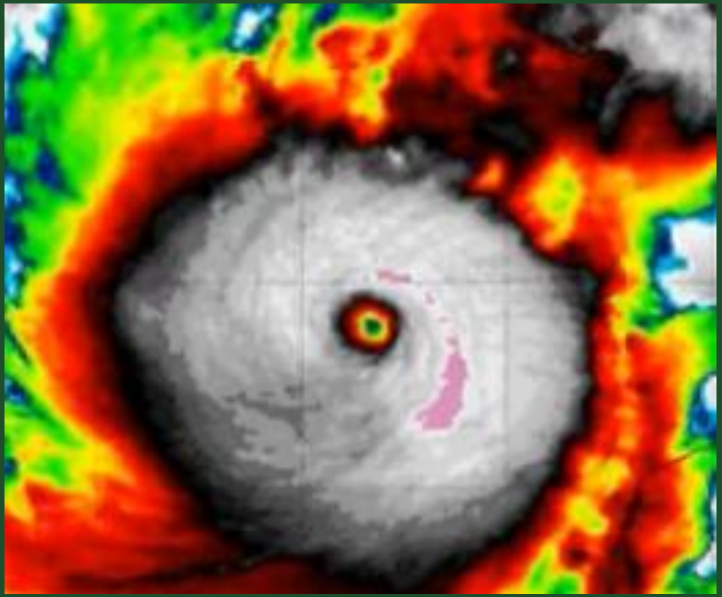
Atlantic Basin Seasonal Hurricane Outlook for 2025 and Longer-Term Trends



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

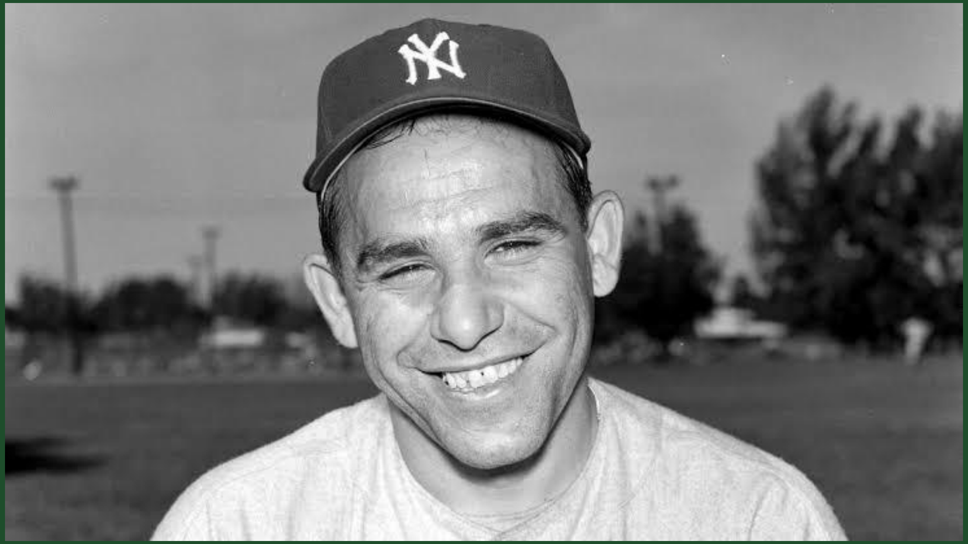
Seasonal Forecasting is more than this!

The Essence of Seasonal Forecasting

"It's tough to make predictions, especially about the future."

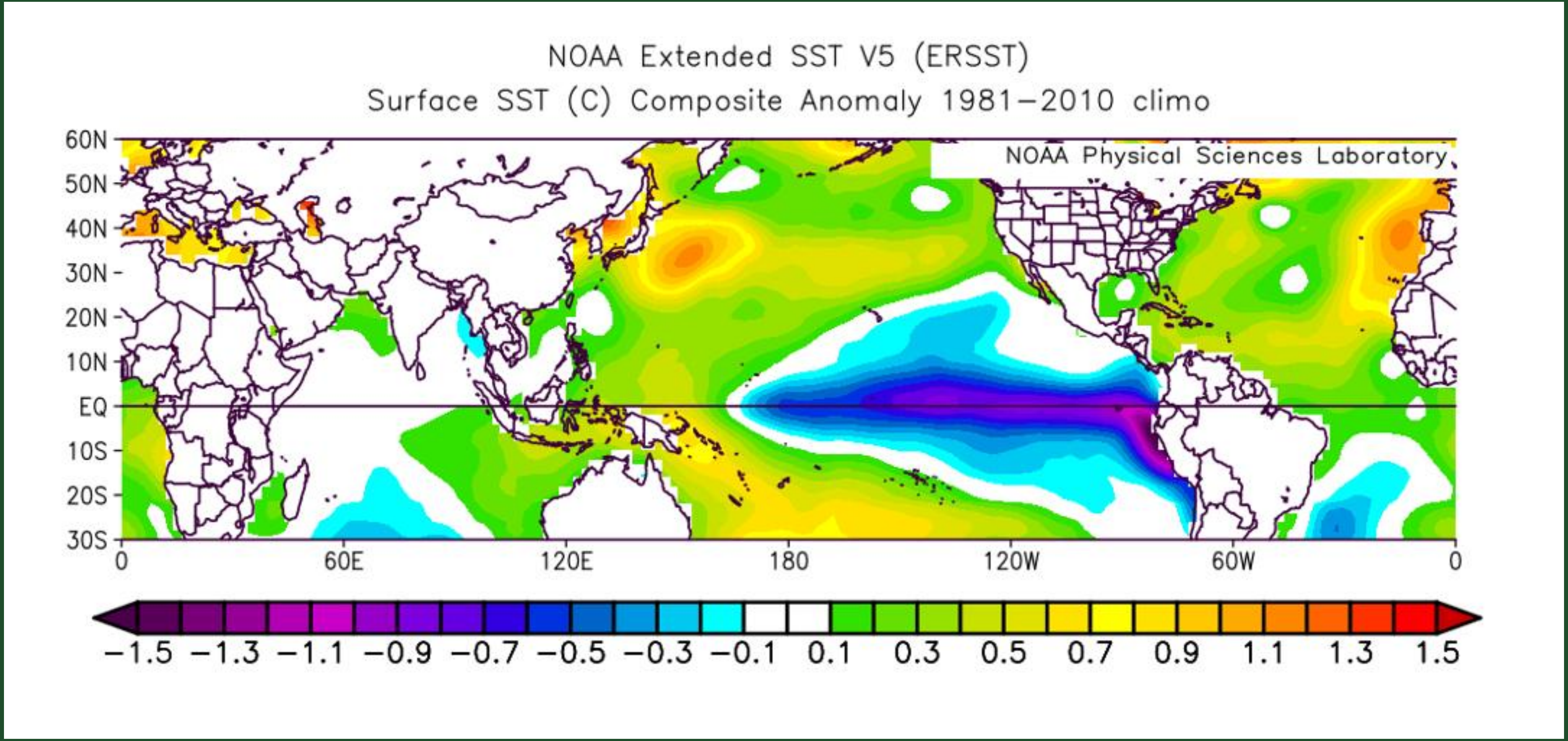
HOWEVER

"You can see a lot by looking"

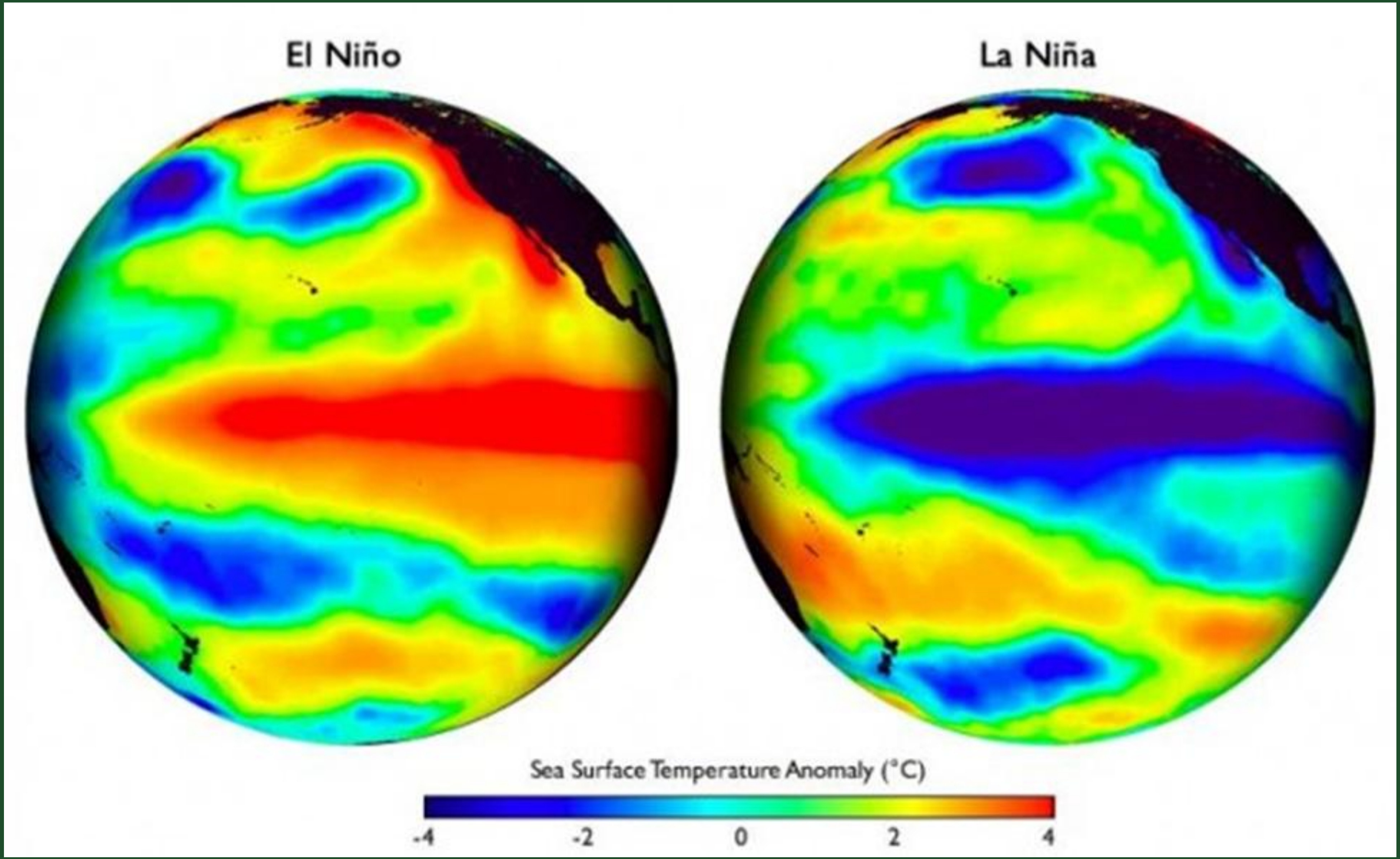


Yogi Berra

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



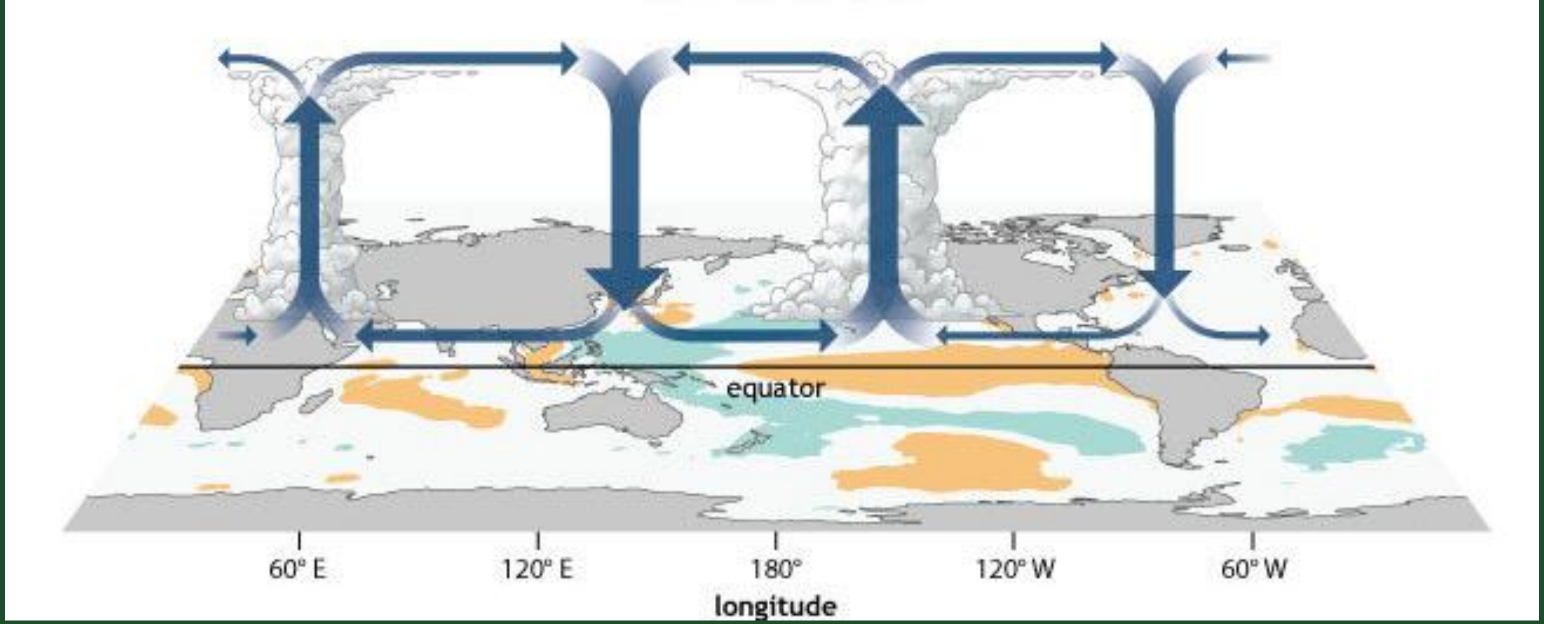
What is El Niño/La Niña?



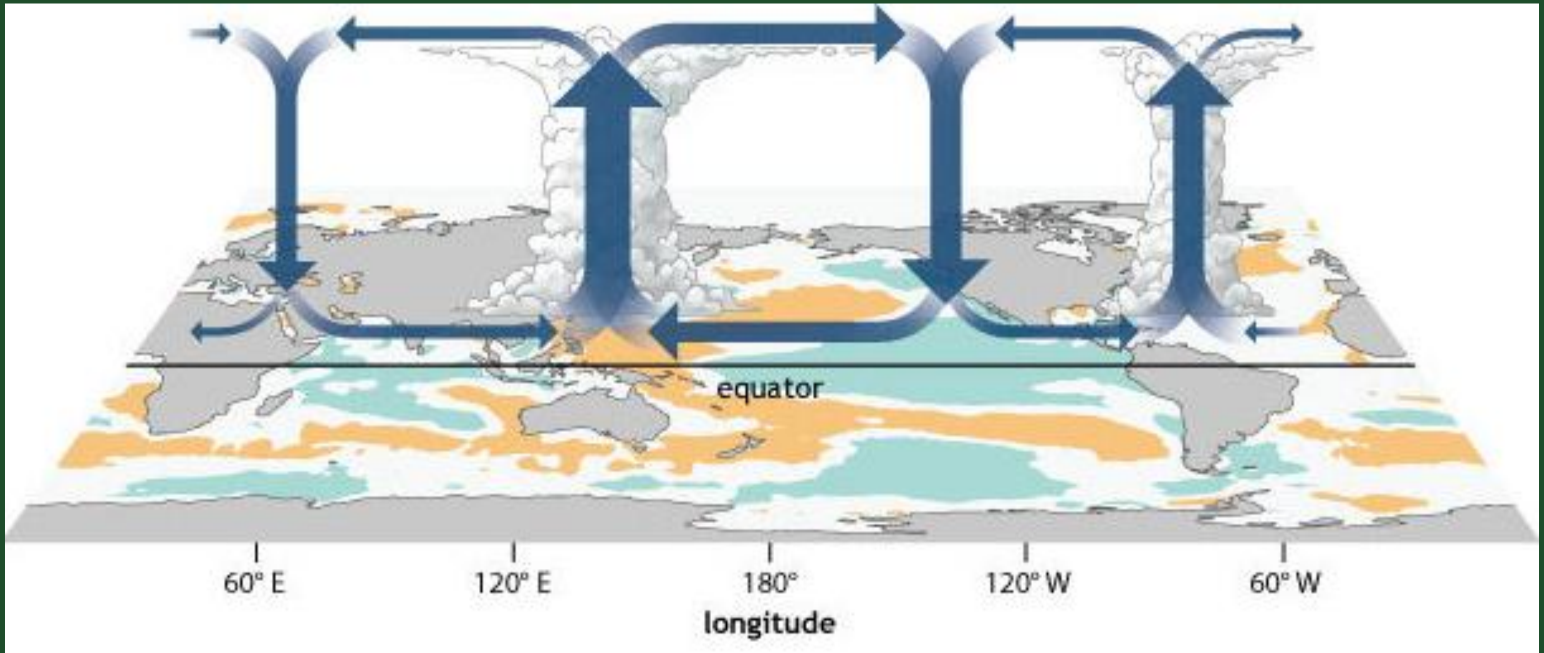
Columbia Univ

ENSO’s Impact on Tropical Circulation

El Niño

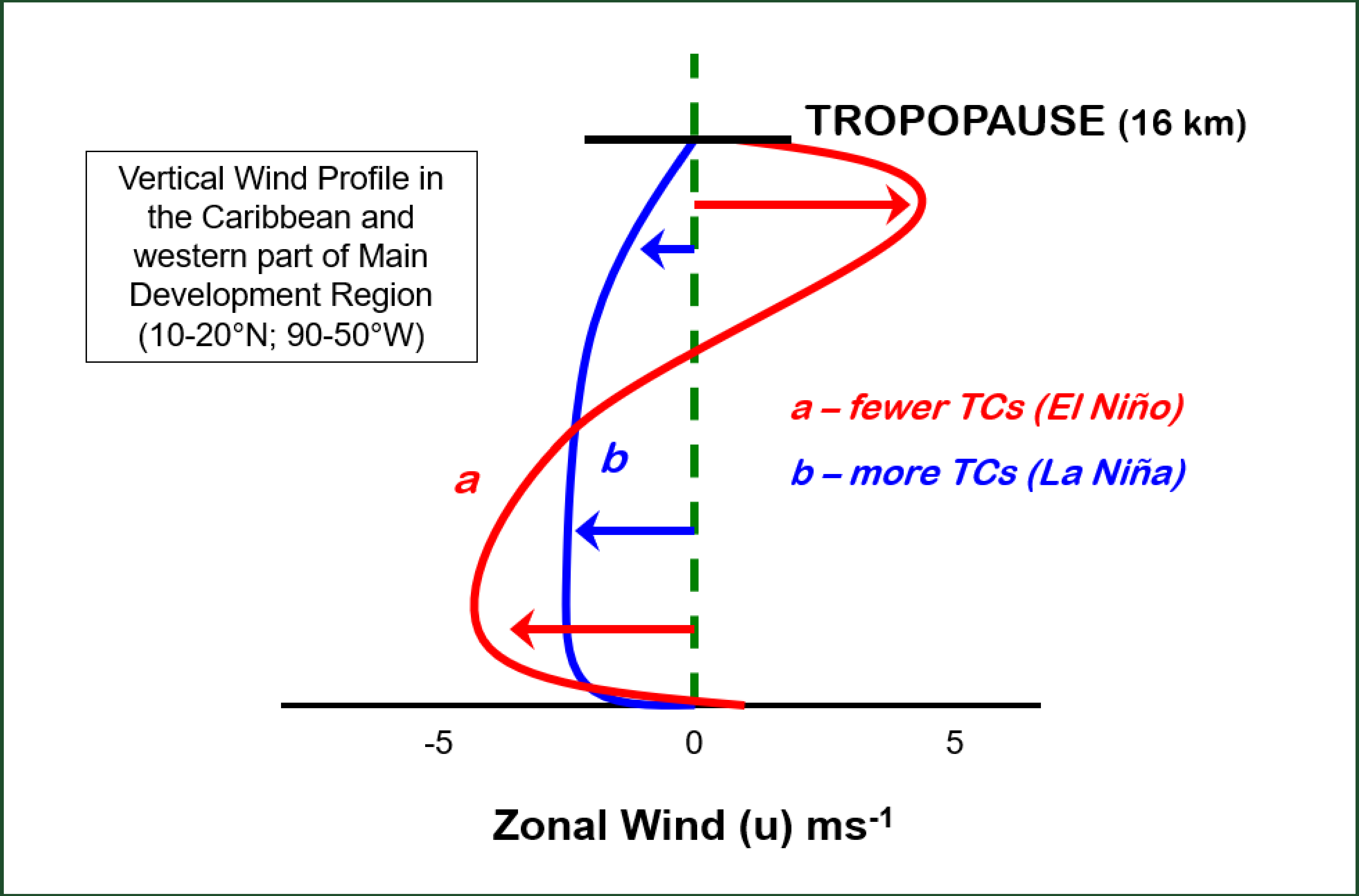


La Niña

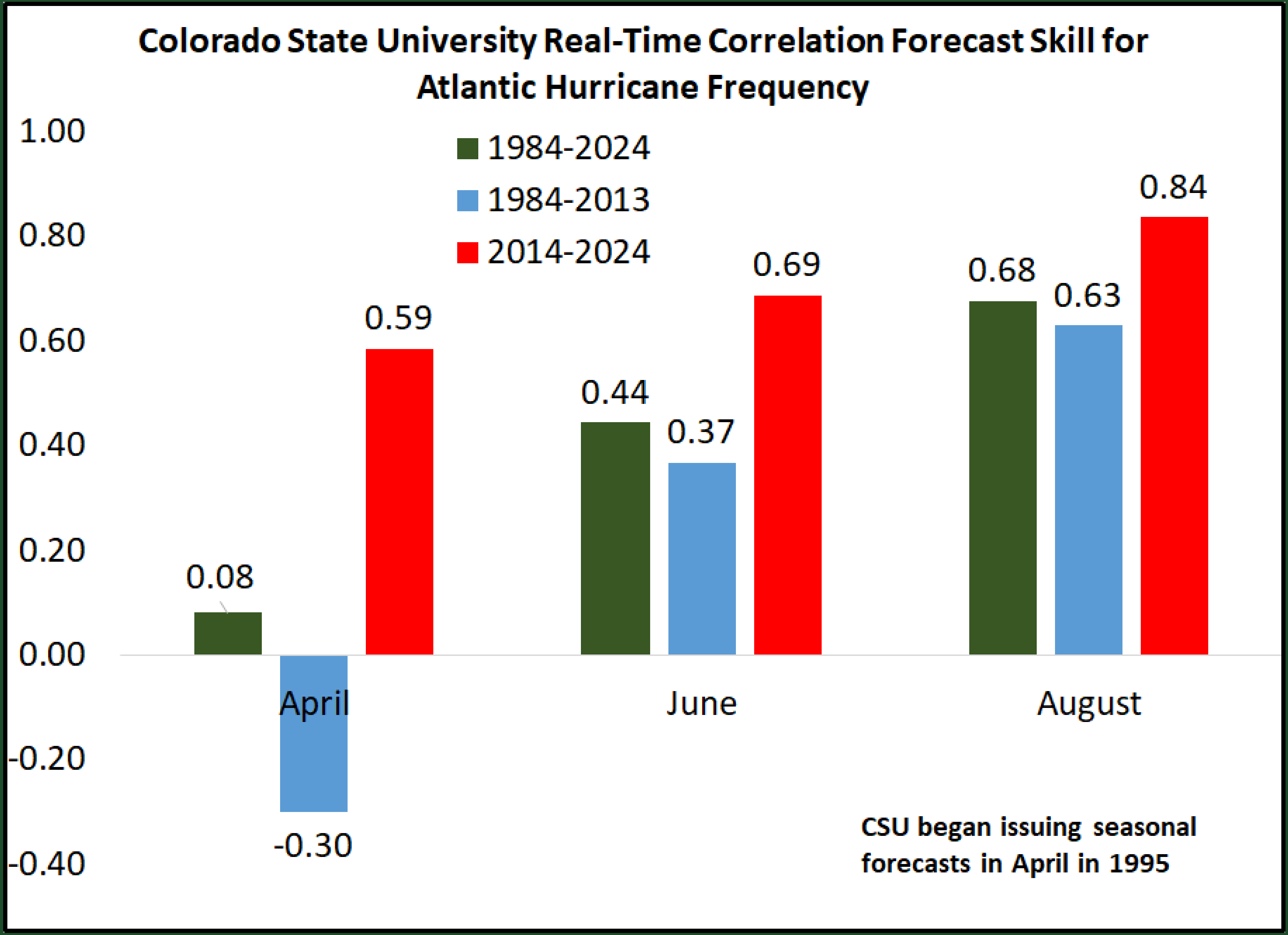


climate.gov

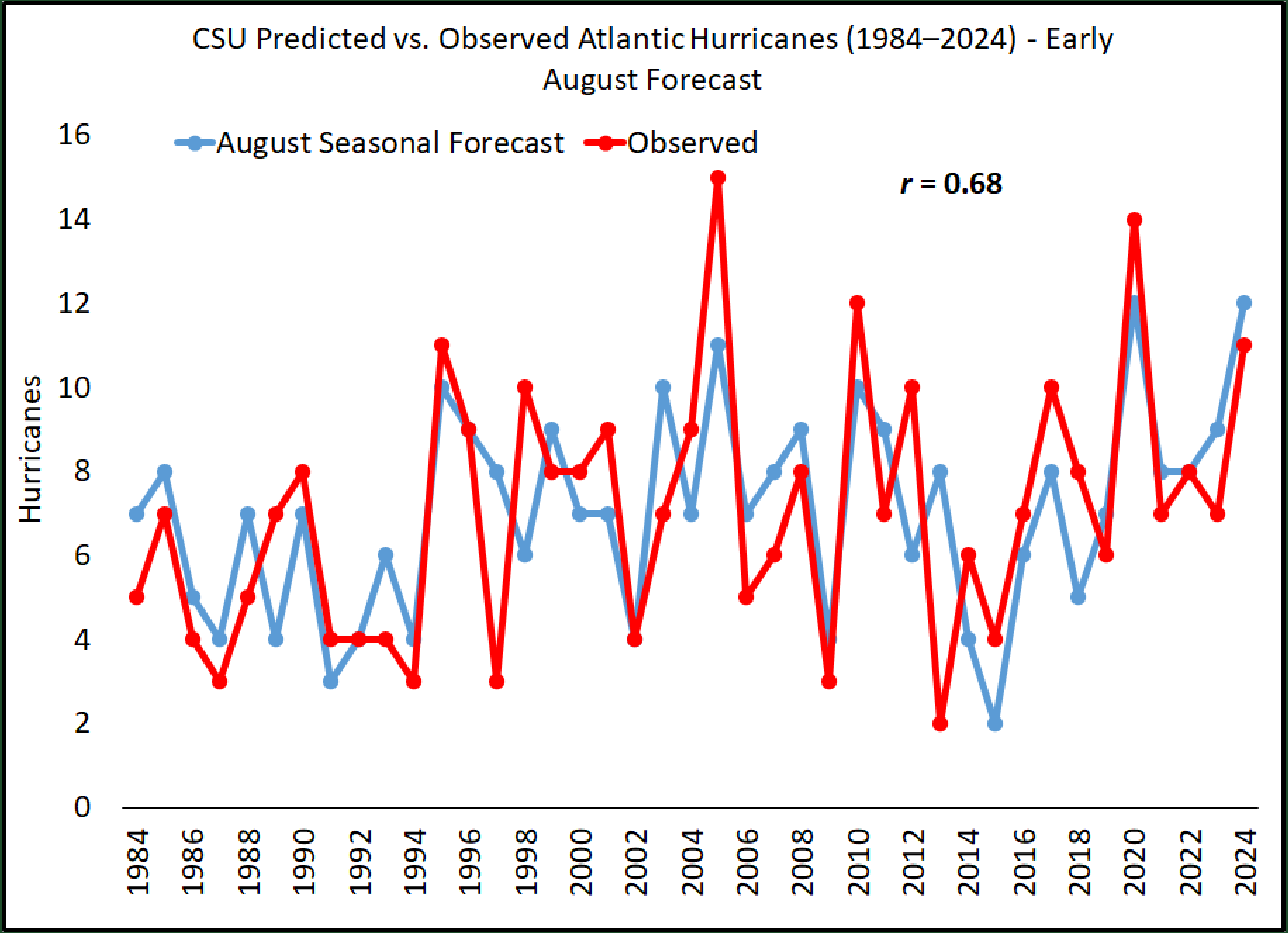
El Niño/La Niña Relationship with Vertical Wind Shear



