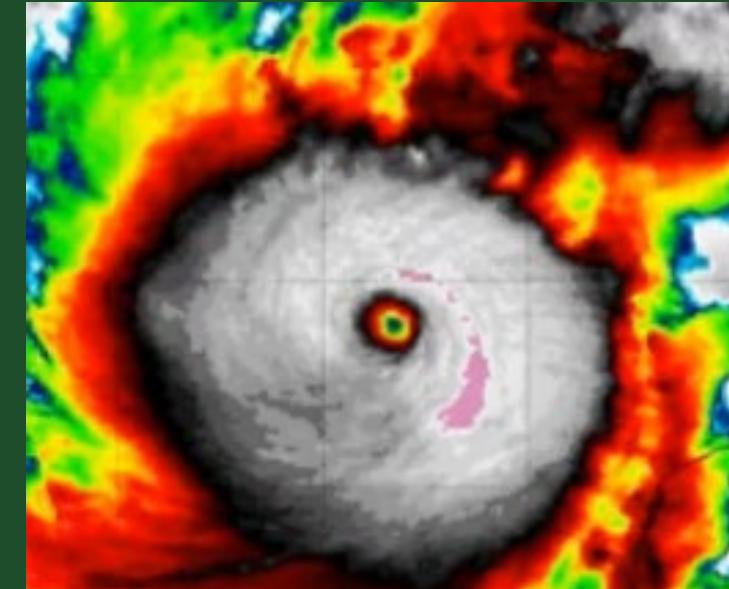


Atlantic Basin Seasonal Hurricane Outlook for 2025

Phil Klotzbach, Department of Atmospheric
Science, Colorado State University



2025 FORECAST AS OF 3 APRIL 2025

Forecast Parameter	CSU Forecast	1991–2020 Average
Named Storms (NS)	17	14.4
Named Storm Days (NSD)	85	69.4
Hurricanes (H)	9	7.2
Hurricane Days (HD)	35	27.0
Major Hurricanes (MH)	4	3.2
Major Hurricane Days (MHD)	9	7.4
Accumulated Cyclone Energy (ACE)	155	123
ACE West of 60°W	93	73
Net Tropical Cyclone Activity (NTC)	165	135

Seasonal Forecasting is more than this!

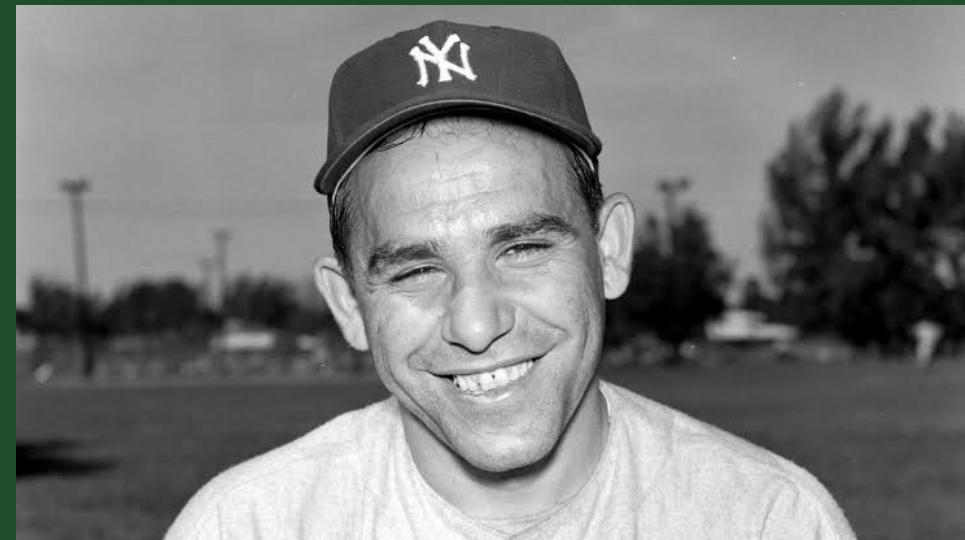


The Essence of Seasonal Forecasting

“It’s tough to make predictions, especially about the future.”

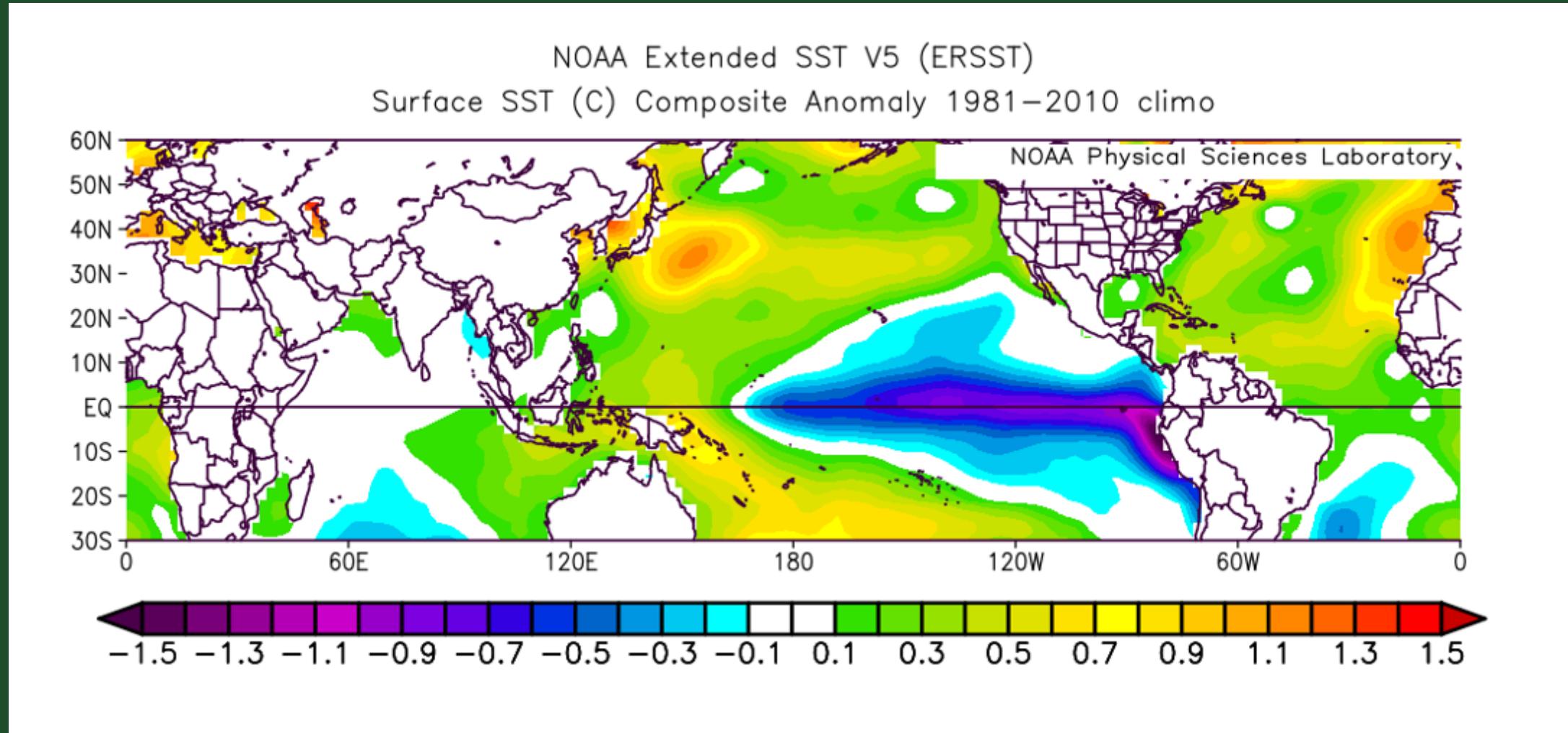
HOWEVER

“You can see a lot by looking”

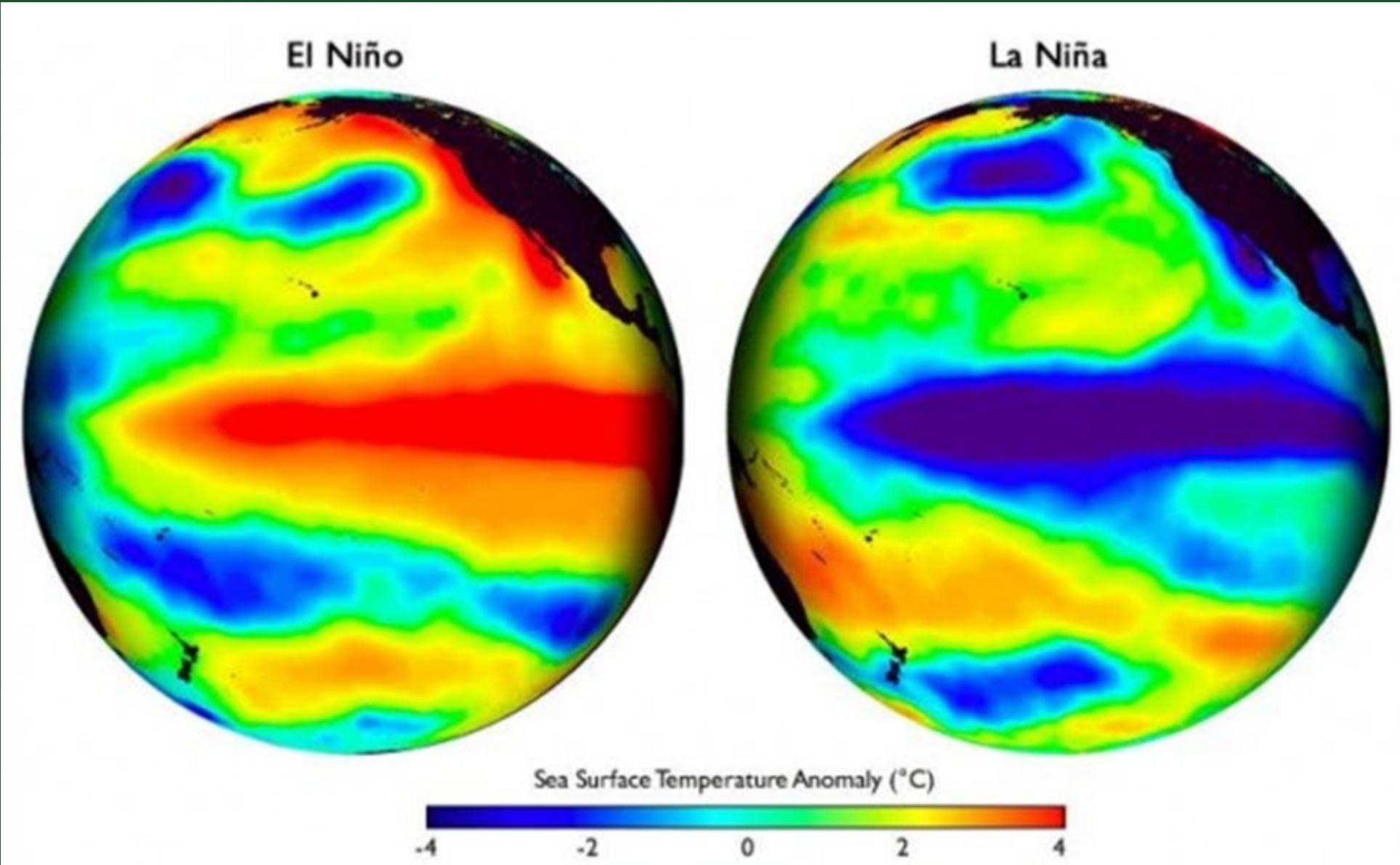


Yogi Berra

June-July Sea Surface Temperatures: Busy Hurricane Seasons minus Quiet Hurricane Seasons

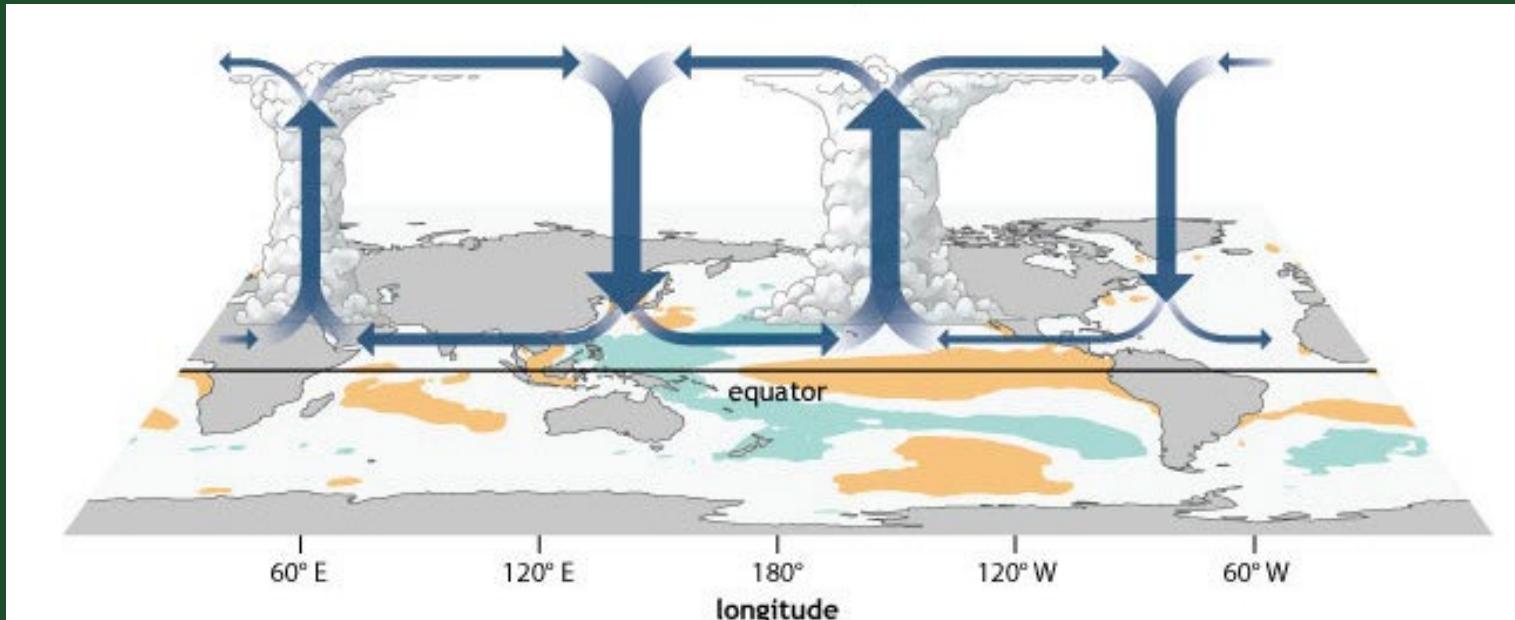


What is El Niño/La Niña?

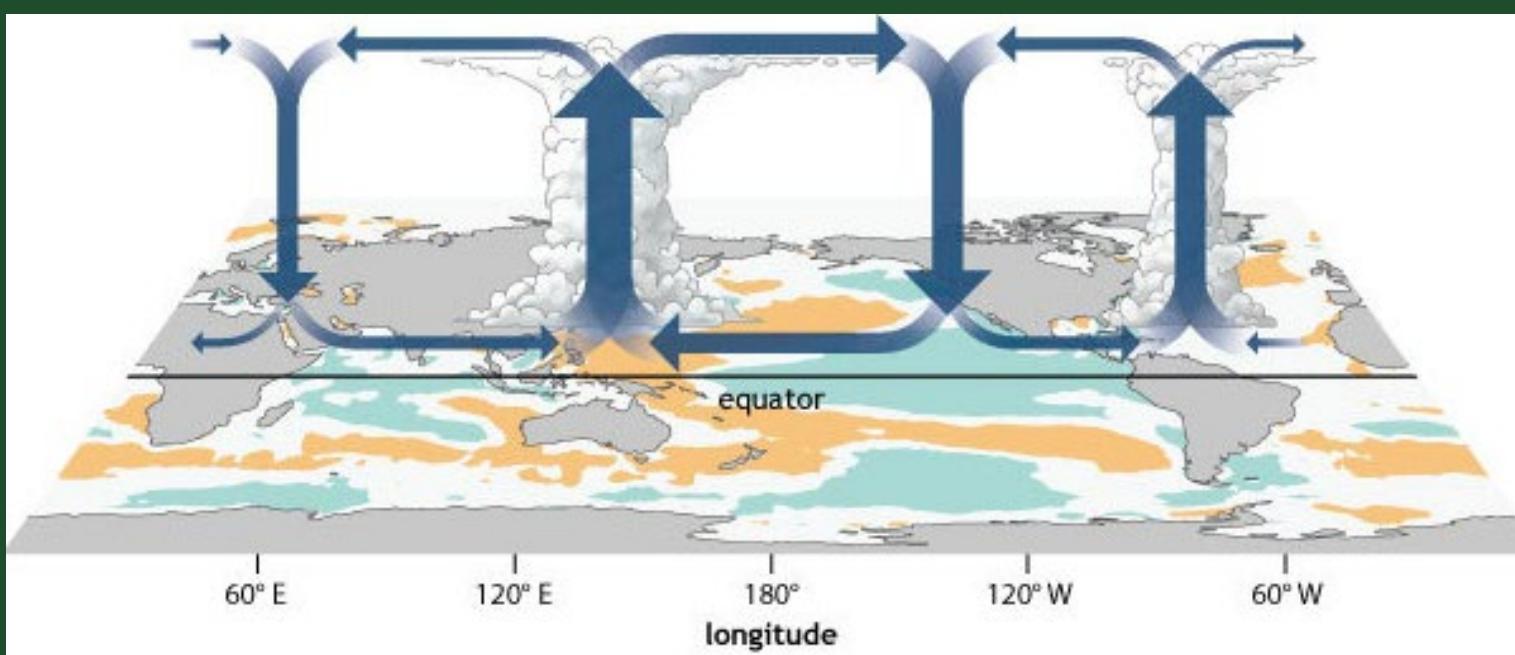


ENSO's Impact on Tropical Circulation

El Niño

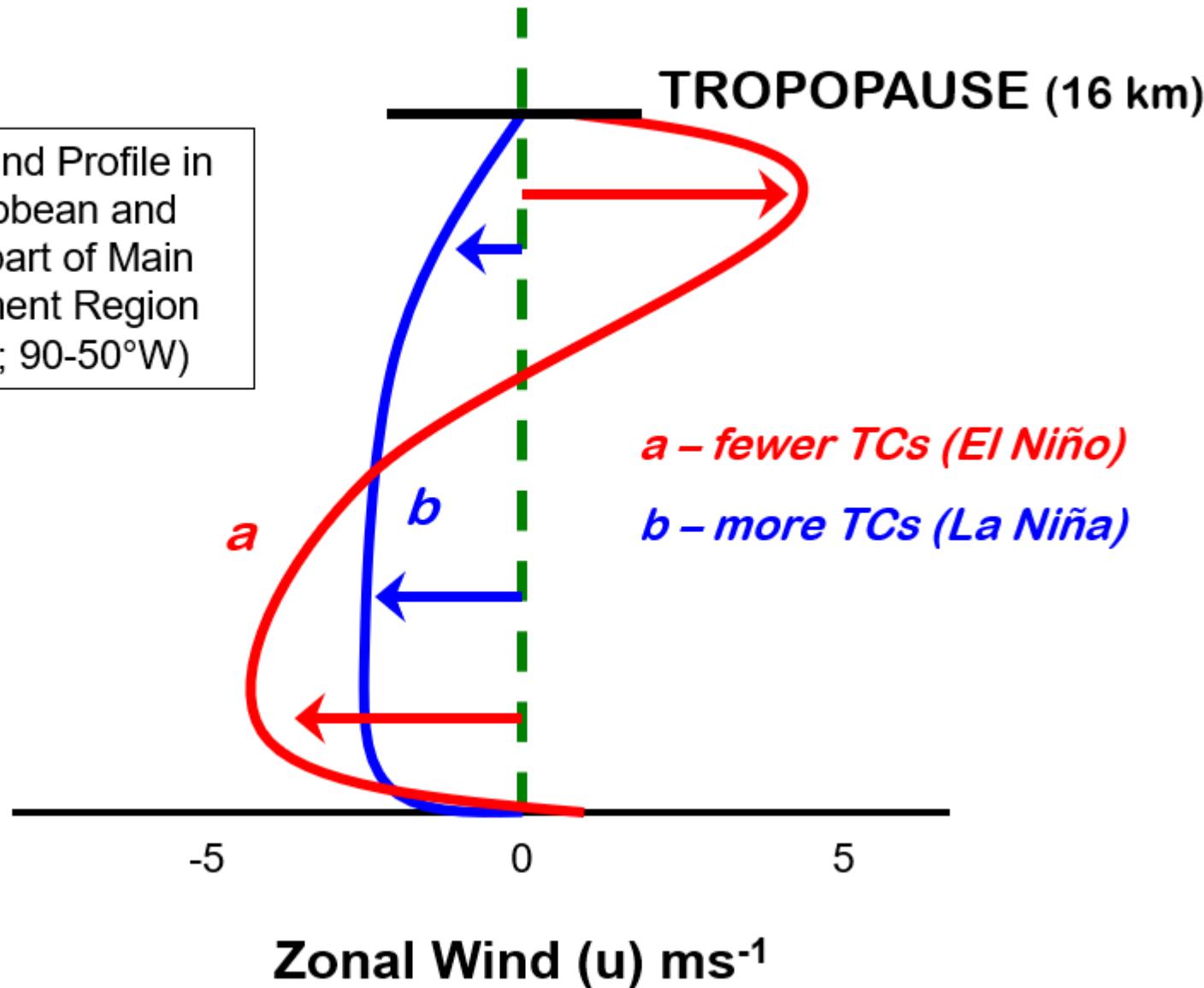


La Niña

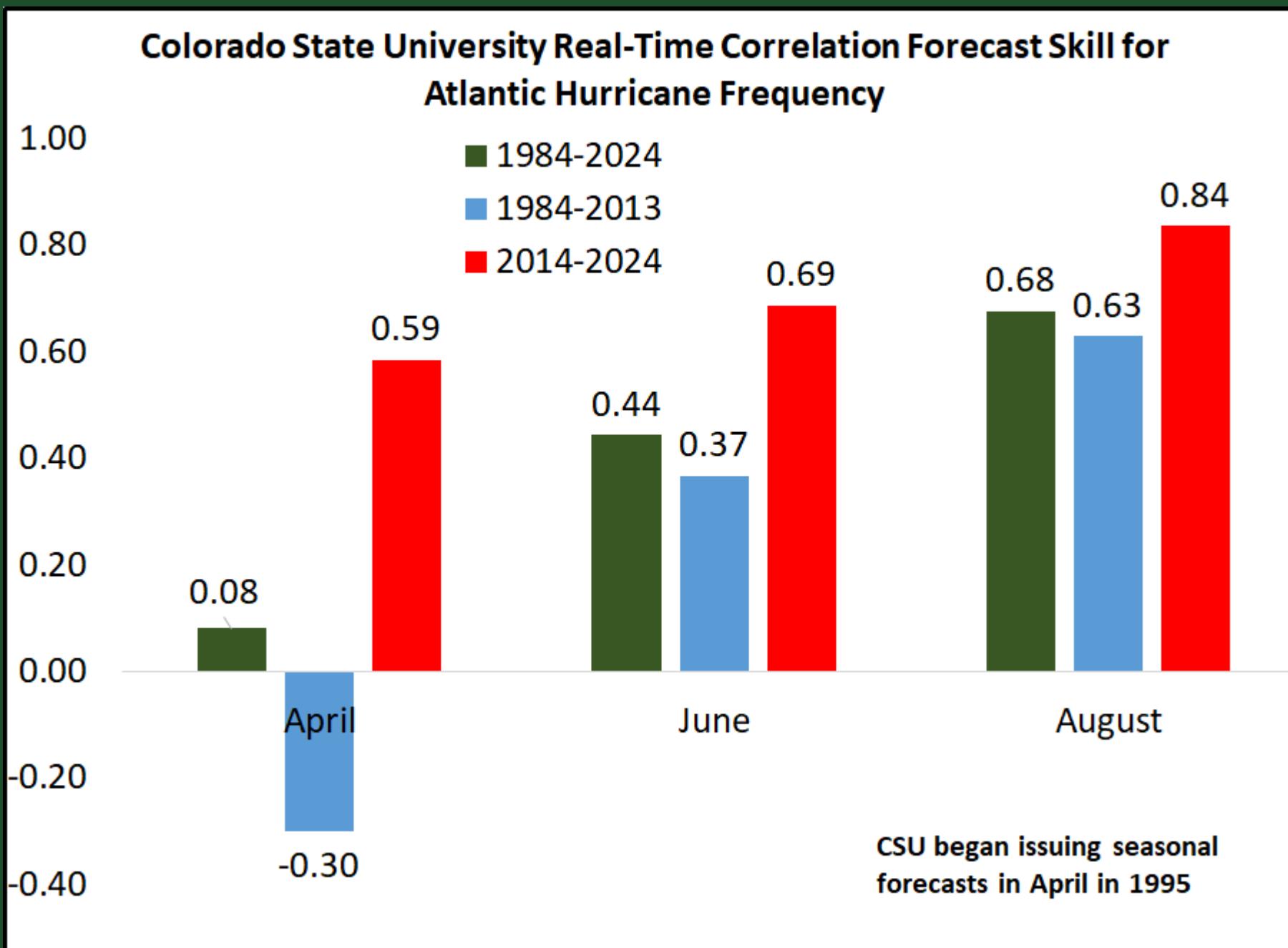


El Niño/La Niña Relationship with Vertical Wind Shear

Vertical Wind Profile in
the Caribbean and
western part of Main
Development Region
(10-20°N; 90-50°W)

