FORECAST OF ATLANTIC SEASONAL HURRICANE ACTIVITY AND LANDFALL STRIKE PROBABILITY FOR 2024

We have slightly increased our forecast and continue to call for an extremely active Atlantic hurricane season in 2024. Sea surface temperatures averaged across the hurricane Main Development Region of the tropical Atlantic and Caribbean remain near record warm levels. Extremely warm sea surface temperatures provide a much more conducive dynamic and thermodynamic environment for hurricane formation and intensification. We anticipate cool neutral ENSO or La Niña during the peak of the Atlantic hurricane season, resulting in reduced levels of tropical Atlantic vertical wind shear. Hurricane Beryl, a deep tropical Category 5 hurricane, is also a likely harbinger of a hyperactive season. This forecast is of above-normal confidence. We anticipate a well above-average probability for major hurricane landfalls along the continental United States coastline and in the Caribbean. As with all hurricane seasons, coastal residents are reminded that it only takes one hurricane making landfall to make it an active season. Thorough preparations should be made every season, regardless of predicted activity.

(as of 9 July 2024)

By Philip J. Klotzbach[1], Michael M. Bell[2], Alexander J. DesRosiers[3], and Levi G. Silvers[4]
With Special Assistance from Carl J. Schreck III[5]
In Memory of William M. Gray[6]

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ATLANTIC BASIN SEASONAL HURRICANE FORECAST FOR 2024

Forecast Parameter and 1991-2020 Average (in parentheses)	Issue Date 4 April 2024	Issue Date 11 June 2024	Issue Date 9 July 2024	Observed Thru 8 July 2024	Remainder of Season Forecast
Named Storms (NS) (14.4)	23	23	25	3	22
Named Storm Days (NSD) (69.4)	115	115	120	11.75	108.25
Hurricanes (H) (7.2)	11	11	12	1	11
Hurricane Days (HD) (27.0)	45	45	50	6.25	43.75
Major Hurricanes (MH) (3.2)	5	5	6	1	5
Major Hurricane Days (MHD) (7.4)	13	13	16	4.5	11.5
Accumulated Cyclone Energy (ACE) (123)	210	210	230	36	194
ACE West of 60°W (73)	125	125	140	29	111
Net Tropical Cyclone Activity (NTC) (135%)	220	220	240	39	201

PROBABILITIES FOR AT LEAST ONE MAJOR (CATEGORY 3-4-5) HURRICANE LANDFALL ON EACH OF THE FOLLOWING COASTAL AREAS (AFTER 8 JULY):

1) Entire continental U.S. coastline - 57% (full-season average from 1880–2020 is 43%)

2) U.S. East Coast Including Florida Peninsula (south and east of Cedar Key, Florida) - 31% (full-season average from 1880–2020 is 21%)

3) Gulf Coast from the Florida Panhandle (west and north of Cedar Key, Florida) westward to Brownsville - 38% (full-season average from 1880–2020 is 27%)

PROBABILITY FOR AT LEAST ONE MAJOR (CATEGORY 3-4-5) HURRICANE TRACKING THROUGH THE CARIBBEAN (10-20°N, 88-60°W) (AFTER 8 JULY):

1) 62% (full-season average from 1880–2020 is 47%)

ABSTRACT

Information obtained through early July indicates that the 2024 Atlantic hurricane season will have activity well above the 1991–2020 average. We estimate that 2024 will have 25 named storms (average is 14.4), 120 named storm days (average is 69.4), 12 hurricanes (average is 7.2), 50 hurricane days (average is 27.0), 6 major (Category 3-4-5) hurricanes (average is 3.2) and 16 major hurricane days (average is 7.4). These numbers include Alberto, Beryl and Chris. The probability of U.S. major hurricane landfall is estimated to be well above its long-period average. We predict Atlantic basin Accumulated Cyclone Energy (ACE) and Net Tropical Cyclone (NTC) activity in 2024 to be ~185% of their 1991–2020 average. We have increased our overall forecast numbers slightly, due in part to Hurricane Beryl.

Coastal residents are reminded that it only takes one hurricane making landfall to make it an active season for them. Thorough preparations should be made for every season, regardless of how much activity is predicted.

We anticipate that cool neutral ENSO or La Niña conditions are likely at the peak of the Atlantic hurricane season. Cool neutral ENSO or La Niña typically increases Atlantic hurricane activity through decreases in vertical wind shear. This year's sea surface temperatures across the tropical Atlantic and Caribbean are much warmer than normal, with temperatures averaged across the Main Development Region currently measuring ~1°C above the 1991–2020 average. This warmth favors an active Atlantic hurricane season via dynamic and thermodynamic conditions that are conducive for developing hurricanes. While early season storm activity in the western Atlantic typically has little relationship with overall basinwide activity, deep tropical hurricane activity in the tropical Atlantic and eastern Caribbean (such as we saw with Beryl) is often associated with hyperactive seasons.

Our confidence this year is higher than normal for a July forecast based on the strength and persistence of the current hurricane-favorable large-scale environmental conditions. We present probabilities of exceedance for hurricanes and Accumulated Cyclone Energy to give interested readers a better idea of the uncertainty associated with these forecasts. The skill of CSU's forecast updates increases as the peak of the Atlantic hurricane season approaches. Our early July forecast has good long-term skill when evaluated using hindcasts.

In addition to current observations, this forecast is based on an extended-range early July statistical prediction scheme that was developed using ~40 years of past data. Analog predictors are utilized as well. We also include statistical/dynamical models based off 25–40 years of past data from the European Centre for Medium Range Weather Forecasts, the UK Met Office, the Japan Meteorological Agency and the Centro Euro-Mediterraneo sui Cambiamenti Climatici model as four additional forecast guidance tools. This model guidance continues to unanimously point towards a hyperactive season.

Why issue extended-range forecasts for seasonal hurricane activity?

We are frequently asked this question. Our answer is that it is possible to say something about the probability of the coming year's hurricane activity which is superior to climatology. The Atlantic basin has the largest year-to-year variability of any of the global tropical cyclone basins. People are curious to know how active the upcoming season is likely to be, particularly if you can show hindcast skill improvement over climatology for many past years.

Everyone should realize that it is impossible to precisely predict this season's hurricane activity in early July. There is, however, much curiosity as to how global ocean and atmosphere features are presently arranged with respect to the probability of an active or inactive hurricane season for the coming year. Our early July statistical and statistical/dynamical hybrid models show strong evidence on ~25–45 years of data that significant improvement over a climatological forecast can be attained. We would never issue a seasonal hurricane forecast unless we had models developed over a long hindcast period which showed skill. We also now include probabilities of exceedance to provide a visualization of the uncertainty associated with these predictions.

We issue these forecasts to satisfy the curiosity of the public and to bring attention to the hurricane problem. There is a general interest in knowing what the odds are for an active or inactive season. One must remember that our forecasts are based on the premise that those global oceanic and atmospheric conditions which preceded comparatively active or inactive hurricane seasons in the past provide meaningful information about similar trends in future seasons.

It is also important that the reader appreciate that these seasonal forecasts are based on statistical and dynamical models which will fail in some years. Moreover, these forecasts do not specifically predict where within the Atlantic basin these storms will strike. The probability of landfall for any one location along the coast is very low and reflects the fact that, in any one season, most U.S. coastal areas will not feel the effects of a hurricane no matter how active the individual season is.

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 on 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 Commodity Weather Group, Gallagher Re, the Insurance Information Institute, Ironshore Insurance, IAA, and Weatherboy. We acknowledge a grant from the G. Unger Vetlesen Foundation for additional financial support.

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 also would like to thank Jhordanne Jones, recent Ph.D. graduate in Michael Bell's research group, for model development and forecast assistance over the past several years. Thanks also extend to several current members of Michael Bell's research group who have provided valuable comments and feedback throughout the forecast preparation process. These members include: Tyler Barbero, Delián Cólon Burgos, Jen DeHart, Nick Mesa, Angelie Nieves-Jiménez and Isaac Schluesche.

We thank 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 Louis-Philippe Caron, Dan Chavas, Jason Dunion, Brian McNoldy, Paul Roundy, Carl Schreck, Mike Ventrice and Peng Xian over the past few years.

DEFINITIONS AND ACRONYMS

Accumulated Cyclone Energy (ACE) - A measure of a named storm's potential for wind 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. ACE is often calculated over a season to reflect overall storm activity that year. The 1991–2020 average value of this parameter is 123 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.

ENSO Longitude Index (ELI) – An index defining ENSO that estimates the average longitude of deep convection associated with the Walker Circulation.

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, one unit of which occurs as 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 30-60 days.

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.

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 1991–2020 average value of this parameter is 135.

Oceanic Nino Index (ONI) – Three-month running mean of SST anomalies in the Nino 3.4 region (5°S–5°N, 170–120°W) based on centered 30-year base periods.

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.

Standard Deviation (SD) – A measure used to quantify the variation in a dataset.

Sea Surface Temperature Anomaly (SSTA) – Observed sea surface temperature differenced from a long-period average, typically 1991–2020 which is the current NOAA climate baseline.

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 hPa (approximately 40000 feet or 12 km) and 850 hPa (approximately 5000 feet or 1.6 km).

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

1 Introduction

This is the 41st year in which the CSU Tropical Meteorology Project has made forecasts of the upcoming season's Atlantic basin hurricane activity. Our research team has shown that a sizable portion of the year-to-year variability of Atlantic tropical cyclone (TC) activity can be hindcast with skill exceeding climatology. This year's July forecast is based on a statistical model as well as output from statistical/dynamical models from the European Centre for Medium-Range Weather Forecasts (ECMWF), the UK Met Office, the Japan Meteorological Agency (JMA) and the Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC). These models show skill at predicting TC activity based on ~25–45 years of historical data. We also select analog seasons, based on currently-observed conditions as well as conditions that we anticipate for the peak of the Atlantic hurricane season. Qualitative adjustments are added to accommodate additional processes which may not be explicitly represented by these analyses. These evolving forecast techniques are based on a variety of climate-related global and regional predictors previously shown to be related to the forthcoming seasonal Atlantic basin TC activity and landfall probability. We believe that seasonal forecasts must be based on methods that show significant hindcast skill in application to long periods of prior data. It is only through hindcast skill that one can demonstrate that seasonal forecast skill is possible. This is a valid methodology provided that the atmosphere continues to behave in the future as it has in the past.

The best predictors do not necessarily have the best individual correlations with hurricane activity. The best forecast parameters are those that explain the portion of the variance of seasonal hurricane activity that are not associated with the other forecast variables. It is possible for an important hurricane forecast parameter to show less of a relationship to a predictand by itself but to have an important influence when included with a set of 2–3 other predictors.

2 July Forecast Methodology

2.1 July Statistical Forecast Scheme

The current iteration of the July statistical forecast model uses ECMWF Reanalysis 5 (ERA5; Hersbach et al. 2020) data for all three predictors. This forecast model was developed over 1979–2020 and then was tested on the 2021 and 2022 Atlantic hurricane seasons (e.g., those years were purposely left out to see how well the model would work at forecasting these omitted years). The model was then used in real-time in 2023. The forecast model did somewhat over-forecast Atlantic hurricane activity last year. This model shows significant skill in cross-validated (e.g., leaving the year out of the developmental model that is being predicted) hindcasts of Accumulated Cyclone Energy (ACE) (r = 0.74) over the period from 1979–2023 (Figure 1).

Figure 2 displays the locations of the three predictors, while Table 1 displays the individual linear correlations between each predictor and ACE over the 1979–2023 hindcast/forecast period. All three predictors correlate significantly at the 5% level using a two-tailed Student's t-test and assuming that each year represents an individual degree of freedom. Table 2 displays the 2024 observed values for the three predictors in the statistical forecast scheme. Table 3 displays the statistical model output for the 2024 hurricane season. The June Atlantic Main Development Region SST predictor is at its warmest value on record, slightly outpacing last year. This predictor is extremely favorable for an active season. The eastern subtropical Atlantic SST predictor is also somewhat warmer than normal, favoring an active season. The tropical Pacific SST predictor is near its long-term average, consistent with the current ENSO neutral conditions. The three predictors in combination call for a well above-average season.

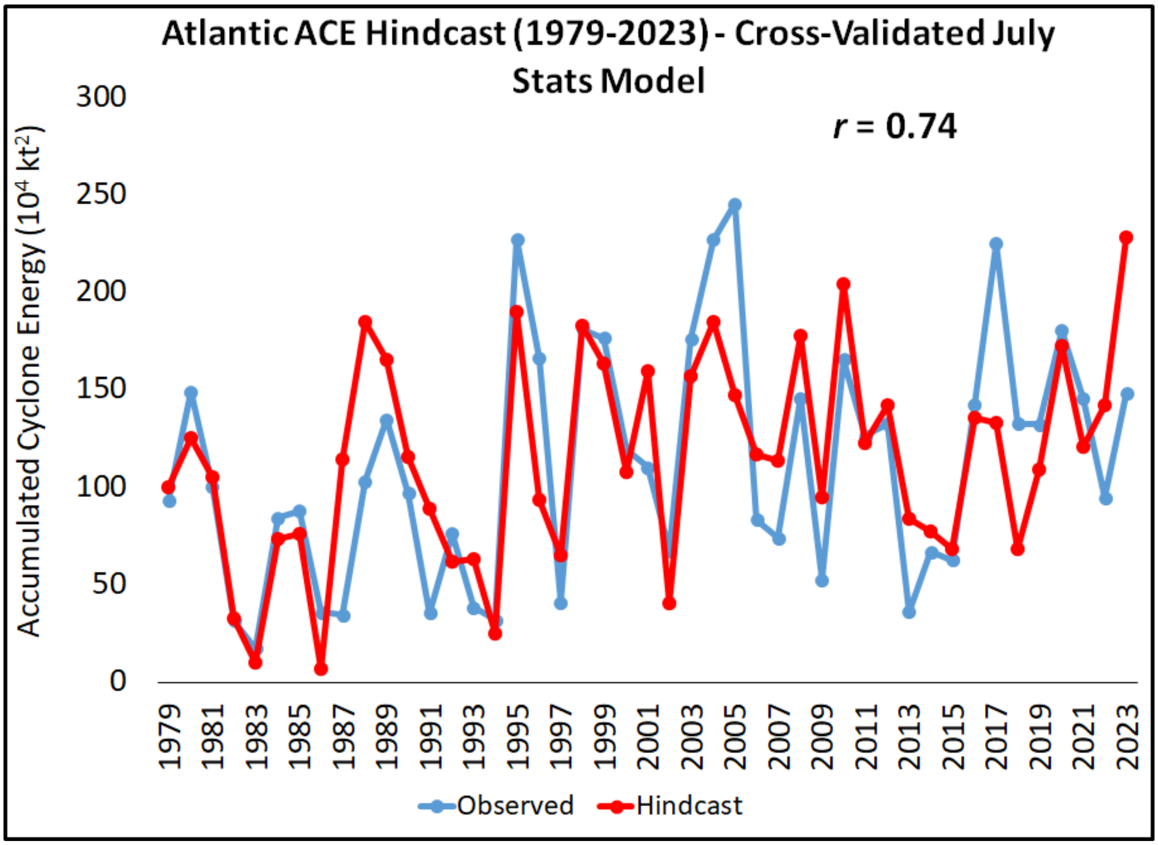

Figure 1: Observed versus early July cross-validated hindcast values of ACE for the statistical model from 1979–2023.

July Forecast Predictors

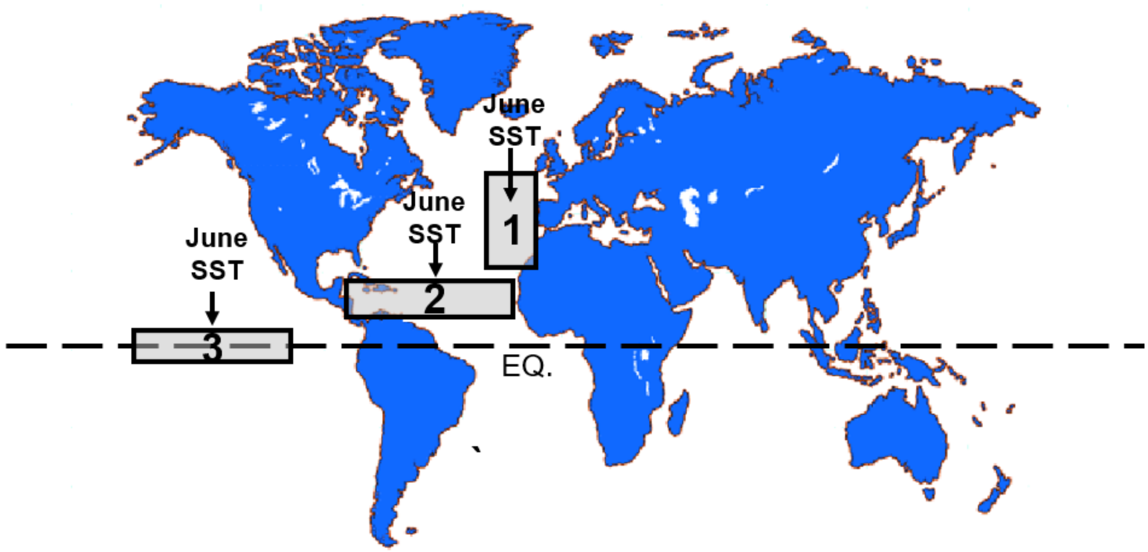

Figure 2: Location of predictors for the early July extended-range statistical prediction for the 2024 hurricane season.

Table 1: Linear correlation between early July predictors and ACE over the period from 1979–2023.

