An updated NMME-based Hybrid Prediction Scheme for Atlantic Hurricane Season Activity

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Special thanks: Jae Schemm and Chrissy Maurin

https://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml

NOAA has been issuing Atlantic Hurricane Season Outlooks since 1998.

Initial outlook: May
Updated outlook: August

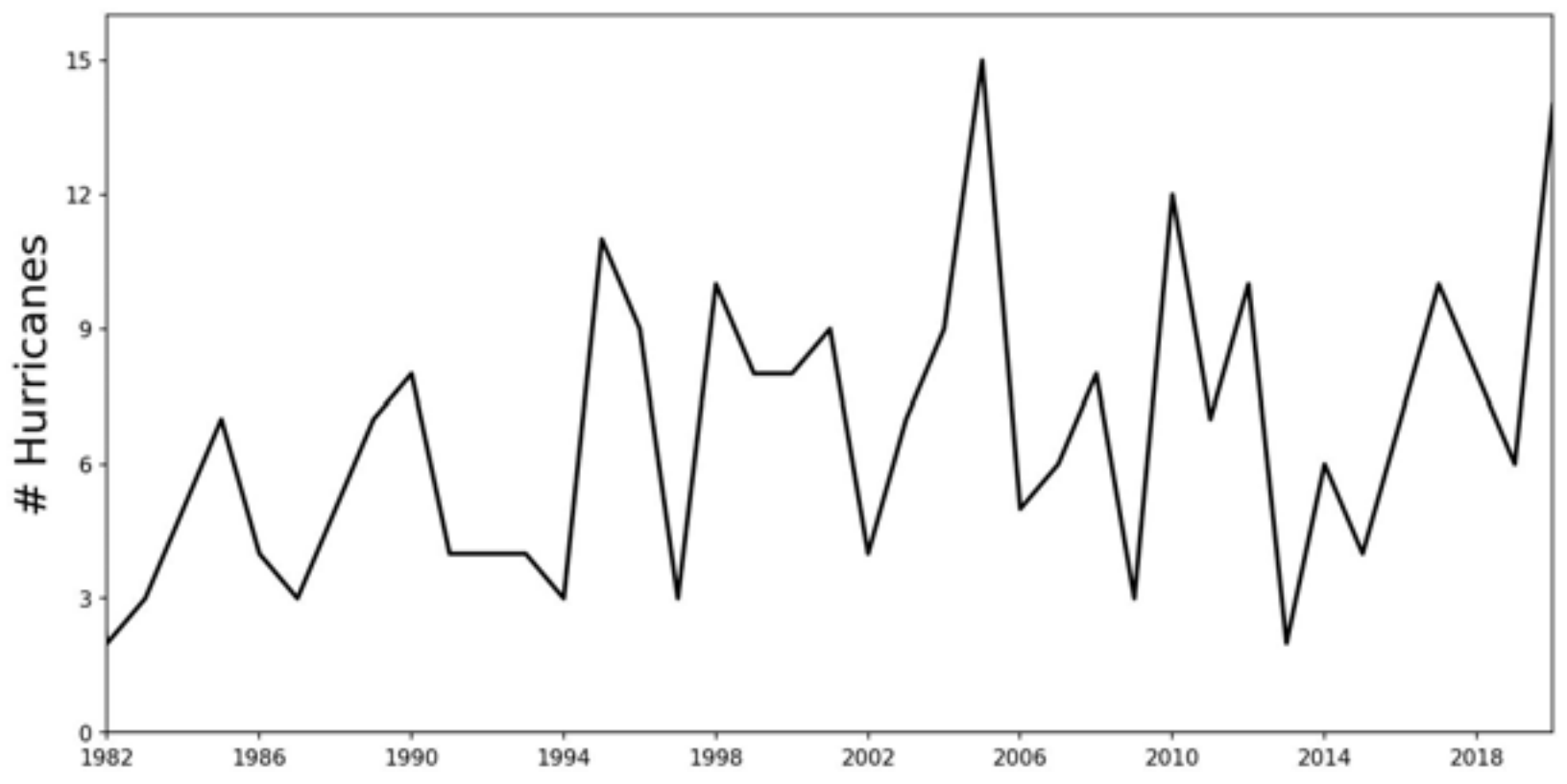
Participants: CPC, NHC, AOML

A companion outlook exists for the East Pacific.