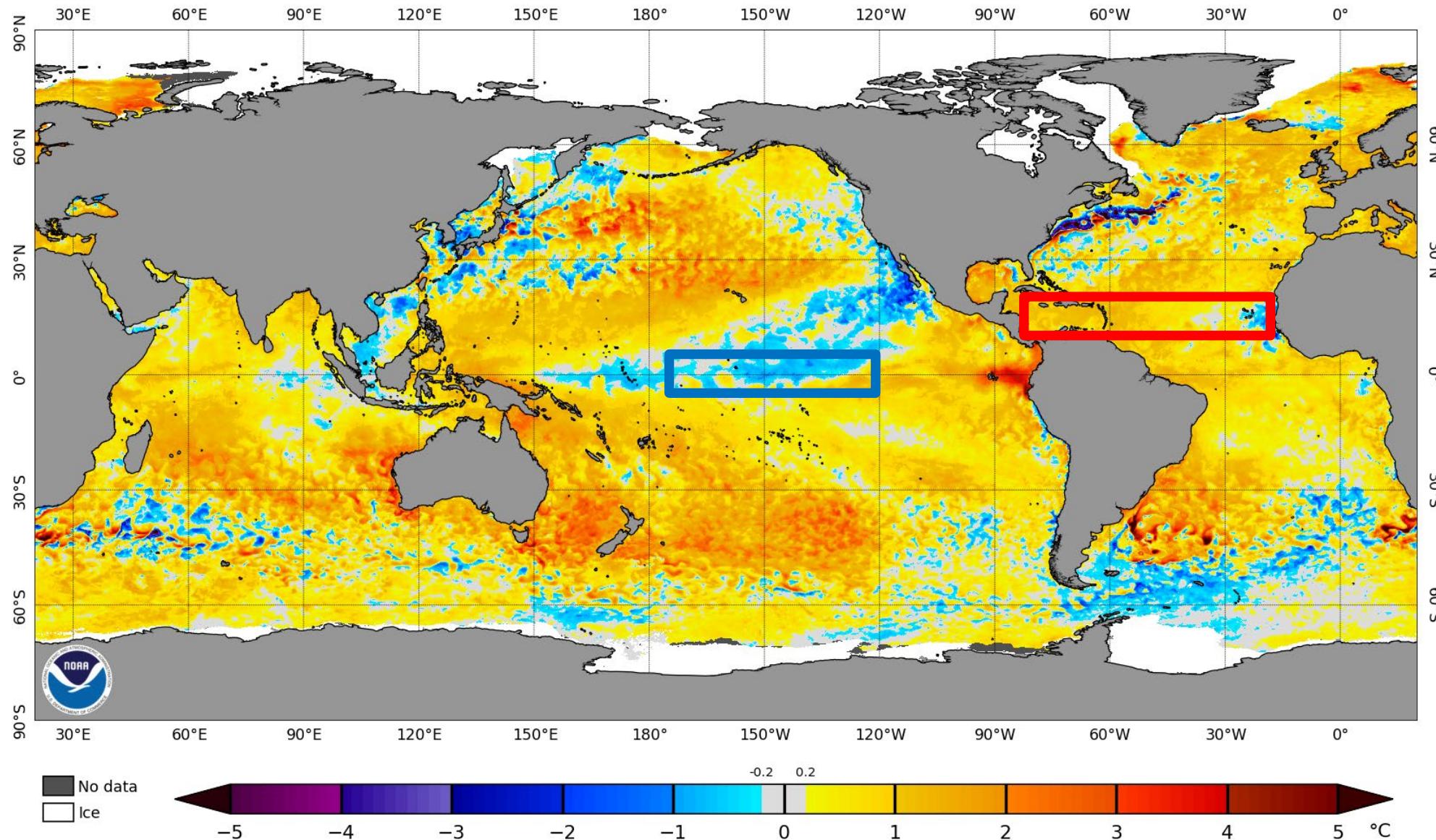


CSU Long-Term Seasonal Hurricane Forecast Track Record

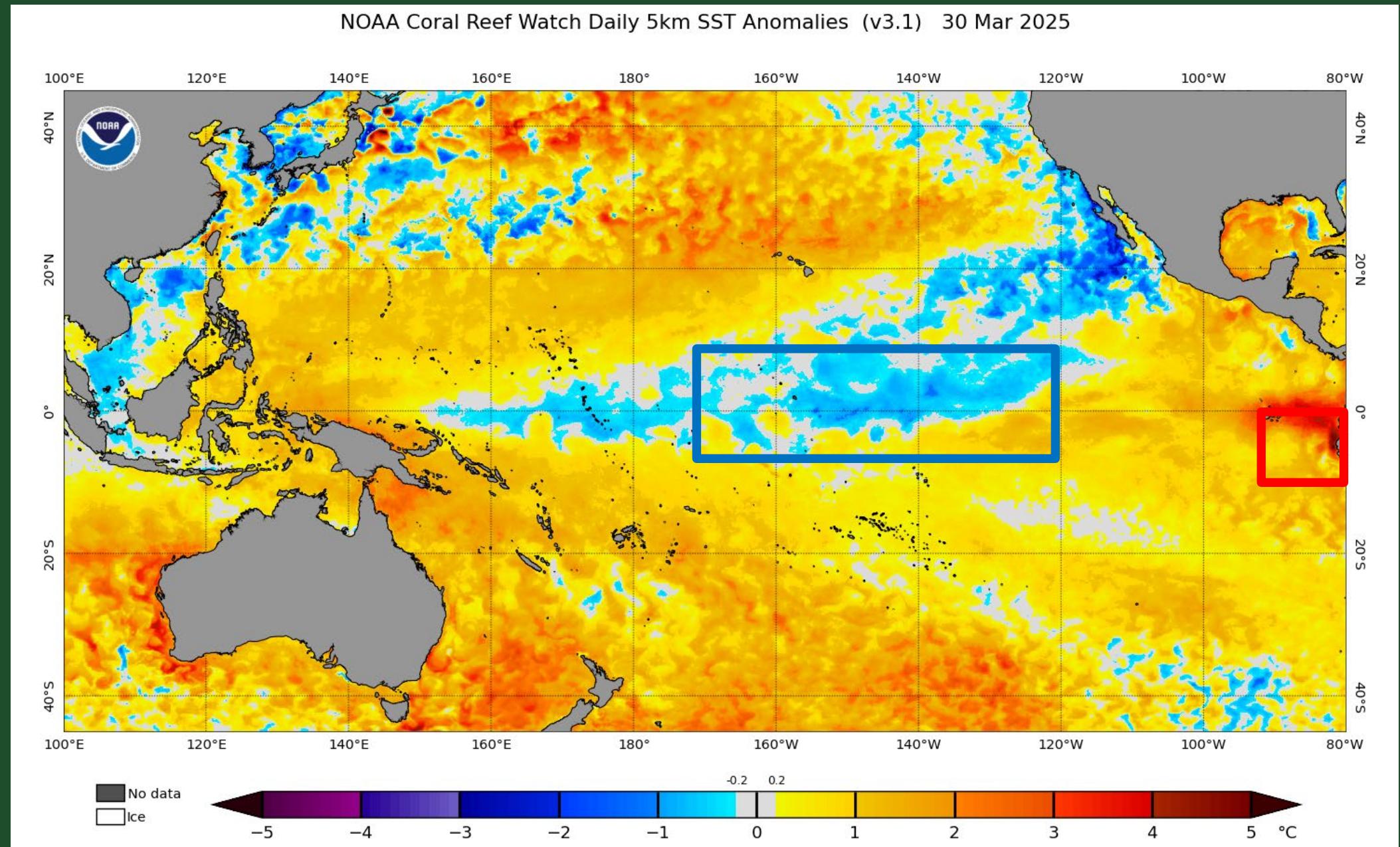


Current Sea Surface Temperature Anomalies

NOAA Coral Reef Watch Daily 5km SST Anomalies (v3.1) 30 Mar 2025

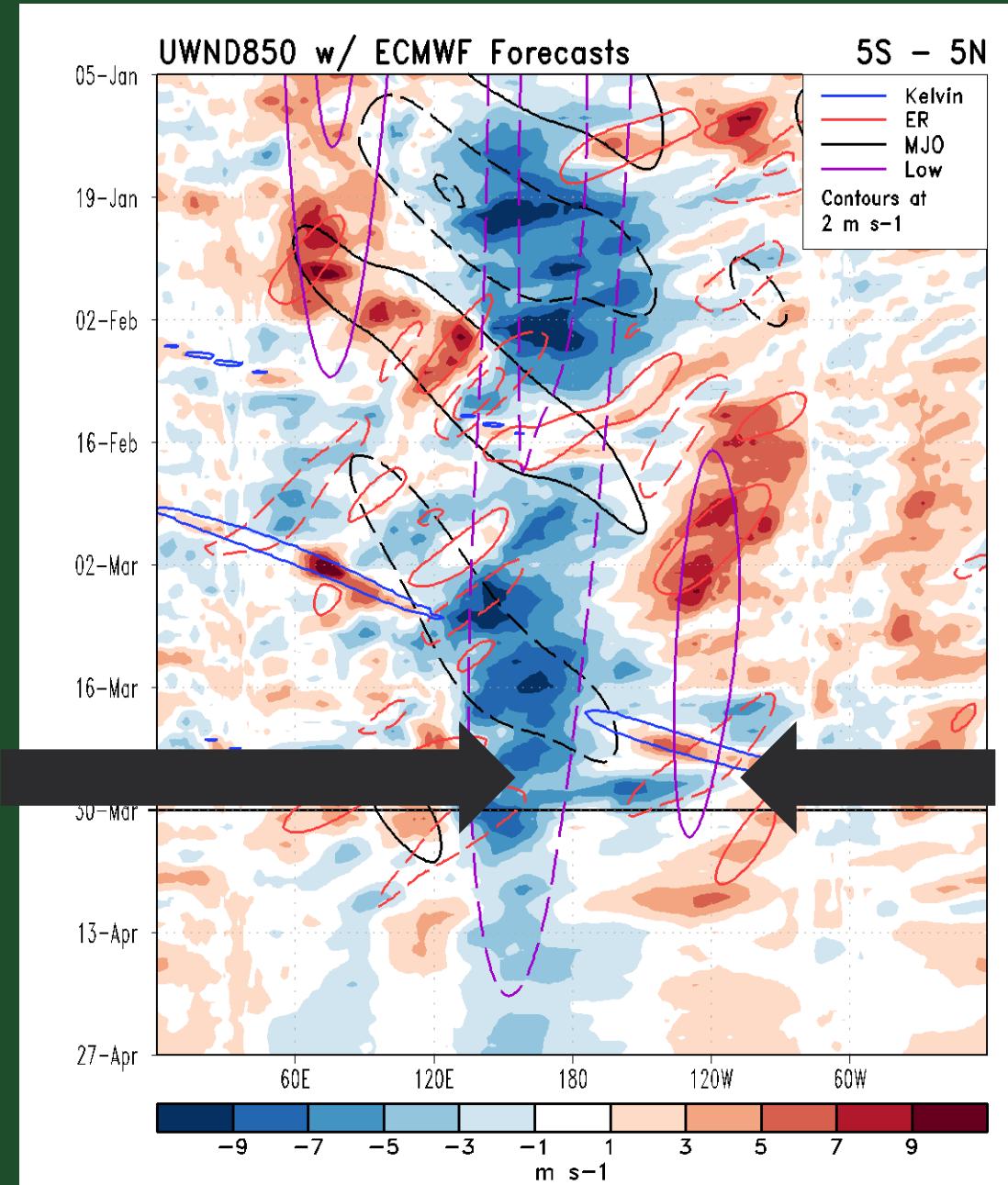


Weak La Niña Looks to be on its Last Legs!

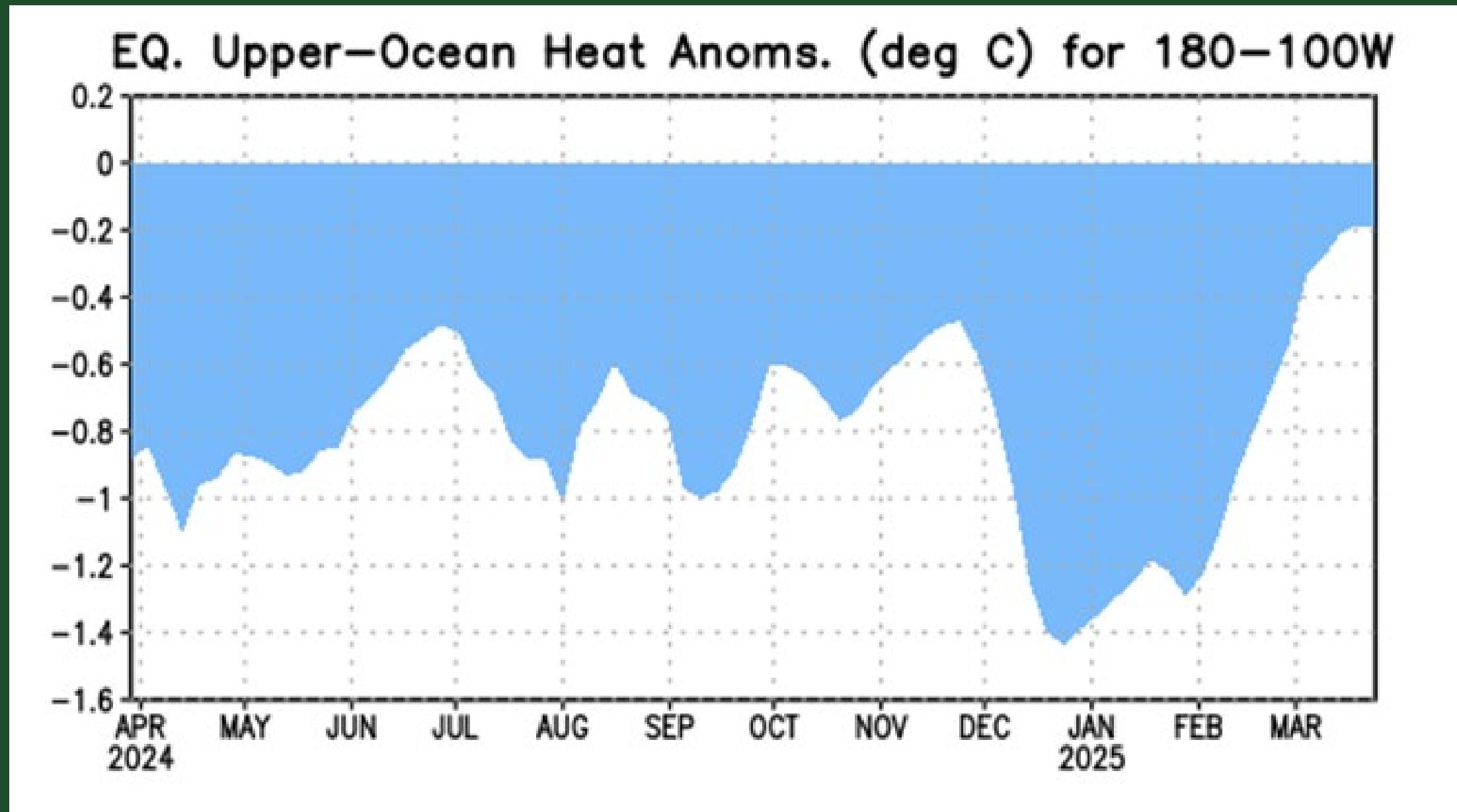


Pronounced Dipole in Pacific Trade Wind Anomalies

Strong Trade Winds

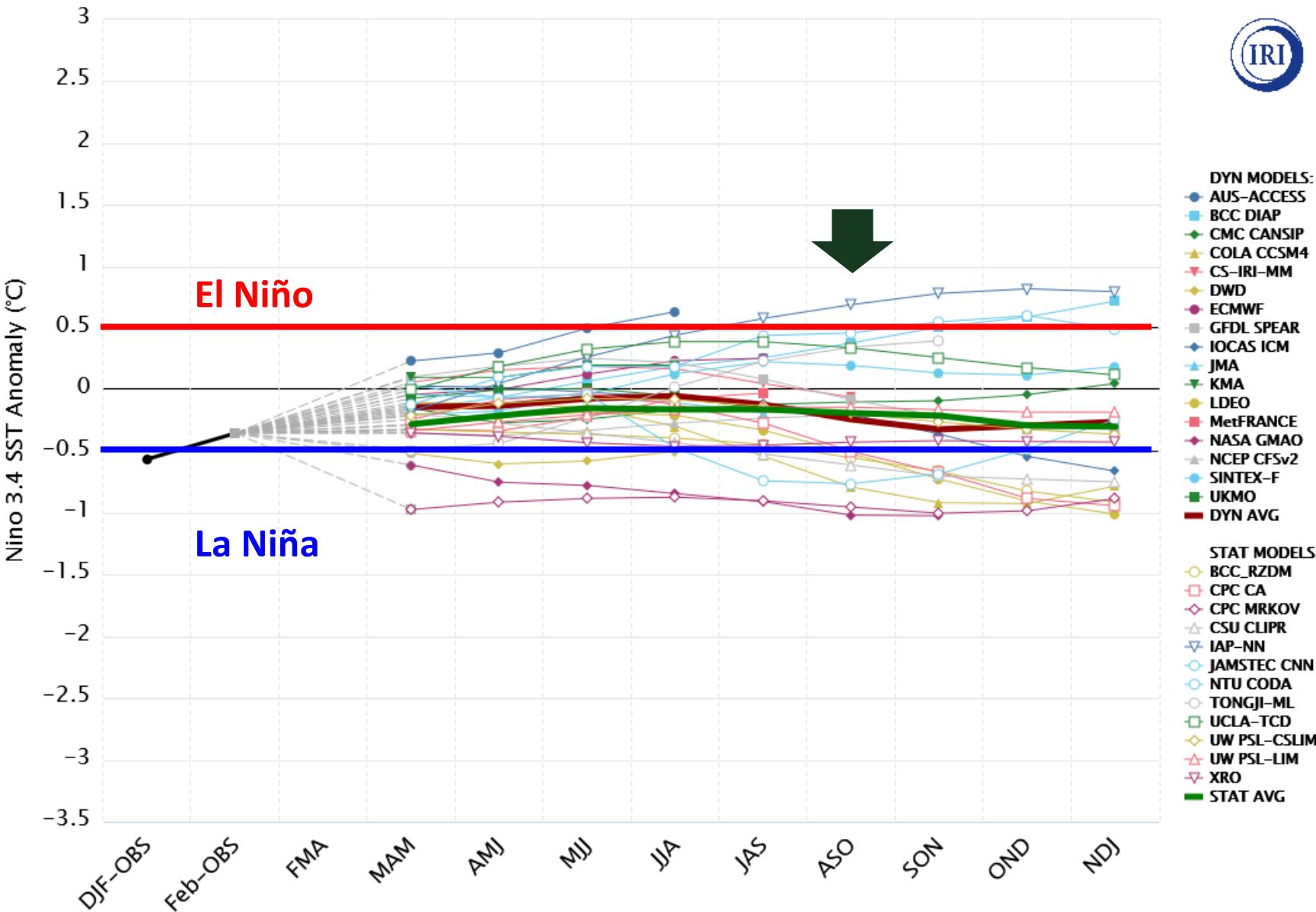


Eastern and Central Tropical Pacific Subsurface Anomalously Warming

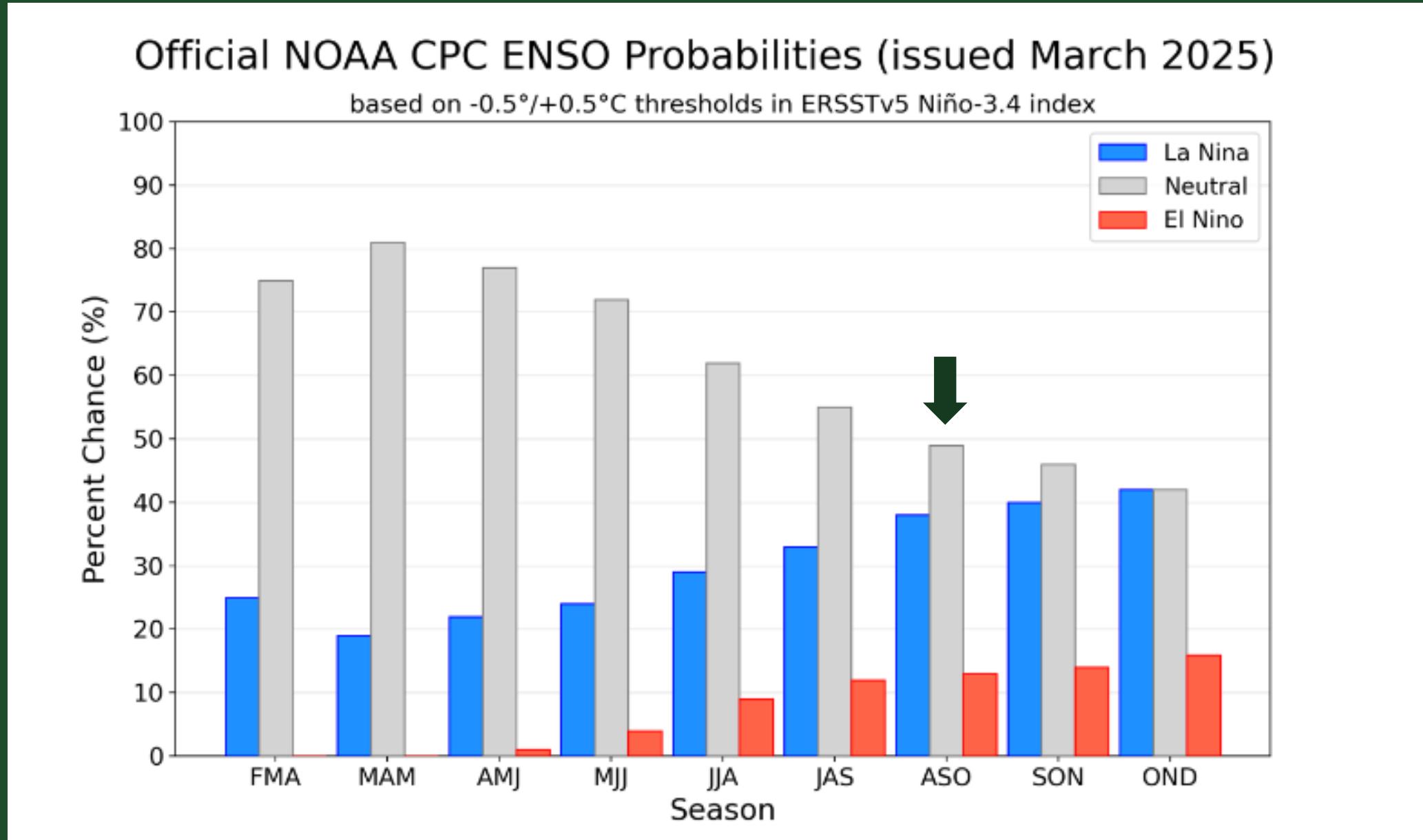


Climate Model Predictions for ENSO

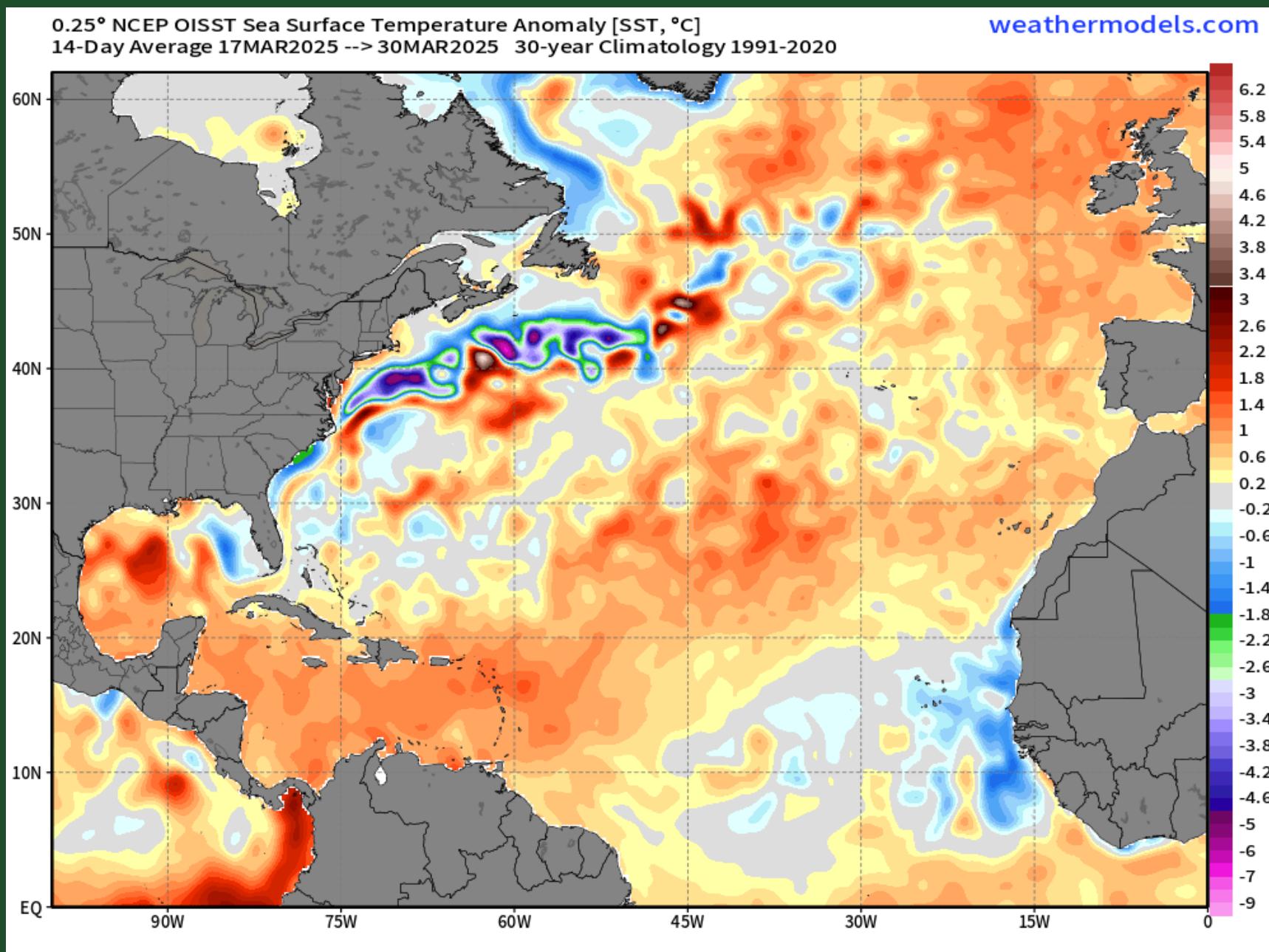
Model Predictions of ENSO from Mar 2025



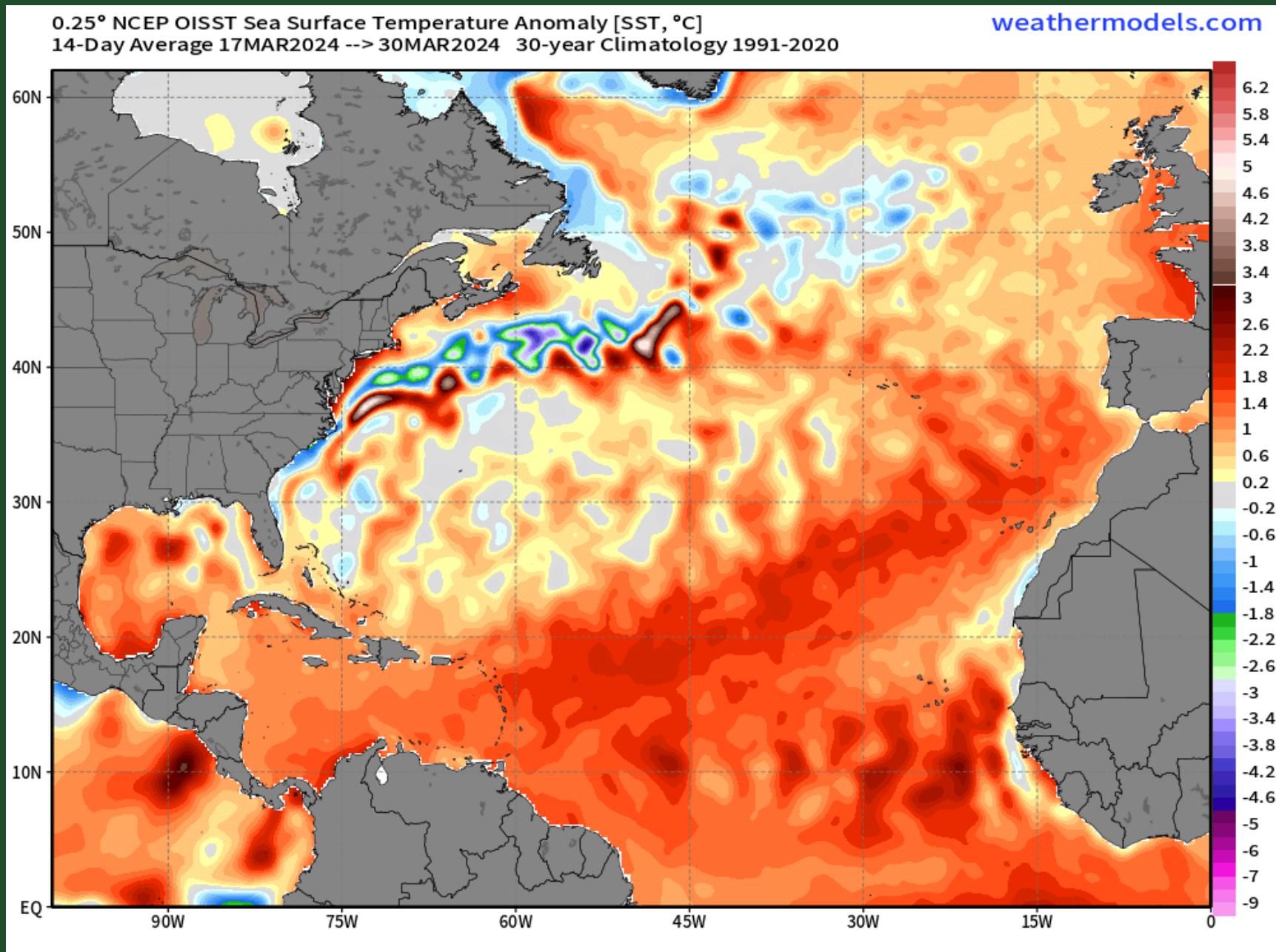
Official NOAA Forecast Favors ENSO Neutral for Aug–Oct



