DISCUSSION OF 2025 ATLANTIC HURRICANE SEASON TO DATE AND FORECAST THOUGHTS ON THE REST OF THE SEASON

The 2025 Atlantic hurricane season started slowly, then had a long-lived major hurricane (Erin) and has since become extremely quiet. As we near the climatological peak of the Atlantic hurricane season with limited prospects for tropical cyclone development in the next several days, we discuss the 2025 season to date and examine why the season has become quiet. These reasons include: 1) a dry and stable tropical Atlantic, 2) a pronounced upper-tropospheric trough in the western Atlantic increasing vertical wind shear and 3) sinking motion over Africa suppressing West African precipitation and likely African easterly wave intensity. We believe that it is a combination of these factors (and perhaps others) that have led to this recent quiet period. We do anticipate the season picking up, however, given that large-scale conditions appear to become more tropical cyclone-favorable later in September. We note that we are not issuing a new seasonal forecast with this discussion.

(as of 9 September 2025)

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In Memory of William M. Gray[6]

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ATLANTIC BASIN SEASONAL HURRICANE FORECASTS FOR 2025

Forecast Parameter and 1991-2020 Average (in parentheses)	Issue Date 3 April 2025	Issue Date 11 June 2025	Issue Date 9 July 2025	Issue Date 6 August 2025
Named Storms (NS) (14.4)	17	17	16	16
Named Storm Days (NSD) (69.4)	85	85	80	80
Hurricanes (H) (7.2)	9	9	8	8
Hurricane Days (HD) (27.0)	35	35	30	30
Major Hurricanes (MH) (3.2)	4	4	3	3
Major Hurricane Days (MHD) (7.4)	9	9	8	8
Accumulated Cyclone Energy (ACE) (123)	155	155	140	140
ACE West of 60°W (73)	93	93	87	87
Net Tropical Cyclone Activity (NTC) (135%)	165	165	145	145

ATLANTIC BASIN ACTIVITY THROUGH 8 SEPTEMBER 2025

Forecast Parameter and 1991–2020 Average thru Sept. 8 (in parentheses)	Observed	% of 1991–2020 Average
Named Storms (NS) (7.9)	6	76%
Named Storm Days (NSD) (31.7)	21.75	69%
Hurricanes (H) (3.1)	1	32%
Hurricane Days (HD) (11.1)	7.25	65%
Major Hurricanes (MH) (1.4)	1	71%
Major Hurricane Days (MHD) (3.4)	3	88%
Accumulated Cyclone Energy (ACE) (53)	39	74%
ACE West of 60°W (34)	31	91%
Net Tropical Cyclone Activity (NTC) (62%)	43	69%

MOTIVATION FOR DISCUSSION ISSUANCE

There has been considerable discussion amongst meteorologists, the media and the general public about the recent quiet period for Atlantic hurricane activity. We felt it was important to issue a formal discussion describing some of the weather phenomena that have likely been responsible for the recent quiet period and provide a qualitative discussion about the potential for hurricane activity for the rest of the season.

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 that are discussed in a paper highlighting his research legacy. His investments in both time and energy on 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 and Alex DesRosiers, Ph.D. graduates from 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, Lauren Beard, Delián Cólon Burgos, Jen DeHart, Chandler Jenkins, Nick Mesa, Isaac Schluesche and Meghan Stell.

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, Michael Lowry, Brian McNoldy, Paul Roundy, Carl Schreck, Mike Ventrice, and Peng Xian over the past few years.

In this report, we begin by discussing conditions that we believe are currently suppressing tropical cyclone (TC) activity, followed by a brief discussion of what the remainder of the 2025 Atlantic hurricane season may look like. We finish by discussing the observed sea surface temperature and zonal wind conditions that broadly favored an active Atlantic hurricane season.

1 Recent Quiet Period for Atlantic Hurricane Activity

Following a relatively quiet start to the hurricane season, Atlantic ACE escalated rapidly with Hurricane Erin generating over 30 ACE during its ~11 day tenure across the Atlantic. Shortly after Erin became post-tropical, Fernand became a tropical storm for several days. However, since Fernand dissipated on 28 August, the Atlantic has produced no named storms. The National Hurricane Center currently is not expecting any TC formations in the next seven days. If that forecast verifies, it will be only the 2nd year since 1950 with no Atlantic named storm activity between 29 August and 16 September. The only other year was 1992. This pronounced quiet period is quite remarkable at this time of year given that it coincides with the climatological peak of the Atlantic hurricane season (Figure 1). This is the second year in a row that the Atlantic hurricane season has gotten very quiet during the climatological peak, despite what would seem to be favorable seasonal conditions for TC activity. We do note that 2024 ended up a hyperactive season following its noted mid-season lull.

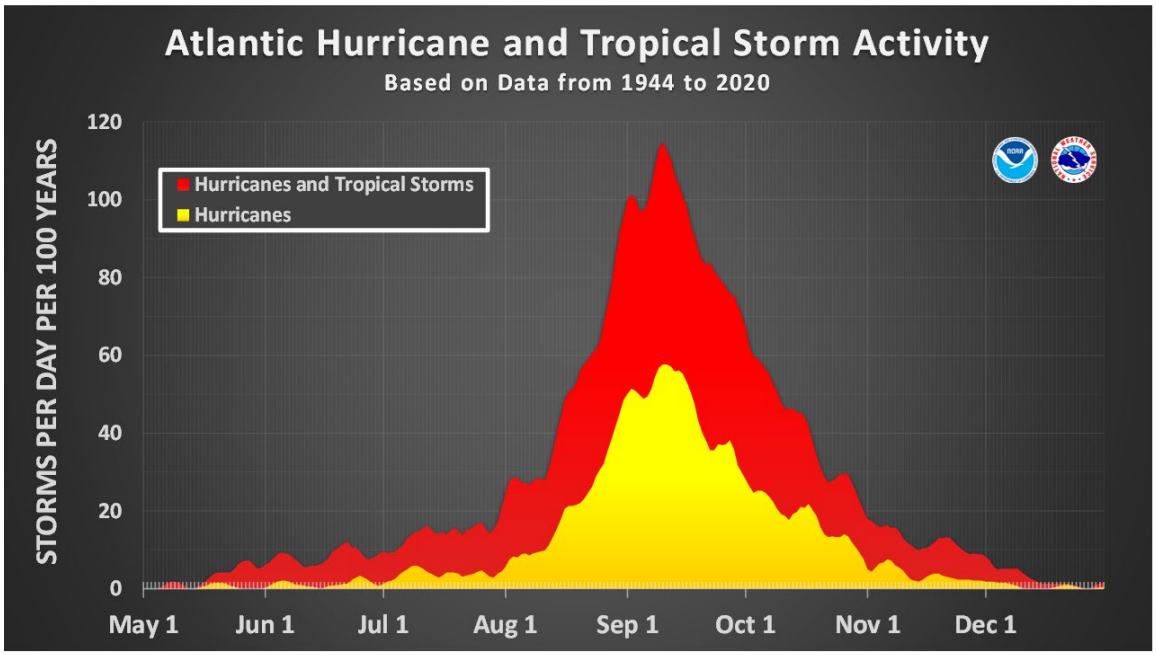

Figure 1: Atlantic tropical cyclone climatology. *(NOAA)*

We believe that several factors have likely contributed to this mid-season lull. We now briefly discuss these factors.

1) Dry and stable tropical Atlantic

While the Atlantic managed Category 5 Hurricane Erin, the Atlantic has struggled with producing deep convection this hurricane season. Vertical instability has been below normal throughout the season to date (Figure 2). The latest Global Forecast System (GFS) analysis also highlights dryness over most of the eastern and central tropical Atlantic (Figure 3). Precipitable water is currently running well below normal, which is likely one reason why there is very little model support for the African easterly wave currently located near Cabo Verde in developing into a TC.

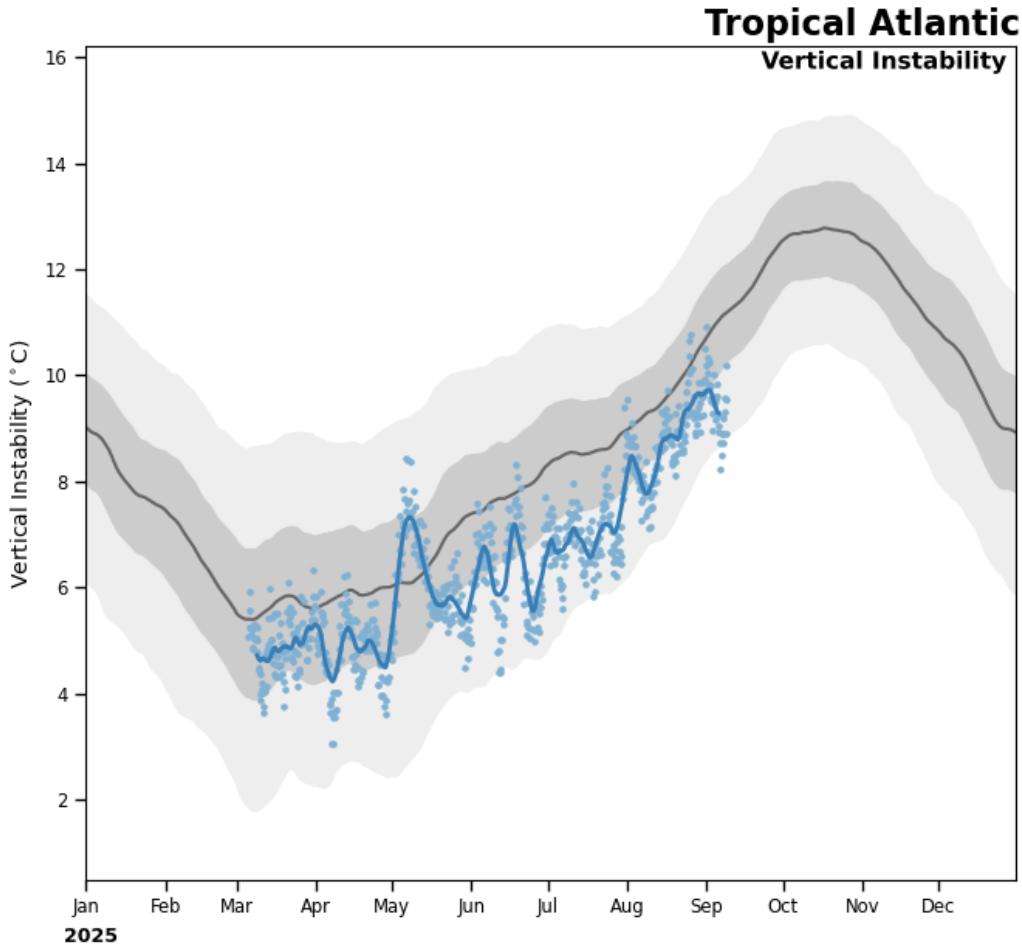

Figure 2: Observed tropical Atlantic vertical instability (blue line) compared with the 1991–2020 average (black line). *(Cooperative Institute for Research in the Atmosphere)*

