

**COLORADO STATE UNIVERSITY FORECAST OF ATLANTIC HURRICANE
ACTIVITY FROM SEPTEMBER 28–OCTOBER 11, 2023 AND OUTLOOK FOR
OCTOBER–NOVEMBER CARIBBEAN ACCUMULATED CYCLONE ENERGY**

We believe that the most likely category for Atlantic hurricane activity in the next two weeks is above-normal (60%), with normal (35%) and below-normal (5%) being less likely. We anticipate near-average October–November Caribbean Accumulated Cyclone Energy.

(as of 28 September 2023)

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In Memory of William M. Gray⁴

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

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1 Introduction

This is the 15th year that we have issued shorter-term forecasts of tropical cyclone (TC) activity 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) and 5) the current seasonal forecast.

Our forecast definition of above-normal, normal, and below-normal Accumulated Cyclone Energy (ACE) periods is defined by ranking observed activity in the satellite era from 1966–2022 and defining above-normal, normal and below-normal two-week periods based on terciles. Since there are 57 years from 1966–2022, we include the 19 years with the most ACE from September 28–October 11 as the upper tercile, the 19 years with the least ACE as the bottom tercile, while the remaining 19 years are counted as the middle tercile.

Table 1: ACE forecast definition for TC activity for September 28–October 11, 2023.

Parameter	Definition	Probability in Each Category
Above-Normal	Upper Tercile (>12 ACE)	60%
Normal	Middle Tercile (4–12 ACE)	35%
Below-Normal	Lower Tercile (<4 ACE)	5%

2 Forecast

We believe that the next two weeks have the highest probability to be characterized by activity at above-normal levels (>12 ACE). There are currently two active tropical cyclones in the Atlantic basin: Philippe and Rina. There is considerable uncertainty as to how these two systems are going to interact with each other in the short-term, which is one of the primary sources of uncertainty for this outlook. There is the potential that Philippe and Rina could generate the ACE needed to meet the above-normal threshold, but Philippe could also shear off Rina with its outflow if Rina gets too close.

The National Hurricane Center is not monitoring any other areas for tropical cyclone (TC) development in the next seven days. Global model ensembles had been hinting at potential development off of the southeast US coast in ~ 7 -10 days, although this signal has gotten weaker since yesterday. There are also possibilities for TC formation in the western Caribbean and in the eastern Main Development Region (although eastern Main Development Region formation climatologically is relatively rare in October) later in the forecast period. The MJO is currently weak and looks to likely remain weak for the next two weeks.

Figure 1 displays the formation locations of tropical cyclones from September 28–October 11 for the years from 1966–2021, along with the maximum intensities that these storms reached. Figure 2 displays the September 28–October 11 forecast period with respect to climatology. The primary threat area for major hurricane formations shifts farther to the west, with formations picking up considerably in the western Caribbean.