Motivation

- Prior work has shown the merit of hybrid multiple linear regression prediction for seasonal prediction of tropical cyclones, with two methods in use at CPC supporting the Hurricane Season Outlook.
  - CFSv2-based: Wang, H., J. E. Schemm, A. Kumar, W. Wang, L. Long, M. Chelliah, G. D. Bell, and P.Peng, 2009: A statistical forecast model for Atlantic seasonal hurricane activity based on the NCEP dynamical seasonal forecast., J. Climate, **22,** 4481-4500.
  - NMME-based: Harnos, D. S., J. E. Schemm, H. Wang, and C. A. Finan, 2019: NMME-based hybrid prediction of Atlantic hurricane season activity. *Climate Dynamics,* **53,** 7267-7285.
- I'm obviously talking about the latter, which has long been published… so why am I here?

Base (training) periods updated



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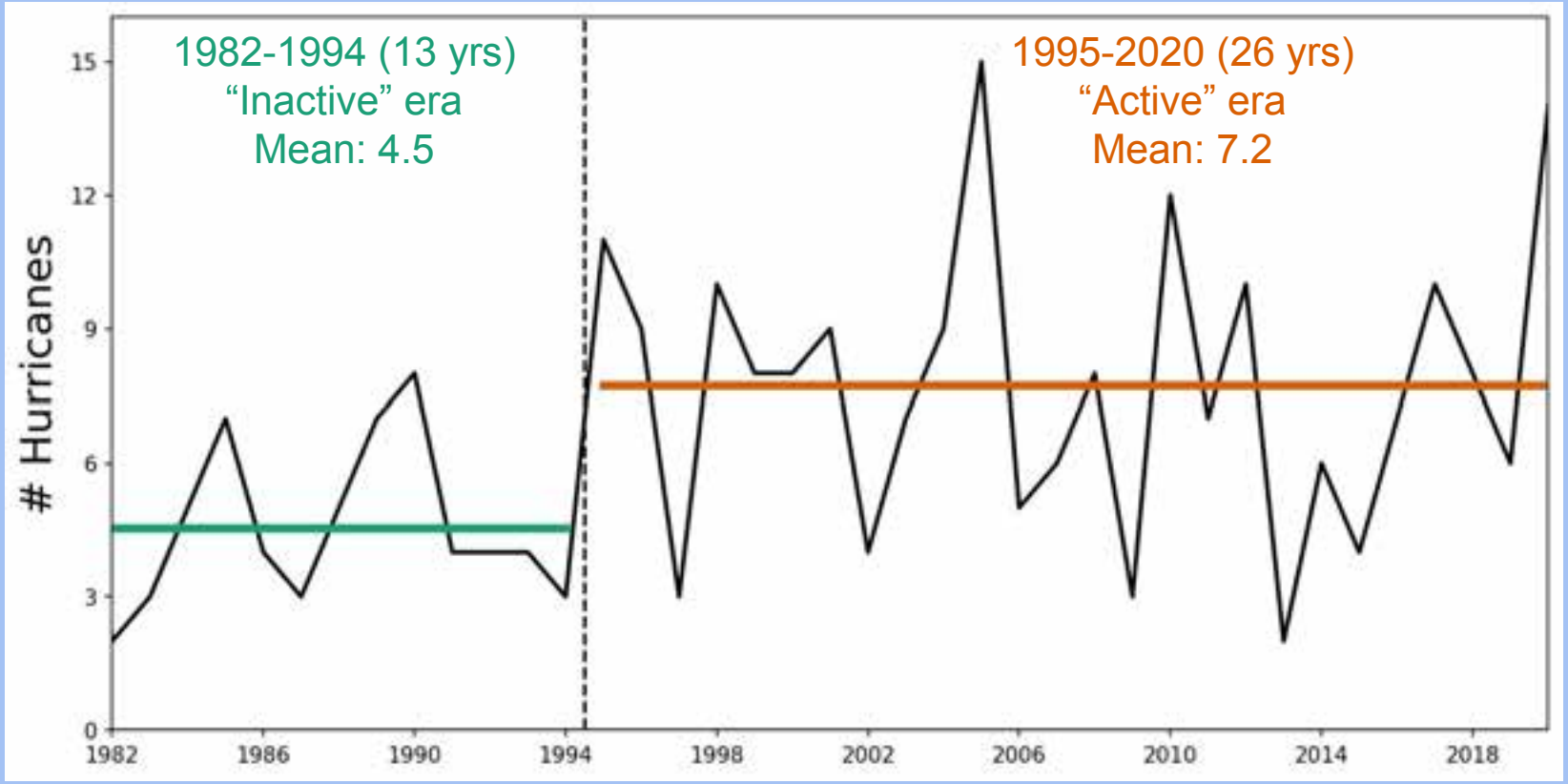