Predictor	Correlation w/ ACE
1) June SST (30°N–50°N, 30°W–10°W) (+)	0.63
2) June SST (10°N–20°N, 85°W–20°W) (+)	0.45
3) June SST (5°S–5°N, 160°W–110°W) (-)	-0.38

Table 2: Listing of early July 2024 predictors for the 2024 hurricane season. A plus (+) means that positive deviations of the parameter are associated with increased hurricane activity, while a minus (-) means that negative deviations of the parameter are associated with increased hurricane activity. SD stands for standard deviation.

Predictor	2024 Forecast Value	Impact on 2024 TC Activity
1) June SST (30°N–50°N, 30°W–10°W) (+)	+1.3 SD	Enhance
2) June SST (10°N–20°N, 85°W–20°W) (+)	+2.8 SD	Strongly Enhance
3) June SST (5°S–5°N, 160°W–110°W) (-)	0.0 SD	Neutral

Table 3: Statistical model output for the 2024 Atlantic hurricane season and the final adjusted forecast.

Forecast Parameter and 1991–2020 Average (in parentheses)	Statistical Forecast	Final Forecast
Named Storms (NS) (14.4)	20.7	25
Named Storm Days (NSD) (69.4)	102.3	125
Hurricanes (H) (7.2)	10.6	12
Hurricane Days (HD) (27.0)	44.9	50
Major Hurricanes (MH) (3.2)	5.3	6
Major Hurricane Days (MHD) (7.4)	13.9	16
Accumulated Cyclone Energy (ACE) (123)	201	230
Net Tropical Cyclone Activity (NTC) (135%)	215	240

The locations and brief descriptions of the predictors for our early July statistical forecast are now discussed. All three predictors correlate with physical features during August through October that are known to be favorable for elevated levels of hurricane activity. These factors are all generally related to August–October vertical wind shear in the Atlantic Main Development Region (MDR) from 10–20°N, 85–20°W as shown in Figure 3.

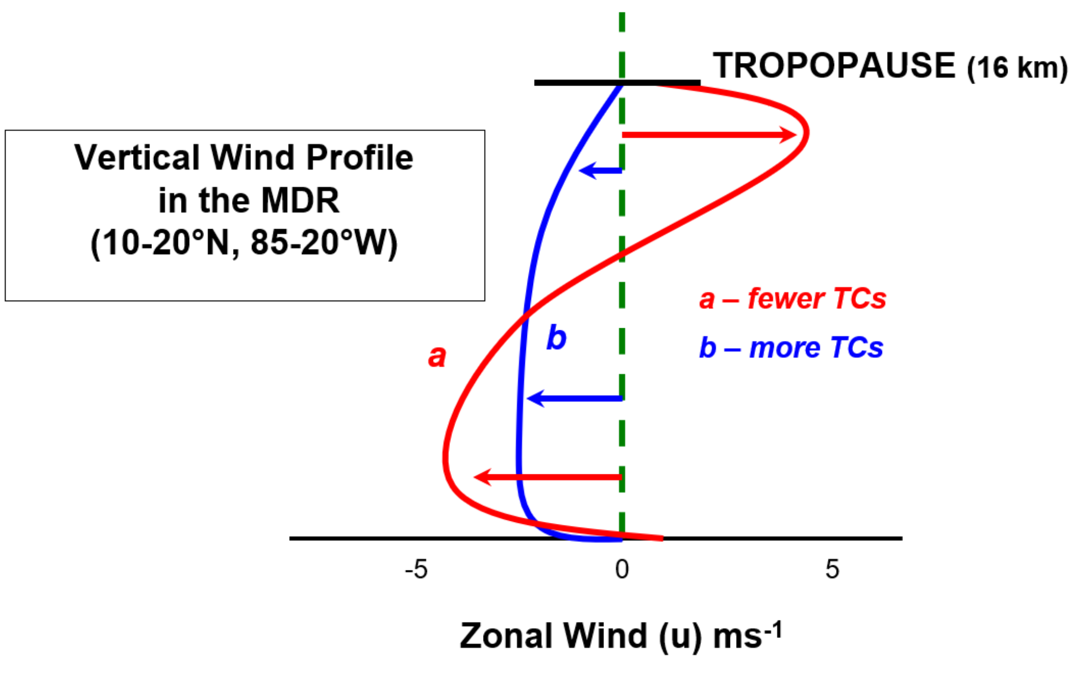

Figure 3: Vertical wind profile typically associated with (a) inactive Atlantic basin hurricane seasons and (b) active Atlantic basin hurricane seasons. Note that (b) has reduced levels of vertical wind shear.

For each of these predictors, we display a four-panel figure showing rank correlations between values of each predictor and August–October values of SST, sea level pressure (SLP), 200 hPa zonal wind, and 850 hPa zonal wind, respectively, since 1979. In general, higher values of tropical Atlantic SSTs, lower values of tropical Atlantic SLP, anomalous tropical Atlantic westerlies at 850 hPa and anomalous tropical Atlantic easterlies at 200 hPa are associated with active Atlantic basin hurricane seasons. All correlations are displayed using ERA5.

Predictor 1. June SSTs in the subtropical eastern Atlantic (+)

(30°N–50°N, 30°W–10°W)

Warmer-than-normal SSTs in the subtropical Atlantic during June are associated with a weaker-than-normal subtropical high and reduced trade wind strength during the boreal summer (Knaff 1997). Positive SSTs in June are correlated with weaker trade winds and weaker upper tropospheric westerly winds, lower-than-normal sea level pressures and above-normal SSTs in the tropical Atlantic during the following August–October period (Figure 4). All of these August–October features are commonly associated with active Atlantic basin hurricane seasons, through reductions in vertical wind shear, increased vertical instability and increased mid-tropospheric moisture, respectively. Predictor 1 correlates quite strongly (r =0.63) with ACE from 1979–2023. Predictor 1 also significantly correlates (r = 0.75) with August–October values of the SST component of the Atlantic Meridional Mode (AMM) (Kossin and Vimont 2007) from 1979–2023. The AMM has been shown to impact Atlantic hurricane activity through alterations in the position and intensity of the Atlantic Inter-Tropical Convergence Zone (ITCZ). Changes in the Atlantic ITCZ bring about changes in tropical Atlantic vertical and horizontal wind shear patterns and in tropical Atlantic SST patterns.

Predictor 2. June SSTs in the Atlantic Main Development Region (+)

(10°N–20°N, 85°W–20°W)

Warmer-than-normal SSTs in the Atlantic Main Development Region (MDR) during June are strongly correlated with warmer-than-normal SSTs in the same region during August-October (r =0.69). A warmer-than-normal MDR during the peak of the Atlantic hurricane season provides a more favorable dynamic and thermodynamic environment for hurricane formation and intensification. Above-normal SSTs in the MDR are also associated with lower-than-normal sea level pressures, weaker trade winds and weaker upper-tropospheric westerly winds, thereby reducing vertical wind shear (Figure 5).

Predictor 3. June SSTs in the central/eastern tropical Pacific (-)

(5°S–5°N, 160°W–110°W)

Anomalously cool SSTs in the eastern and central tropical Pacific in June correlate strongly with anomalously cool SSTs in the Nino 3.4 region during August-October (r =0.84). The Nino 3.4 region is the region that NOAA uses to assess the strength of ENSO events. As would be expected given this significant correlation, cool values of Predictor 3 are also associated with reduced vertical wind shear during the peak of the Atlantic hurricane season, especially in the Caribbean and western tropical Atlantic, where ENSO typically has its strongest impacts (Figure 6).

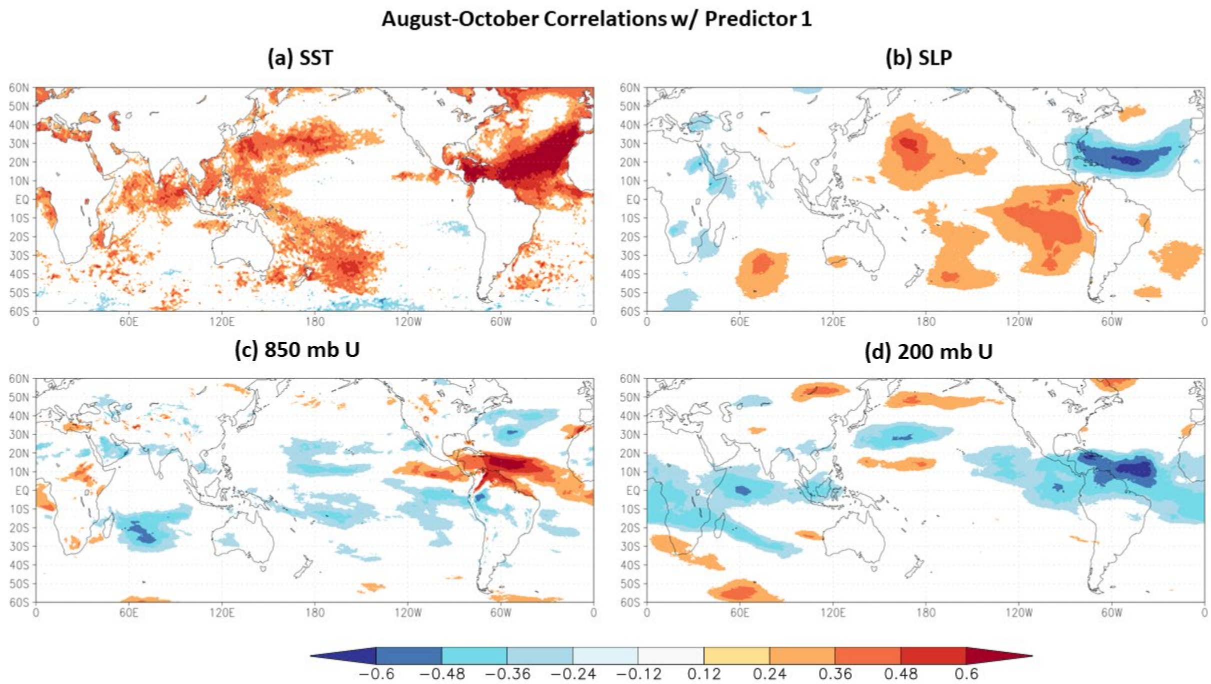

Figure 4: Rank correlations between June SST in the subtropical eastern Atlantic (Predictor 1) and (panel a) August–October sea surface temperature, (panel b) August–October sea level pressure, (panel c) August–October 850 hPa zonal wind and (panel d) August–October 200 hPa zonal wind. All four of these parameter deviations in the tropical Atlantic are known to be favorable for enhanced hurricane activity.

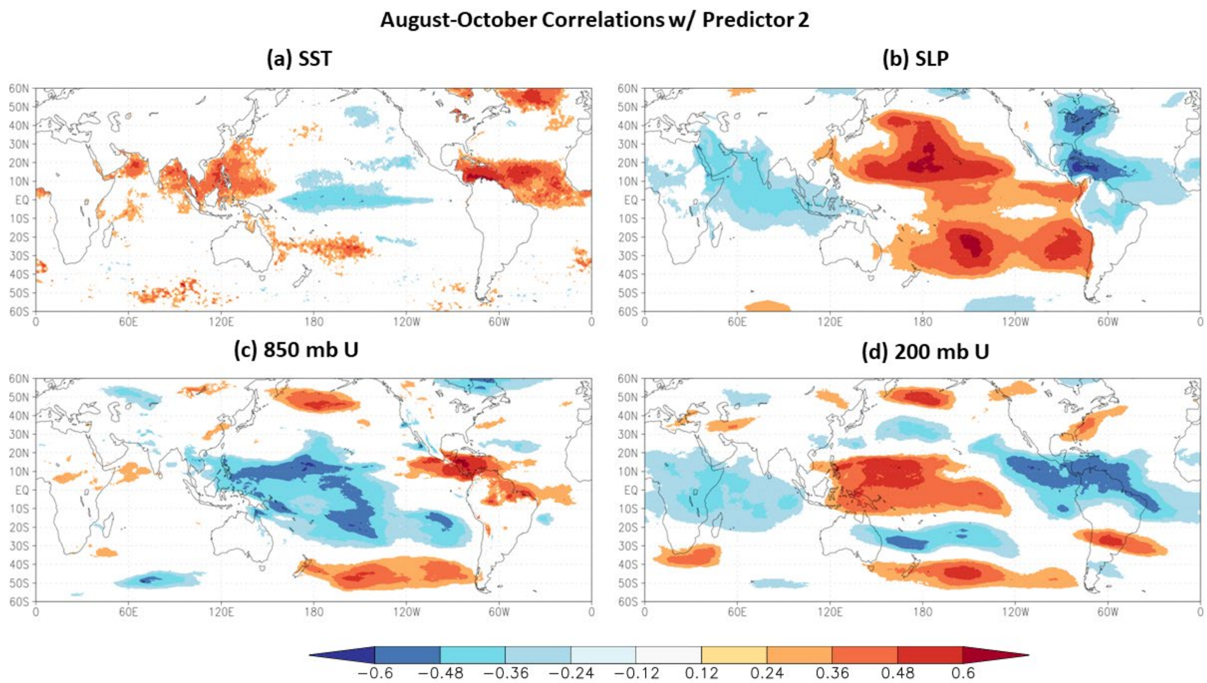

Figure 5: As in Figure 4 but for June SST in the Atlantic Main Development Region.

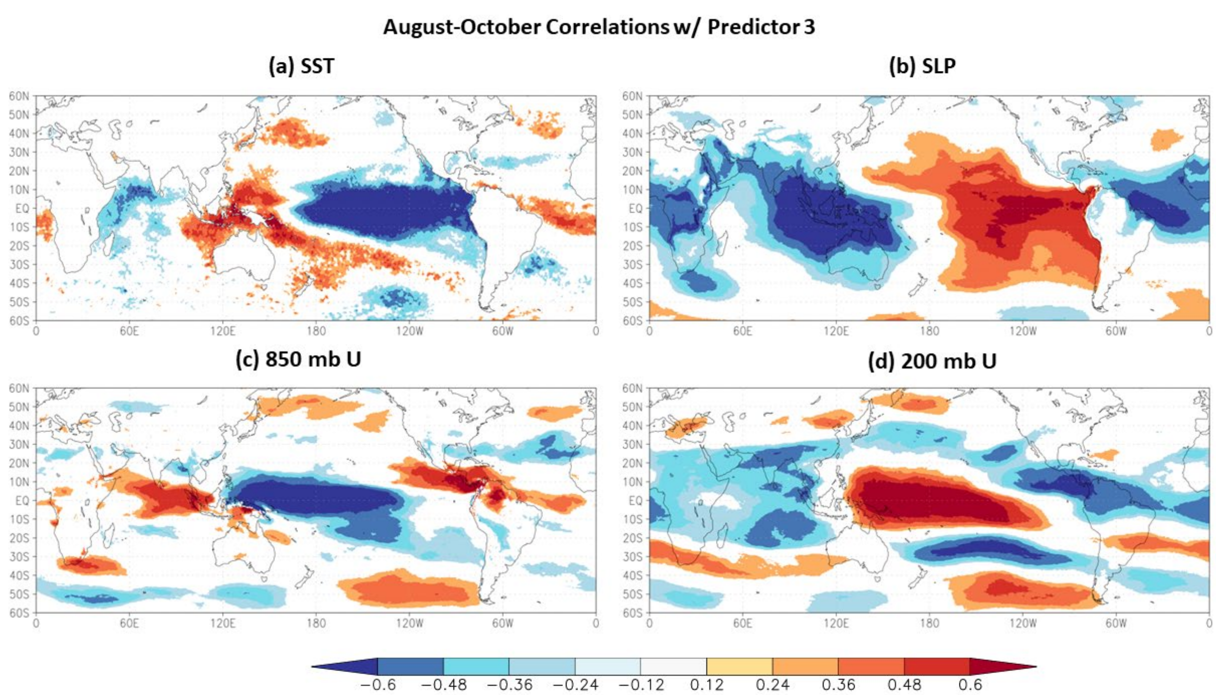

Figure 6: As in Figure 5 but for June SST in the tropical eastern and central Pacific. The sign of the predictor has been reversed for ease of comparison with Figures 4 and 5.

2.2 July Statistical/Dynamical Forecast Schemes

We developed a statistical/dynamical hybrid forecast model scheme that we used for the first time in 2019. This model, developed in partnership with Louis-Philippe Caron and the data team at the Barcelona Supercomputing Centre, originally used output from the ECMWF SEAS5 model to forecast the input to our early August statistical forecast model. We have modified our statistical/dynamical model and now use four different models: ECMWF, UK Met, JMA and CMCC. We evaluate model forecasts of August-September SSTs in the eastern/central equatorial Pacific and in the eastern/central North Atlantic. We then use the forecasts of these individual parameters to forecast ACE for the 2024 season. All other predictands (e.g., named storms, major hurricanes) are calculated based on their historical relationships with ACE. We note that the UK Met Office, JMA and CPCC have shorter hindcasts available on the Copernicus website (the website where we download our climate model forecasts).

Via the Copernicus website, ECMWF climate model output data are available on the 6th of the month, while all other climate model data are available on the 10th of the month. Given that this forecast is released on 9 July, the results displayed here are from the July ECMWF model output and from a June forecast for all other models discussed herein.

a) ECMWF Statistical/Dynamical Model Forecast

Figure 7 displays the locations of the two forecast parameters, while Table 4 displays ECMWF's forecasts of these parameters for 2024 from a 1 July initialization date. The ECMWF model is predicting the second warmest (trailing 2023) eastern/central North Atlantic on record (since 1981) and near-average SSTs in the normal eastern/central tropical Pacific. The extreme warmth that is predicted for the eastern/central North Atlantic results in an extremely active forecast from this model. Figure 8 displays cross-validated hindcasts of ECMWF hindcasts of ACE from 1981–2023, while Table 5 presents the forecast from ECMWF for the 2024 Atlantic hurricane season.