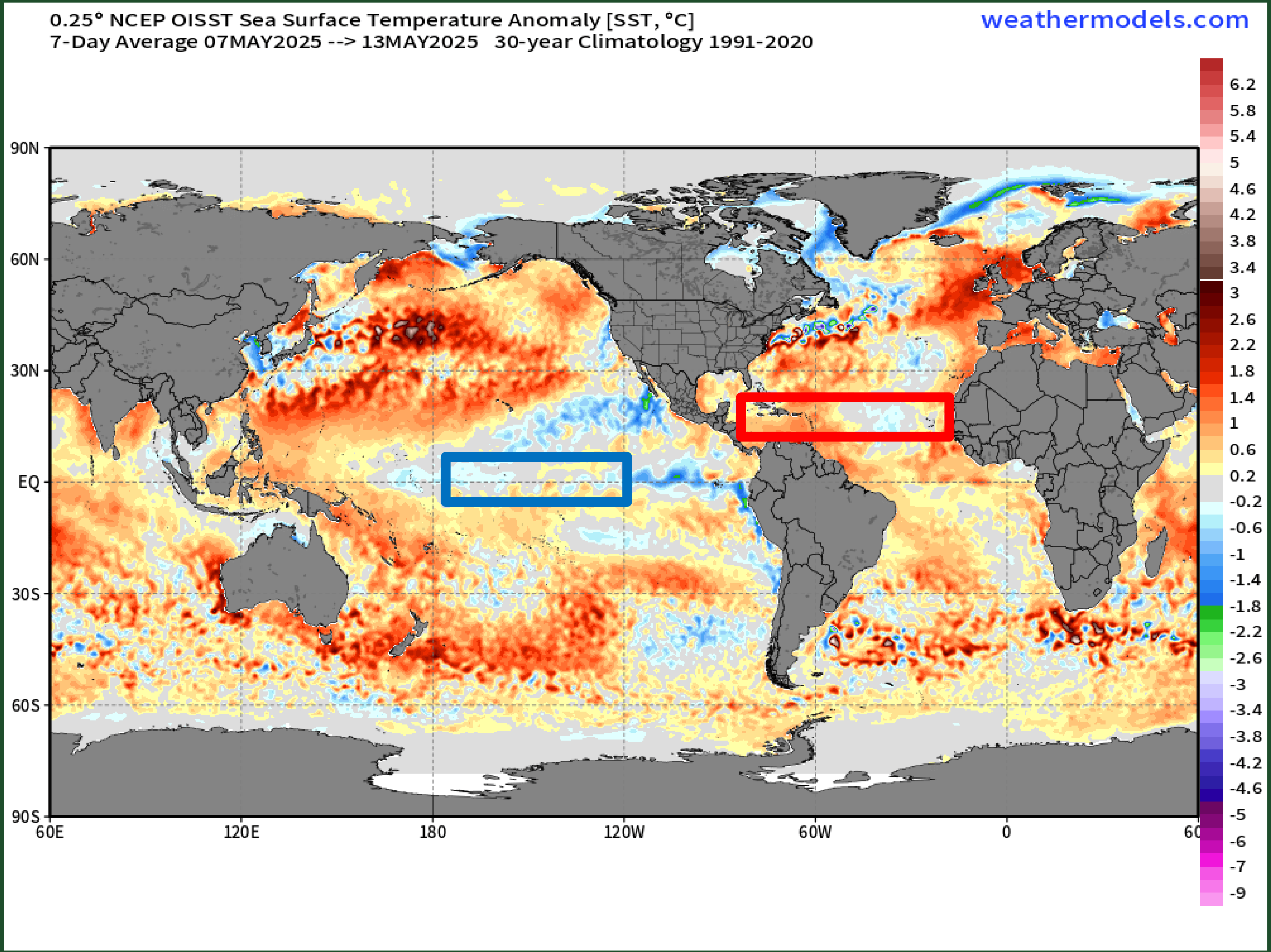
CSU Long-Term Seasonal Hurricane Forecast Track Record



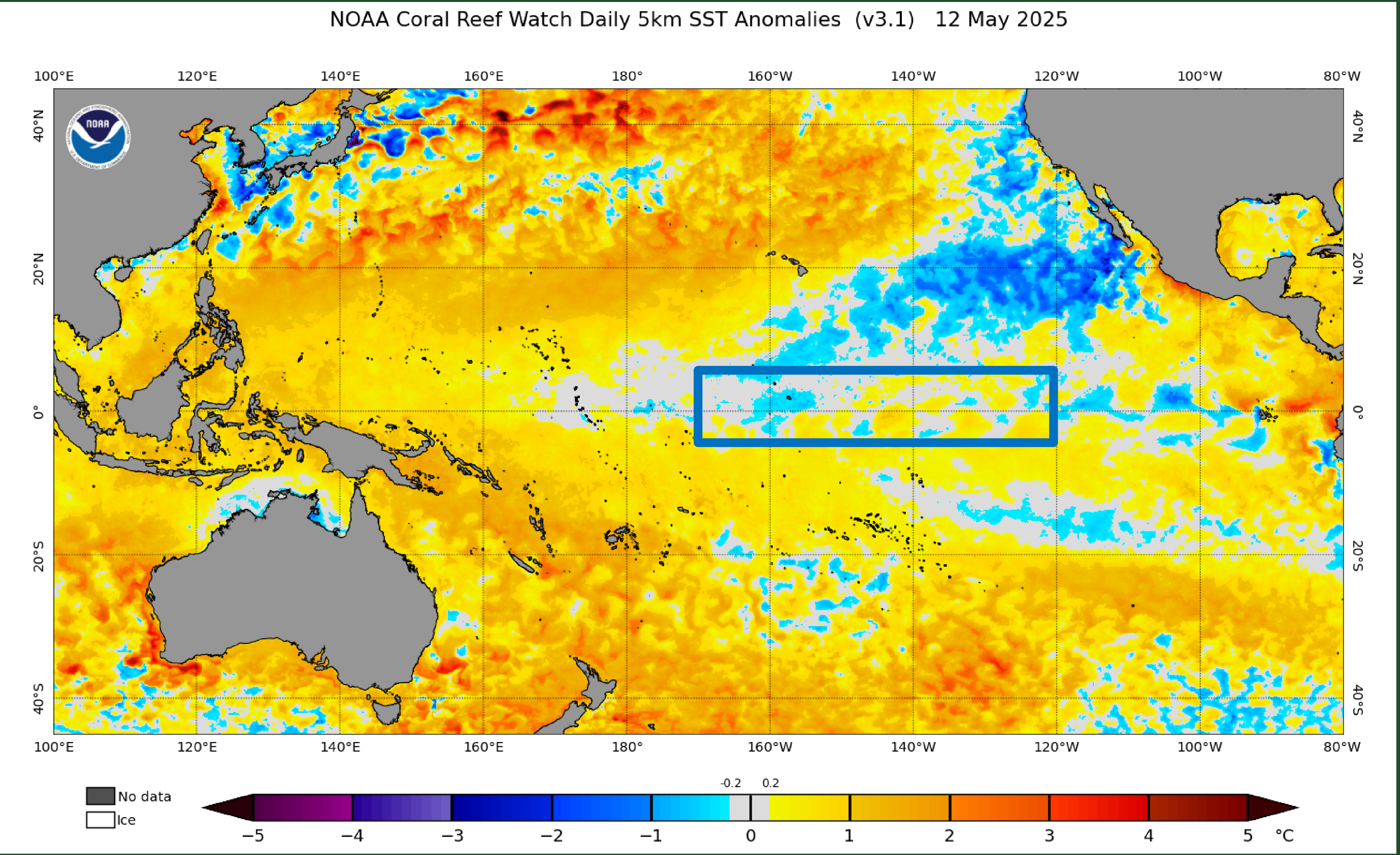
Early August CSU Predicted vs. Observed Hurricane Forecast (1984–2024)



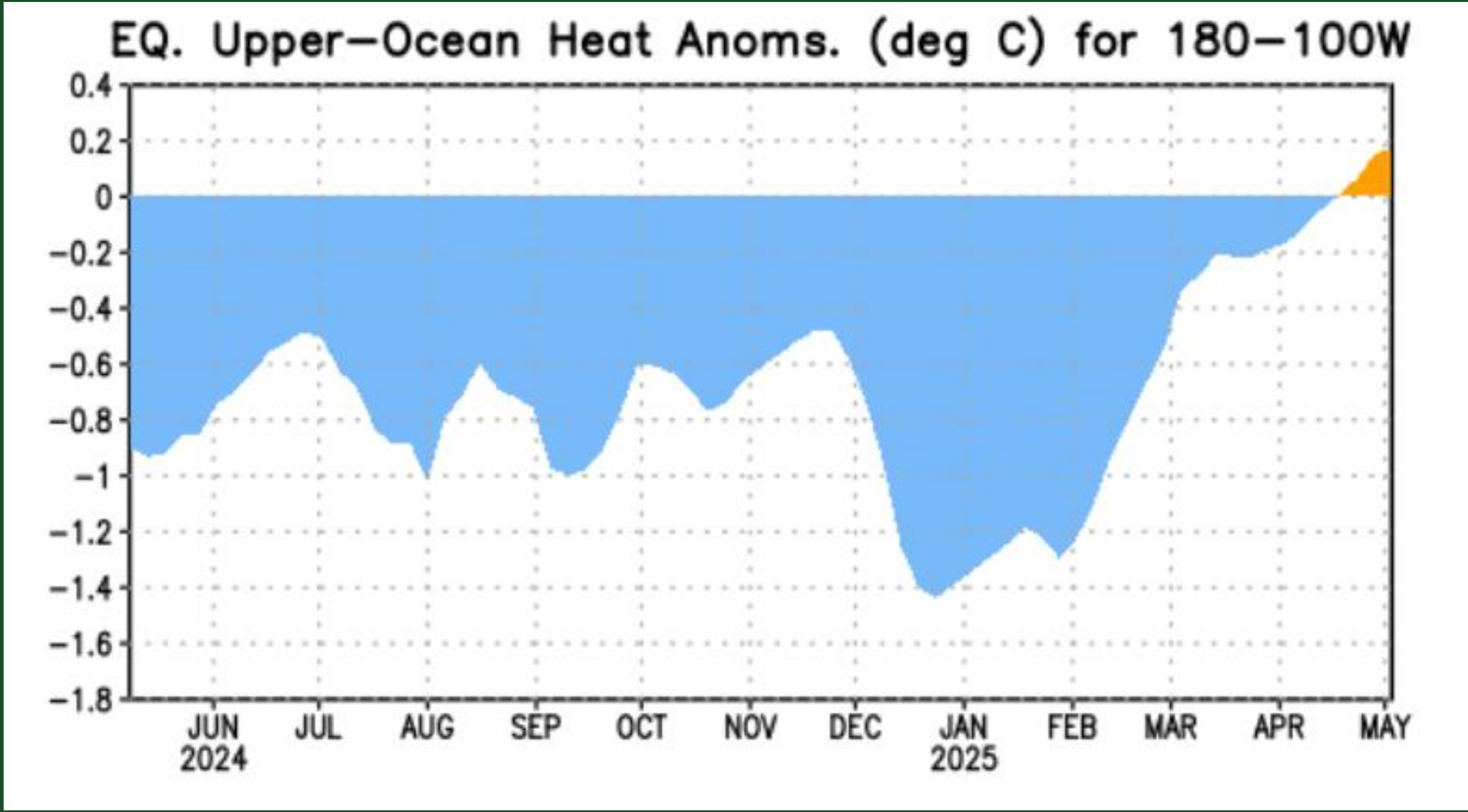
Current Sea Surface Temperature Anomalies



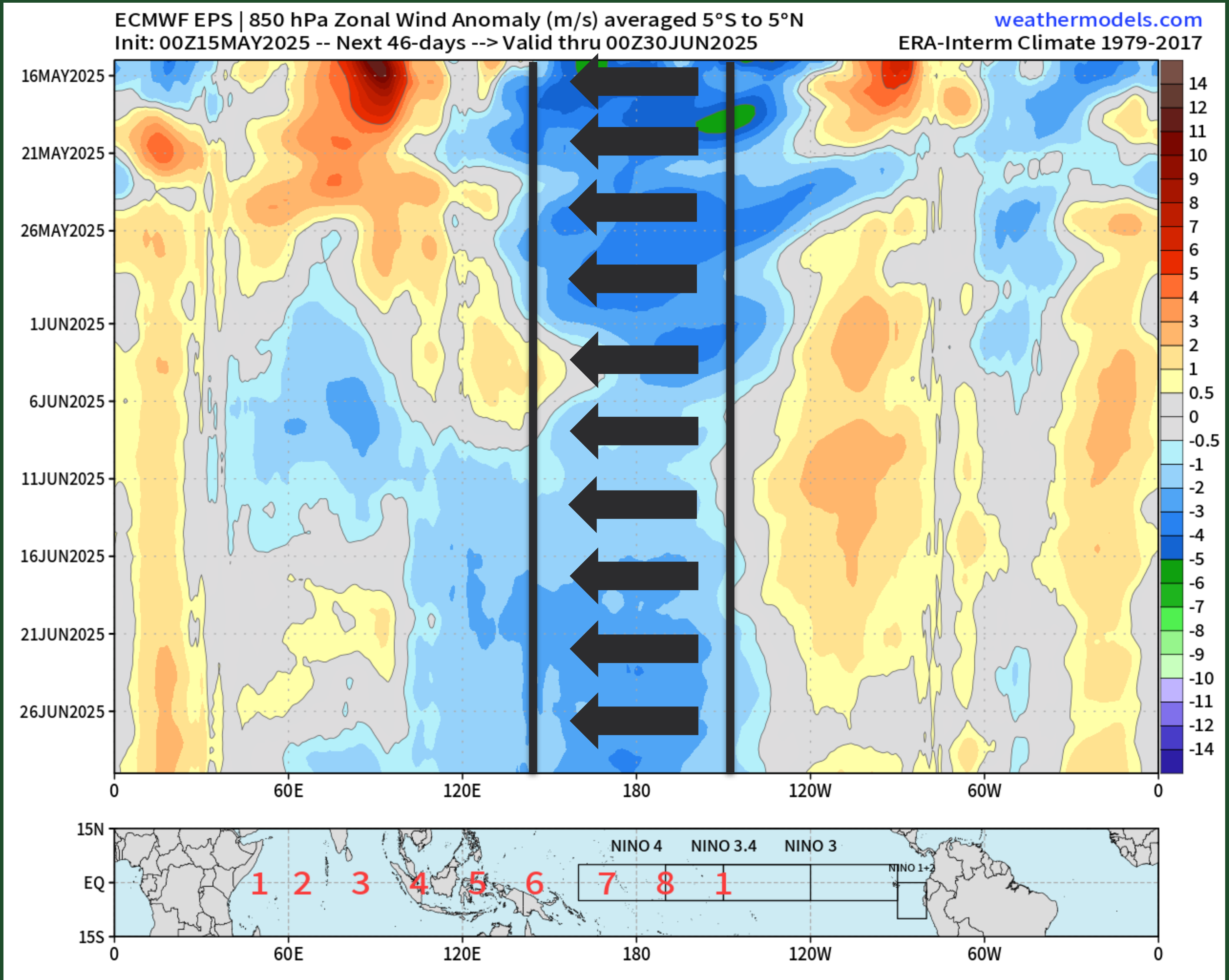
Currently ENSO Neutral Conditions



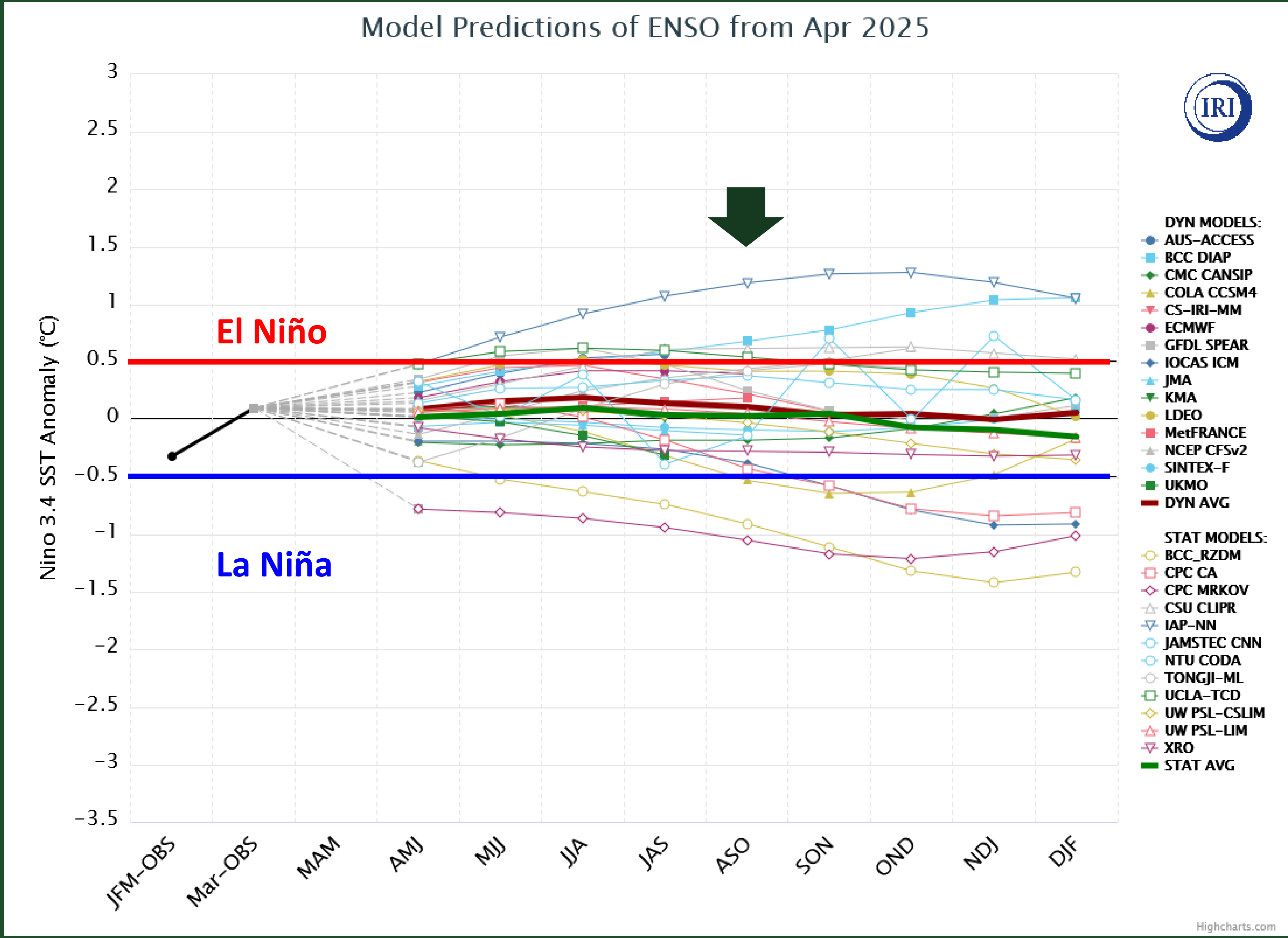
Eastern and Central Tropical Pacific Subsurface Anomalously Warming



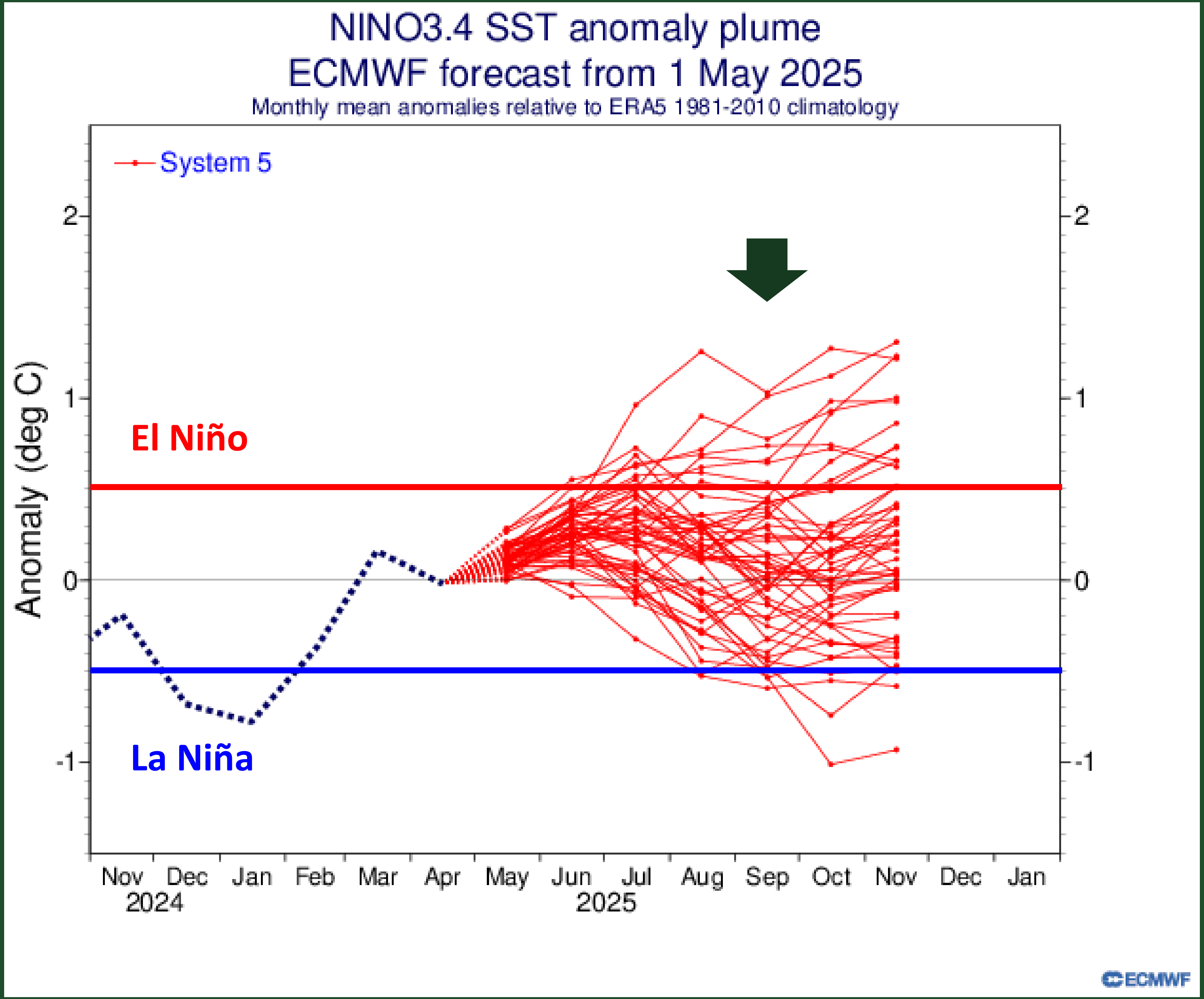
Strong Winds Across the Central Pacific Likely to Keep El Niño at Bay