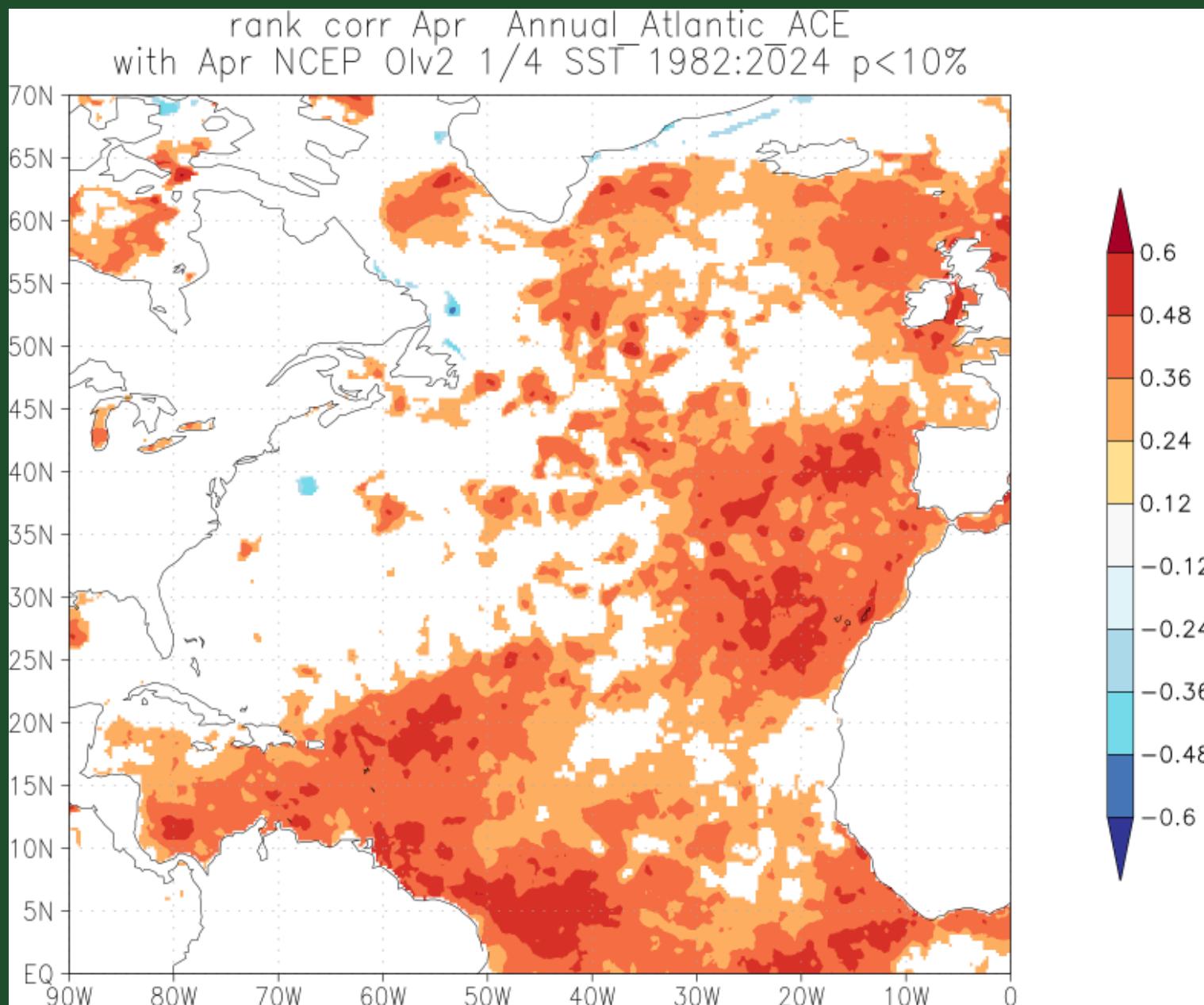
Current North Atlantic Sea Surface Temperature Anomalies



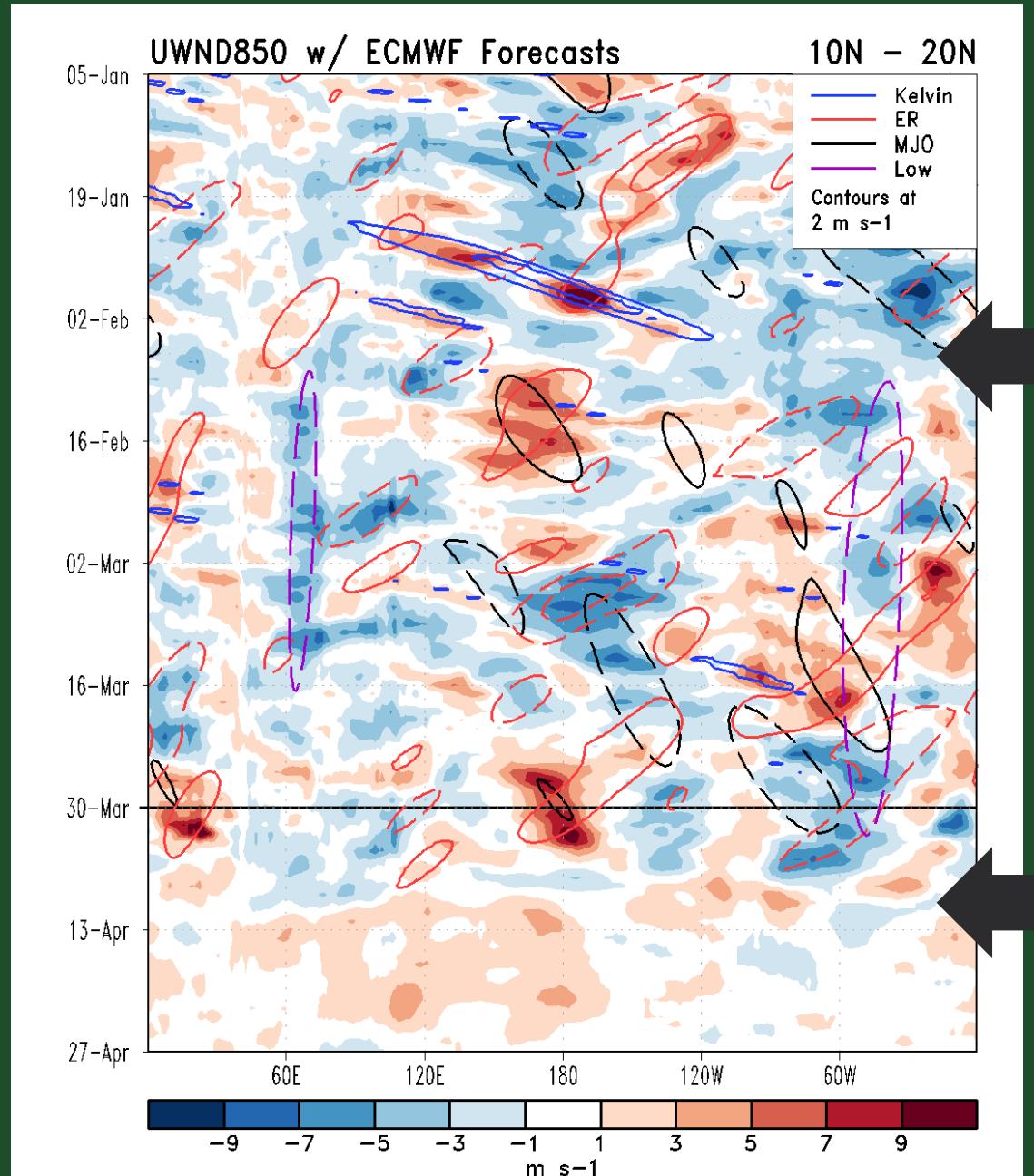
Thankfully Not as Warm as Last Year at This Time!



April Atlantic SST Rank Correlation with Atlantic ACE



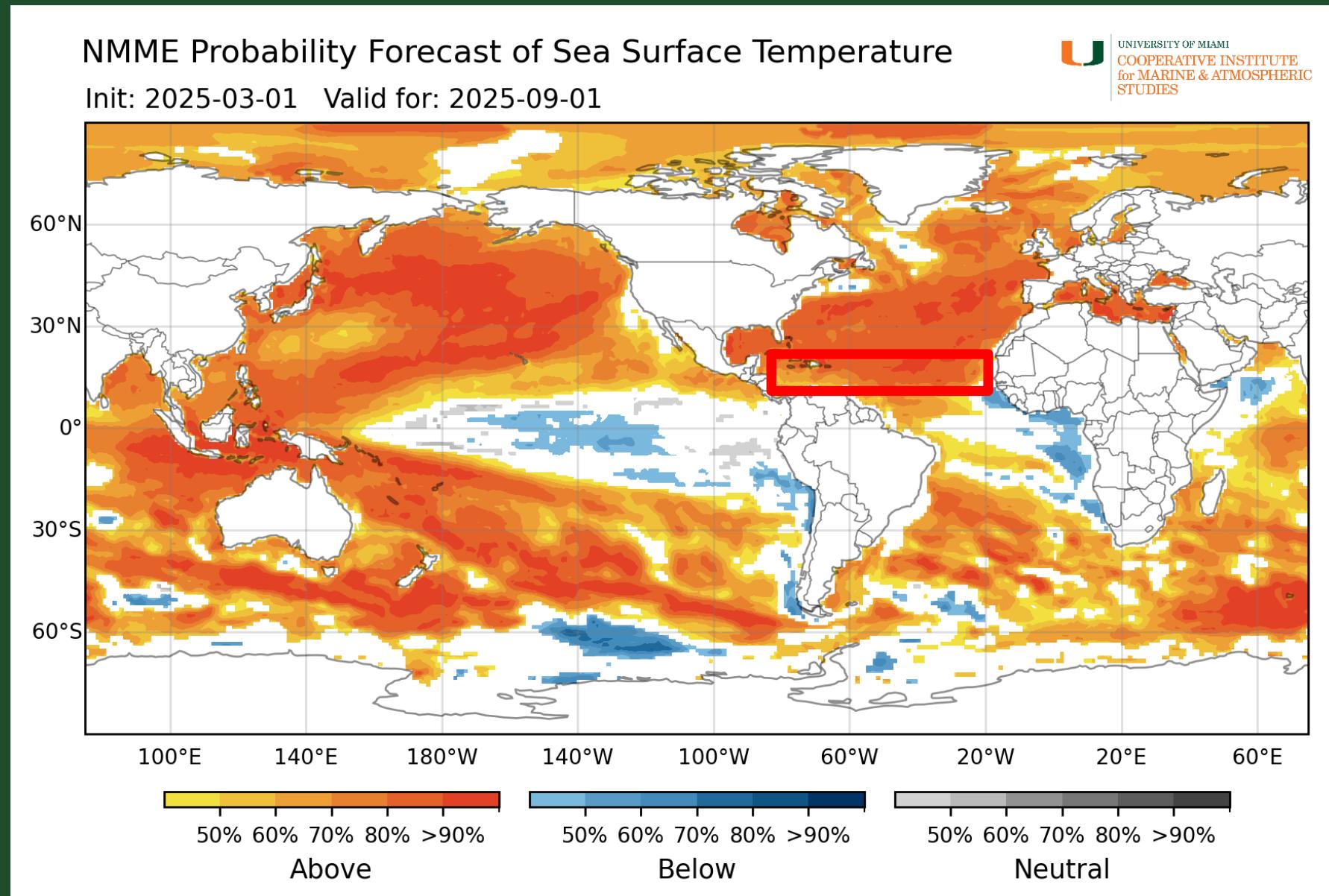
Strong Trades Forecast to Weaken in Next Few Weeks



Strong Trade
Winds

Weaker Trade
Winds

NMME Forecasting High Probability of Warm Atlantic for September



ECMWF July–September Probability Sea Surface Temperature Forecast

ECMWF Seasonal Forecast

Prob(most likely category of forecast SST)

Forecast start is 01/03/25, climate period is 1993-2016

Ensemble size = 51, climate size = 600

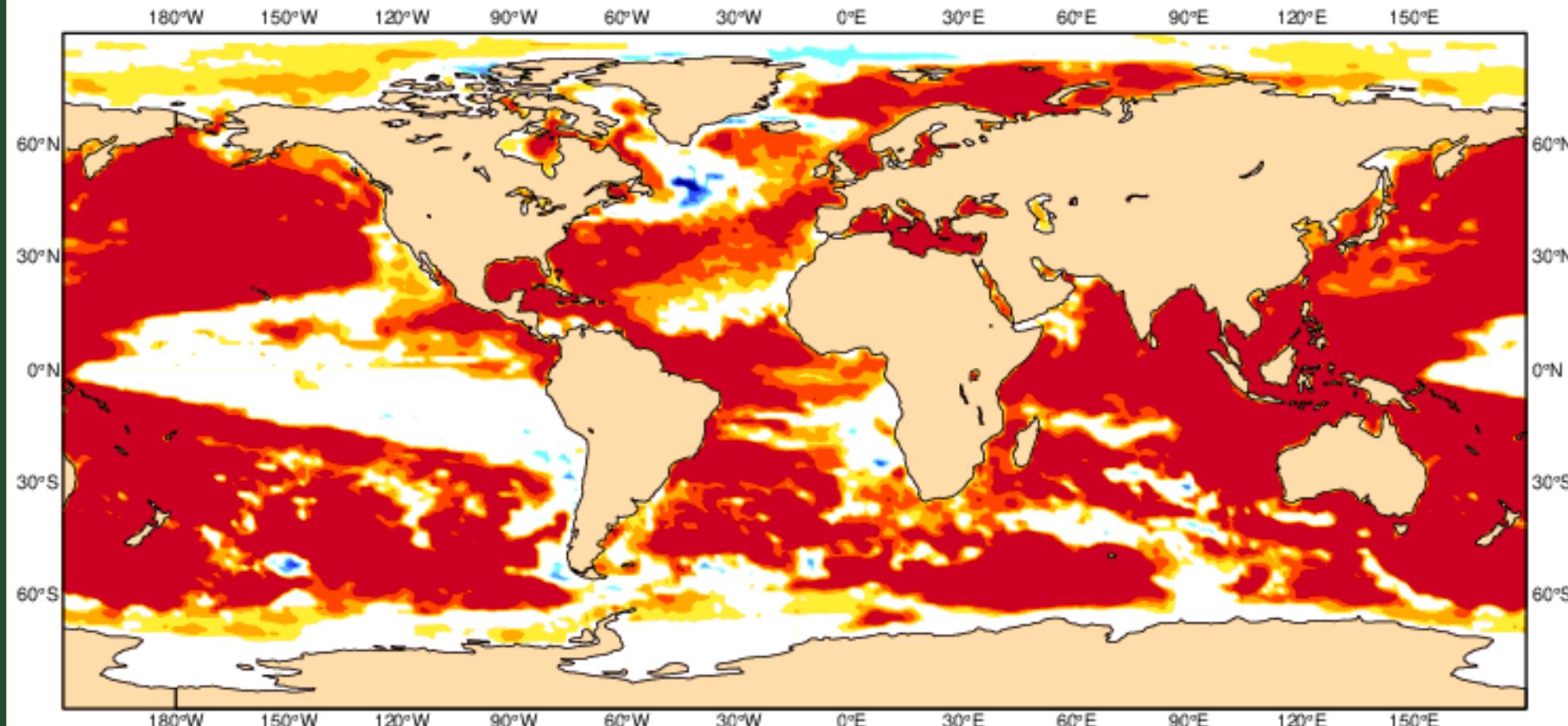
System 5

JAS 2025

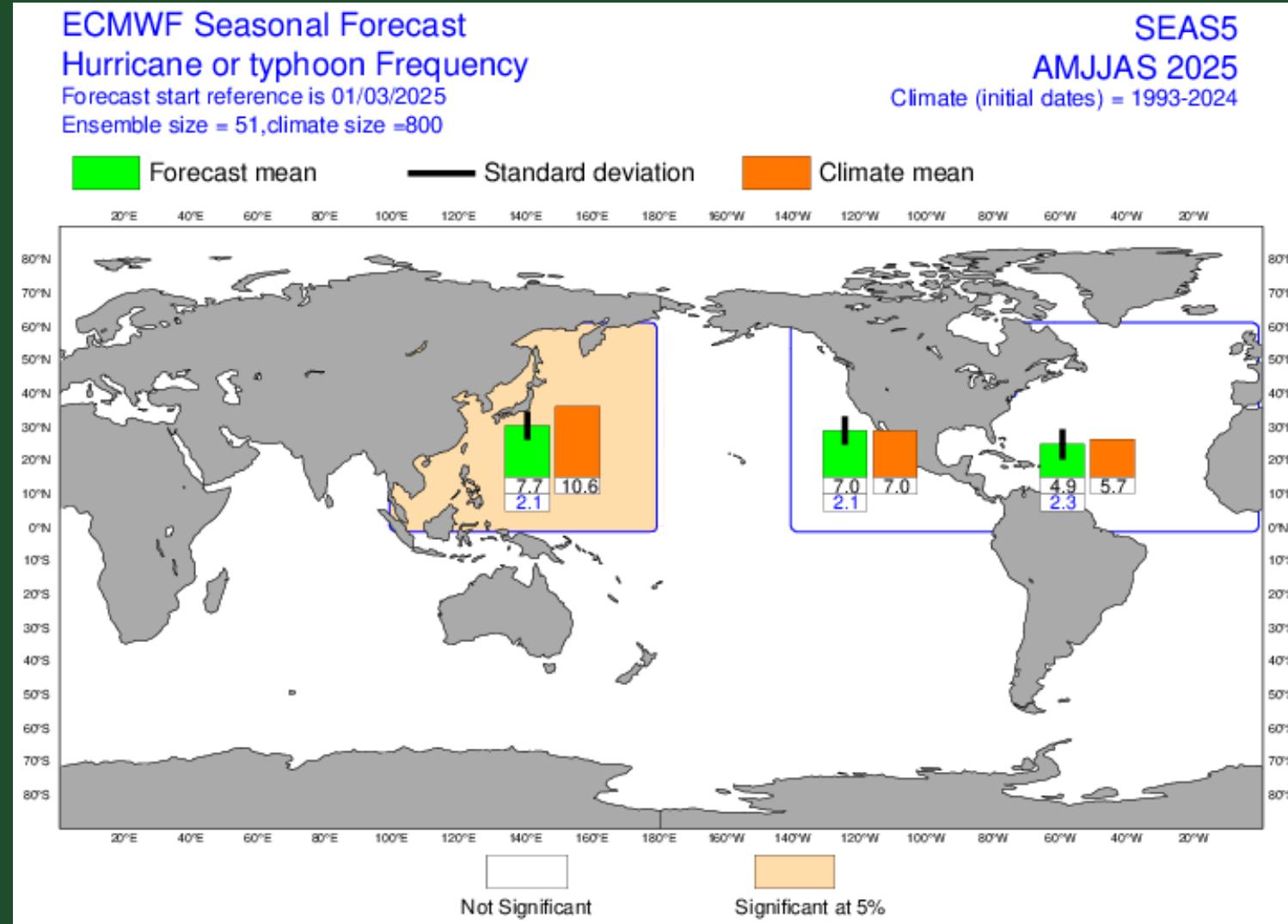
<---- Prob(below lower tercile)

Prob(above upper tercile) ---->

■ 70..100% ■ 60..70% ■ 50..60% ■ 40..50% ■ other ■ 40..50% ■ 50..60% ■ 60..70% ■ 70..100%