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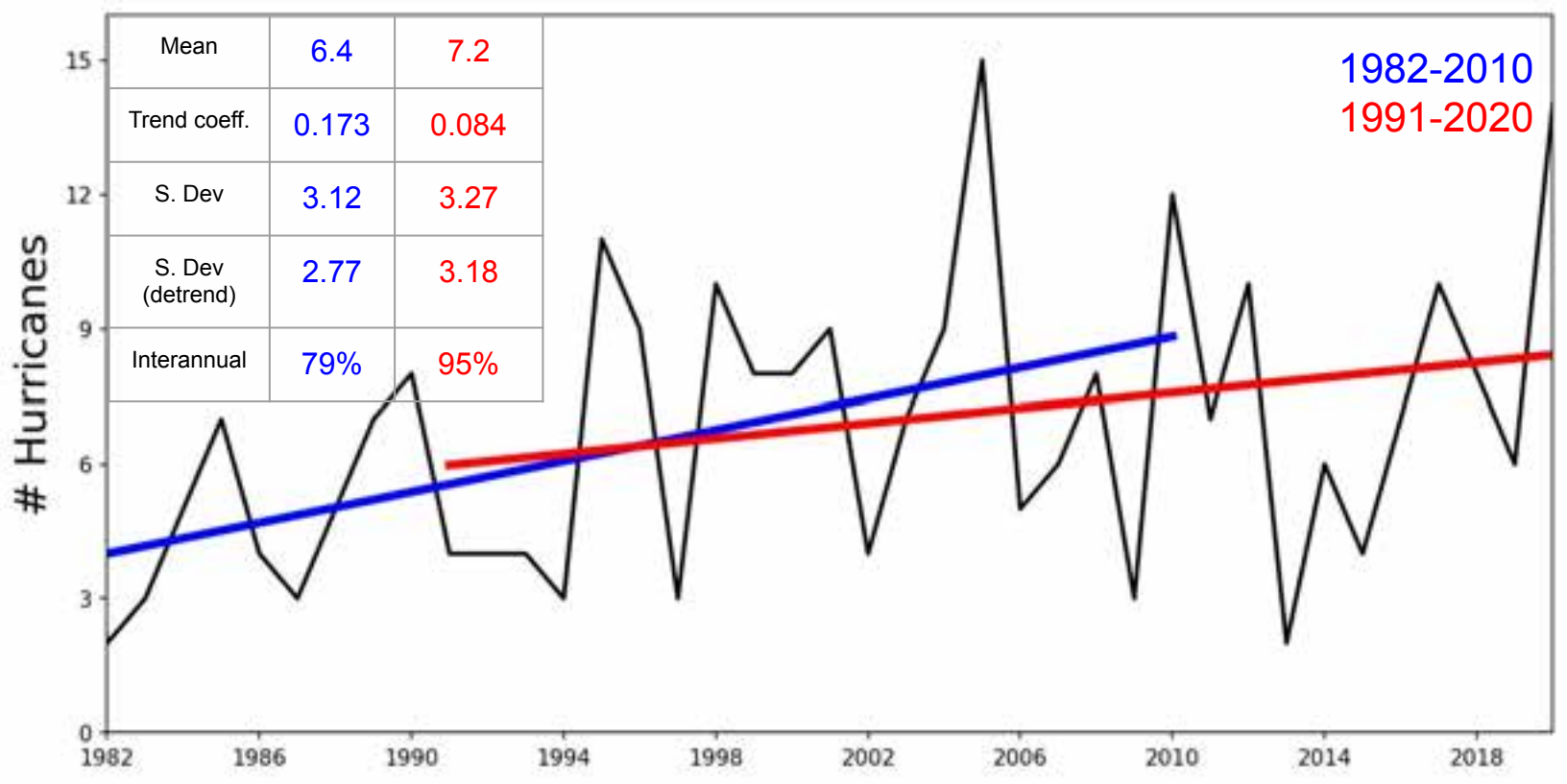

