SUMMARY OF 2020 ATLANTIC TROPICAL CYCLONE ACTIVITY AND VERIFICATION OF AUTHORS' SEASONAL AND TWO-WEEK FORECASTS

The 2020 Atlantic hurricane season broke the record for the most named storms to form in a single Atlantic hurricane season and had activity well above-average for most other metrics. The seasonal forecasts of Accumulated Cyclone Energy made by the Tropical Meteorology Project verified quite well. The season was also extremely active from a landfalling perspective, with 12 named storms making landfall in the continental US, breaking the prior record of 9 set in 1916. Hurricane Laura was the most intense landfalling storm of 2020 in the continental US. Laura made landfall as a Category 4 hurricane in southwest Louisiana.

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In Memory of William M. Gray[4]

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

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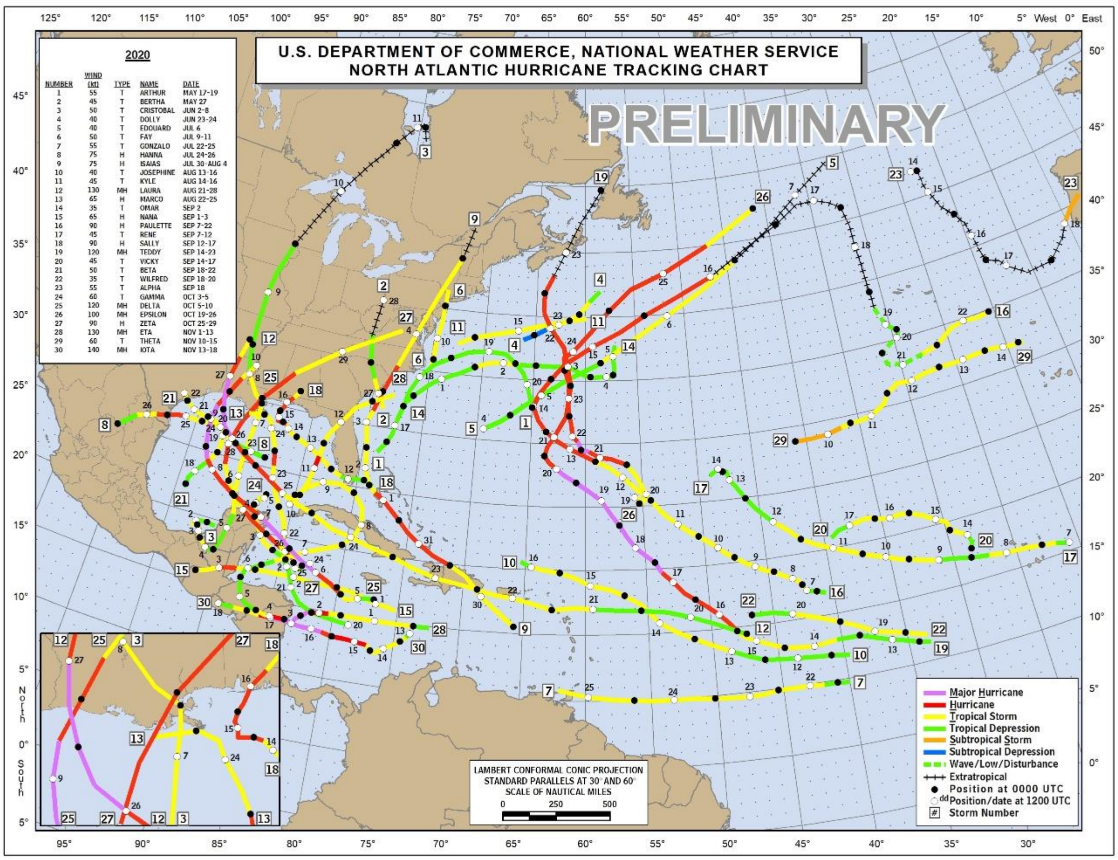
ATLANTIC BASIN SEASONAL HURRICANE FORECASTS FOR 2020

Forecast Parameter and 1981-2010 Average (in parentheses)	Issue Date 2 April 2020	Issue Date 4 June 2020	Issue Date 7 July 2020	Issue Date 5 August 2020	**Observed 2020 Activity Thru 11/30**	% of 1981-2010 Average
Named Storms (NS) (12.1)	16	19	20	24	**30**	248%
Named Storm Days (NSD) (59.4)	80	85	85	100	**118**	199%
Hurricanes (H) (6.4)	8	9	9	12	**13**	203%
Hurricane Days (HD) (24.2)	35	40	40	45	**34.75**	144%
Major Hurricanes (MH) (2.7)	4	4	4	5	**6**	222%
Major Hurricane Days (MHD) (6.2)	9	9	9	11	**8.75**	141%
Accumulated Cyclone Energy (ACE) (106)	150	160	160	200	**180**	170%
Net Tropical Cyclone Activity (NTC) (116%)	160	170	170	215	**225**	194%



2020 Atlantic basin tropical cyclone tracks through November 30. 30 named storms, 13 hurricanes and 6 major hurricanes occurred. Figure courtesy of Ethan Gibney (NOAA).

ABSTRACT

This report summarizes tropical cyclone (TC) activity which occurred in the Atlantic basin during 2020 and verifies the authors' seasonal Atlantic basin forecasts. Also verified are six two-week Atlantic basin forecasts issued during the peak months of the hurricane season that were based on a combination of current activity, model forecasts and the phase of the Madden-Julian Oscillation (MJO).

The first quantitative seasonal forecast for 2020 was issued on 2 April with updates on 4 June, 7 July and 5 August. These seasonal forecasts also contained estimates of the probability of US and Caribbean hurricane landfall during 2020.

The 2020 hurricane season was extremely active. The season had 30 named storms, breaking the old record of 28 named storms set in 2005. The season also had a near-record number of hurricanes and major hurricanes. Our seasonal forecasts of Accumulated Cyclone Energy (ACE) generally verified quite well, with April, June and July slightly underestimating seasonal ACE and the August forecast slightly overestimating seasonal ACE. Our storm number forecasts, while correctly calling for a well above-average number of storms, were generally lower than observed, with the August forecast coming the closest to observed numbers. As we anticipated, the 2020 Atlantic hurricane season had an anomalously warm tropical Atlantic as well as La Niña conditions, although the La Niña currently underway is a bit stronger than we anticipated. August generated a near-average amount of ACE, but August also had the strongest landfalling hurricane to hit the continental US in 2020 (Laura as a Category 4 hurricane). September produced the most Atlantic named storms in a calendar month on record (10 named storms), but ACE was only somewhat above-average. October-November were extremely prolific, producing more major hurricanes than any October-November on record. Also, ACE in October-November 2020 was one of the highest on record.

Six consecutive two-week forecasts were issued during August-October, the peak months of the Atlantic hurricane season. These forecasts were based on current hurricane activity, predicted activity by global models and Madden-Julian Oscillation (MJO) phase. These forecasts predicted the correct tercile in 4 out of 6 outlooks that were issued.

Integrated measures such as Net Tropical Cyclone (NTC) activity and Accumulated Cyclone Energy (ACE) were well above average. Tropical Atlantic sea surface temperatures were warmer than normal during the peak of the 2020 hurricane season. Vertical wind shear was also below-average during the peak of the season.

The 2020 Atlantic hurricane season will be remembered for the extreme levels of landfalling activity in the continental US, as well as the tremendous amount of late-season hurricane activity that occurred in the Caribbean. More named storms made landfall in the continental US than any other season on record, and the five named storms that formed in the Caribbean during October-November tied the record set in 2005. In addition, many of the Atlantic landfalling storms of 2020 were rapidly intensifying up to (or almost up to) the point of landfall.

DEFINITIONS AND ACRONYMS

Accumulated Cyclone Energy (ACE) - A measure of a named storm's potential for wind and storm surge destruction defined as the sum of the square of a named storm's maximum wind speed (in 10^4 $knots^2$) for each 6-hour period of its existence. The 1981-2010 average value of this parameter is 106 for the Atlantic basin.

Atlantic Multi-Decadal Oscillation (AMO) – A mode of natural variability that occurs in the North Atlantic Ocean and evidencing itself in fluctuations in sea surface temperature and sea level pressure fields. The AMO is likely related to fluctuations in the strength of the oceanic thermohaline circulation. Although several definitions of the AMO are currently used in the literature, we define the AMO based on North Atlantic sea surface temperatures from 50-60°N, 50-10°W and sea level pressure from 0-50°N, 70-10°W.

Atlantic Basin – The area including the entire North Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico.

El Niño – A 12-18 month period during which anomalously warm sea surface temperatures occur in the eastern half of the equatorial Pacific. Moderate or strong El Niño events occur irregularly, about once every 3-7 years on average.

Hurricane (H) - A tropical cyclone with sustained low-level winds of 74 miles per hour (33 ms^{-1} or 64 knots) or greater.

Hurricane Day (HD) - A measure of hurricane activity, with one day defined to be four 6-hour periods during which a tropical cyclone is observed or is estimated to have hurricane-force winds.

Indian Ocean Dipole (IOD) - An irregular oscillation of sea surface temperatures between the western and eastern tropical Indian Ocean. A positive phase of the IOD occurs when the western Indian Ocean is anomalously warm compared with the eastern Indian Ocean.

Madden Julian Oscillation (MJO) – A globally propagating mode of tropical atmospheric intra-seasonal variability. The wave tends to propagate eastward at approximately 5 ms^{-1}, circling the globe in roughly 40-50 days.

Main Development Region (MDR) – An area in the tropical Atlantic where a majority of major hurricanes form, which we define as 7.5-22.5°N, 20-75°W.

Major Hurricane (MH) - A hurricane which reaches a sustained low-level wind of at least 111 mph (96 knots or 50 ms^{-1}) at some point in its lifetime. This constitutes a category 3 or higher on the Saffir/Simpson scale.

Major Hurricane Day (MHD) - Four 6-hour periods during which a hurricane has an intensity of Saffir/Simpson category 3 or higher.

Multivariate ENSO Index (MEI) – An index defining ENSO that takes into account tropical Pacific sea surface temperatures, sea level pressures, zonal and meridional winds and cloudiness.

Named Storm (NS) - A hurricane, a tropical storm or a sub-tropical storm.

Named Storm Day (NSD) - As in HD but for four 6-hour periods during which a tropical or sub-tropical cyclone is observed (or is estimated) to have attained tropical storm-force winds.

Net Tropical Cyclone (NTC) Activity –Average seasonal percentage mean of NS, NSD, H, HD, MH, MHD. Gives overall indication of Atlantic basin seasonal hurricane activity. The 1950-2000 average value of this parameter is 100.

Saffir/Simpson Hurricane Wind Scale – A measurement scale ranging from 1 to 5 of hurricane wind intensity. One is a weak hurricane; whereas, five is the most intense hurricane.

Southern Oscillation Index (SOI) – A normalized measure of the surface pressure difference between Tahiti and Darwin. Low values typically indicate El Niño conditions.

Sea Surface Temperature – SST

Sea Surface Temperature Anomaly – SSTA

Thermohaline Circulation (THC) – A large-scale circulation in the Atlantic Ocean that is driven by fluctuations in salinity and temperature. When the THC is stronger than normal, the AMO tends to be in its warm (or positive) phase, and more Atlantic hurricanes typically form.

Tropical Cyclone (TC) - A large-scale circular flow occurring within the tropics and subtropics which has its strongest winds at low levels; including hurricanes, tropical storms and other weaker rotating vortices.

Tropical Storm (TS) - A tropical cyclone with maximum sustained winds between 39 mph (18 ms^{-1} or 34 knots) and 73 mph (32 ms^{-1} or 63 knots).

Vertical Wind Shear – The difference in horizontal wind between 200 mb (approximately 40000 feet or 12 km) and 850 mb (approximately 5000 feet or 1.6 km).

1 knot = 1.15 miles per hour = 0.515 meters per second

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.

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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 would like to acknowledge assistance from Louis-Philippe Caron and the data team at the Barcelona Supercomputing Centre for providing data and insight on the statistical/dynamical models. We have also benefited from meteorological discussions with Carl Schreck, Louis-Philippe Caron, Brian McNoldy, Paul Roundy, Jason Dunion, Peng Xian and Amato Evan over the past few years.

1 Preliminary Discussion

1a. Introduction

The year-to-year variability of Atlantic basin hurricane activity is the largest of any of the globe's tropical cyclone (TC) basins. There has always been and will continue to be much interest in knowing if the coming Atlantic hurricane season is going to be unusually active, very quiet or near average. There was never a way of objectively determining how active the coming Atlantic hurricane season was going to be until the early to mid-1980s when global data sets became more accessible.