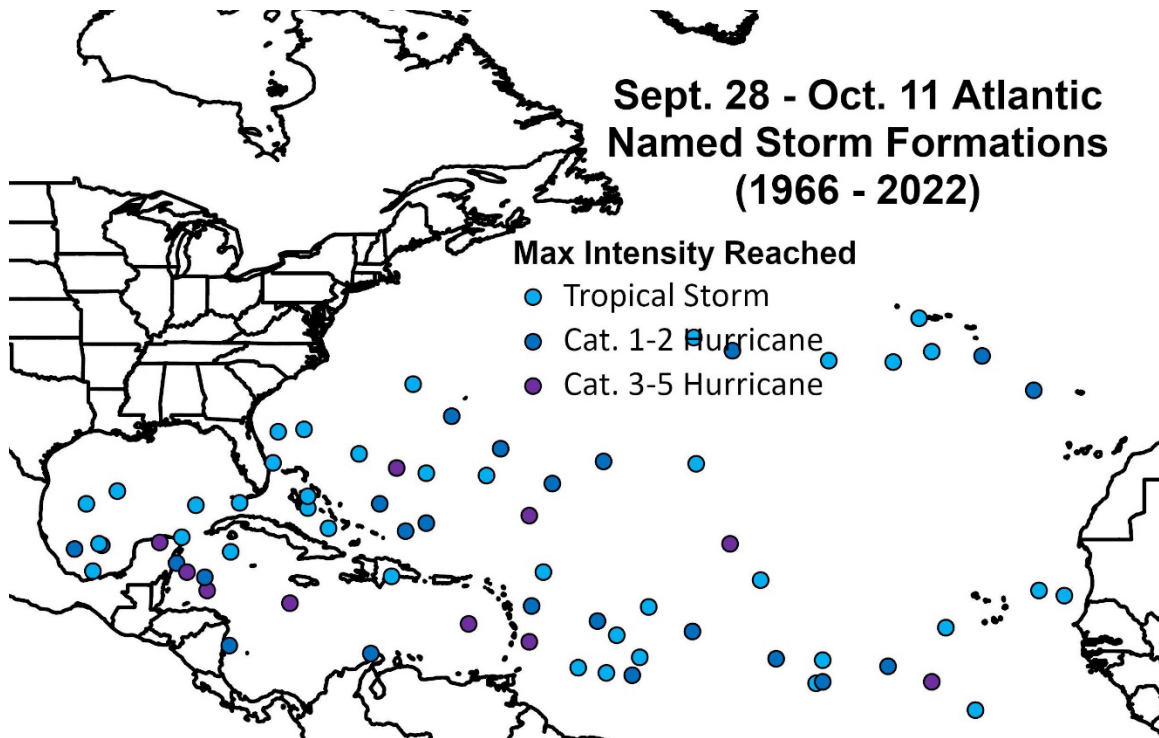


Figure 1: Atlantic named storm formations from September 28–October 11 during the years from 1966-2022 and the maximum intensity that these named storms reached.

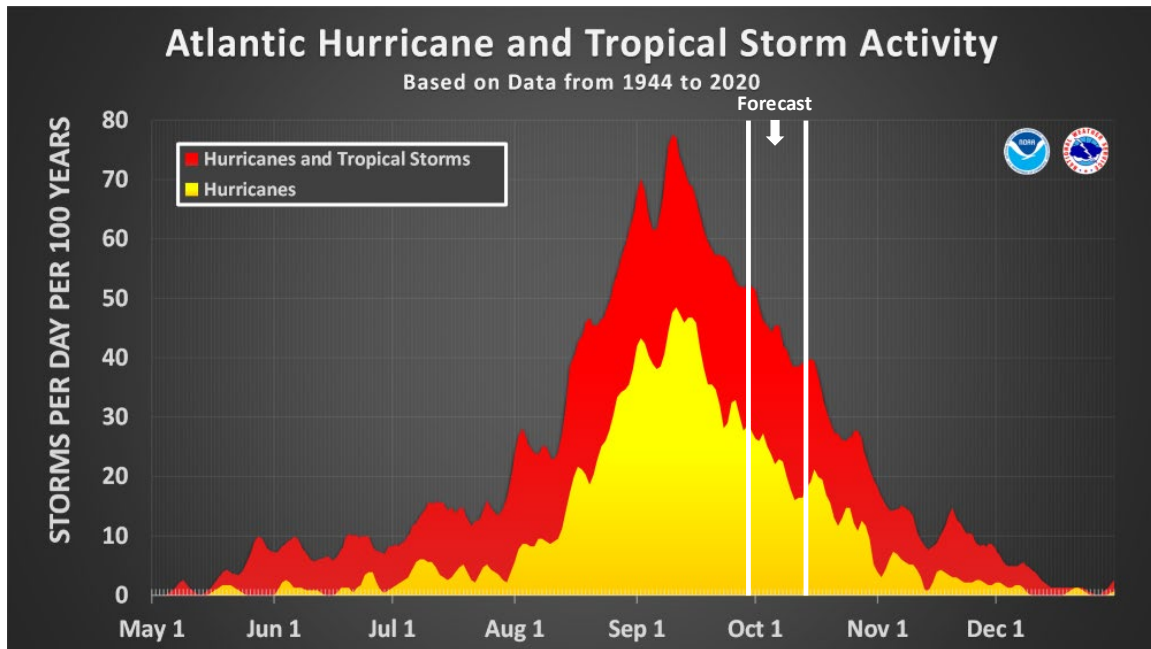


Figure 2: The current forecast period (September 28–October 11) with respect to climatology, delimited with white lines. Figure courtesy of NOAA.