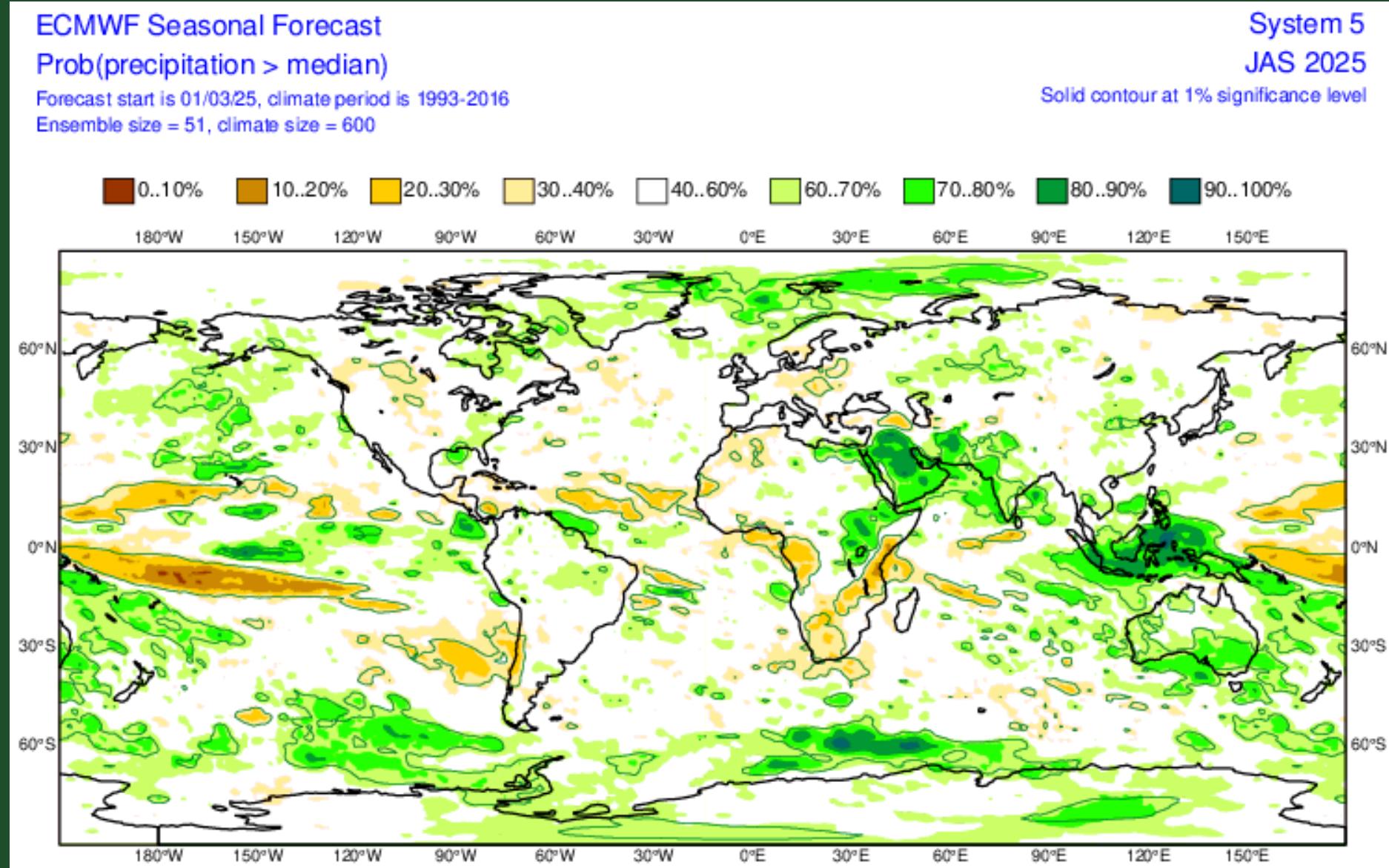


ECMWF Atlantic Hurricane Forecast through September

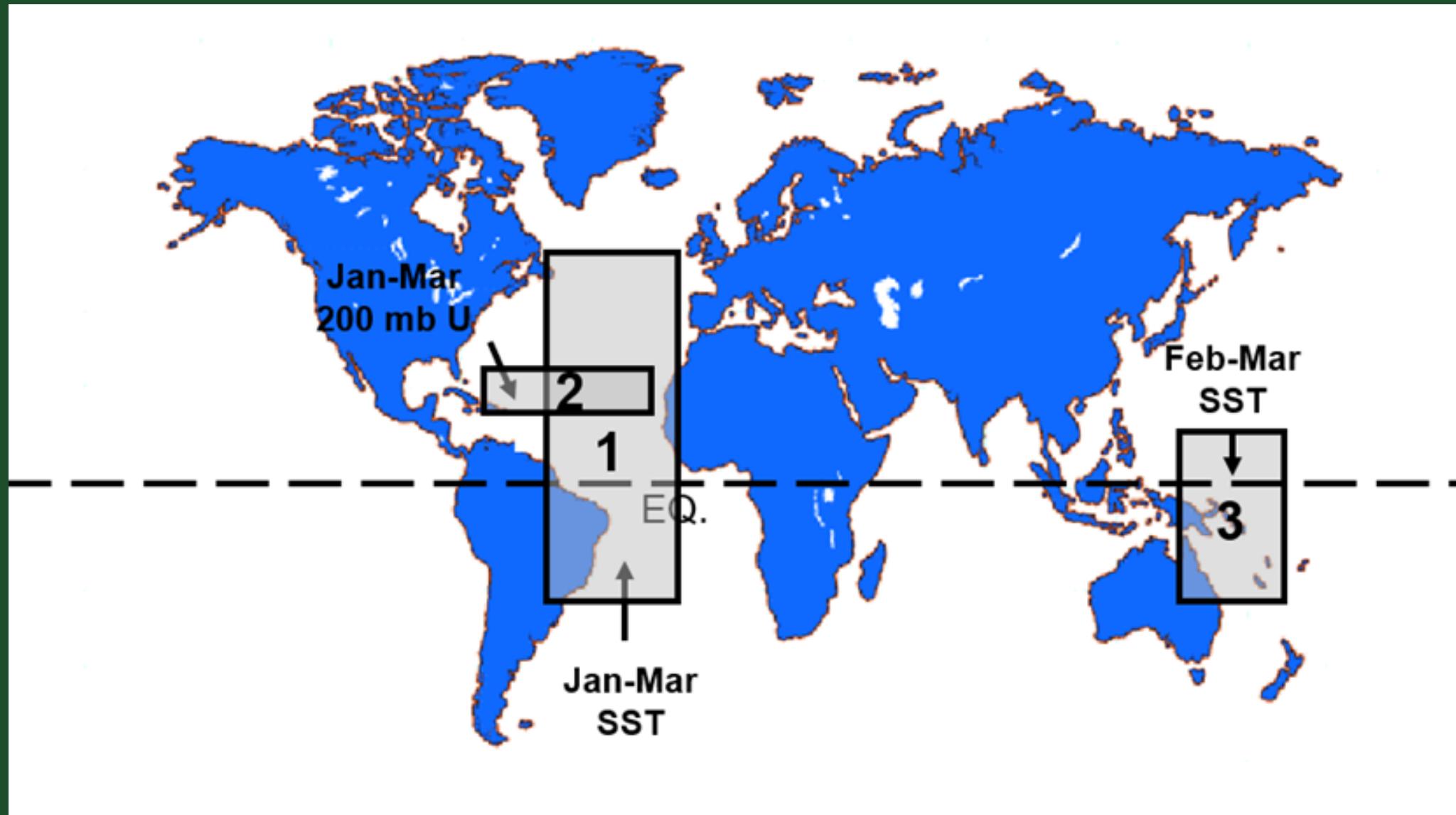


Forecast – 4.9
Climatology – 5.7

ECMWF July–September Precipitation Forecast



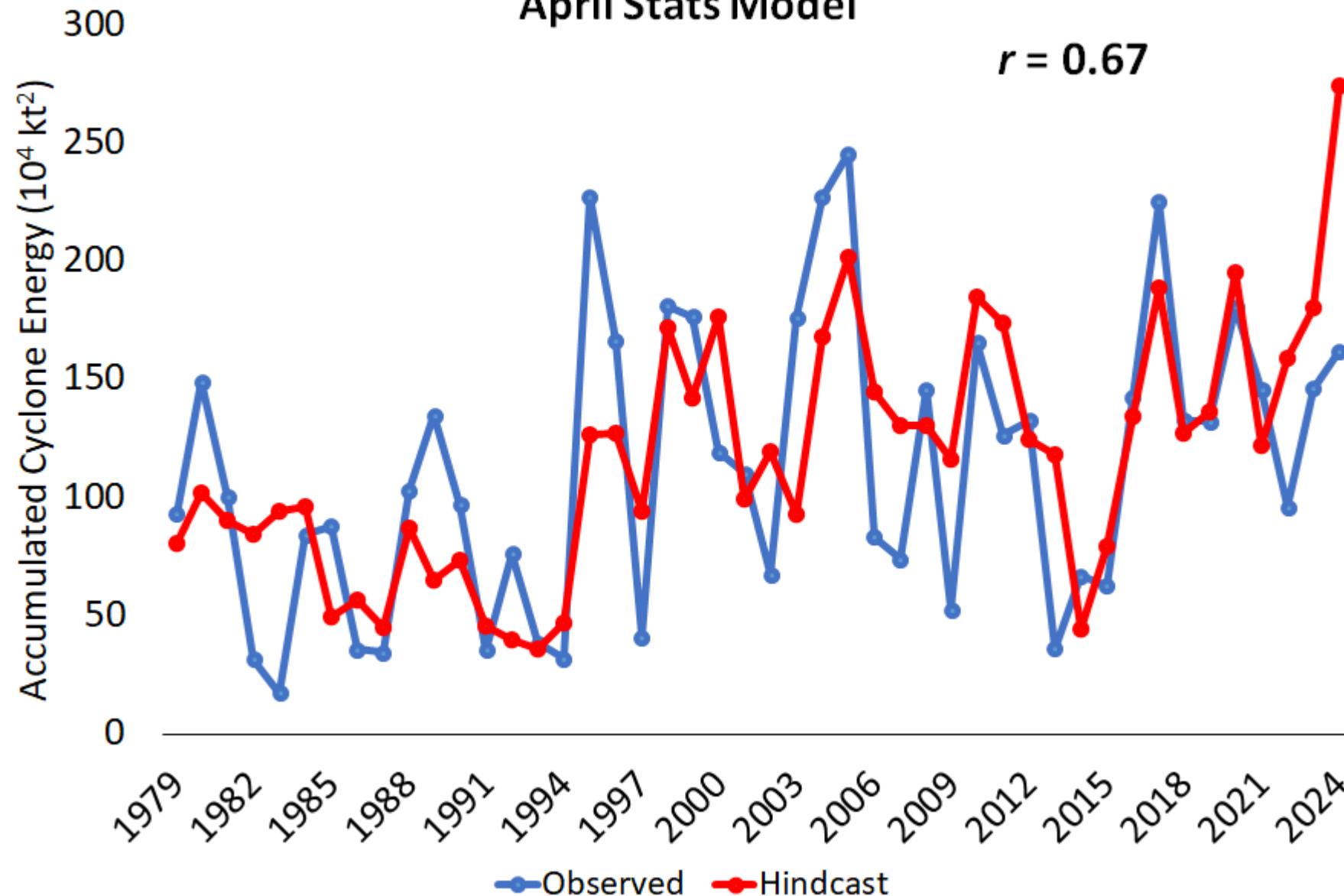
April Statistical Model Forecast



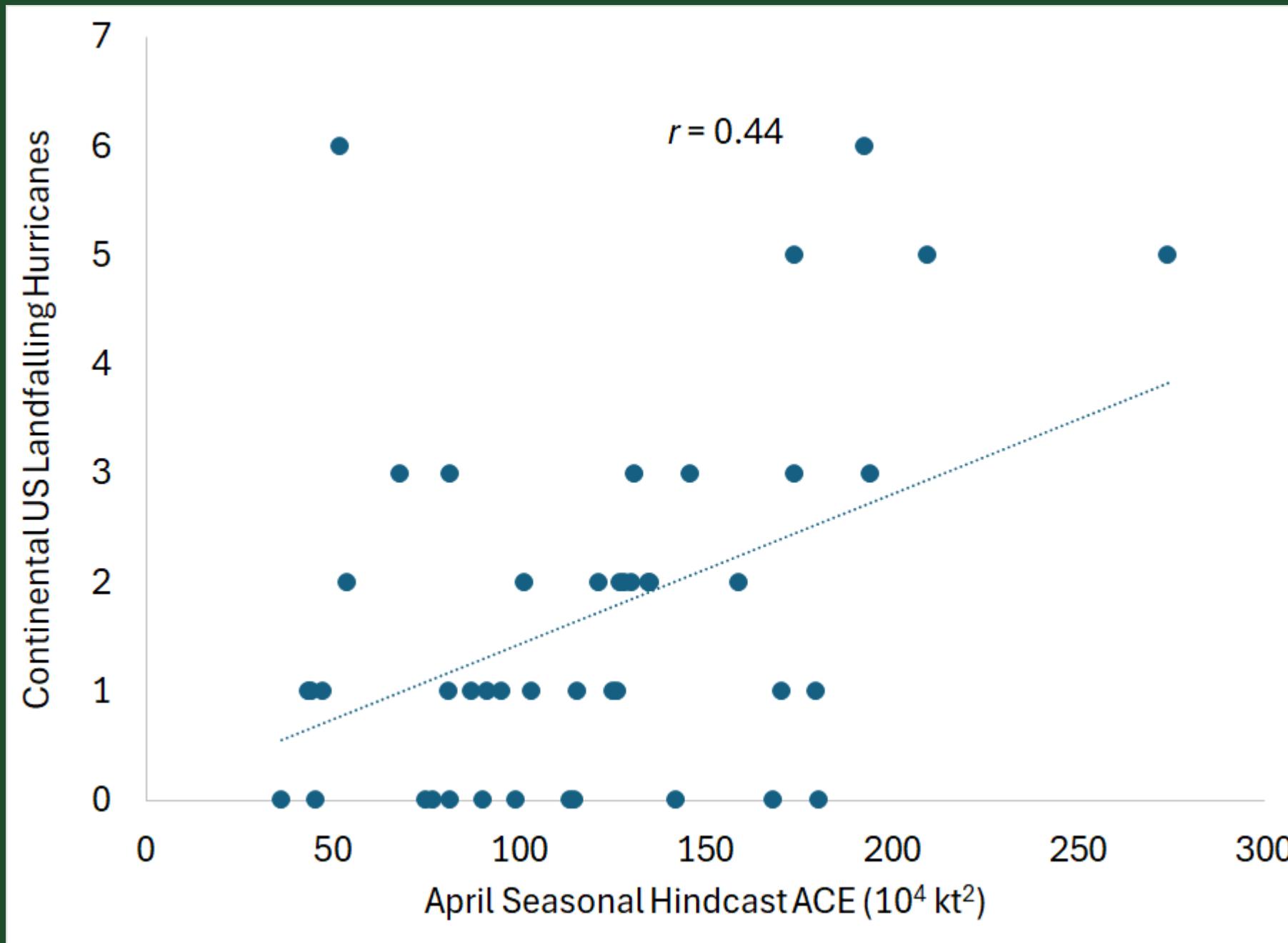
Statistical Model Hindcast Skill

Atlantic ACE Hindcast (1979–2024) - Cross-Validated
April Stats Model

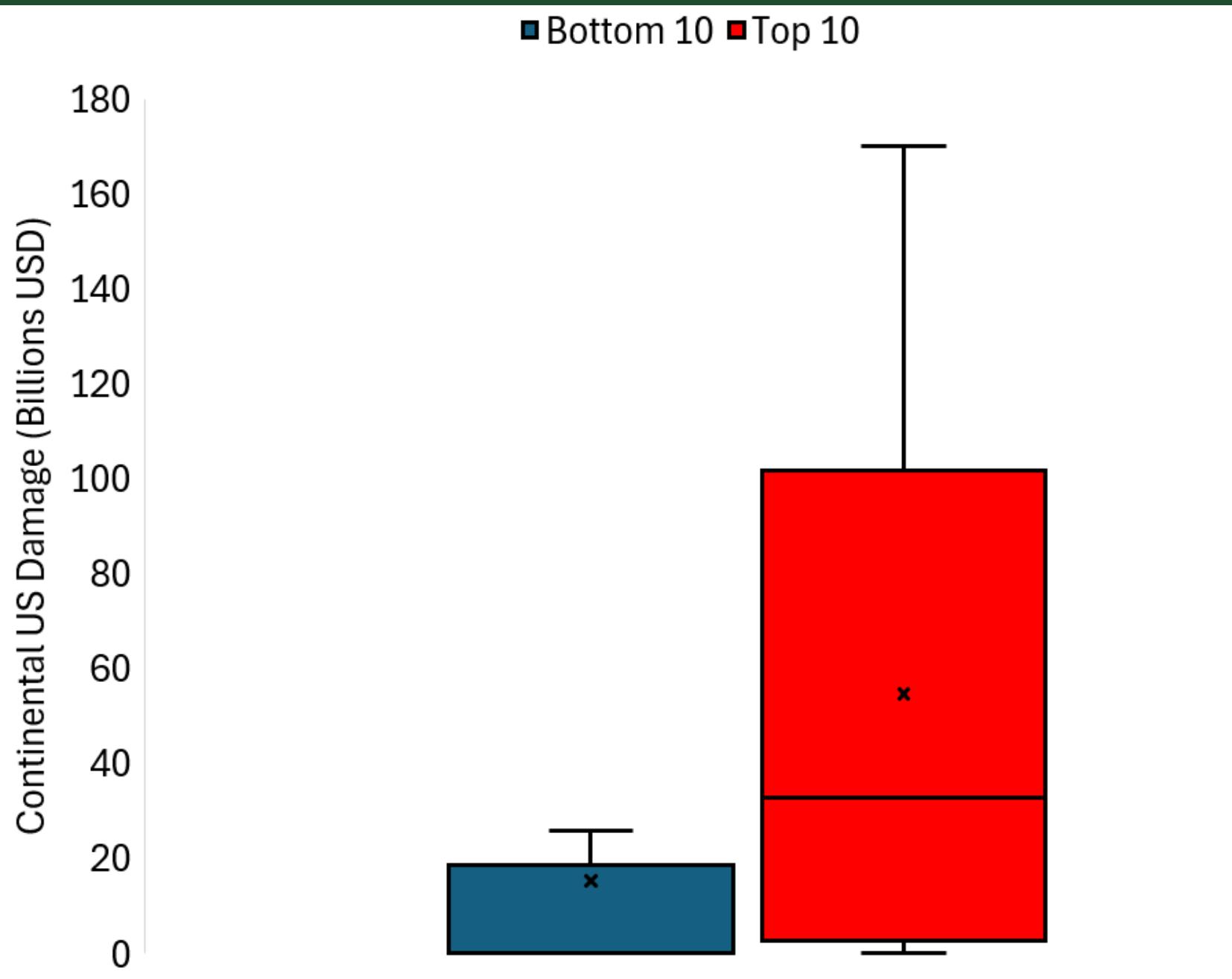
$r = 0.67$



CSU April Statistical Model Hindcasts vs. Continental US Landfalling Hurricanes



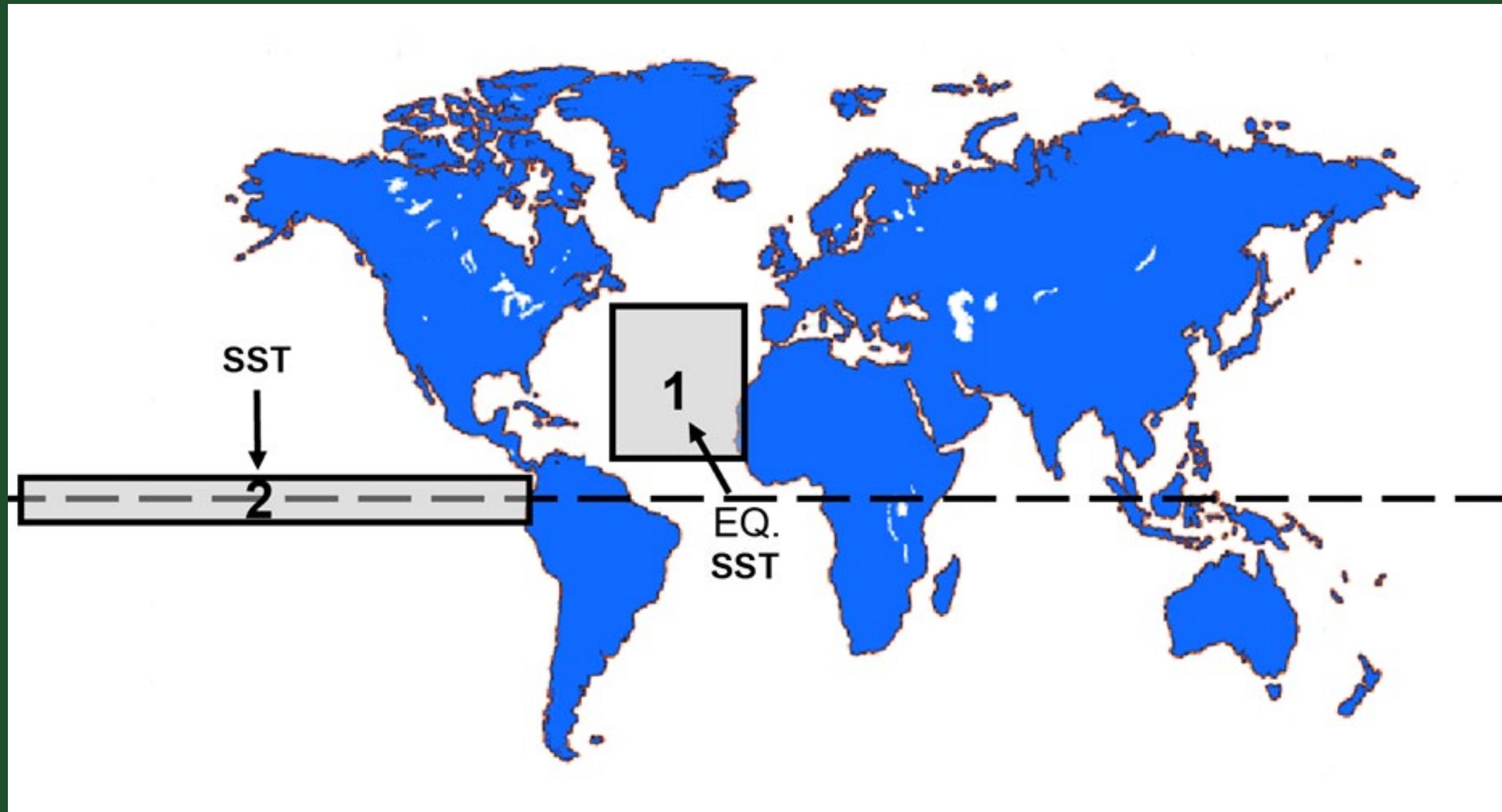
CSU April Stats Model Hindcasts vs. Continental US Hurricane Normalized Damage



2025 Statistical Model Forecast

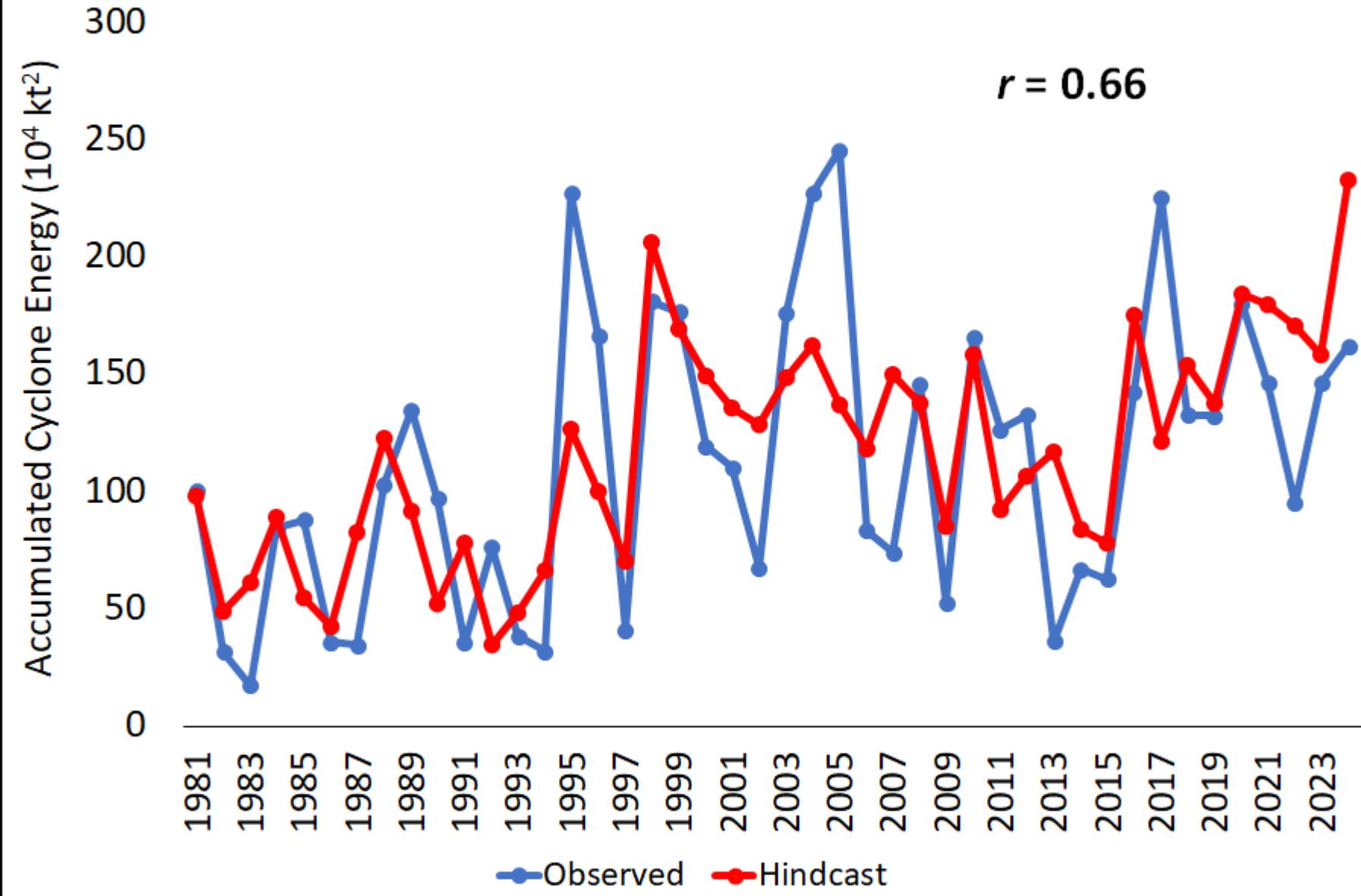
Forecast Parameter 1991-2020 Climatology in Parentheses	Statistical Model Forecast	Final Forecast
Named Storms (NS) (14.4)	17.6	17
Named Storm Days (NSD) (69.4)	81.3	85
Hurricanes (H) (7.2)	8.4	9
Hurricane Days (HD) (27.0)	33.5	35
Major Hurricanes (MH) (3.2)	3.9	4
Major Hurricane Days (MHD) (7.4)	9.7	9
Accumulated Cyclone Energy (ACE) (123)	151	155
Net Tropical Cyclone Activity (NTC) (135)	166	165

Statistical/Dynamical Model Forecast – Forecasting August Values



Statistical/Dynamical Model Hindcast Skill (ECMWF)

Atlantic ACE Hindcast (1981–2024) - March ECMWF



ECMWF Forecasts of SST Anomalies: July–September 2025

ECMWF Seasonal Forecast

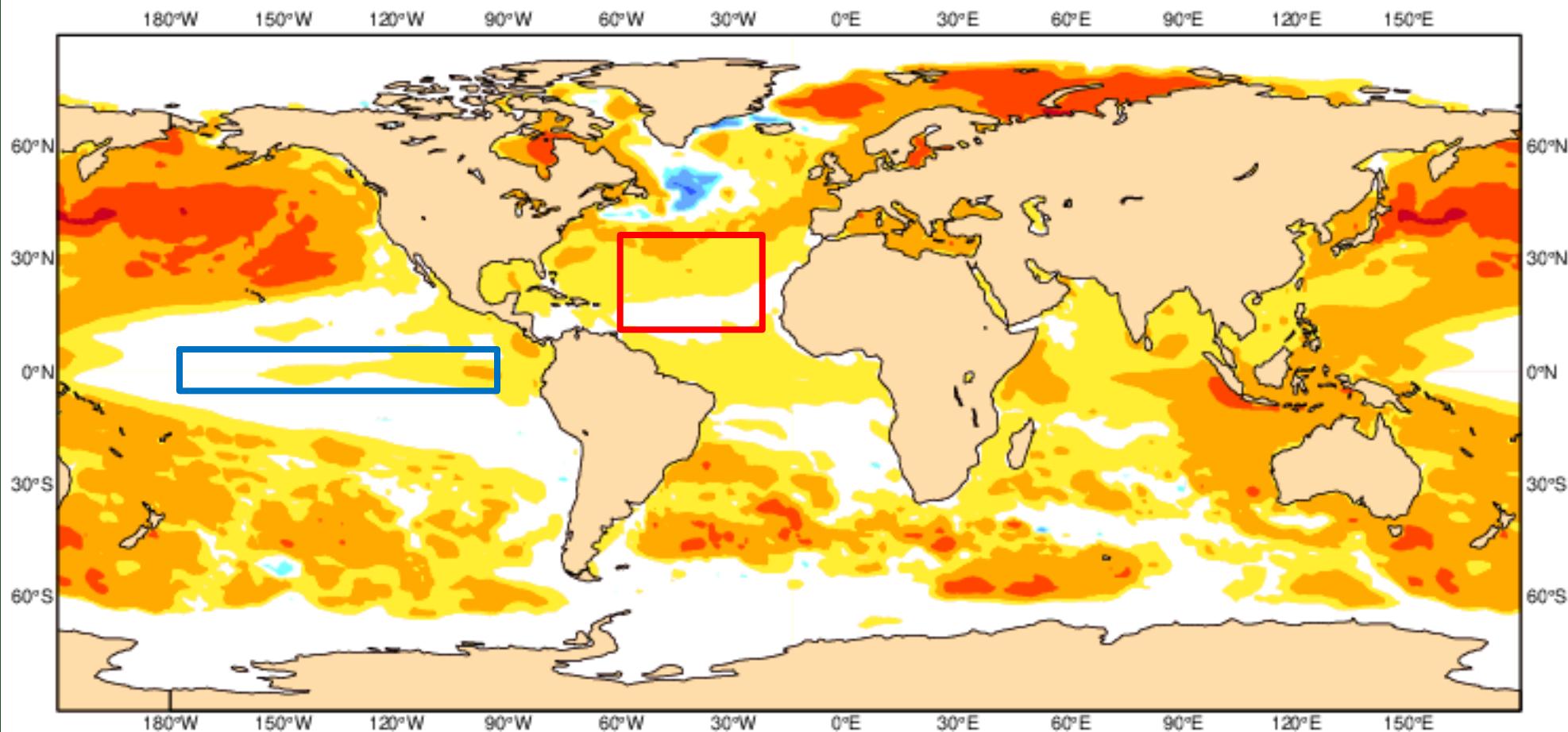
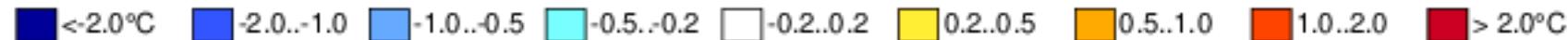
Mean forecast SST anomaly

Forecast start is 01/03/25, climate period is 1993-2016

Ensemble size = 51, climate size = 600

System 5

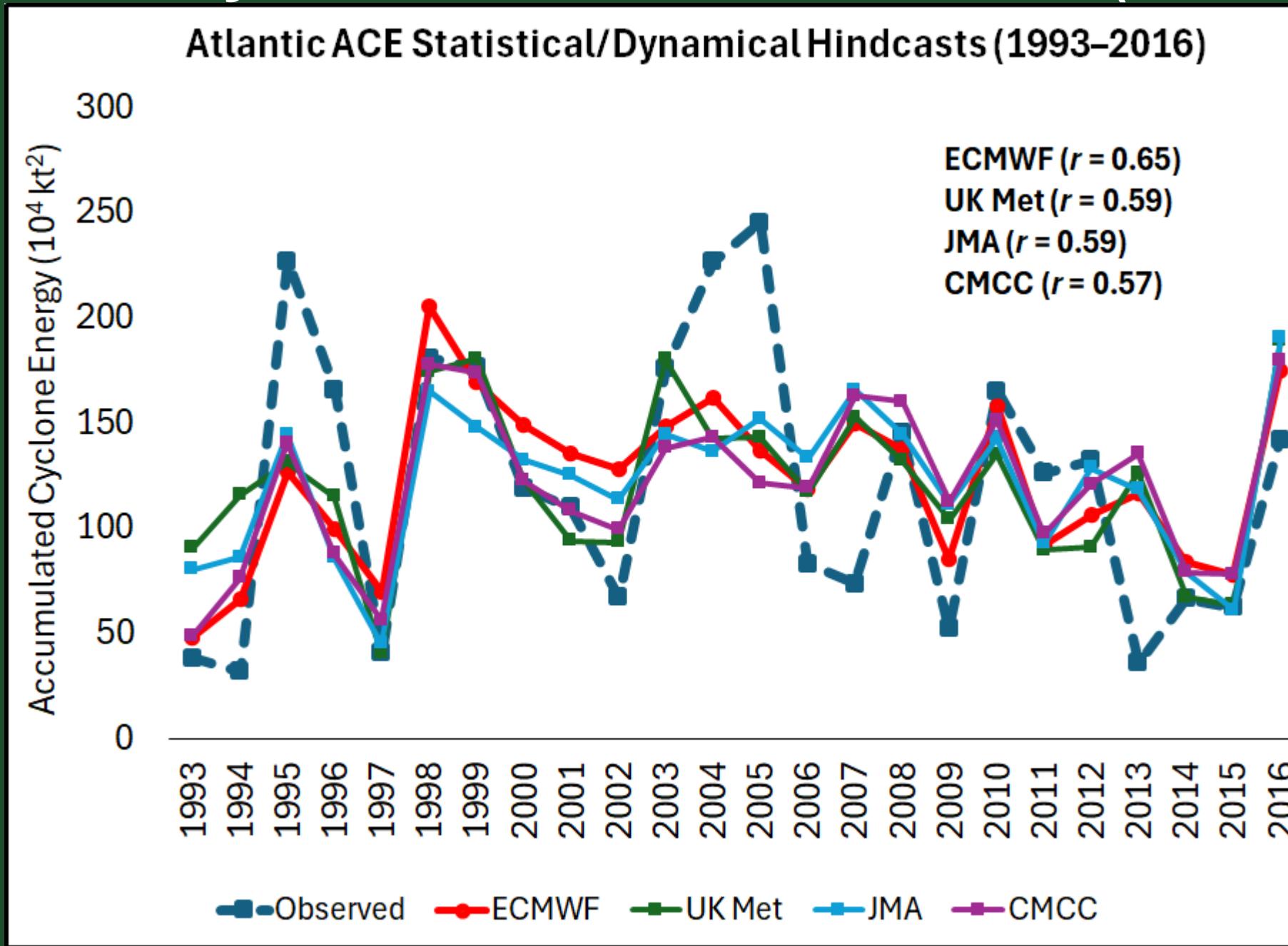
JAS 2025



2025 ECMWF Statistical/Dynamical Model Forecast

Forecast Parameter 1991–2020 Climatology in Parentheses	ECMWF Forecast	Final Forecast
Named Storms (NS) (14.4)	18.8	17
Named Storm Days (NSD) (69.4)	89.3	85
Hurricanes (H) (7.2)	9.3	9
Hurricane Days (HD) (27.0)	37.8	35
Major Hurricanes (MH) (3.2)	4.4	4
Major Hurricane Days (MHD) (7.4)	11.3	9
Accumulated Cyclone Energy (ACE) (123)	170	155
Net Tropical Cyclone Activity (NTC) (135)	185	165