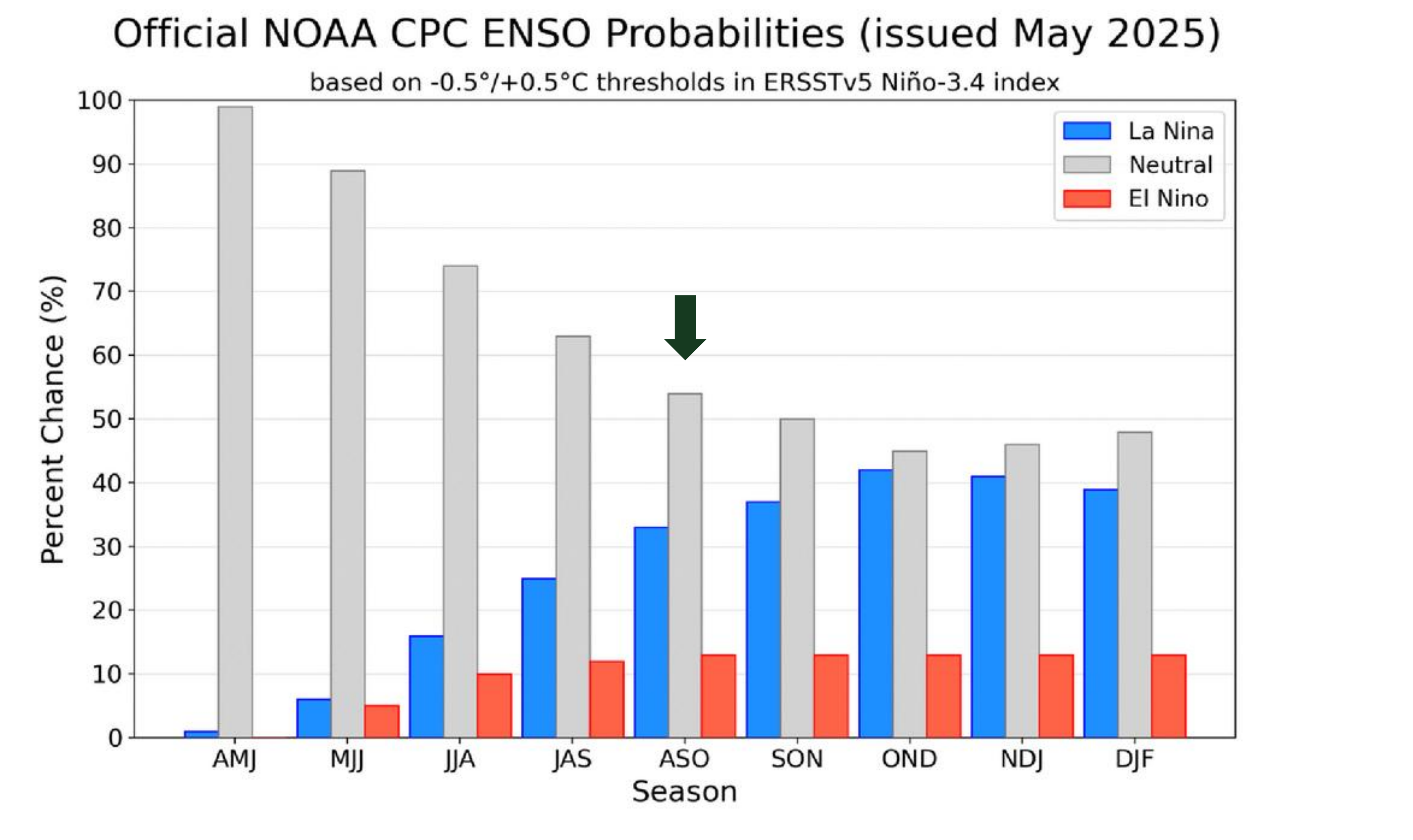
Climate Model Predictions for ENSO



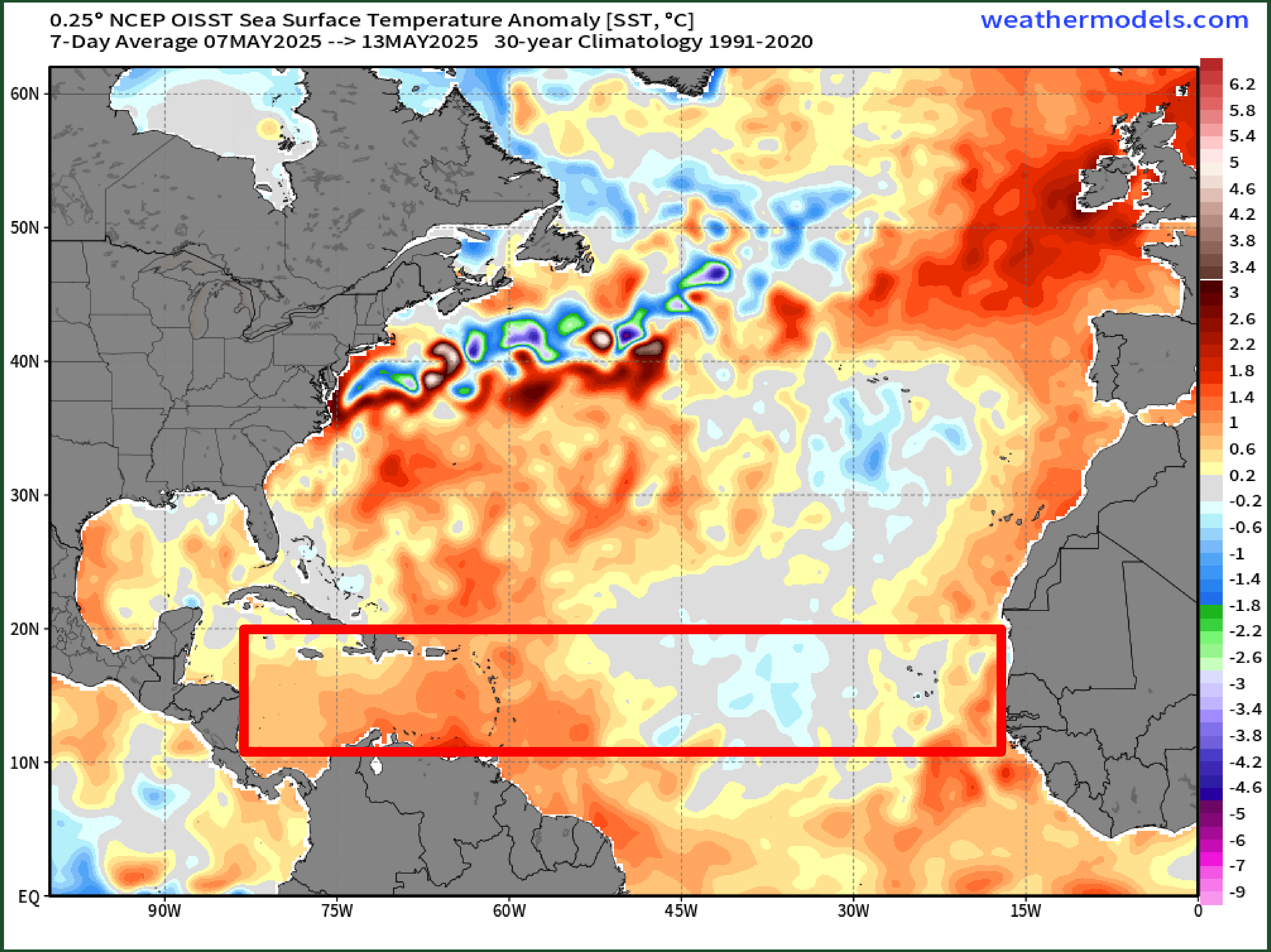
ECMWF Model Predictions for ENSO



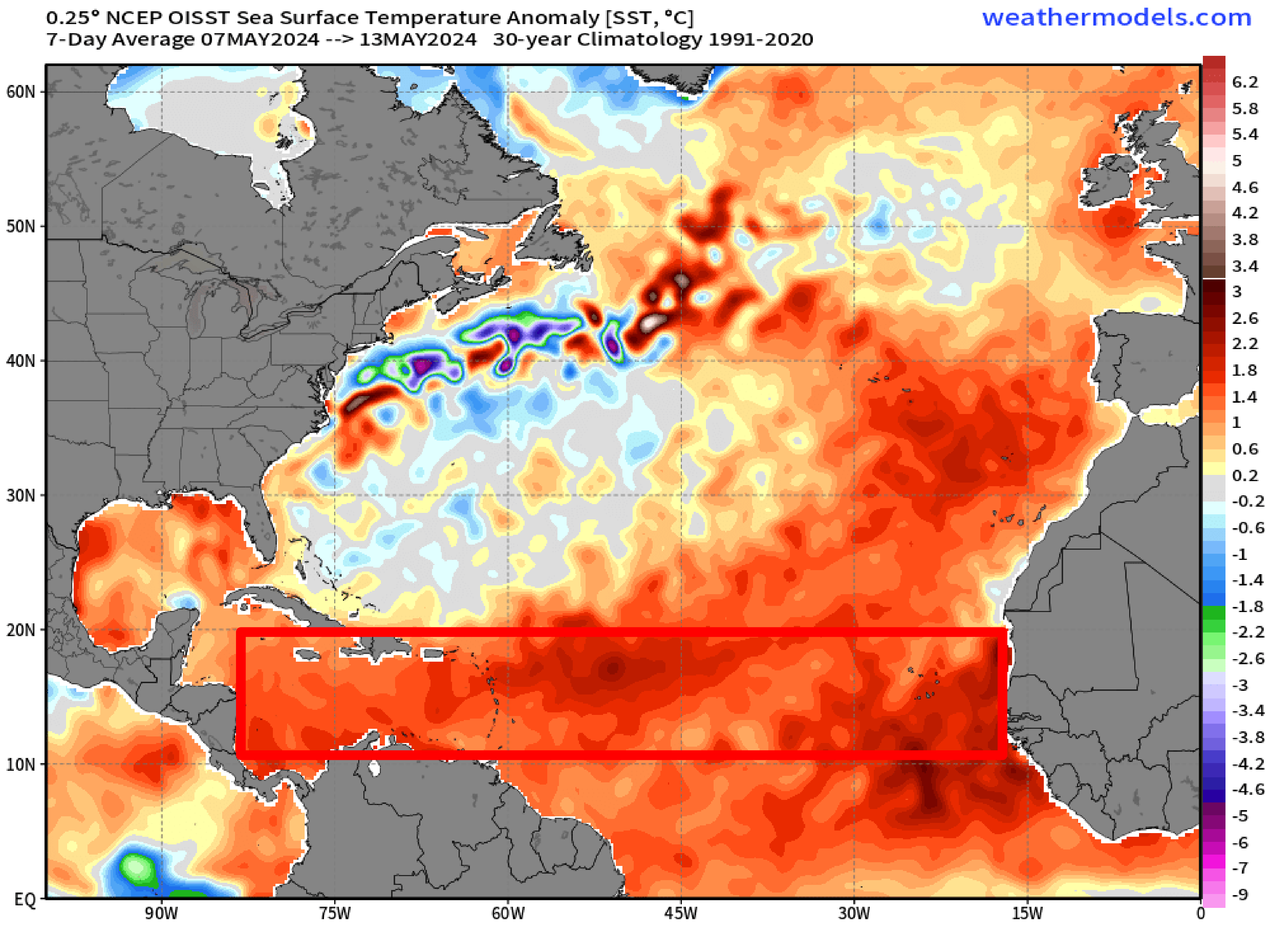
Official NOAA Forecast Favors ENSO Neutral for Aug–Oct



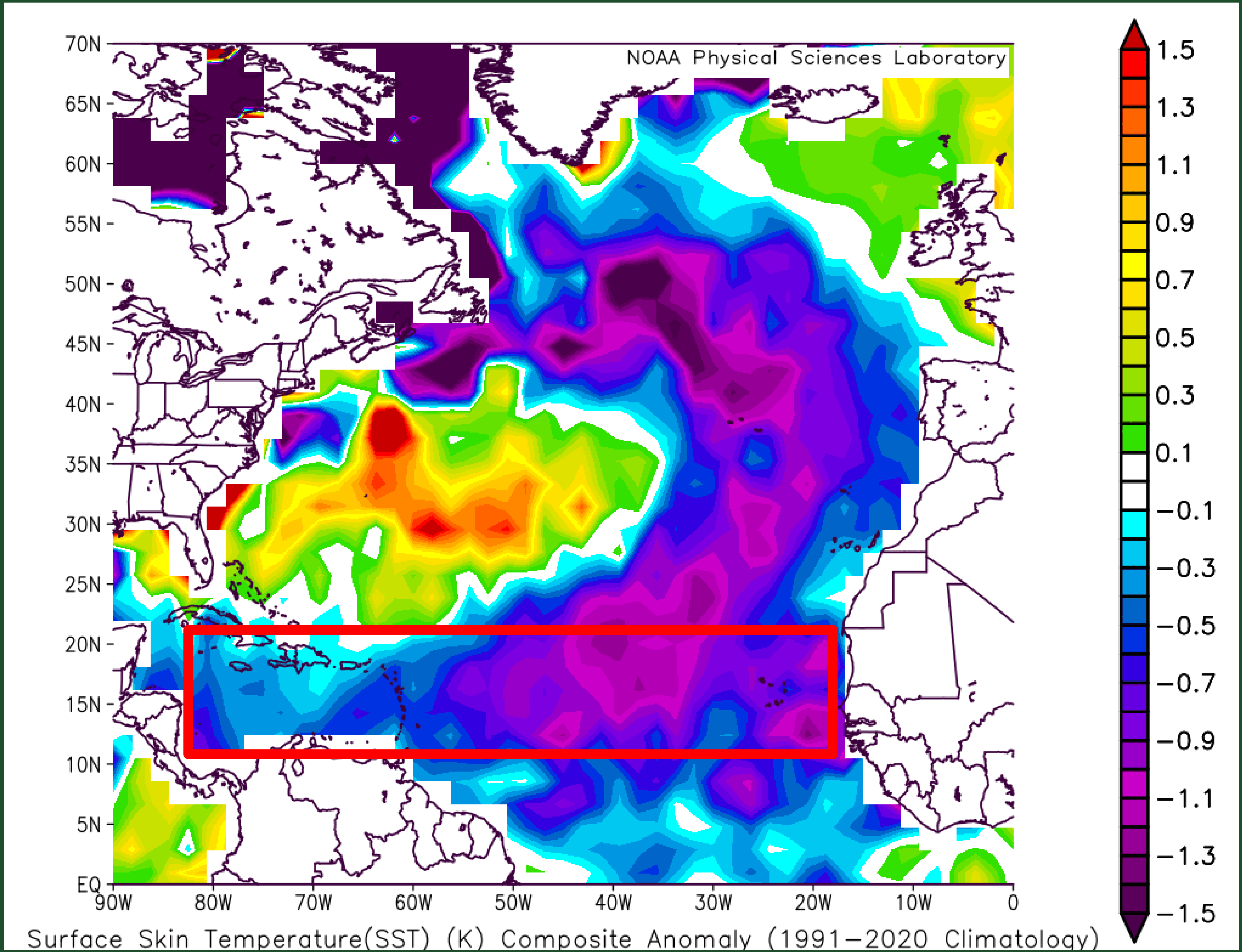
Current North Atlantic Sea Surface Temperature Anomalies



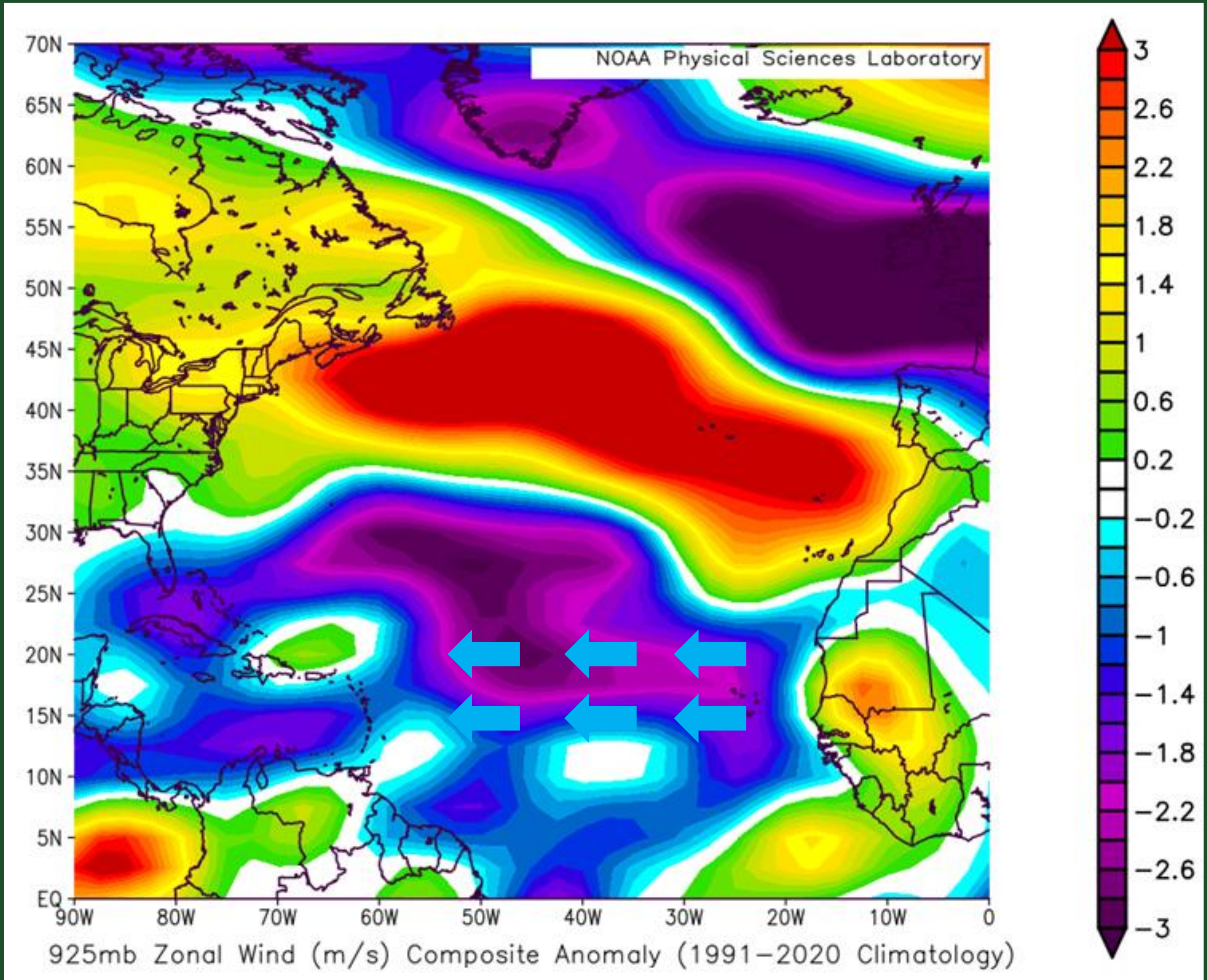
Thankfully Not as Warm as Last Year at This Time!



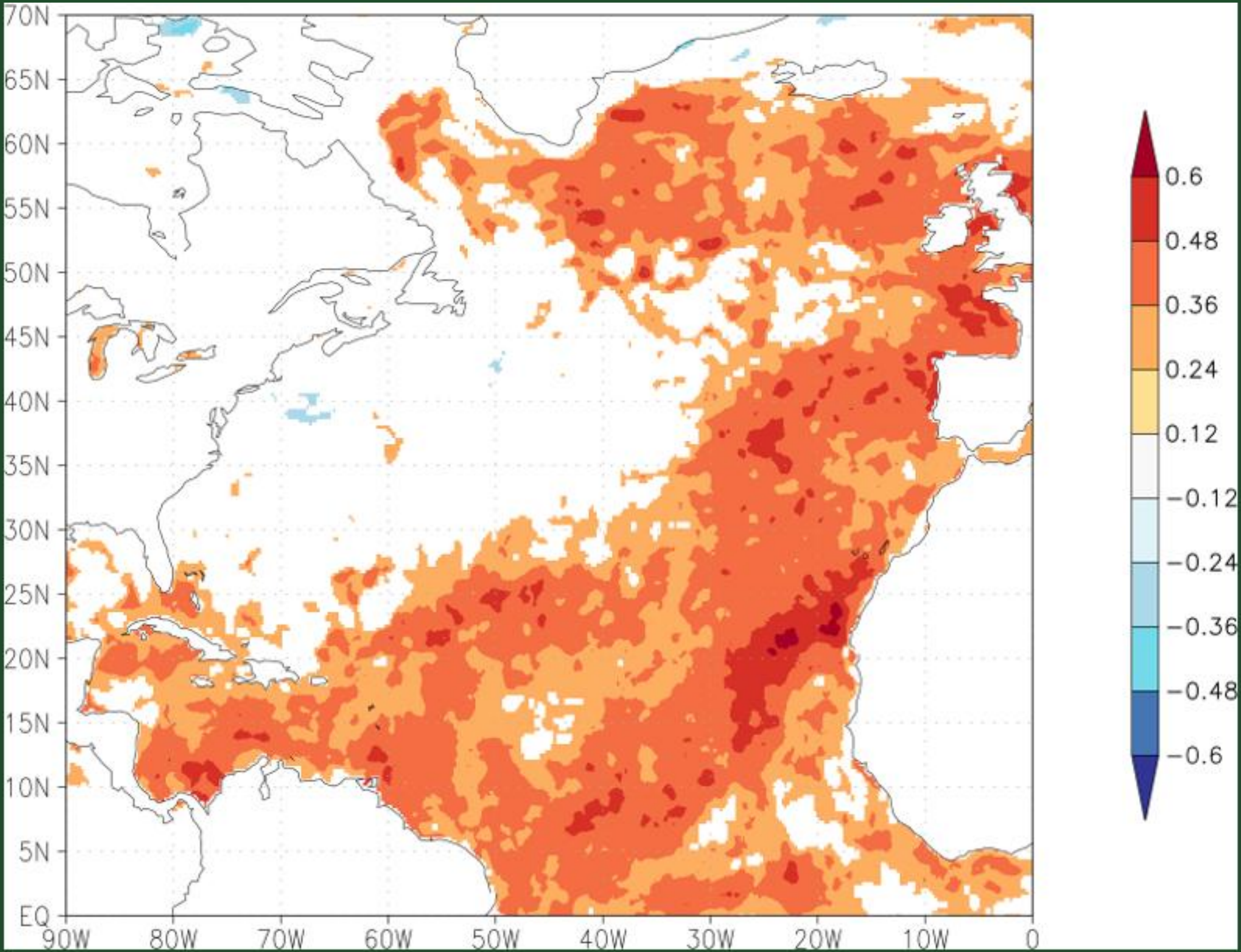
Atlantic has Cooled off Substantially since Late January