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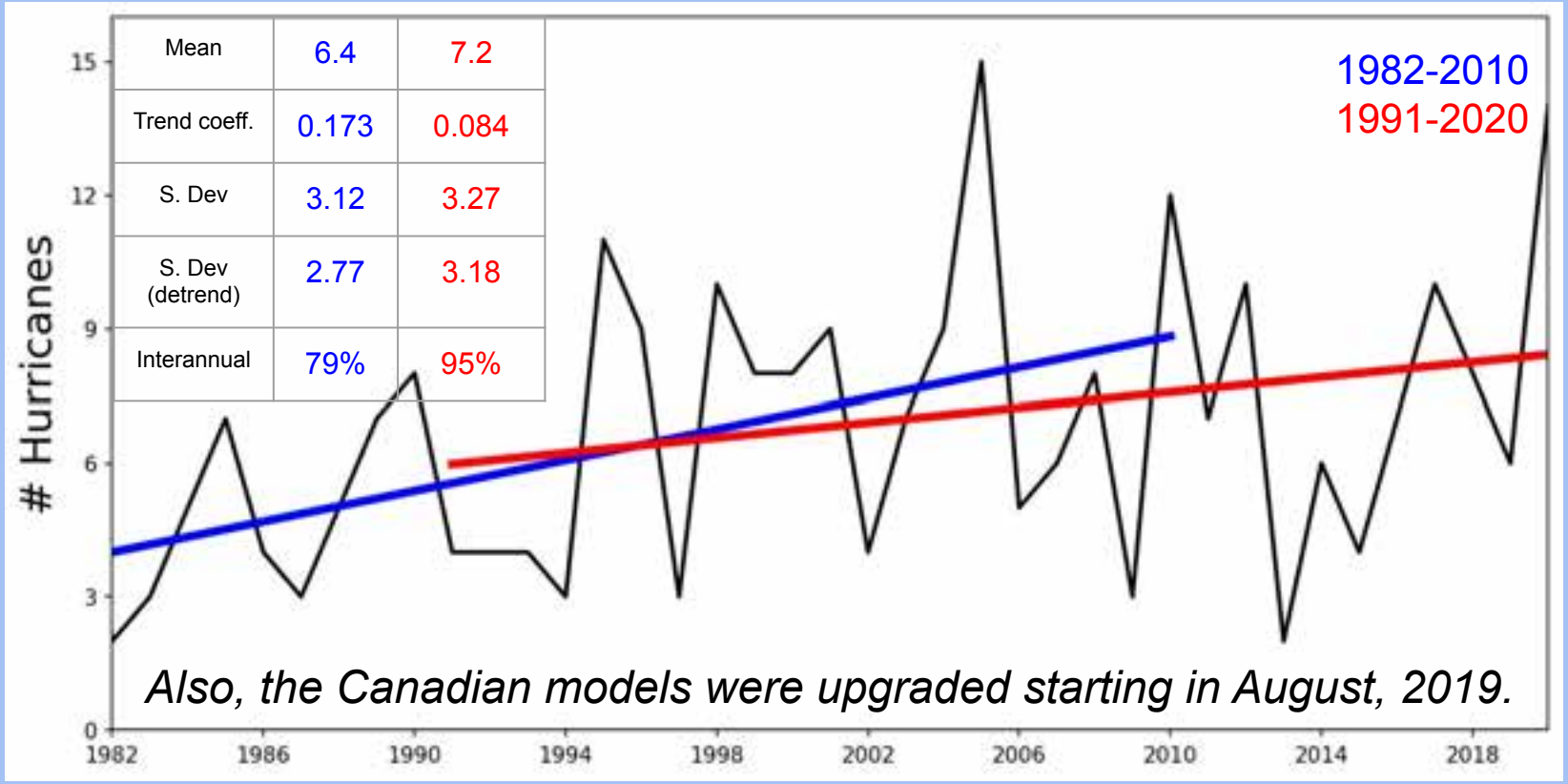
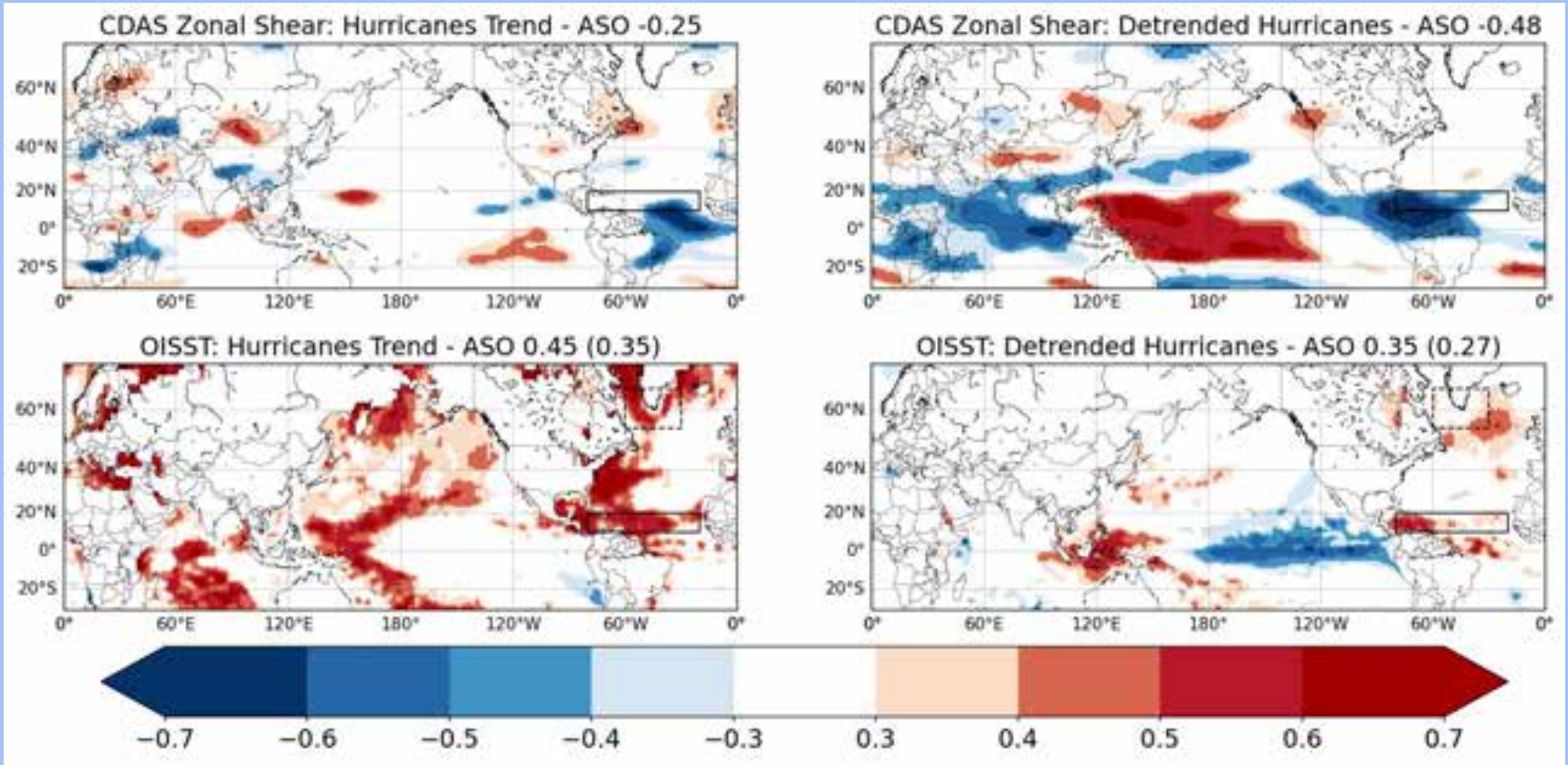