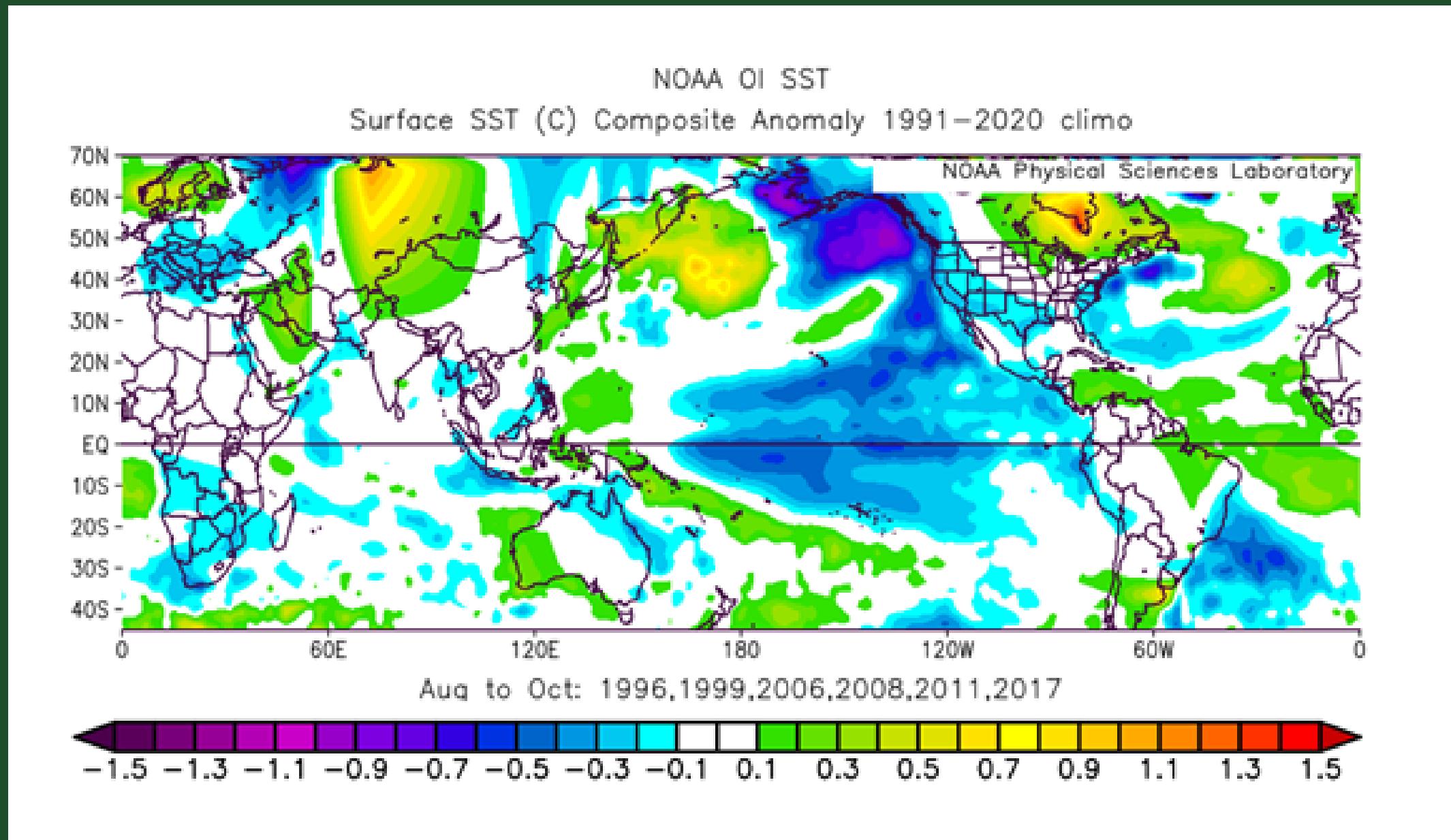
Statistical/Dynamical Model Hindcast Skill (4 Models)



2025 Additional Statistical/Dynamical Model Forecasts

Forecast Parameter 1991-2020 Climatology in Parentheses	UK Met Forecast	JMA Forecast	CMCC Forecast	2025 Forecast
Named Storms (NS) (14.4)	18.4	19.0	21.2	17
Named Storm Days (NSD) (69.4)	86.8	91.0	105.6	85
Hurricanes (H) (7.2)	9.0	9.4	11.0	9
Hurricane Days (HD) (27.0)	36.5	38.7	46.7	35
Major Hurricanes (MH) (3.2)	4.3	4.6	5.5	4
Major Hurricane Days (MHD) (7.4)	10.8	11.6	14.5	9
Accumulated Cyclone Energy (ACE) (123)	164	174	209	155
Net Tropical Cyclone Activity (NTC) (135)	179	189	223	165

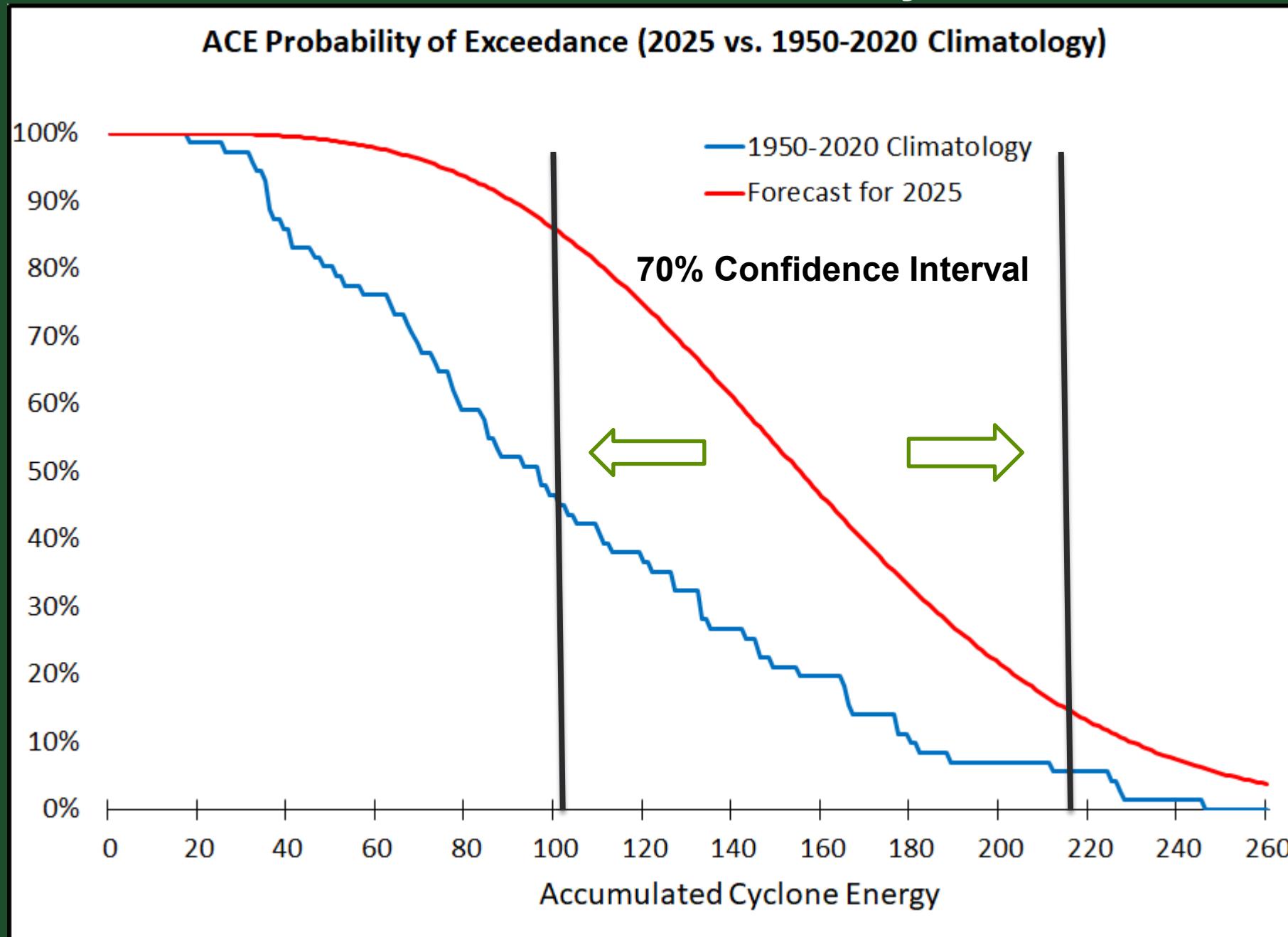
August–October Sea Surface Temperature Anomalies in Analog Years



BEST ANALOG YEARS FOR 2025 (APRIL FORECAST)

	NS	NSD	H	HD	MH	MHD	ACE	NTC
1996	13	79.00	9	45.00	6	13.00	166	192
1999	12	78.50	8	41.00	5	14.25	177	182
2006	10	58.00	5	21.25	2	2.00	83	87
2008	16	88.25	8	30.50	5	7.50	146	162
2011	19	89.75	7	26.00	4	4.50	126	145
2017	17	93.00	10	51.75	6	19.25	225	232
MEAN	14.5	81.1	7.8	35.9	4.7	10.1	154	167
2025 Forecast	17	85	9	35	4	9	155	165

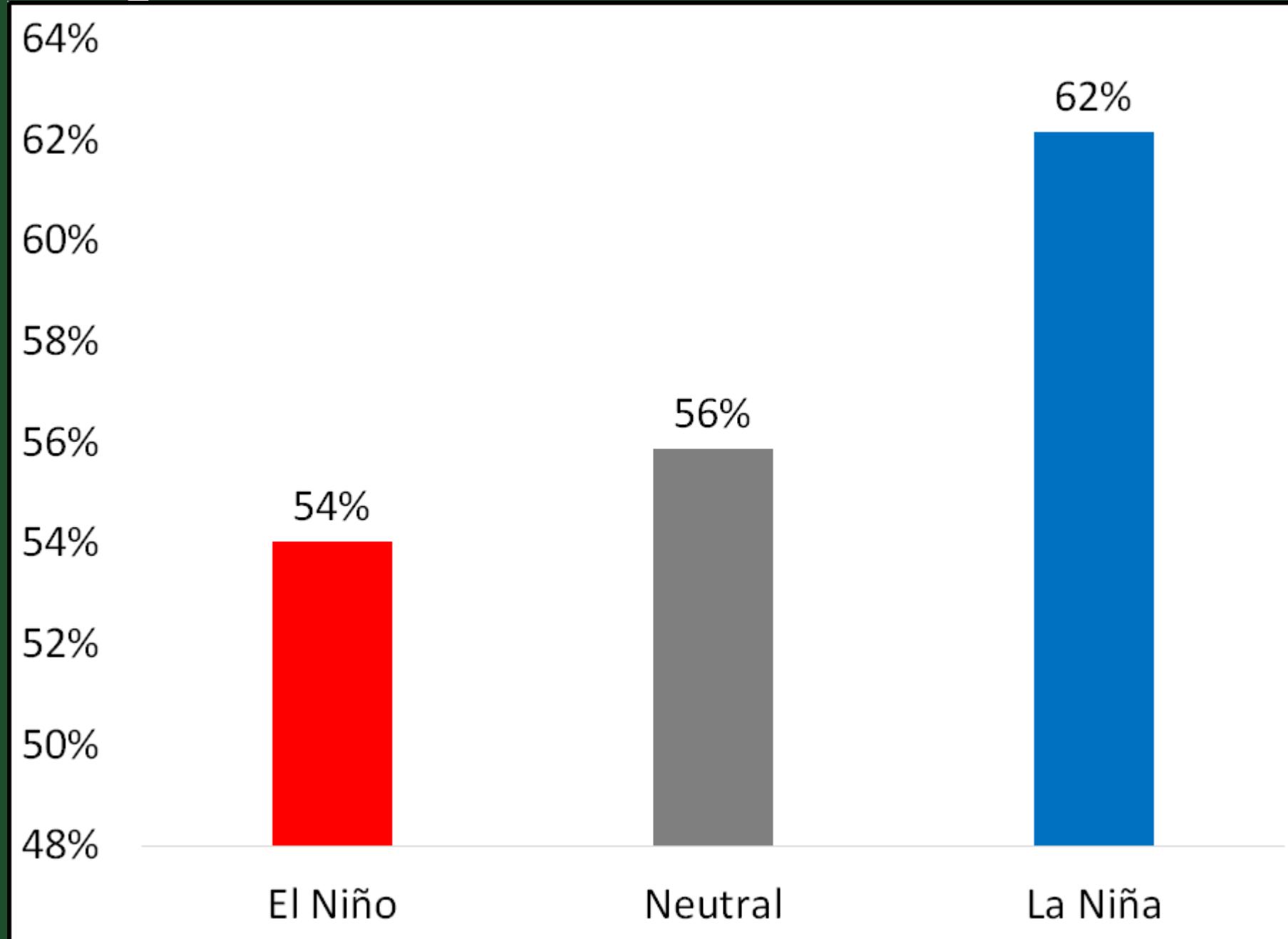
Seasonal Hurricane Forecast Probability of Exceedance



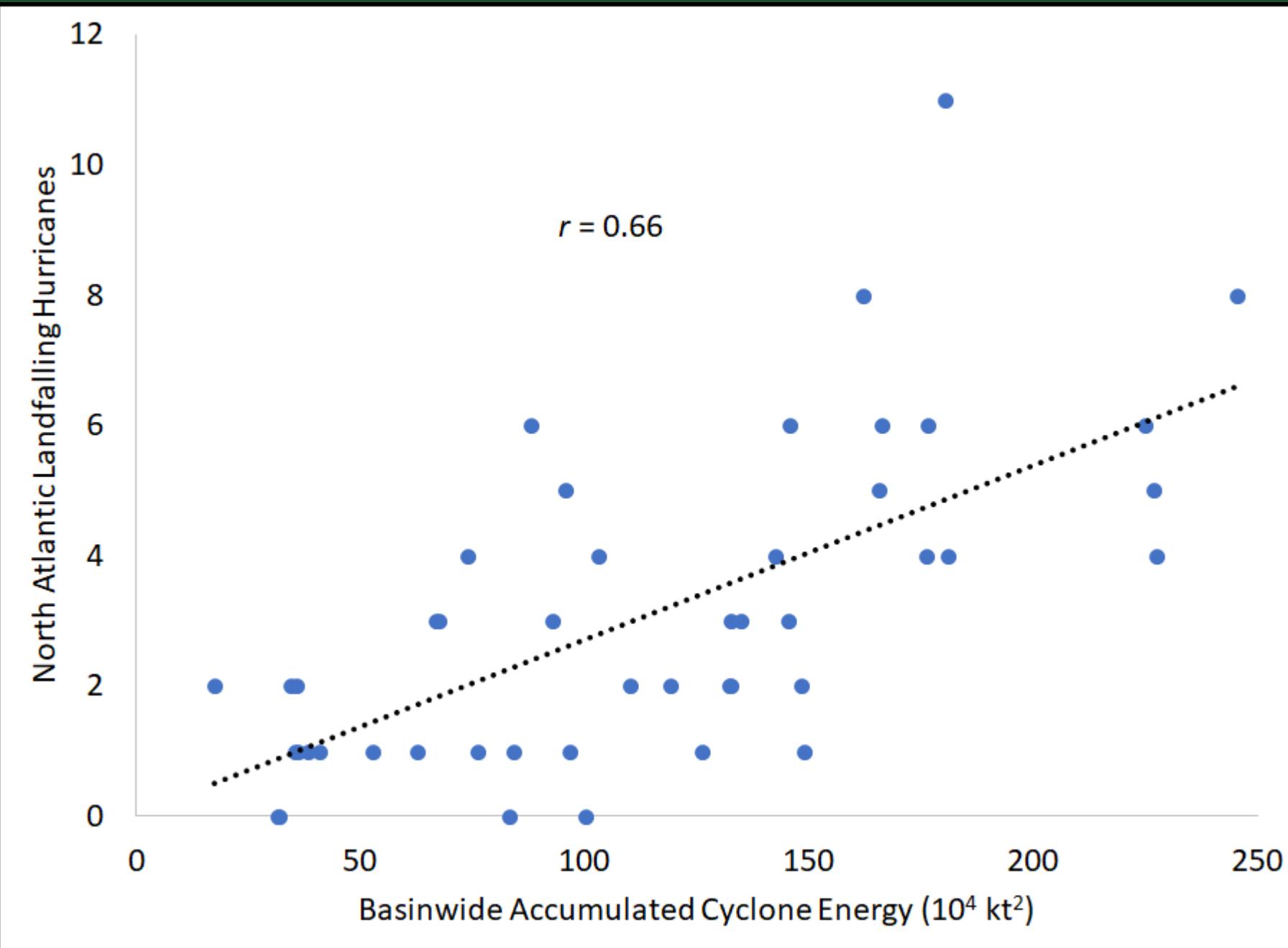
2025 Seasonal Hurricane Forecast Model Uncertainty

Forecast Parameter	2025 Forecast	Uncertainty Range (~70% of Forecasts Fall within Range)
Named Storms (NS)	17	14–20
Named Storm Days (NSD)	85	62–109
Hurricanes (H)	9	7–12
Hurricane Days (HD)	35	22–50
Major Hurricanes (MH)	4	2–6
Major Hurricane Days (MHD)	9	6–14
Accumulated Cyclone Energy (ACE)	155	102–215
ACE West of 60°W	93	57–136
Net Tropical Cyclone Activity (NTC)	165	113–222

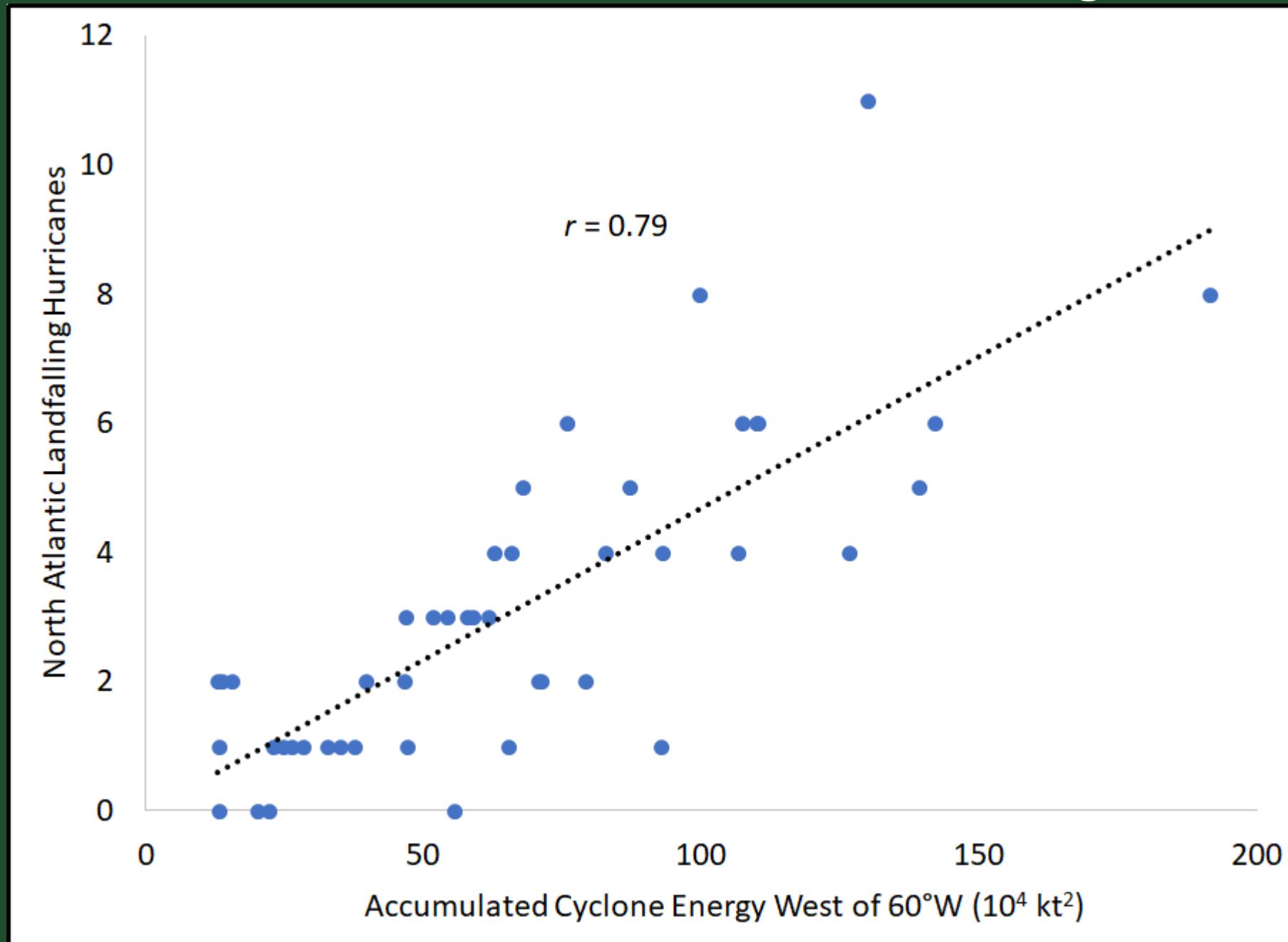
Percentage of Basinwide ACE West of 60°W vs. ENSO Phase



Basinwide ACE vs. North Atlantic Landfalling Hurricanes



ACE West of 60°W vs. North Atlantic Landfalling Hurricanes



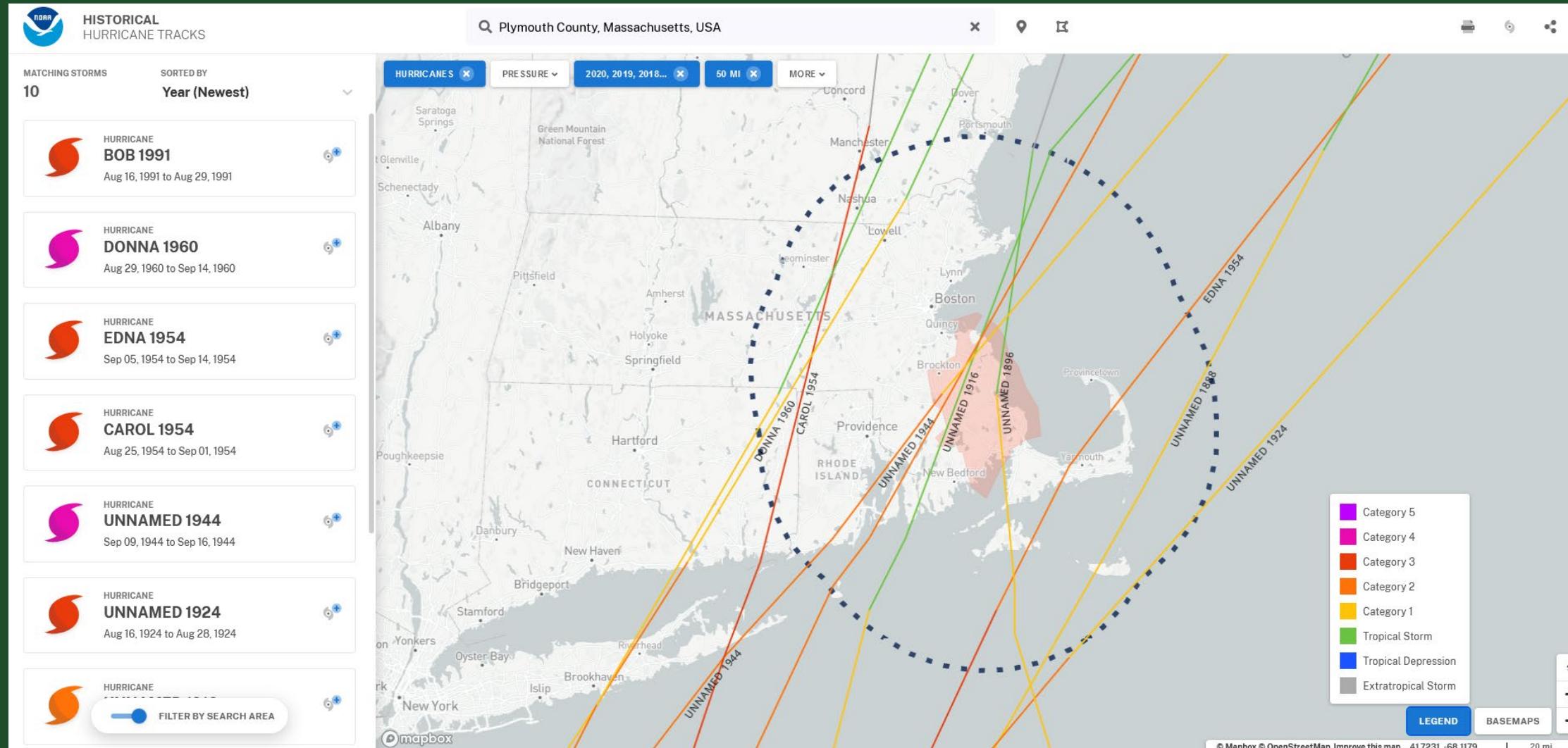
2025 PROBABILITIES FOR AT LEAST ONE MAJOR (CATEGORY 3-4-5) HURRICANE LANDFALL IN EACH OF THE FOLLOWING AREAS

(1880–2020 PROBABILITIES IN PARENTHESES)

- 1) Entire U.S. coastline – 51% (43%)
- 2) U.S. East Coast including Peninsula Florida – 26% (21%)
- 3) Gulf Coast from the Florida Panhandle westward to Brownsville – 33% (27%)
- 4) Caribbean (10-20°N, 88-60°W) – 56% (47%)

Count all named storms, hurricanes and major hurricanes within 50 miles of each county/parish (1880–2020)

Example: All Hurricanes within 50 miles of Plymouth County, MA



<https://coast.noaa.gov/hurricanes/>

2025 Probabilities (1880–2020 Probabilities in Parentheses)

State	>=1 Hurricane Within 50 Miles	>=1 Major Hurricane Within 50 Miles
Florida	65% (56%)	35% (29%)
Louisiana	46% (38%)	18% (14%)
Massachusetts	18% (14%)	4% (3%)
Mississippi	35% (28%)	9% (8%)
New York	12% (9%)	3% (2%)
North Carolina	46% (38%)	9% (8%)
Texas	44% (36%)	19% (16%)

2025 Atlantic Seasonal Hurricane Forecast Schedule

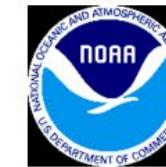
Date	3 April	11 June	9 July	6 Aug
Seasonal Forecast	X	X	X	X