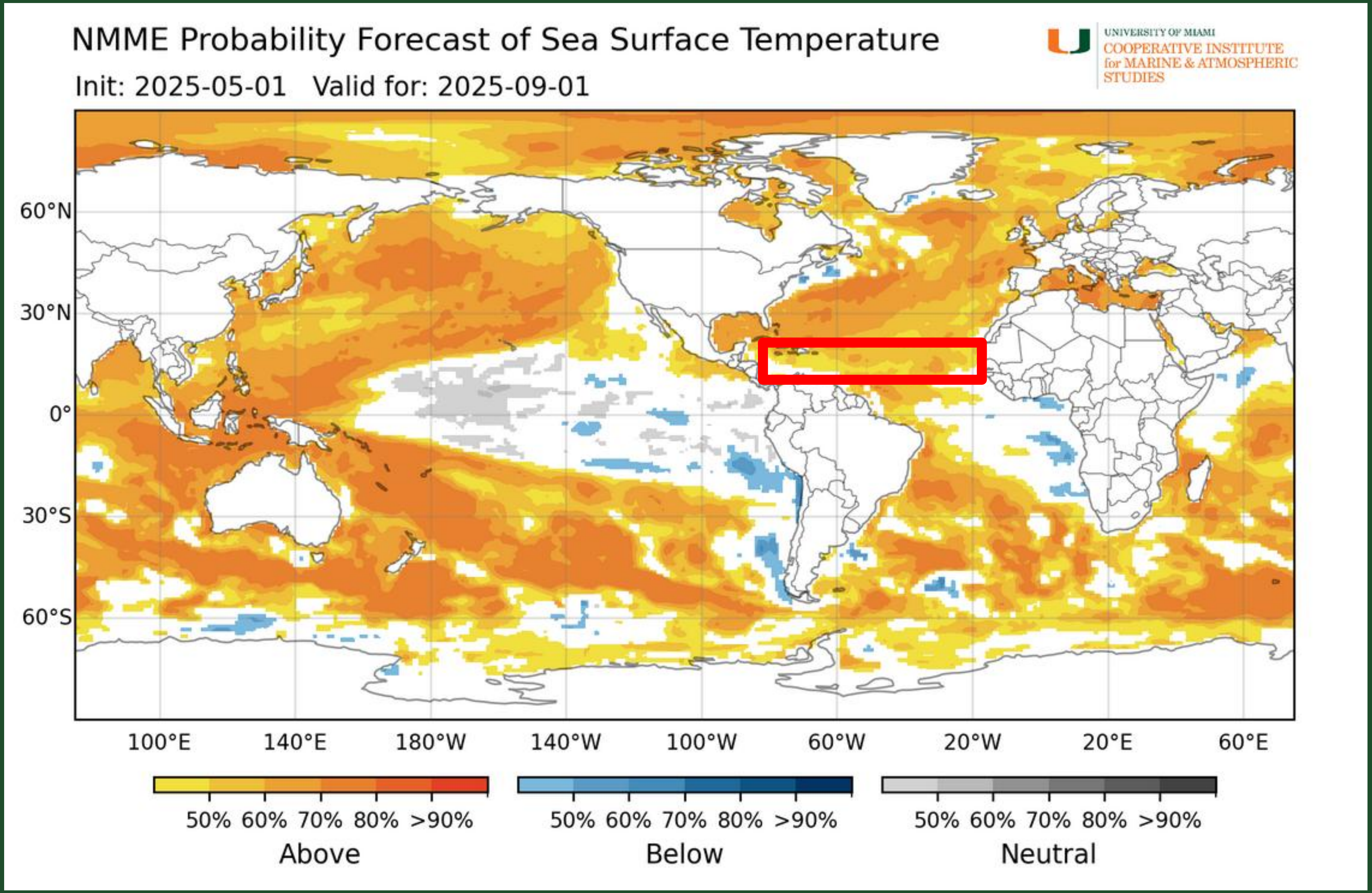
Strong Winds Blowing Across Tropical Atlantic (February – Early May)



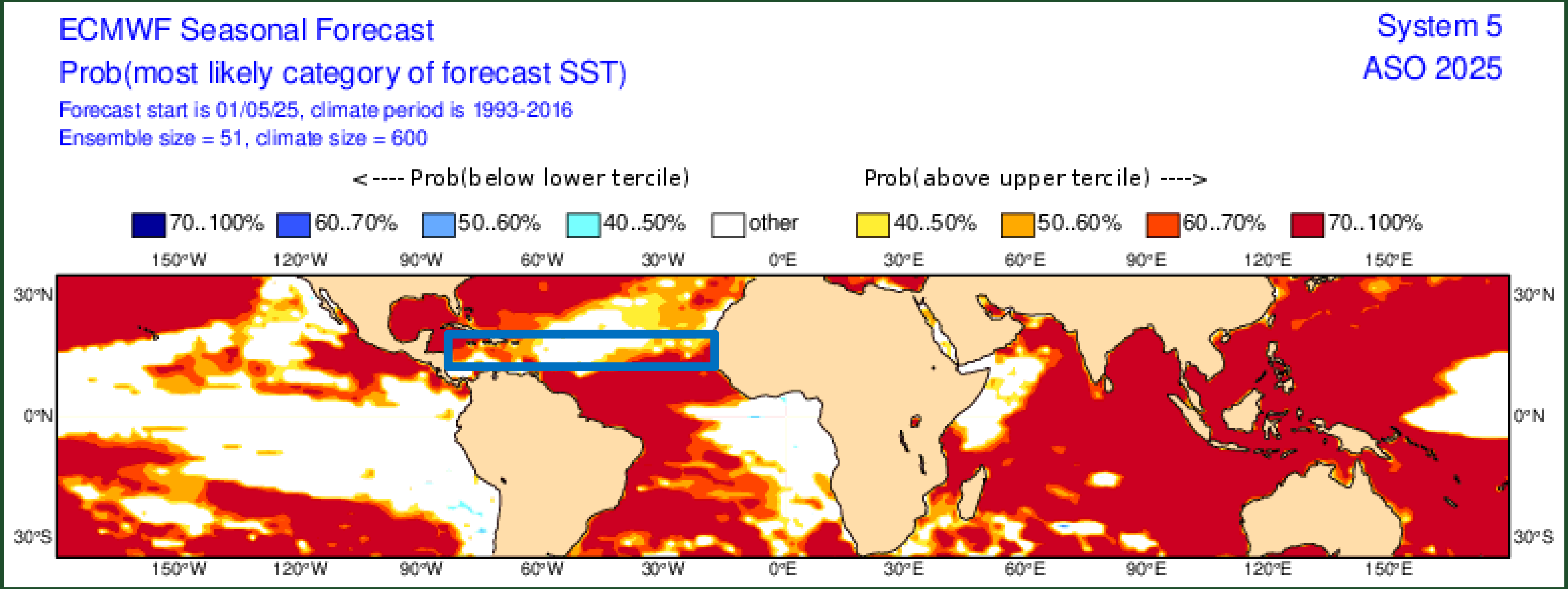
May Atlantic SST Rank Correlation with Atlantic ACE



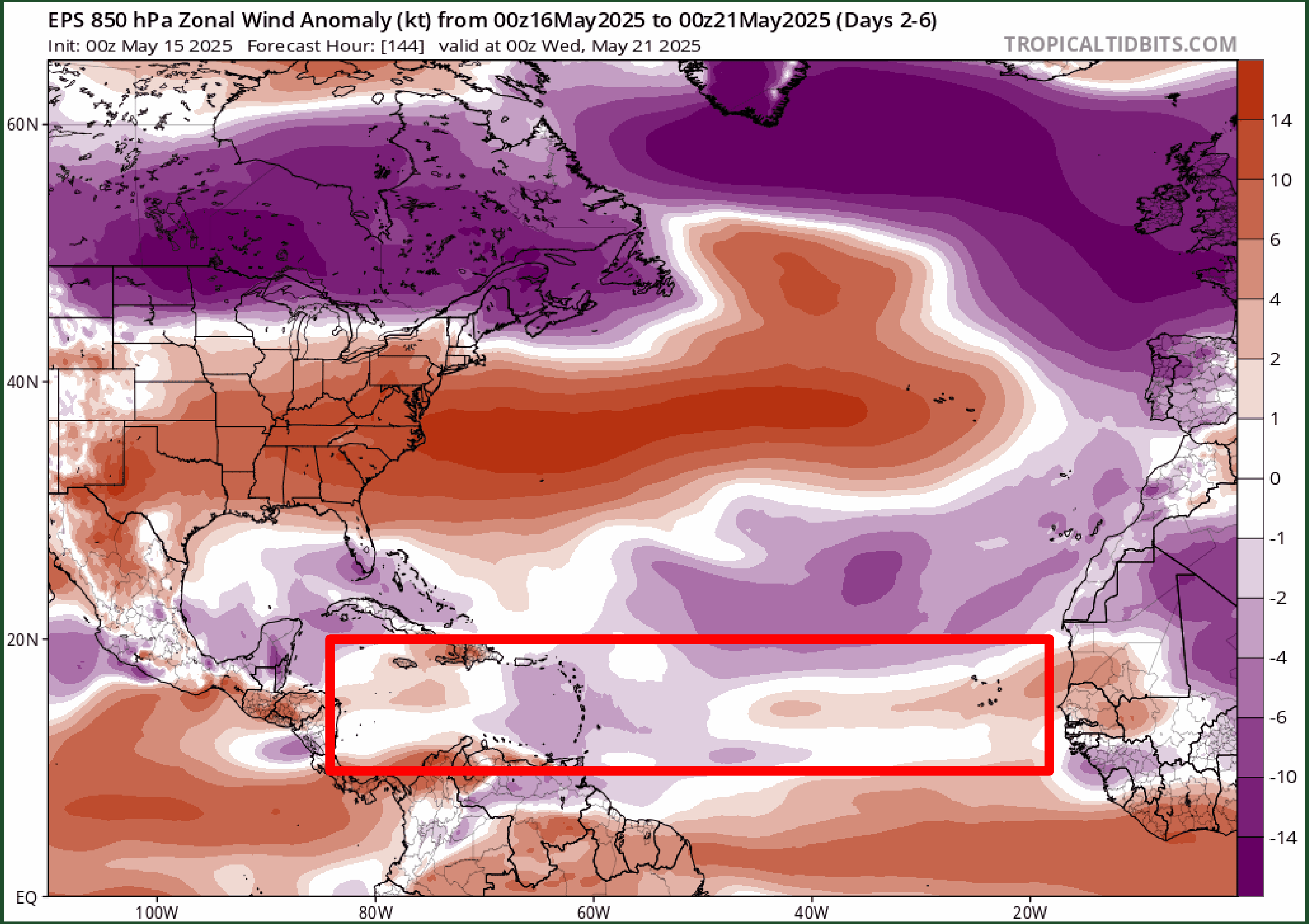
NMME Forecasting High Probability of Warm Atlantic for September



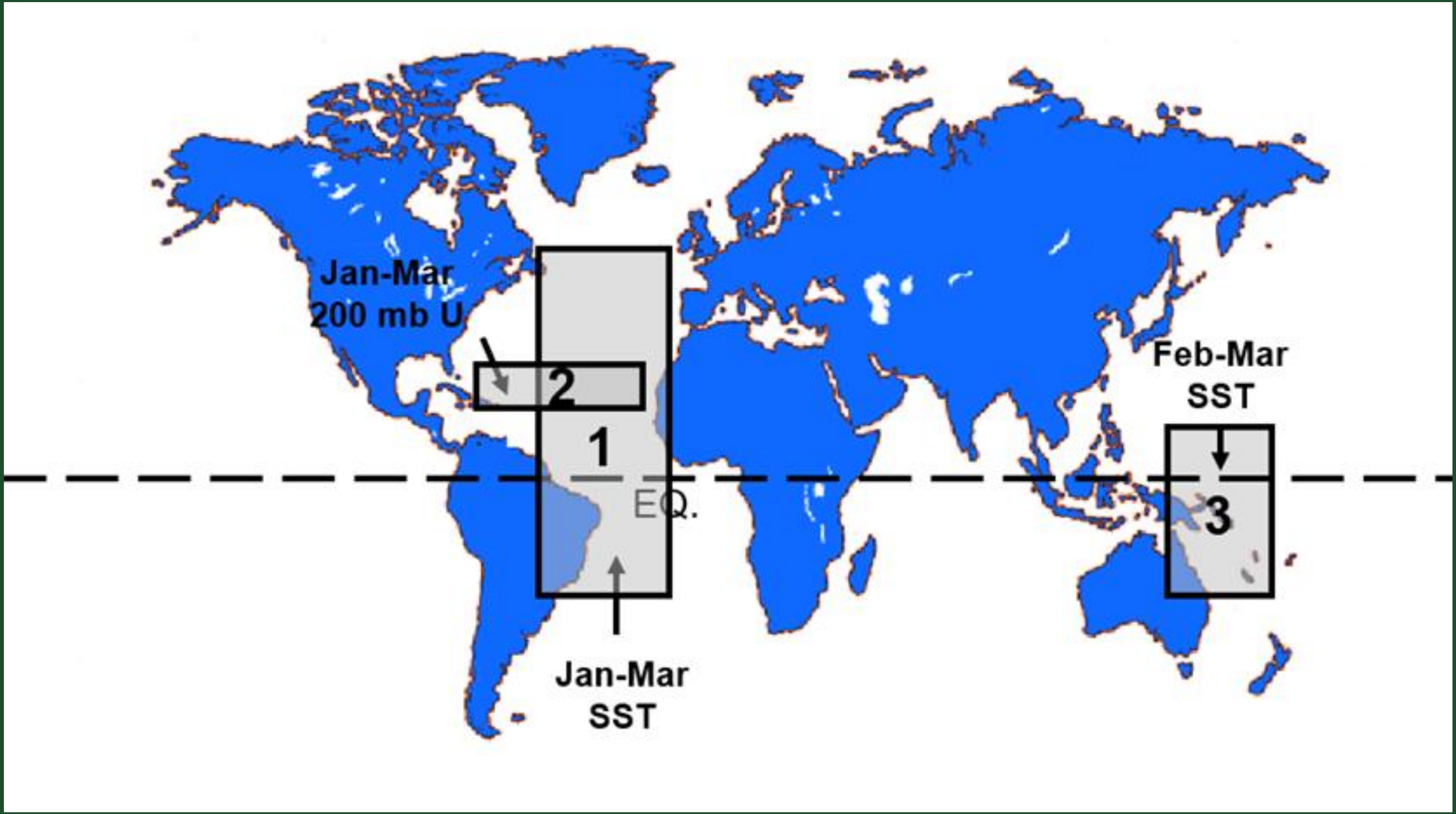
ECMWF Forecasting High Probability of Warm Atlantic for Aug – Oct



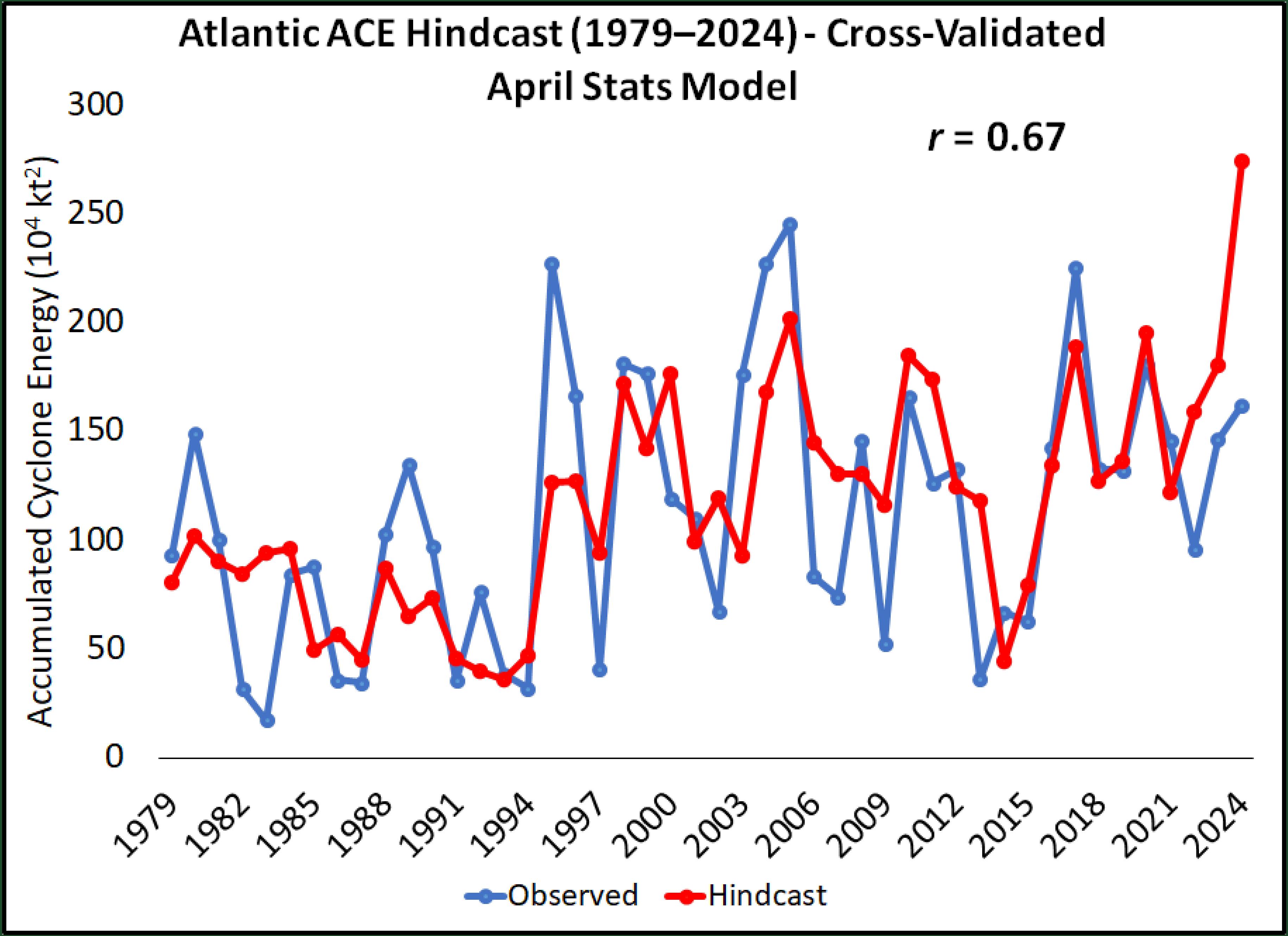
ECMWF Forecasting Relatively Strong Low-Level Winds Coming Up



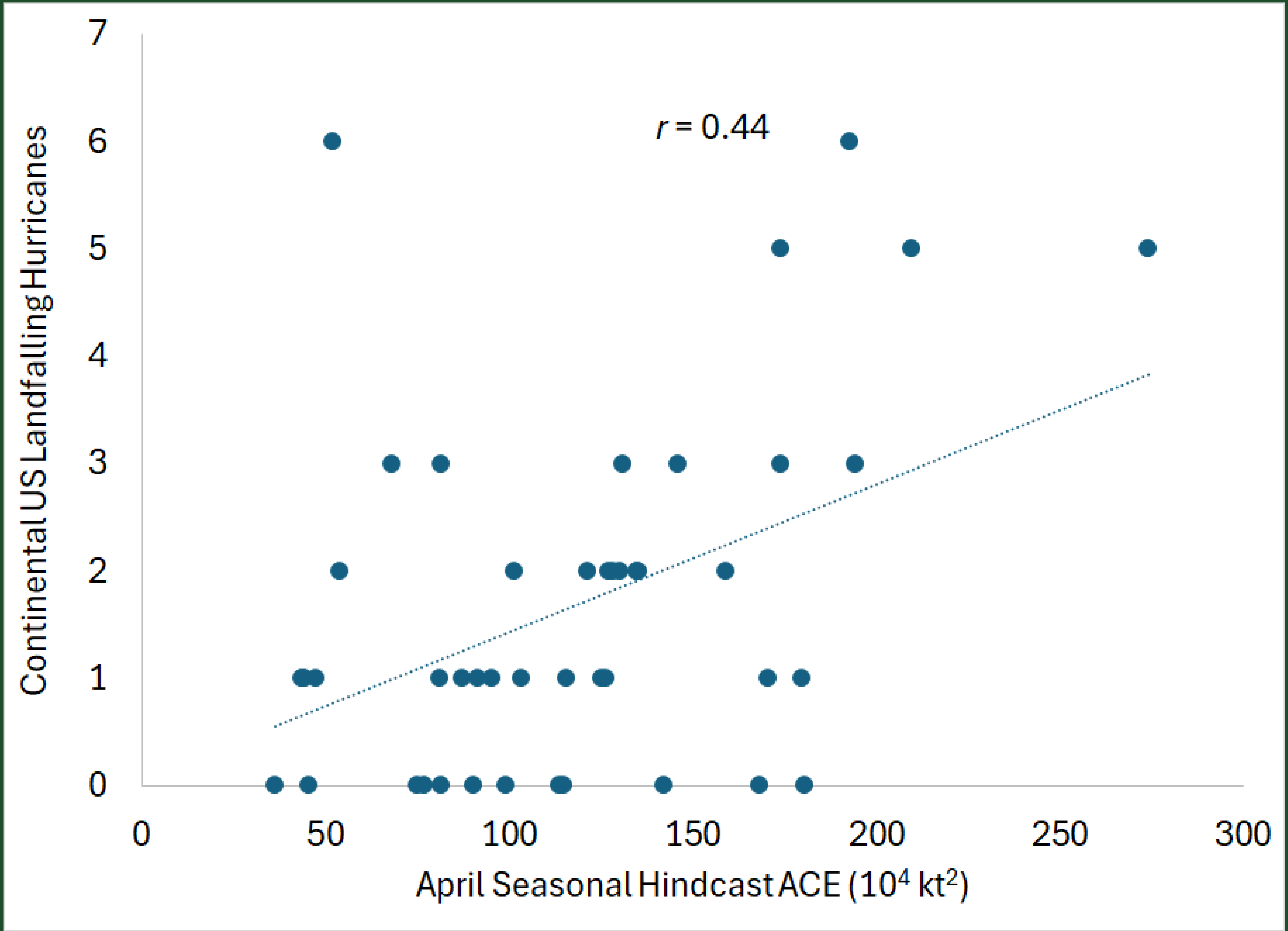
April Statistical Model Forecast



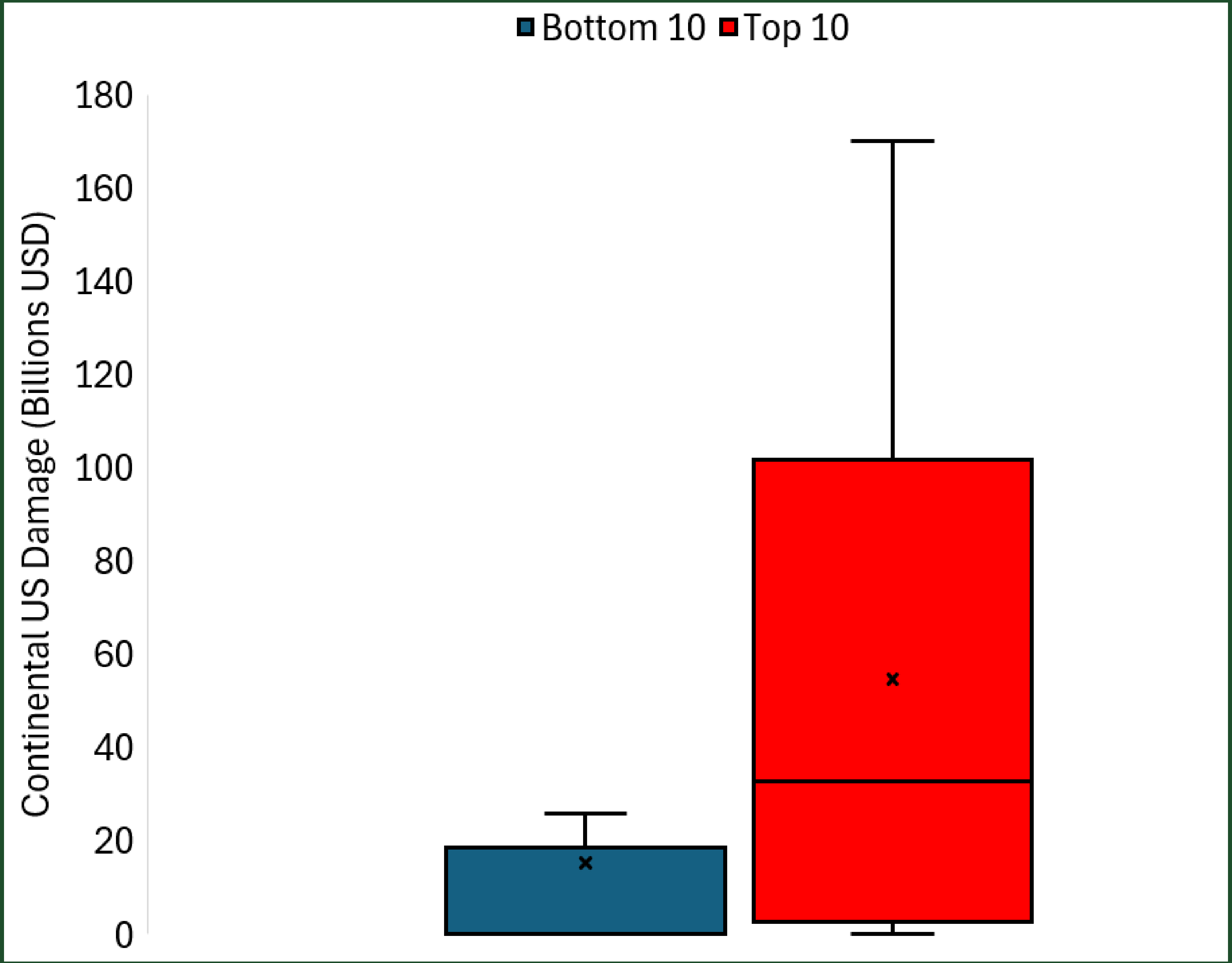
Statistical Model Hindcast Skill



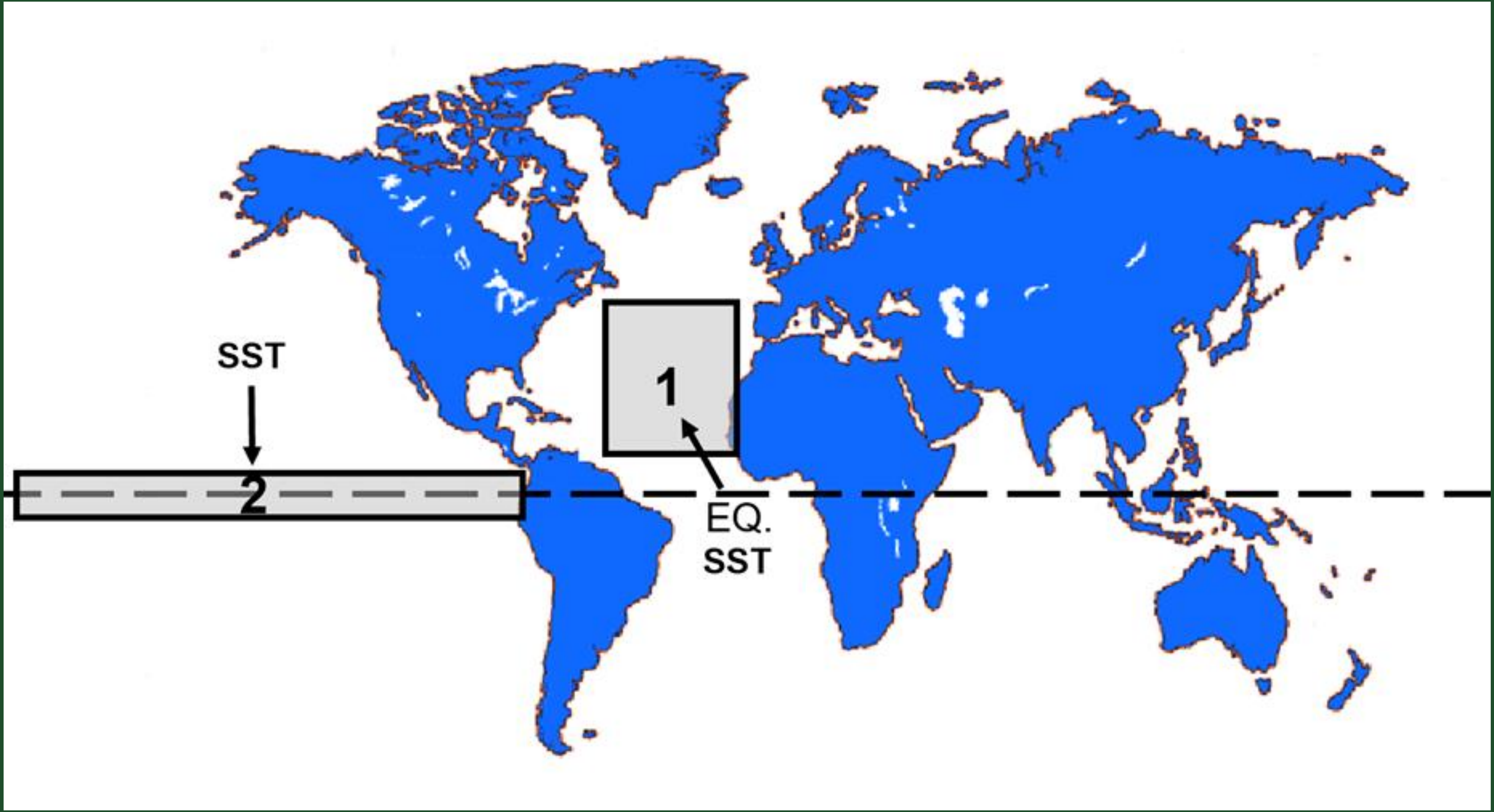
CSU April Statistical Model Hindcasts vs. Continental US Landfalling Hurricanes