We now examine how we believe each of the five factors discussed in the introduction will impact Atlantic TC activity for the period from September 28–October 11.

1) Current Storm Activity

There are currently two active TCs in the Atlantic: Philippe and Rina. There is the potential that these two systems could combine to generate the ACE needed to meet the above-normal threshold, but the interaction between the two systems remains highly uncertain. Philippe and Rina are forecast to generate ~ 7 ACE between them in the next five days, which is why we gave a very low probability of having a below-average two-week period.

2) National Hurricane Center Tropical Weather Outlook

The latest NHC Tropical Weather Outlook is not monitoring any additional areas for potential TC development in the next seven days.

3) Global Model Analysis

The ECMWF Ensemble Prediction System (EPS) (Figure 3) shows a relatively high likelihood that either Philippe or Rina will develop into a hurricane (and potentially a major hurricane) in about one week's time. The EPS also does have hints of both TC development off the US East Coast and in the western Caribbean/southern Gulf of Mexico later in the forecast period. The Global Ensemble Forecast System also favors

intensification of either Philippe or Rina into a hurricane (or perhaps major hurricane) (Figure 4). The GEFS also shows potential development later in the forecast period in the eastern Main Development Region and the Gulf of Mexico.

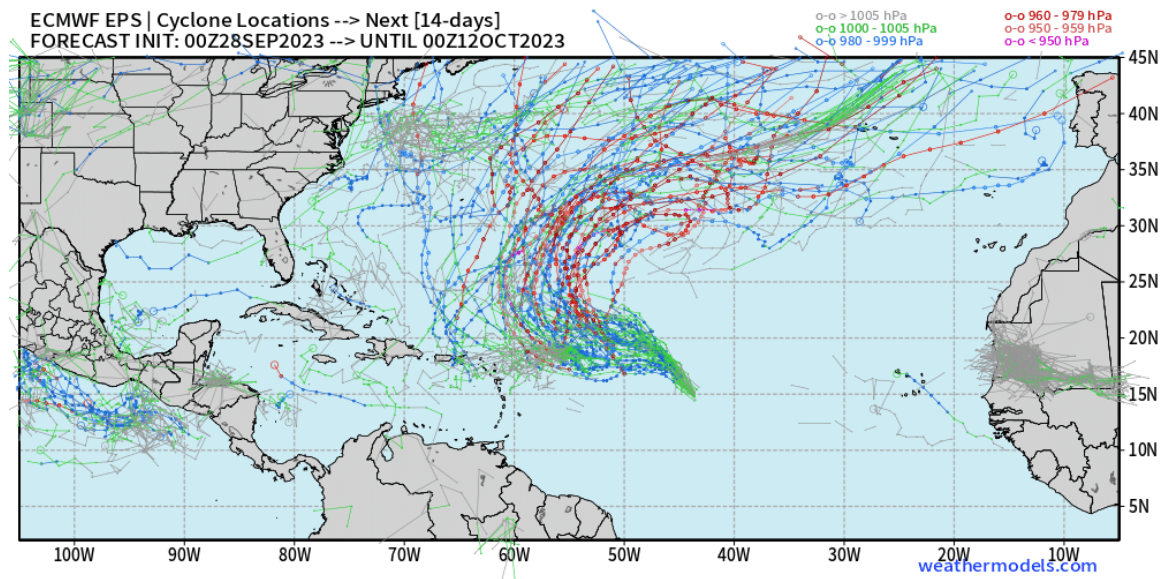


Figure 3: Cyclone locations from the ECMWF EPS ensemble for the next 14 days. Figure courtesy of weathermodels.com