Seasonal Hurricane Predictions Platform

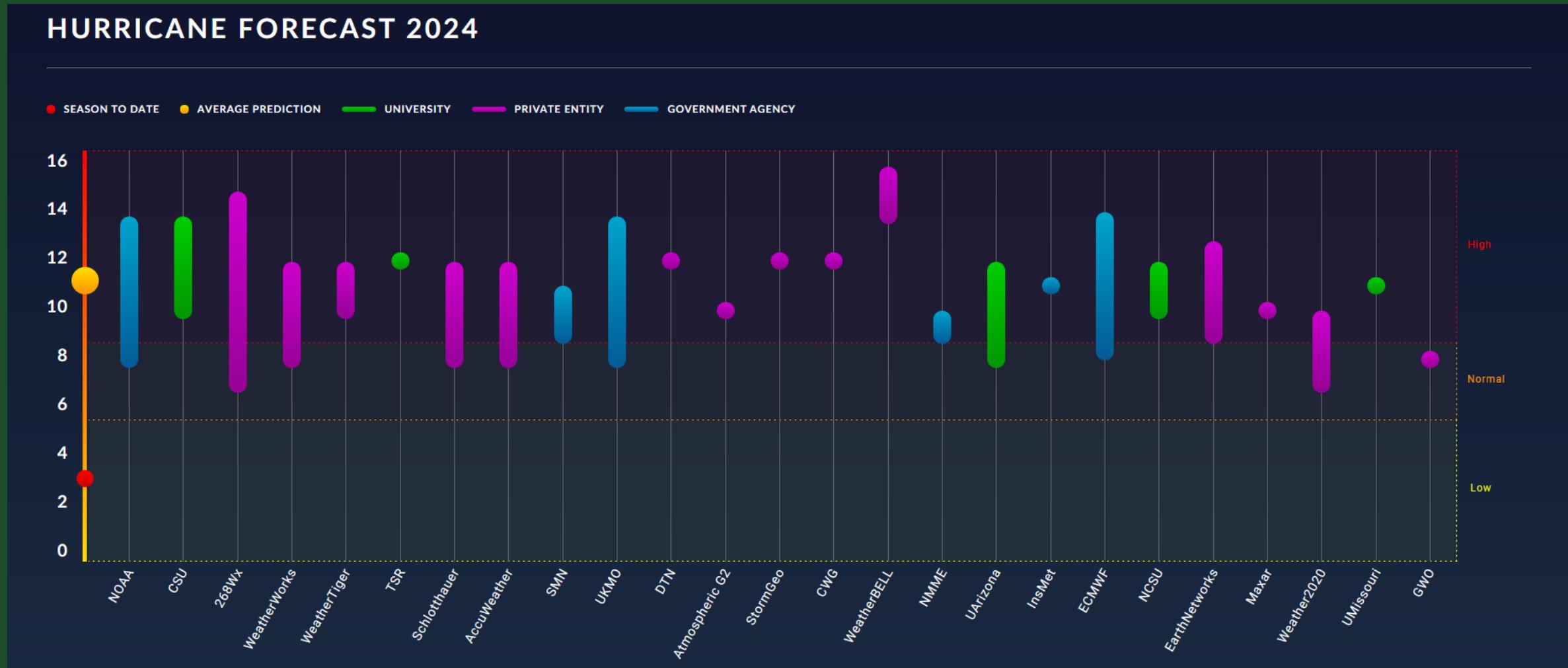


Barcelona
Supercomputing
Center
Centro Nacional de Supercomputación

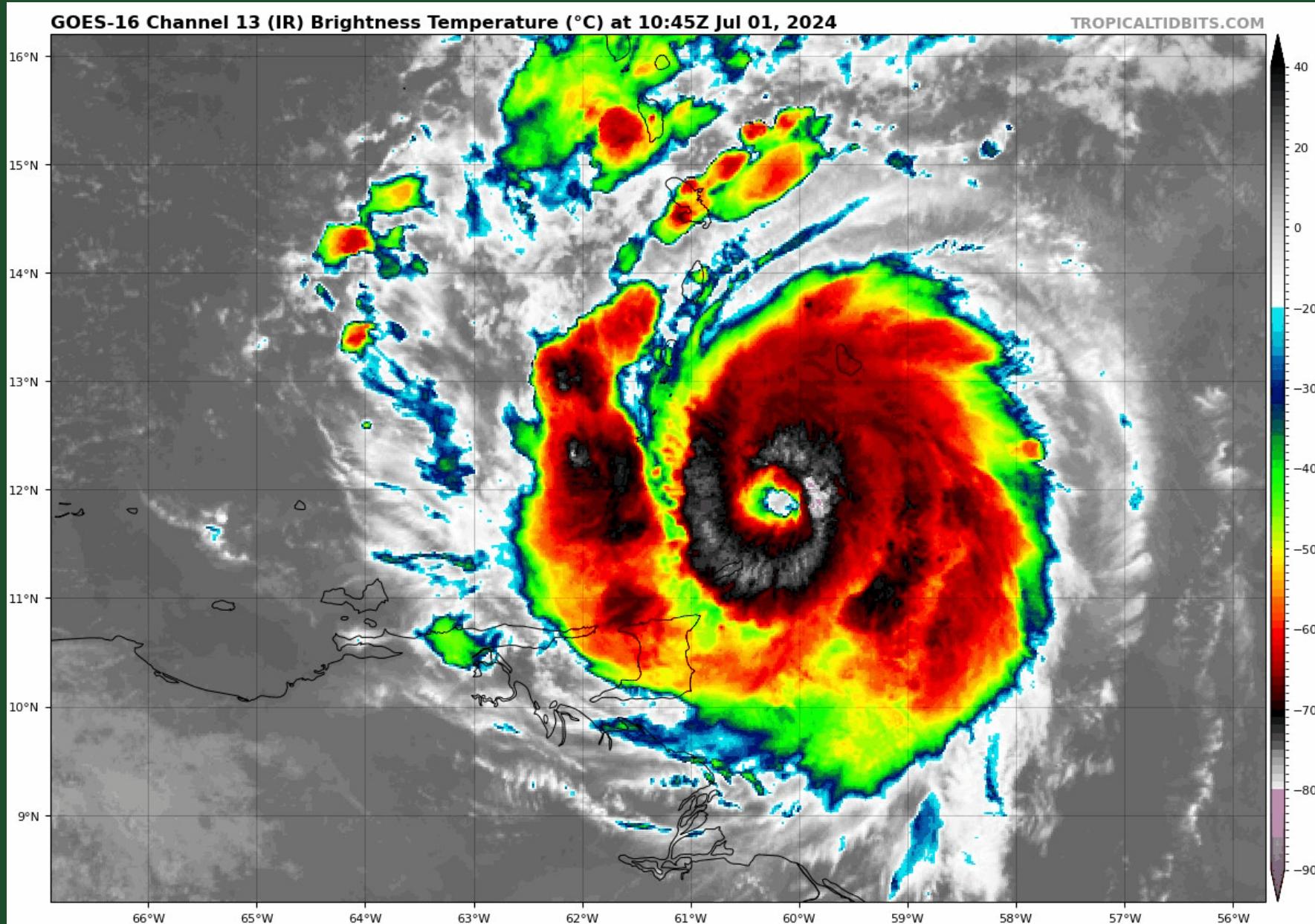
<http://www.seasonalhurricanepredictions.org>
Contributing Forecast Groups



Seasonalhurricanepredictions.org Visualization – 2024 Hurricane Season Example



The 2024 Atlantic Hurricane Season

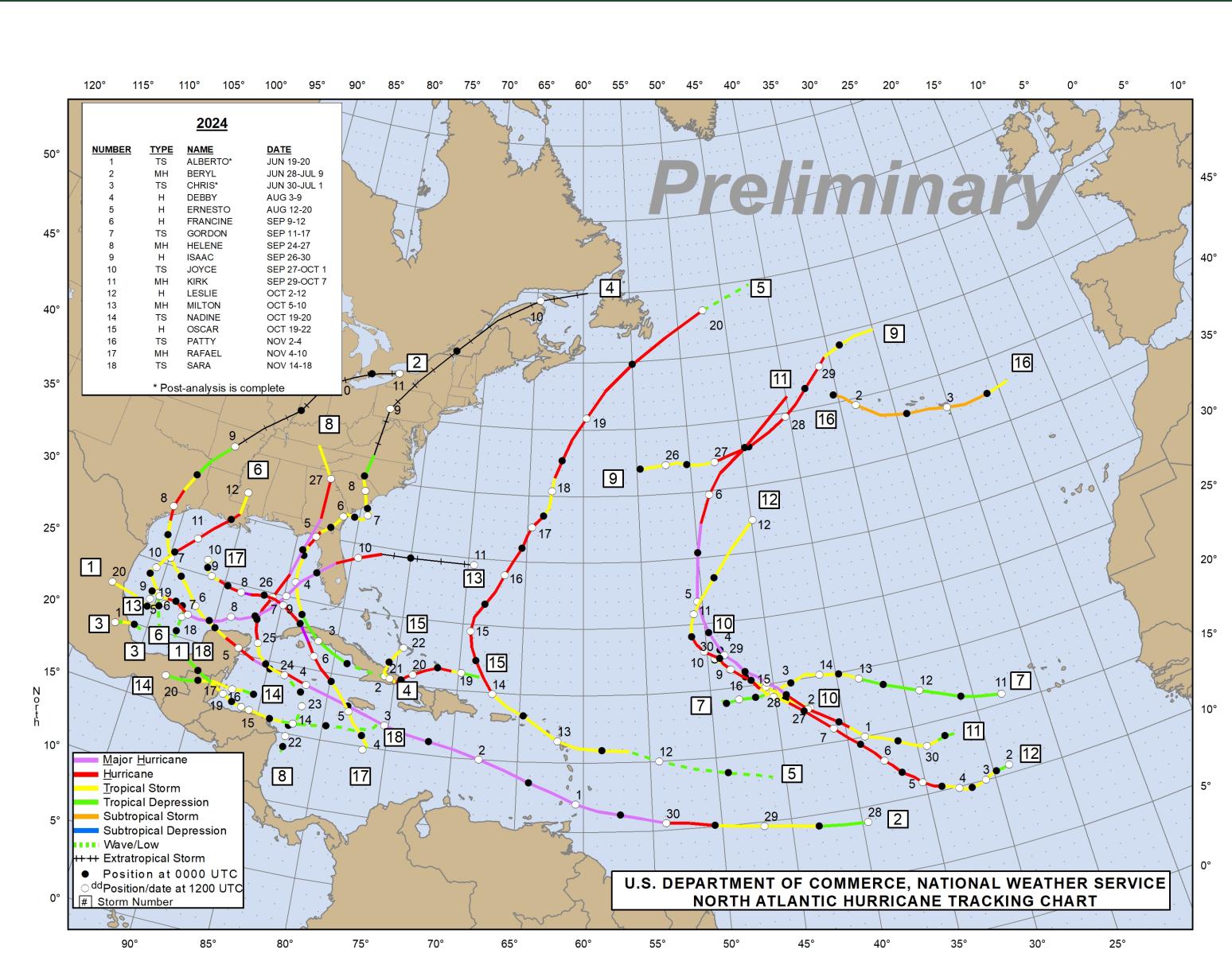


2024 Atlantic Hurricane Activity vs. Average

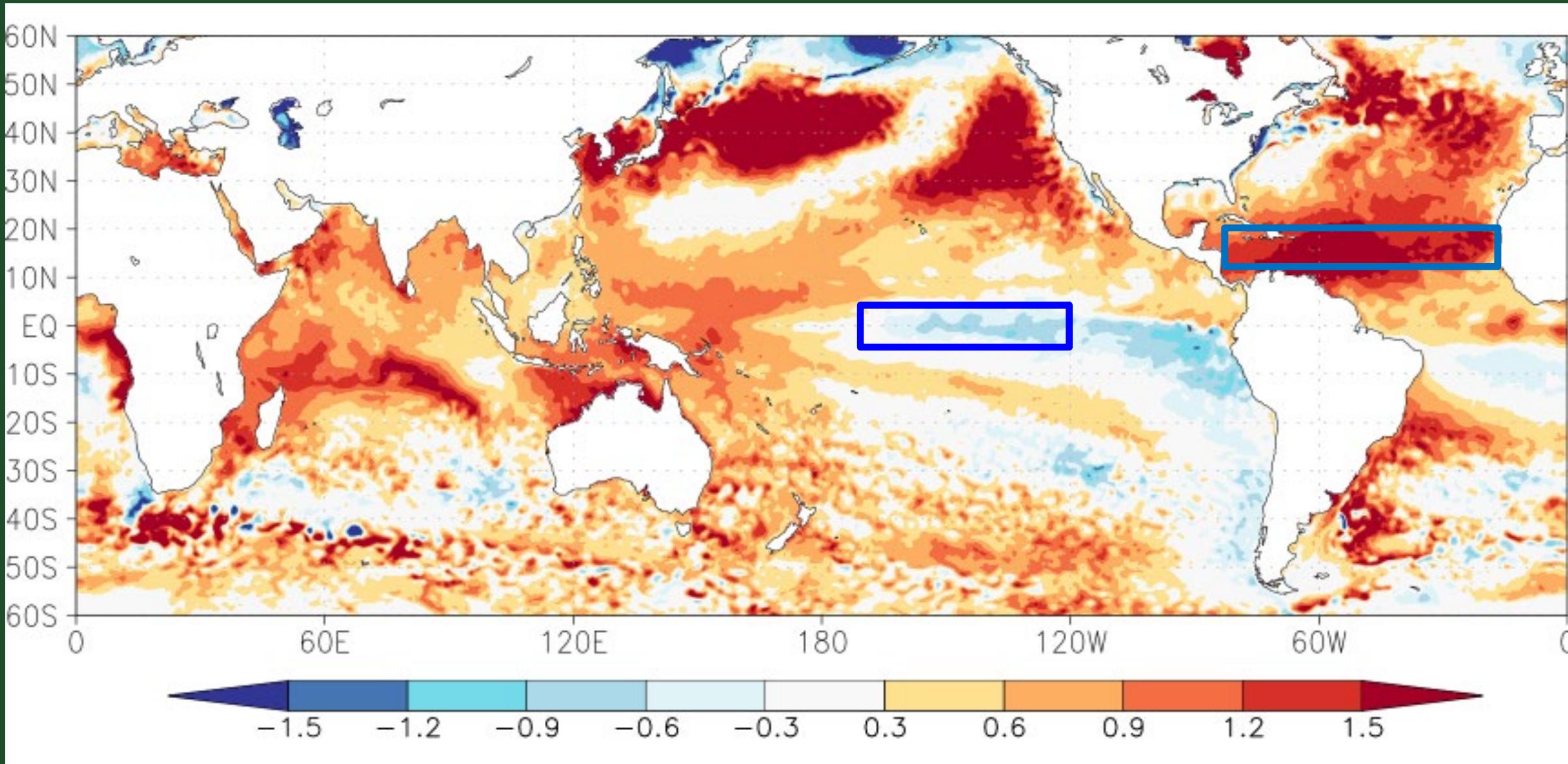
Forecast Parameter	2024 Observed	1991–2020 Average	2024 % of 1991– 2020 Average
Named Storms (NS)	18	14.4	125%
Named Storm Days (NSD)	77.25	69.4	111%
Hurricanes (H)	11	7.2	153%
Hurricane Days (HD)	37.50	27.0	139%
Major Hurricanes (MH)	5	3.2	156%
Major Hurricane Days (MHD)	11.50	7.3	158%
Accumulated Cyclone Energy (ACE)	162	123	132%

2024 Atlantic Hurricane Tracks

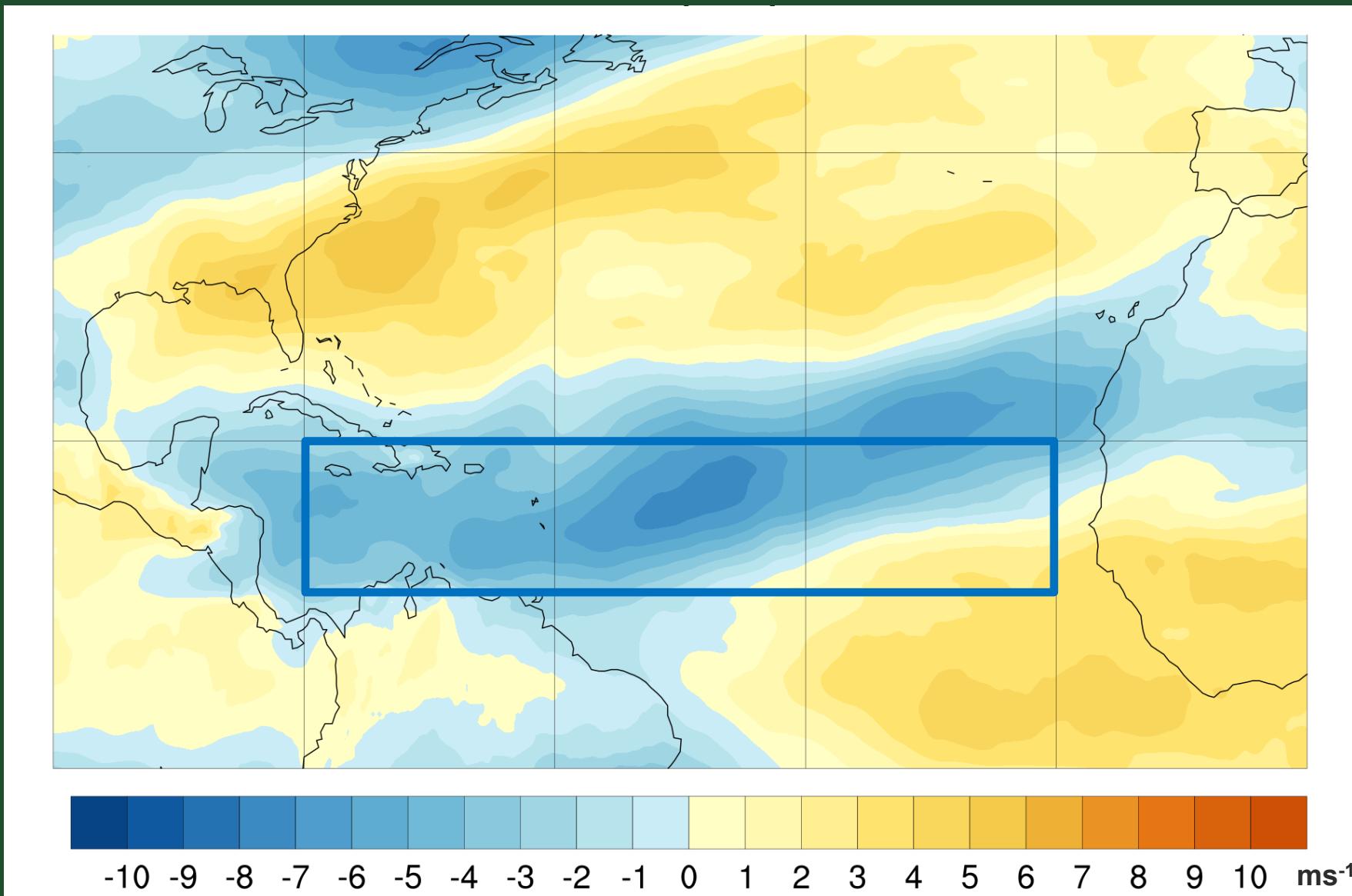
Preliminary



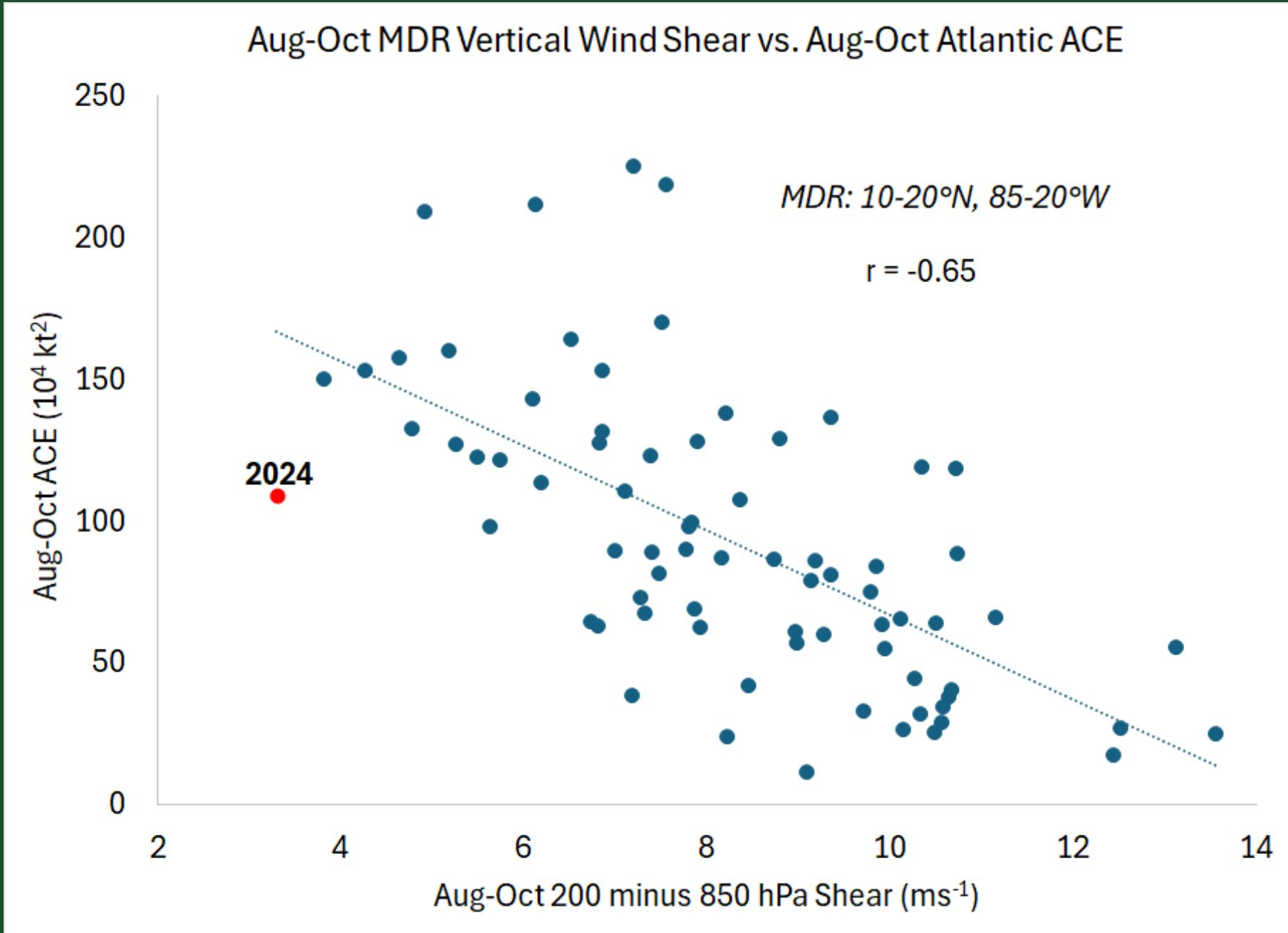
August-October 2024 Sea Surface Temperature Anomalies



August-October 2024 Vertical (200 minus 850 hPa) Wind Shear Anomalies



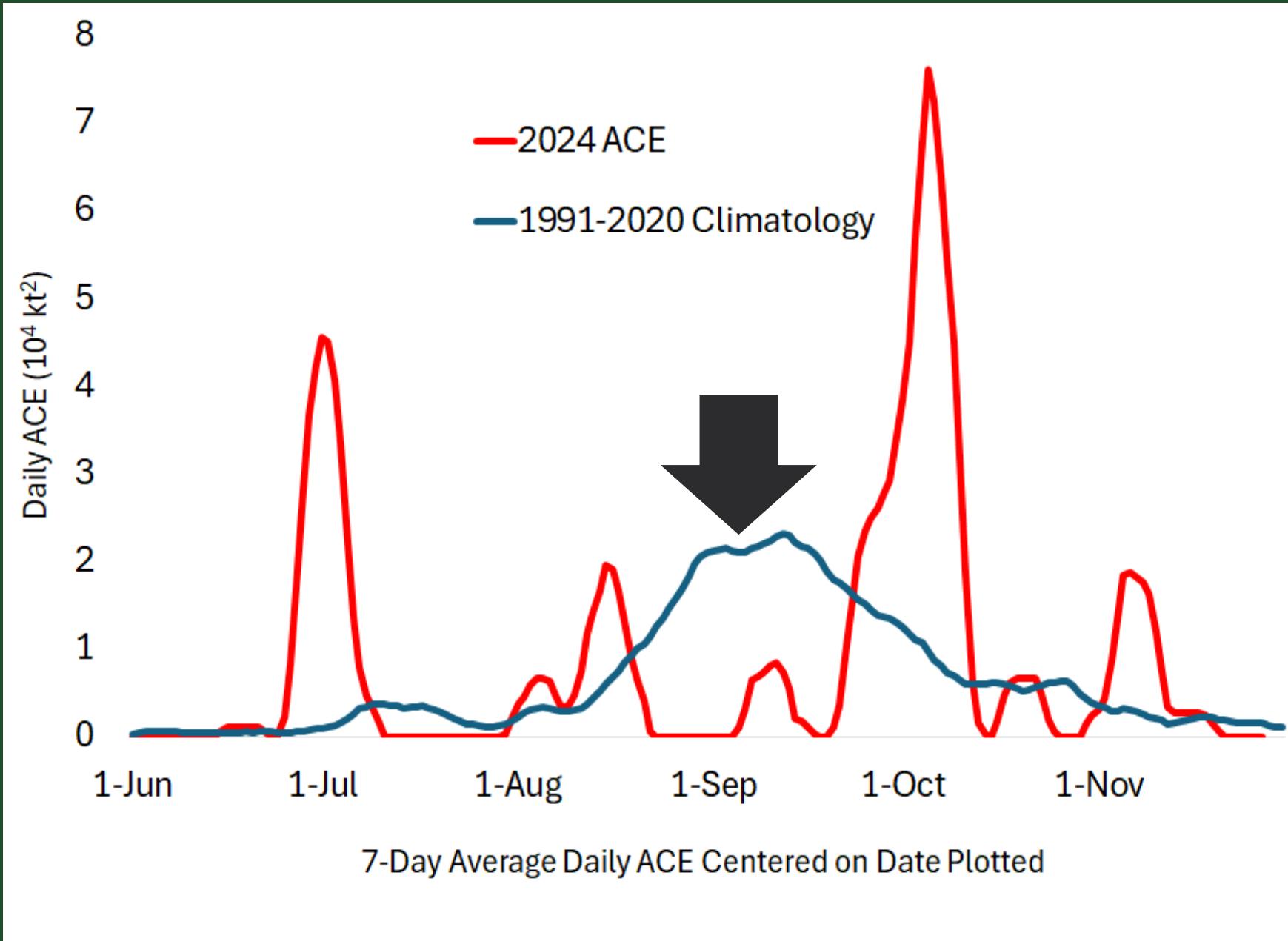
August – October Wind Shear vs. ACE Relationship



2024 CSU Seasonal Hurricane Forecasts

Forecast Parameter (1991-2020 Average)	Issue Date 4 April	Issue Date 11 June	Issue Date 9 July	Issue Date 6 Aug	Observed
Named Storms (NS) (14.4)	23	23	25	23	18
Named Storm Days (NSD) (69.4)	115	115	120	120	77.25
Hurricanes (H) (7.2)	11	11	12	12	11
Hurricane Days (HD) (27.0)	45	45	50	50	37.50
Major Hurricanes (MH) (3.2)	5	5	6	6	5
Major Hurricane Days (MHD) (7.4)	13	13	16	16	11.50
Accumulated Cyclone Energy (ACE) (123)	210	210	230	230	162

2024 Atlantic Hurricane Season Lull



2024 Atlantic Hurricane Season Lull

FORBES > INNOVATION > SCIENCE

EDITORS' PICK

Hurricane Season Surprisingly Quiet — What Happened To All The Storms?

Jim Foerster Contributor 

CLIMATE & ENVIRONMENT

Los Angeles Times

After a violent start, the Atlantic hurricane season has gone unusually quiet

SEPTEMBER 6, 2024 | 5 MIN READ

SCI
AM

Atlantic Hurricane Lull Puzzles Scientists

Meteorologists predicted a busy Atlantic hurricane season—and a recent lull in activity doesn't negate that

BY MEGHAN BARTELS EDITED BY ANDREA THOMPSON

2024 Atlantic Hurricane Season Lull

The Remarkable 2024 North Atlantic Mid-Season Hurricane Lull

P. J. Klotzbach¹, E. Bercos-Hickey², K. M. Wood³, C. J. Schreck III⁴, M. M. Bell¹, E. S. Blake⁵, S. G. Bowen⁶, L.-P. Caron⁷, D. R. Chavas⁸, J. M. Collins⁹, E. J. Gibney¹⁰, K. A. Hansen¹¹, A. T. Hazleton¹², J. J. Jones¹³, M. R. Lowry¹⁴, A. T. Nieves-Jimenez¹, C. M. Patricola¹⁵, L. G. Silvers¹, R. E. Truchelut¹⁶, and J. Uehling⁴

¹Department of Atmospheric Science, Colorado State University, Fort Collins, CO, USA.

²Climate and Ecosystem Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA.

³Department of Hydrology and Atmospheric Sciences, The University of Arizona, Tucson, Arizona, USA.

⁴North Carolina Institute for Climate Studies, Cooperative Institute for Satellite Earth Systems Studies, North Carolina State University, Asheville, North Carolina, USA.

⁵NOAA/National Hurricane Center, Miami, FL, USA.

⁶Gallagher Re, Chicago, IL, USA.

⁷Ouranos, Montreal, Quebec, Canada.

⁸Department of Earth, Atmospheric and Planetary Sciences, Purdue University, West Lafayette, Indiana, USA.

⁹School of Geosciences, University of South Florida, Tampa, Florida, USA.

¹⁰University Corporation for Atmospheric Research/Cooperative Programs for the Advancement of Earth System Science, San Diego, California, USA.

¹¹Naval Research Council, Washington, DC, USA.

¹²University of Miami, CIMAS, Miami, Florida, USA.