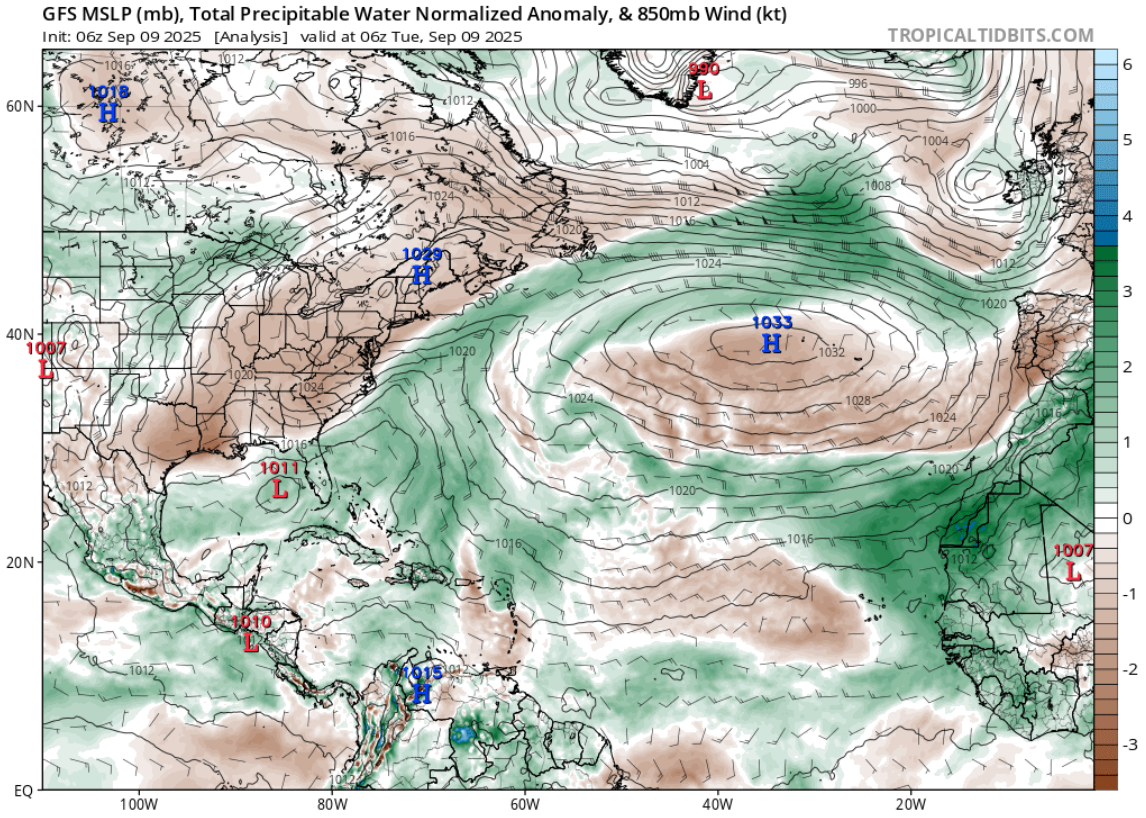

Figure 3: Observed anomalous precipitable water across the tropical Atlantic according to the latest GFS analysis. *(Tropical Tidbits)*

Over the past ~2 weeks, this dryness has likely emanated from two sources. The Azores High and pressures across the eastern tropical Atlantic have been quite a bit higher than normal (Figure 4). Associated with the circulation around a high pressure system is anomalous northerly flow on its eastern flank (Figure 5). This anomalous flow brings down drier air from the subtropics into the tropics, inhibiting deep convection. Over the past ~2 weeks, the trade winds across the tropical Atlantic have generally been stronger than normal as well (Figure 6). The other large driver is likely the pronounced tropical upper tropospheric trough (TUTT) that has developed in the western subtropical Atlantic. TUTTs bring down dry air from the subtropics into the tropics, thereby also contributing to drying out the atmosphere. The development of the TUTT is discussed in the next sub-section.

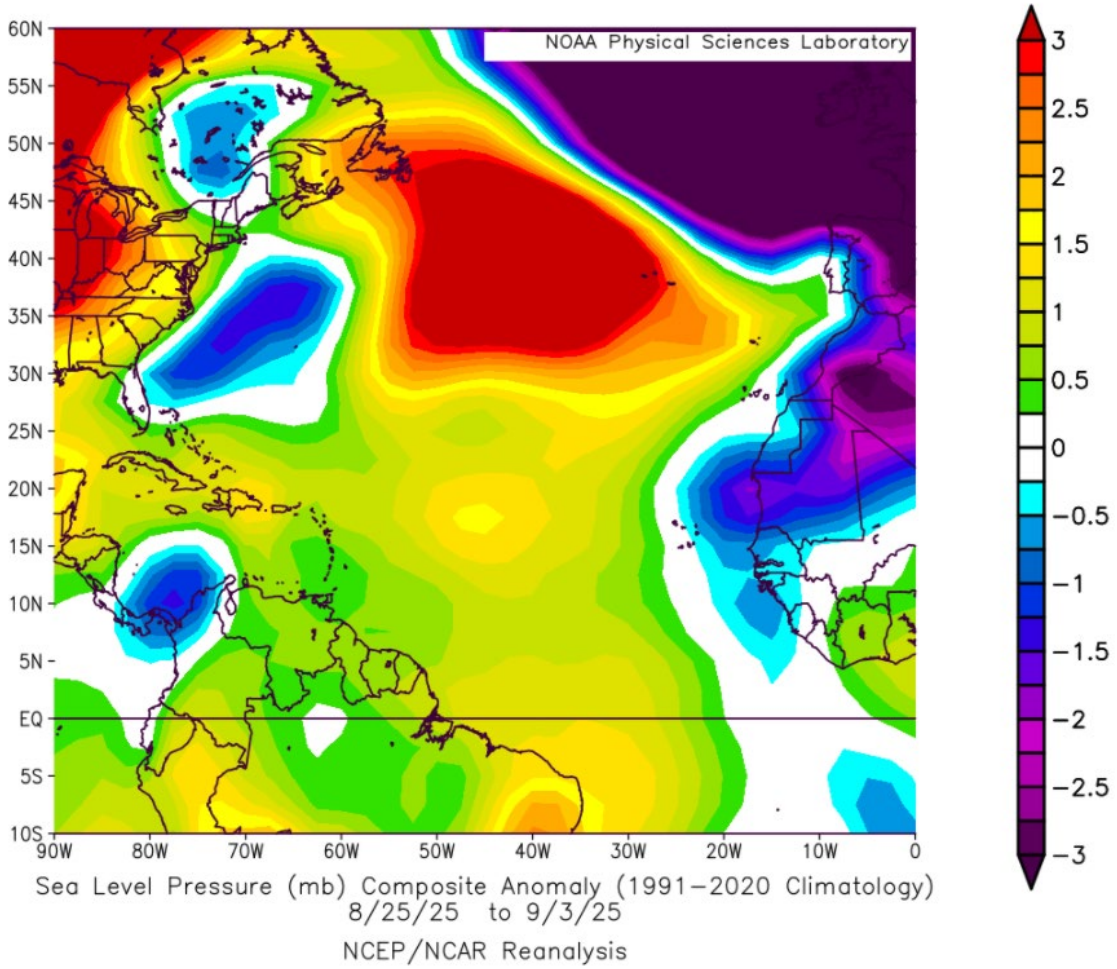

Figure 4: Atlantic sea level pressure anomalies from 25 August to 3 September.

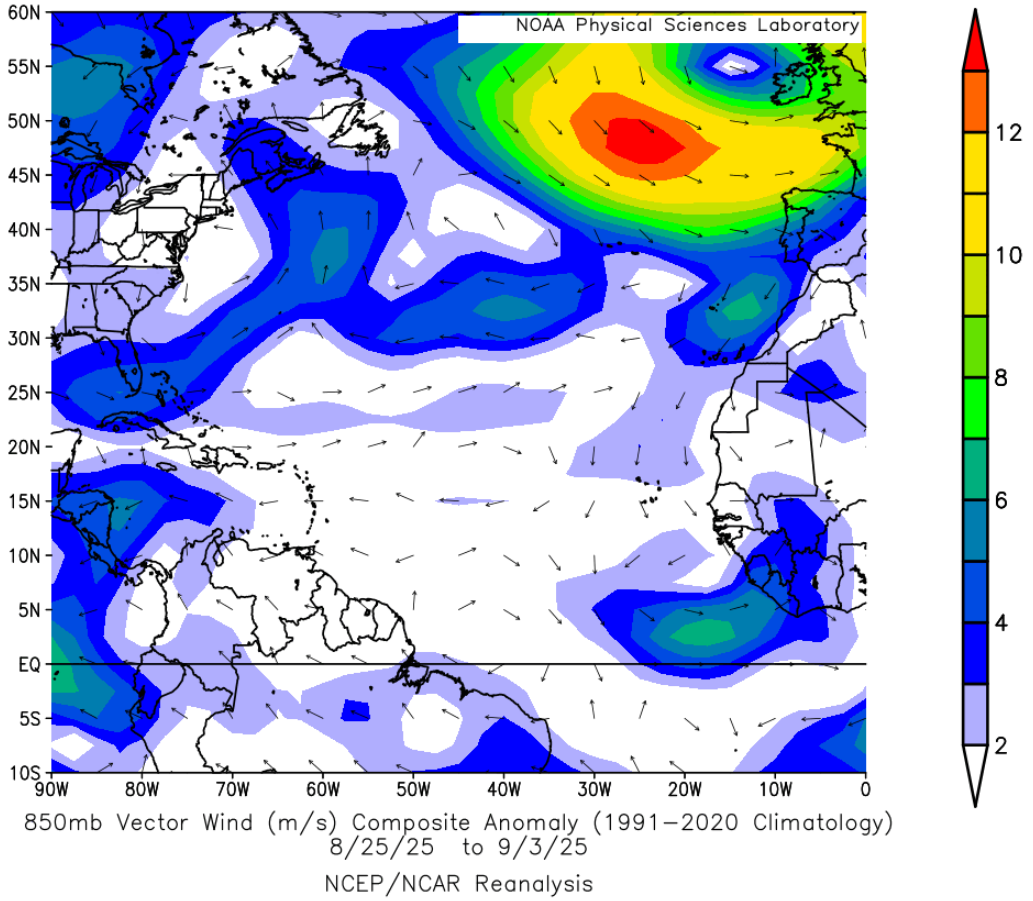

Figure 5: Atlantic 850 hPa vector wind anomalies from 25 August to 3 September.