Solid line (in titles): Main Development Region (MDR); 10-20°N, 20-80°W

Dashed line (parentheses in titles): North Atlantic (NATL); 55-65°N, 30-60°W

Period: 1991-2020

CPC's NMME-based Hybrid Prediction System

Predictors:

- Forecast ASO zonal wind shear (u_{200}- u_{850}) over the Main Development Region
- Observed 3-month mean SST over the North Atlantic

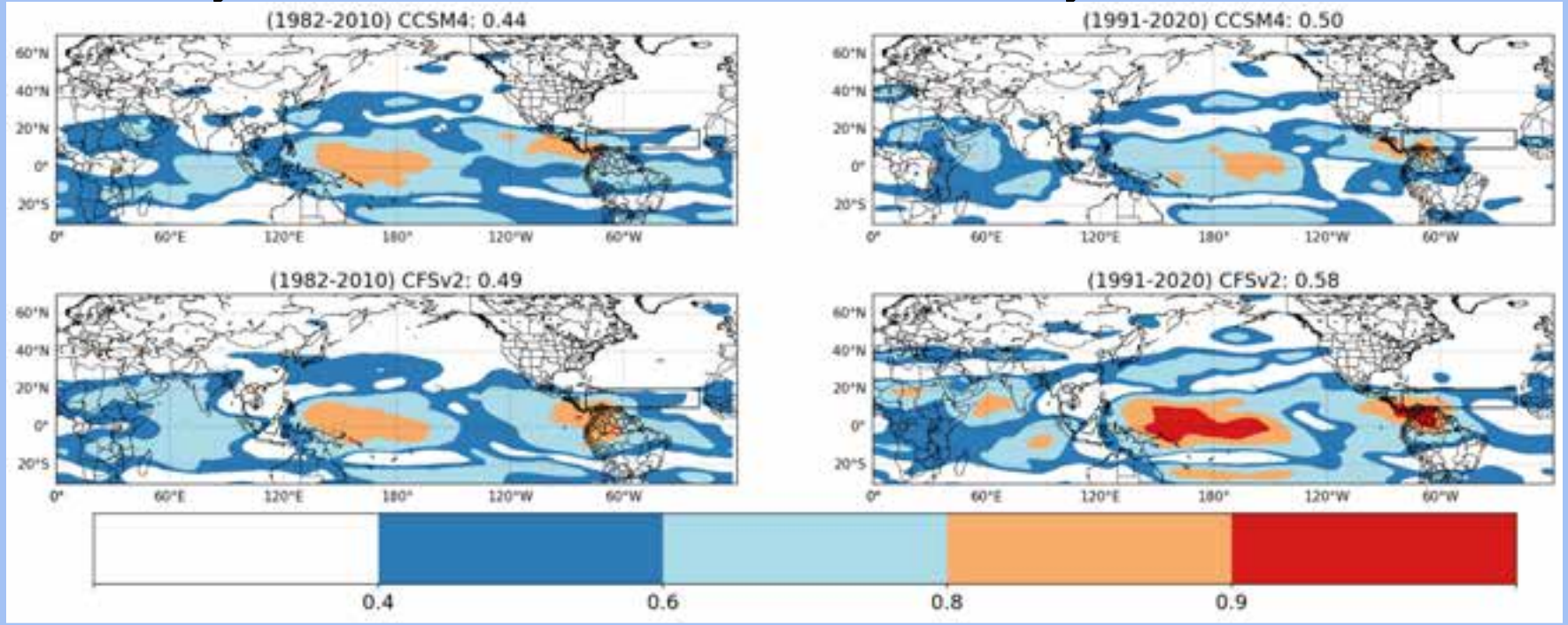
Predictands: number of named storms, **hurricanes**, major hurricanes and percentage of median ACE index

Participating models:

	CFSv2	CCSM4	CanCM3	CanCM4	GEM-NEMO	CanCM4i
1982-2010	32	10	10	10		
1991-2020	32	10			10	10