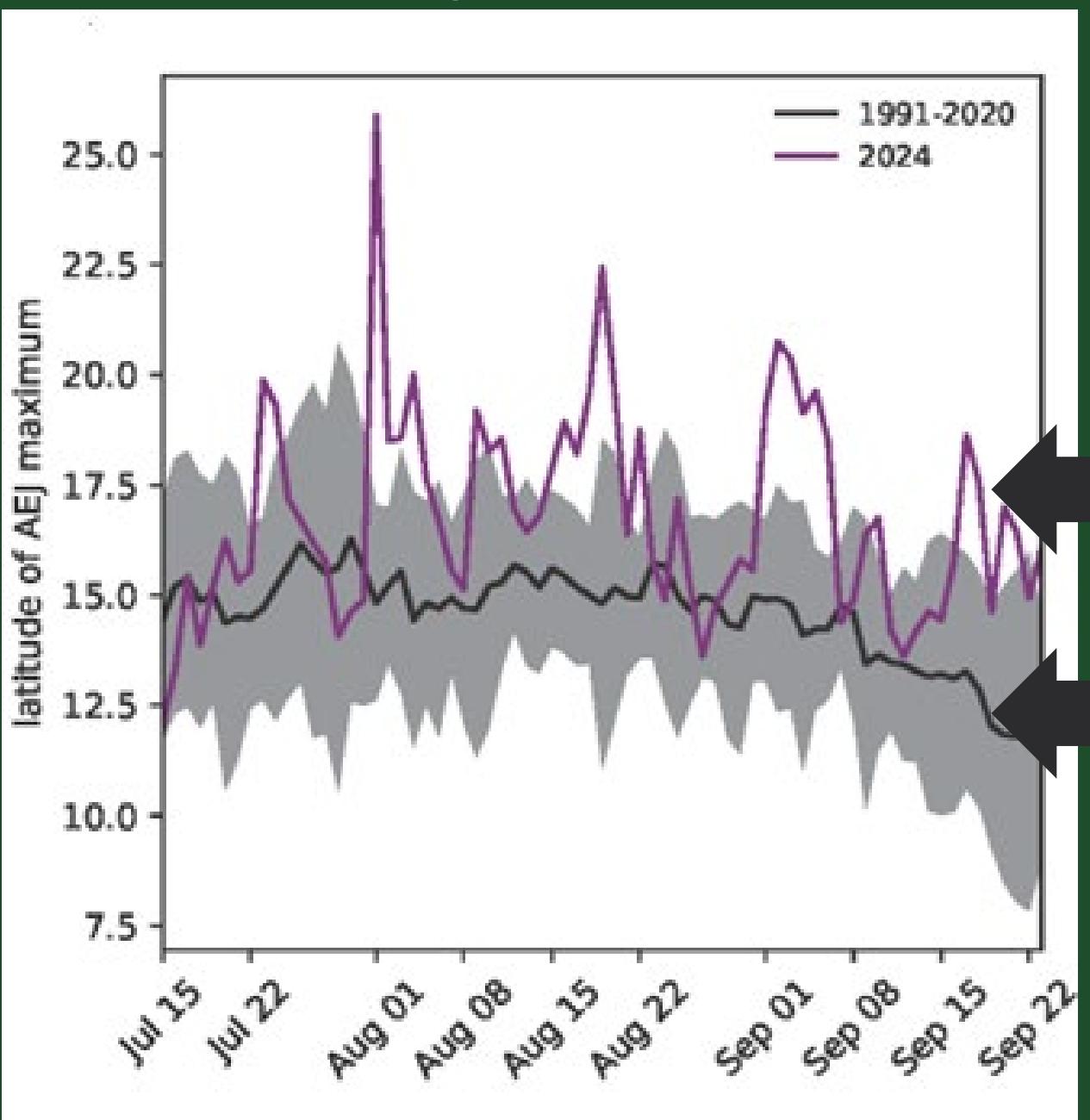
¹³Department of Meteorology and Atmospheric Science, Penn State University, State College, Pennsylvania, USA.

¹⁴WPLG TV, Miami, Florida, USA.

¹⁵Department of Geological and Atmospheric Sciences, Iowa State University, Ames, IA, USA.

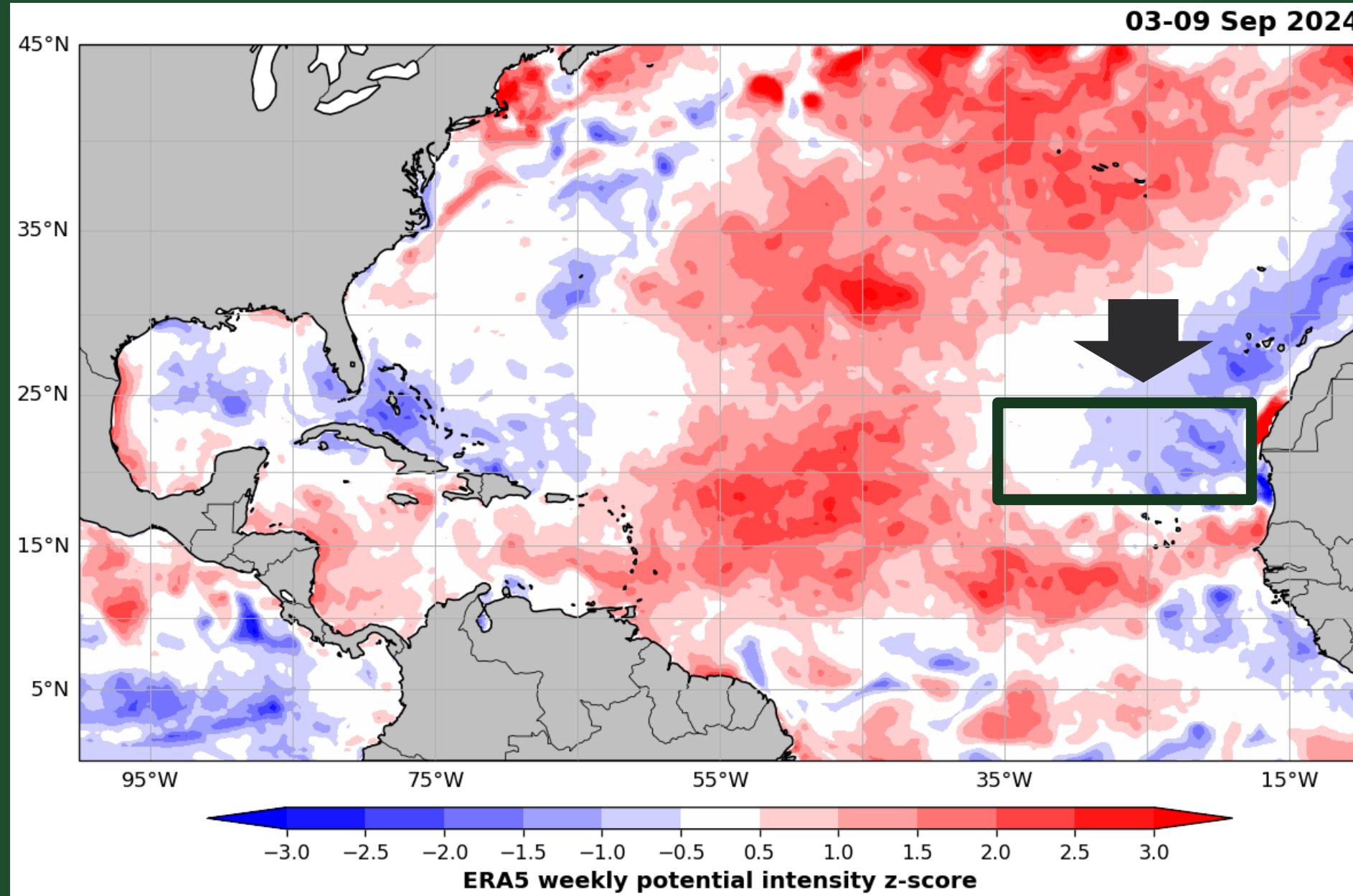
¹⁶WeatherTiger LLC, Tallahassee, Florida, USA.

African Easterly Waves Too Far North

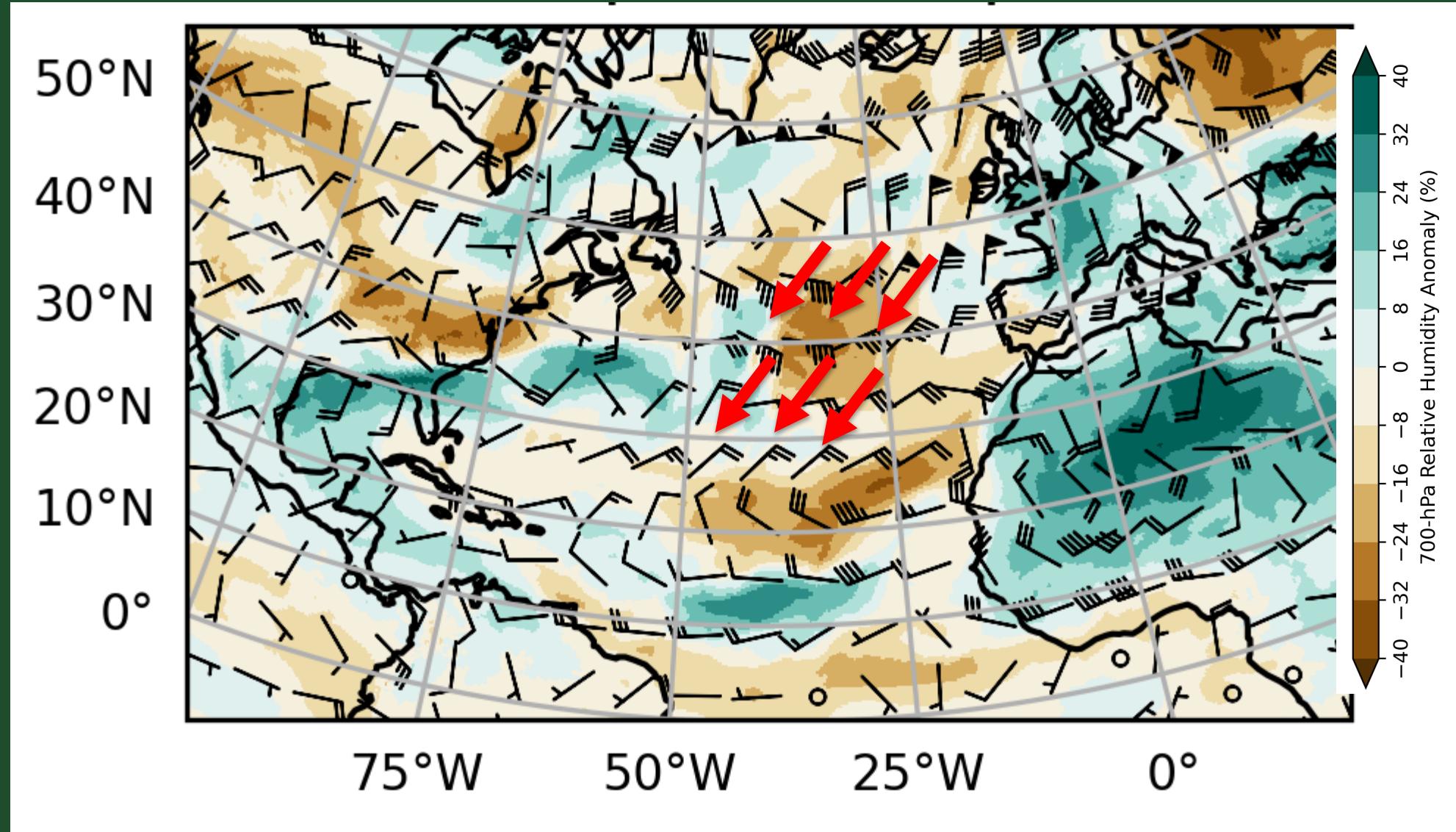


2024
1991–2020
Average

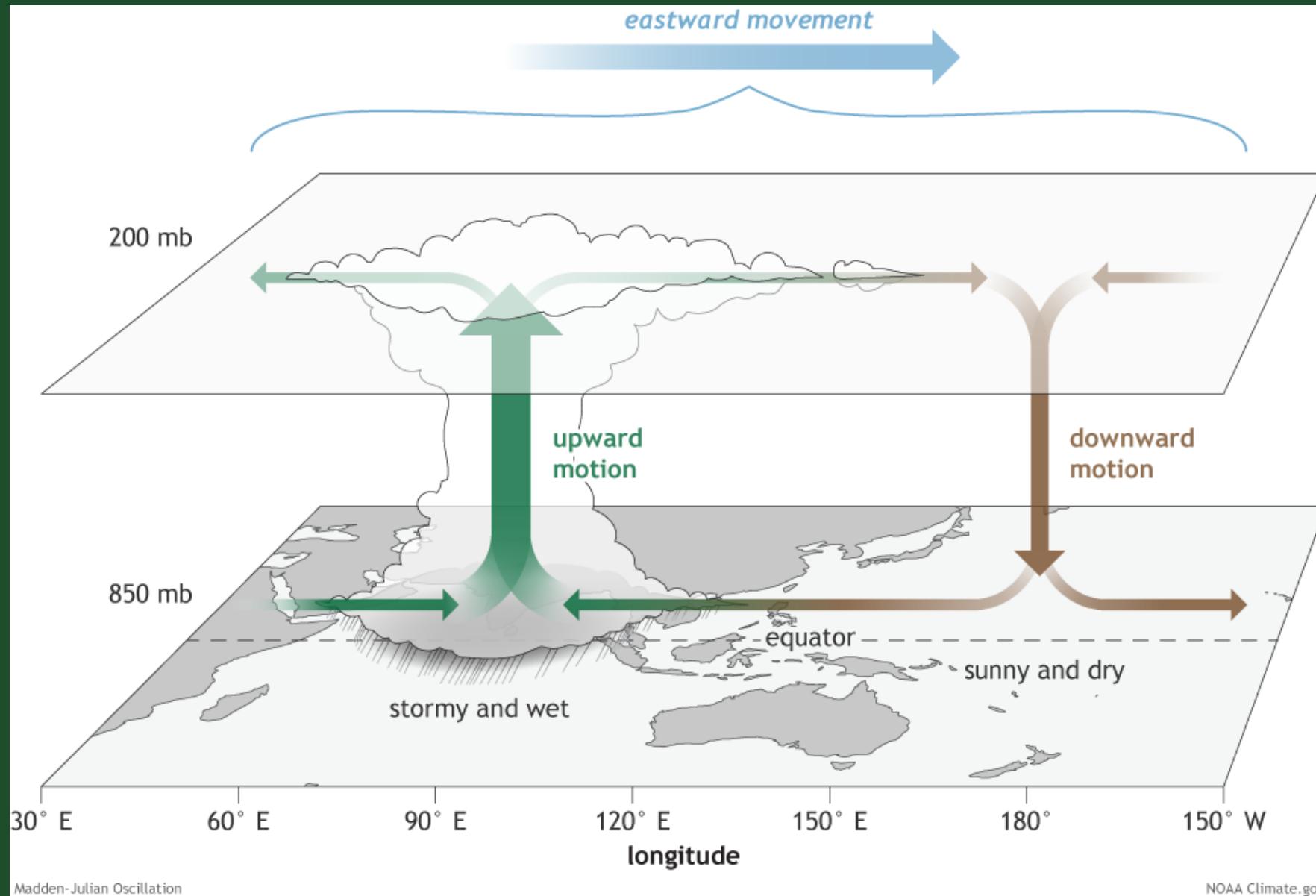
3 – 9 September 2024 Potential Intensity (Atmospheric Juiciness)



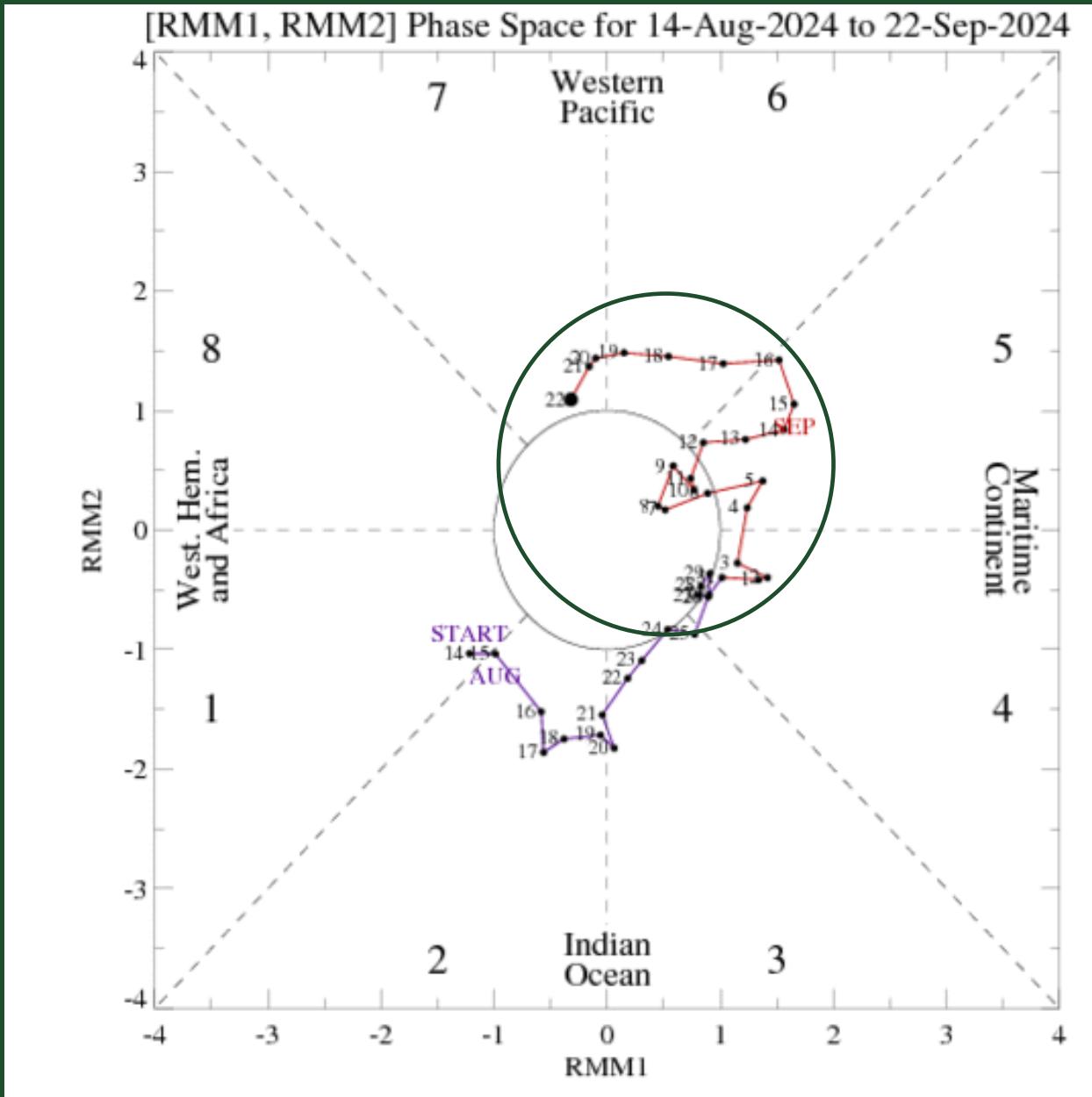
3 – 9 September 2024 Low-Level Winds and Moisture



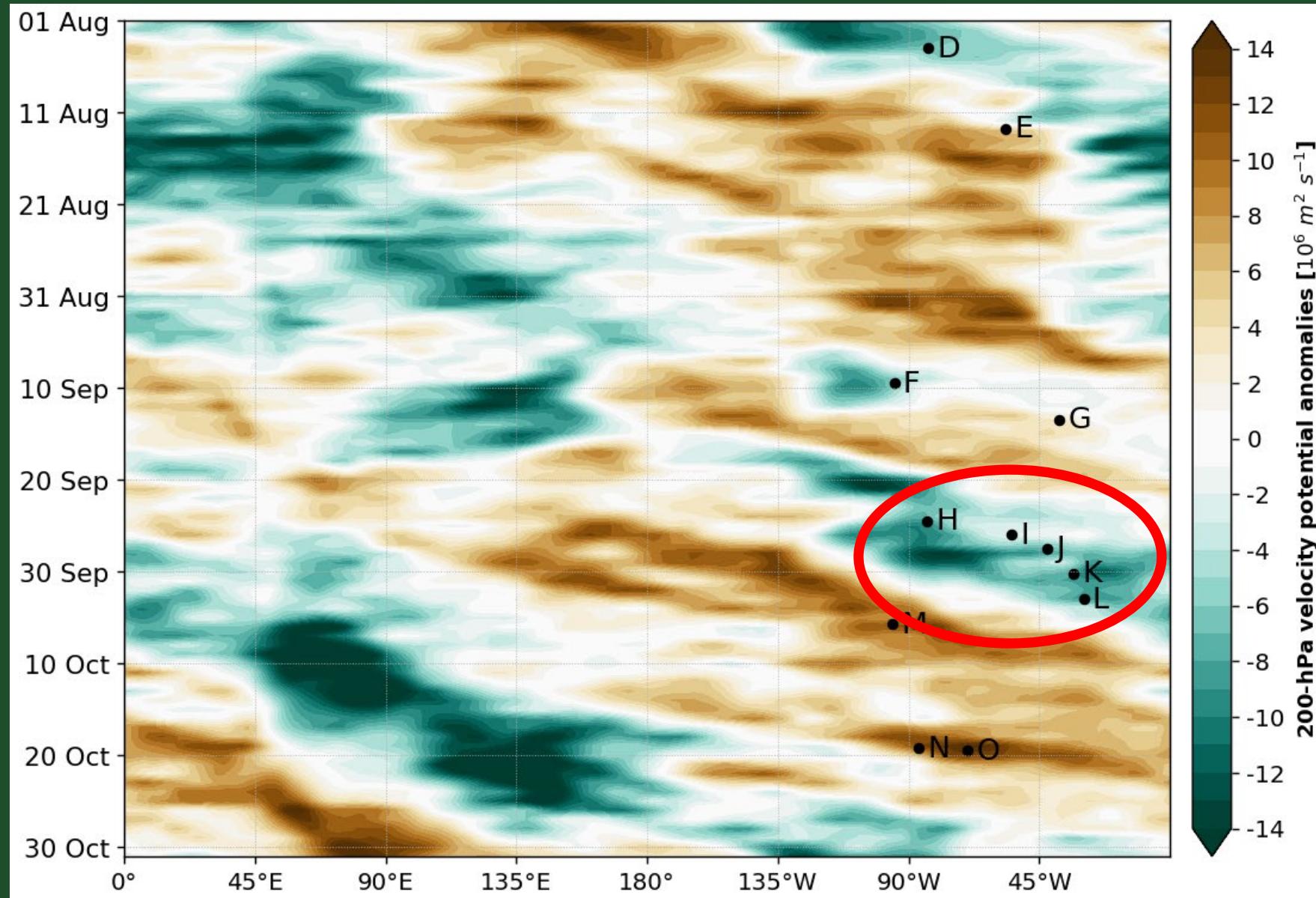
Madden-Julian Oscillation (MJO) Circulation



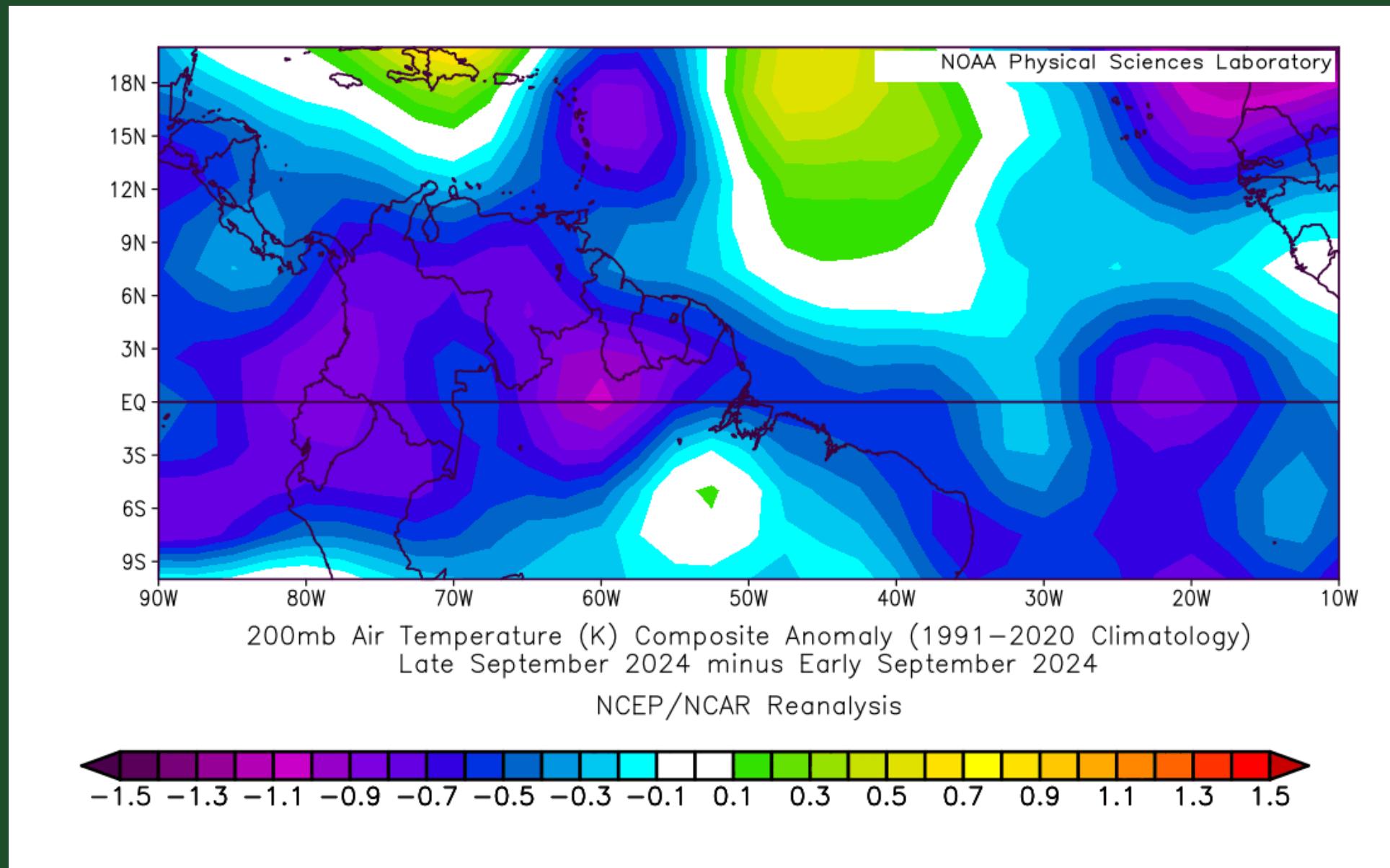
Unfavorable MJO Phases – Late Aug to Mid Sep



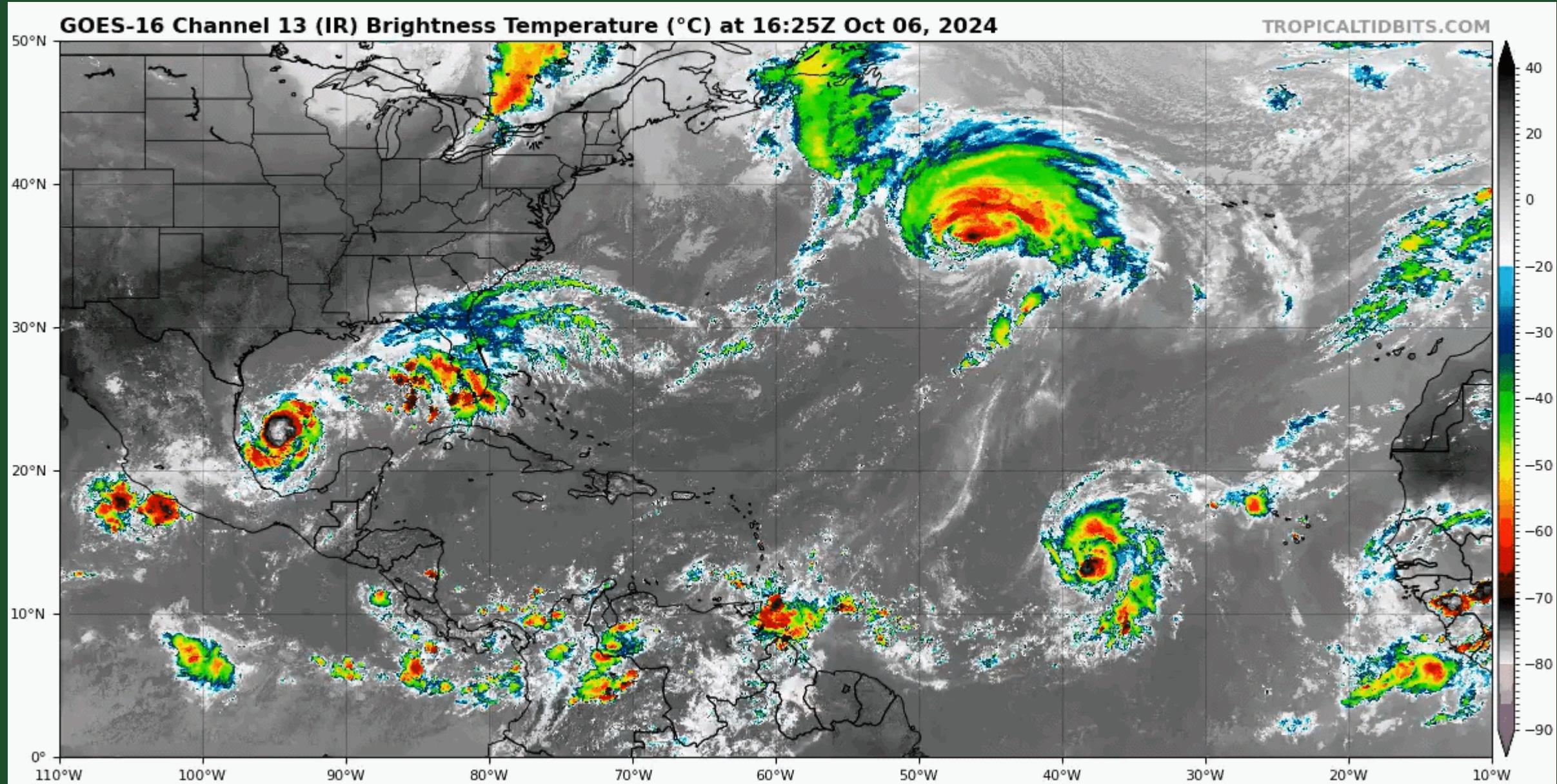
Favorable MJO Phases – Late Sep to Early Oct