Analyzing the available data in the 1980s, we found that the coming Atlantic seasonal hurricane season did indeed have various precursor signals that extended backward in time from zero to 6-8 months before the start of the season. These precursor signals involved El Niño – Southern Oscillation (ENSO), Atlantic sea surface temperatures (SSTs) and sea level pressures, West African rainfall, the Quasi-Biennial Oscillation (QBO) and a number of other global parameters. Much effort has since been expended by our project's current and former members (along with other research groups) to try to quantitatively maximize the best combination of hurricane precursor signals to give the highest amount of reliable seasonal hindcast skill. We have experimented with a large number of various combinations of precursor variables and now find that our most reliable statistical forecasts utilize a combination of three or four variables.

A cardinal rule that has always been followed is to issue no forecast for which we do not have substantial hindcast skill extending back in time for at least 30 years. We now use the high resolution ERA5 dataset as the atmospheric input to our statistical models and the high resolution NOAA Optimum Interpolation sea surface temperature (SST) dataset as the SST input to our statistical models. These data products are available in near-real time, allowing us to be able to use the same datasets to make predictor estimates that we used to develop the statistical models.

Beginning with the April 2019 forecast, CSU also began issuing statistical-dynamical model forecasts. In 2020, these predictions used the current ECMWF climate model (SEAS5) and Met Office climate model (GloSea5) to predict the large-scale conditions in July that underpin the early August statistical seasonal hurricane forecast model. These statistical-dynamical forecasts have shown skill at predicting Accumulated Cyclone Energy (ACE) based on hindcast data since 1981 for SEAS5 and since 1993 for GloSea5 and successfully called for an above-average Atlantic hurricane season in 2020.

The explorative process to skillful prediction should continue to develop as more data becomes available and as more robust relationships are found. There is no one best forecast scheme that can always be confidently applied. We have learned that precursor relations can change with time and that one must be alert to these changing relationships. For instance, earlier seasonal forecasts relied heavily on the stratospheric QBO and West African rainfall. These precursor signals have not worked in recent years. Because of this, other precursor signals have been substituted in their place. As new data and new insights are gathered in the coming years, it is to be expected that our forecast schemes will in future years also need revision. Keeping up with the changing global climate system, using new data signals, and exploring new physical relationships is a full-time job. Success can never be measured by the success of a few real-time forecasts but only by long-period hindcast relationships and sustained demonstration of real-time forecast skill over a decade or more.

1b. Seasonal Forecast Theory

A variety of atmosphere-ocean conditions interact with each other to cause year-to-year and month-to-month hurricane variability. The interactive physical linkages between these precursor physical parameters and hurricane variability are complicated and cannot be well elucidated to the satisfaction of the typical forecaster making short range (1-5 days) predictions where changes in the current momentum and pressure fields are the crucial factors. Seasonal forecasts, unfortunately, must deal with the much more complicated interaction of the energy-moisture fields along with the momentum fields.

We find that there is a rather high (50-60 percent) degree of year-to-year hurricane forecast potential if one combines 3-4 semi-independent atmospheric-oceanic parameters together. The best predictors (out of a group of 3-4) do not necessarily have the best individual correlations with hurricane activity. The best forecast parameters are those that explain a portion of the variance of seasonal hurricane activity that is not associated with the other variables. It is possible for an important hurricane forecast parameter to show only a marginally significant correlation with the predictand by itself but to have an important influence when included with a set of 3-4 other predictors.

In a four-predictor empirical forecast model, the contribution of each predictor to the net forecast skill can only be determined by the separate elimination of each parameter from the full four-predictor model while noting the hindcast skill degradation. When taken from the full set of predictors, one parameter may degrade the forecast skill by 25-30 percent, while another degrades the forecast skill by only 10-15 percent. An individual parameter that, through elimination from the forecast, degrades a forecast by as much as 25-30 percent may, in fact, by itself, show less direct correlation with the predictand. A direct correlation of a forecast parameter may not be the best measure of the importance of this predictor to the skill of a 3-4 parameter forecast model. This is the nature of the seasonal or climate forecast problem where one is dealing with a very complicated atmospheric-oceanic system that is highly non-linear. There is a maze of changing physical linkages between the many variables. These linkages can undergo unknown changes from weekly to decadal time scales. It is impossible to fully understand how all these processes interact with each other. Despite the complicated relationships that are involved, all of our statistical models show considerable hindcast skill. We are confident that in applying these skillful hindcasts to future forecasts that appreciable real-time skill will continue to result.

2 Tropical Cyclone Activity for 2020

Figure 1 and Table 1 summarize Atlantic basin TC activity which occurred in 2020. Overall, the season was extremely active with a record number of named storm formations. Online entries from [Wikipedia](https://en.wikipedia.org) are available for in-depth discussions of each TC that occurred in 2020. The National Hurricane Center is also currently in the process of writing up extensive [reports](https://www.nhc.noaa.gov) on all 2020 TCs.

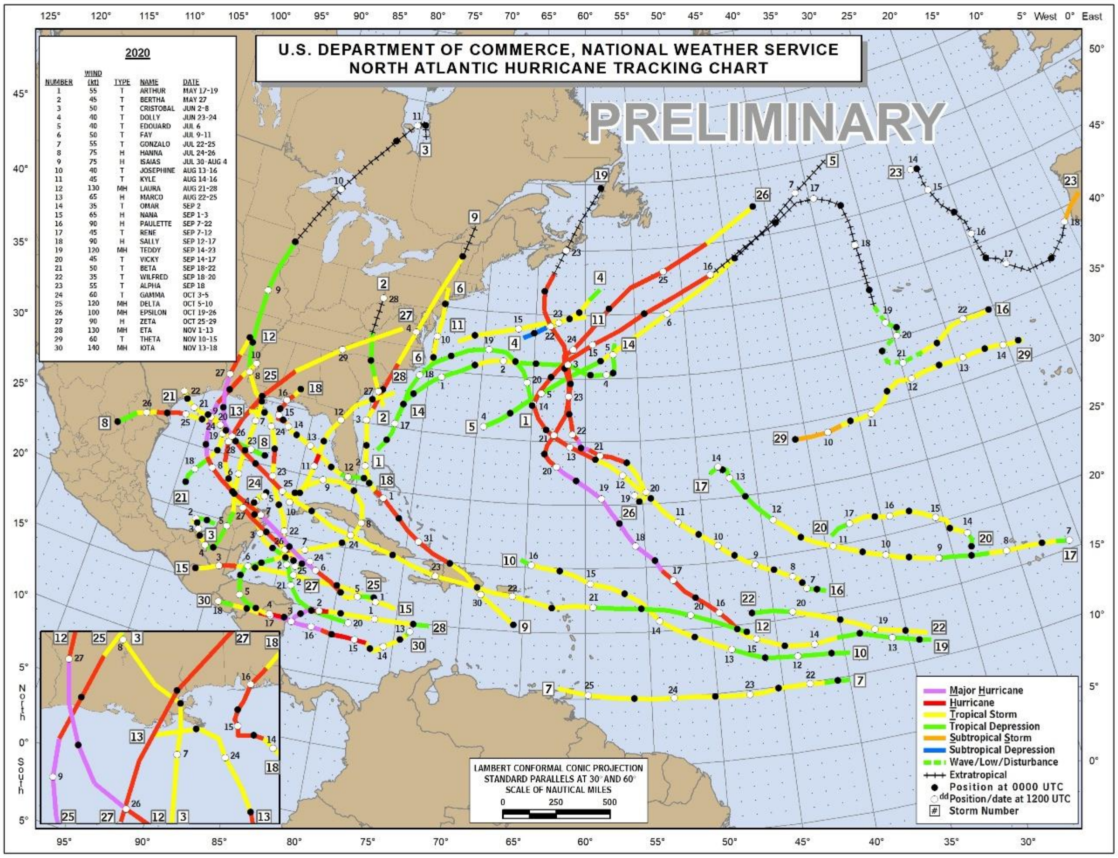

Figure 1: 2020 Atlantic basin TC tracks through November 30. 30 named storms, 13 hurricanes and 6 major hurricanes occurred. Figure courtesy of Ethan Gibney (NOAA).

Table 1: Observed 2020 Atlantic basin TC activity through November 30. Data is calculated from the NHC operational best track and may differ slightly from what was provided in NHC's real-time advisories.

Real-Time North Atlantic Ocean Statistics by Storm for 2020

Year	Storm#	Name	Dates TC Active	Max Wind (kts)	MSLP (mb)	Named Storm Days	Hurricane Days	Major Hurricane Days	Accumulated Cyclone Energy
2020	1	ARTHUR	5/17-5/19	50	991	2.50	0.00	0.00	1.8
2020	2	BERTHA	5/27-5/27	45	1007	0.50	0.00	0.00	0.4
2020	3	CRISTOBAL	6/2-6/8	50	992	4.75	0.00	0.00	3.5
2020	4	DOLLY	6/23-6/24	40	1002	1.00	0.00	0.00	0.6
2020	5	EDOUARD	7/6-7/6	40	1005	1.00	0.00	0.00	0.6
2020	6	FAY	7/9-7/11	50	998	1.50	0.00	0.00	1.1
2020	7	GONZALO	7/22-7/25	55	997	3.50	0.00	0.00	2.8
2020	8	HANNA	7/24-7/26	75	973	3.00	0.75	0.00	3.4
2020	9	ISAIAS	7/30-8/4	75	987	6.00	2.25	0.00	9.2
2020	10	JOSEPHINE	8/13-8/16	40	1005	3.00	0.00	0.00	1.8
2020	11	KYLE	8/14-8/16	45	1000	1.50	0.00	0.00	1.0
2020	12	LAURA	8/21-8/28	130	938	6.75	2.25	1.00	12.8
2020	13	MARCO	8/22-8/25	65	991	3.25	0.25	0.00	3.4
2020	14	OMAR	9/2-9/2	35	1003	0.75	0.00	0.00	0.4
2020	15	NANA	9/1-9/3	65	994	2.75	0.25	0.00	2.6
2020	16	PAULETTE	9/7-9/22	90	965	10.25	3.50	0.00	15.9
2020	17	RENE	9/7-9/12	45	1000	4.00	0.00	0.00	2.2
2020	18	SALLY	9/12-9/17	90	967	4.50	2.00	0.00	7.4
2020	19	TEDDY	9/14-9/23	120	945	9.00	7.25	2.75	27.8
2020	20	VICKY	9/14-9/17	45	1000	3.00	0.00	0.00	2.1
2020	21	BETA	9/18-9/22	50	994	4.00	0.00	0.00	3.3
2020	22	WILFRED	9/18-9/20	35	1007	1.75	0.00	0.00	0.9
2020	23	ALPHA	9/18-9/18	45	998	0.50	0.00	0.00	0.4
2020	24	GAMMA	10/3-10/5	60	980	2.75	0.00	0.00	2.5
2020	25	DELTA	10/5-10/10	120	953	5.25	4.25	2.00	15.7
2020	26	EPSILON	10/19-10/26	100	952	6.75	4.75	0.50	13.1
2020	27	ZETA	10/25-10/29	90	973	4.50	2.25	0.00	7.5
2020	28	ETA	11/1-11/13	130	923	10.25	2.50	1.25	18.1
2020	29	THETA	11/10-11/15	60	989	5.25	0.00	0.00	5.3
2020	30	IOTA	11/13-11/18	140	917	4.50	2.50	1.25	12.7

3 Special Characteristics of the 2020 Hurricane Season

The 2020 hurricane season was extremely active, with a record-setting number of named storms and near-record numbers of named storm days and hurricanes. Most other TC metrics were also well above average. From an Accumulated Cyclone Energy perspective, June-July were above-average, August was near average, September was somewhat above average and October-November were at near record levels.

Below is a selection of some of the records that were set during the season:

Basinwide Statistics

- 30 named storms formed in the Atlantic this season. This is the most on record, eclipsing the old record of 28 named storms set in 2005.

- The 2020 Atlantic hurricane season had the earliest forming ‘C’ named storm and the earliest named storm formation from the ‘E’ storm onwards.

- 10 named storms formed in September. This is the most September named storm formations on record, breaking the old record of 8 named storms set in 2002, 2007 and 2010.

- 5 named storms formed in the Caribbean after 1 October (Gamma, Delta, Zeta, Eta and Iota). This ties the record of 5 post-1 October named storm formations set in 2005.

- 4 major hurricanes formed in the Atlantic basin after 1 October (Delta, Epsilon, Eta and Iota). The prior record for Atlantic major hurricanes forming after 1 October was 2, set several different times.