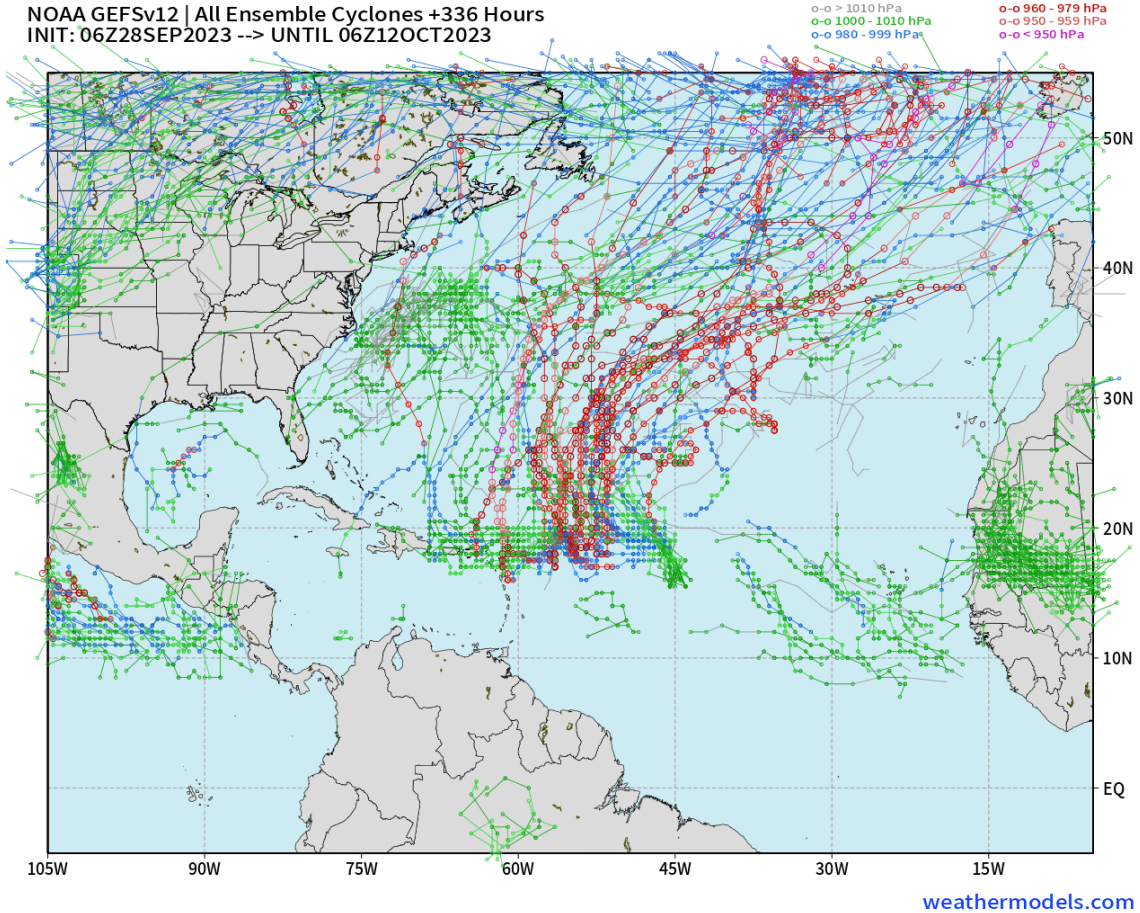


Figure 4: Cyclone locations from the Global Ensemble Forecast System for the next 14 days. Figure courtesy of weathermodels.com.

4) Madden-Julian Oscillation

The MJO, as measured by the Wheeler-Hendon index, is currently weak (Figure 5). There are some hints at potential intensification into phases 7-1 later in the forecast period, but given the lack of MJO activity in recent weeks and the lack of a strong model signal, we generally expect to continue to see weak MJO propagation continue. The broad-scale velocity potential pattern looks to be less favorable for Atlantic hurricane activity for days ~4-12, with the potential for upward motion occurring over the eastern North Pacific (Figure 6). This pattern tends to suppress Atlantic vertical motion and TC activity. However, there could be a lull in eastern North Pacific upward motion later in the forecast period, resulting in reduced vertical wind shear (Figure 7), and potentially favoring western Caribbean TC formation at that time.