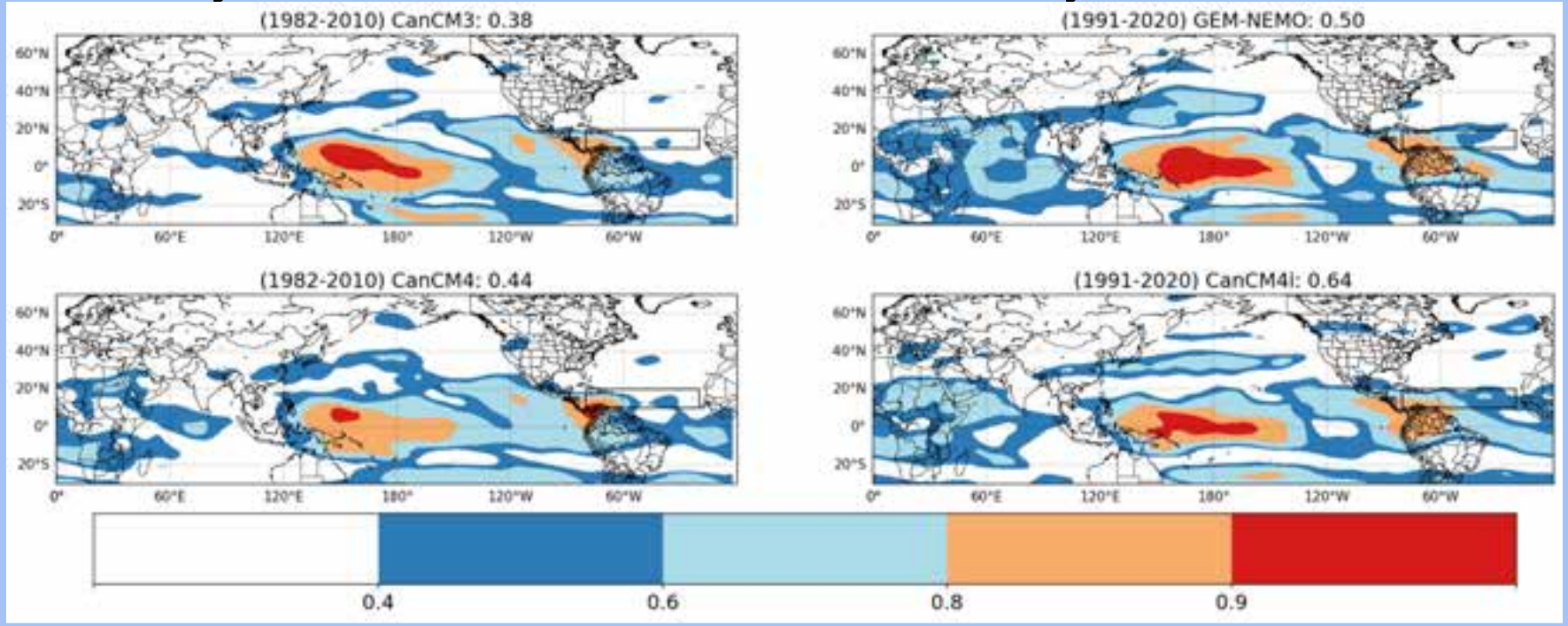
NMME mean is each model's ensemble mean averaged together (equal weight).

Anomaly Correlations - Zonal Shear; July Initialization



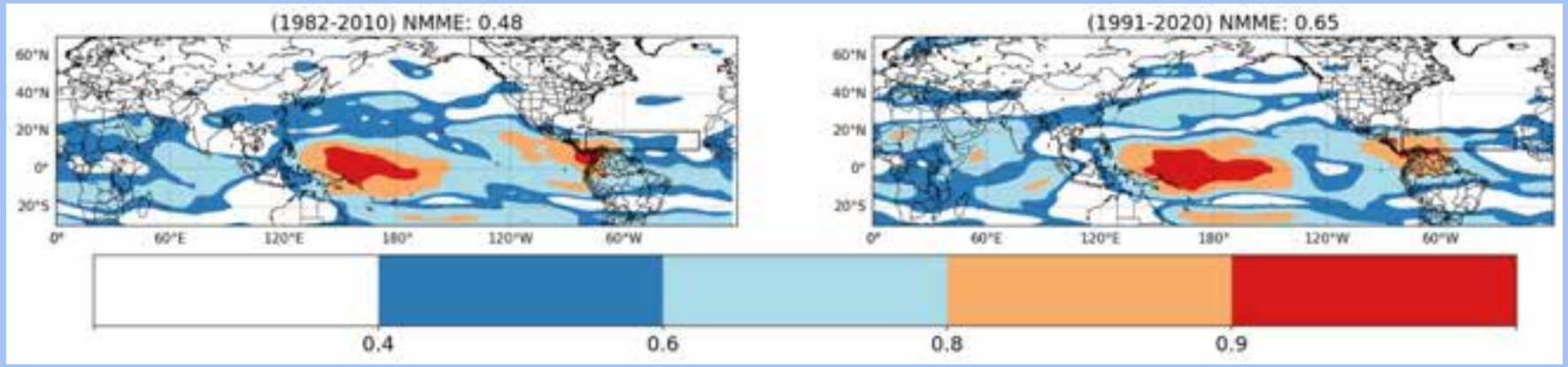
Improvements are subtle, and generally focused over the Western Caribbean.