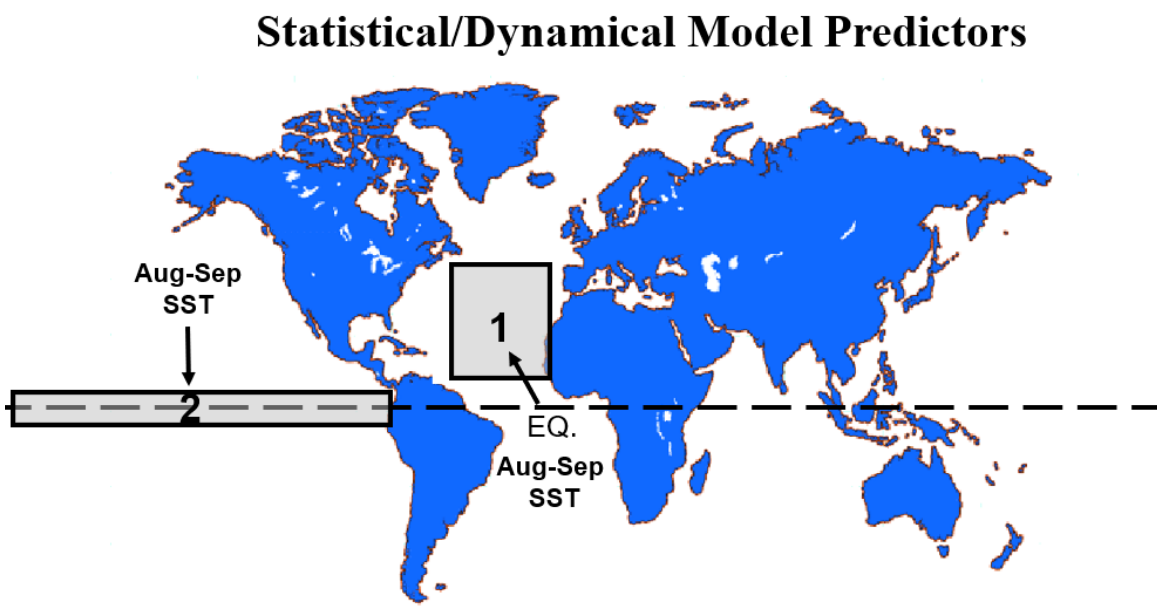

Figure 7: Location of predictors for our statistical/dynamical extended-range statistical prediction for the 2024 hurricane season. This forecast uses dynamical model predictions from ECMWF, the UK Met Office, JMA and CMCC to predict August–September conditions in the two boxes displayed and uses those predictors to forecast ACE.

Table 4: Listing of predictions of August–September large-scale conditions from ECMWF model output, initialized on 1 July. A plus (+) means that positive deviations of the parameter are associated with increased hurricane activity, while a minus (-) means that negative deviations of the parameter are associated with increased hurricane activity.

Predictor	Values for 2024 Forecast	Effect on 2024 Hurricane Season
1) ECMWF Prediction of Aug-Sep SST (10–45°N, 60–20°W) (+)	+3.9 SD	Strongly Enhance
2) ECMWF Prediction of Aug-Sep SST (5°S–5°N, 180–90°W) (-)	0.0 SD	Neutral

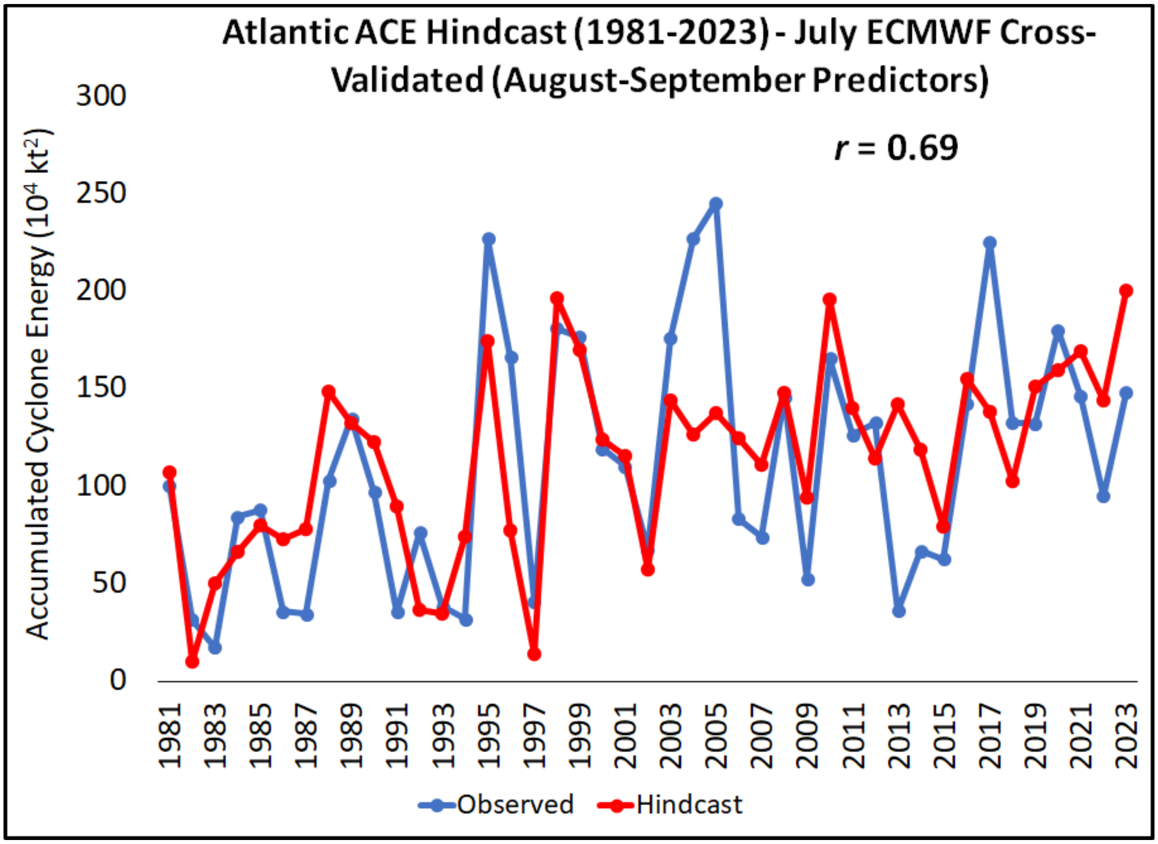

Figure 8: Observed versus cross-validated statistical/dynamical hindcast values of ACE for 1981–2023 from ECMWF.

Table 5: Statistical/dynamical model output from ECMWF for the 2024 Atlantic hurricane season and the final adjusted forecast.

Forecast Parameter and 1991–2020 Average (in parentheses)	ECMWF Hybrid Forecast	Final Forecast
Named Storms (14.4)	23.6	25
Named Storm Days (69.4)	122.0	125
Hurricanes (7.2)	12.7	12
Hurricane Days (27.0)	55.7	50
Major Hurricanes (3.2)	6.5	6
Major Hurricane Days (7.4)	17.7	16
Accumulated Cyclone Energy Index (123)	248	230
Net Tropical Cyclone Activity (135%)	262	240

b) UK Met Office Statistical/Dynamical Model Forecast

Table 6 displays the UK Met Office forecast of the August-September parameters for 2024 from a 1 June initialization date. The UK Met Office is calling for cool neutral/weak La Niña conditions and an extremely warm central/eastern North Atlantic on record. Figure 9 displays hindcasts for the UK Met Office of ACE from 1993–2016, while Table 7 presents the forecast from the UK Met Office for the 2024 Atlantic hurricane season. We note that the UK Met Office, JMA and CPCC have shorter hindcasts available on the Copernicus website (the website where we download our climate model forecasts). Like ECMWF, the Met Office statistical/dynamical model is calling for an extremely active season.

Table 6: Listing of predictions of August-September large-scale conditions from UK Met model output, initialized on 1 June. A plus (+) means that positive deviations of the parameter are associated with increased hurricane activity, while a minus (-) means that negative deviations of the parameter are associated with increased hurricane activity.

Predictor	Values for 2024 Forecast	Effect on 2024 Hurricane Season
1) UK Met Prediction of Aug-Sep SST (10–45°N, 60–20°W) (+)	+4.5 SD	Strongly Enhance
2) UK Met Prediction of Aug-Sep SST (5°S–5°N, 180–90°W) (-)	-0.8 SD	Enhance

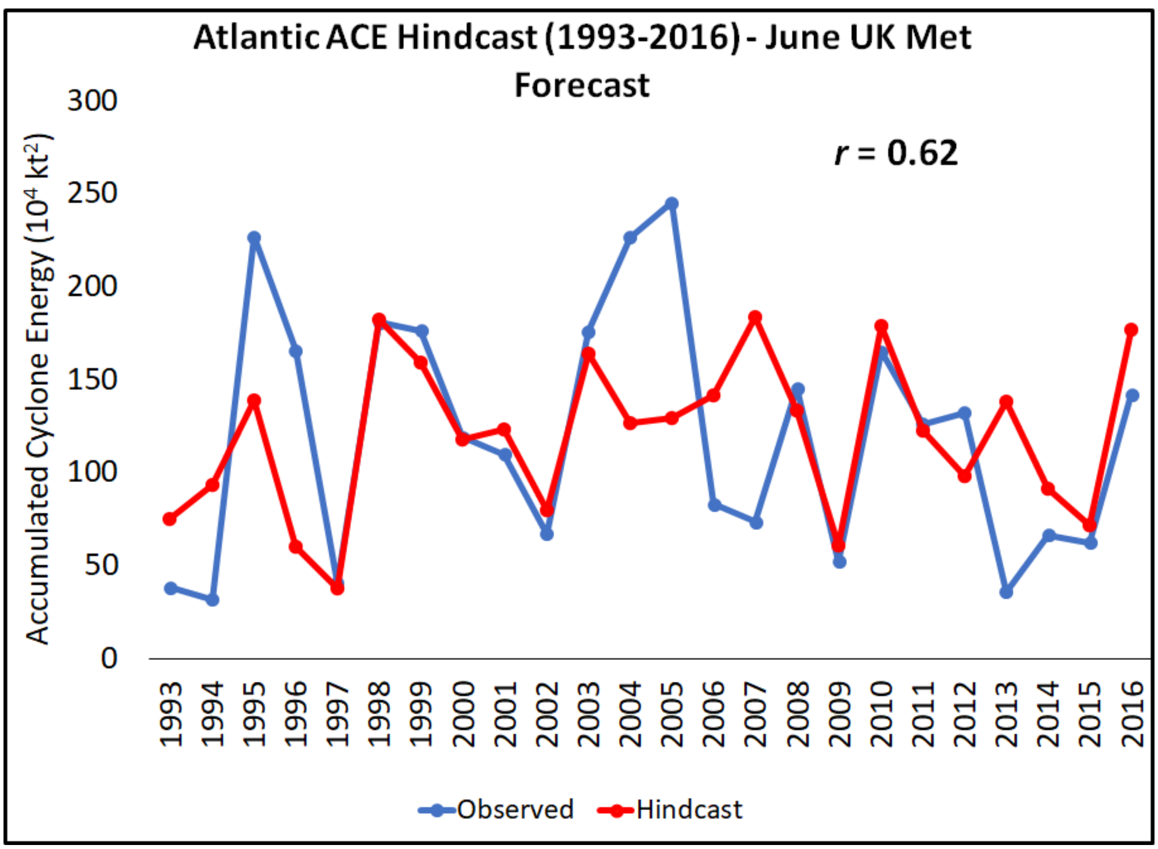

Figure 9: Observed versus statistical/dynamical hindcast values of ACE for 1993–2016 from the UK Met Office.

Table 7: Statistical/dynamical model output from the UK Met Office for the 2024 Atlantic hurricane season and the final adjusted forecast.

Forecast Parameter and 1991–2020 Average (in parentheses)	Met Office Hybrid Forecast	Final Forecast
Named Storms (14.4)	24.1	25
Named Storm Days (69.4)	124.9	125
Hurricanes (7.2)	13.0	12
Hurricane Days (27.0)	57.2	50
Major Hurricanes (3.2)	6.7	6
Major Hurricane Days (7.4)	18.3	16
Accumulated Cyclone Energy Index (123)	255	230
Net Tropical Cyclone Activity (135%)	269	240

c) JMA Met Office Statistical/Dynamical Model Forecast

Table 8 displays the JMA forecasts of the August–September parameters for 2024 from a 1 June initialization date. The ensemble average of the JMA seasonal forecast is calling for an extremely warm North Atlantic as well as a weak La Niña. Figure 9 displays JMA hindcasts of ACE from 1993–2016, while Table 9 presents the forecast from the JMA for the 2024 Atlantic hurricane season. The statistical/dynamical model based off JMA is calling for an extremely active season.

Table 8: Listing of predictions of August-September large-scale conditions from JMA model output, initialized on 1 June. A plus (+) means that positive deviations of the parameter are associated with increased hurricane activity, while a minus (-) means that negative deviations of the parameter are associated with increased hurricane activity.

Predictor	Values for 2024 Forecast	Effect on 2024 Hurricane Season
1) JMA Prediction of Aug-Sep SST (10–45°N, 60–20°W) (+)	+3.8 SD	Strongly Enhance
2) JMA Prediction of Aug-Sep SST (5°S–5°N, 180–90°W) (-)	-0.7 SD	Enhance

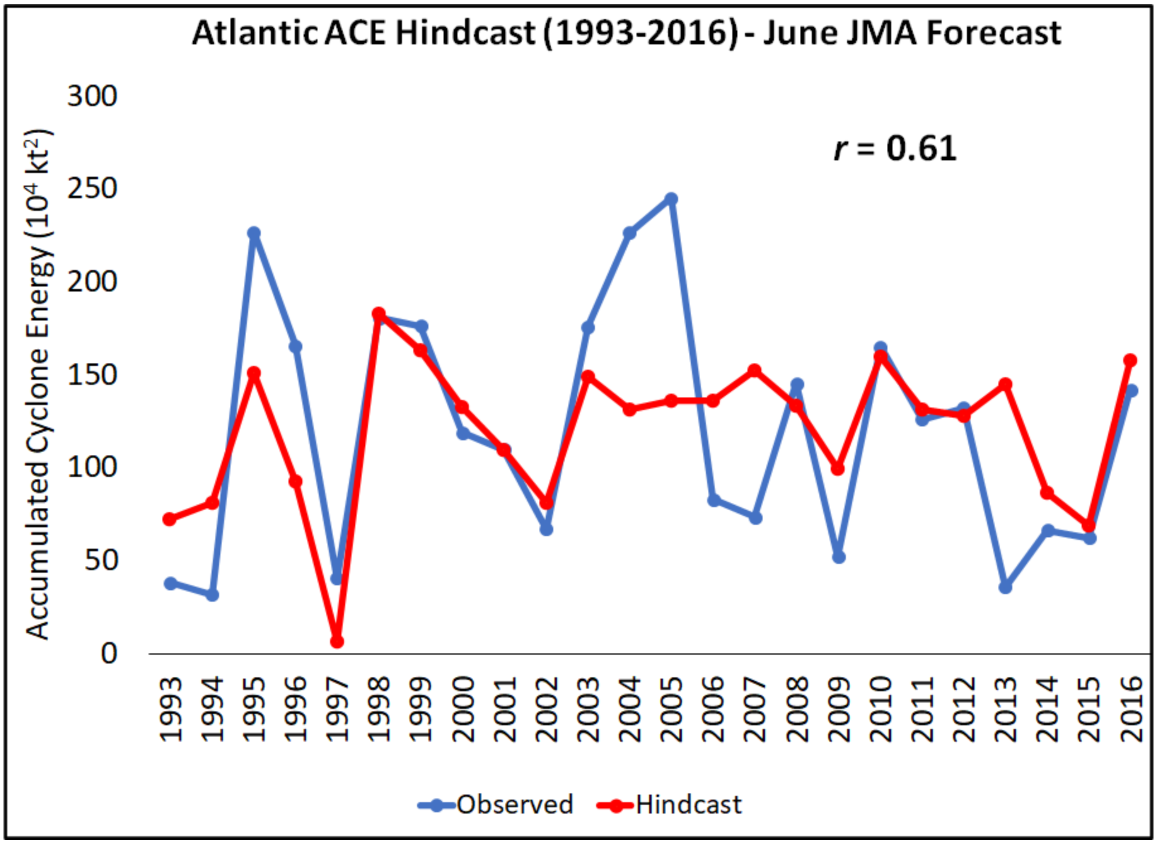

Figure 10: Observed versus statistical/dynamical hindcast values of ACE for 1993–2016 from the JMA.

Table 9: Statistical/dynamical model output from the JMA for the 2024 Atlantic hurricane season and the final adjusted forecast.