- November produced 20 named storm days. That ties 2020 with 1932 for the most November Atlantic named storm days on record.

- 3 Atlantic named storms formed in November (Eta, Theta and Iota). This ties 2020 with 1931, 1961, 2001 and 2005 for the most November named storm formations on record.

- November generated 36 ACE. This is the 2^{nd}-most ACE generated by an Atlantic hurricane season on record, trailing 1932 (which generated a whopping 71 ACE).

- 118 named storm days were generated by the 2020 Atlantic hurricane season. Only 3 seasons on record have produced more named storm days (in descending order): 2005, 1933 and 1995.

- 13 hurricanes formed in the Atlantic basin in 2020. This is the 2^{nd}-most hurricanes to form in the Atlantic on record, trailing only 2005 (15 hurricanes).

- 6 major hurricanes formed in the Atlantic basin in 2020. This is tied for the 2^{nd}-most major hurricanes to form in the Atlantic on record, trailing only 2005 (7 major hurricanes). Other years with 6 major hurricanes are: 1926, 1933, 1950, 1996, 2004, 2005 and 2017.

- 180 Accumulated Cyclone Energy units were generated in the Atlantic in 2020. This is the 6^{th}-most in the satellite era (since 1966), trailing in descending order: 2005, 1995, 2004, 2017, and 1998.

- 75 Accumulated Cyclone Energy units were generated in the Atlantic in October-November. This is the 2rd-most ACE generated in October-November in the satellite era (since 1966), trailing only 2016.

Individual Storm/Landfall Statistics

- 12 Atlantic named storms made landfall in the continental US in 2020 – the most on record. The prior record was 9 named storm landfalls in the continental US set in 1916.

- 6 Atlantic hurricanes made landfall in the continental US in 2020 – tying 2020 with 1886 and 1985 for the most hurricane landfalls in the continental US in a single season on record.

- 5 named storms made landfall in Louisiana – the most named storms to make landfall in Louisiana in a single season on record. The old record was 4 named storms set in 2002.

- Hurricane Laura made landfall with maximum sustained winds of 130 kt in Cameron Parish, Louisiana. Laura is tied with the Last Island Hurricane of 1856 for the strongest winds for a Louisiana hurricane landfall on record.

- Hurricane Laura's central pressure at landfall in Cameron Parish, Louisiana was 938 hPa. Laura is in 4th place for lowest central pressure for a Louisiana landfall – trailing (in order from strongest): Katrina (2005), Last Island Hurricane (1856) and Rita (2005)

- Hurricane Zeta made landfall in Louisiana with 95 kt maximum sustained winds on October 28 – the strongest hurricane landfall that late in the calendar year since the Halloween Hurricane made landfall in South Carolina on October 31, 1899 (also with 95 kt maximum sustained winds).

- Hurricane Eta made landfall in Nicaragua with maximum sustained winds of 120 kt – the strongest November landfalling hurricane in Nicaragua on record until that point. Eta's November landfall intensity record for Nicaragua was broken just 13 days later by Iota

- Hurricane Iota became a Category 5 hurricane on November 16. Iota was the latest Atlantic calendar year Category 5 hurricane on record, breaking the old record of November 8 set by the Cuba hurricane of 1932

- Hurricane Iota made landfall in Nicaragua with maximum sustained winds of 135 kt – the strongest November landfalling hurricane in Nicaragua on record.

- 9 named storms rapidly intensified in 2020 (intensification of a named storm by at least 30 kt in 24 hr). These named storms were: Hanna, Laura, Sally, Teddy, Delta, Epsilon, Zeta, Eta and Iota. The 9 rapidly intensifying named storms of 2020 ties 1995 and 2010 for the most rapidly intensifying named storms in a single Atlantic hurricane season on record. Tropical Storm Gamma also met the rapid intensification criteria by intensifying 35 mph in 24 hr, but it was a tropical depression at the start of its rapid intensification phase.

4 Verification of Individual 2020 Lead Time Forecasts

Table 2 is a comparison of our forecasts for 2020 for four different lead times along with this year's observations. The 2020 Atlantic hurricane season was extremely active.

Table 2: Verification of our 2020 seasonal hurricane predictions.

Forecast Parameter and 1981-2010 Average (in parentheses)	Issue Date 2 April 2020	Issue Date 4 June 2020	Issue Date 7 July 2020	Issue Date 5 August 2020	**Observed 2020 Activity Thru 11/11**
Named Storms (NS) (12.1)	16	19	20	24	**30**
Named Storm Days (NSD) (59.4)	80	85	85	100	**118**
Hurricanes (H) (6.4)	8	9	9	12	**13**
Hurricane Days (HD) (24.2)	35	40	40	45	**34.75**
Major Hurricanes (MH) (2.7)	4	4	4	5	**6**
Major Hurricane Days (MHD) (6.2)	9	9	9	11	**8.75**
Accumulated Cyclone Energy (ACE) (106)	150	160	160	200	**180**
Net Tropical Cyclone Activity (NTC) (116%)	160	170	170	215	**225**

Table 3 provides the same forecasts but using the ~70% confidence intervals for each forecast calculated using the methodology outlined in Saunders et al. (2020). More details can be found in the individual seasonal forecasts, but in summary, we fit our cross-validated errors to various statistical distributions to more robustly calculate the uncertainty ranges with our forecasts. Forecast quantities that fell within the 70% confidence interval are highlighted in bold-faced font.

Table 3: Verification of CSU's 2020 seasonal hurricane predictions with 70% confidence intervals.

Forecast Parameter and 1981-2010 Average (in parentheses)	2 April 2020	Update 4 June 2020	Update 7 July 2020	Update 5 August 2020	Observed 2020 Total Thru 11/30
Named Storms (NS) (12.1)	13-19	16-22	17-23	21-27	30
Named Storm Days (NSD) (59.4)	60-100	63-107	65-106	**79-121**	118
Hurricanes (H) (6.4)	6-10	7-11	7-11	**10-14**	13
Hurricane Days (HD) (24.2)	**23-48**	**27-55**	**28-54**	**32-59**	34.75
Major Hurricanes (MH) (2.7)	**3-6**	**2-6**	**3-6**	**3-7**	6
Major Hurricane Days (MHD) (6.2)	**6-13**	**6-14**	**6-14**	**7-16**	8.75
Accumulated Cyclone Energy (ACE) (106)	**104-201**	**109-216**	**112-212**	**149-255**	180
Net Tropical Cyclone Activity (NTC) (116%)	115-208	120-223	124-220	**166-266**	225

4.1 Verification of Statistical-Dynamical Model Forecasts

We have issued statistical-dynamical model forecasts for the Atlantic basin hurricane season since 2019. This model, developed in partnership with Louis-Philippe Caron and the data team at the Barcelona Supercomputing Centre, uses output from both the ECMWF SEAS5 model and the GloSea5 model to forecast the input to our early August statistical forecast model. The early August statistical forecast model shows the highest level of skill of any of our statistical models, since it is the model released just before the peak of the Atlantic hurricane season in September. Both ECMWF SEAS5 and GloSea5 are able to forecast the large-scale fields that go into the early August statistical forecast model with considerable skill by March. This skill then improves as the peak of the hurricane season approaches. Table 4 displays the statistical-dynamical model input to our seasonal hurricane forecast scheme in early April, early June and early July from the ECMWF SEAS5 model. Table 5 displays the same input from the GloSea5 model. Both statistical-dynamical models predicted a well above-average season at all three lead times. The reason for the sizeable drop in the ECMWF SEAS5 forecast in early July is that the model weighs the Caribbean trade wind predictor much more strongly in early July than in either early April or June. SEAS5 overpredicted the strength of the July Caribbean trade winds, which in reality were much weaker than normal. Weaker Caribbean trades are typically a harbinger of a very active Atlantic hurricane season.

Table 4: Statistical-dynamical model forecast input from ECMWF SEAS5 for the early April, early June and early July Atlantic basin seasonal hurricane forecasts for 2020.

Forecast Parameter and 1981-2010 Average (in parentheses)	Issue Date 2 April 2020	Issue Date 4 June 2020	Issue Date 7 July 2020	**Observed 2020 Activity**
Named Storms (NS) (12.1)	16.9	17.2	14.7	**30**
Named Storm Days (NSD) (59.4)	92.0	92.9	75.9	**118**
Hurricanes (H) (6.4)	9.6	9.9	7.9	**13**
Hurricane Days (HD) (24.2)	41.0	42.6	31.7	**34.75**
Major Hurricanes (MH) (2.7)	4.6	4.7	3.5	**6**
Major Hurricane Days (MHD) (6.2)	12.2	12.8	8.8	**8.75**
Accumulated Cyclone Energy (ACE) (106)	180	187	140	**180**
Net Tropical Cyclone Activity (NTC) (116%)	189	196	150	**225**

Table 5: Statistical-dynamical model forecast input from GloSea5 for the early April, early June and early July Atlantic basin seasonal hurricane forecasts for 2020.

Forecast Parameter and 1981-2010 Average (in parentheses)	Issue Date 2 April 2020	Issue Date 4 June 2020	Issue Date 7 July 2020	**Observed 2020 Activity**
Named Storms (NS) (12.1)	14.8	14.1	14.8	**30**
Named Storm Days (NSD) (59.4)	76.3	71.4	76.3	**118**
Hurricanes (H) (6.4)	7.9	7.4	7.9	**13**
Hurricane Days (HD) (24.2)	31.9	29.2	31.9	**34.75**
Major Hurricanes (MH) (2.7)	3.5	3.2	3.5	**6**
Major Hurricane Days (MHD) (6.2)	8.9	7.9	8.9	**8.75**
Accumulated Cyclone Energy (ACE) (106)	141	129	141	**180**
Net Tropical Cyclone Activity (NTC) (116%)	151	139	151	**225**

4.2 Verification of Two-Week Forecasts

This is the 12th year that we have issued shorter-term forecasts of tropical cyclone activity (TC) starting in early August. These two-week forecasts are based on a combination of observational and modeling tools. The primary tools that are used for this forecast are as follows: 1) current storm activity, 2) National Hurricane Center Tropical Weather Outlooks, 3) forecast output from global models, 4) the current and projected state of the Madden-Julian Oscillation (MJO) (Figure 2) and 5) the current seasonal forecast.

The metric that we tried to predict with these two-week forecasts is the Accumulated Cyclone Energy (ACE) index, which is defined to be the square of a named storm's maximum wind speed (in 10^4 knots^2) for each 6-hour period of its existence over the two-week forecast period. These forecasts are too short in length to show significant skill for individual event parameters such as named storms and hurricanes.

Our forecast definition of above-normal, normal, and below-normal ACE periods is defined by ranking observed activity in the satellite era from 1966-2019 and defining above-normal, normal and below-normal two-week periods based on terciles. Since there are 54 years from 1966-2019, each tercile is composed of 18 years. The 18 years with the most active ACE periods are classified as the upper tercile, the 18 years with the least active ACE periods are classified as the lower tercile, while the remaining 18 years are classified as the middle tercile.

Table 6 displays the six two-week forecasts that were issued during the 2020 hurricane season and shows their verification. We correctly predicted four of the six two-week periods. We slightly over-estimated activity in late August and early September. While these two periods had a considerable number of named storm formations, the storms that formed did not intensify as much as we had anticipated, hence leading to lower ACE. In addition, the flurry of Atlantic TC activity that occurred in mid-September occurred slightly too late to register in the September 2-15 period.

