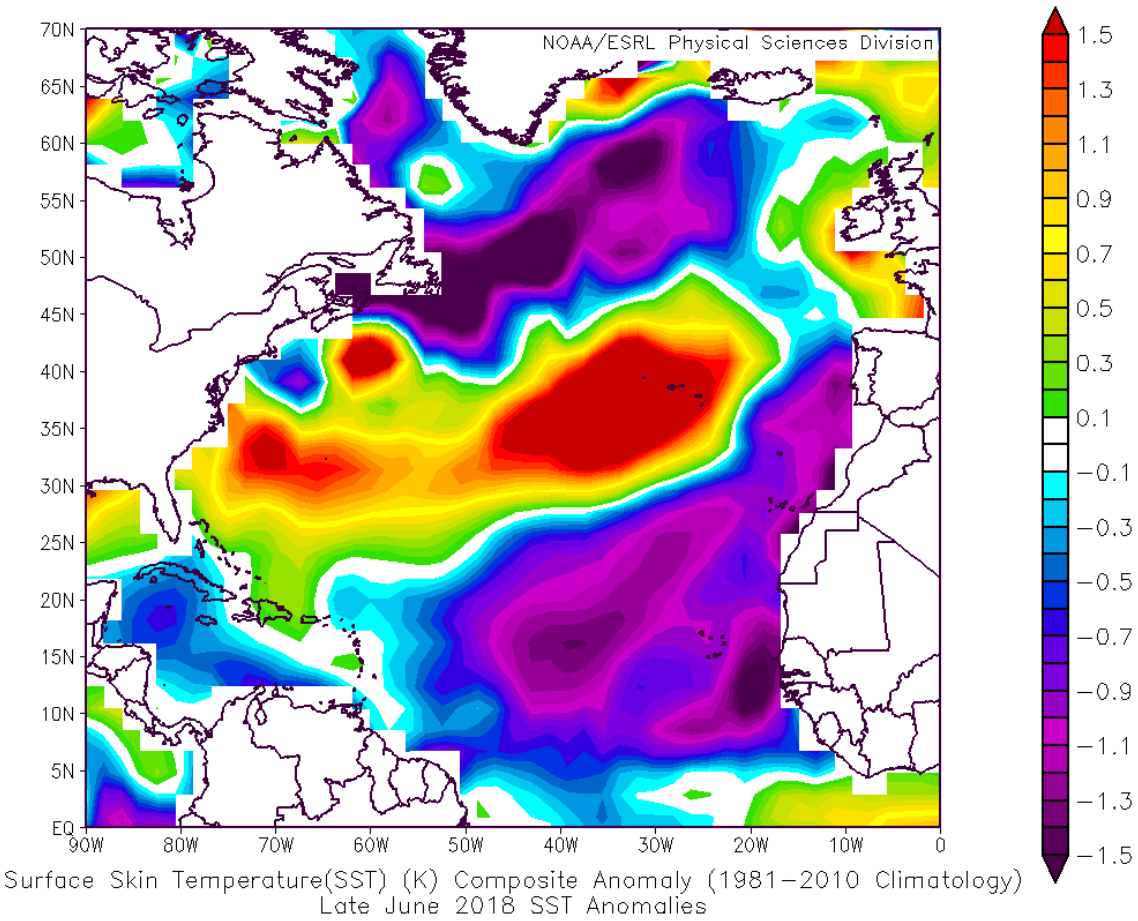

Figure 5: Late June 2018 SST anomalies across the Atlantic.