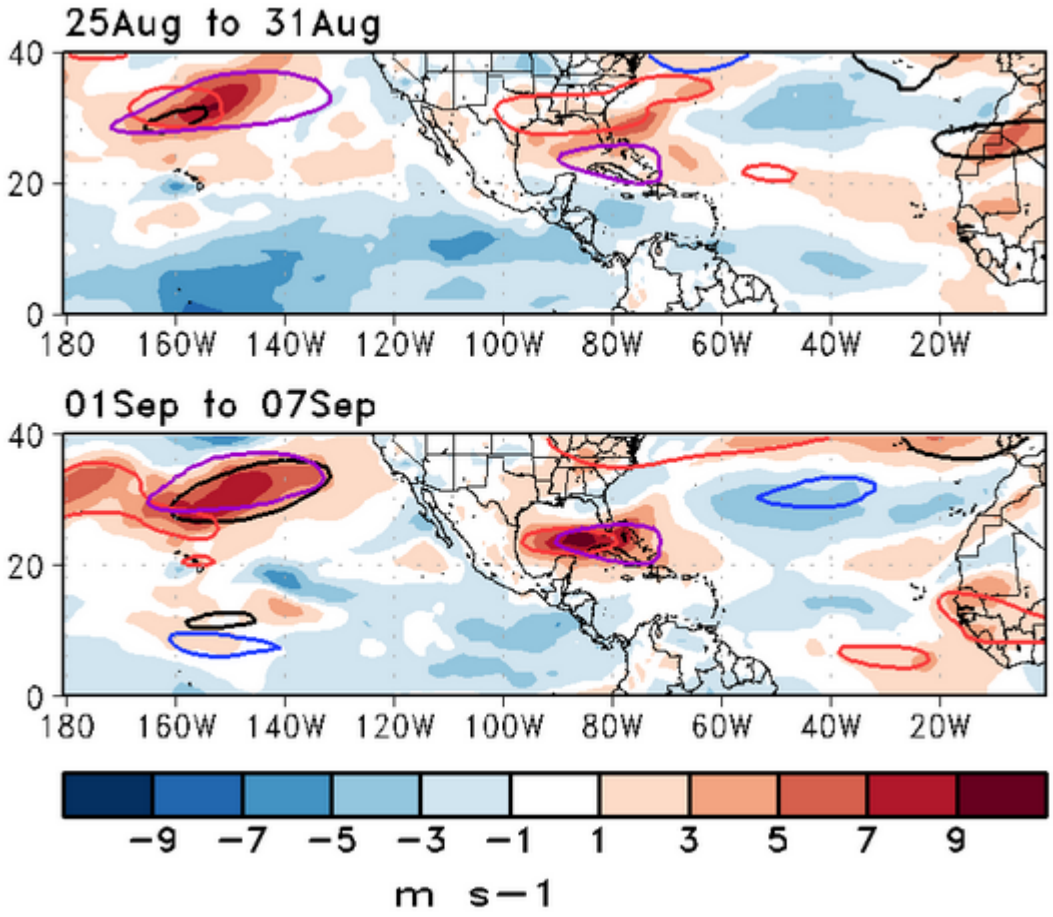

Figure 6: 850 hPa zonal wind anomalies over the past two weeks. *(Nick Novella (NOAA/CPC)).*

2) Tropical upper-tropospheric trough development

As discussed in the last section, a TUTT has recently developed across the western Atlantic. This TUTT can be clearly seen in the latest analysis of the 200 hPa zonal wind field from the GFS (Figure 7). TUTTs are commonly associated with two features that are detrimental for TC development: increased vertical wind shear and increased mixing of dry air from the subtropics into the tropics.

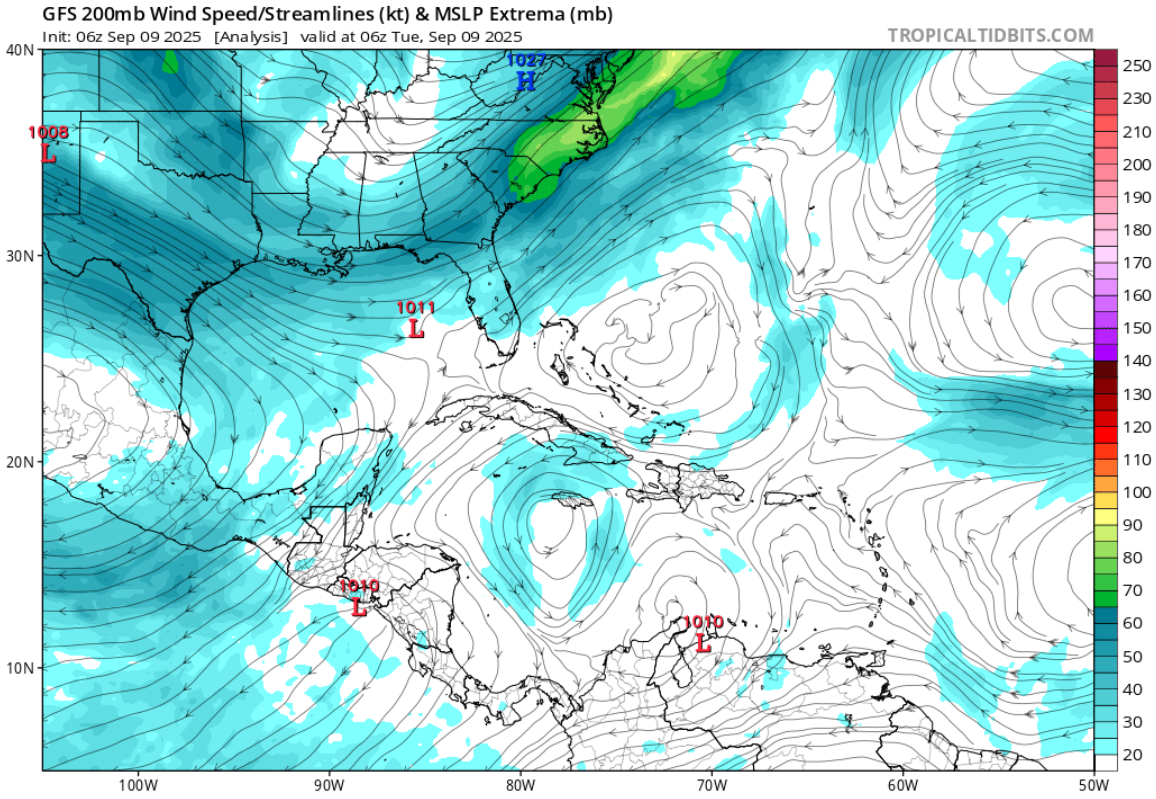

Figure 7: Currently analyzed 200 hPa zonal winds across the western Atlantic. A pronounced TUTT is present across the western Atlantic. *(Tropical Tidbits)*

As previously discussed, vertical wind shear has generally been below normal since early August across most of the Atlantic. However, in recent days, vertical wind shear in the western Atlantic has increased markedly, with above-average vertical wind shear across most of the western Atlantic in the past two weeks (Figure 8).

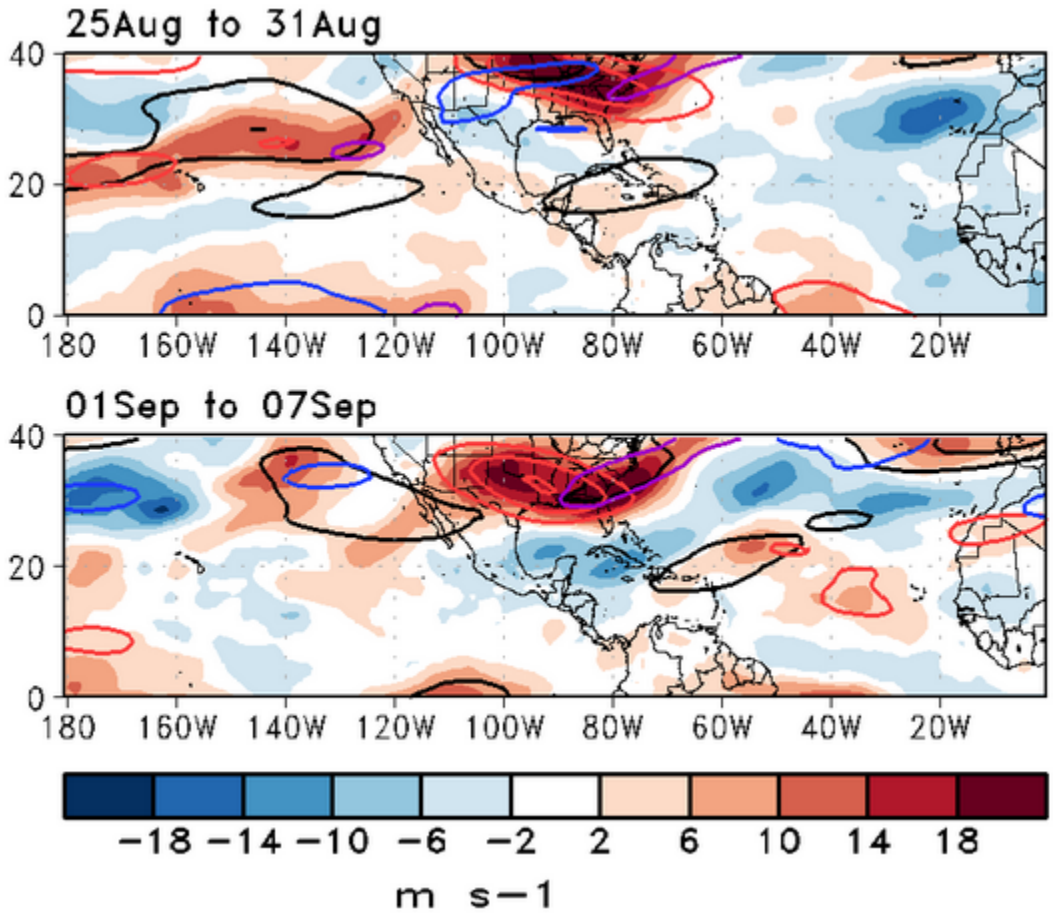

Figure 8: 200 hPa zonal wind anomalies over the past two weeks. (*Nick Novella (NOAA/CPC)).*

While TUTT development tends to be less frequent in hurricane seasons where the Atlantic is warm and cool neutral ENSO conditions are present, they still do occur. Often, these TUTT events are driven by enhanced convection over the Pacific Ocean, which triggers poleward-propagating Rossby waves that can then result in anticyclonic wavebreaking and associated development of TUTTs where the jet decelerates. During late August, enhanced convection developed over the Pacific (Figure 9), and at the same time, we had a pronounced trough develop in the southeast US, with a ridge farther offshore (Figure 10). That pressure pattern resulted in a deceleration of the jet stream in the western Atlantic (Figure 11), favoring TUTT development in this region.