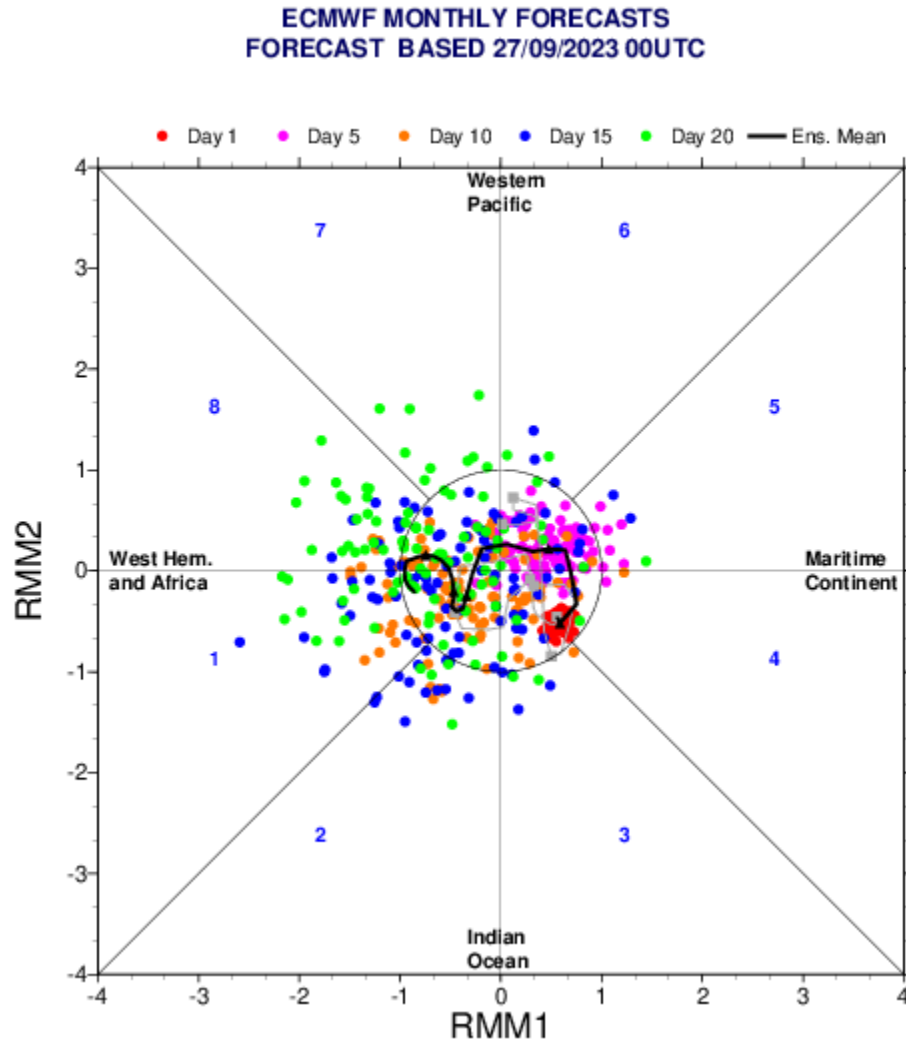


Figure 5: Predicted propagation of the MJO by the ECMWF Ensemble Prediction System. Figure courtesy of ECMWF.