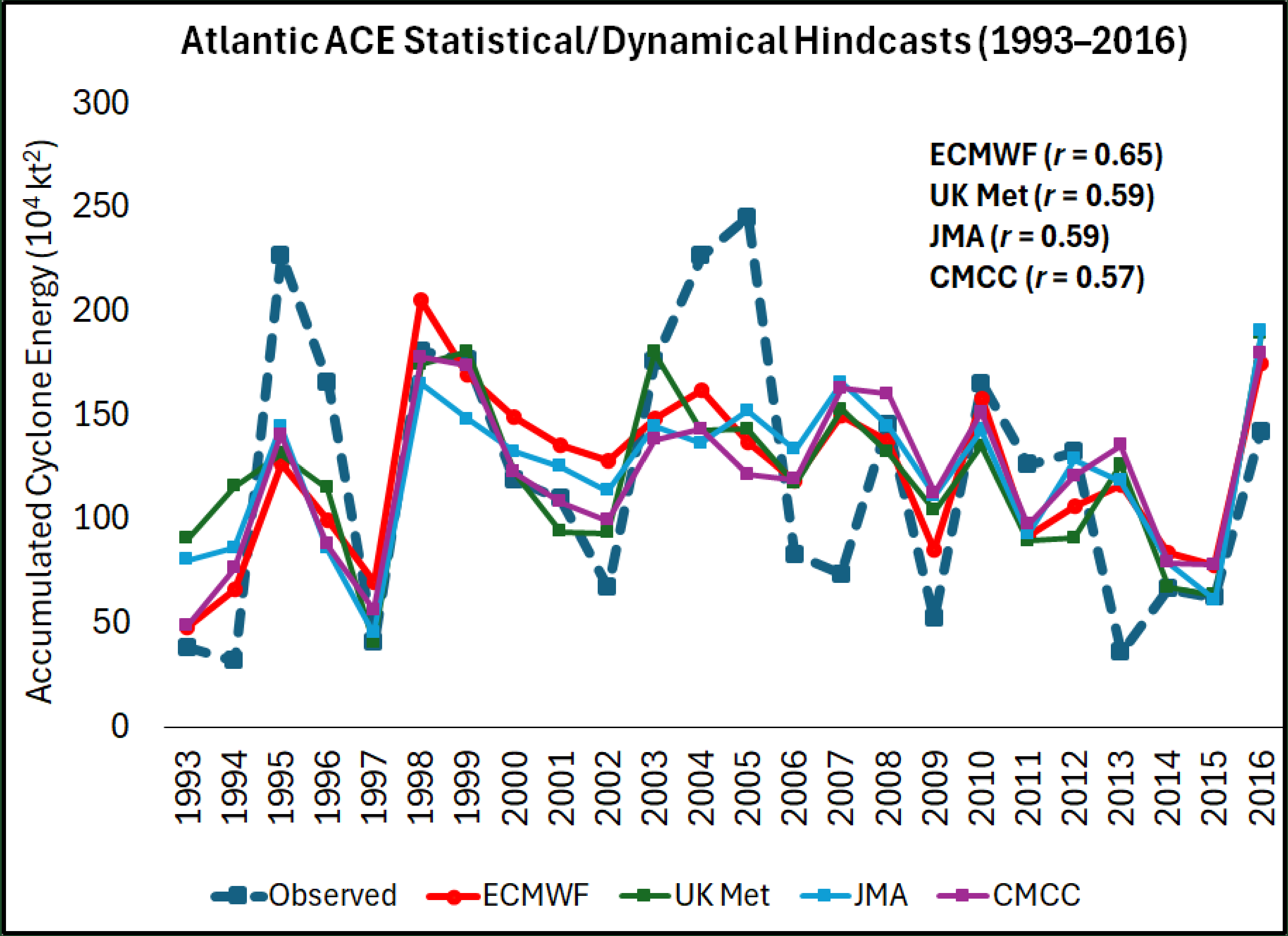
CSU April Stats Model Hindcasts vs. Continental US Hurricane Normalized Damage



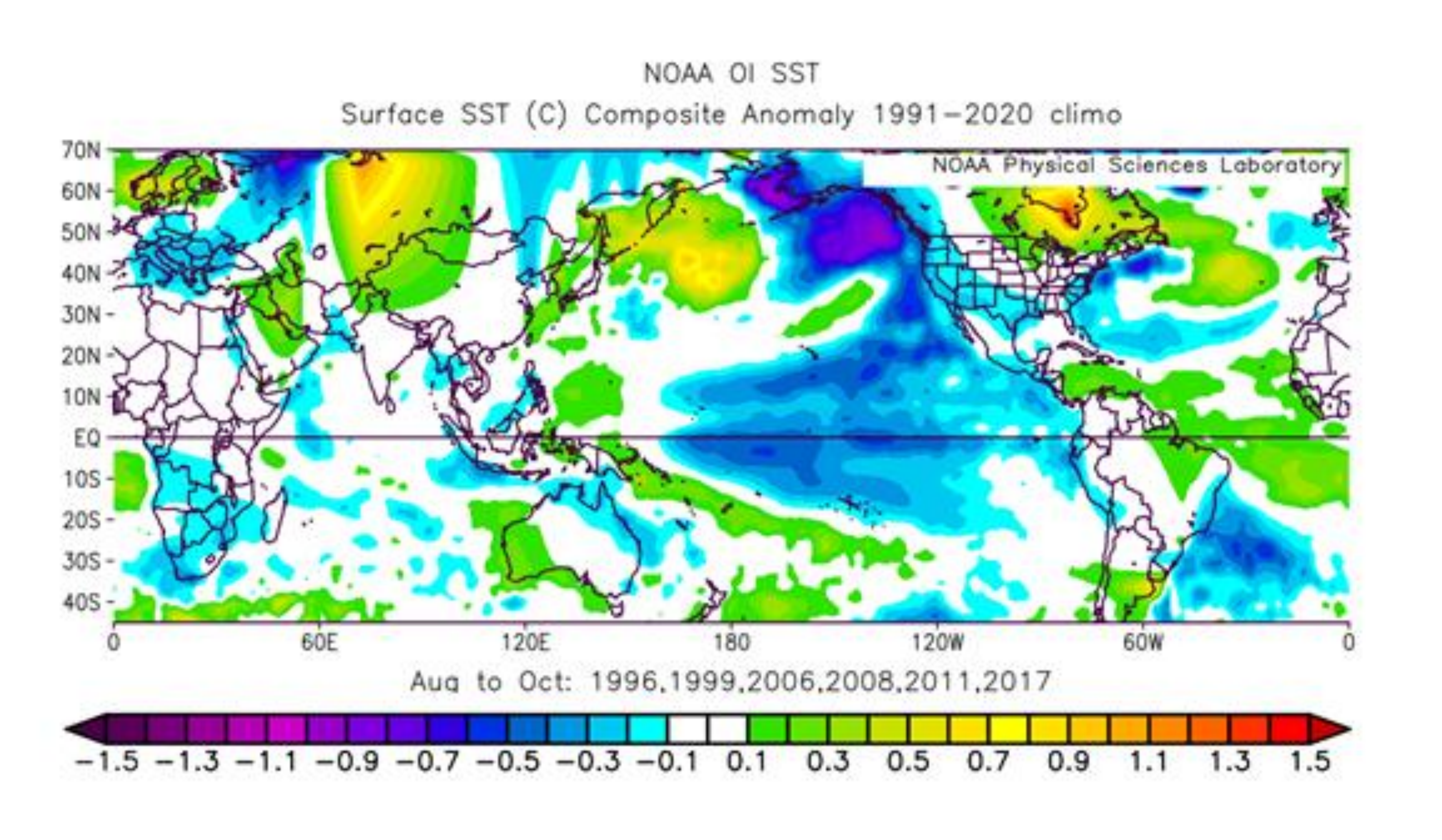
Statistical/Dynamical Model Forecast – Forecasting August Values



Statistical/Dynamical Model Hindcast Skill (4 Models)



August–October Sea Surface Temperature Anomalies in Analog Years



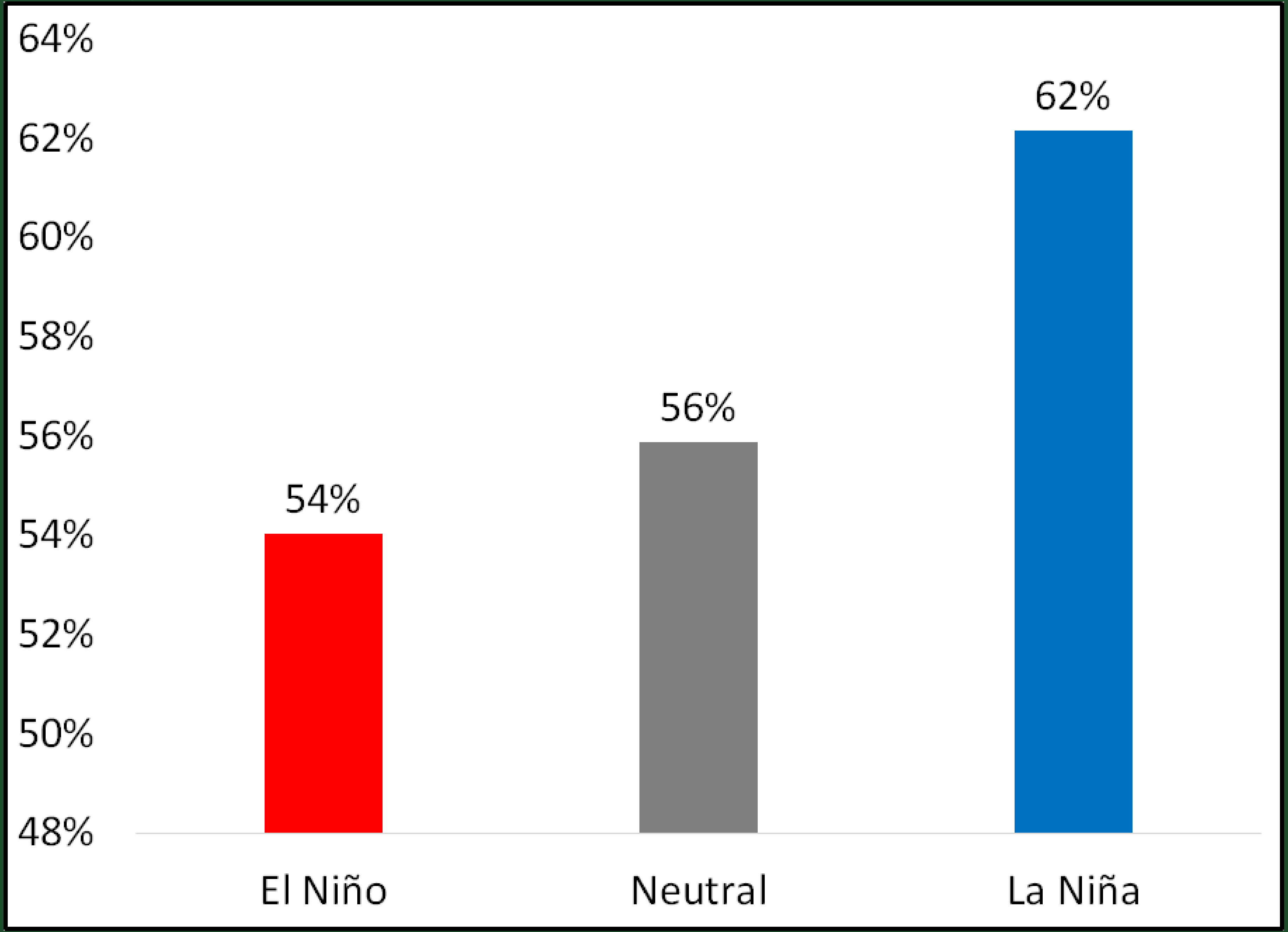
BEST ANALOG YEARS FOR 2025 (APRIL FORECAST)

	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

2025 Seasonal Hurricane Forecast Model Uncertainty

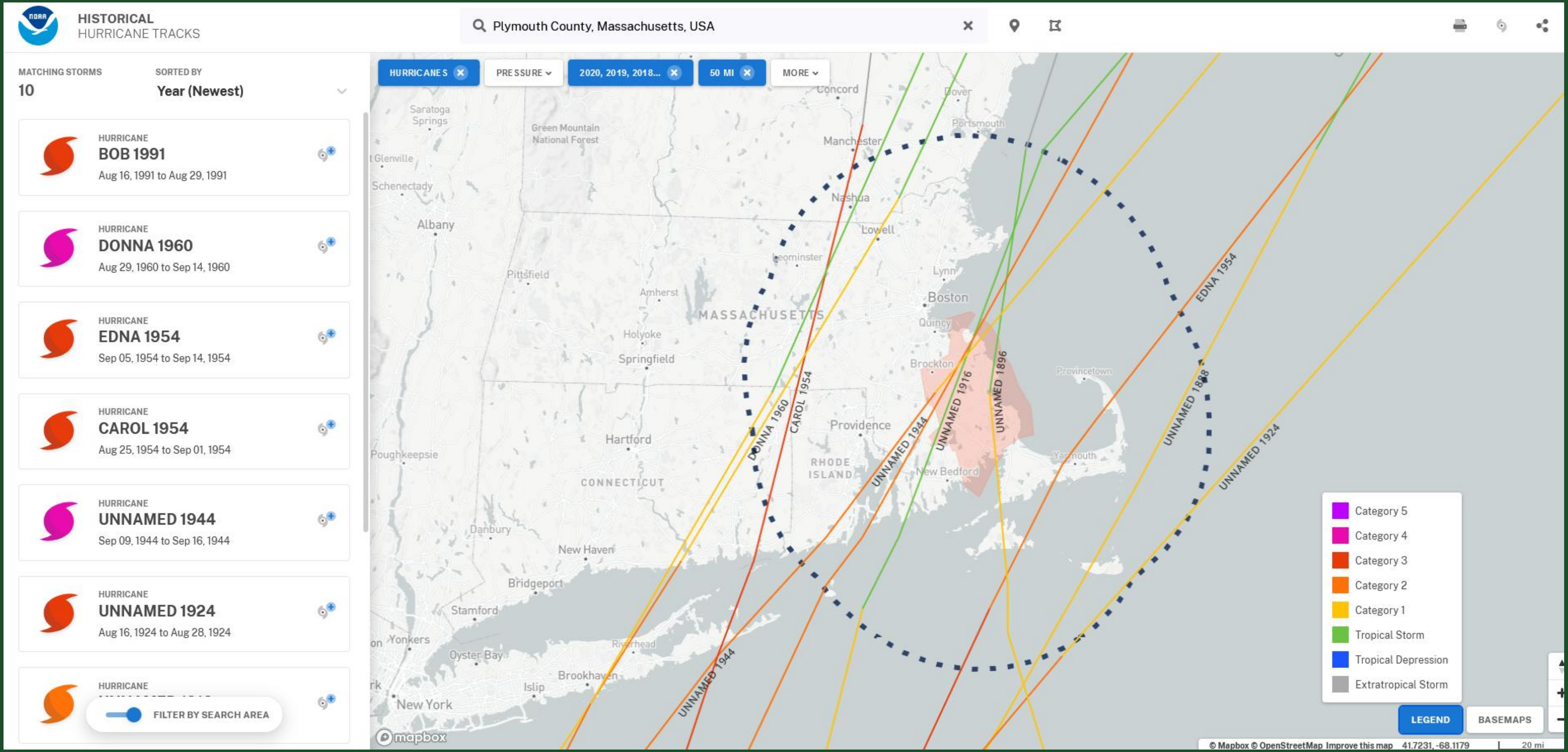
Forecast Parameter	2025 Forecast	Uncertainty Range (~70% of Forecasts Fall within Range)
Named Storms (NS)	17	14–20
Named Storm Days (NSD)	85	62–109
Hurricanes (H)	9	7–12
Hurricane Days (HD)	35	22–50
Major Hurricanes (MH)	4	2–6
Major Hurricane Days (MHD)	9	6–14
Accumulated Cyclone Energy (ACE)	155	102–215
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



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

Colorado State University

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

http://www.seasonalhurricanepredictions.org

Contributing Forecast Groups

AXA

AccuWeather

Coastal Carolina University

Colorado State University

INSMET
Instituto de Meteorologia

MAXAR

NC State University

Climate Analytics

NOAA
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Penn
University of Pennsylvania

Weather 20/20

NMME The North American Multi-Model Energy

Earth Networks
An aem brand

CWG

Tropical Storm Risk.com

SMN

ECMWF
European Centre for Medium Range Weather Forecasts

The University of Arizona

Met Office

268Wx
Destin
268Weather

StormGeo

MU

WeatherWorks
Your Weather Experts

WeatherBell
Analytics LLC

The Weather Company

Weather Tiger

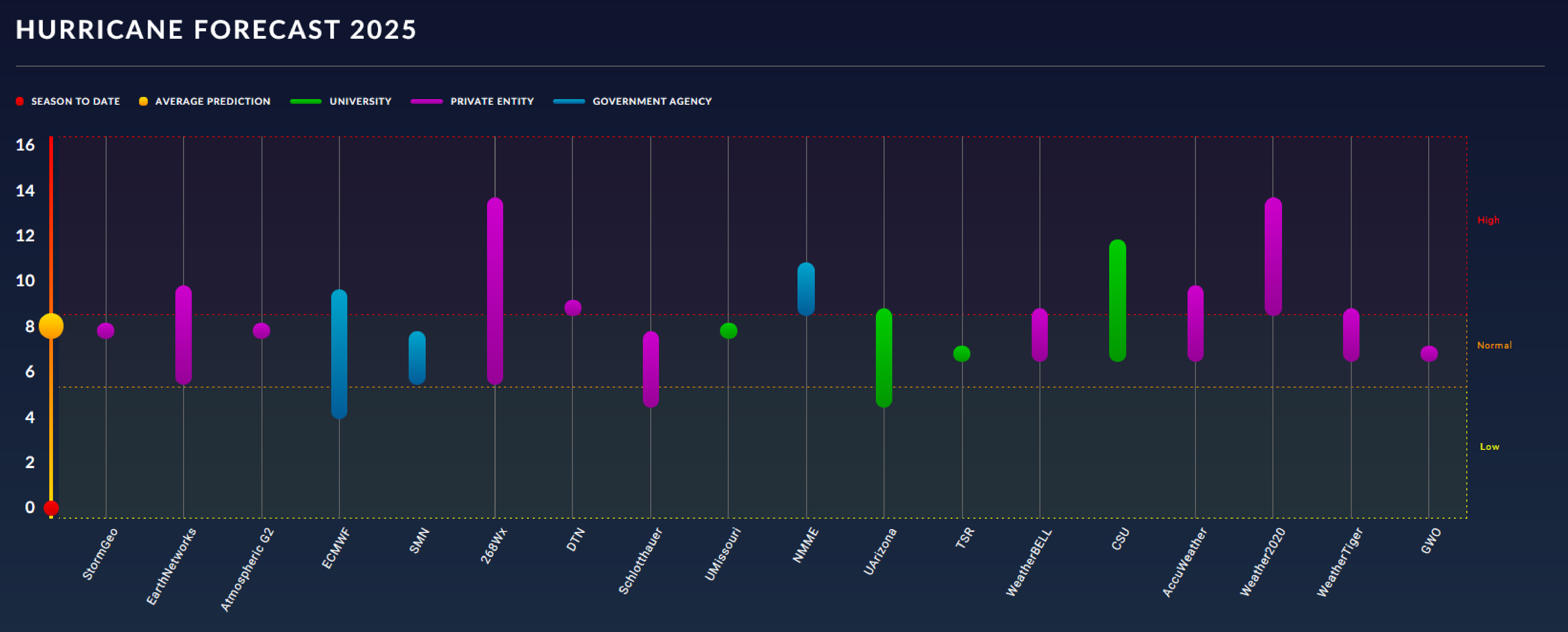
Global Weather Oscillations
ClimatePulse Technology