Forecast Parameter and 1991–2020 Average (in parentheses)	JMA Hybrid Forecast	Final Forecast
Named Storms (14.4)	22.3	25
Named Storm Days (69.4)	113.2	125
Hurricanes (7.2)	11.8	12
Hurricane Days (27.0)	50.8	50
Major Hurricanes (3.2)	5.9	6
Major Hurricane Days (7.4)	16.0	16
Accumulated Cyclone Energy Index (123)	227	230
Net Tropical Cyclone Activity (135%)	241	240

d) CMCC Statistical/Dynamical Model Forecast

Table 10 displays the CMCC forecasts of the August–September parameters for 2024 from a 1 June initialization date. The ensemble average of the CMCC seasonal forecast is calling for an extremely warm North Atlantic as well as cool neutral ENSO/weak La Niña. Figure 10 displays hindcasts for the CMCC of ACE from 1993–

2016, while Table 11 presents the forecast from the CMCC for the 2024 Atlantic hurricane season. The statistical/dynamical model based off of CMCC is calling for a hyperactive 2024 Atlantic hurricane season.

Table 10: Listing of predictions of August-September large-scale conditions from CMCC model output, initialized on 1 June. A plus (+) means that positive deviations of the parameter are associated with increased hurricane activity, while a minus (-) means that negative deviations of the parameter are associated with increased hurricane activity.

Predictor	Values for 2024 Forecast	Effect on 2024 Hurricane Season
1) CMCC Prediction of Aug-Sep SST (10–45°N, 60–20°W) (+)	+4.3 SD	Strongly Enhance
2) CMCC Prediction of Aug-Sep SST (5°S–5°N, 180–90°W) (-)	-0.6 SD	Enhance

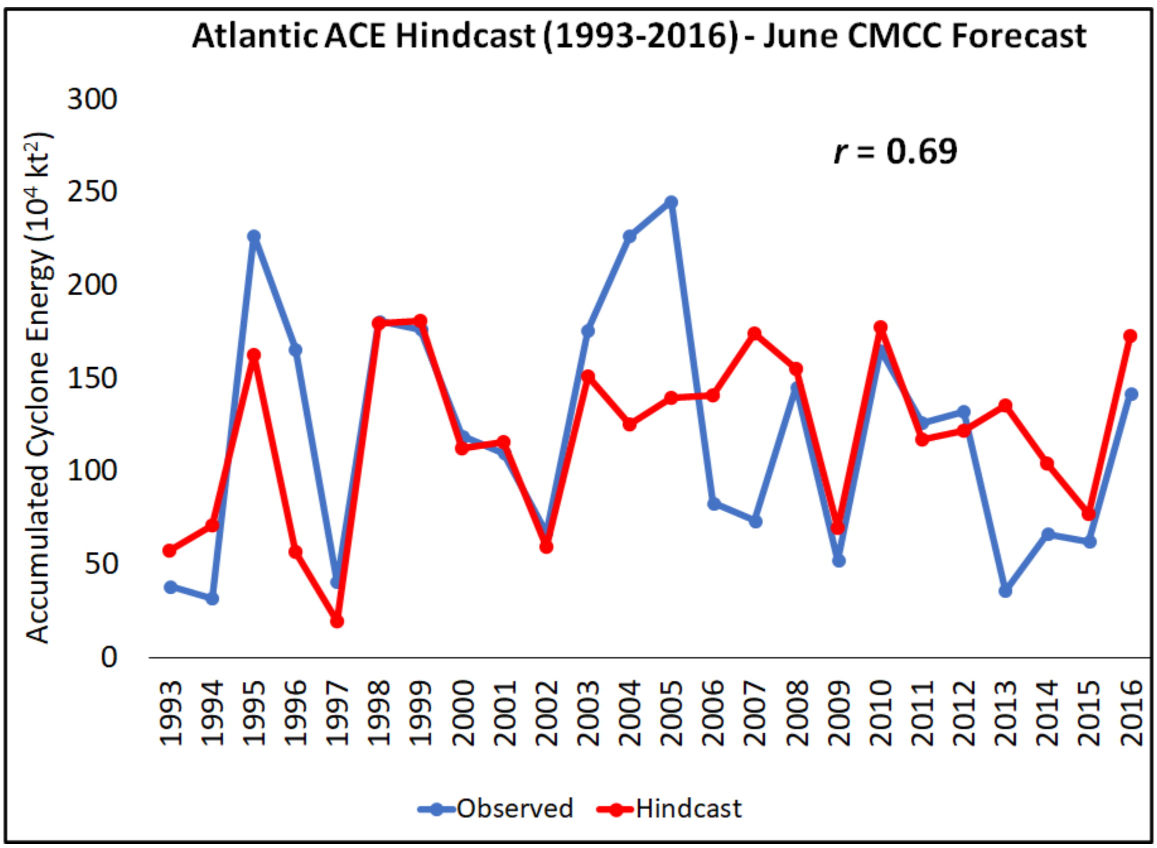

Figure 11: Observed versus statistical/dynamical hindcast values of ACE for 1993–2016 from the CMCC.

Table 11: Statistical/dynamical model output from the CMCC for the 2024 Atlantic hurricane season and the final adjusted forecast.

Forecast Parameter and 1991–2020 Average (in parentheses)	CMCC Hybrid Forecast	Final Forecast
Named Storms (14.4)	24.5	25
Named Storm Days (69.4)	128.3	125
Hurricanes (7.2)	13.3	12
Hurricane Days (27.0)	59.1	50
Major Hurricanes (3.2)	6.9	6
Major Hurricane Days (7.4)	19.0	16
Accumulated Cyclone Energy Index (123)	263	230
Net Tropical Cyclone Activity (135%)	277	240

2.3 July Analog Forecast Scheme

Certain years in the historical record have global oceanic and atmospheric patterns and trends which resemble 2024. These years also provide useful clues as to likely levels of activity that the forthcoming 2024 hurricane season may bring. For this early July forecast, we determine which of the prior years in our database have distinct trends in key environmental conditions which are similar to current early July 2024 conditions and, more importantly, projected August–October 2024 conditions. Table 12 lists our analog selections, while Figure 12 shows the composite August–October SST in our seven analog years. Selecting analogs for this season poses an additional challenge in that we have not observed an Atlantic this warm in the historical record without El Niño conditions. Last year had a similarly extremely warm Atlantic but also had a strong El Niño.

We searched for years that were generally characterized by El Niño conditions the previous winter and had La Niña conditions during the peak of the Atlantic hurricane season (August–October). We also selected years that had above-average SSTs relative to their long-term averages in the tropical Atlantic, although none of these years had SSTs in the tropical Atlantic in early July that were as warm as they are now. We also selected several years that were characterized by very busy starts to the season, such as 1886, 1933 and 2005. We anticipate that the 2024 hurricane season will have activity near the average of our seven analog years for most parameters. The busy hurricane seasons in all analog years underscore the higher-than-normal confidence in an active 2024 hurricane season. Named storm activity was likely significantly underestimated in 1886, 1926 and 1933, given the extremely limited observational network available in those years.

Table 12: Analog years for 2024 with the associated hurricane activity listed for each year.

Year	NS	NSD	H	HD	MH	MHD	ACE	NTC
1886	12	84.25	10	49.50	4	4.50	166.2	155.3
1926	11	86.75	8	58.50	6	22.75	229.6	230.3
1933	20	125.25	11	57.00	6	21.75	258.6	263.1
1995	19	120.50	11	60.25	5	11.75	227.4	221.3
2005	28	126.25	15	49.75	7	17.50	245.3	276.7
2010	19	89.50	12	38.50	5	11.00	165.5	196.4
2020	30	122.75	14	35.25	7	8.25	180.4	235.5
Average	19.9	107.9	11.6	49.8	5.7	13.9	217.8	237.2
2024 Forecast	**25**	**125**	**12**	**50**	**6**	**16**	**230**	**240**

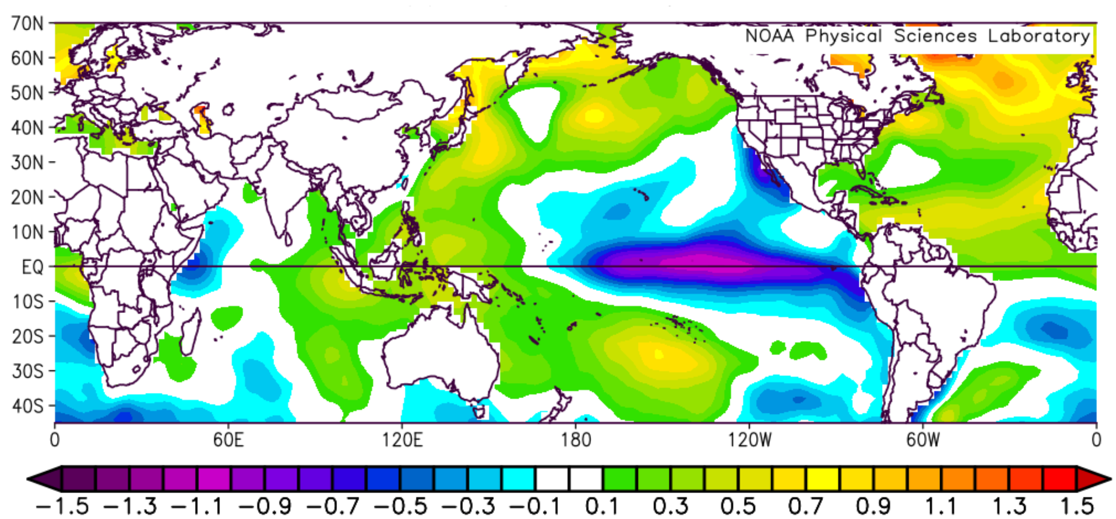

Figure 12: Average August–October SST anomalies in our seven analog years.

2.4 ACE West of 60°W Forecast

We now explicitly forecast ACE occurring west of 60°W. While there is a relatively robust relationship between basinwide ACE and North Atlantic landfalling hurricanes (defined as hurricanes making landfall west of 60°W), there is an improved relationship between North Atlantic landfalling hurricanes and ACE west of 60°W (Figures 13 and 14) since 1950.

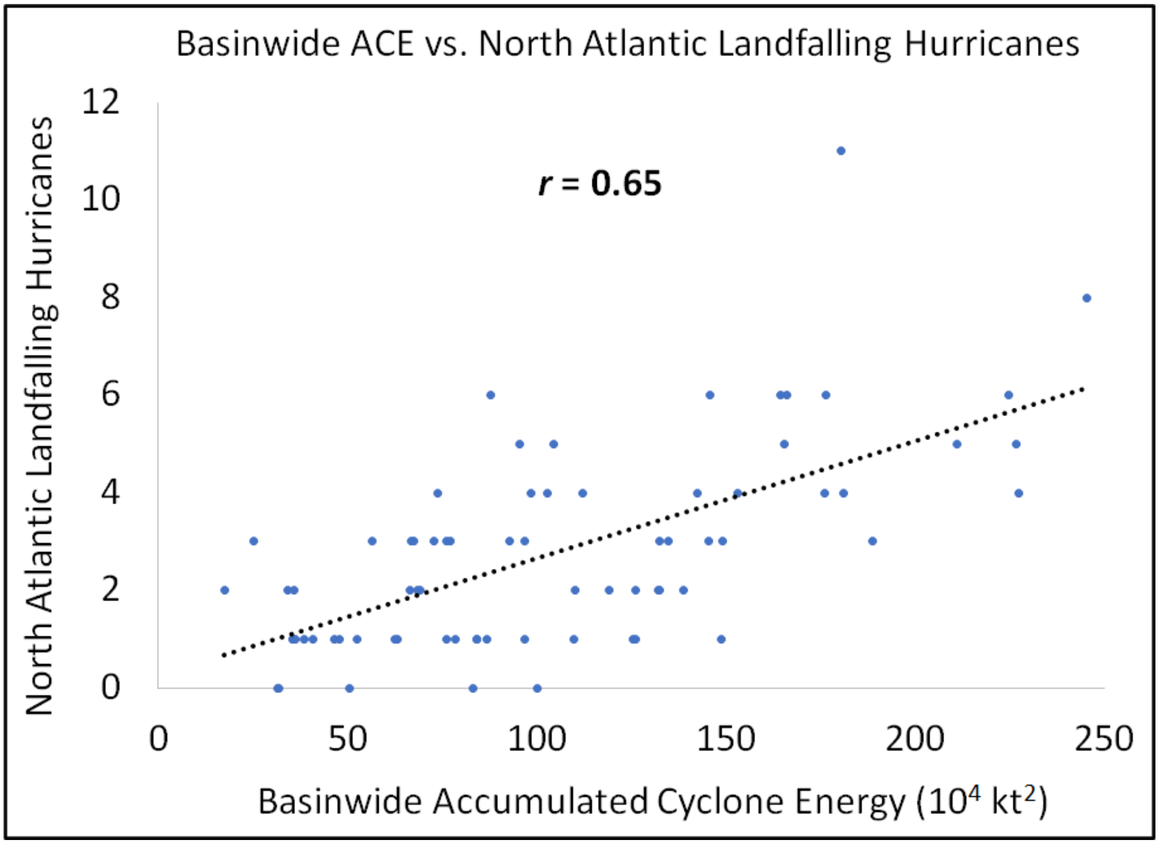

Figure 13: Scatterplot showing relationship between basinwide ACE and North Atlantic landfalling hurricanes.

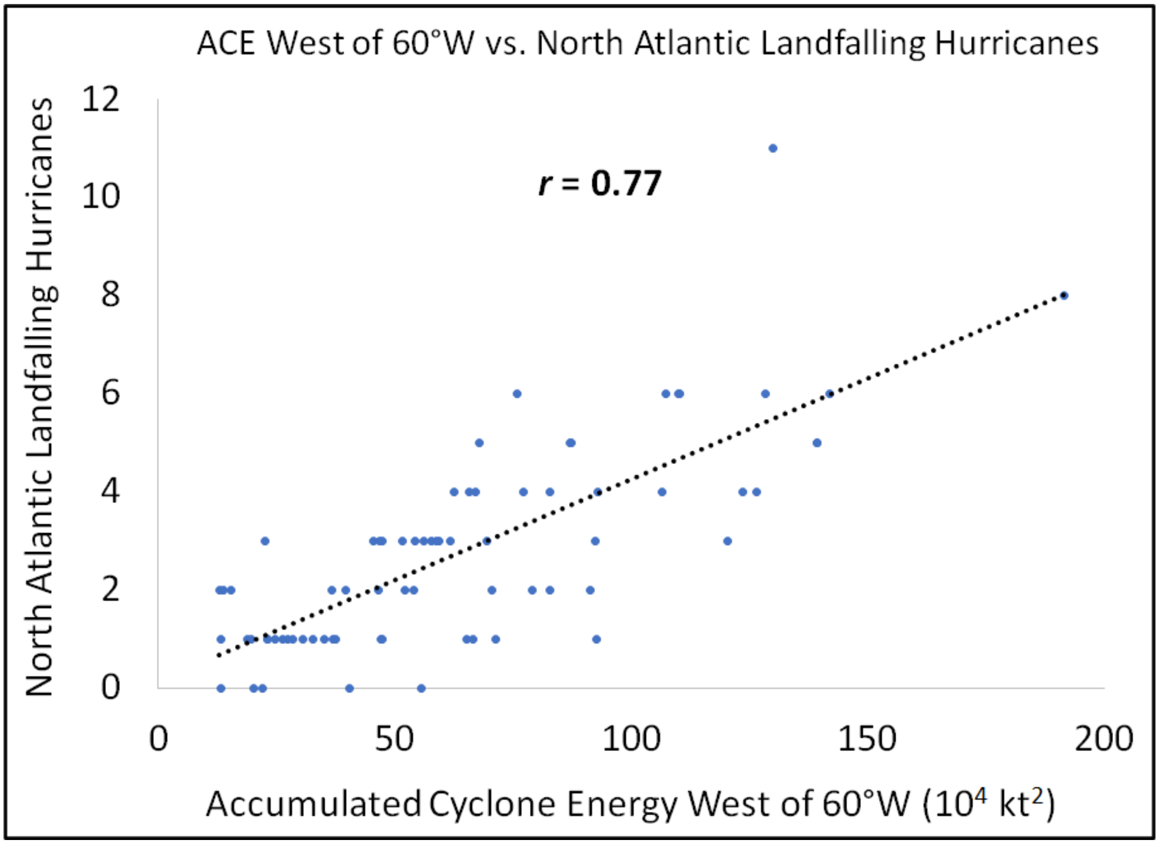

Figure 14: Scatterplot showing relationship between ACE west of 60°W and North Atlantic landfalling hurricanes.

In general, years characterized by El Niño conditions tend to have slightly less ACE west of 60°W than La Niña seasons, likely due to both more conducive conditions in the western Atlantic in La Niña seasons, as well as an increased chance of recurvature for TCs in El Niño seasons (Colbert and Soden 2012). This was certainly the case in 2023. A strong El Niño occurred, the subtropical high was quite weak, and many of the TCs that occurred recurved east of 60°W. Caribbean TC activity was also suppressed last year.

We use data from 1979–2023 and base ENSO classifications on the August–October-averaged Oceanic Nino Index (ONI). Years with an ONI >= 0.5°C were classified as El Niño, years with an ONI <= -0.5°C were classified as La Niña, while all other seasons were classified as neutral ENSO.

We find that 51% of basinwide ACE occurred west of 60°W in El Niño years, while 60% of basinwide ACE occurred west of 60°W in La Niña years (Figure 15). In neutral ENSO years, 59% of basinwide ACE occurred west of 60°W. Given that we are favoring La Niña with this outlook, we are estimating ~60% of basinwide ACE to occur west of 60°W in 2024.

Hurricane Beryl is an excellent example of why ACE west of 60°W is an important metric. Beryl generated ~28 ACE west of 60°W and caused considerable damage in the Caribbean, Mexico and Texas.