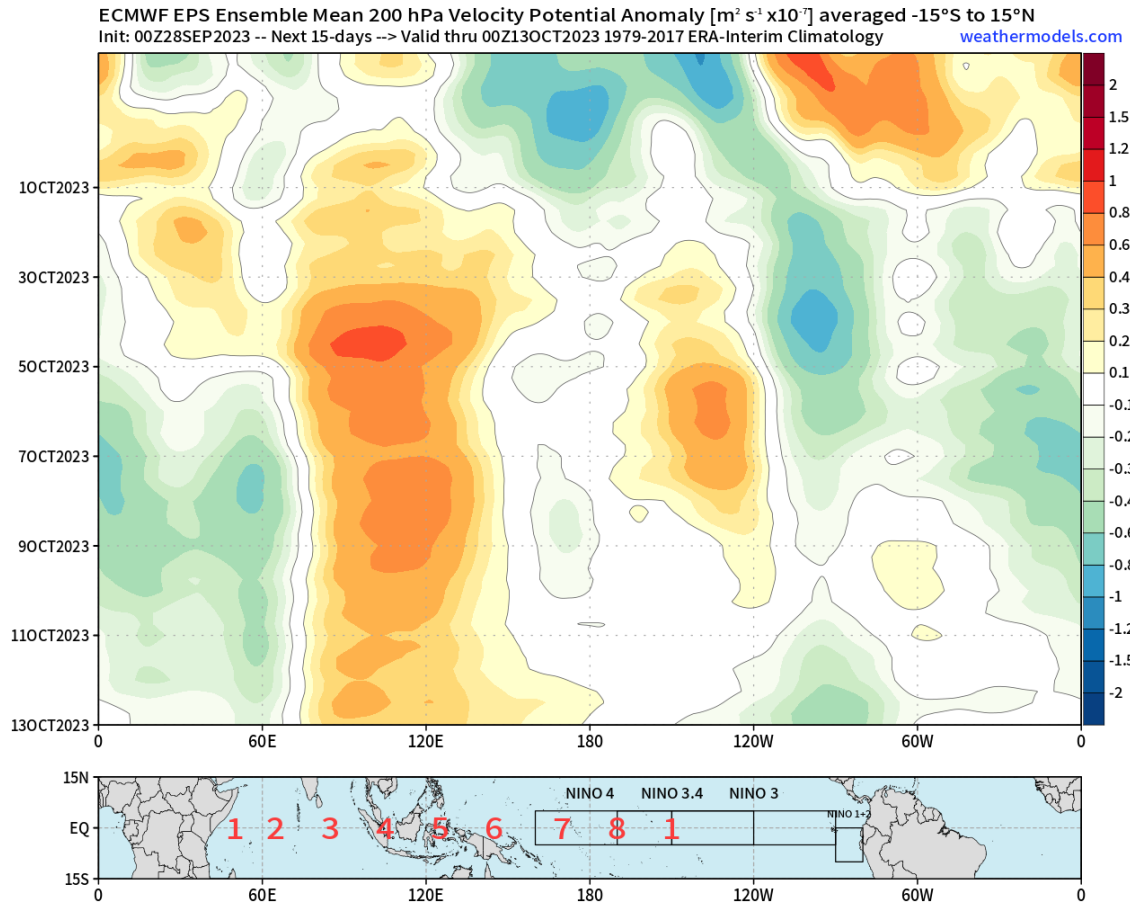


Figure 6: Forecast upper-level velocity potential anomalies by the ECMWF Ensemble Prediction System. Figure courtesy of [weathermodels.com](https://www.weathermodels.com).