dtn

CU

Veri Tas Lux Mea

Seasonalhurricanepredictions.org Visualization – 2025 Hurricane Season

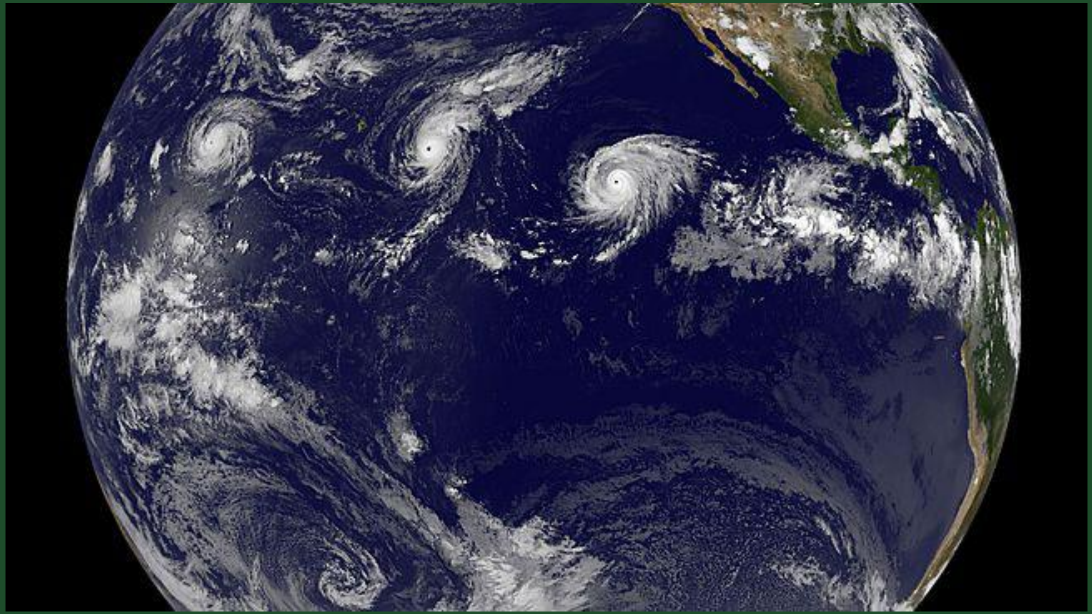


Trends in Global Tropical Cyclone Activity: 1990–2021

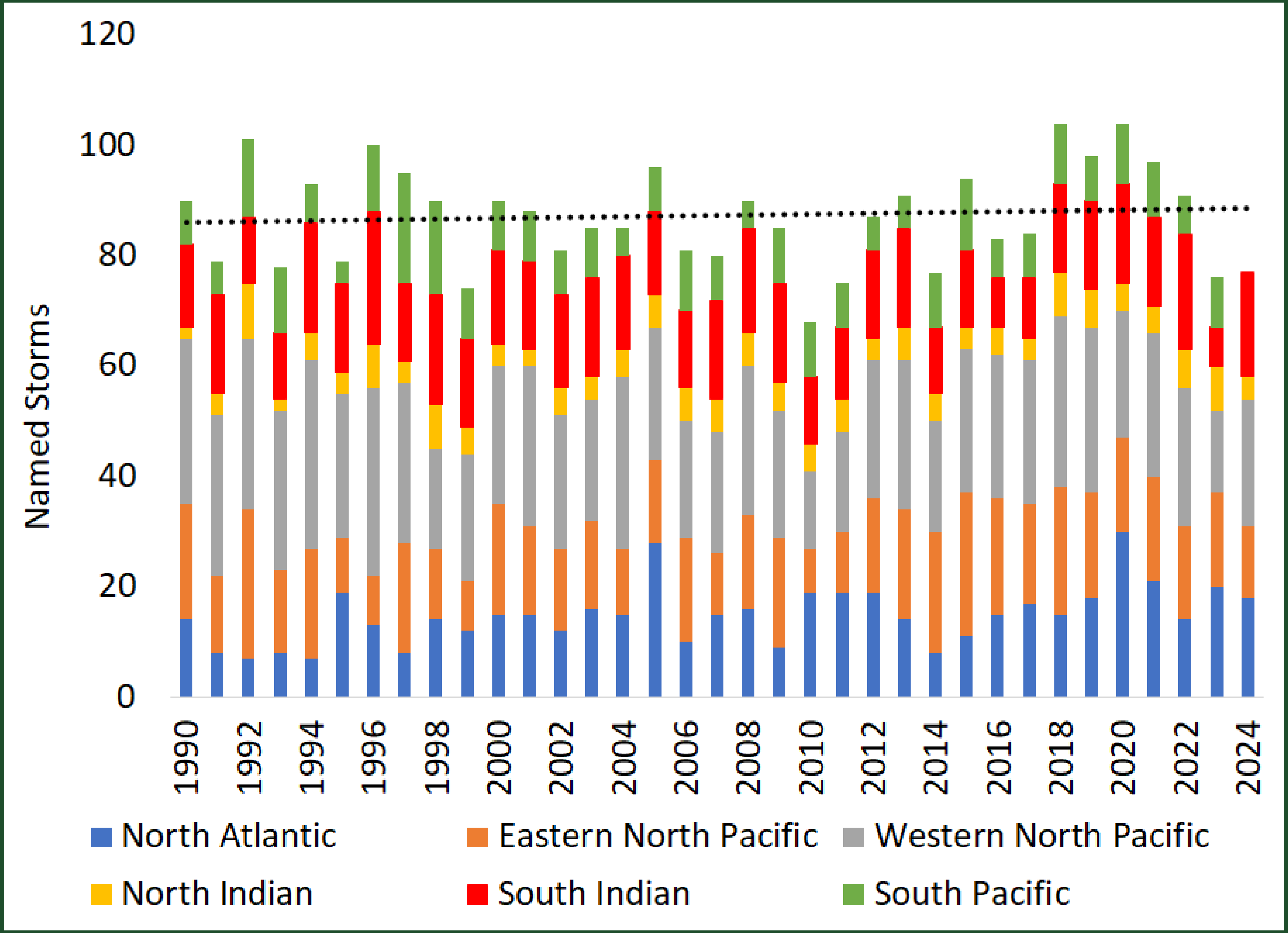
Published in 2022 in *Geophysical Research Letters*

Updated with Data Through 2024

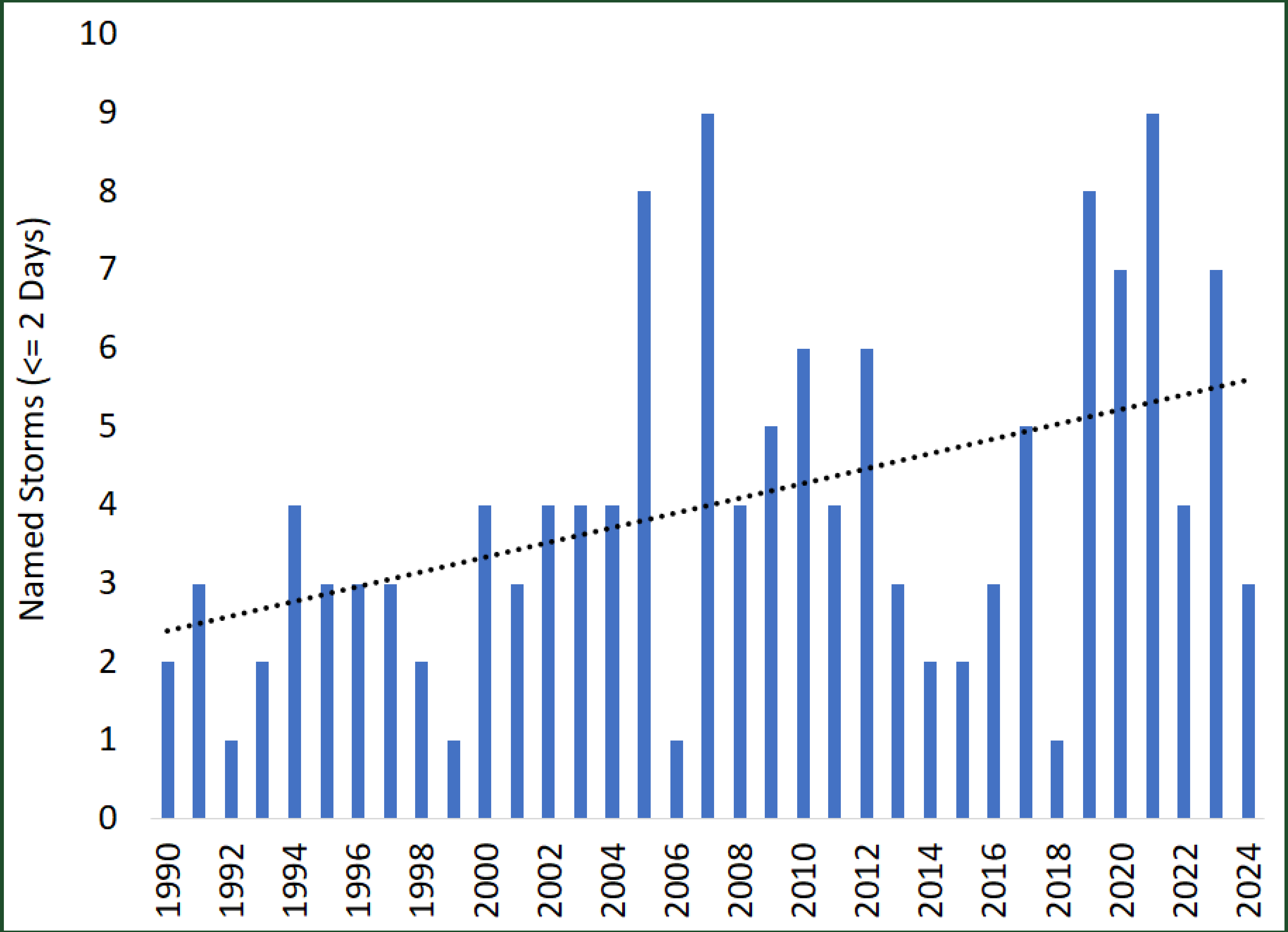
Co-authors: Kim Wood*, Carl Schreck, Steve Bowen, Christina Patricola, Michael Bell



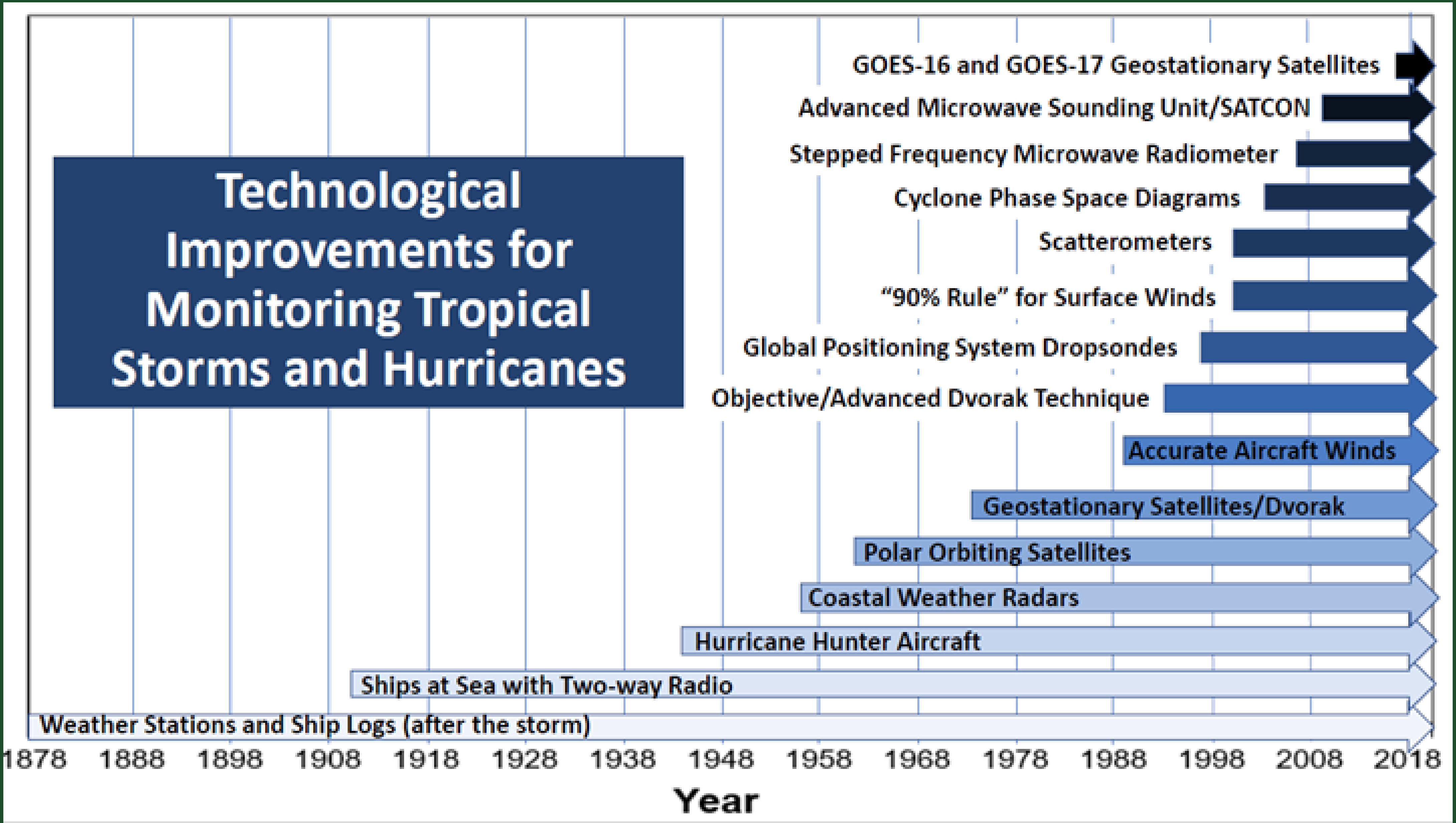
Global Named Storms (>=39 mph) (1990–2024)



Atlantic Named Storms (<=2 Days) (1990–2024)

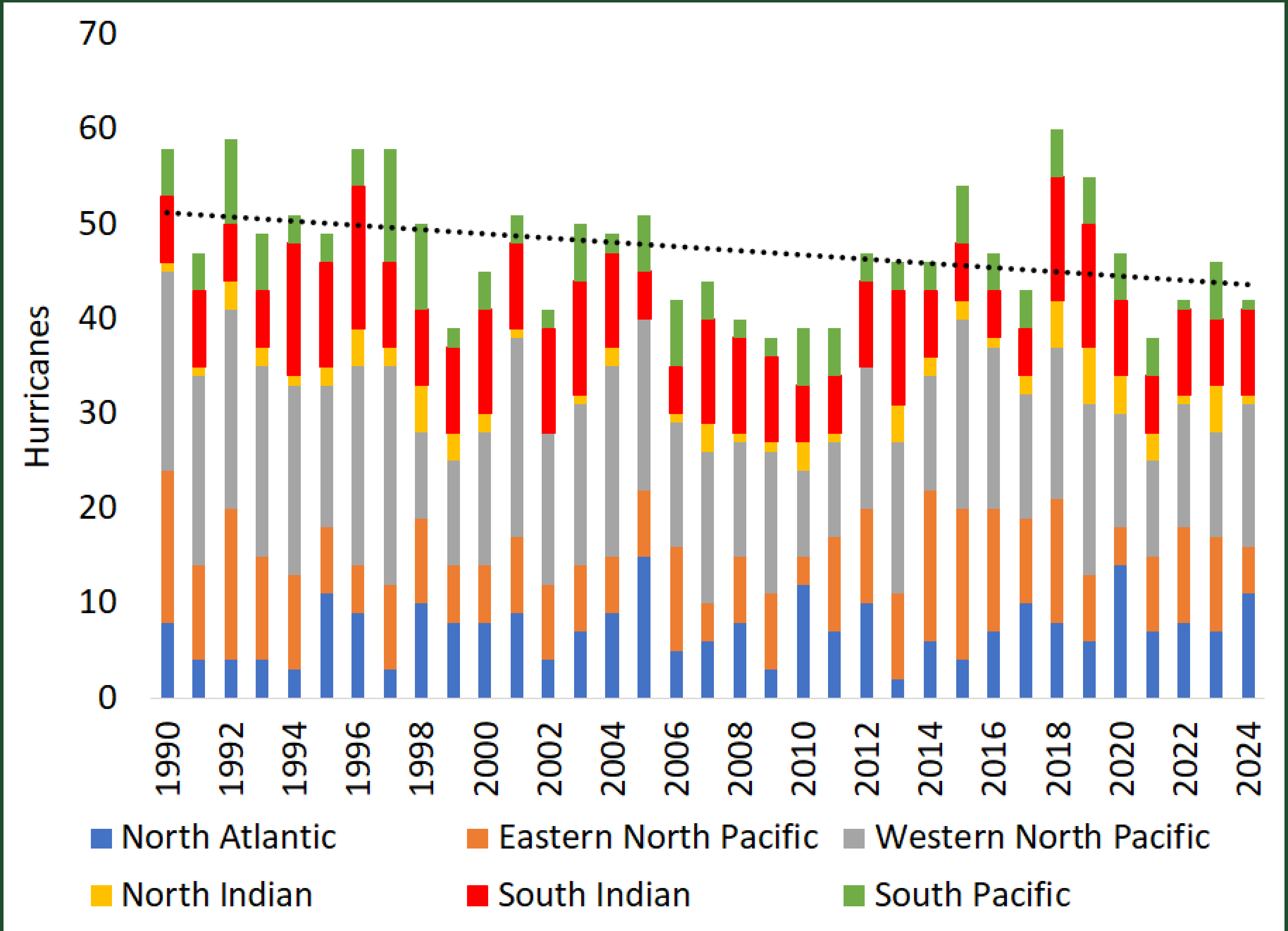


Atlantic Hurricane Observational Network Improvements

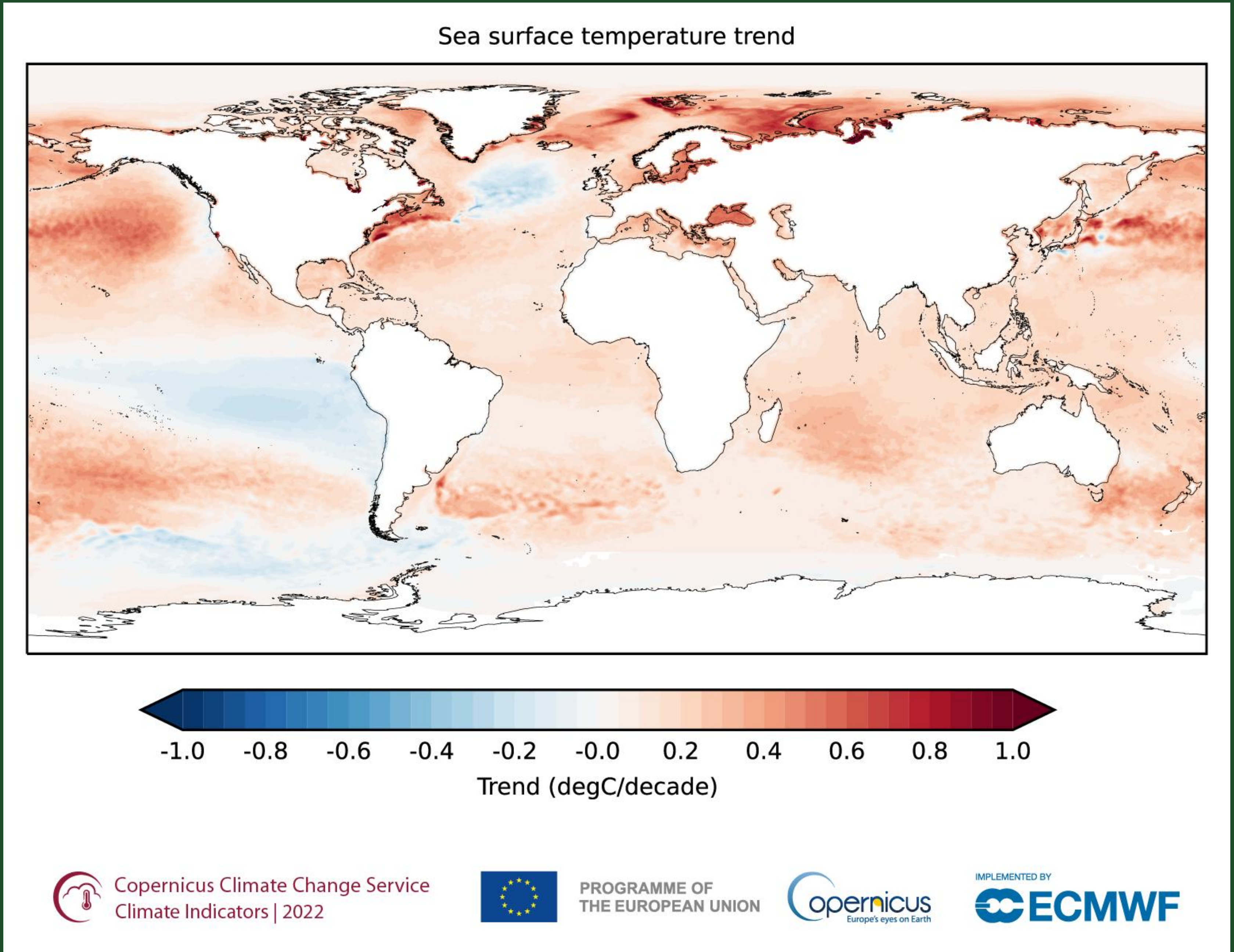


Chris Landsea (NHC)

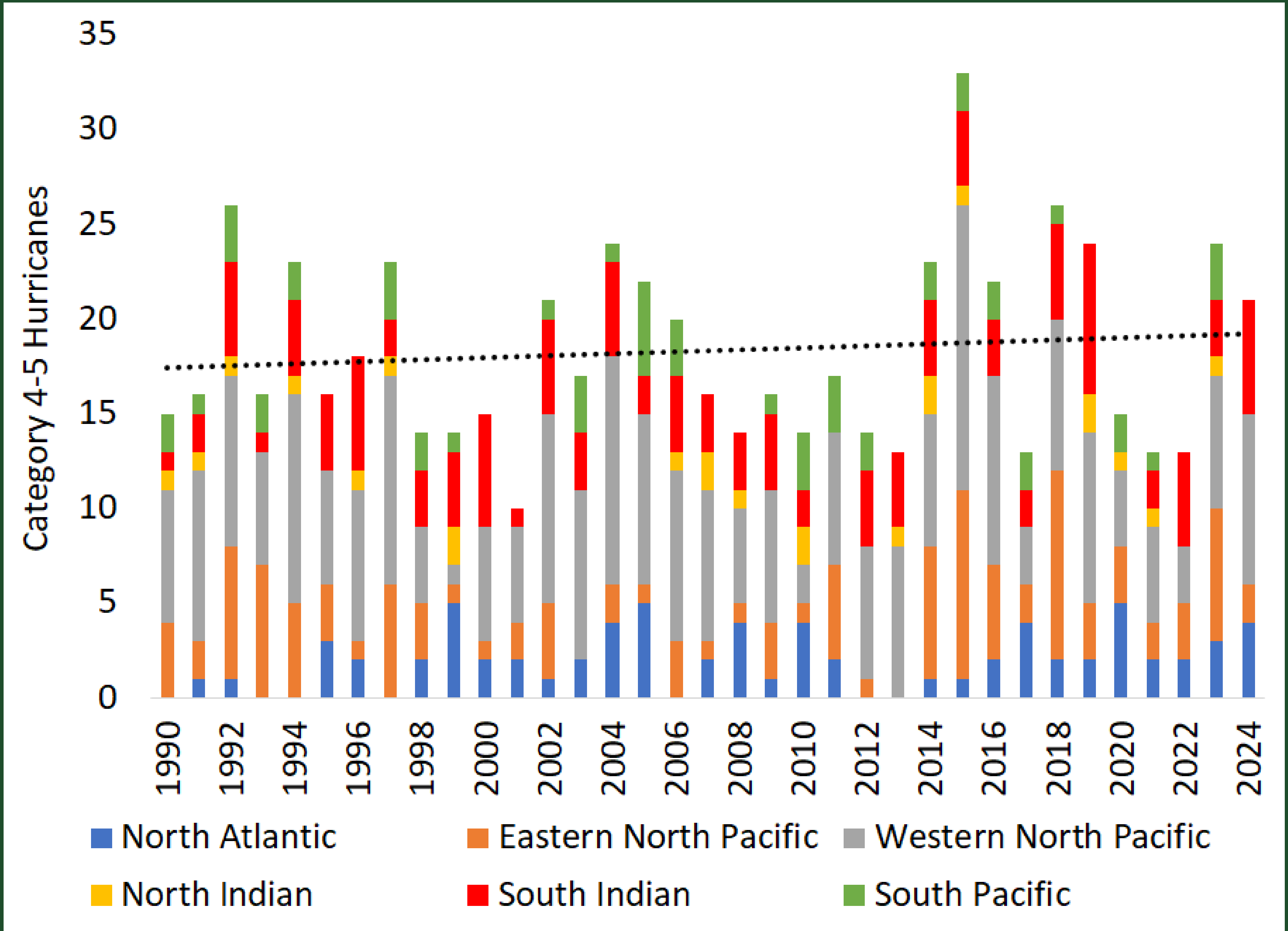
Global Hurricanes/Typhoons (1990–2024)