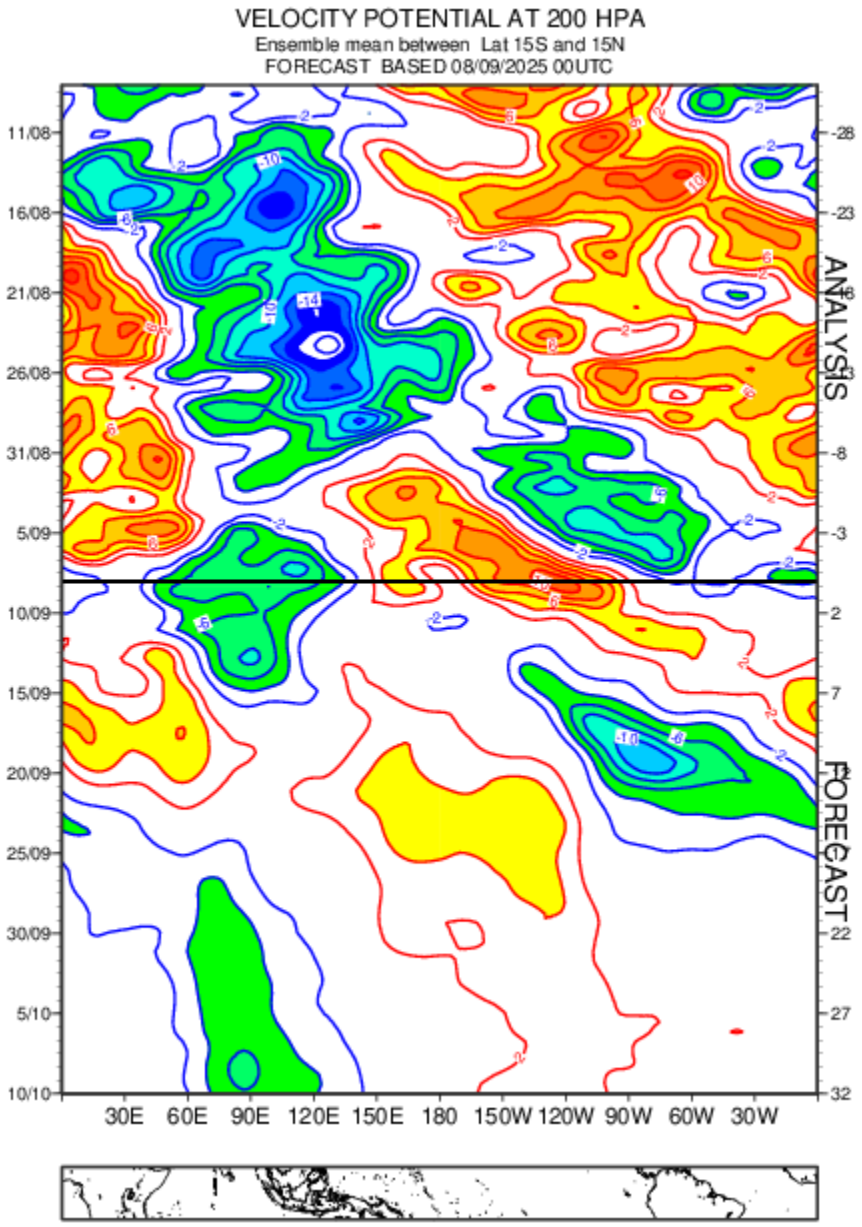

Figure 9: 200 hPa velocity potential anomalies since early August as well as ECMWF forecasts through 10 October. Negative velocity potential anomalies are typically associated with upward motion. *(ECMWF)*

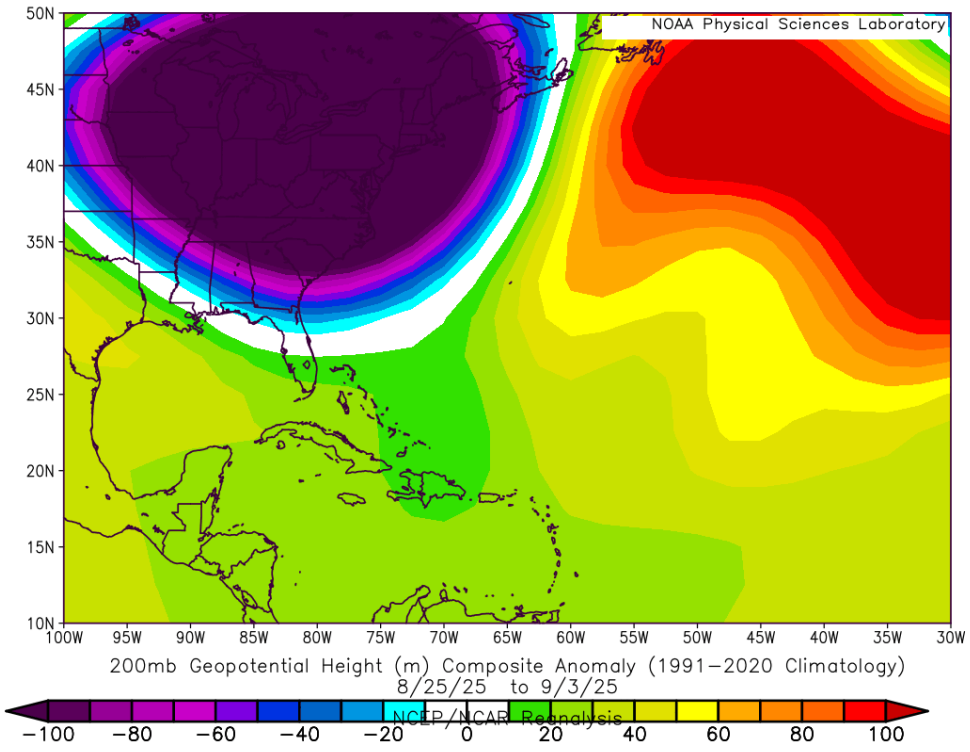

Figure 10: 200 hPa geotential height anomalies from 25 August to 3 September.

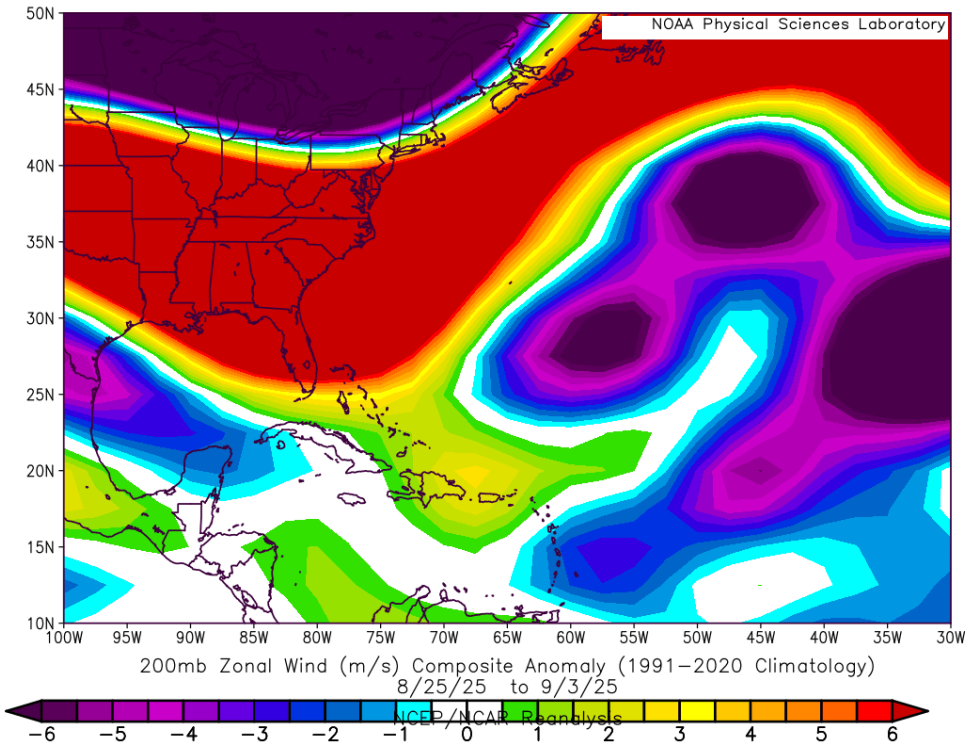

Figure 11: 200 hPa zonal wind anomalies from 25 August to 3 September.

3) Recent anomalous subsidence and dryness over West Africa

Over the past couple of weeks, we have generally had subsidence over Africa (Figure 9). This has led to reduced precipitation over West Africa (Figure 12), likely due to weaker African easterly waves. In general, higher amplitude (e.g., stronger) African easterly waves are more likely to form into TCs than are weaker African easterly waves. Consequently, these weaker waves, combined with less favorable shear and moisture conditions have caused the Atlantic hurricane season to become extremely quiet.

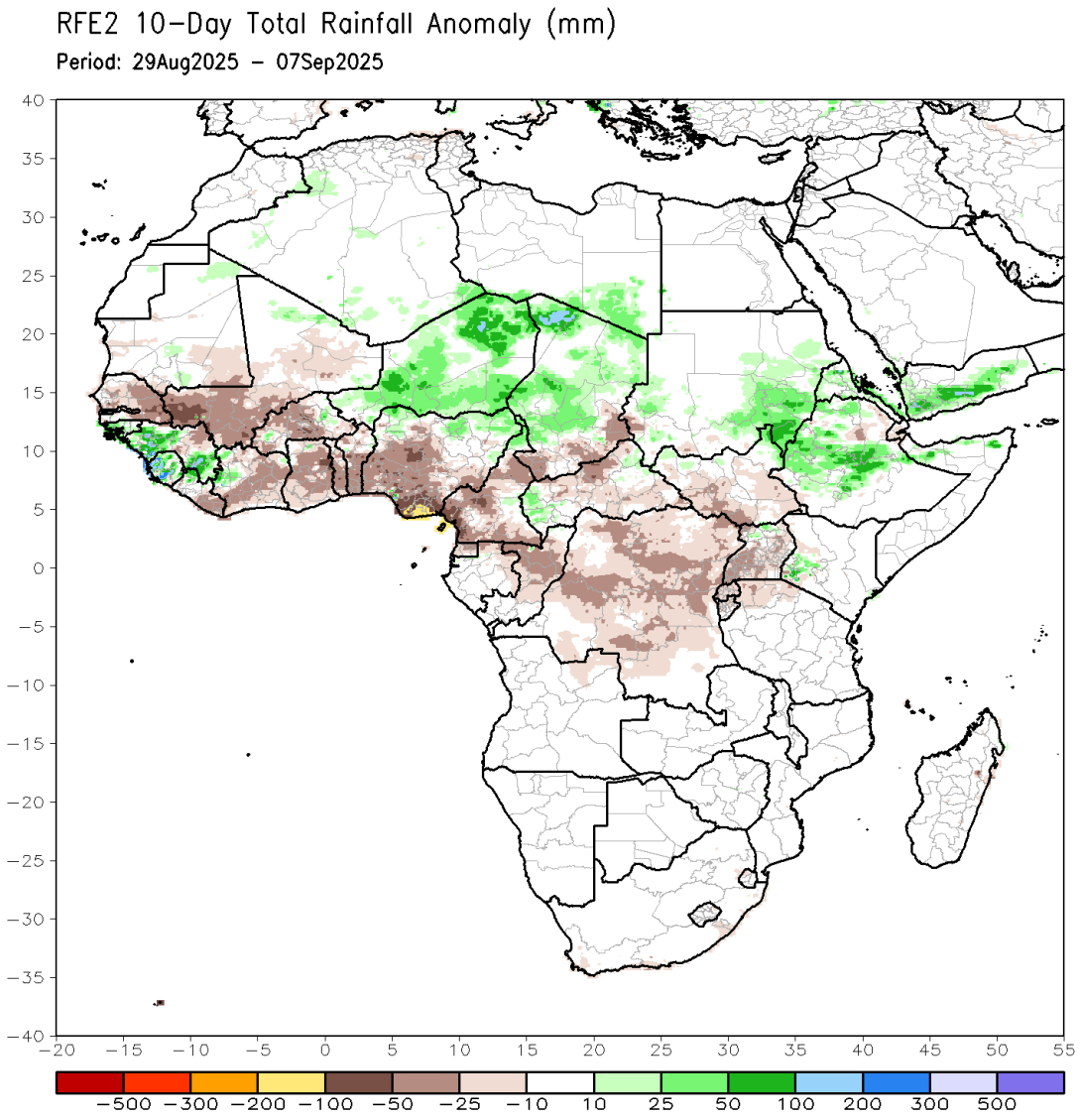

Figure 12: Observed African precipitation from 29 August to 7 September based on the Rainfall Estimation Algorithm version 2.0. *(NOAA)*