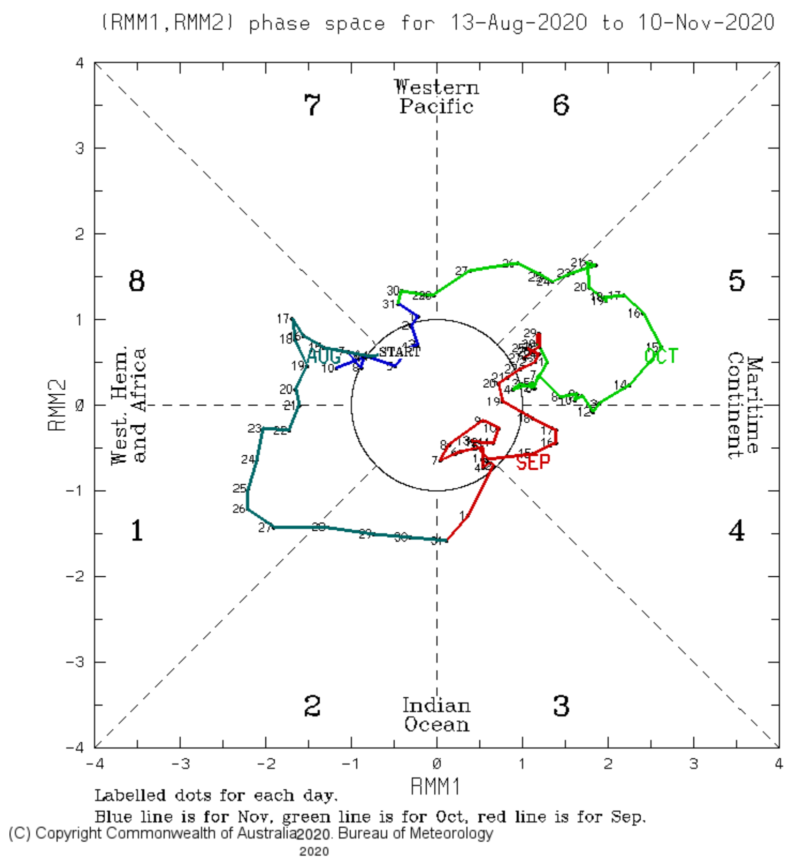

Figure 2: Propagation of the Madden-Julian Oscillation (MJO) based on the Wheeler-Hendon classification scheme over the period from August 13 to November 10. The Maritime Continent refers to Indonesia and the surrounding islands. RMM stands for Real-Time Multivariate MJO. Figure courtesy of Bureau of Meteorology.

Table 6: Two-week Atlantic ACE forecast verification for 2020. Forecasts that verified in the correct category are highlighted in blue, while forecasts that missed by one category are highlighted in green.

Forecast Period	Predicted ACE	Observed ACE
8/5 – 8/18	**Near-Normal (2-6)**	**3**
8/19 – 9/1	**Above-Normal (>22)**	**17**
9/2 – 9/15	**Above-Normal (>34)**	**25**
9/16 – 9/29	**Above-Normal (>23)**	**36**
9/30 – 10/13	**Above-Normal (>9)**	**18**
10/14 – 10/27	**Above-Normal (>7)**	**17**

5 Landfall Probabilities

The 2020 Atlantic hurricane season was record-breaking active, with 12 named storms making a total of 13 landfalls in the continental US (Figure 3). Eta made two landfalls in Florida. Six of the 12 named storms making landfall in 2020 did so at hurricane strength, with Hurricane Laura being the only major hurricane to make landfall in the continental US in 2020. The prior record for named storms making landfall in the continental US was 9 named storms in 1916. The average number of continental US landfalls (excluding multiple landfalls from the same system) from 1900-2019 are 3.1 named storms, 1.6 hurricanes and 0.5 major hurricanes per year.

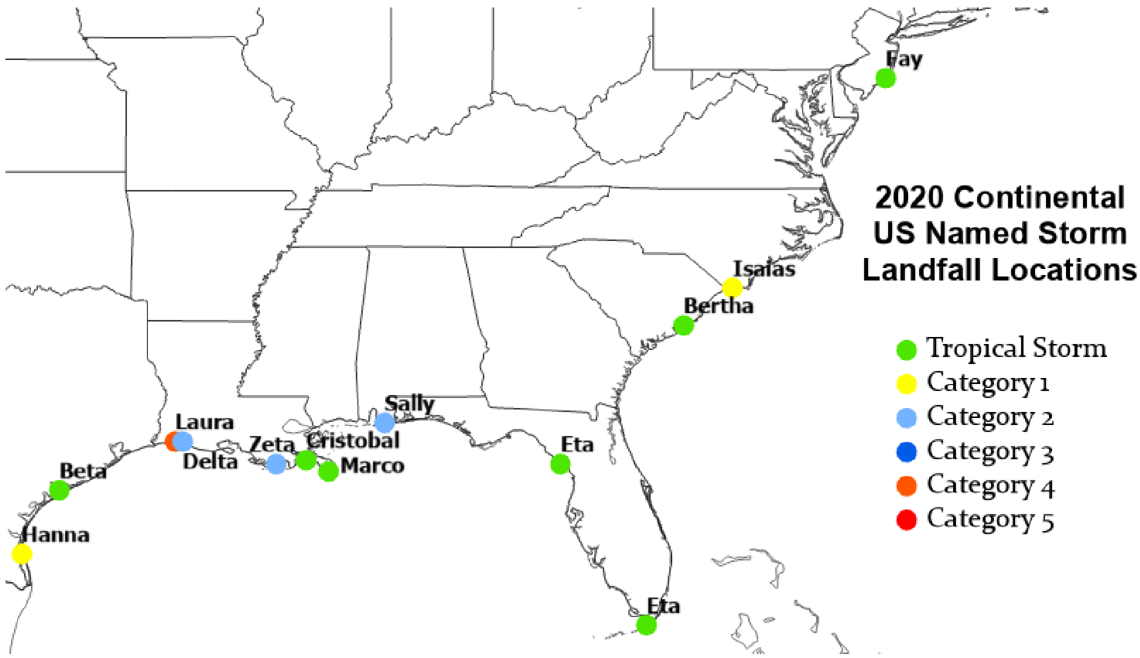

Figure 3: Location of the named storms making landfall in the continental US during the 2020 Atlantic hurricane season. Eta made two separate landfalls in Florida.

Using our Caribbean basin definition (10-20°N, 88-60°W), there were 10 named storms, of which five were at hurricane strength during the 2020 Atlantic hurricane season in the Caribbean. Delta, Eta and Iota became major hurricanes in the Caribbean. The season was extremely active in the Caribbean, especially during October-November.

Every hurricane season, we issue forecasts of the seasonal probability of hurricane landfall along the US coastline as well as the Caribbean. Whereas individual hurricane landfall events cannot be accurately forecast, the net seasonal probability of landfall can be issued using past climatology and this year's forecast in combination. Our landfall probabilities have statistical skill, especially over several-year periods. With the premise that landfall is a function of varying climate conditions, US probabilities have been calculated through a statistical analysis of all US hurricane and named storm landfalls during a 100-year period (1900-1999). Specific landfall probabilities can be given for all TC intensity classes for a set of distinct US coastal regions. Net landfall probability is statistically related to overall Atlantic basin Net Tropical Cyclone (NTC) activity. Table 7 gives verifications of our landfall probability estimates for the United States and for the

Caribbean in 2020. In this table, we only count the strongest landfall for each storm, so Eta only counts as one named storm landfall for the Florida Peninsula/East Coast region.

Landfall probabilities include specific forecasts of the probability of US landfalling tropical storms (TS) and hurricanes of category 1-2 and 3-4-5 intensity for each of 11 units of the US coastline (Figure 4). These 11 units are further subdivided into 205 coastal and near-coastal counties. The climatological and current-year probabilities are available online via the Landfalling Hurricane Probability Webpage.

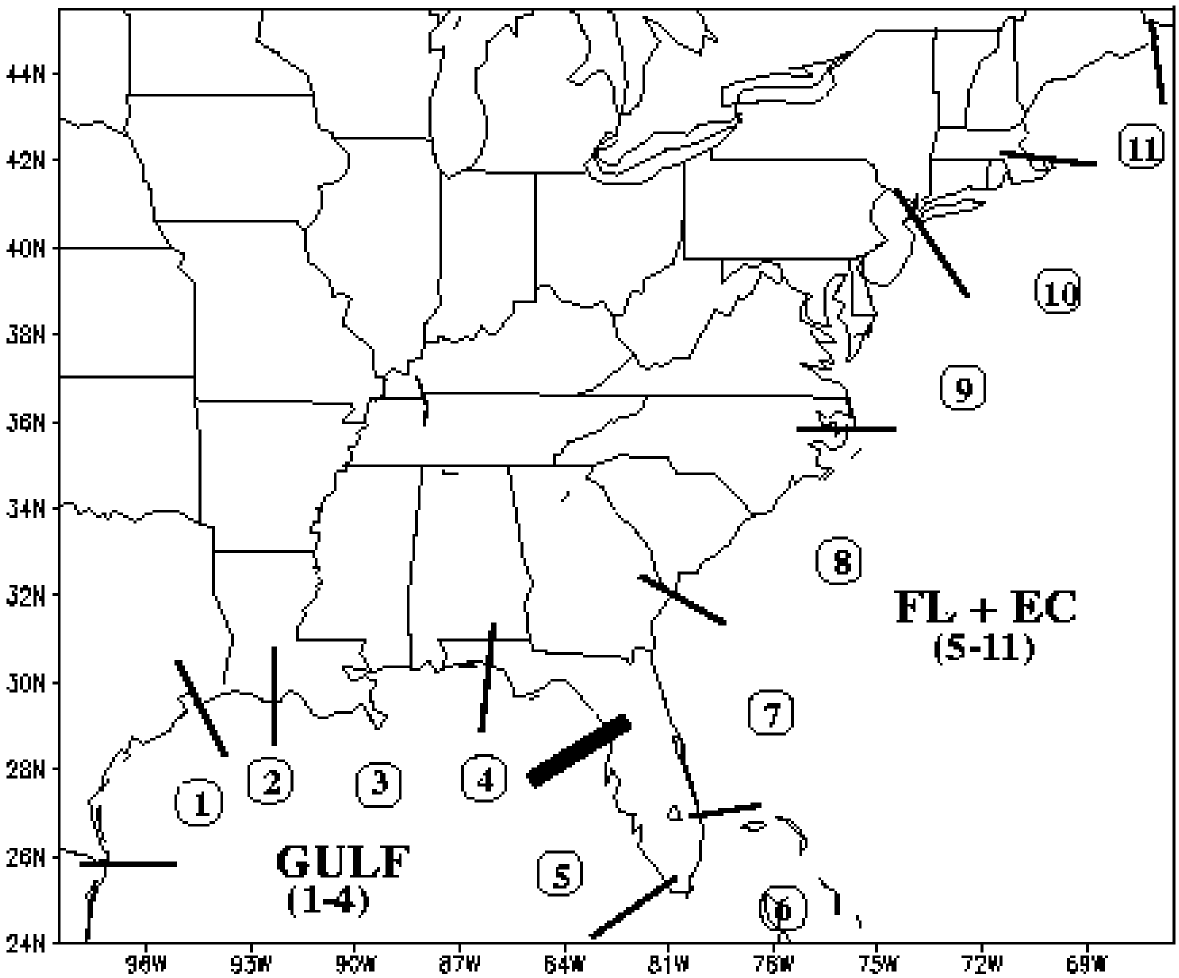

Figure 4: Location of the 11 coastal regions for which separate hurricane landfall probability estimates are made. These subdivisions were determined by the historical frequency of landfalling major hurricanes.

Table 7: Estimated forecast probability (percent) of one or more landfalling tropical storms (TS), category 1-2 hurricanes, and category 3-4-5 hurricanes, total hurricanes and named storms along the entire US coastline, along the Gulf Coast (Regions 1-4), along the Florida Peninsula and the East Coast (Regions 5-11) and in the Caribbean for 2020 at various lead times. The mean annual percentage of one or more landfalling systems during the 20th century is given in parentheses in the August forecast column. Table (a) is for the entire United States, Table (b) is for the US Gulf Coast, Table (c) is for the Florida Peninsula and the East Coast and Table (d) is for the Caribbean. Early August probabilities are calculated based on storms forming after 1 August.

(a) The entire US (Regions 1-11)
Forecast Date

	2 Apr.	4 June	5 August	Observed Number
TS	92%	92%	94% (79%)	6
HUR (Cat 1-2)	84%	85%	87% (68%)	5
HUR (Cat 3-4-5)	69%	70%	74% (52%)	1
All HUR	95%	95%	97% (84%)	6
Named Storms	99%	99%	99% (97%)	12

(b) The Gulf Coast (Regions 1-4)
Forecast Date

	2 Apr.	4 June	5 August	Observed Number
TS	76%	77%	80% (59%)	3
HUR (Cat 1-2)	59%	60%	64% (42%)	4
HUR (Cat 3-4-5)	44%	45%	48% (30%)	1
All HUR	77%	78%	81% (60%)	5
Named Storms	94%	95%	96% (83%)	8

(c) Florida Peninsula Plus the East Coast (Regions 5-11)
Forecast Date

	2 Apr.	4 June	5 August	Observed Number
TS	67%	68%	72% (50%)	3
HUR (Cat 1-2)	60%	62%	66% (44%)	1
HUR (Cat 3-4-5)	45%	46%	49% (31%)	0
All HUR	78%	79%	83% (61%)	1
Named Storms	93%	93%	95% (81%)	4

(d) Caribbean (10-20°N, 88-60°W)
Forecast Date

	2 Apr.	4 June	5 August	Observed Number
TS	94%	94%	96% (82%)	4
HUR (Cat 1-2)	74%	75%	79% (57%)	3
HUR (Cat 3-4-5)	58%	59%	63% (42%)	3
All HUR	89%	90%	92% (75%)	6
Named Storms	99%	99%	99% (96%)	10

6 Summary of Atmospheric/Oceanic Conditions

In this section, we go into more detail discussing large-scale conditions that we believe significantly impacted the 2020 Atlantic basin hurricane season.