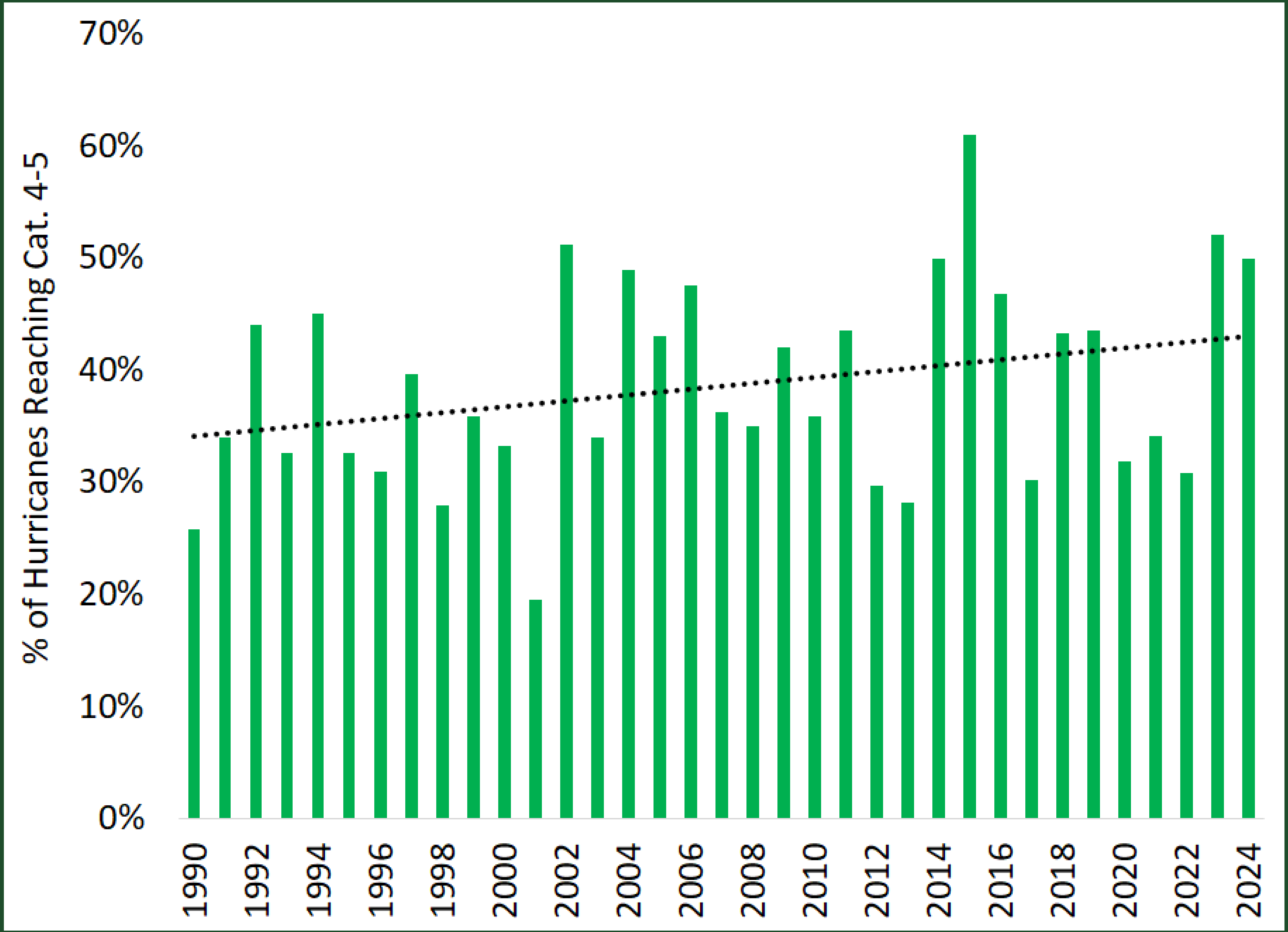
Trend Towards More La Niña-Like Environment since 1990



Category 4-5 Hurricanes (1990–2024)

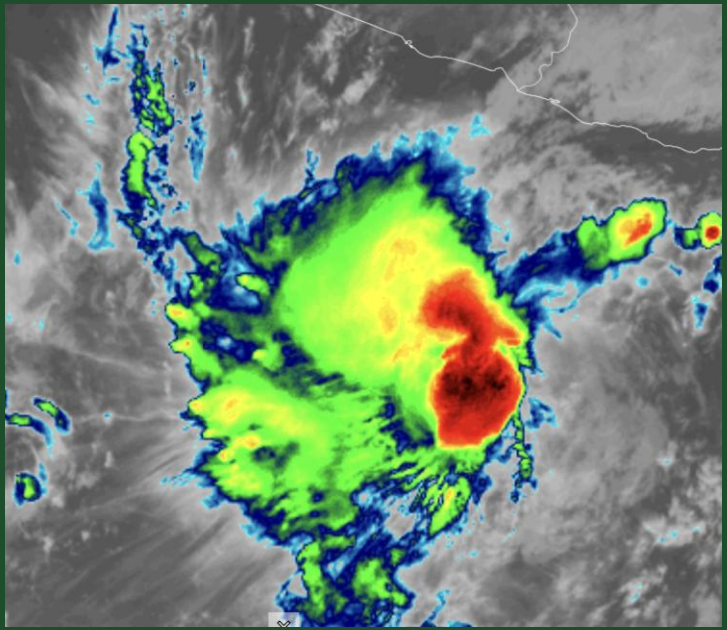


Global Cat. 4-5 Hurricane Percentage (>=130 mph winds) (1990–2024)

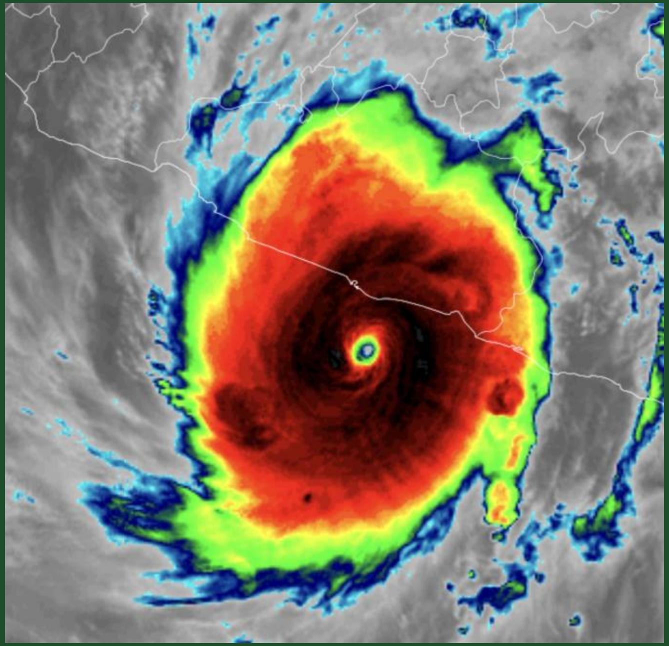


What About Rapid Intensification?

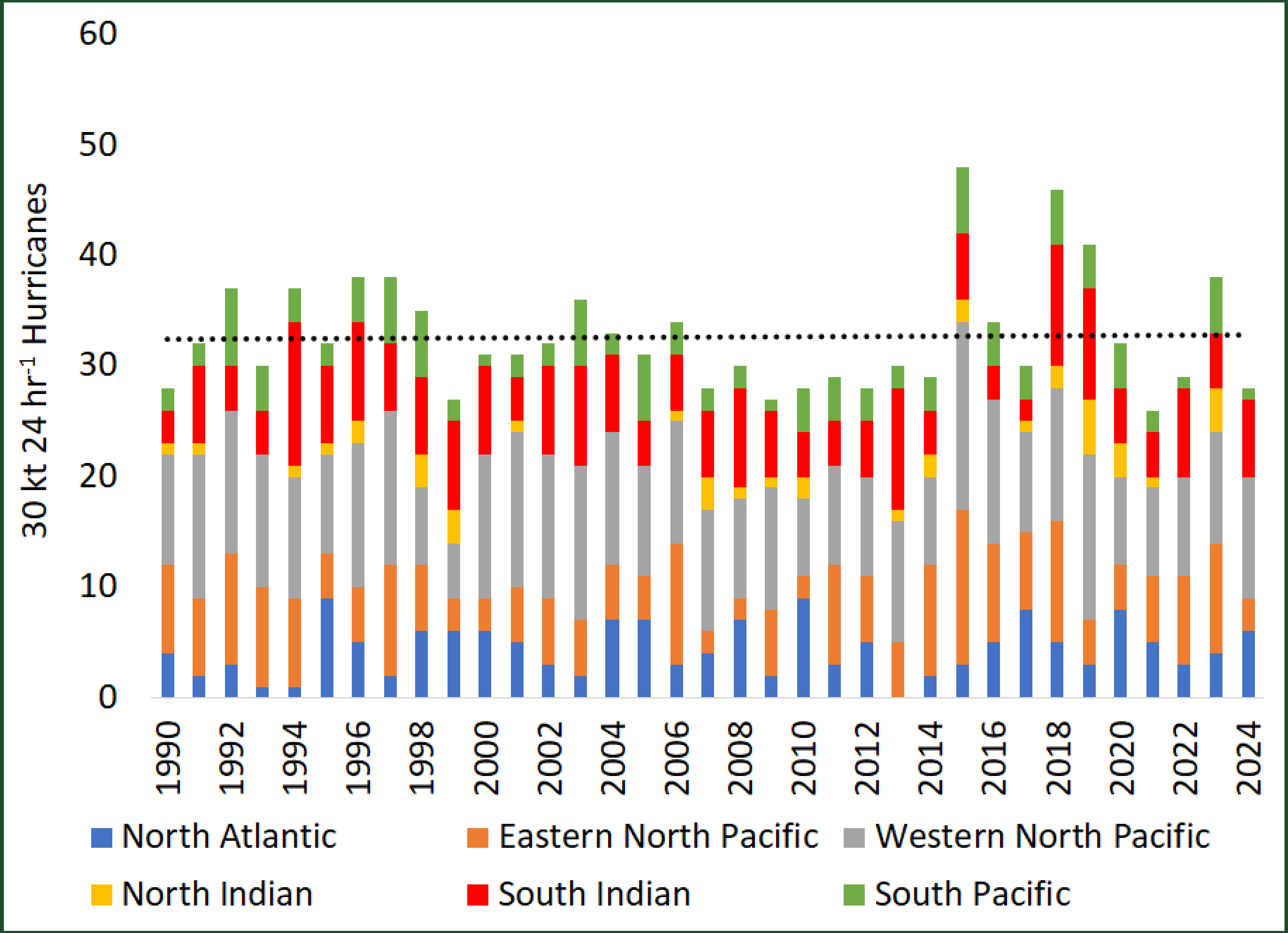
Hurricane Otis (2023)



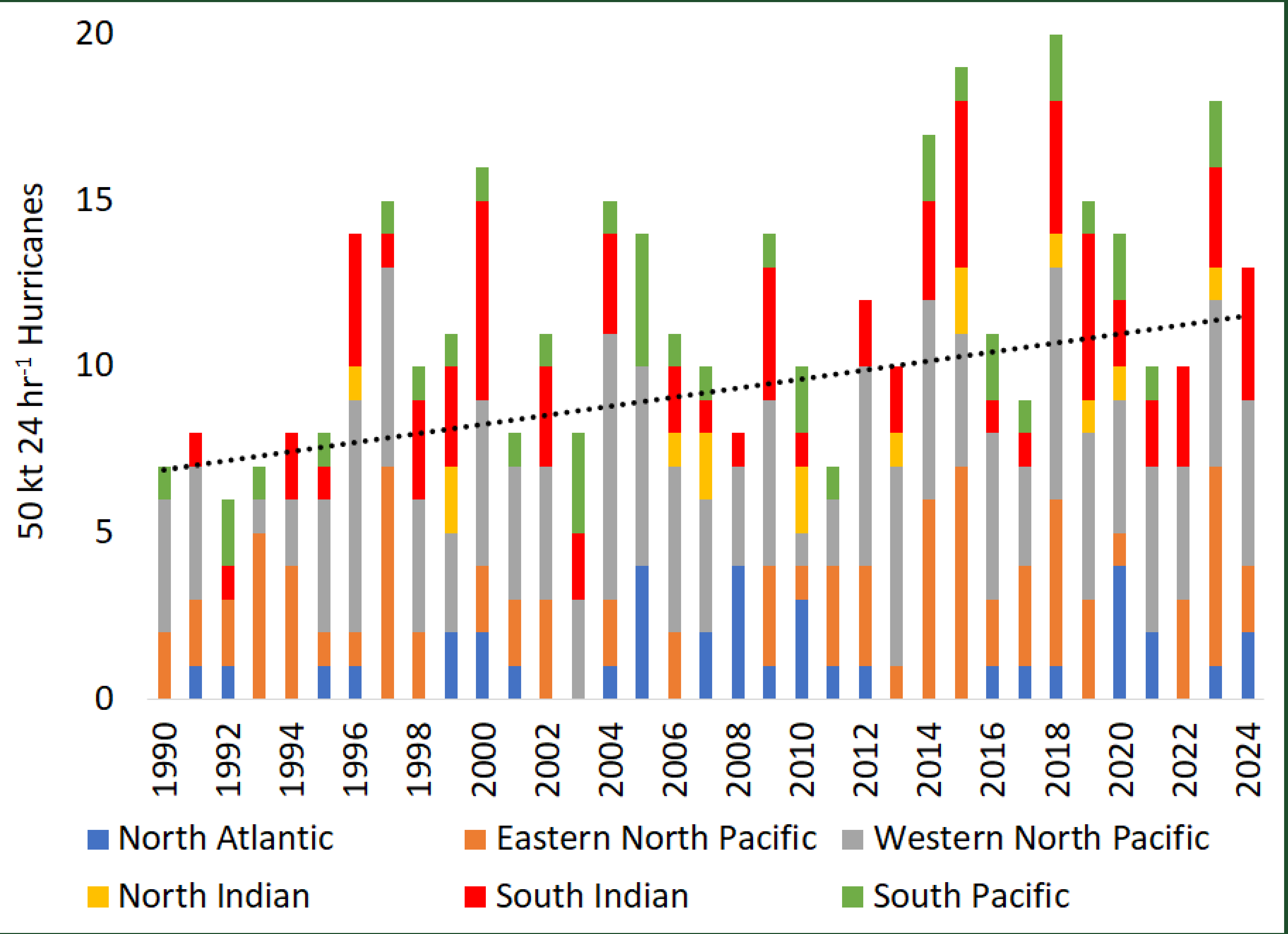
26 hr



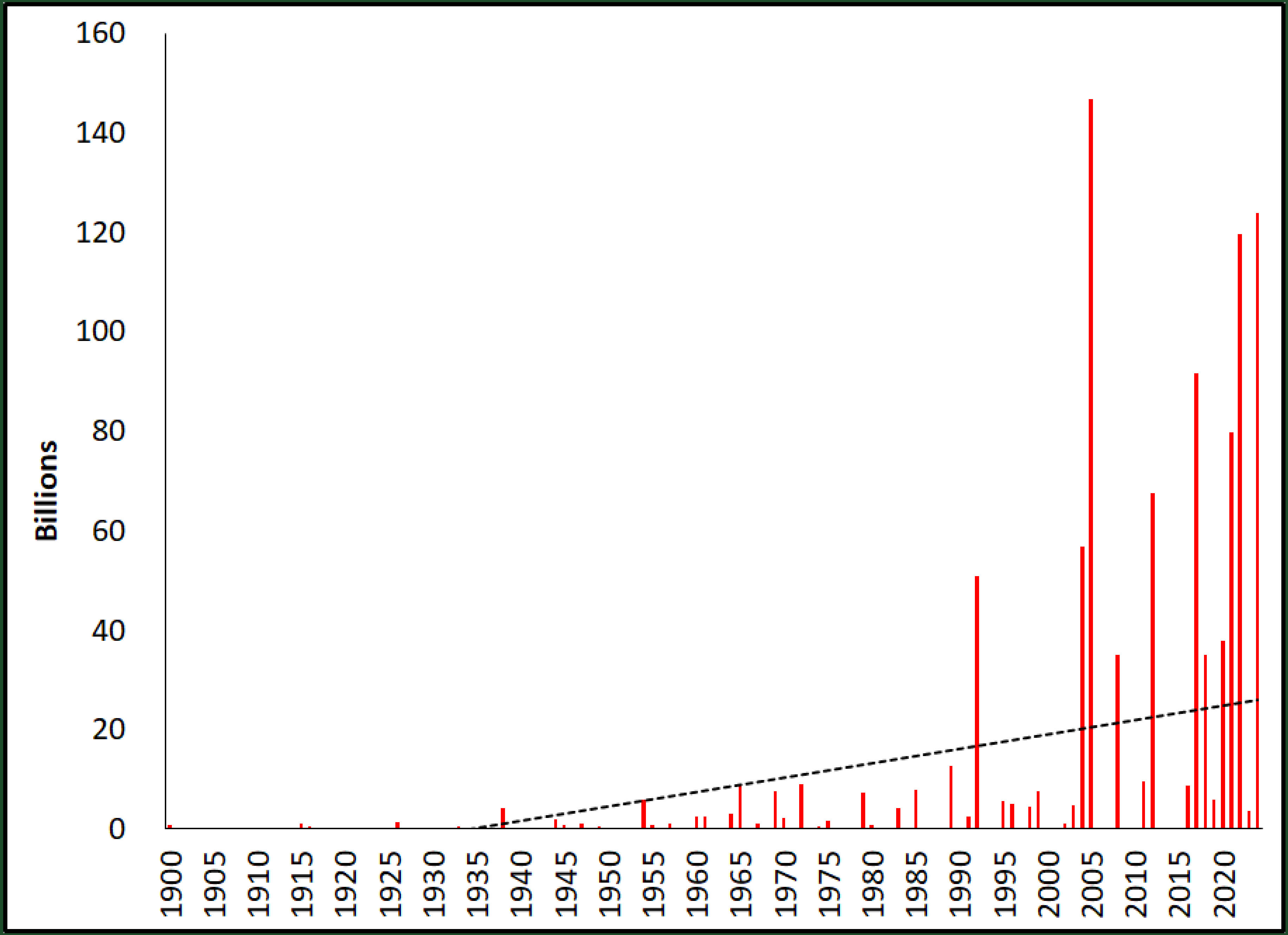
Rapidly Intensifying Hurricanes (>=35 mph 24 hr^{-1}) (1990–2024)



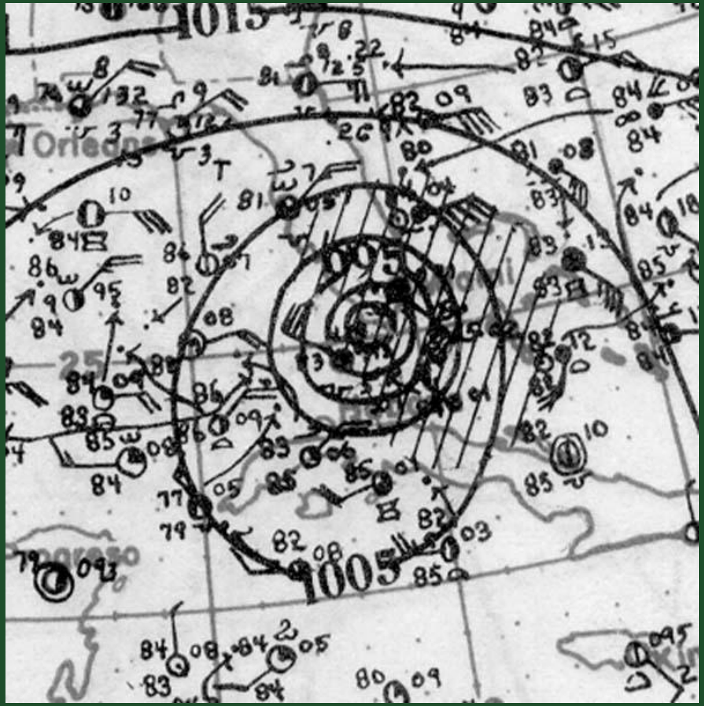
Super Rapidly Intensifying Hurricanes (>=60 mph 24 hr^{-1}) (1990–2024)



Continental US Hurricane Losses (2024 USD) – Adjusted for Inflation



1926 Great Miami Hurricane (145 mph winds, 930 hPa) – Category 4



Miami-Dade County Population Explosion since 1926

Miami-Dade County Population: ~100,000

Miami-Dade County Population: ~2.7 Million

1926

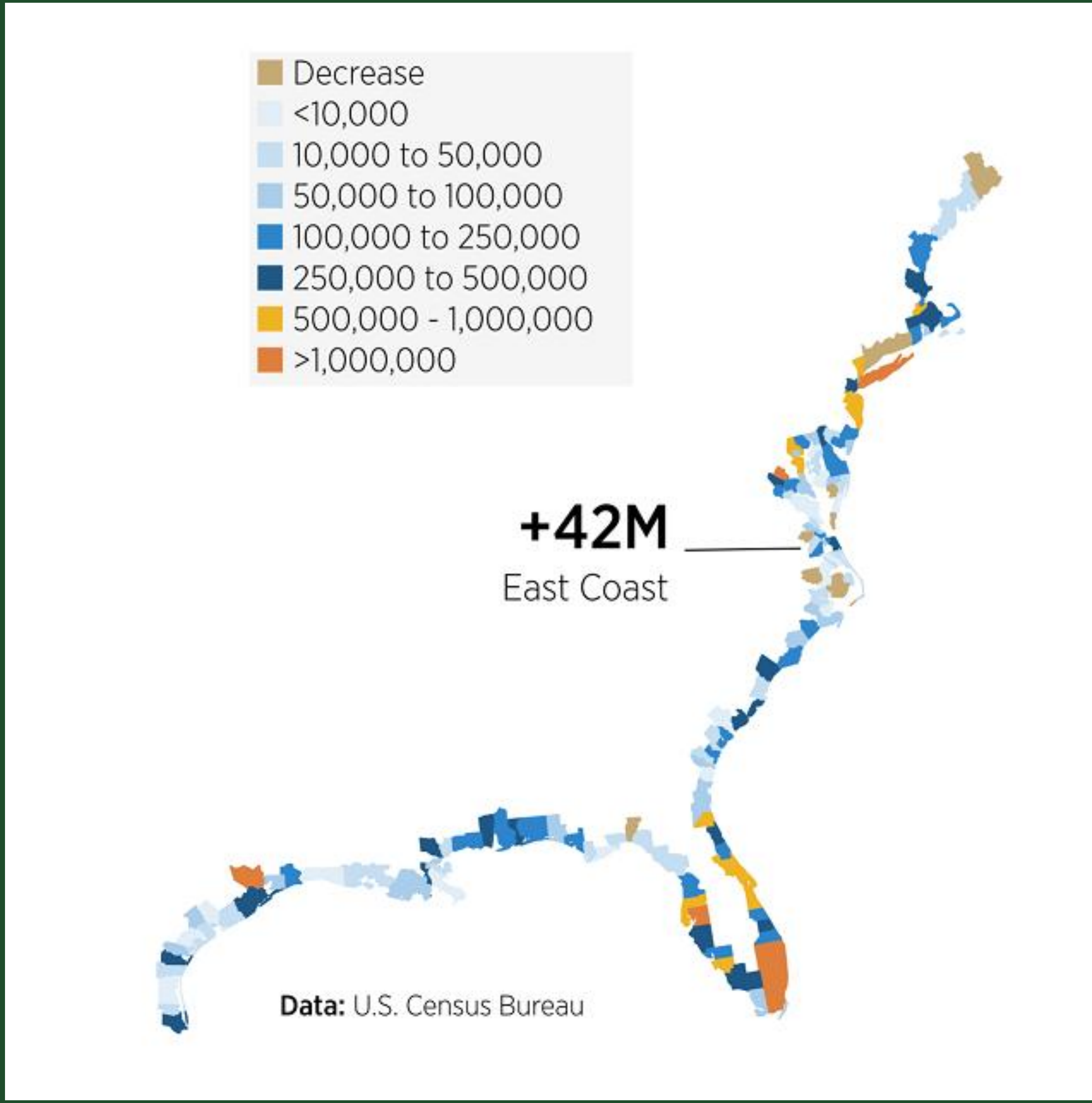
2025

1926 Great Miami Hurricane - >$200 Billion Economic Damage in 2024

Weinkle, J. et al. (2018). Normalized hurricane damage in the continental United States 1900–2017. *Nature Sustainability* 1(12):808-813.

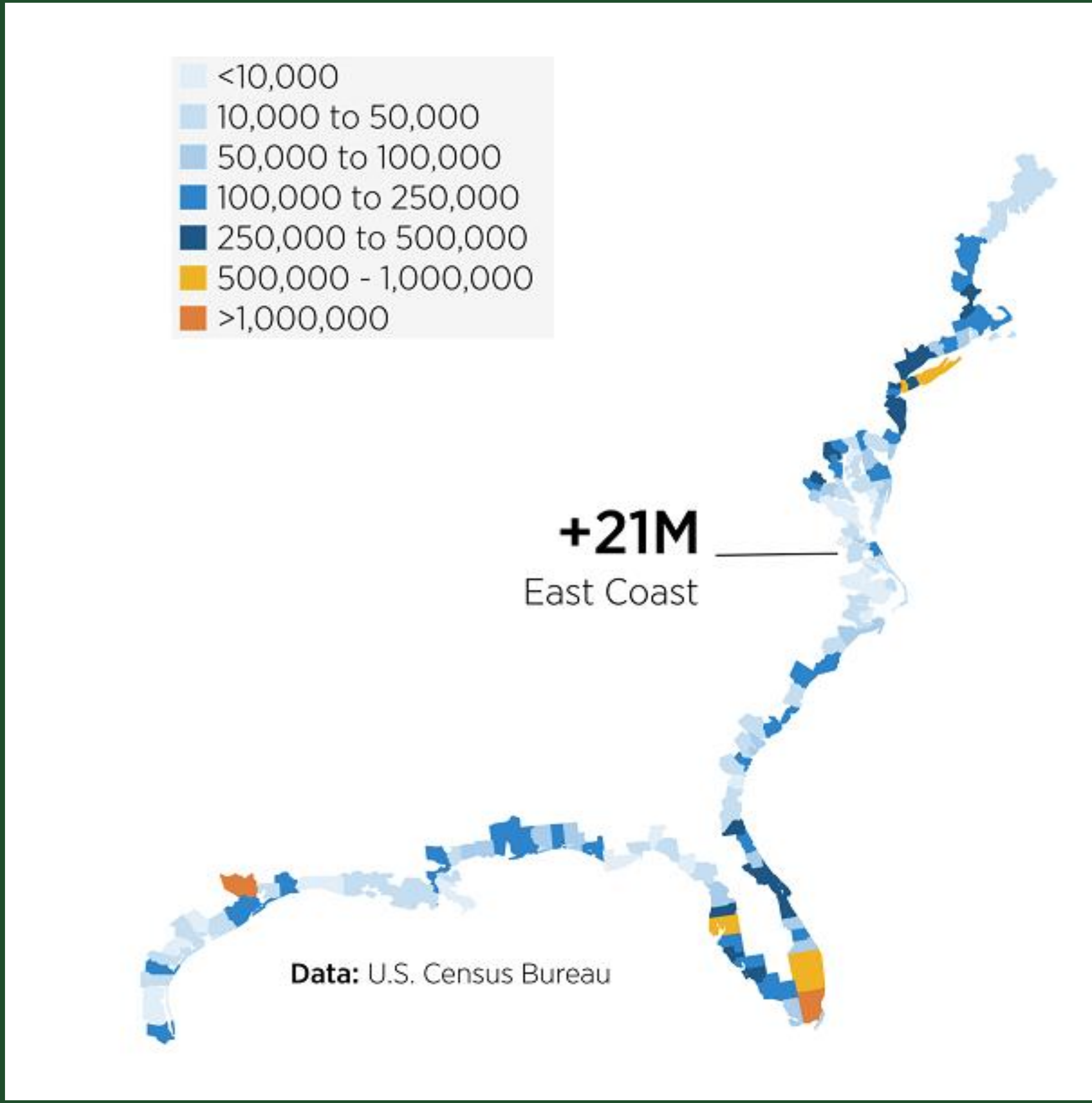
Klotzbach, P. J., Bowen, S. G., Pielke, R., Jr., & Bell, M. M. (2018). Continental U.S. Hurricane Landfall Frequency and Associated Damage: Observations and Future Risks, *Bulletin of the American Meteorological Society*, *99*(7), 1359-1376.