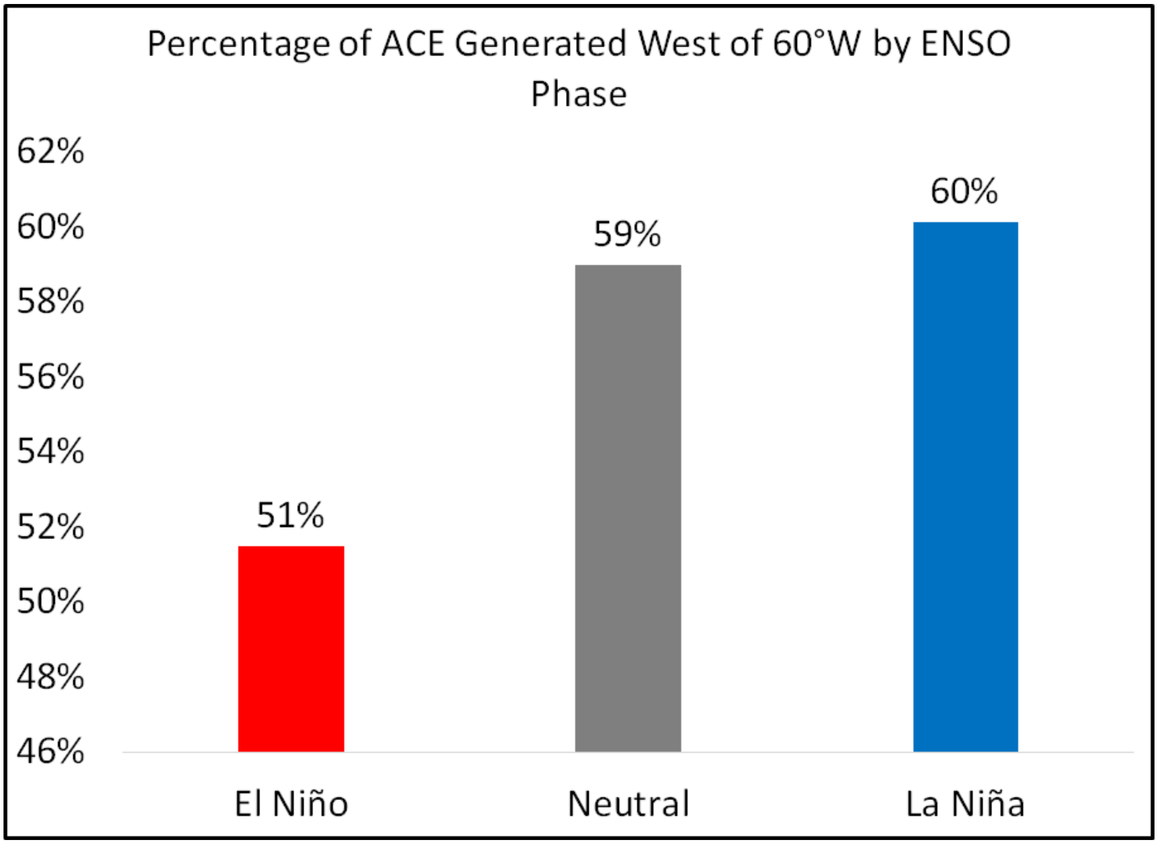

Figure 15: Percentage of ACE generated west of 60°W by ENSO phase.

2.5 July Forecast Summary and Final Adjusted Forecast

Table 13 shows our final adjusted early July forecast for the 2024 season which is a combination of our statistical scheme, our statistical/dynamical schemes, our analog scheme and qualitative adjustments for other factors not explicitly contained in any of these schemes. The various forecast models all predict a hyperactive Atlantic hurricane season. While there remains uncertainty with any seasonal hurricane forecast issued in early July, the confidence in our prediction is higher than normal for an early July outlook.

Table 13: Summary of our early July statistical forecast, our statistical/dynamical forecasts, our analog forecast, the average of these six schemes and our adjusted final forecast for the 2024 hurricane season.

Forecast Parameter and 1991–2020 Average (in parentheses)	Statistical Scheme	ECMWF Scheme	Met Office Scheme	JMA Scheme	CMCC Scheme	Analog Scheme	6-Scheme Average	Adjusted Final Forecast
Named Storms (14.4)	20.7	23.6	24.1	22.3	24.5	19.1	22.4	25
Named Storm Days (69.4)	102.3	122.0	124.9	113.2	128.3	104.0	115.8	120
Hurricanes (7.2)	10.6	12.7	13.0	11.8	13.3	11.4	12.1	12
Hurricane Days (27.0)	44.9	55.7	57.2	50.8	59.1	48.3	52.7	50
Major Hurricanes (3.2)	5.3	6.5	6.7	5.9	6.9	5.1	6.1	6
Major Hurricane Days (7.4)	13.9	17.7	18.3	16.0	19.0	14.4	16.6	15
Accumulated Cyclone Energy Index (123)	201	248	255	227	263	206	233	230
Net Tropical Cyclone Activity (135%)	215	262	269	241	277	219	247	240

3 Forecast Uncertainty

This season we continue to use probability of exceedance curves as discussed in Saunders et al. (2020) to quantify forecast uncertainty. In that paper, we outlined an approach that uses statistical modeling and historical skill of various forecast models to arrive at a probability that specific values for hurricane numbers and ACE would be exceeded. Here we display probability of exceedance curves for hurricanes and ACE (Figures 16 and 17), using the error distributions calculated from both normalized cross-validated statistical as well as the cross-validated statistical/dynamical hindcasts from SEAS5. Hurricane numbers are fit to a Poisson distribution, while ACE is fit to a Weibull distribution. Table 14 displays one standard deviation uncertainty ranges (~68% of all forecasts within this range). This uncertainty estimate is also very similar to the 70% uncertainty range that NOAA provides with its forecasts. We use Poisson distributions for all storm parameters (e.g., named storms, hurricanes and major hurricanes) while we use a Weibull distribution for all integrated parameters except for major hurricane days (e.g., named storm days, ACE, etc.). We use a Laplace distribution for major hurricane days. As noted earlier, we are more confident than normal for a July forecast given how robust our primary predictors are (e.g., likely cool neutral ENSO/La Niña, extremely warm Atlantic sea surface temperatures) for an active Atlantic hurricane season.

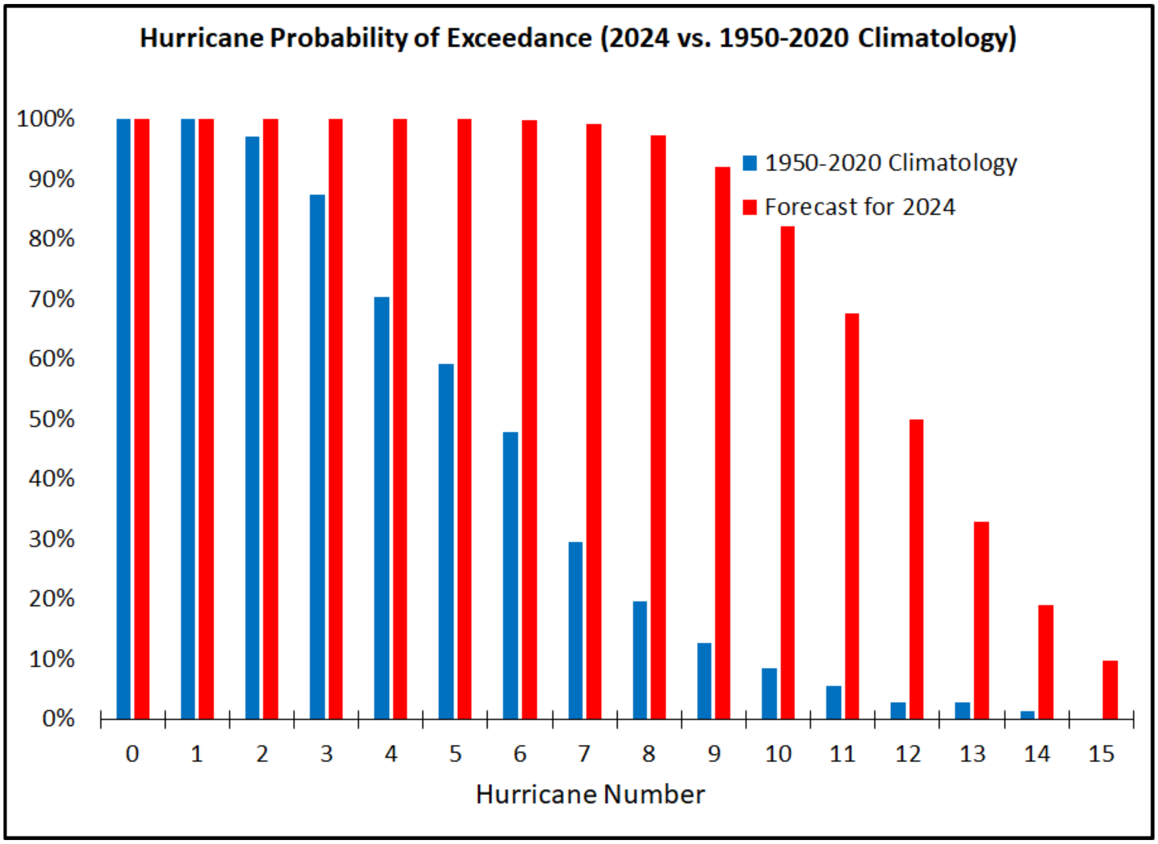

Figure 16: Probability of exceedance plot for hurricane numbers for the 2024 Atlantic hurricane season. The values on the x-axis indicate that the number of hurricanes exceeds that specific number. For example, 97% of Atlantic hurricane seasons from 1950–2020 have had more than two hurricanes.

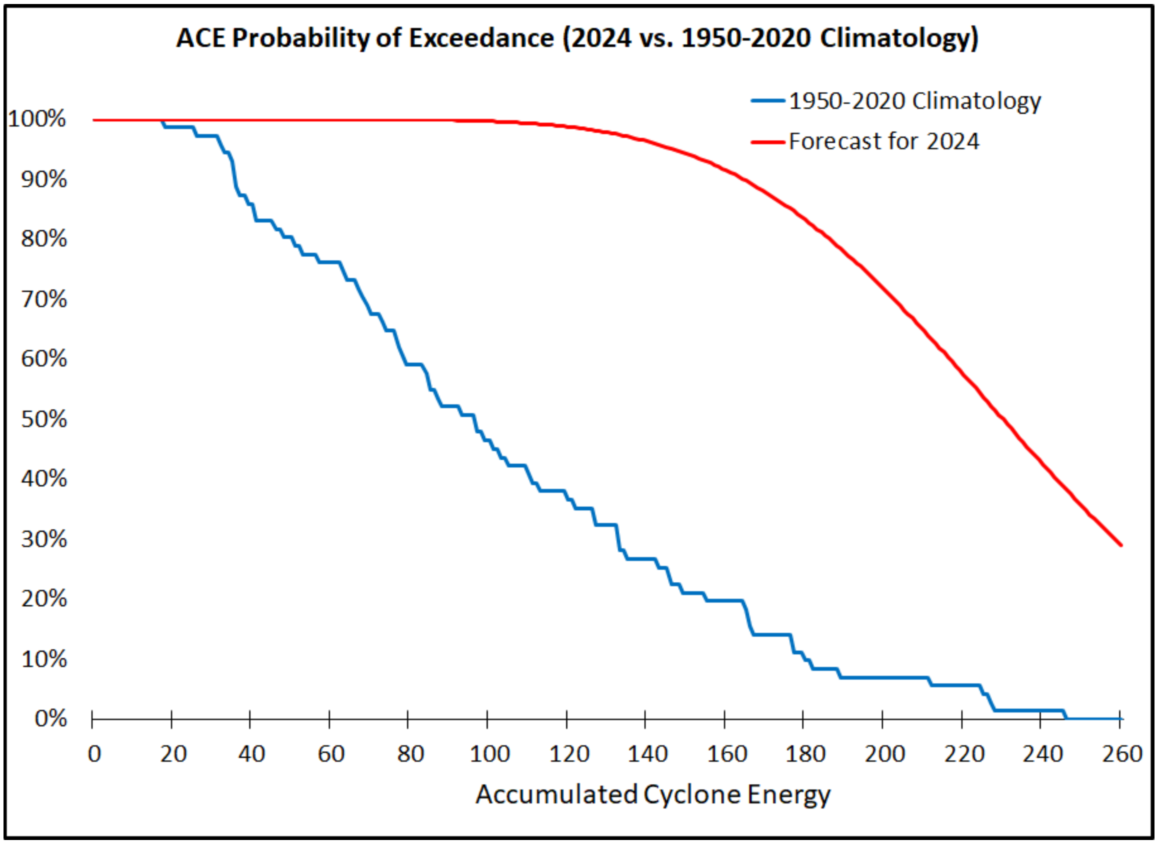

Figure 17: As in Figure 16 but for ACE.

Table 14: Forecast ranges for each parameter. Note that the forecast spread may not be symmetric around the mean value, given the historical distribution of tropical cyclone activity.

Parameter	2024 Forecast	Uncertainty Range (68% of Forecasts Likely to Fall in This Range)
Named Storms (NS)	25	22 – 28
Named Storm Days (NSD)	125	104 – 146
Hurricanes (H)	12	10 – 14
Hurricane Days (HD)	50	37 – 64
Major Hurricanes (MH)	6	4 – 7
Major Hurricane Days (MHD)	16	11 – 23
Accumulated Cyclone Energy (ACE)	230	176 – 280
ACE West of 60°W	140	101 – 183
Net Tropical Cyclone (NTC) Activity	240	190 – 285

4 ENSO

The tropical Pacific has generally shown little change in SST anomalies over the past few weeks (Figure 18). NOAA officially declared that El Niño dissipated in mid-June. Portions of the far eastern tropical Pacific now have SST anomalies <–0.5°C, while the central tropical Pacific SST anomalies remain near 0.5°C. The latest weekly SST in the Nino 3.4 region (5°S–5°N, 170–120°W) is 0.4°C, which is typical of neutral ENSO conditions (generally defined to be SSTs between –0.5°C and 0.5°C).

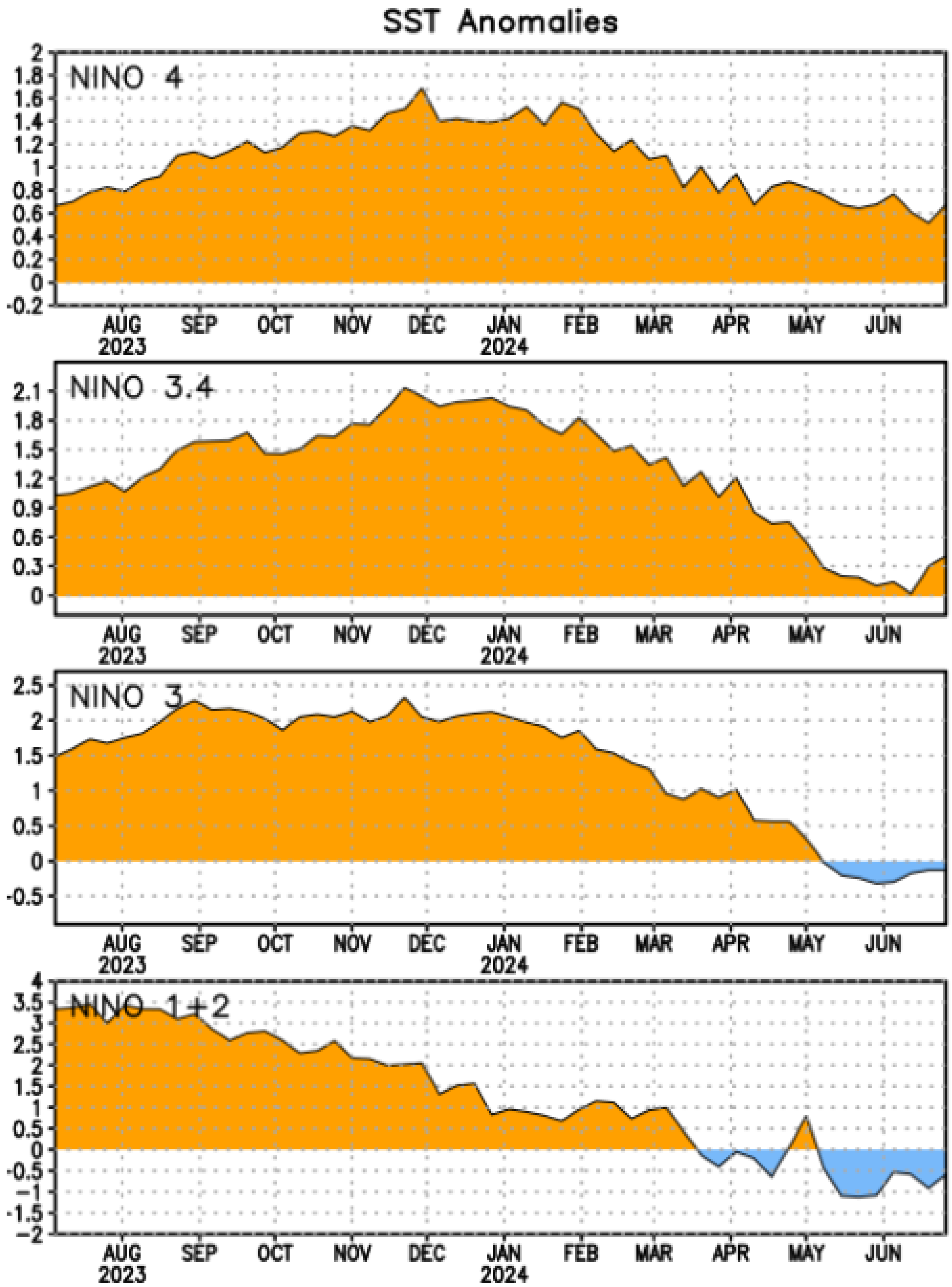

Figure 18: SST anomalies for several ENSO regions over the past year. Figure courtesy of Climate Prediction Center.