3 What Does the Rest of the Atlantic Hurricane Season Have in Store?

We believe that the next ~7–10 days are likely to remain quiet in the Atlantic, given largely TC-unfavorable vertical wind shear and moisture patterns (Figure 13). However, after that point, vertical wind shear is forecast by ECMWF to weaken substantially, potentially yielding much more Atlantic favorable TC conditions later this month. While the Madden-Julian oscillation (MJO) has generally been weak in recent days, there is the potential for the MJO to intensify over Africa and the Indian Ocean in ~2 weeks (Figure 14). If this were to occur, it would likely result in suppressed convection over the Pacific and rising motion over Africa/Indian Ocean, as forecast by

ECMWF (Figure 9). This pattern is much more conducive for Atlantic TC activity than is the current upper-level pattern.

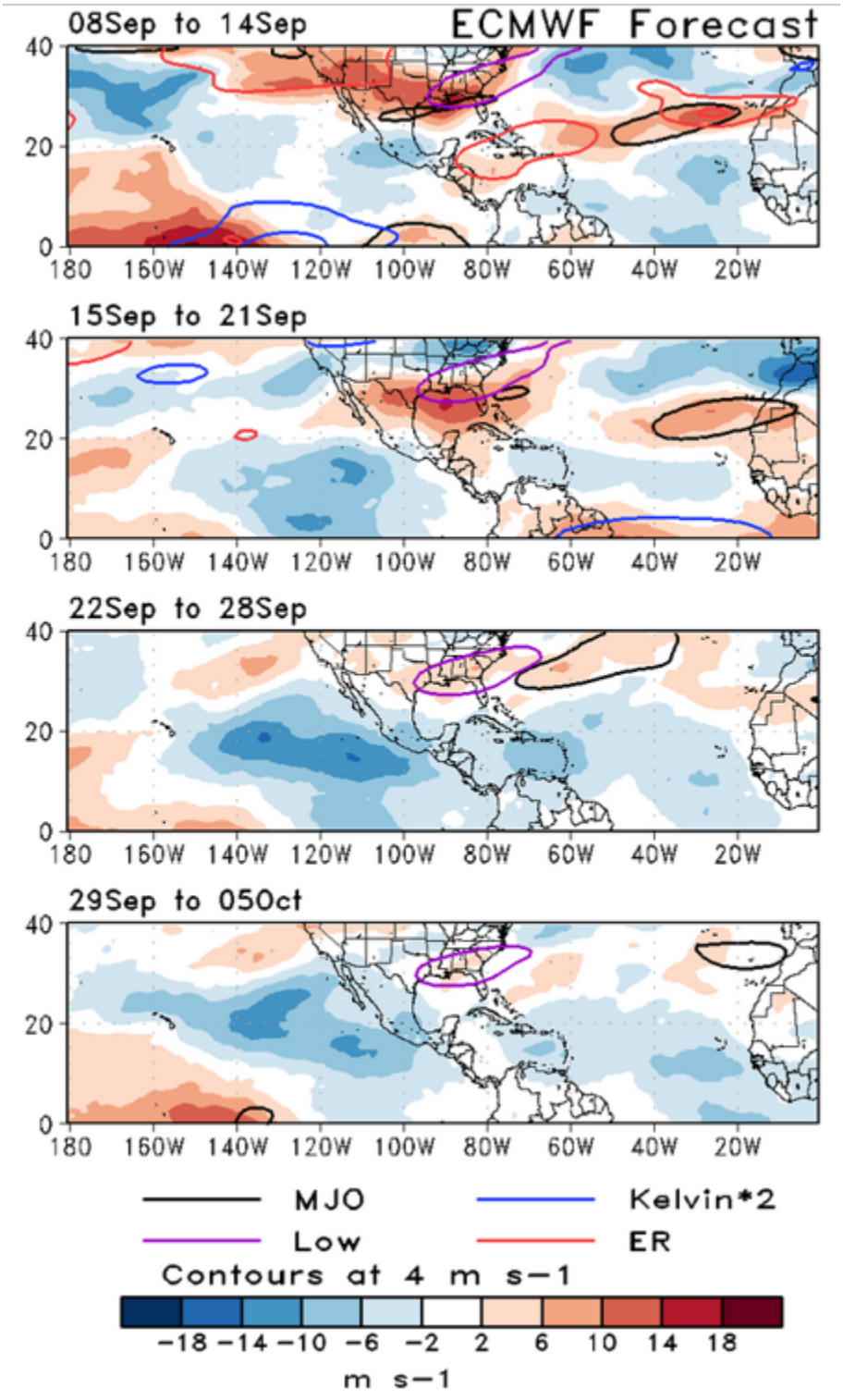

Figure 13: ECMWF forecast zonal vertical wind shear anomalies across the Western Hemisphere for the next four weeks. (*Nick Novella (NOAA/CPC)).*

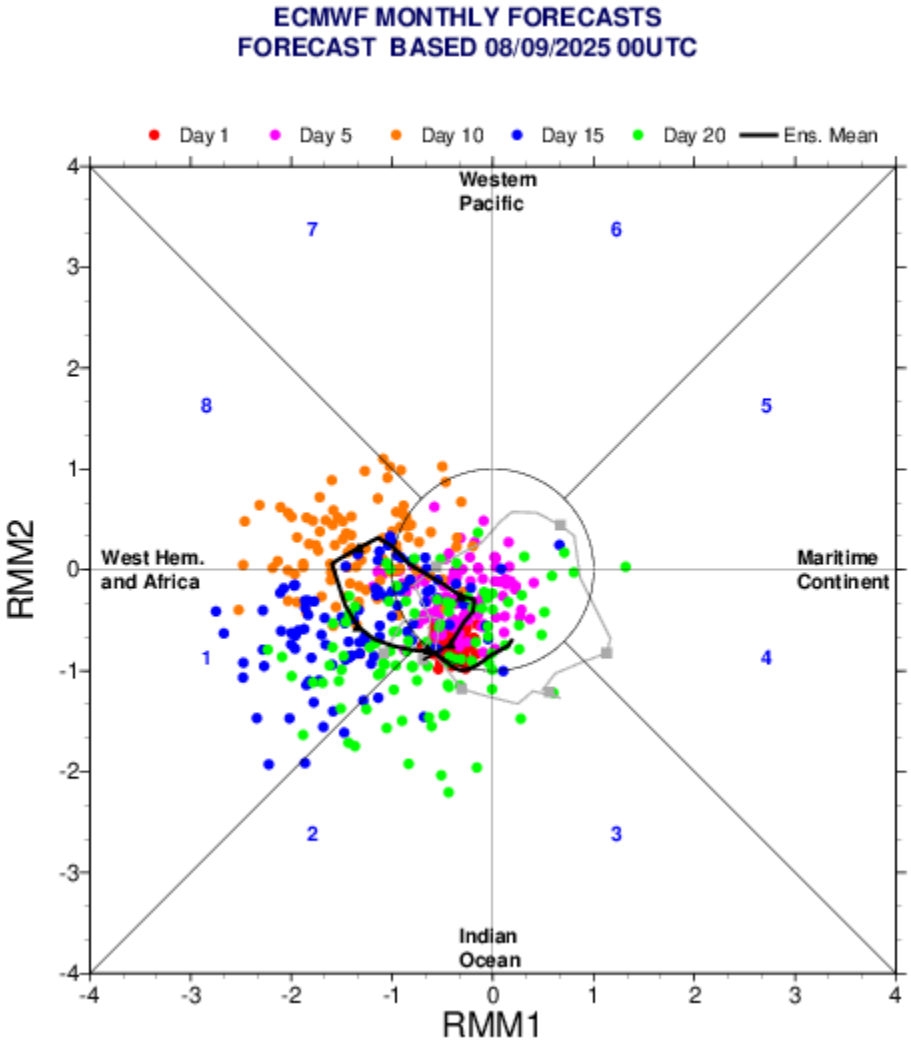

Figure 14: Observed and forecast MJO propagation by ECMWF. *(ECMWF)*

Typically TUTTs propagate southwestward and weaken with time, likely reducing that source of strong vertical wind shear. Also, while sea level pressure is forecast to be remain quite high across the tropical and subtropical Atlantic for the next five days (Figure 15), ECMWF does forecast a marked weakening of the subtropical high by days 6–10 (Figure 16), likely reducing the source of dry air advection in the east Atlantic. Also, lower pressure in the tropical Atlantic as forecast by ECMWF is typically associated with increased instability, favoring TC formation.