US Gulf/East Coast Population Change Since 1900



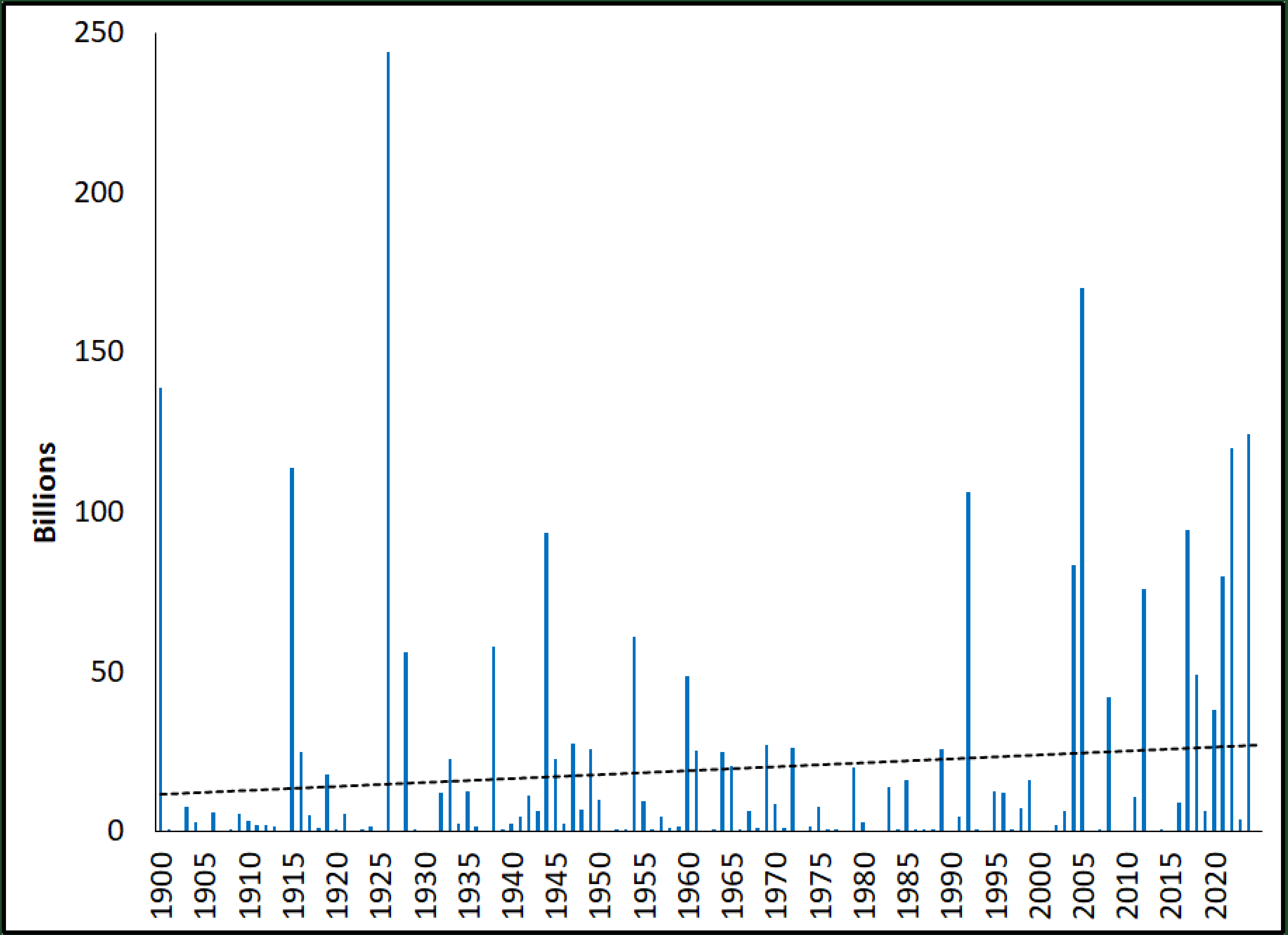
Steve Bowen (Gallagher Re)

US Gulf/East Coast Housing Unit Change Since 1900

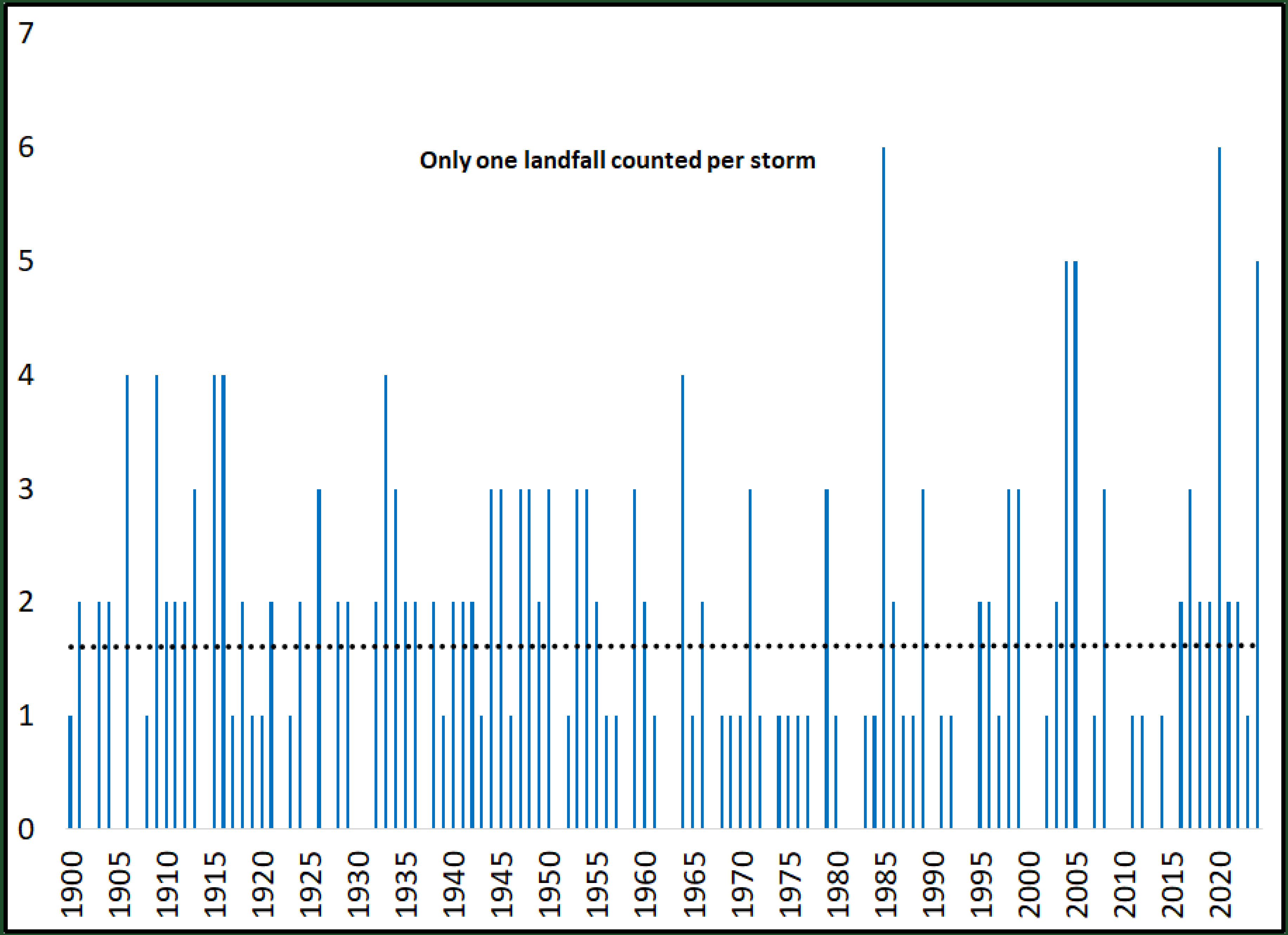


Steve Bowen (Gallagher Re)

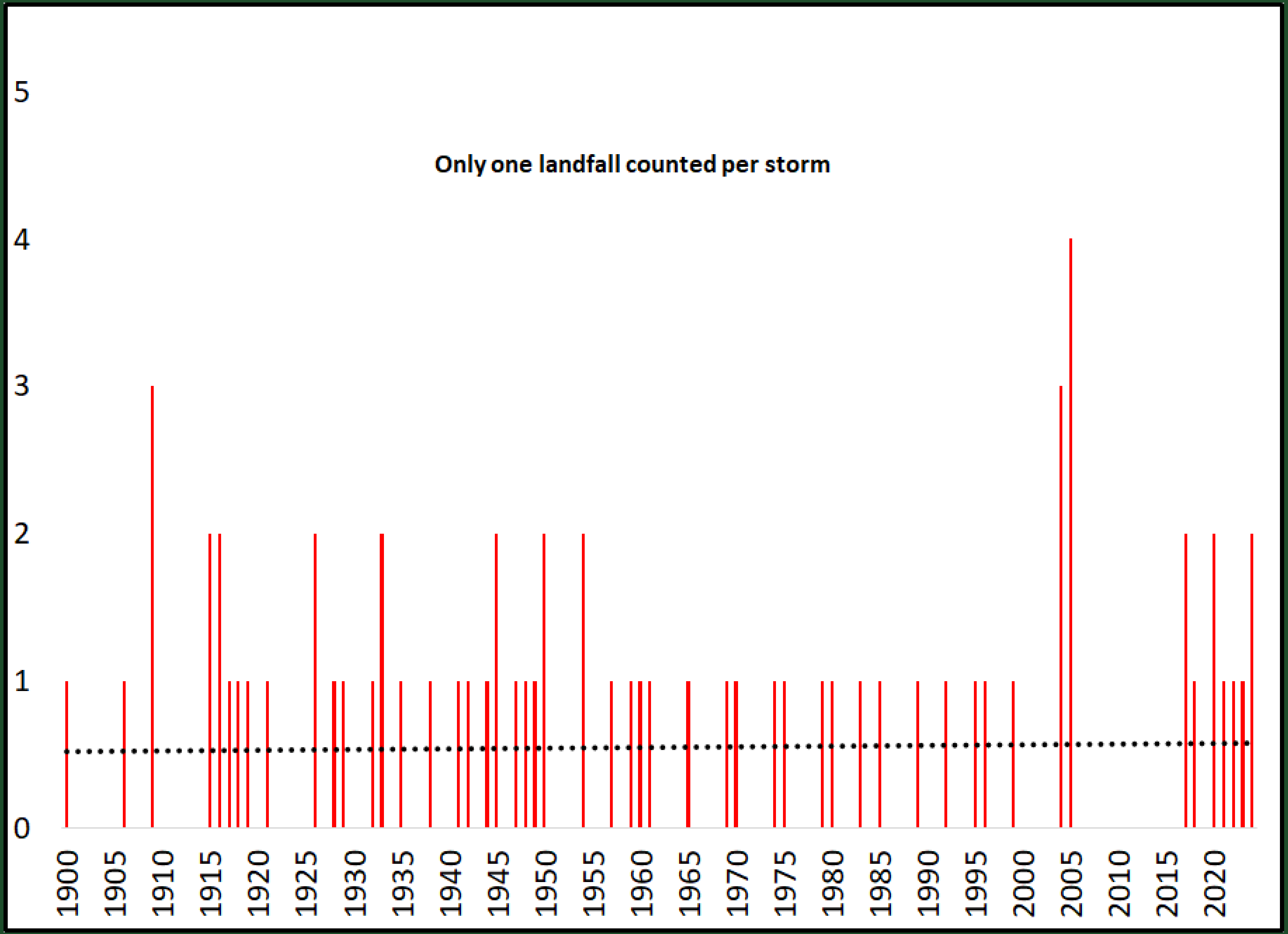
Normalized Continental US Hurricane Losses (1900–2024)



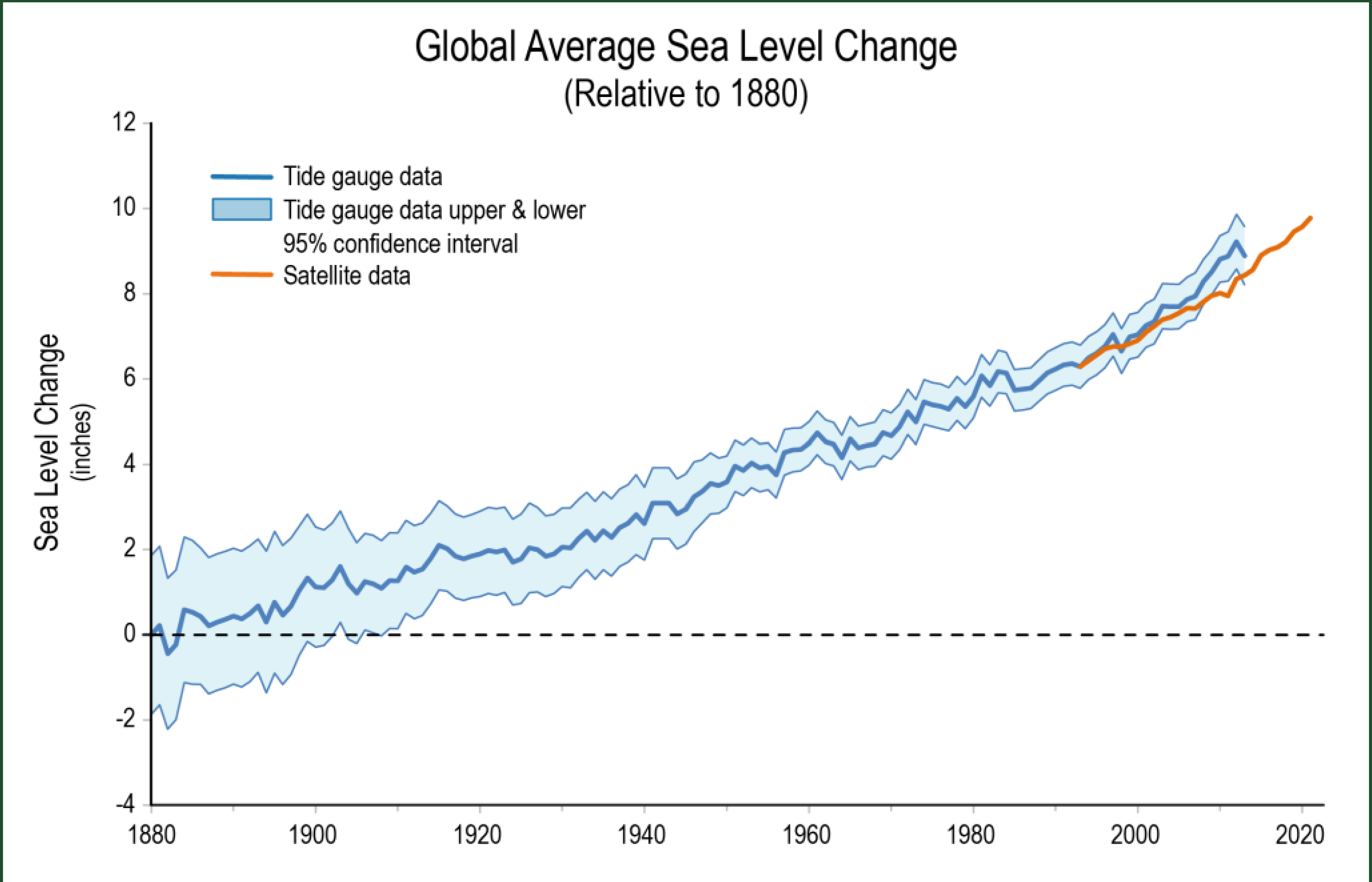
Observed Continental US Landfalling Hurricane Activity (1900–2024)



Observed Continental US Landfalling Major Hurricane Activity (1900–2024)

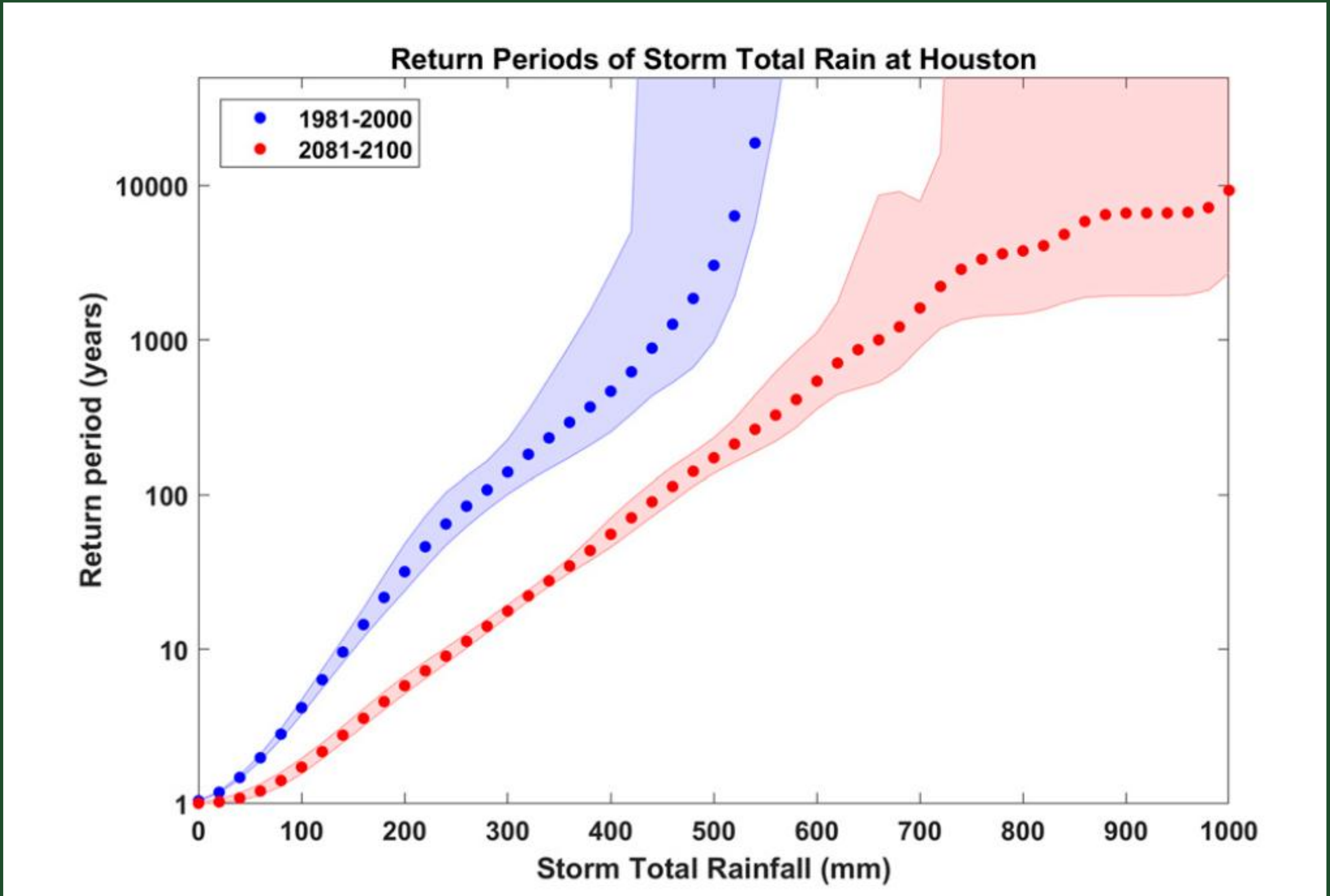


Observed Sea Level Change (1880–2024)



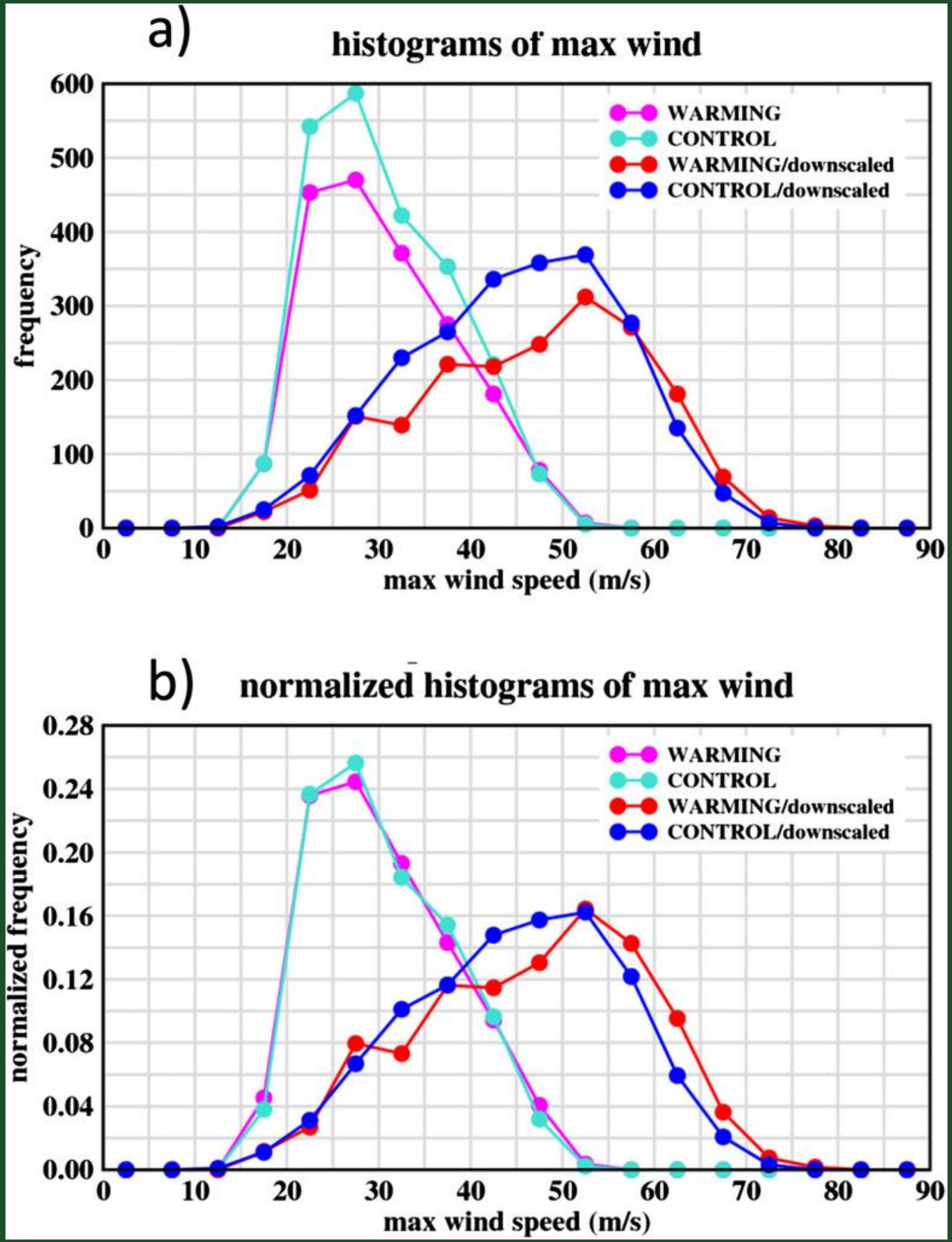
globalchange.gov

Projected Increase in Heavy Rainfall Events



Emanuel et al. (2017)

Late 21st Century Projections of Global Hurricane Intensity



Knutson et al. (2015)

Tropical Cyclone Trend Summary

- Global hurricane frequency has trended downward, likely due to long-term trend towards La Niña

- High-end rapid intensification has trended upward, likely due to increasing tropical sea surface temperatures

- No long-term trend in continental US landfalling hurricane frequency

- Inflation-adjusted damage for continental US landfalling hurricanes has skyrocketed, mostly driven by growth in population and wealth along the coastline

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!"

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