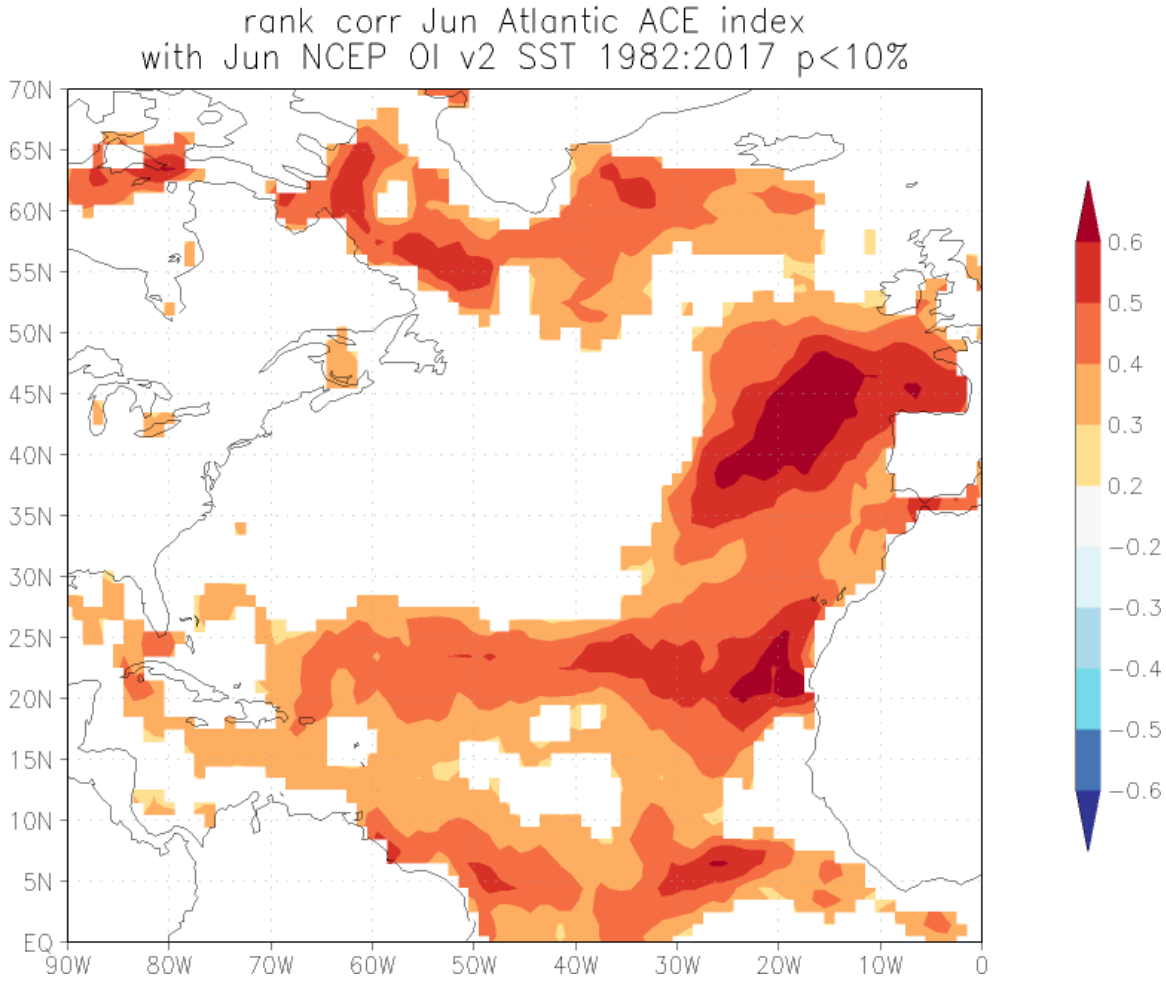

Figure 6: Rank correlation map between June SSTs and annual Atlantic ACE.

A colder-than-normal tropical Atlantic inhibits hurricane formation for several reasons. In addition to colder water providing less fuel for developing tropical cyclones, it also is typically characterized by higher sea level pressure anomalies as well as drier air masses and more subsidence. Drier and more stable air suppresses deep thunderstorm formation which are the building blocks of hurricanes. Sea level pressure anomalies have been running well above average since the beginning of June in the Main Development Region (MDR) (10-20°N, 60-20°W) (Figure 7). The tropical Atlantic has been much more stable than normal, as evidenced by below-average vertical instability (Figure 8).