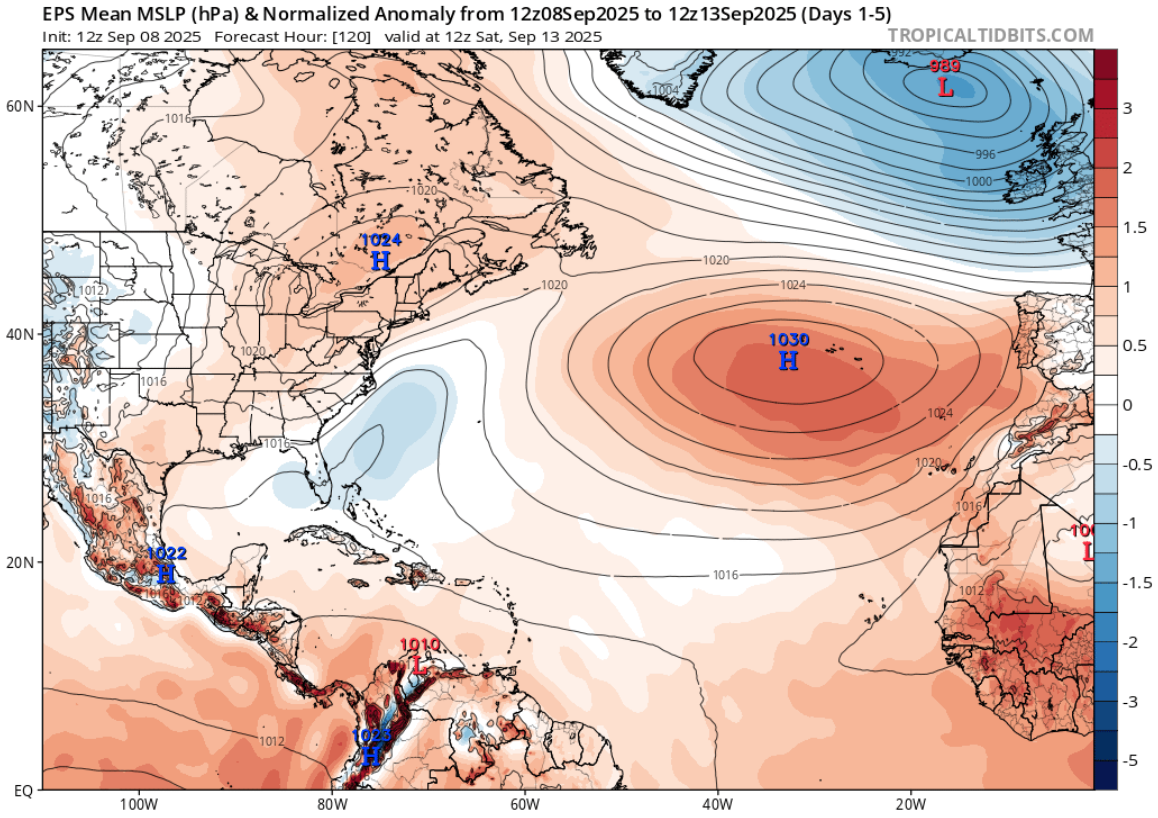

Figure 15: Forecast sea level pressure anomalies from ECMWF for the next five days. *(Tropical Tidbits)*

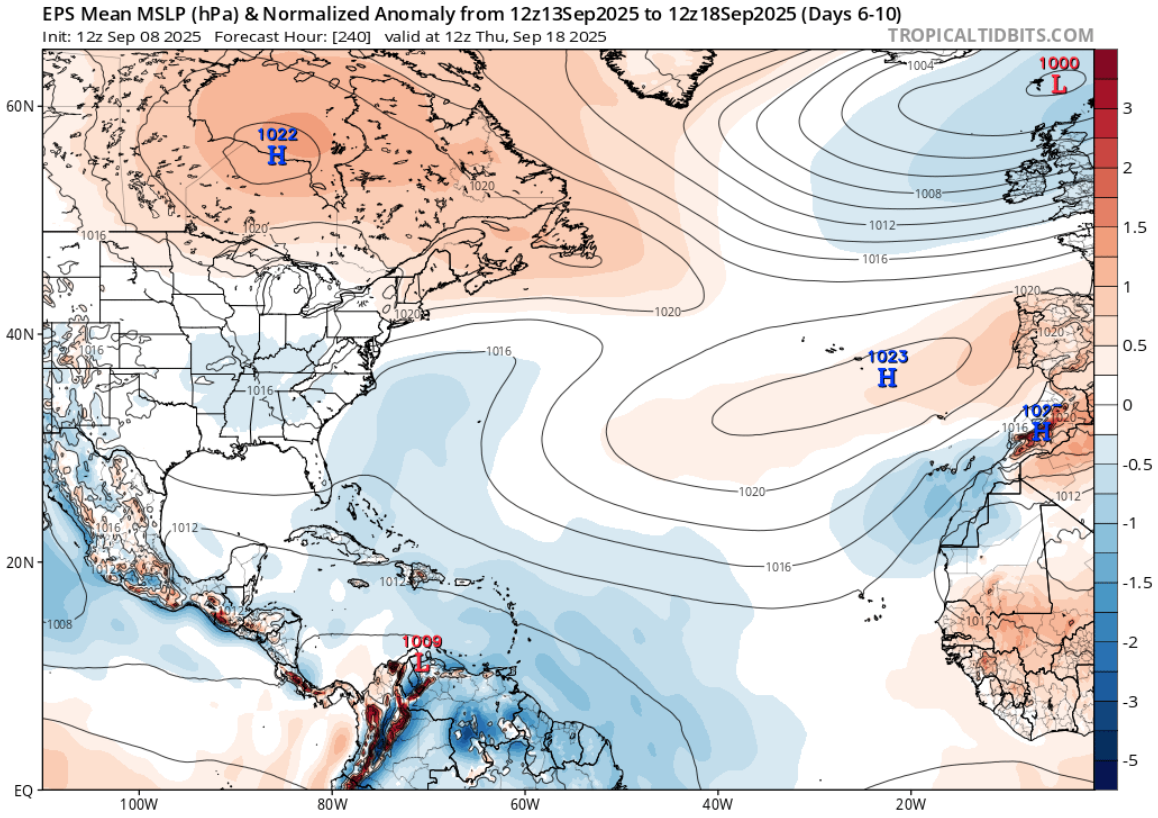

Figure 16: Forecast sea level pressure anomalies from ECMWF for days 6–10. (*Tropical Tidbits)*.

As noted earlier, one of the issues plaguing the Atlantic this hurricane season has been insufficient instability. As shown in Figure 2, climatologically, vertical instability continues to increase across the Atlantic, which should help mitigate this issue in the Atlantic. While vertical wind shear typically increases in the tropical Atlantic as September progresses, the anomalously low vertical wind shear forecast by ECMWF could potentially extend the eastern Atlantic TC season, similar to what we saw last year with Kirk and Leslie forming in late September and early October, respectively. Also, a very warm western tropical Atlantic/Caribbean and cool neutral ENSO conditions (discussed in Section 3) typically favors a more robust Central American gyre and reduced vertical wind shear in the western Atlantic, potentially favoring late-season Caribbean TC activity as well.

3 Favorable Conditions for the Atlantic Hurricane Season

This is the 42nd year in which the CSU Tropical Meteorology Project has made forecasts of the upcoming season's Atlantic basin hurricane activity. As shown on page 2, CSU's forecasts for the 2025 hurricane season were slightly above average. Most forecast groups listed on the Seasonal Hurricane Predictions platform predicted a near to slightly above-average season, with the average of all forecasts calling for eight hurricanes (Figure 17).

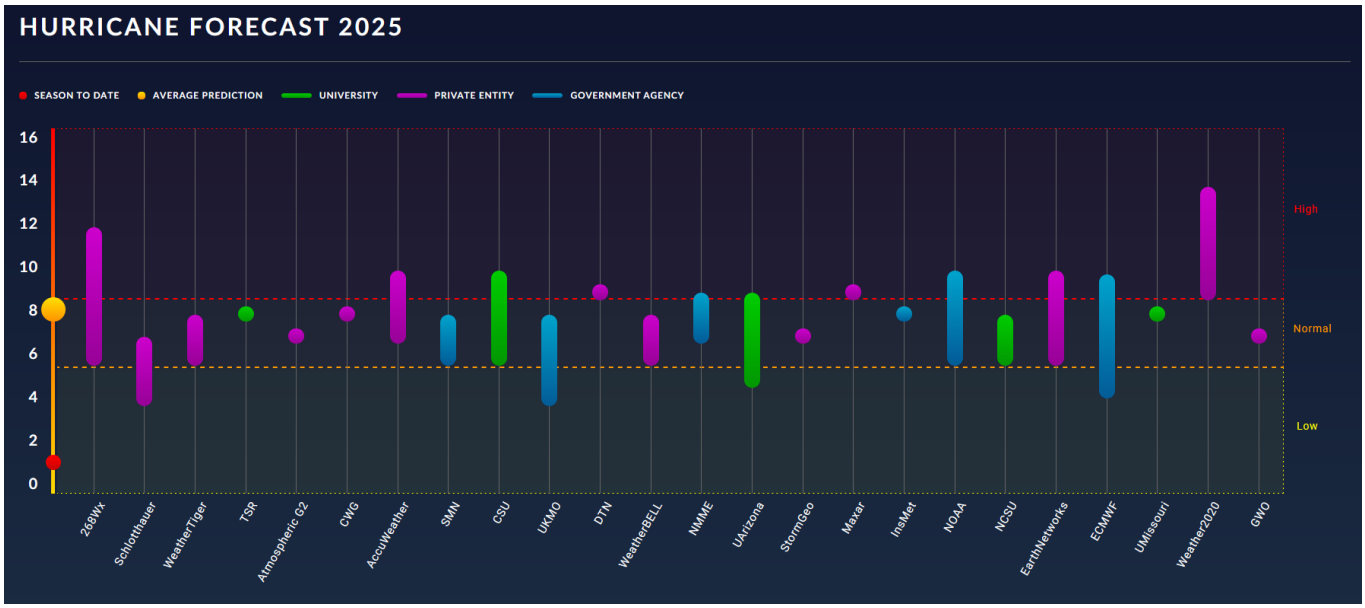

Figure 17: Atlantic seasonal hurricane forecasts for the 2025 season as displayed on the Seasonal Hurricane Predictions platform (https://seasonalhurricanepredictions.org/). The orange dot on the y-axis denotes the average of all of the seasonal forecasts, while the red dot on the y-axis denotes the observed value of hurricanes to date.

Two primary reasons that we gave for our forecast for a slightly above-average Atlantic hurricane season were a warmer-than-normal tropical Atlantic and likely cool neutral ENSO conditions. Figure 18 displays currently observed global sea surface temperatures. 30-day-averaged sea surface temperatures (SSTs) in the Atlantic's Main Development Region (MDR, 10–20°N, 85–20°W) are the 6th warmest on record (since 1979. These anomalously warm SSTs in the MDR are tracking in line with what we typically have experienced in hyperactive Atlantic hurricane seasons (ACE >=160; Figure 19).