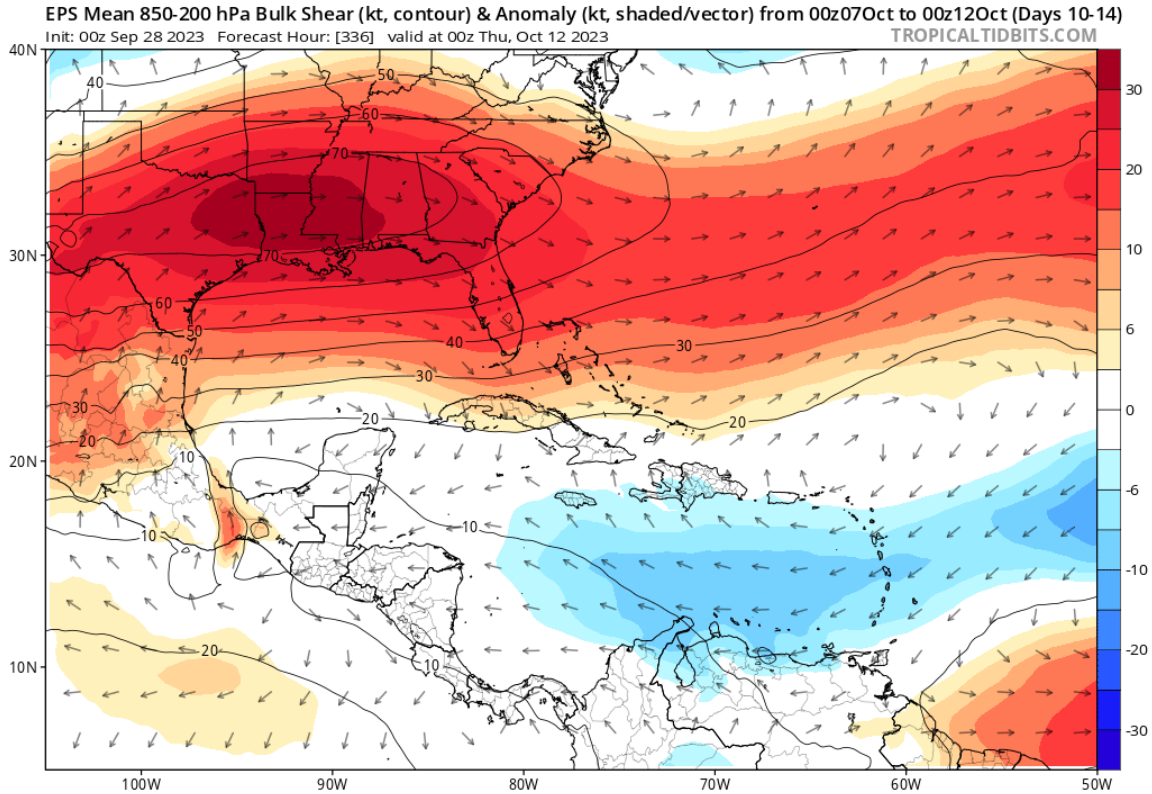


Figure 7: Forecast 200-850 hPa western Atlantic vertical wind shear anomalies for October 7-11 from the ECMWF Ensemble Prediction System. Figure courtesy of Tropical Tidbits.

5) Seasonal Forecast

The most recent seasonal forecast calls for an above-average season. We favor above-average ACE as the most likely outcome for the next two weeks.

3 Upcoming Forecasts

A final two-week forecast will be issued on October 12.

VERIFICATION OF SEPTEMBER 14–27 FORECAST

The two-week forecast of tropical cyclone activity from September 14–27 verified in the normal category (10–26 ACE). A total of 25 ACE was observed during the two-week period, which is just barely below the above-normal threshold. We assigned a probability of 15% for normal ACE given Lee and Margot’s forecast tracks/intensities at the start of the two-week period as well as the strong model support for Nigel becoming a major hurricane. Lee and Margot did not produce quite as much ACE as we anticipated, and Nigel was also a bit weaker and faster than we anticipated at the start of the two-week forecast. Ophelia and Philippe also formed during the two-week period but generated fairly low levels of ACE. During the two-week period, Nigel produced 10 ACE, Lee and Margot each produced 5 ACE, Philippe produced 3 ACE and Ophelia produced 2 ACE.

Table 2 displays the percentage chance that we gave for each category being reached and observed ACE.

Table 2: ACE forecast for TC activity for September 15–28, the probability assigned for each category being reached and observed ACE.

ACE Category	Definition	Probability in each Category	Observed ACE
Above-Normal	Upper Tercile (>26 ACE)	85%	25
Normal	Middle Tercile (10–26 ACE)	15%	
Below-Normal	Lower Tercile (<10 ACE)	0%	

COLORADO STATE UNIVERSITY FORECAST OF OCTOBER-NOVEMBER CARIBBEAN ACE

In 2011, we published a paper detailing a model that forecast October-November Caribbean hurricane days (Klotzbach 2011) using the state of ENSO and sea surface temperatures in the western tropical Atlantic and Caribbean (e.g., the Atlantic Warm Pool). In an analysis of a recently published article on the October-November portion of the 2020 Atlantic hurricane season (Klotzbach et al. 2022), we revised the model slightly to use the ENSO Longitude Index (Williams and Patricola 2018) to assess the state of ENSO and now use ACE as our primary forecast metric.

For this outlook, we use SSTs from the ERA5 reanalysis to estimate the strength of the Atlantic warm pool, while Christina Patricola has kindly provided an estimated value of the ENSO Longitude Index using daily NOAA OI SSTs. We find that using three-month averages optimizes the hindcast skill of this model over the period from 1979-2022. Table 3 displays the locations and time periods of the predictors, their standardized values relative to 1991-2020 and their effect on October-November Caribbean ACE, defined to span 10-20°N, 88-60°W.

For 2023, the ENSO Longitude Index is strongly positive, indicating a robust El Niño event. The Atlantic warm pool is record warm this year. These two predictors, in combination, favor a somewhat below-average end to the Atlantic hurricane season in the Caribbean, due to strong El Niños historically dominating over warm Atlantic warm pools.

Table 3: Listing of predictors of October-November Caribbean ACE. A plus (+) means that positive deviations of the parameter indicate increased October-November Caribbean ACE this year, and a minus (-) means that positive deviations of the parameter indicate decreased October-November Caribbean ACE this year.