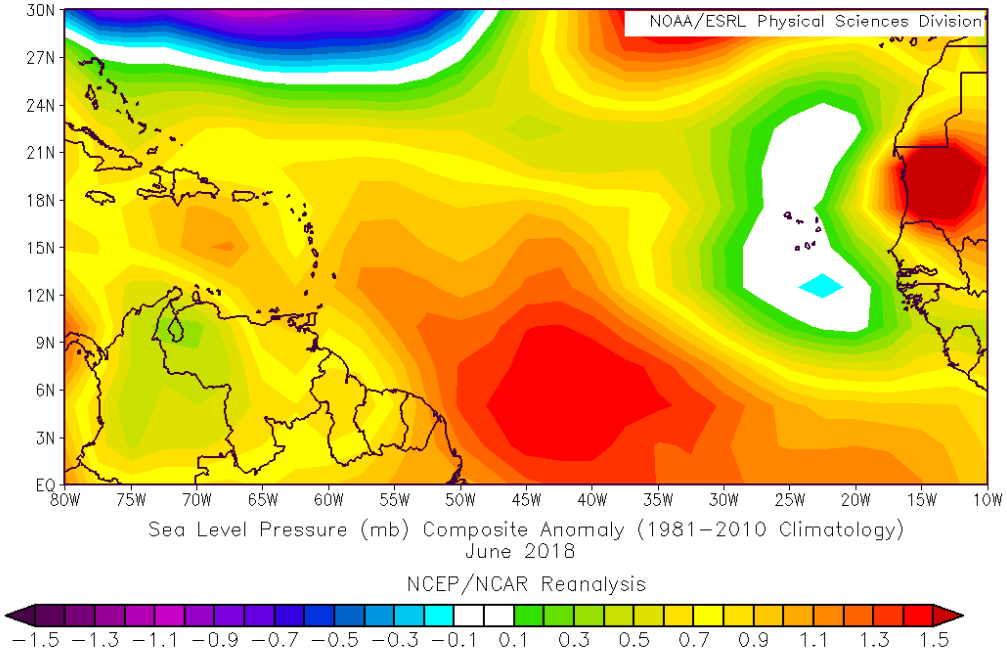

Figure 7: Sea level pressure anomalies across the tropical Atlantic during June 2018. Sea level pressure anomalies are running well above average this month.