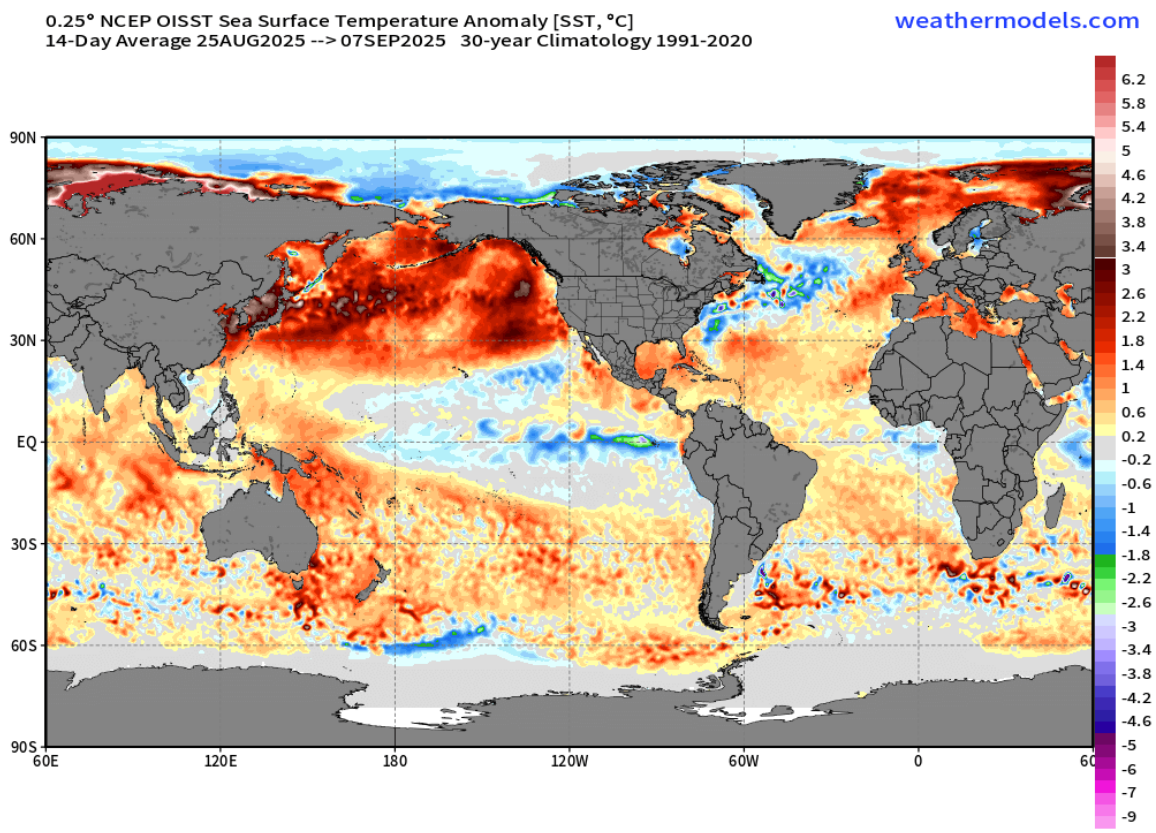

Figure 18: Observed sea surface temperatures averaged from 25 August–7 September.*(weathermodels.com)*

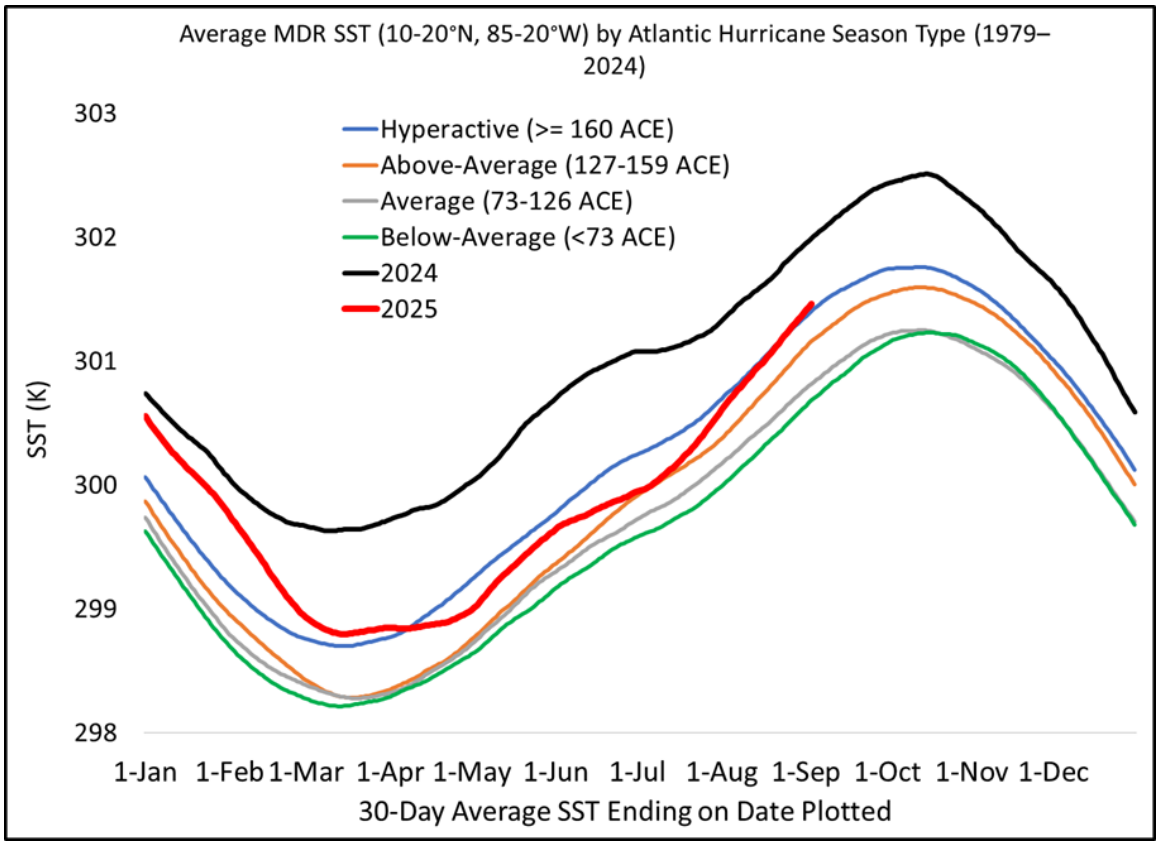

Figure 19: 30-day average SSTs averaged across the Main Development Region for various Atlantic hurricane season types from 1979–2024 based on NOAA's definition. Also plotted are SSTs for 2024 (for comparison). Sea surface temperature anomalies in the tropical Atlantic in 2025 are tracking where they typically do for a hyperactive Atlantic hurricane season.

The tropical Pacific is currently characterized by cool neutral ENSO conditions, with SST anomalies in the Nino 3.4 region (5°S–5°N, 170–120°W), the primary region that NOAA uses to define ENSO events, of approximately -0.4°C. While not quite reaching the La Niña definition of -0.5°C, typically cool neutral ENSO conditions are also associated with reduced levels of Atlantic vertical wind shear (Figure 20).

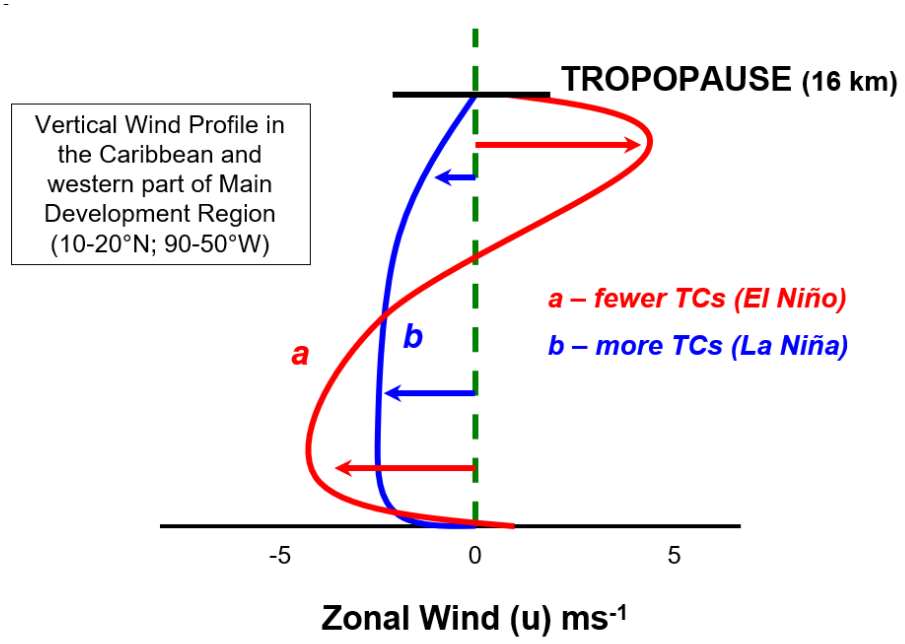

Figure 20: Typical Caribbean/western Atlantic vertical wind shear profile in El Niño vs. La Niña.

Overall zonal vertical wind shear since early August has been quite favorable for Atlantic hurricane activity, with below-normal levels of vertical wind shear across most of the central and western tropical Atlantic (Figure 21). Current 30-day-averaged zonal vertical wind shear is the 2nd lowest on record across the western Atlantic (10–20°N, 85–50°W) (Figure 22). Historically, the relationship between 30-day averaged western Atlantic vertical wind shear ending in early September and seasonal ACE is quite robust (r = -0.70; Figure 23).

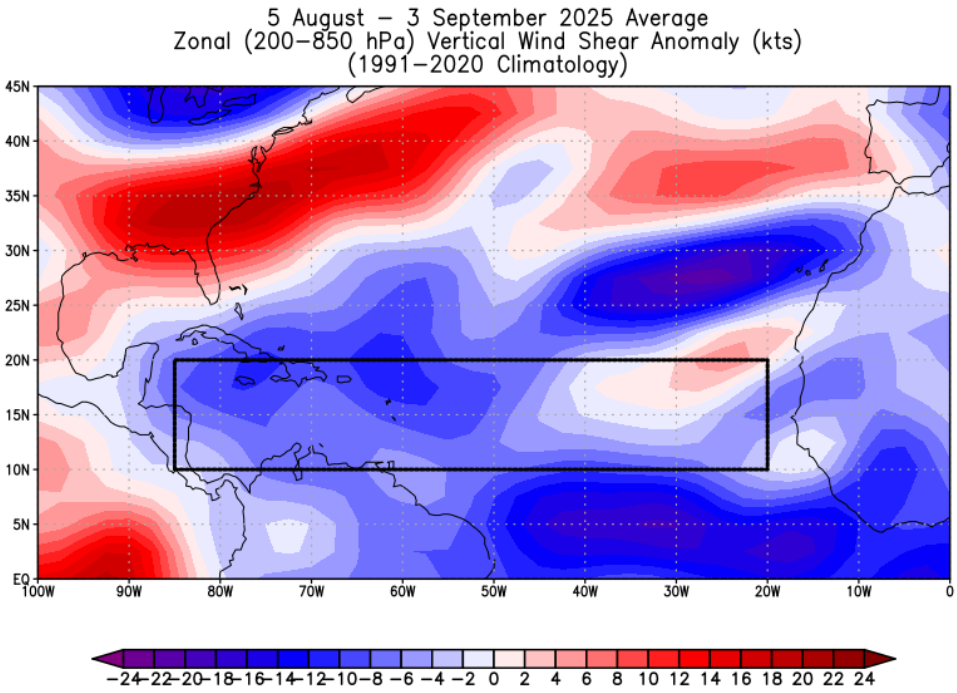

Figure 21: Observed tropical and subtropical Atlantic zonal wind shear anomalies from 5 August–3 September.