Predictor	Values for 2023 Forecast	Effect on Oct-Nov Caribbean ACE
1) July-September ENSO Longitude Index (-)	+1.7 SD	Strongly Suppress
2) July-September SST (10-20°N, 85-50°W) (+)	+2.6 SD	Strongly Enhance

These two predictors are then combined in a rank regression model to forecast October-November Caribbean ACE. The model shows a hindcast correlation skill of 0.80 over the period from 1979-2022 (Figure 8).

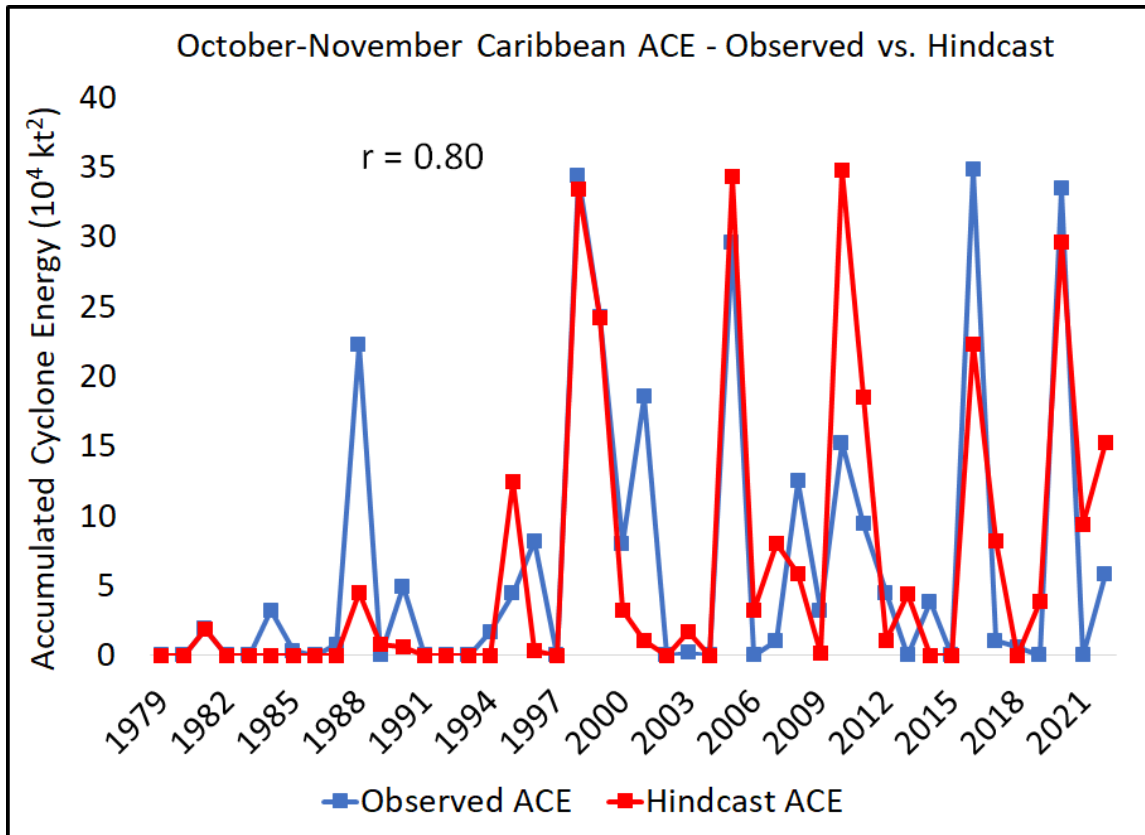


Figure 8: Observed vs. hindcast October-November Caribbean from 1979-2022.

As you can see from the above graph, Caribbean ACE is strongly positively skewed with several years having 0 ACE in the Caribbean during October-November, with other years (such as 2020) having over 30 ACE. The median 1991-2020 ACE is 2, while the mean 1991-2020 ACE is 8.

The forecast from the statistical model for October-November Caribbean ACE in 2023 is 5, which is well above the median but somewhat below the average ACE for the two-month period. We have adjusted the final forecast upwards to 8 ACE given that the warm Atlantic has tended to dominate the moderate/strong El Niño so far this year.