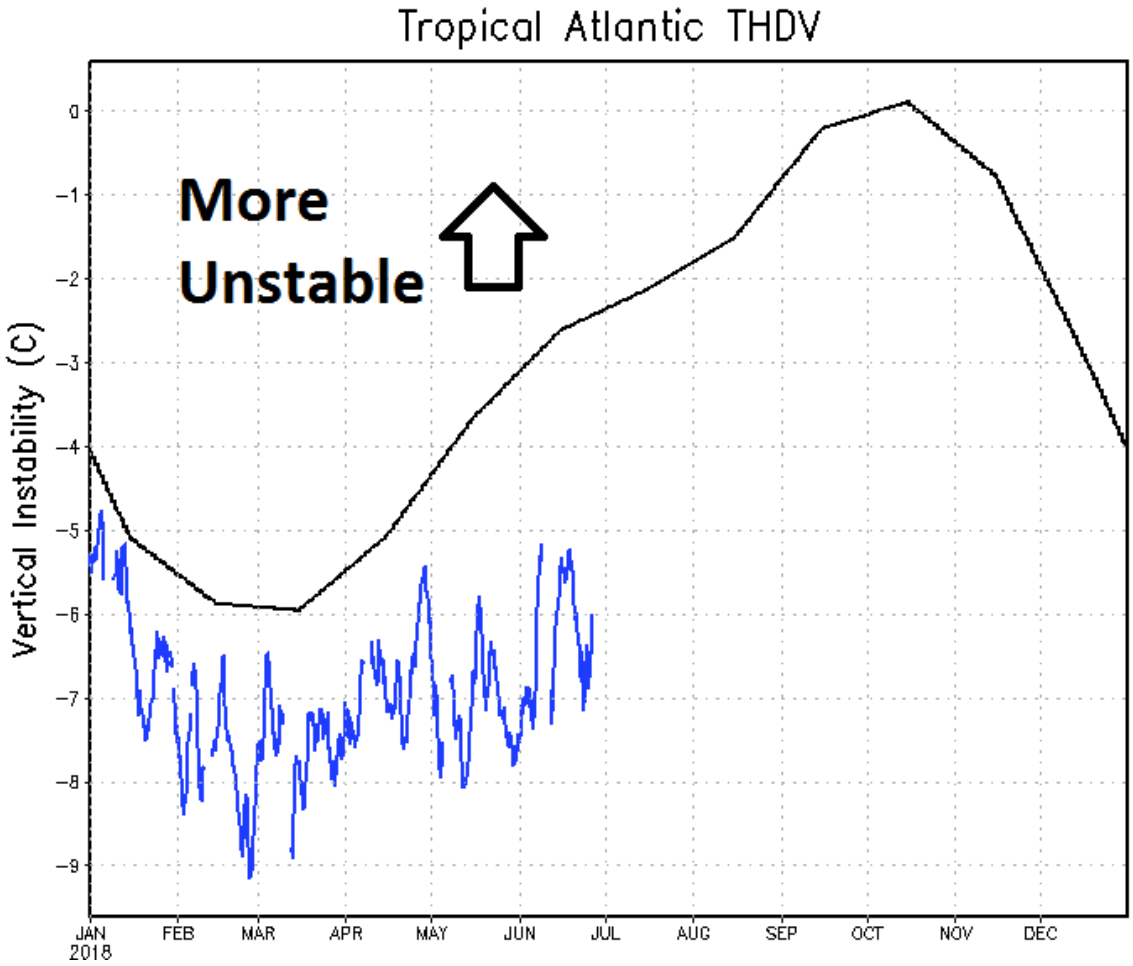

Figure 8: Vertical instability as measured across the tropical Atlantic in 2018. The atmosphere has generally been more stable than normal for the entire year, with the tropical Atlantic being remarkably stable currently. Figure courtesy of the Cooperative Institute for Research in the Atmosphere (CIRA).

Levels of vertical wind shear across the Caribbean have been well above-average while they have been near normal across the tropical Atlantic over the past 30 days (Figure 9). In general, the correlation between shear and Atlantic ACE is stronger in the Caribbean than it is in the tropical Atlantic. The relationship between shear and Atlantic hurricanes is much stronger in July than it is in June.

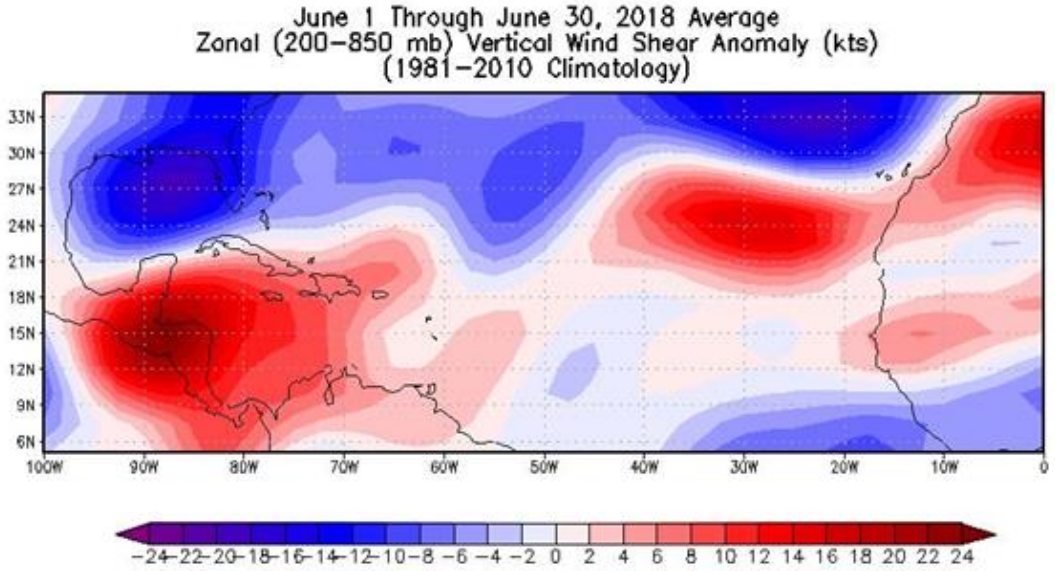

Figure 9: Recent 30-day anomalies of zonal vertical wind shear across the tropical Atlantic and Caribbean differenced from the 1981-2010 climatology.

7 Forthcoming Updated Forecasts of 2018 Hurricane Activity

We will be issuing a final seasonal update of our 2018 Atlantic basin hurricane forecasts on Thursday**, 2 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 2018 forecasts will be issued in late November 2018. All of these forecasts are available online.