6.1 ENSO

Borderline warm neutral/weak El Niño conditions were present during the winter of 2019/2020. From our early April forecast, we correctly anticipated that El Niño was unlikely for the 2020 season. However, we did not anticipate as quick a transition to La Niña conditions as actually occurred. Weak to moderate La Niña conditions were present during the peak of the Atlantic hurricane season (August-October), with the August-October-averaged Oceanic Nino Index reaching -0.9°C. Below are some quotes excerpted from our seasonal forecasts issued this year discussing our thoughts on the likely state of ENSO.

(2 April 2020) –

"Based on the above information, our best estimate is that we will likely not have El Niño conditions for the peak of the Atlantic hurricane season. Even if El Niño does not develop, there remains considerable uncertainty as to whether the tropical Pacific will have neutral ENSO conditions or transition towards La Niña."

(4 June 2020) –

"Based on the above information, our best estimate is that we will likely have either cool neutral ENSO or weak La Niña for the peak of the Atlantic hurricane season."

(5 August 2020) –

"Current cool neutral ENSO conditions may transition to weak La Niña conditions by later this summer."

The dynamical and statistical models initialized during the late winter/early spring significantly over-predicted ENSO SSTs during the peak of the Atlantic hurricane season. Figure 5 displays the ECMWF seasonal forecast for Nino 3.4 from March, which is the forecast information that we had available for our early April seasonal forecast. The observed values was colder than all of its ensemble members by June and was lower than almost all ensemble members throughout the rest of the forecast period until September. Figure 6 displays the March ENSO prediction plume from ~25 statistical and dynamical models. The observed monthly ENSO values during the Atlantic hurricane season were cooler than most forecast models for the Atlantic hurricane season. The Climate Forecast System version 2 had the closest forecast to observations for the peak of the Atlantic hurricane season (August-October).

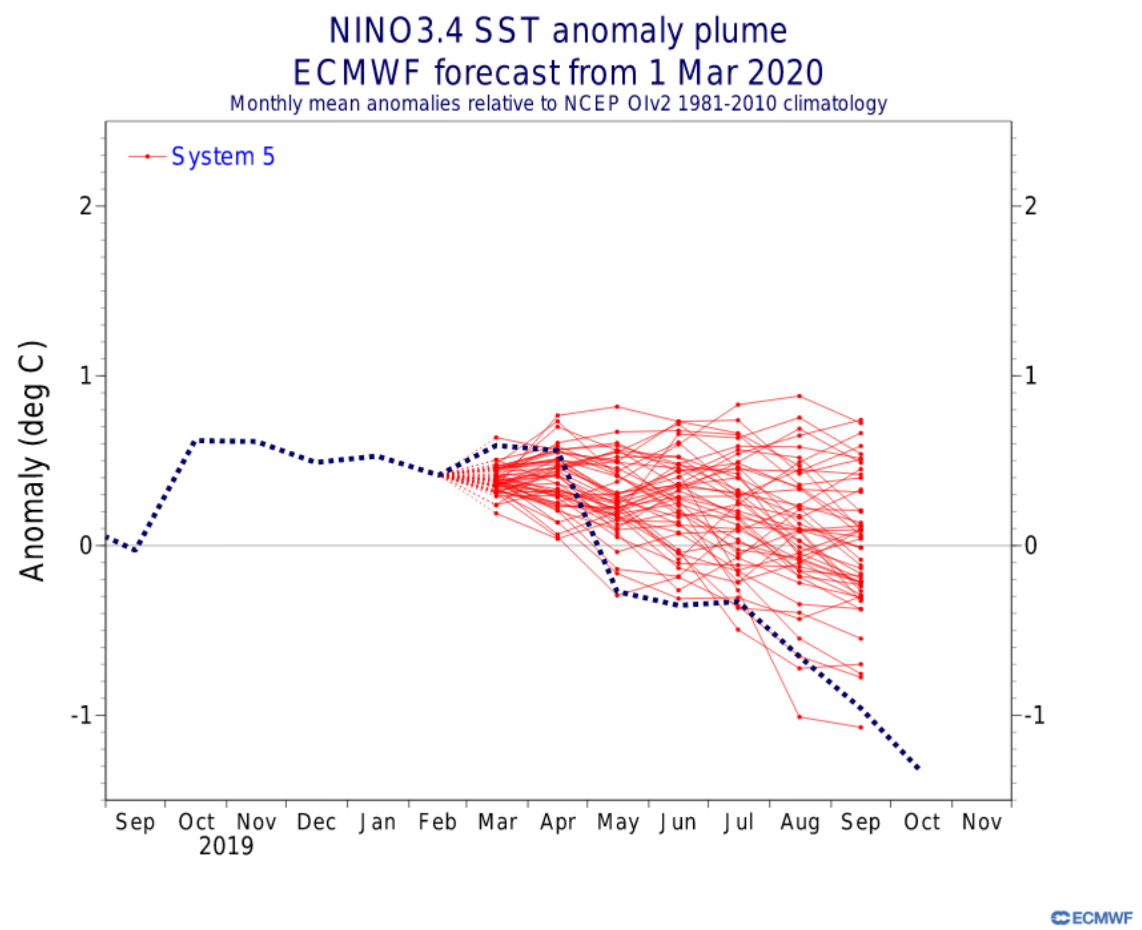

Figure 5: ECMWF ensemble prediction for Nino 3.4 from 1 March – the most recent information that we had available for our early April forecast in 2020. The blue dotted line represents the observed value.

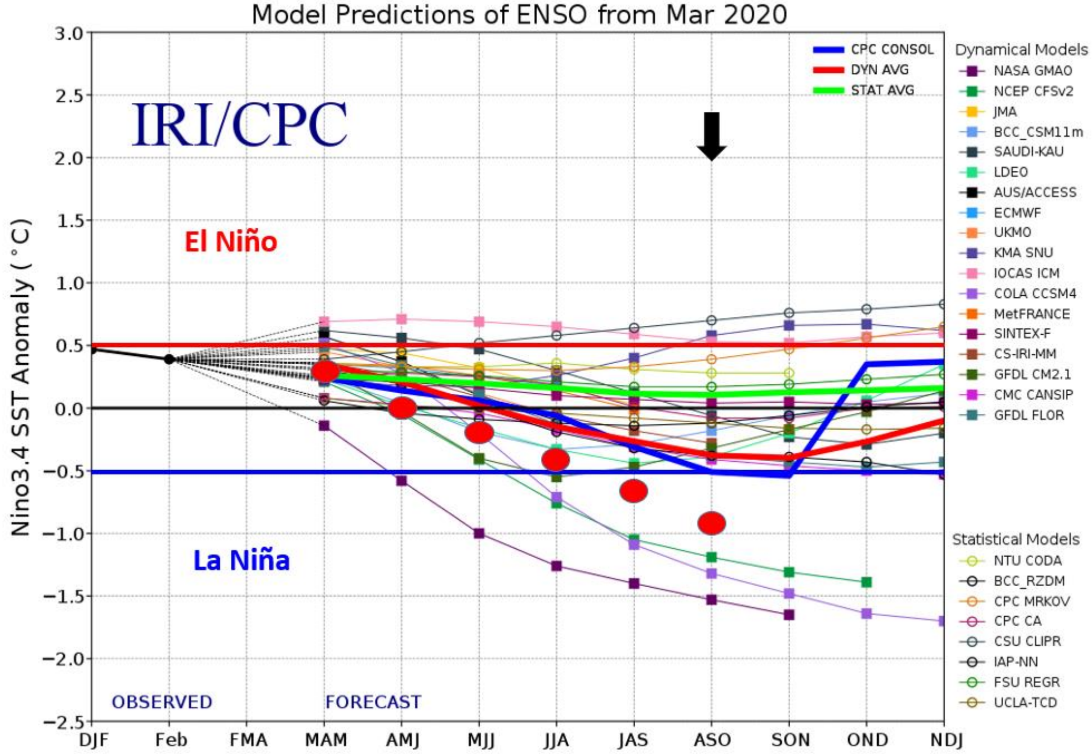

Figure 6: Ensemble prediction from ~25 statistical and dynamical models for Nino 3.4 from mid-March. The black arrow highlights August-October – the peak three months of the Atlantic hurricane season. Red dots represent observed values for each three-month period.

Borderline warm neutral/weak El Niño conditions were present during the winter of 2019/2020 and the early spring of 2020 before rapid anomalous cooling took place during the remainder of the spring, summer and fall. SSTs across the tropical Pacific are now well below-normal and are currently approaching the threshold for strong La Niña conditions. Table 8 displays anomalies in the various Nino regions in January, April, July and October 2020, respectively.

Table 8: January anomalies, April anomalies, July anomalies, and October anomalies for the Nino 1+2, Nino 3, Nino 3.4 and Nino 4 regions. SST anomaly differences from January 2020 are in parentheses.

Region	January 2020 Anomaly (ºC)	April 2020 Anomaly (ºC)	July 2020 Anomaly (ºC)	October 2020 Anomaly (ºC)
Nino 1+2	+0.0	+0.4 (+0.4)	-0.7 (-0.7)	-1.2 (-1.2)
Nino 3	+0.2	+0.5 (+0.3)	-0.7 (-0.9)	-1.3 (-1.5)
Nino 3.4	+0.5	+0.5 (0.0)	-0.3 (-0.8)	-1.4 (-1.9)
Nino 4	+1.0	+0.8 (-0.2)	0.0 (-1.0)	-0.8 (-1.8)

An additional way to visualize the changes in ENSO that occurred over the past several months is to look at upper-ocean heat content anomalies in the eastern and central tropical Pacific (Figure 7). Upper-ocean heat content anomalies were above-average in through last winter, fell rapidly through May, rebounded through early July and have since plummeted to below -1°C. Current upper ocean heat content anomalies in the eastern and central tropical Pacific are typically associated with moderate to strong La Niña events.

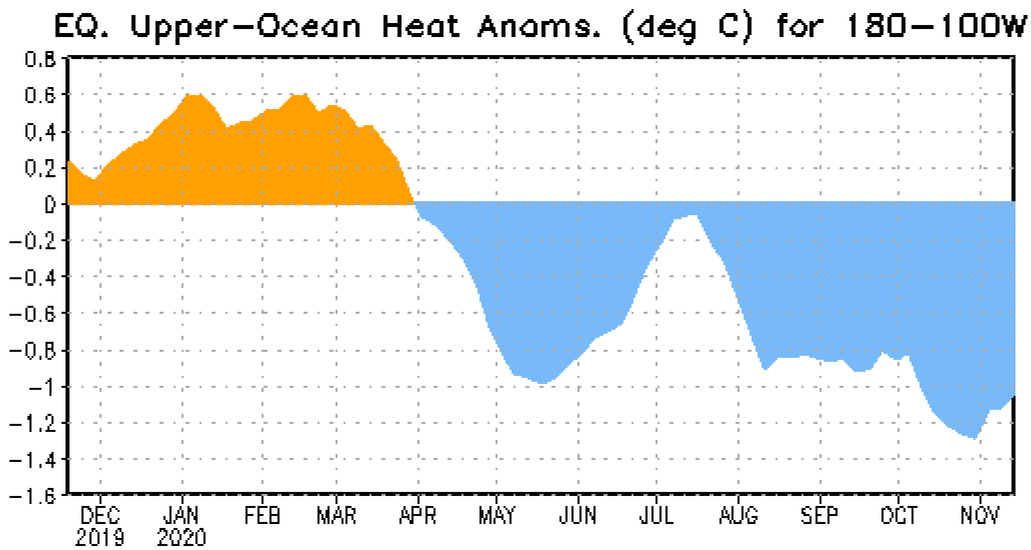

Figure 7: Upper ocean (0-300 meter) heat content anomalies in the eastern and central tropical Pacific from December 2019 – November 2020.

6.2 Intra-Seasonal Variability

The MJO was fairly strong in late August through early September, then weakened during most of September (Figure 8). Another amplified MJO phase began in the middle of October and continued through early November. The peak of the 2020 Atlantic hurricane season when measured by ACE was characterized by a near-average August, a slightly-above average September and an extremely active October (Figure 9). November 2020 has generated more ACE than any November in the Atlantic satellite era (since 1966).