Upper-ocean heat content anomalies in the eastern and central tropical Pacific decreased through most of April and since have risen gradually (Figure 19). This increase in upper-ocean heat content anomalies is one reason why the trend towards La Niña is slower than we had earlier anticipated (Figure 20). Central Pacific trade winds have generally been near average over the past few weeks, which has likely inhibited this La Niña transition as well.

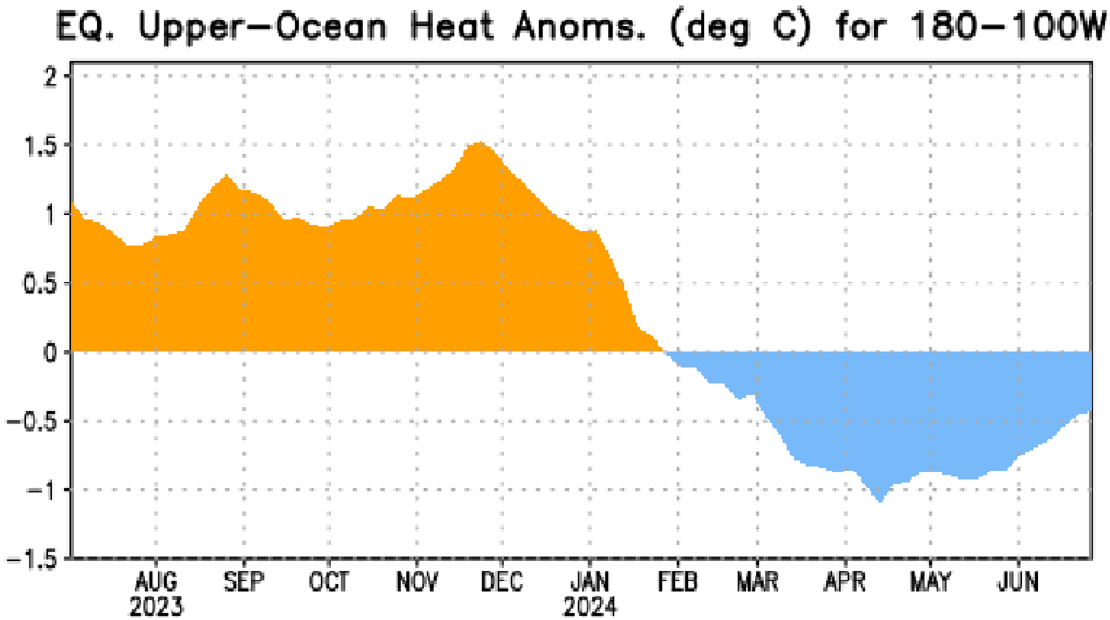

Figure 19: Central and eastern equatorial Pacific upper ocean (0-300 meters) heat content anomalies over the past year. Figure courtesy of Climate Prediction Center.

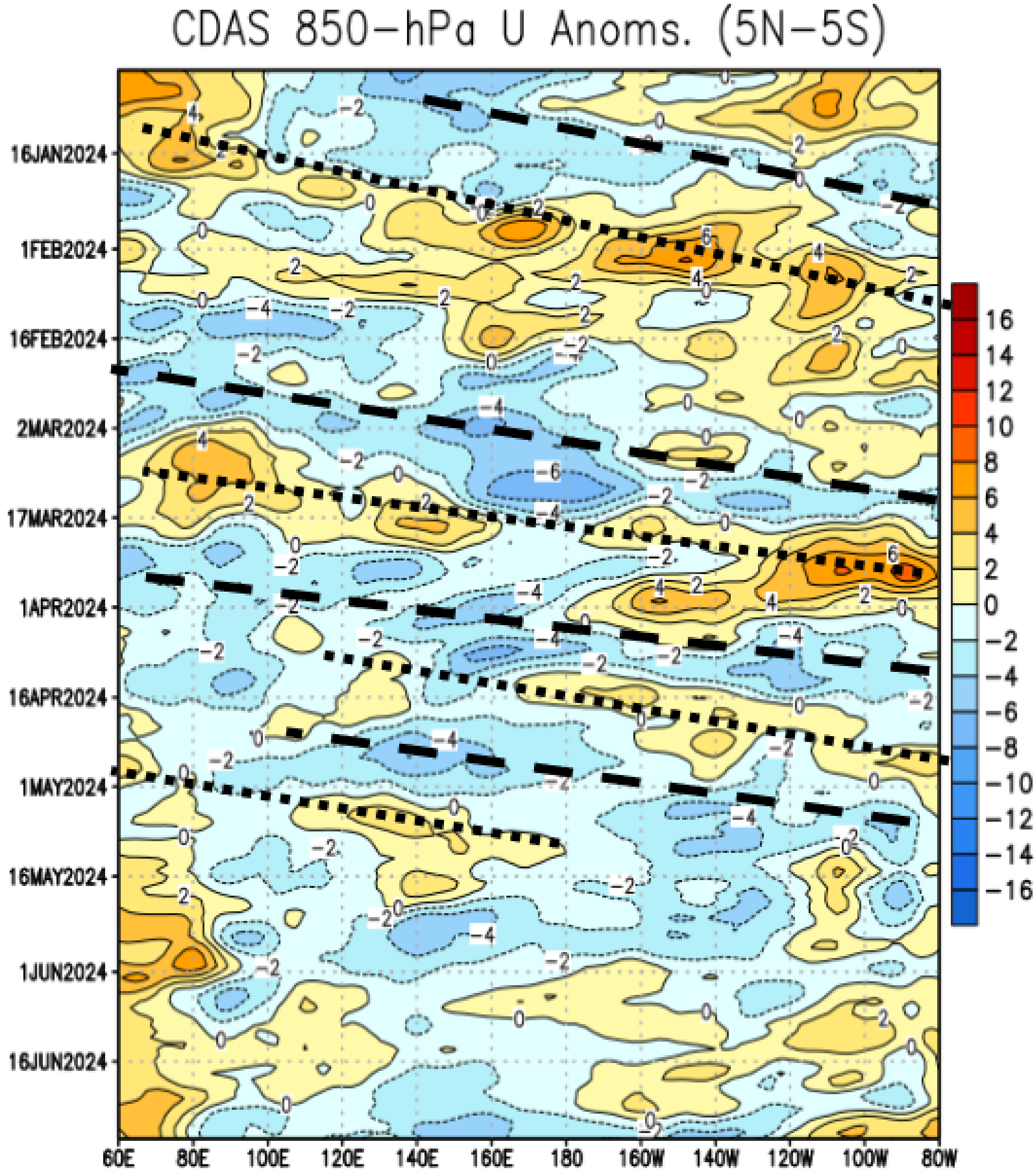

Figure 20: Anomalous equatorial low-level winds spanning from 60°E to 80°W. Figure courtesy of Climate Prediction Center.

SSTs are near average across most of the equatorial Pacific, with below-average SSTs in parts of the eastern tropical Pacific and above-average in the central tropical Pacific (Figure 21). The western North Pacific is warmer than normal, while the current spatial pattern of SSTs in the North Pacific (e.g., well above-average SST anomalies across most of the North Pacific and below-average SSTs off the west coast of California) are indicative of a strongly negative phase of the Pacific Decadal Oscillation. The June Pacific Decadal Oscillation index in 2024 is its lowest June value since 1890.

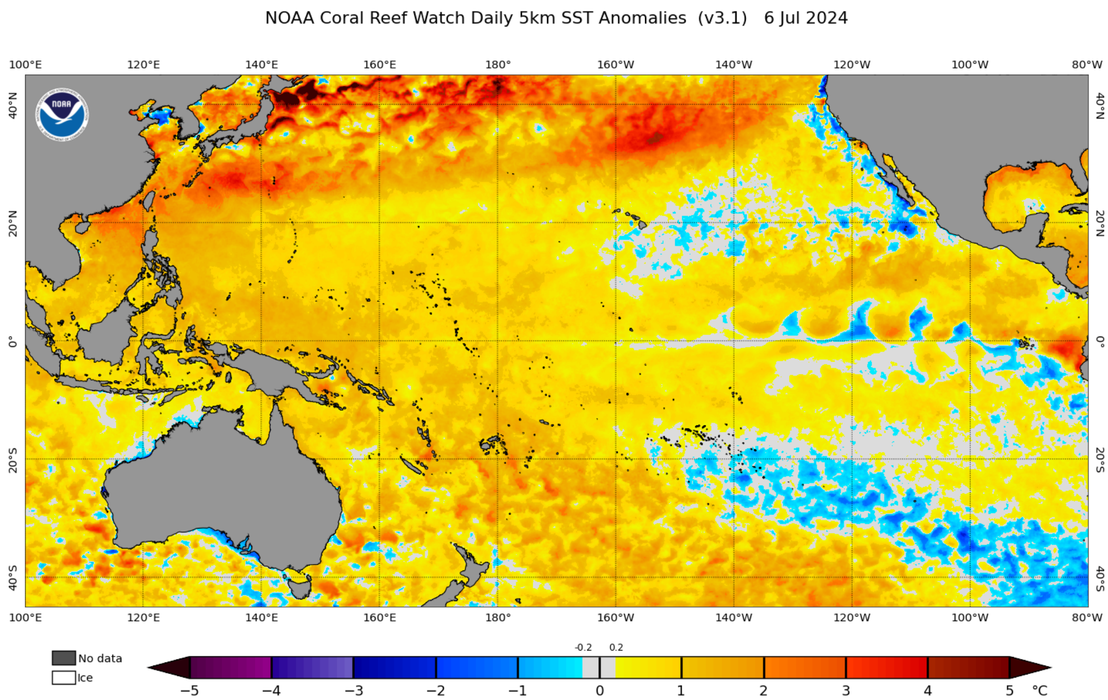

Figure 21: Current SST anomalies across the tropical and subtropical Pacific.

Table 15 displays May and June SST anomalies for several Nino regions. Over the past month, SST anomalies have shown little change across the tropical Pacific.

Table 15: May and June SST anomalies for Nino 1+2, Nino 3, Nino 3.4, and Nino 4, respectively. June-May SST anomaly differences are also provided.

Region	May SST Anomaly (°C)	June SST Anomaly (°C)	June – May SST Anomaly (°C)
Nino 1+2	–0.7	–0.7	0.0
Nino 3	0.0	–0.1	–0.1
Nino 3.4	0.3	0.2	–0.1
Nino 4	0.7	0.7	0.0

During the past month, any oceanic Kelvin wave activity has been weak, with NOAA last identifying a robust Kelvin wave reaching the South American coast in late May (Figure 22). This lack of robust Kelvin wave activity is likely due to the aforementioned average trade winds that have predominated across the central tropical Pacific in the past few weeks.

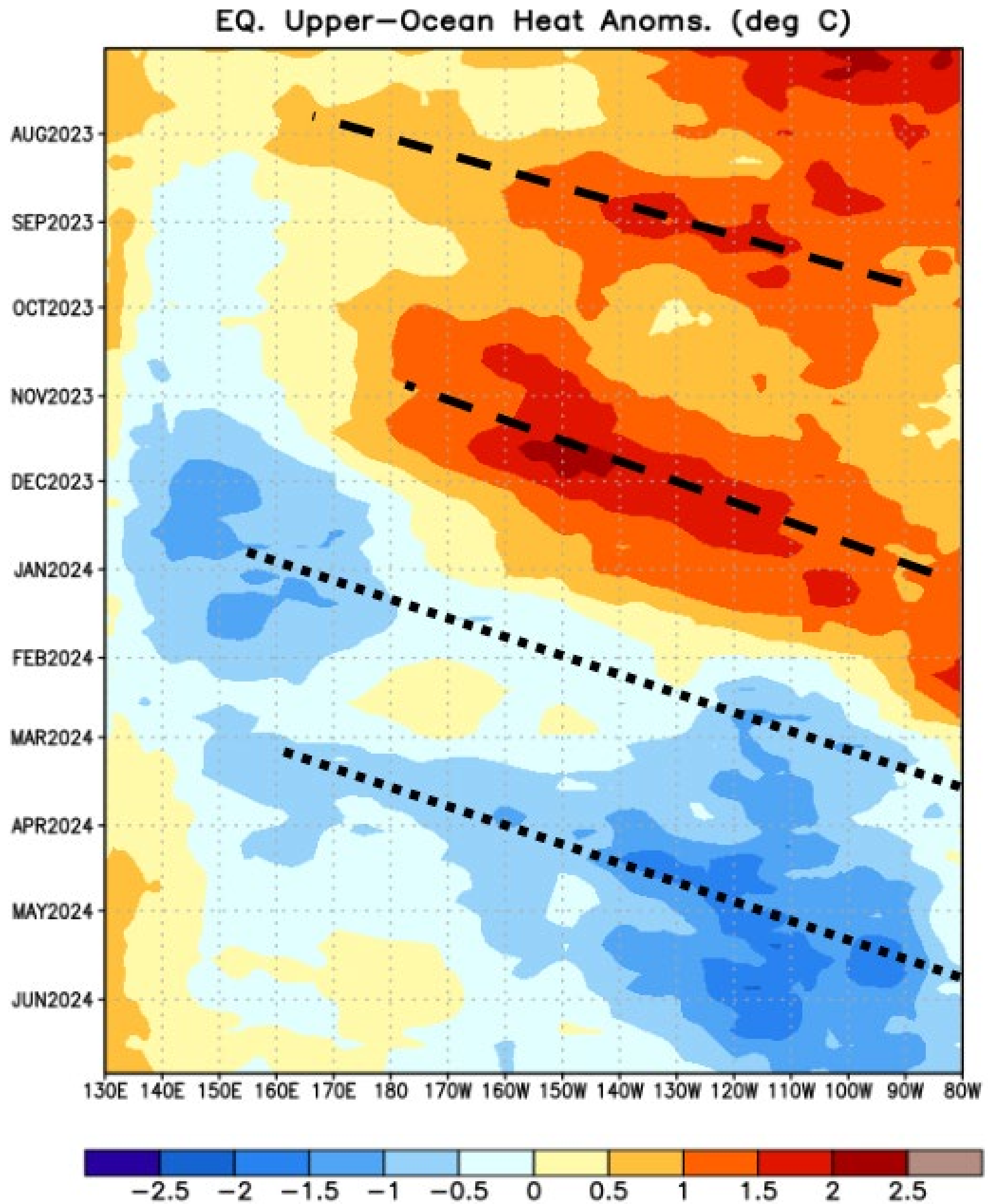

Figure 22: Upper-ocean heat content anomalies in the tropical Pacific since July 2023. Dashed lines indicate downwelling Kelvin waves, while dotted lines indicate upwelling Kelvin waves. Downwelling Kelvin waves result in upper-ocean heat content increases, while upwelling Kelvin waves result in upper-ocean heat content decreases. Figure courtesy of Climate Prediction Center.

Over the next few weeks, we will continue to closely monitor low-level winds over the tropical Pacific, as these winds will play an important role if we transition to La Niña conditions or remain in neutral ENSO conditions for the peak of the Atlantic hurricane season. The central tropical Pacific has experienced a trade wind surge in recent days, and SST anomalies have begun to cool in response. Trade winds are forecast to generally be anomalously strong over the next few weeks (Figure 23), which is why we think that La Niña is still favored for the peak of the Atlantic hurricane season (August–October).

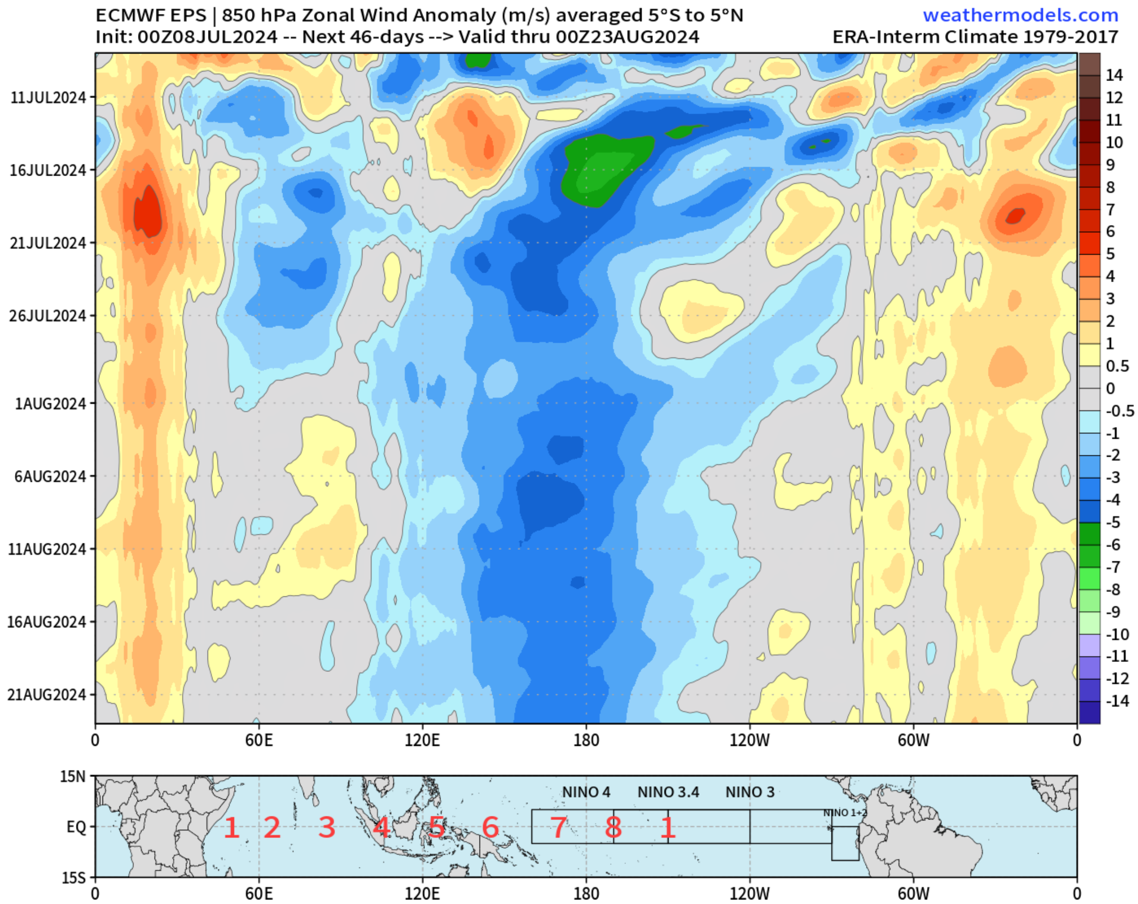

Figure 23: ECMWF forecast 850 hPa zonal equatorial winds for the next 46 days. Figure courtesy of weathermodels.com.