Upper-Level Temperatures Cooled - Increasing Potential Intensity: Late September minus Early September 2024



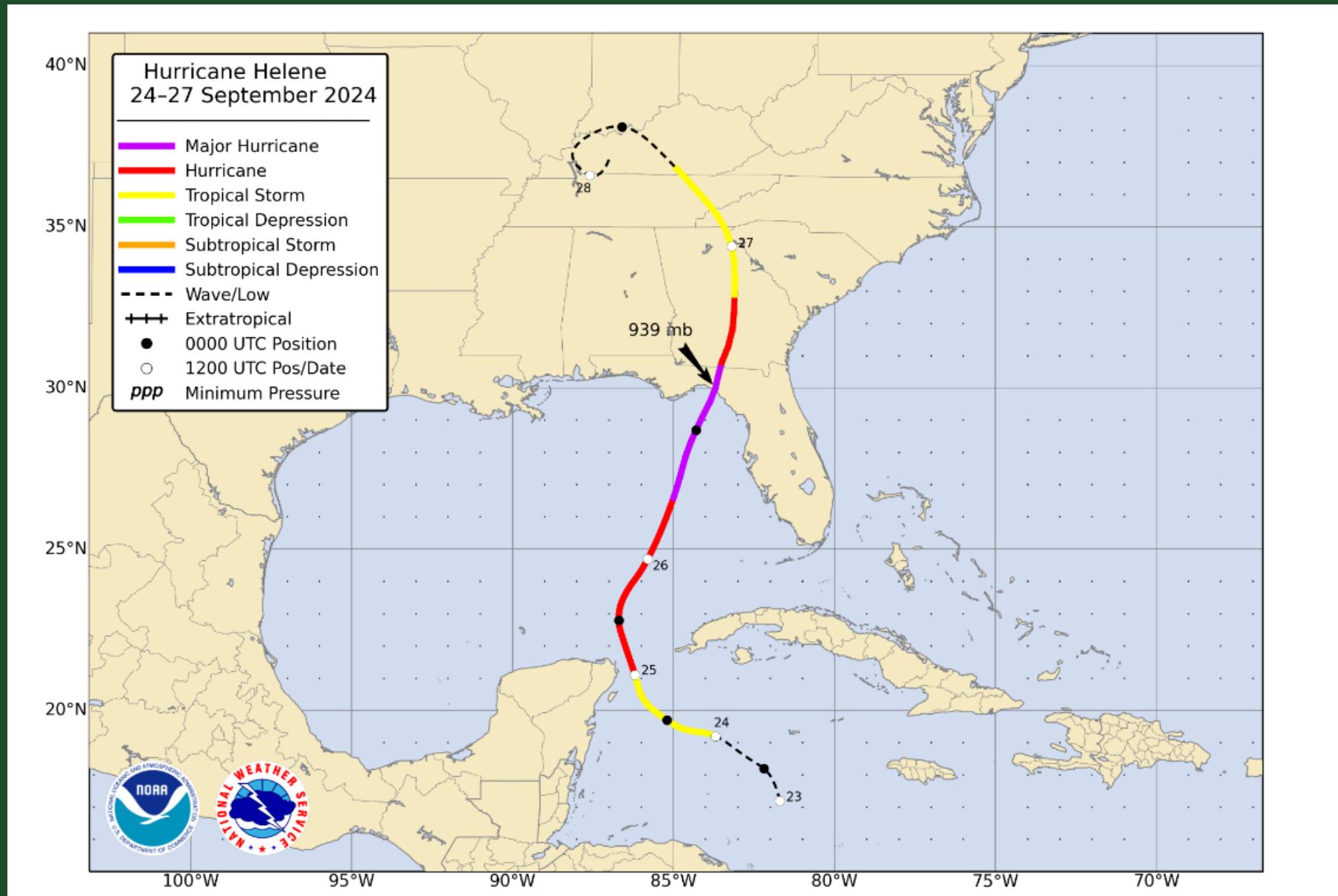
3 Hurricanes in October Simultaneously for First Time on Record



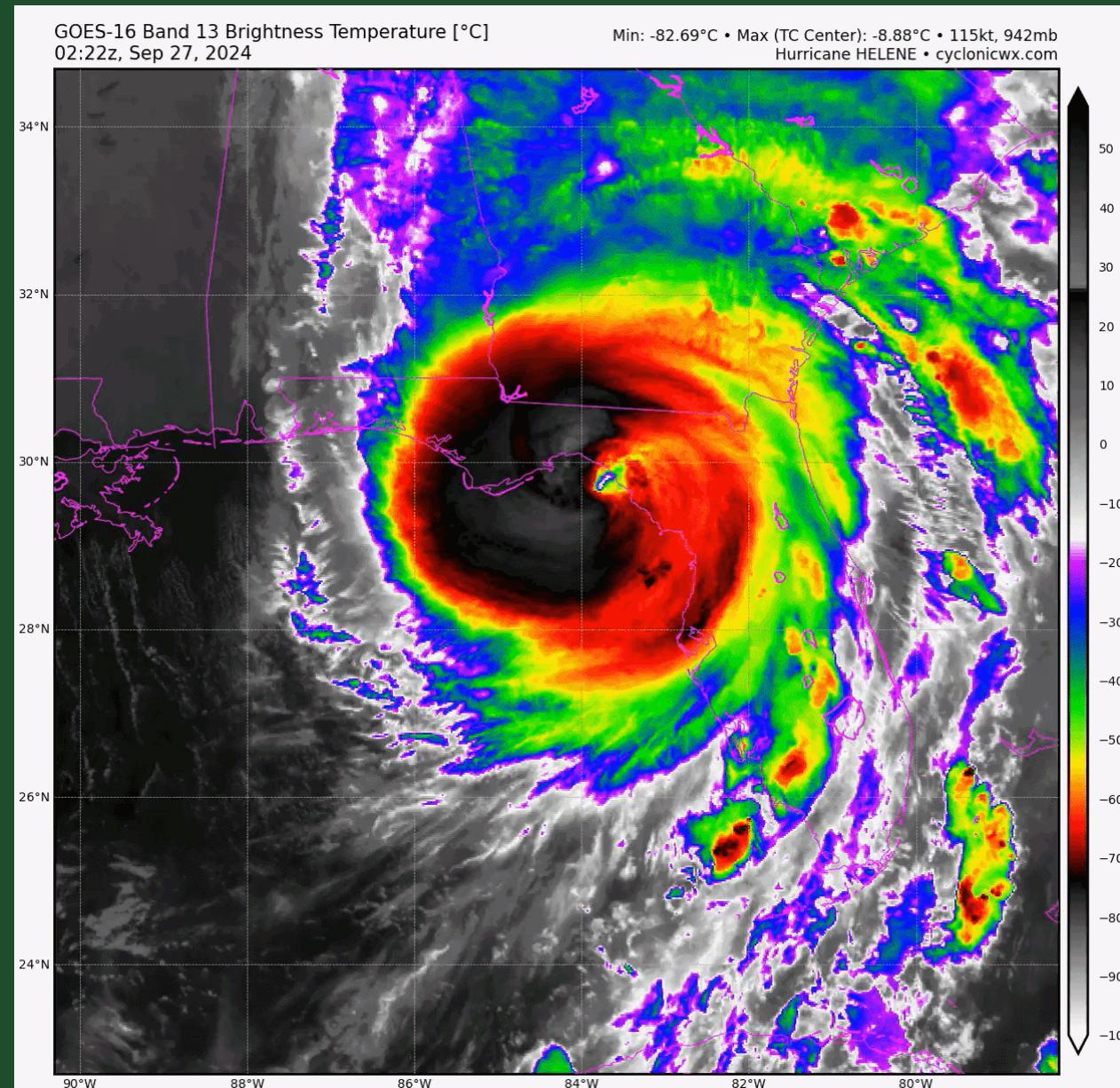
Atlantic Hurricane Activity from 24 Sep – 11 Oct

Forecast Parameter	2024 Observed	1991-2020 Avg	2024 All-Time Rank (since 1851)
Named Storms (NS)	6	1.8	1
Hurricanes (H)	5	1.2	1
Major Hurricanes (MH)	3	0.5	1
Accumulated Cyclone Energy (ACE)	79	20	1

Hurricane Helene



Hurricane Helene Landfall (140 mph, 939 mb)



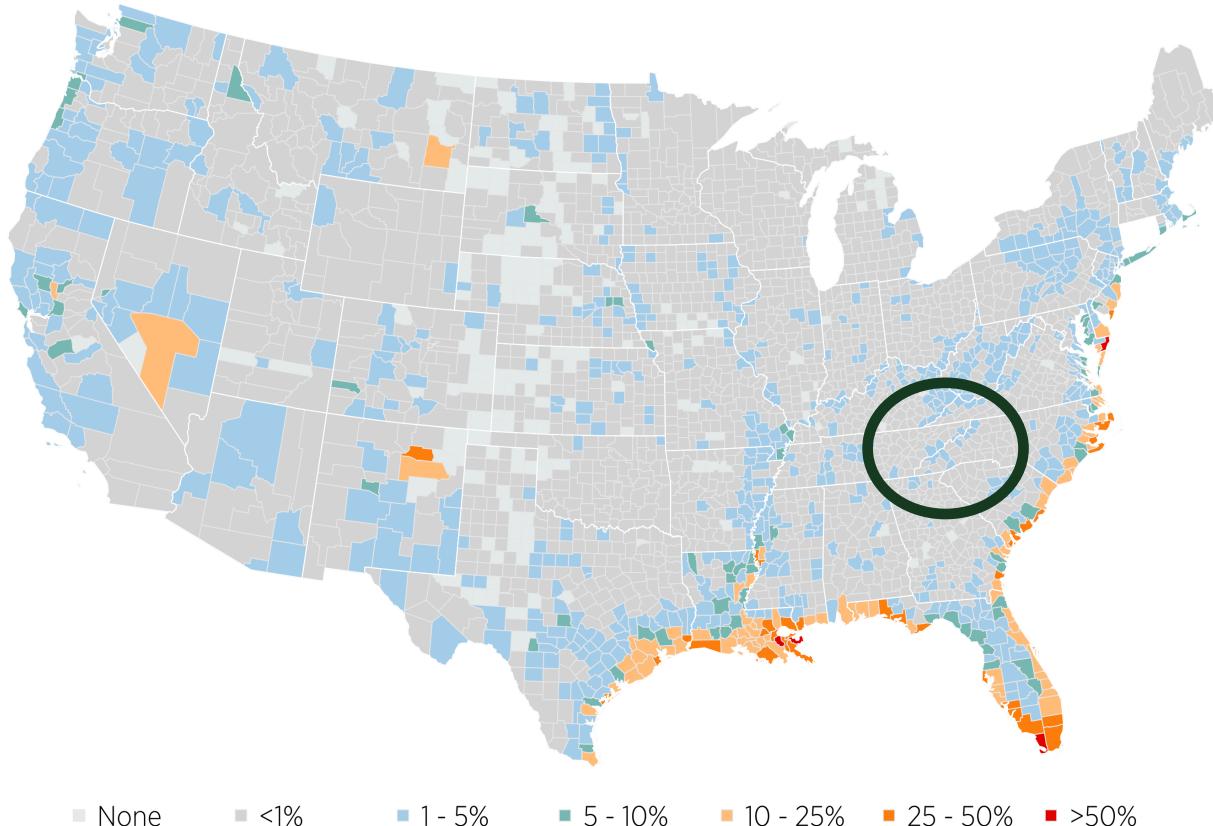
Hurricane Helene Notable Facts

- 175 direct fatalities, \$79 billion USD in damage (\$20 billion USD insured)
- Strongest hurricane to make landfall in the Big Bend on record (since 1851)
- ~16' storm surge between Keaton Beach and mouth of the Steinhatchee River
- >15" of rainfall for portions of western North Carolina (31.33" at Busick, NC), >10" of rainfall for parts of FL, GA, SC, VA, and TN

National Flood Insurance Program Take-Up Rate Per County

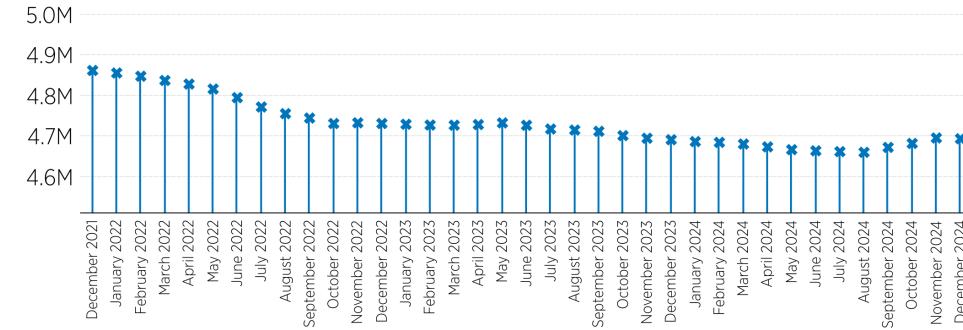
National Flood Insurance Program (NFIP)

Take-Up Per County: As of December 31, 2024



NOTE: Graphic is based on county-level 2023 U.S. Census Bureau Housing Units versus the number of active NFIP policies per county as made available from FEMA

Total Active U.S. NFIP Policies: 2021-2024

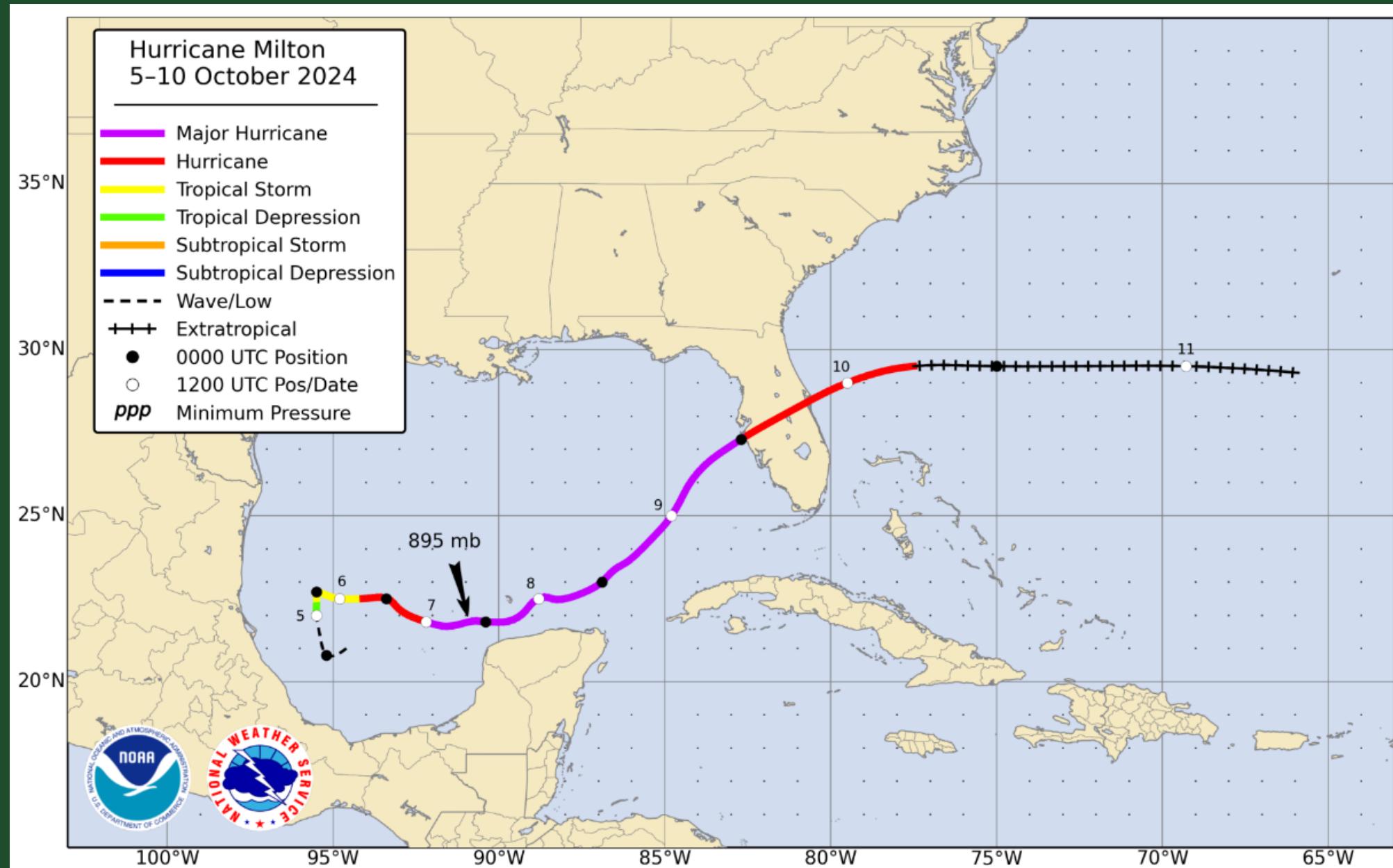


	December 2020	December 2021	December 2022	December 2023	December 2024
GRAND TOTAL	5,033,115	4,862,726	4,731,848	4,691,845	4,694,271
FLORIDA	1,732,602	1,678,429	1,662,277	1,714,311	1,782,864
TEXAS	792,706	773,919	706,221	664,174	638,027
LOUISIANA	504,227	504,764	481,691	454,933	433,986
NEW JERSEY	214,553	199,037	206,563	204,494	201,401
SOUTH CAROLINA	210,797	198,561	203,322	201,460	198,232
CALIFORNIA	210,015	199,220	191,678	192,701	183,498
NEW YORK	169,137	166,781	168,387	168,283	167,996
NORTH CAROLINA	142,293	135,566	133,171	131,581	131,817
VIRGINIA	103,536	98,877	95,354	92,814	92,554
GEORGIA	81,440	78,961	76,260	73,782	73,299
MARYLAND	65,394	63,324	63,656	63,201	63,209
HAWAII	61,434	59,599	58,372	55,674	60,182
MASSACHUSETTS	57,347	54,510	54,664	55,921	56,885
MISSISSIPPI	61,820	60,547	57,887	54,785	52,778

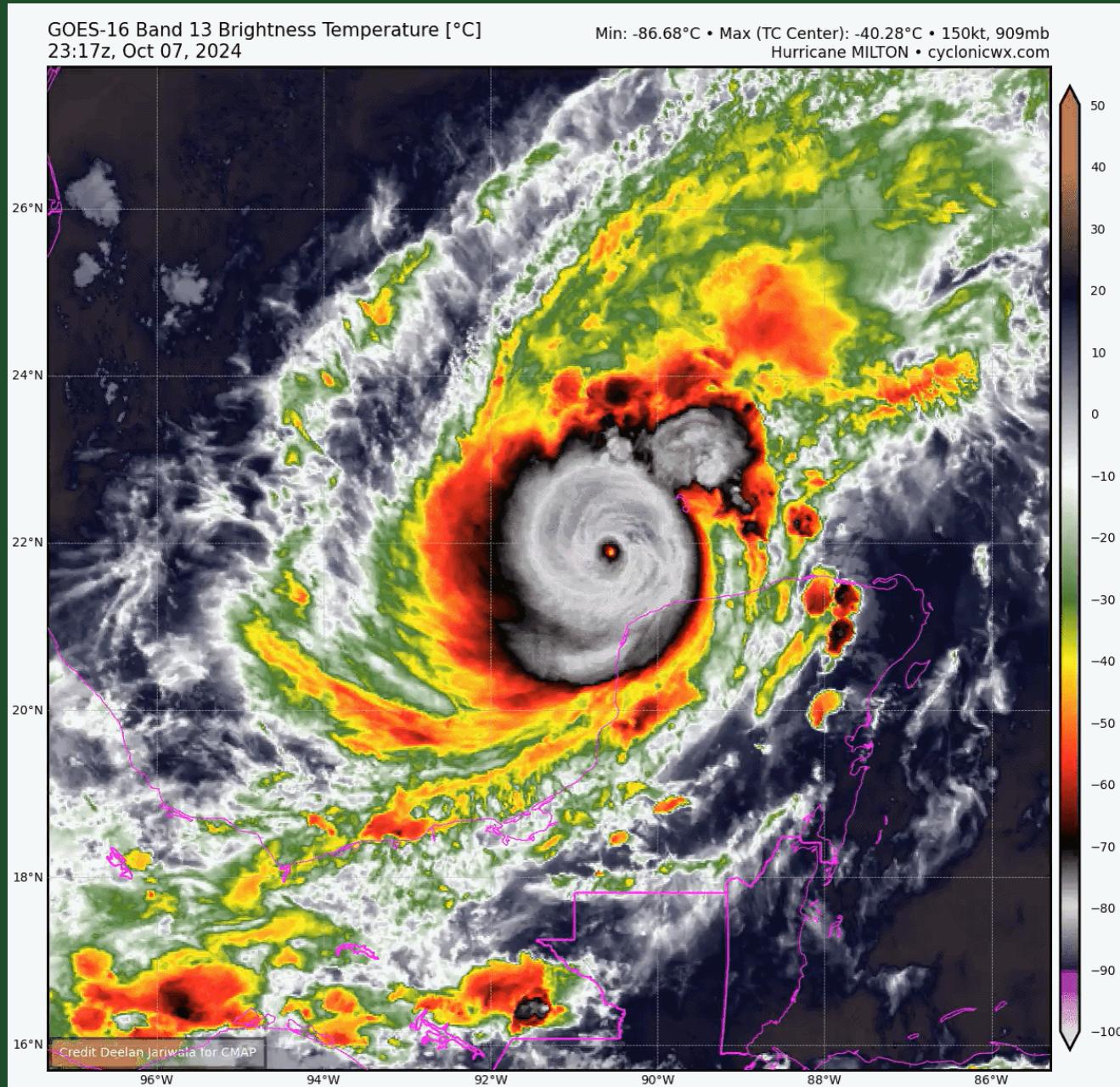
Data: FEMA & U.S. Census Bureau Graphic & Analysis: Steve Bowen (Gallagher Re)

Steve Bowen (Gallagher Re)

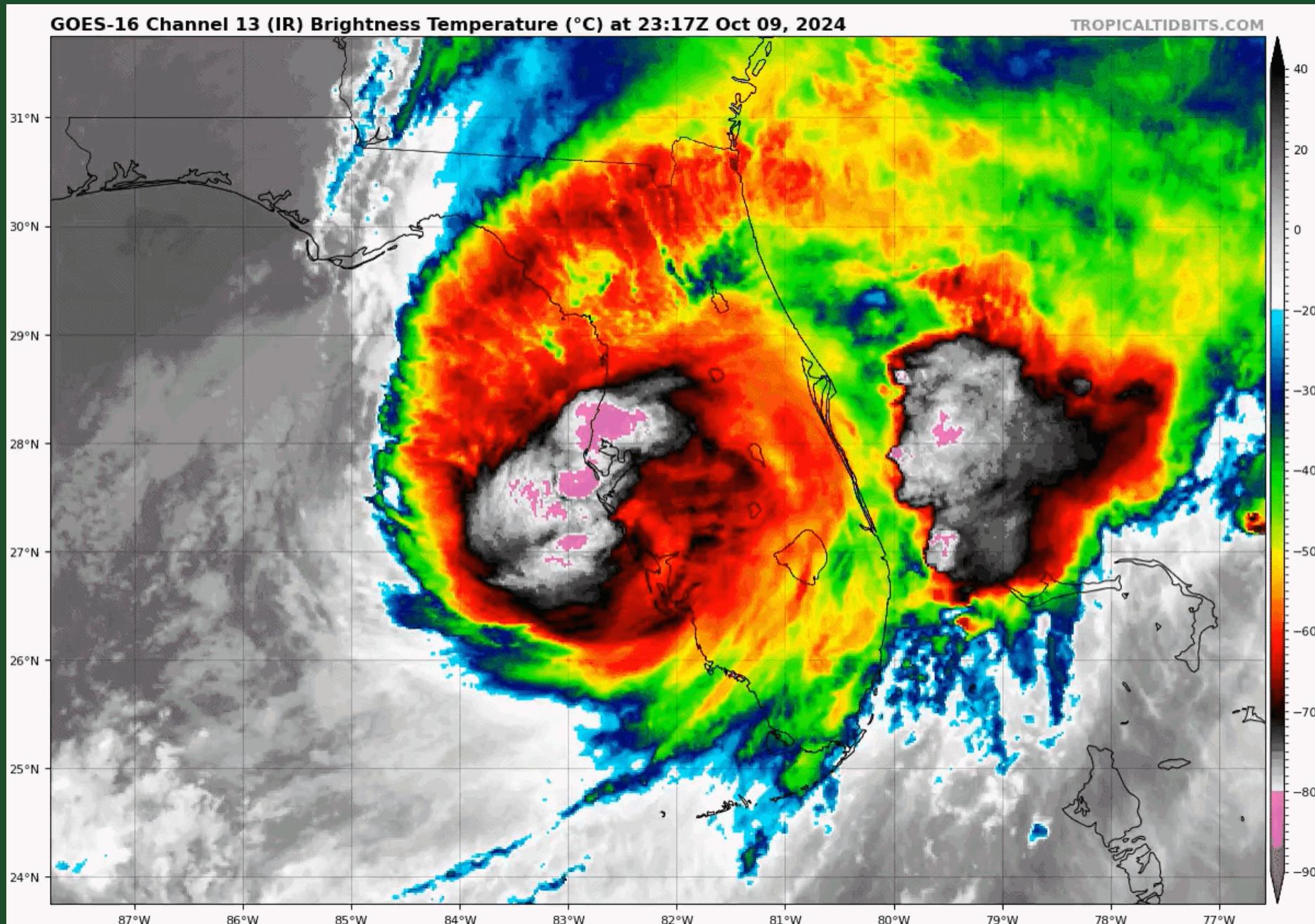
Hurricane Milton



Hurricane Milton at Max Intensity (180 mph, 895 mb)



Hurricane Milton Landfall (115 mph, 958 hPa)



Hurricane Milton Notable Facts

- Minimum central pressure of 895 mb – the lowest since Wilma (2005)
- 90 mph 24 hr^{-1} max intensification rate – max 24 hr rate since Felix (2007)
- 15 fatalities, \$34 billion in economic damage (\$20 billion insured)
- ~18" of rain in St. Petersburg
- ~10' peak storm surge near Manasota Key (Charlotte County)
- 45 tornadoes, 3 EF3 tornadoes

Arago's Admonition

“Never, no matter what may be the progress of science, will honest scientific men (or women) who have regard for their reputations venture to predict the weather!”

Contact Info

- **Phil Klotzbach**
- **Email:** philk@atmos.colostate.edu
- **Web:** tropical.colostate.edu
- **Twitter (X):** [@philklotzbach](https://twitter.com/philklotzbach)