Table 9 displays the number of storms that were first named in each phase of the MJO over the course of the 2020 Atlantic hurricane season. Sixteen named storms formed during phases 1-3 of the MJO, while only six named storms formed in during phases 5-7 of the MJO. Climatologically, phases 1-3 of the MJO are the most active for Atlantic TC formation and intensification, while phases 5-7 of the MJO are the most inactive. In general, the relationships that have previously been documented between MJO phase and Atlantic hurricane activity matched up fairly well with what was observed in 2020.

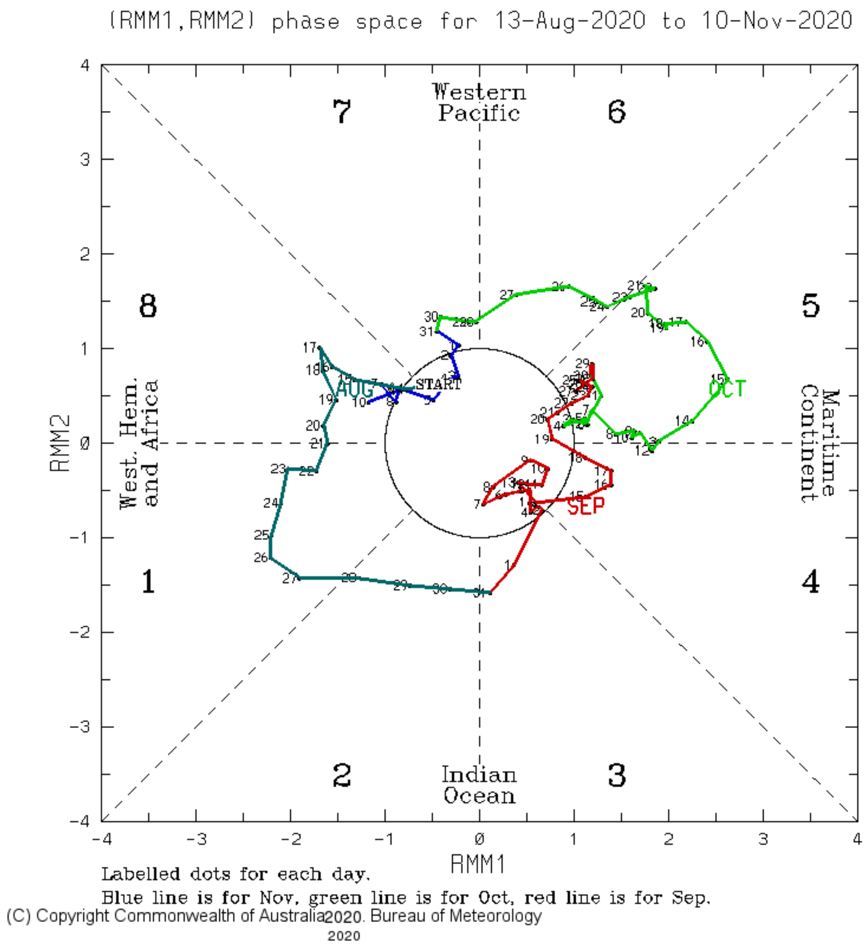

Figure 8: Propagation of the Madden-Julian Oscillation (MJO) based on the Wheeler-Hendon classification scheme over the period from August 13 to November 10. Figure courtesy of [Bureau of Meteorology](#).

Table 8: Normalized values of named storms (NS), named storm days (NSD), hurricanes (H), hurricane days (HD), major hurricanes (MH), major hurricane days (MHD) and Accumulated Cyclone Energy (ACE) generated by all TCs forming in each phase of the MJO over the period from 1974-2007. Normalized values are calculated by dividing storm activity by the number of days spent in each phase and then multiplying by 100. This provides the level of TC activity that would be expected for 100 days given a particular MJO phase.

MJO Phase	NS	NSD	H	HD	MH	MHD	ACE
Phase 1	6.4	35.9	3.7	17.9	1.8	5.3	76.2
Phase 2	7.5	43.0	5.0	18.4	2.1	4.6	76.7
Phase 3	6.3	30.8	3.0	14.7	1.4	2.8	56.0
Phase 4	5.1	25.5	3.5	12.3	1.0	2.8	49.4
Phase 5	5.1	22.6	2.9	9.5	1.2	2.1	40.0
Phase 6	5.3	24.4	3.2	7.8	0.8	1.1	35.7
Phase 7	3.6	18.1	1.8	7.2	1.1	2.0	33.2
Phase 8	6.2	27.0	3.3	10.4	0.9	2.6	46.8
Phase 1-2	7.0	39.4	4.3	18.1	1.9	4.9	76.5
Phase 6-7	4.5	21.5	2.5	7.5	1.0	1.5	34.6
Phase 1-2 / Phase 6-7	1.6	1.8	1.7	2.4	2.0	3.2	2.2

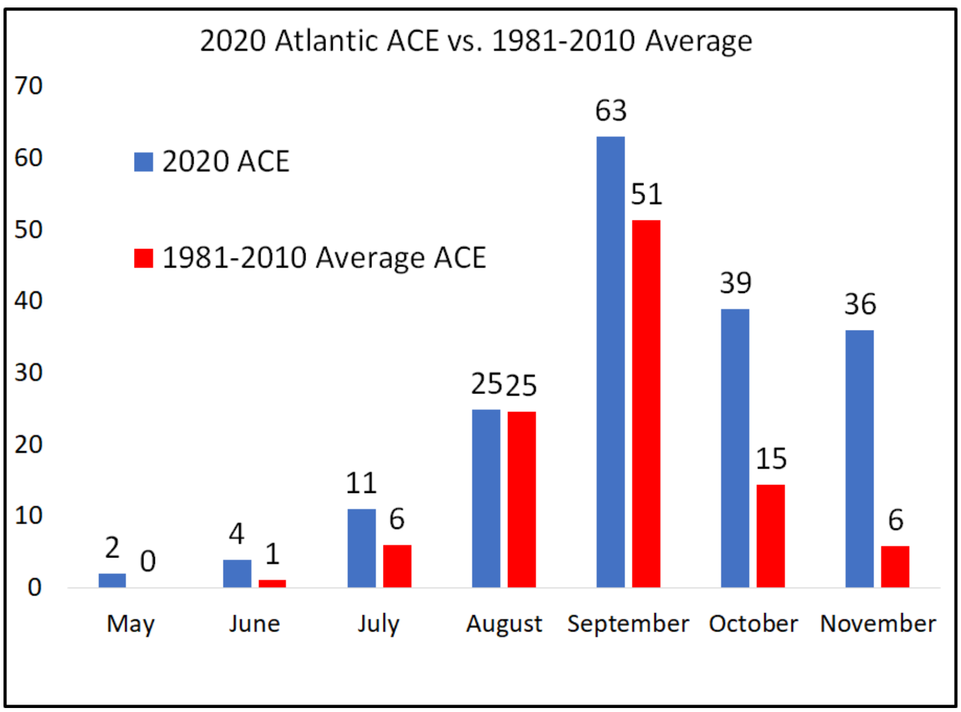

Figure 9: Atlantic Accumulated Cyclone Energy generated by month during 2020 (blue columns) compared with the 1981-2010 average (red columns)

Table 9: TC formations by MJO phase during the 2020 Atlantic hurricane season.

MJO Phase	TC Formations
1	6
2	3
3	7
4	4
5	3
6	1
7	2
8	4

6.3 Atlantic SST

The early April seasonal Atlantic hurricane forecast called for an above-normal season, due in part to warm water anomalies across the eastern tropical and subtropical Atlantic (Figure 10). While the far North Atlantic was colder than normal, we did not observe significant anomalous cooling in the tropical Atlantic like we had in other prior recent winters.

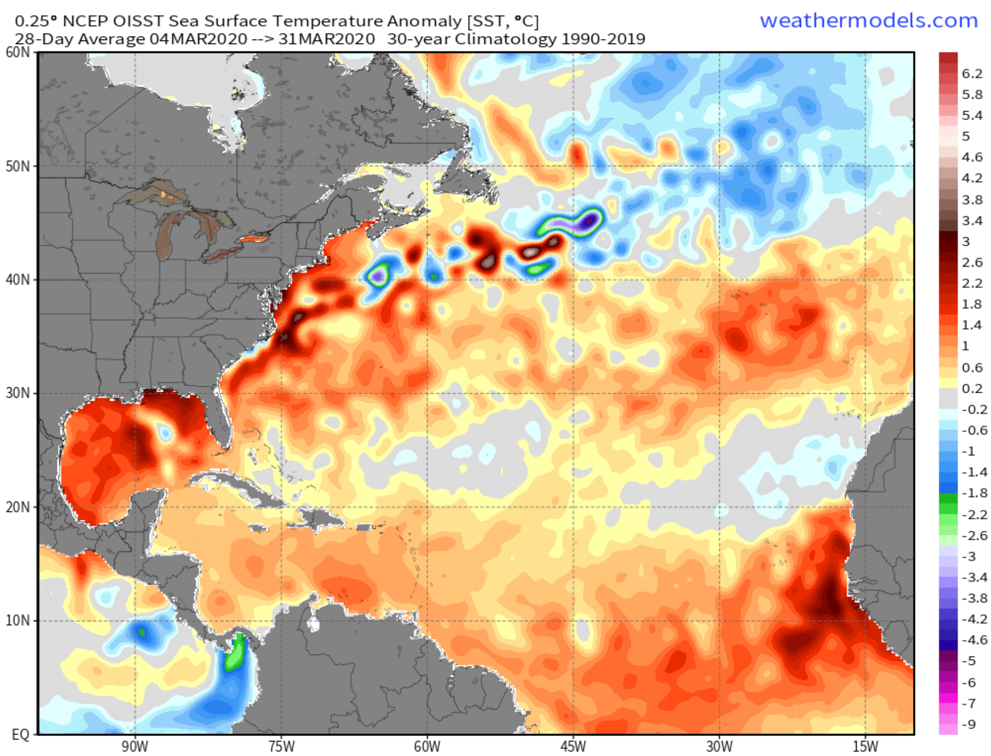

Figure 10: 28-day-averaged SST anomalies ending on March 31, 2020.

A similar SST anomaly pattern was evident at the time of CSU's next forecast issued in early June (Figure 11), with extremely warm SSTs in the subtropical eastern Atlantic. Warm SST anomalies in the subtropical eastern Atlantic during the spring are typically a harbinger of a very active Atlantic hurricane season.

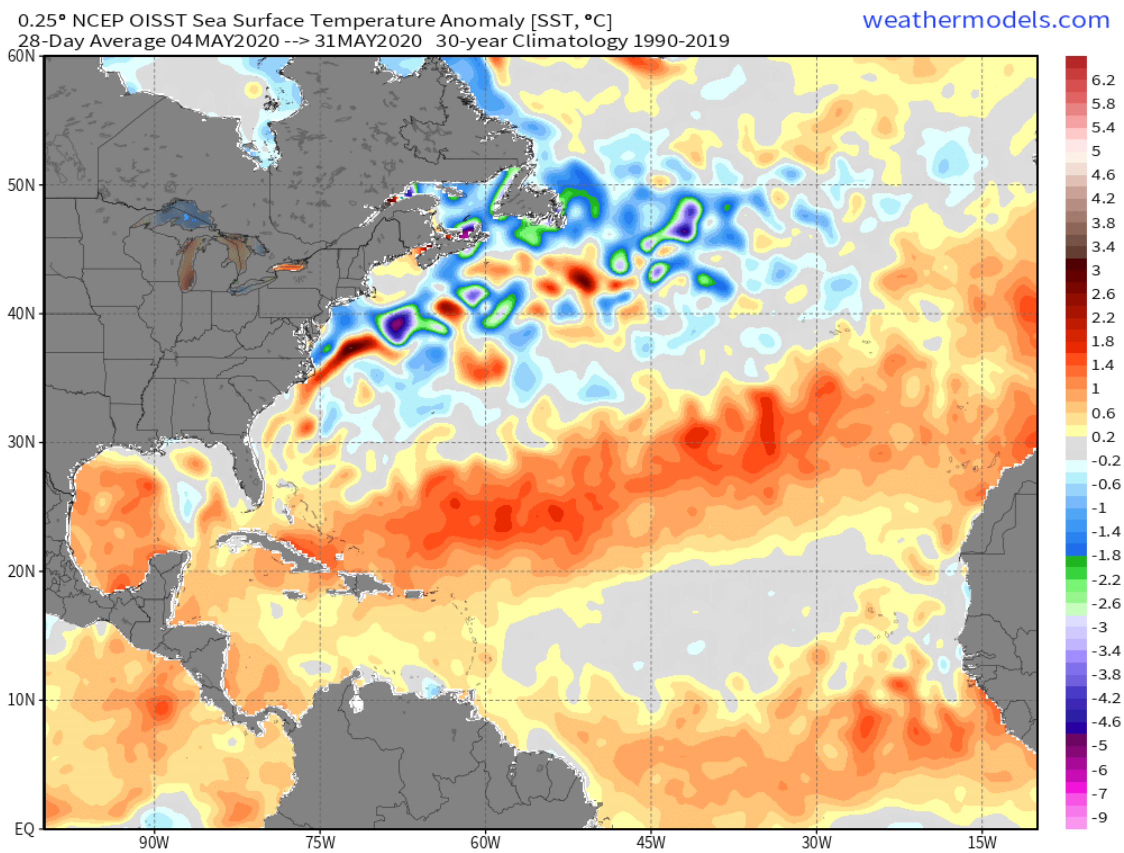

Figure 11: 28-day-averaged SST anomalies ending on May 31, 2020.