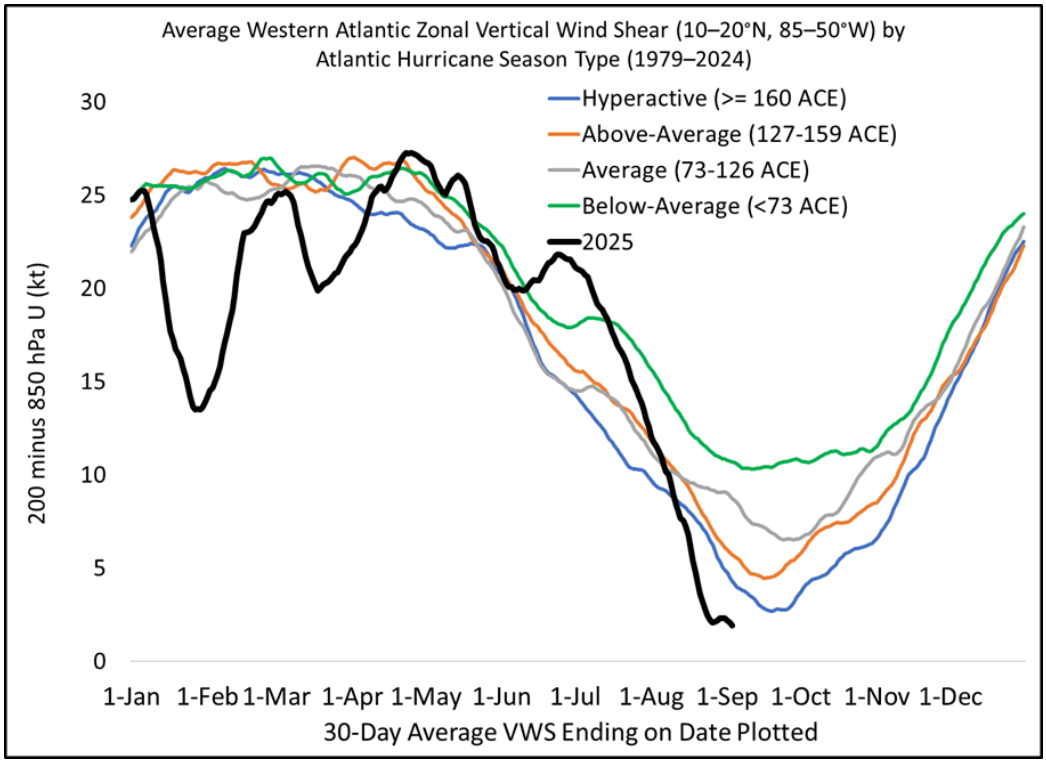

Figure 22: 30-day average western tropical Atlantic zonal vertical wind shear for various Atlantic hurricane season types from 1979–2024 based on NOAA's definition. Western

tropical Atlantic zonal vertical wind shear anomalies in the western tropical Atlantic in 2025 is the 2nd lowest on record for 30-day averages ending on 3 September.

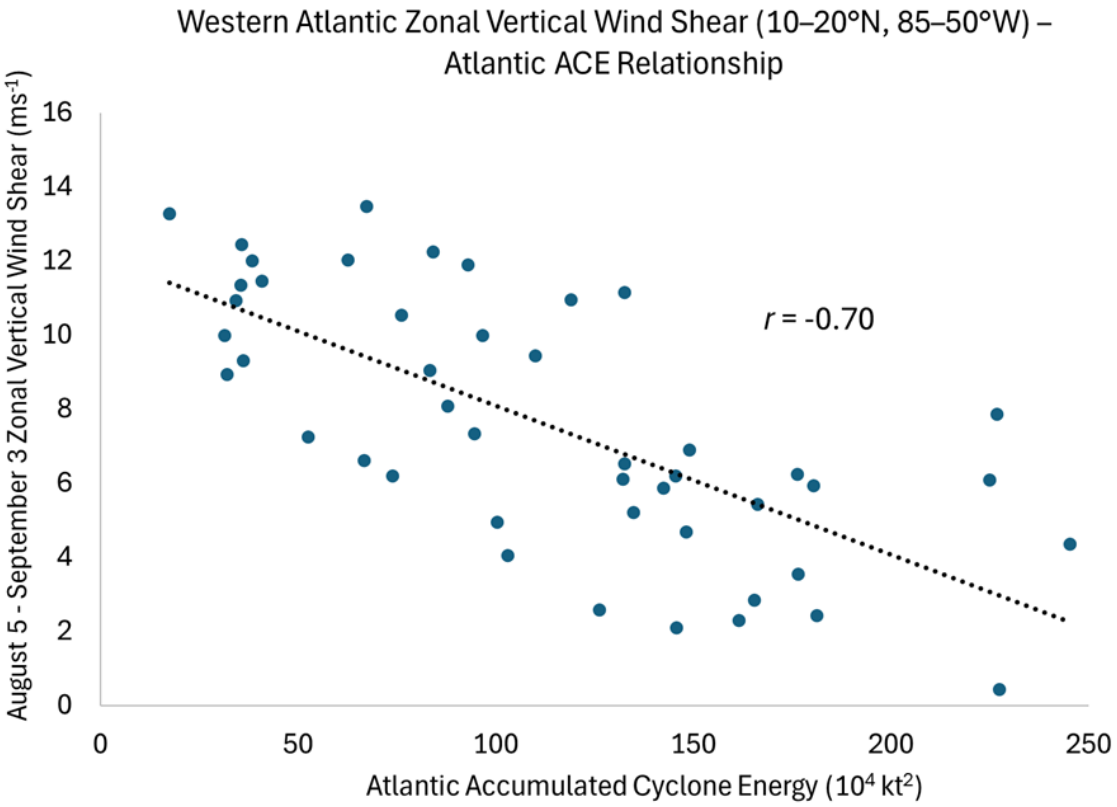

Figure 23: Observed relationship between 30-day-averaged zonal vertical wind shear in the western Atlantic (10–20°N, 85–50°W) ending on 3 September and seasonal Atlantic ACE from 1979–2024. 2025 has the second lowest zonal vertical wind shear ending on 3 September on record.

We have also generally had upper-level winds that favor a busy Atlantic hurricane season, with stronger 200 hPa easterly winds extending across Africa (Figure 24) indicating a strong tropical easterly jet favoring stronger African easterly waves. The zonal wind pattern that we have observed since 1 August correlates quite well with the August 200 hPa zonal wind pattern that is typically associated with busy Atlantic hurricane seasons (Figure 25).

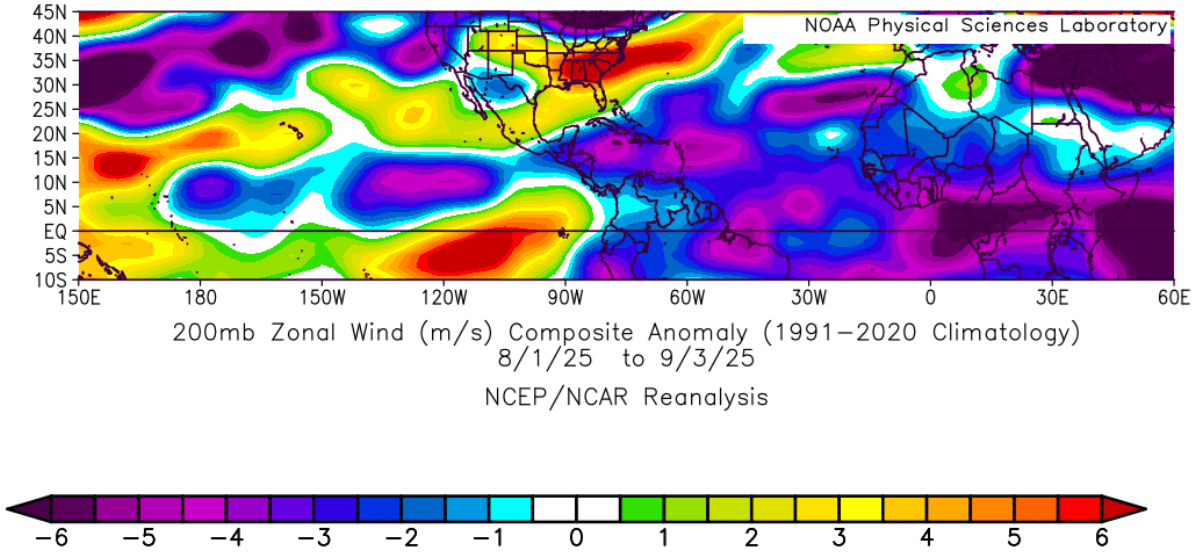

Figure 24: 200 hPa zonal wind anomalies from August 1 to 3 September.

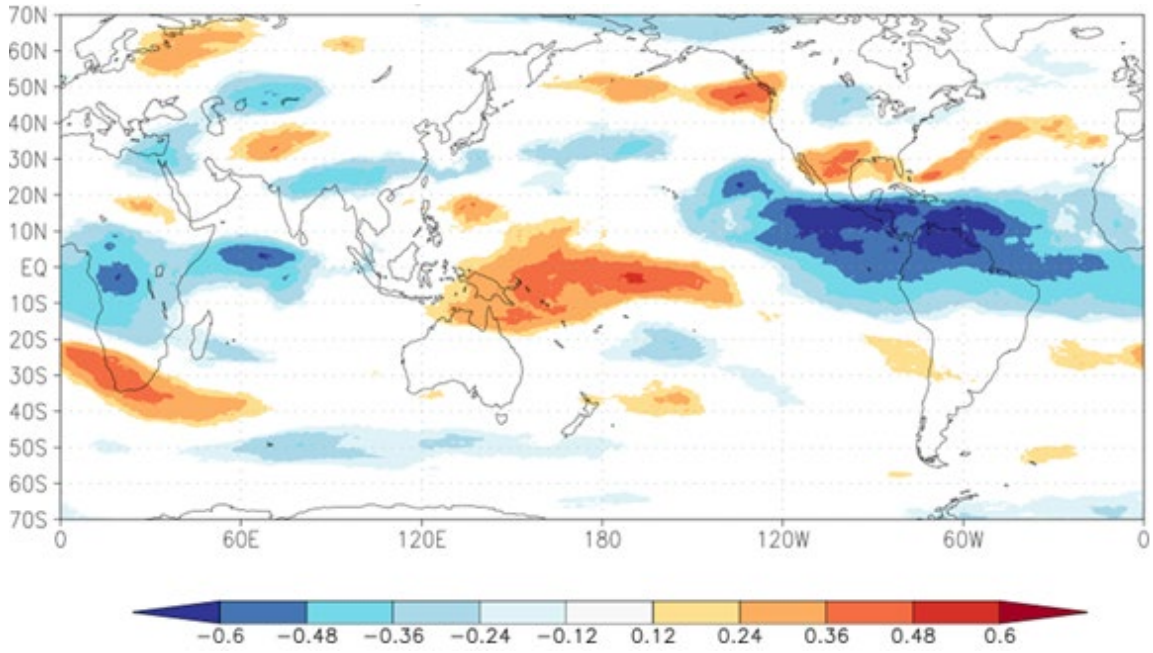

Figure 25: Correlation between August 200 hPa zonal wind and seasonal Atlantic ACE.

Given the broadly TC-favorable sea surface temperature conditions just discussed as well as the forecast TC-favorable wind shear conditions for later September/early October, we advise considerable caution on writing off the 2025 Atlantic hurricane season. As we saw last year, Atlantic TC seasons can change from quiet to busy in a hurry. We will have a complete forecast verification discussion on 18 November.