The latest plume of ENSO predictions from several statistical and dynamical models shows considerable spread by the peak of the Atlantic hurricane season in August–October (Figure 24), with about an even split between models forecasting ENSO neutral and La Niña conditions.

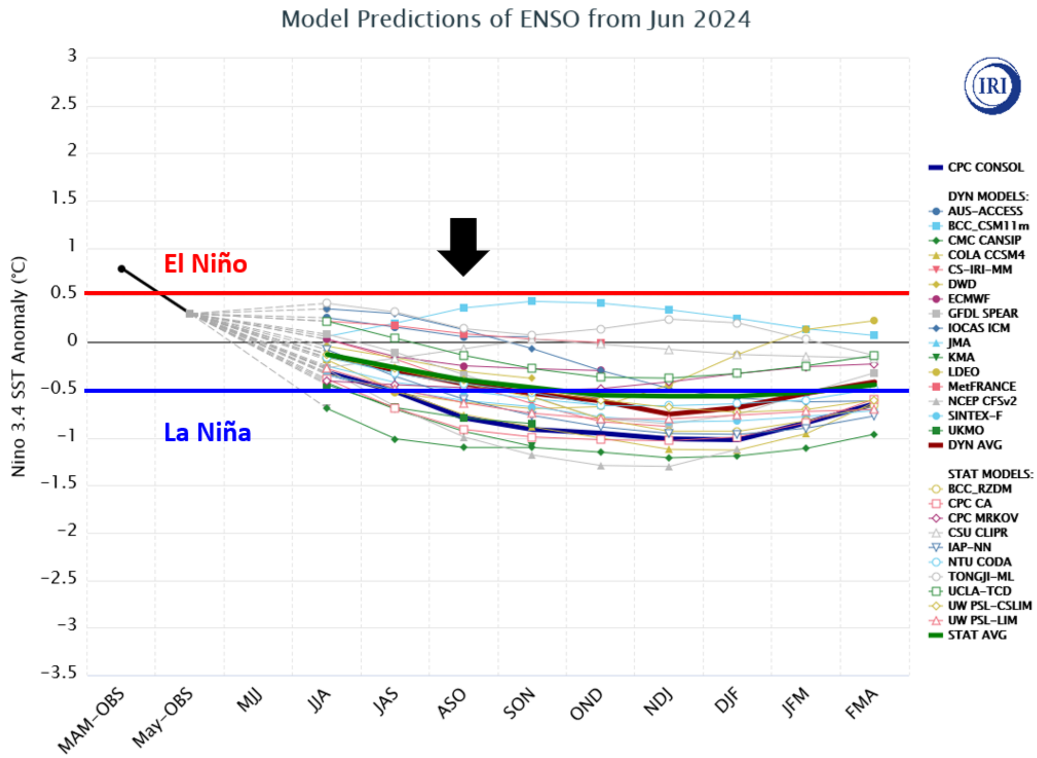

Figure 24: ENSO forecasts from various statistical and dynamical models for Nino 3.4 SST anomalies based on late May to early June initial conditions. Figure courtesy of the International Research Institute (IRI). The black arrow delineates the peak of the Atlantic hurricane season (August–October).

The latest official forecast from NOAA favors La Niña for August–October. NOAA is currently predicting a 75% chance of La Niña, a 24% chance of ENSO neutral conditions and a nominal 1% chance of El Niño for the peak of the Atlantic hurricane season (Figure 25).

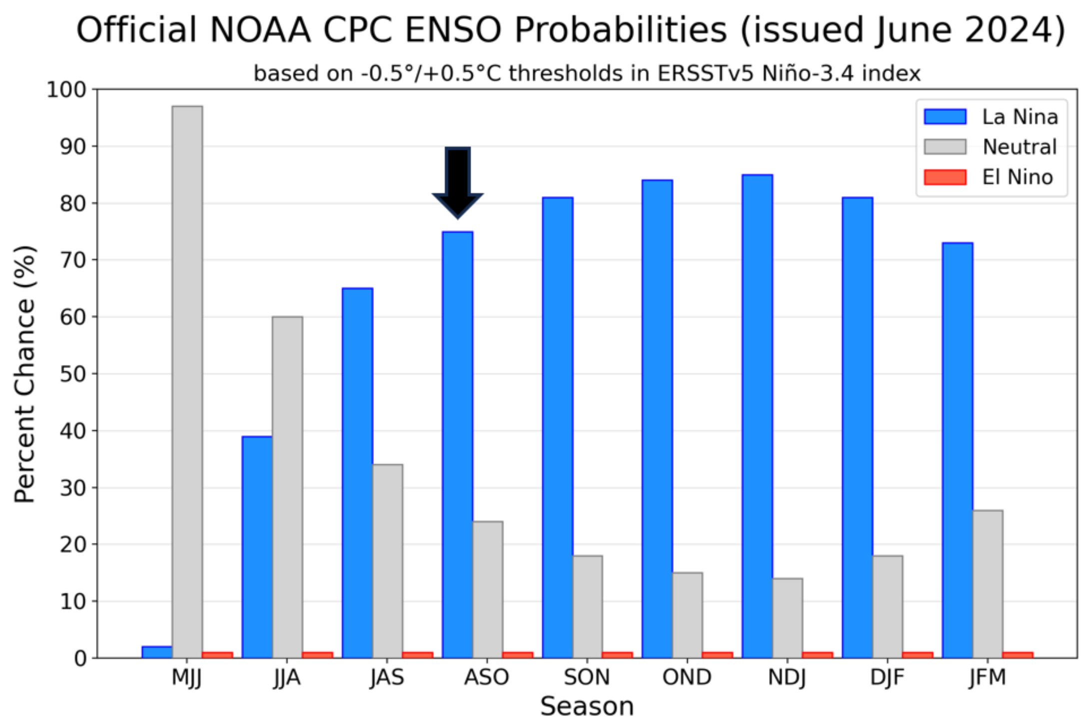

Figure 25: Official probabilistic ENSO forecast from NOAA. The black arrow delineates the peak of the Atlantic hurricane season (August–October).

Based on the above information, we continue to think that weak La Niña conditions are likely for the peak of the Atlantic hurricane season. Even if we do not transition to La Niña, we anticipate cool neutral ENSO conditions. The near-certain removal of the hurricane-unfavorable conditions presented by El Niño provide a likely opportunity for storms that form to capitalize on the strong oceanic heat in the basin (e.g., Hurricane Beryl) regardless of the strength of a potentially developing La Niña.

5 Current Atlantic Basin Conditions

Currently, SSTs are at or near record warm levels across the Atlantic Main Development Region (10–20ºN, 85–20ºW) (Figure 26). Overall Atlantic SST anomalies across the Main Development Region have leveled off over the past month, but are still at a similar magnitude as seen in early July 2023 across the tropical Atlantic. These SST anomalies are still tracking as the second warmest on record, behind only 2023. Over the past month, trade winds across the tropical Atlantic have been weaker than normal, while they have been stronger than normal in the subtropical eastern Atlantic, which has led to anomalous cooling extending from Cabo Verde to the west coast of the Iberian Peninsula (Figure 27). Stronger trade winds lead to more evaporation and mixing, favoring anomalous cooling. Eastern subtropical Atlantic SST anomalies are important in that when the subtropical Atlantic cools relative to the tropical Atlantic, it can cause an increased tropical-subtropical temperature gradient that favors increased tropical upper-tropospheric trough activity and associated increased shear. However, long-range forecasts of shear from the ECMWF and other climate models still predict reduced shear across the Main Development Region for the next several months.

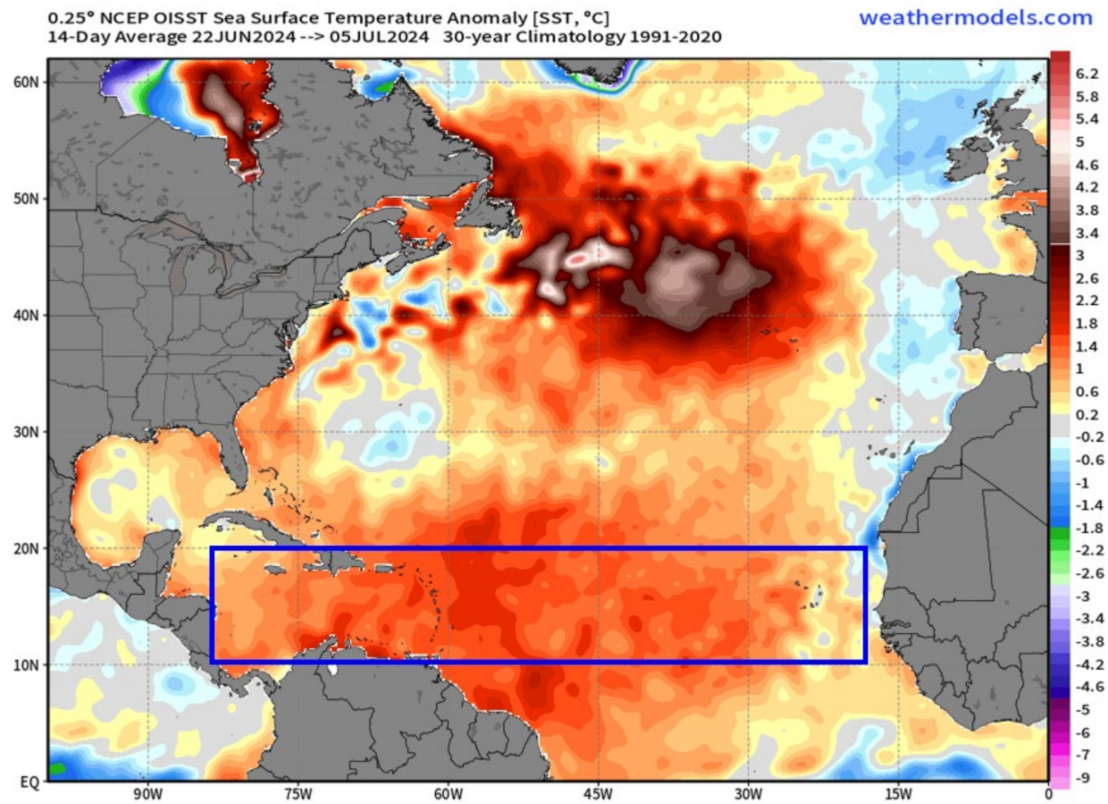

Figure 26: Late June/early July 2024 North Atlantic SST anomalies. The blue rectangle denotes the Atlantic Main Development Region.

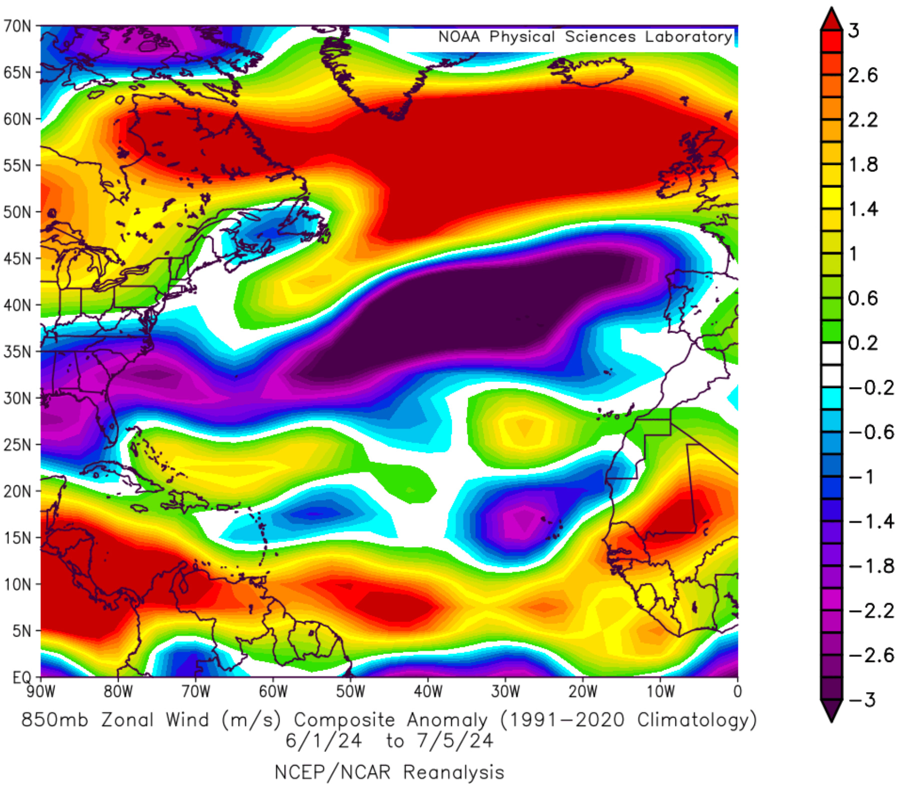

Figure 27: Zonal wind anomalies averaged across the North Atlantic Ocean from June through 5 July 2024.

Figure 28 shows the forecast for the next four weeks of low-level winds across the Atlantic. The stronger trade winds in the subtropical eastern Atlantic look to relent somewhat. In general, trade winds are forecast to be weaker than average across the tropical Atlantic, indicating that extremely warm SST anomalies are likely to continue. Overall, the current SST anomaly pattern correlates well with the July SST pattern that is typically seen in active Atlantic hurricane seasons (Figure 29).

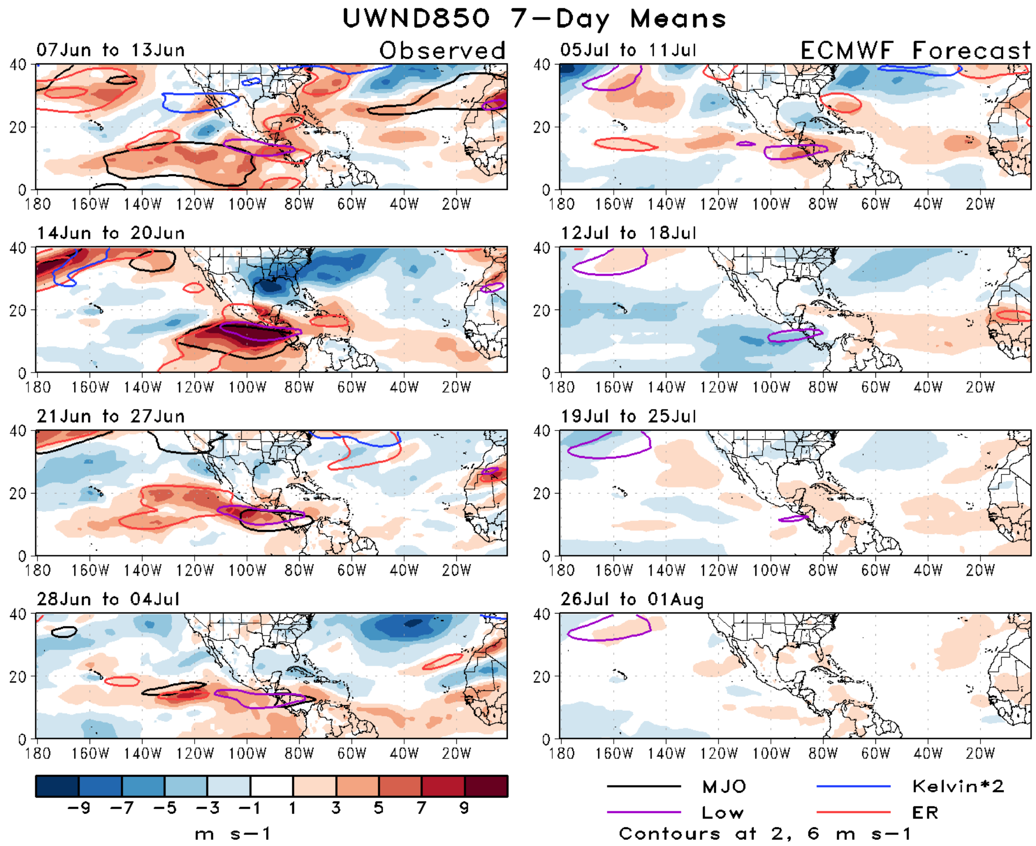

Figure 28: Observed low-level zonal winds across portions of the Western Hemisphere over the past four weeks and predicted low-level zonal winds from ECMWF through 1 August. Figure courtesy of Nick Novella (NOAA).