Tropical Atlantic SST anomalies remained well above normal through July (Figure 12). The Main Development Region (MDR), which we define to be 10-20°N, 60-20°W, was 0.7°C above the 1982-2010 MDR average for July and the 3rd warmest on record (since 1982), trailing 2010 (1.1°C above normal) and 2005 (0.9°C above normal).

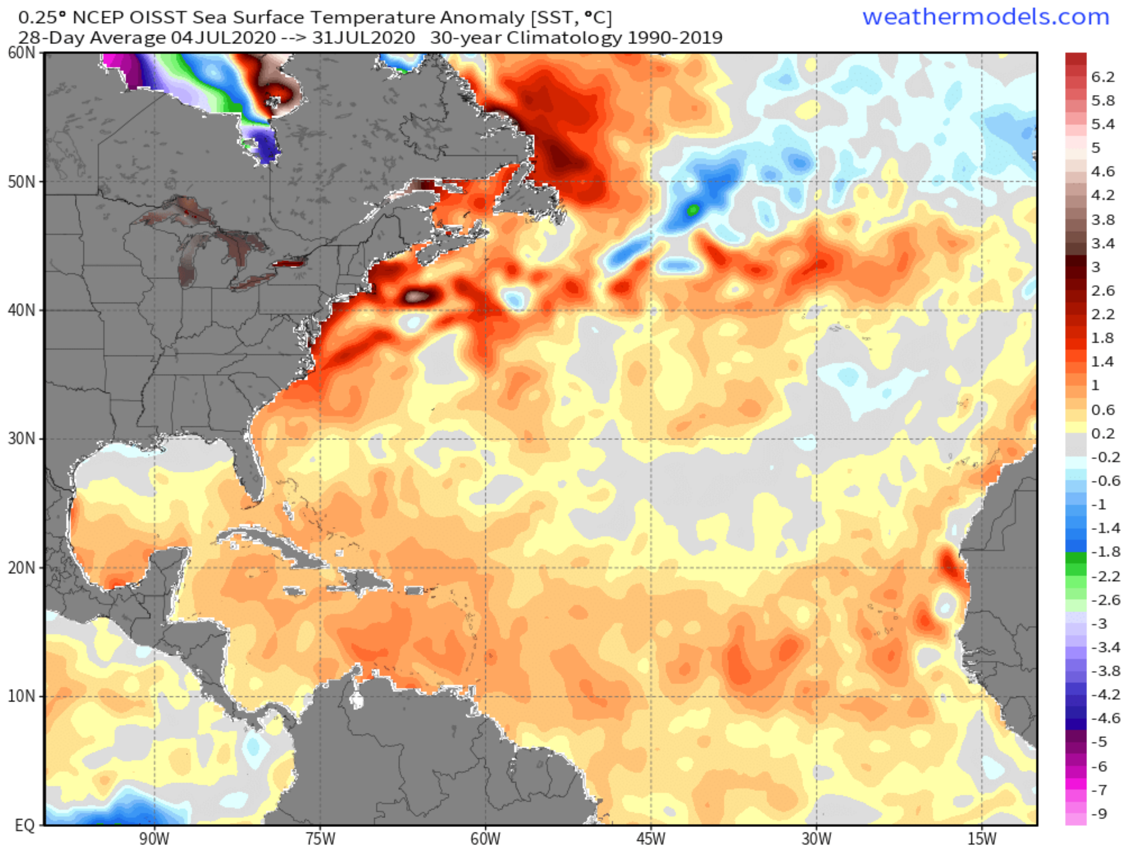

Figure 12: 28-day-averaged SST anomalies ending on July 31, 2020.

These warm tropical SST anomalies persisted through the peak of the Atlantic hurricane season, with September 2020 SST anomalies also reaching 0.7°C above normal (Figure 13). While these SST anomalies were well above normal, several years did eclipse September 2020 SST anomalies in the MDR including (in descending order from warmest): 2005, 2010, 2012, 2015, 2008 and 2019. SST anomalies remained well above normal across the Caribbean, and this area became the prime formation region for the extremely active October-November that was observed.

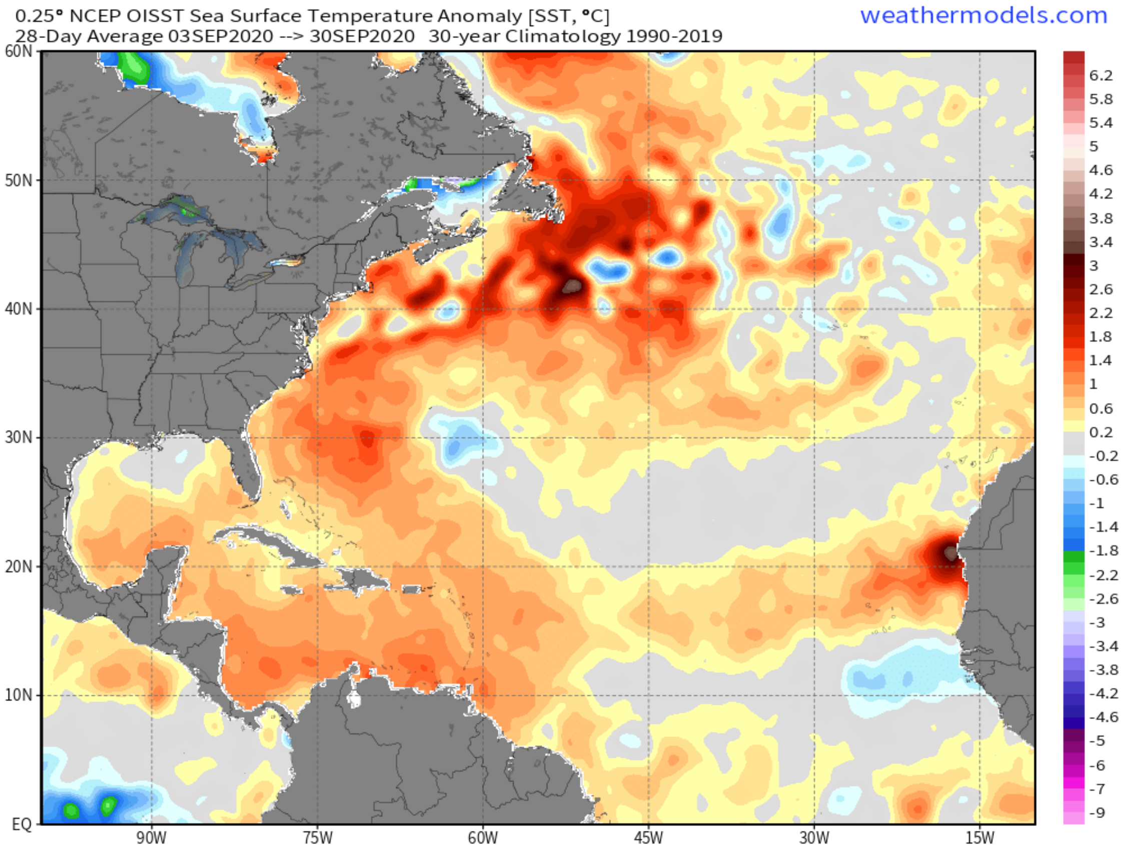

Figure 13: 28-day-averaged SST anomalies ending on September 30, 2020.

6.4 Tropical Atlantic SLP

Tropical Atlantic sea level pressure values are another important parameter to consider when evaluating likely TC activity in the Atlantic basin. In general, lower sea level pressures across the tropical Atlantic imply increased instability, increased low-level moisture, and conditions that are generally favorable for TC development and intensification. The August-October portion of the 2020 Atlantic hurricane season was characterized by below-normal sea level pressures across the tropical Atlantic, Caribbean and Gulf of Mexico (Figure 14), in line with the well above-average hurricane season that occurred.

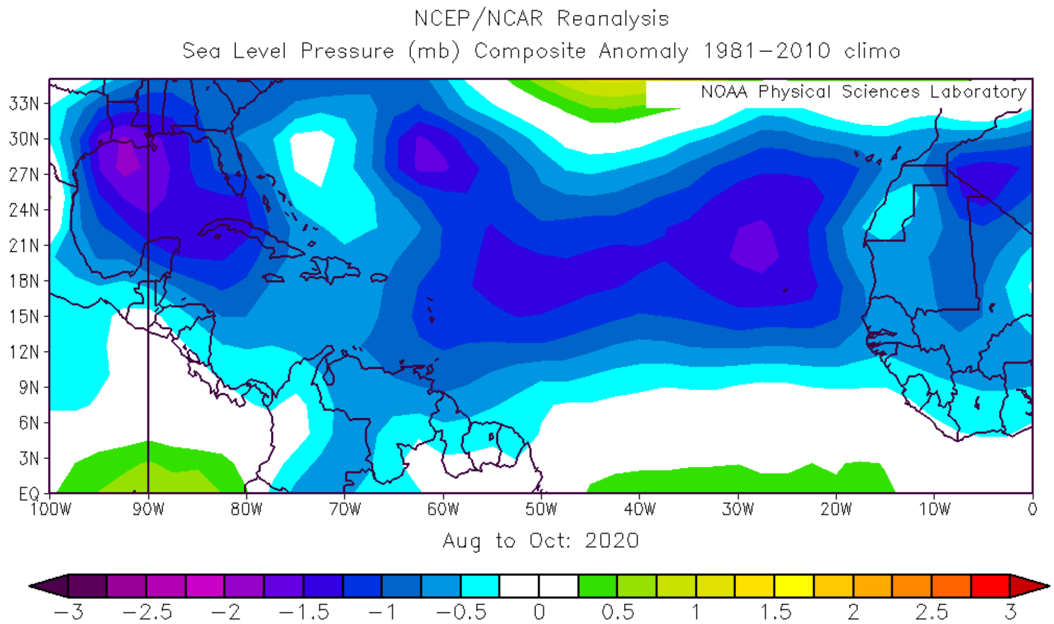

Figure 14: August-October 2020 tropical and sub-tropical North Atlantic sea level pressure anomalies.

6.5 Tropical Atlantic Vertical Wind Shear

During the peak of the Atlantic season from August to October, wind shear anomalies were below-normal across the Caribbean and tropical Atlantic, as highlighted by the black box extending from 10-20°N, 90-20°W (Figure 15). Zonal wind shear anomalies across the Caribbean and tropical Atlantic were the lowest in the ERA5 reanalysis record (since 1979) (Figure 16). Weaker than normal zonal vertical wind shear is typically associated with above-average Atlantic hurricane seasons. These extremely favorable wind shear conditions were likely one of the reasons why the 2020 Atlantic hurricane season was much more active than normal.

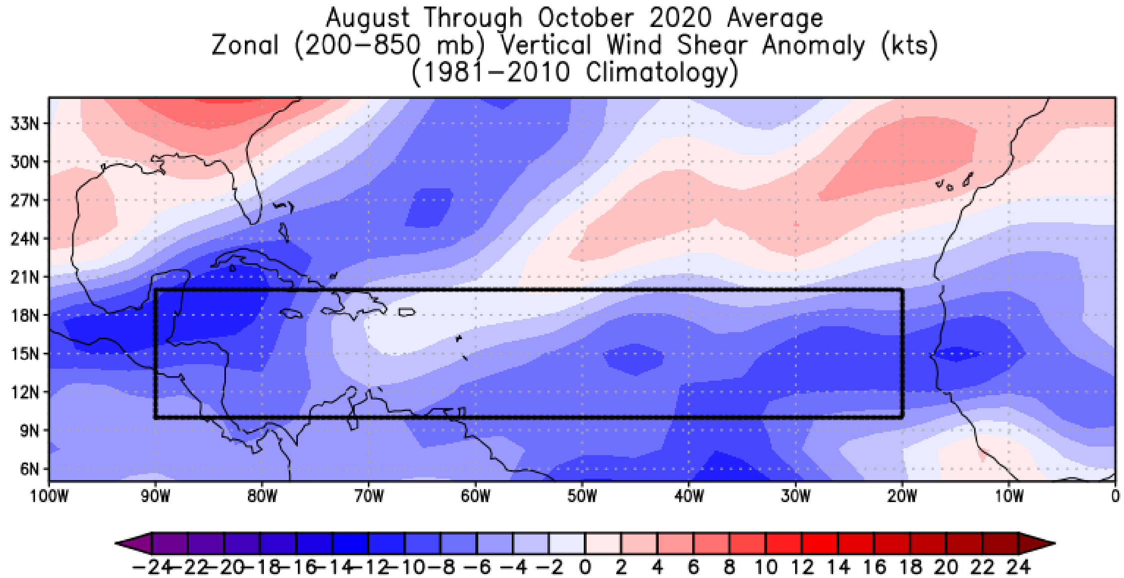

Figure 15: Anomalous vertical wind shear observed across the Atlantic from August to October. The black box highlights the tropical Atlantic and Caribbean.

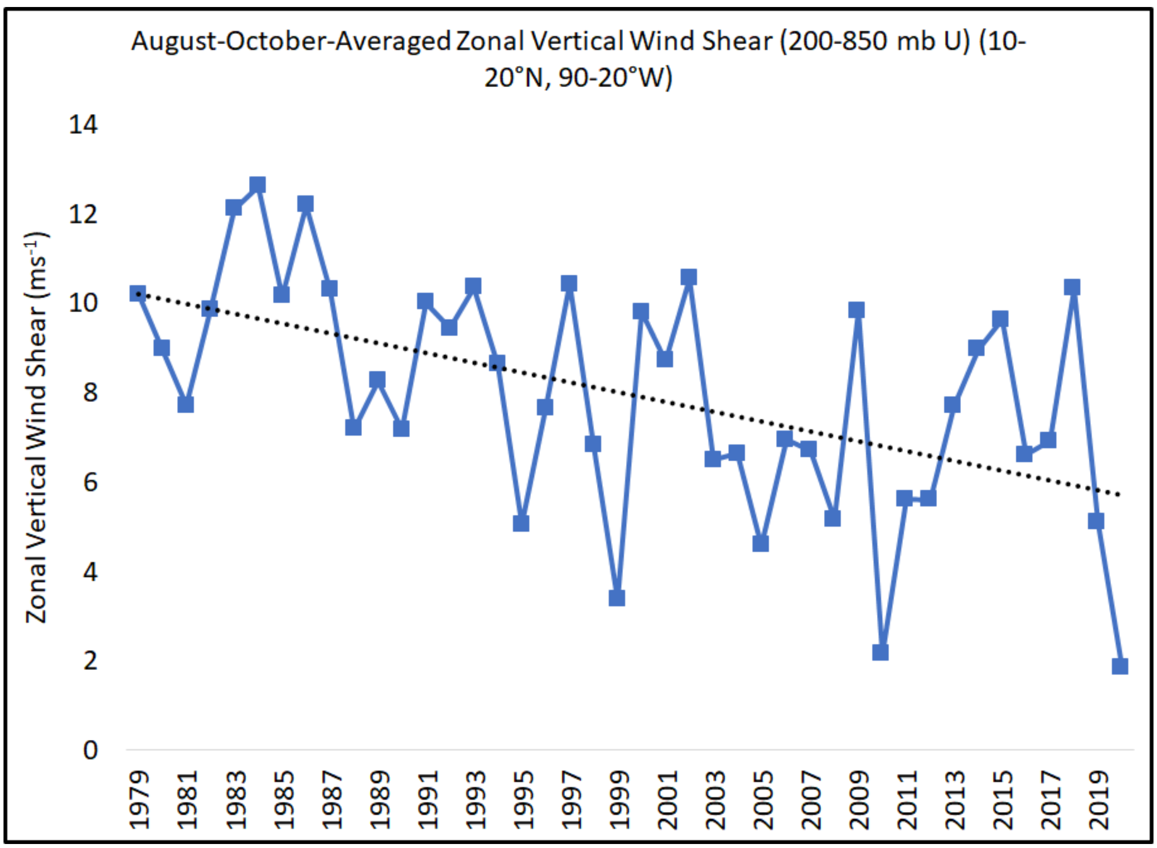

Figure 16: Zonal vertical wind shear averaged from 10-20°N, 90-20°W during August-October from 1979-2020.

6.6 Steering Currents

The steering currents in August-October 2020 were characterized by an anomalous mid-level high pressure zone located from the southeastern United States extending northeastward towards the Atlantic Provinces of Canada (compared to the 2006-2016 period of the US major hurricane landfall drought) (Figure 17). This type of steering pattern aided in TCs tracking generally westward across the Atlantic. Several TCs that formed off of Africa were sheared apart before they even reached the central Atlantic, however.

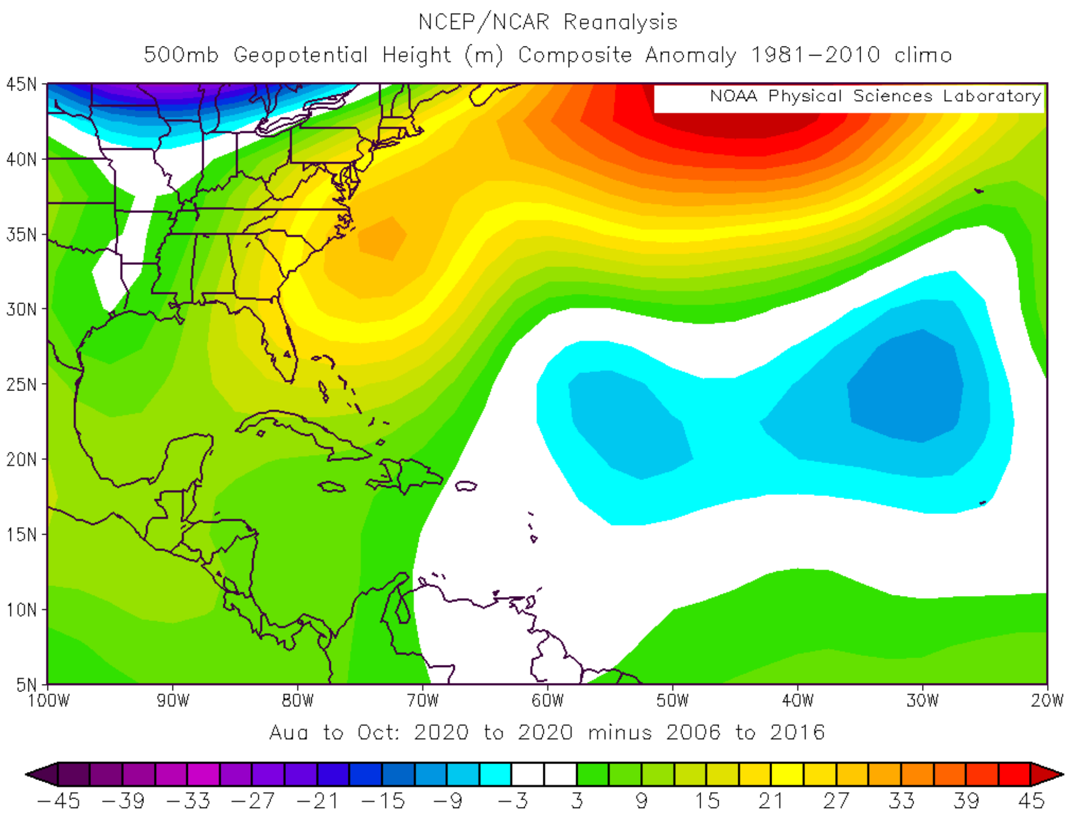

Figure 17: 500-mb height in the central and western part of the Atlantic from August to October in 2020 differenced from the August-October 2006 to 2016 period.

7 Forecasts of 2021 Hurricane Activity

We will be issuing our first outlook for the 2021 hurricane season on Thursday, 10 December 2020. This forecast will provide a qualitative outlook for factors likely to impact the 2021 hurricane season. This December forecast will include the dates of all of our updated 2021 forecasts. All of these forecasts will be made available online.

8 Verification of Previous Forecasts

Table 10: Verification of the authors' early August forecasts of Atlantic named storms and hurricanes between 1984-2020. Observations only include storms that formed after 1 August. Note that these early August forecasts have either exactly verified or forecasted the correct deviation from climatology in 31 of 37 years for named storms and 29 of 37 years for hurricanes. If we predict an above- or below-average season, it tends to be above or below average, even if our exact forecast numbers do not verify.

Year	Predicted NS	Observed NS	Predicted H	Observed H
1984	10	12	7	5
1985	10	9	7	6
1986	7	4	4	3
1987	7	7	4	3
1988	11	12	7	5
1989	9	8	4	7
1990	11	12	6	7
1991	7	7	3	4
1992	8	6	4	4
1993	10	7	6	4
1994	7	6	4	3
1995	16	14	9	10
1996	11	10	7	7
1997	11	3	6	1
1998	10	13	6	10
1999	14	11	9	8
2000	11	14	7	8
2001	12	14	7	9
2002	9	11	4	4
2003	14	12	8	5
2004	13	14	7	9
2005	13	20	8	12
2006	13	7	7	5
2007	13	12	8	6
2008	13	12	7	6
2009	10	9	4	3
2010	16	17	9	11
2011	12	15	9	7
2012	10	15	5	9
2013	14	9	8	2
2014	9	7	3	5
2015	5	8	2	4
2016	15	15	6	7
2017	11	12	8	10
2018	9	12	3	6
2019	12	16	6	5
2020	15	21	10	11
Average	**11.0**	**11.2**	**6.2**	**6.2**
1984-2020 Correlation		**0.64**		**0.56**

Table 11: Summary verification of the authors' five previous years of seasonal forecasts for Atlantic TC activity from 2015-2019.

2015	9 April	Update 1 June	Update 1 July	Update 4 August	Obs.
Hurricanes	3	3	3	2	4
Named Storms	7	8	8	8	11
Hurricane Days	10	10	10	8	12
Named Storm Days	30	30	30	25	43.50
Major Hurricanes	1	1	1	1	2
Major Hurricane Days	0.5	0.5	0.5	0.5	4
Accumulated Cyclone Energy	40	40	40	35	63
Net Tropical Cyclone Activity	45	45	45	40	81

2016	14 April	Update 1 June	Update 1 July	Update 4 August	Obs.
Hurricanes	6	6	6	6	7
Named Storms	13	14	15	15	15
Hurricane Days	21	21	21	22	27.75
Named Storm Days	52	53	55	55	82.25
Major Hurricanes	2	2	2	2	4
Major Hurricane Days	4	4	4	5	10.25
Accumulated Cyclone Energy	93	94	95	100	143
Net Tropical Cyclone Activity	101	103	105	110	156

2017	6 April	Update 1 June	Update 5 July	Update 4 August	Obs.
Hurricanes	4	6	8	8	10
Named Storms	11	14	15	16	17
Hurricane Days	16	25	35	35	51.75
Named Storm Days	50	60	70	70	93
Major Hurricanes	2	2	3	3	6
Major Hurricane Days	4	5	7	7	19.25
Accumulated Cyclone Energy	75	100	135	135	225
Net Tropical Cyclone Activity	85	110	140	140	232

2018	5 April	Update 31 May	Update 2 July	Update 2 August	Obs.
Hurricanes	7	6	4	5	8
Named Storms	14	14	11	12	15
Hurricane Days	30	20	15	15	27.50
Named Storm Days	70	55	45	53	86.75
Major Hurricanes	3	2	1	1	2
Major Hurricane Days	7	4	2	2	5.25
Accumulated Cyclone Energy	130	90	60	64	133
Net Tropical Cyclone Activity	135	100	70	78	129

2019	4 April	Update 4 June	Update 9 July	Update 5 August	Obs.
Hurricanes	5	6	6	7	6
Named Storms	13	14	14	14	18
Hurricane Days	16	20	20	20	23.50
Named Storm Days	50	55	55	55	70.00
Major Hurricanes	2	2	2	2	3
Major Hurricane Days	4	5	5	5	9.50
Accumulated Cyclone Energy	80	100	100	105	132
Net Tropical Cyclone Activity	90	105	105	110	141