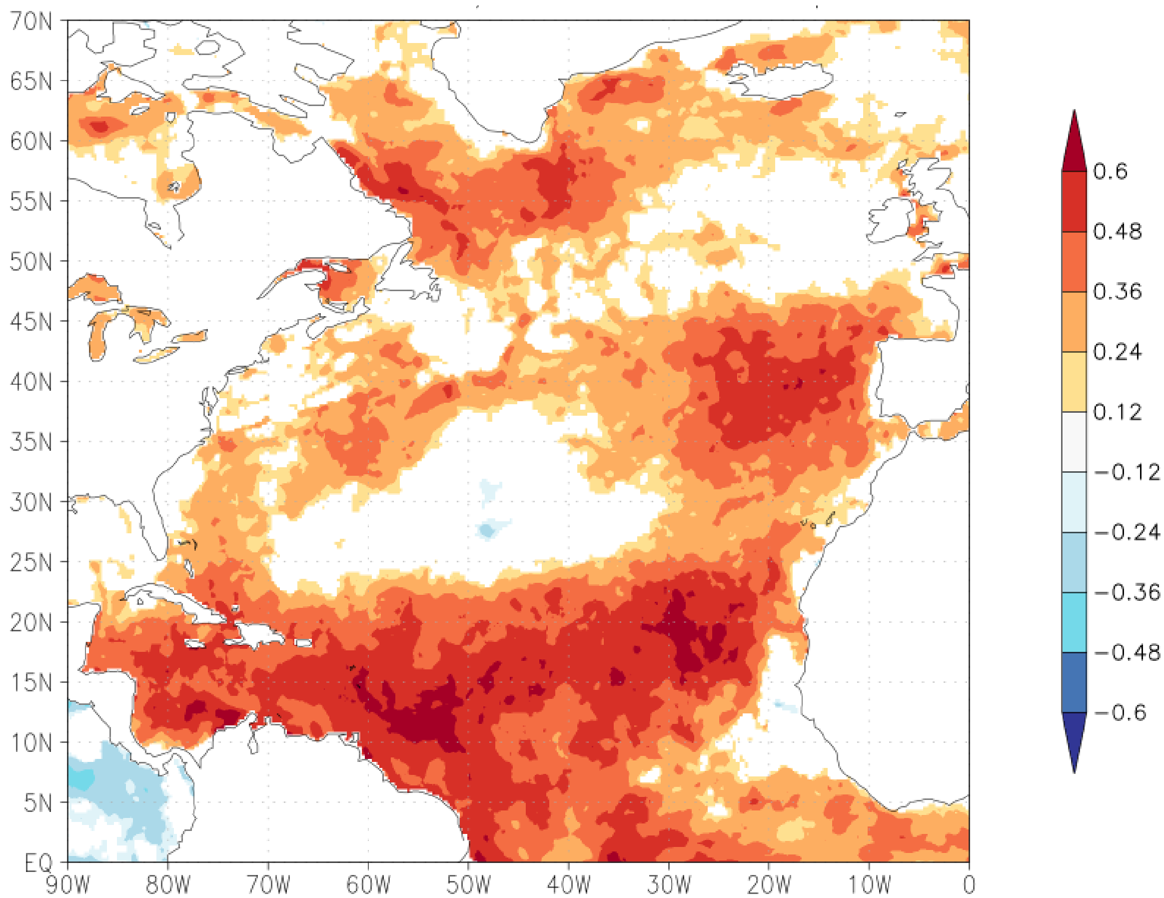

Figure 29: Rank correlations between July sea surface temperatures in the North Atlantic and annual Atlantic ACE from 1982–2023.

6 West Africa Conditions

The West African monsoon has gotten off to a modestly above-normal start, with precipitation averaged across the Sahel being slightly above normal during June/early July (Figure 30). An active West African monsoon is typically associated with more active Atlantic hurricane seasons.

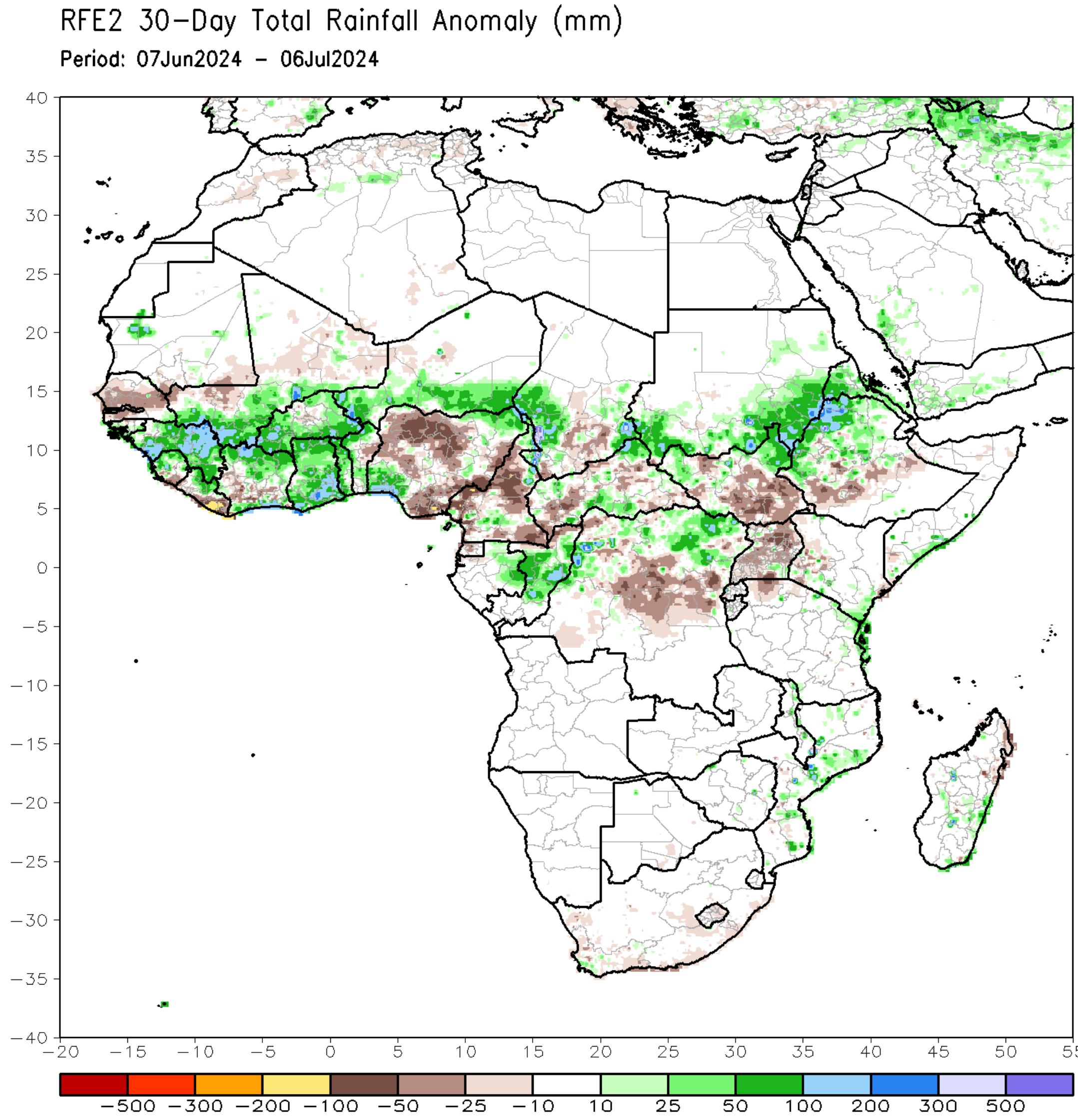

Figure 30: June/early July 2024 rainfall estimates from the African Rainfall Estimation Algorithm, version 2.

7 Hurricane Beryl

In general, early season Atlantic hurricane activity has little correlation with overall Atlantic hurricane activity. However, when this activity occurs in the tropical Atlantic (south of 23.5°N, east of 75°W), it is often a harbinger of a very active season. Hurricane Beryl was an extremely impressive hurricane, generating the most ACE of any individual hurricane activity prior to 1 August on record. All seasons since 1900 with a hurricane in the tropical Atlantic prior to 1 August were classified as above-normal seasons using NOAA's ACE definition (>126.1 ACE): 1916, 1926, 1933, 1961, 1996, 2005, 2008, 2018, 2020 and 2021. The average of these seasons produced 10 hurricanes and an ACE of 184. Several of these years were prior to the satellite era (before 1966), and it is consequently likely that hurricanes and ACE were underestimated.

Only four other years have had major hurricanes in the tropical Atlantic prior to 1 August: 1926, 1996, 2005, and 2008. These seasons also averaged 10 hurricanes but a slightly higher ACE of 197. One of the main reasons we increased our ACE forecast for the full 2024 season was due to Hurricane Beryl having already generated ~35 ACE by itself.

8 Tropical Cyclone Impact Probabilities for 2024

This year, we continue to calculate the impacts of tropical cyclones for each state and county/parish along the Gulf and East Coasts, tropical cyclone-prone provinces of Canada, states in Mexico, islands in the Caribbean and countries in Central America. We have used NOAA's Historical Hurricane Tracks website and selected all named storms, hurricanes and major hurricanes that have tracked within 50 miles of each landmass from 1880–2020. This approach allows for tropical cyclones that may have made landfall in an immediately adjacent region to be counted for all regions that were in close proximity to the landfall location of the storm. We then fit the observed frequency of storms within 50 miles of each landmass using a Poisson distribution to calculate the climatological odds of one or more events within 50 miles.

Net landfall probability is shown to be linked to overall Atlantic basin ACE. Long-term statistics show that, on average, the more active the overall Atlantic basin hurricane season is, the greater the probability of hurricane landfalls for various landmasses in the basin. Beginning this year, we are adjusting landfall probabilities based on the ratio of predicted ACE west of 60°W to the average ACE west of 60°W, as almost all landmasses that we are issuing probabilities for are west of 60°W.

Table 17 displays the climatological odds of storms tracking within 50 miles of each state along the Gulf and East Coasts along with the odds for the remainder of 2024. Landfall probabilities are above their long-term averages. Probabilities for other Atlantic basin landmasses are available on our website.

Given that landfall rates between 1880–2020 and 1991–2020 are similar for the continental US, we adjust all landfall rates based on a ratio of the forecast ACE relative to the 1991–2020 Atlantic west of 60°W ACE climatology. We prefer to use 1880–2020 for landfall statistics to increase the robustness of the historical landfall dataset. Also, storms near landfall are likely better observed than those farther east in the basin prior to the satellite era (e.g., mid-1960s). Slight differences in ACE west of 60°W between the two periods (73 for 1991–2020 vs. 66 for 1880–2020) are likely mostly due to improved observational technology in the more recent period.

Table 17: Post-8 July probability of >=1 named storm, hurricane and major hurricane tracking within 50 miles of each coastal state from Texas to Maine. Probabilities are provided for both the full season 1880–2020 climatological average as well as the probability for the remainder of 2024, based on the latest CSU seasonal hurricane forecast.

		2024 Probability			Climatological	
	Probability >=1	event within	50 miles	Probability >=1	event within	50 miles
State	Named Storm	Hurricane	Major Hurricane	Named Storm	Hurricane	Major Hurricane
Alabama	73%	39%	12%	58%	28%	8%
Connecticut	31%	11%	2%	22%	8%	1%
Delaware	32%	9%	1%	23%	6%	1%
Florida	95%	71%	40%	86%	56%	29%
Georgia	78%	42%	9%	63%	30%	6%
Louisiana	80%	52%	21%	66%	38%	14%
Maine	31%	10%	2%	21%	7%	1%
Maryland	43%	16%	1%	31%	11%	1%
Massachusetts	45%	21%	4%	33%	14%	3%
Mississippi	68%	40%	11%	53%	28%	8%
New Hampshire	26%	8%	2%	18%	6%	1%
New Jersey	32%	10%	1%	23%	7%	1%
New York	37%	14%	3%	26%	9%	2%
North Carolina	82%	52%	11%	68%	38%	8%
Rhode Island	29%	11%	2%	20%	8%	1%
South Carolina	72%	40%	12%	57%	29%	8%
Texas	76%	50%	23%	61%	36%	16%
Virginia	60%	28%	2%	46%	20%	1%

7 Summary

An analysis of a variety of different atmosphere and ocean measurements (through early July) which are known to have long-period statistical relationships with the upcoming season's Atlantic tropical cyclone activity, as well as output from dynamical models, indicate that 2024 will have well above-average activity. The big question marks with this season's prediction are the persistence of the anomalous warmth in the tropical Atlantic, as well as the potential strength of a La Niña, should it develop.

8 Forthcoming Updated Forecasts of 2024 Hurricane Activity

We will be issuing a final seasonal update of our 2024 Atlantic basin hurricane forecasts on **Tuesday 6 August**. We will also begin issuing two-week forecasts for Atlantic TC activity on **6 August**. A verification and discussion of all 2024 forecasts will be issued on **Tuesday, 26 November**. All forecasts and verifications are available on our website.

9 Verification of Previous Forecasts

CSU's seasonal hurricane forecasts have shown considerable improvement in recent years, likely due to a combination of improved physical understanding, adoption of statistical/dynamical models and more reliable reanalysis products. Figure 31 displays correlations between observed and predicted Atlantic hurricanes from 1984–2013, from 2014–2023 and from 1984–2023 for the June and August forecasts and from 1995–2013, 2014–2023 and from 1995–2023 for the April forecast, respectively. Correlation skill has improved at all lead times in recent years, with the most noticeable improvements at longer lead times. While ten years is a relatively short sample size, improvements in both modeling and physical understanding should continue to result in future improvements in seasonal Atlantic hurricane forecast skill. More detailed verification statistics are also available:

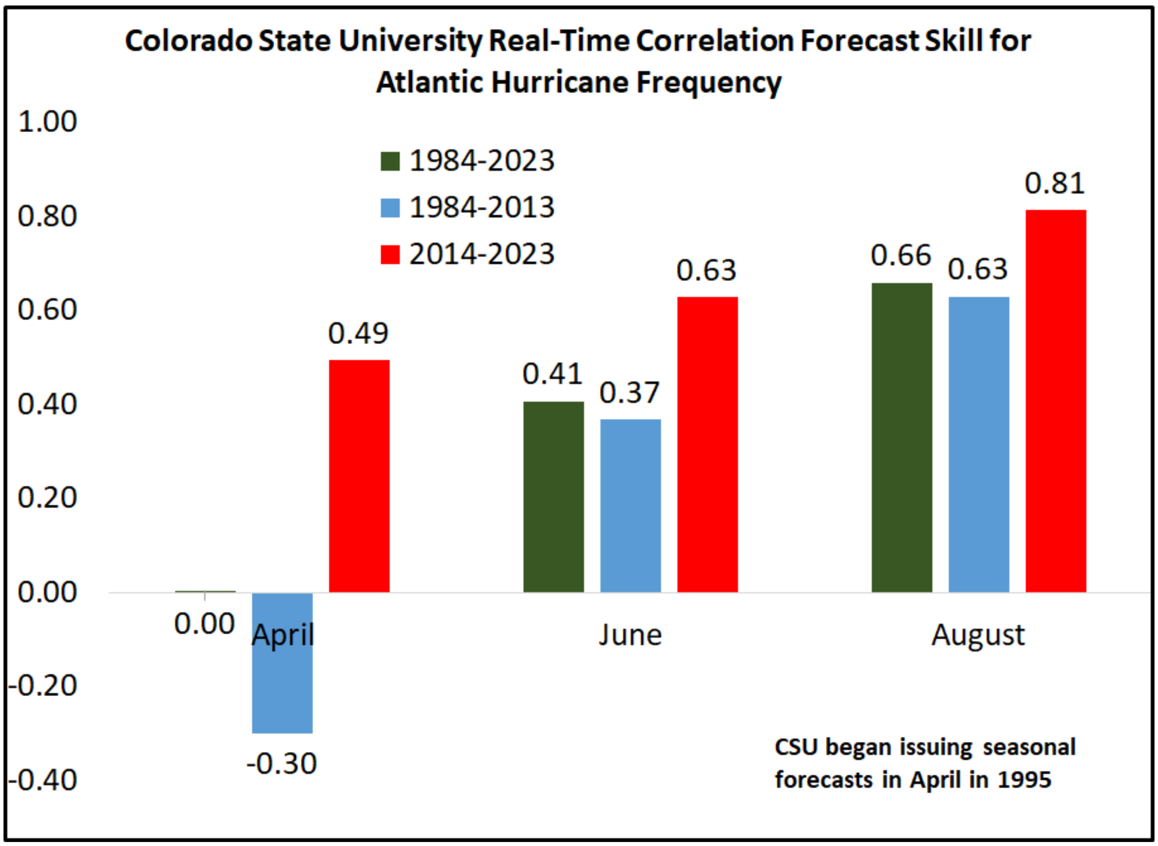

Figure 31: CSU's real-time forecast skill for Atlantic hurricanes using correlation as the skill metric. Correlation skills are displayed for three separate time periods: 1984–2013, 2014–2023 and 1984–2023 for the June and August forecasts and for 1995–2013, 2014–2023 and 1995–2023 for the April forecast.