Anomaly Correlations - Zonal Shear; July Initialization



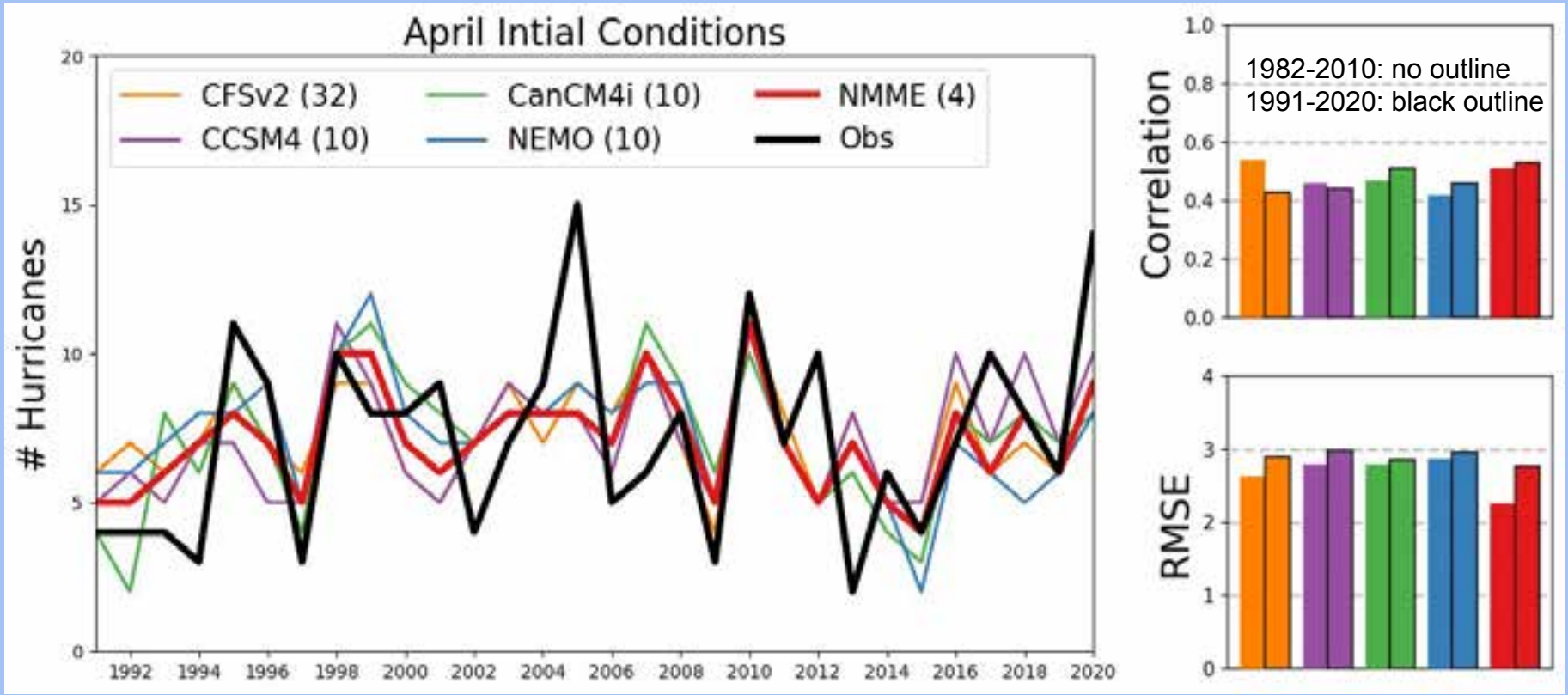
More marked improvement over the MDR, eastward extension of high ACs.

Anomaly Correlations - Zonal Shear; July Initialization



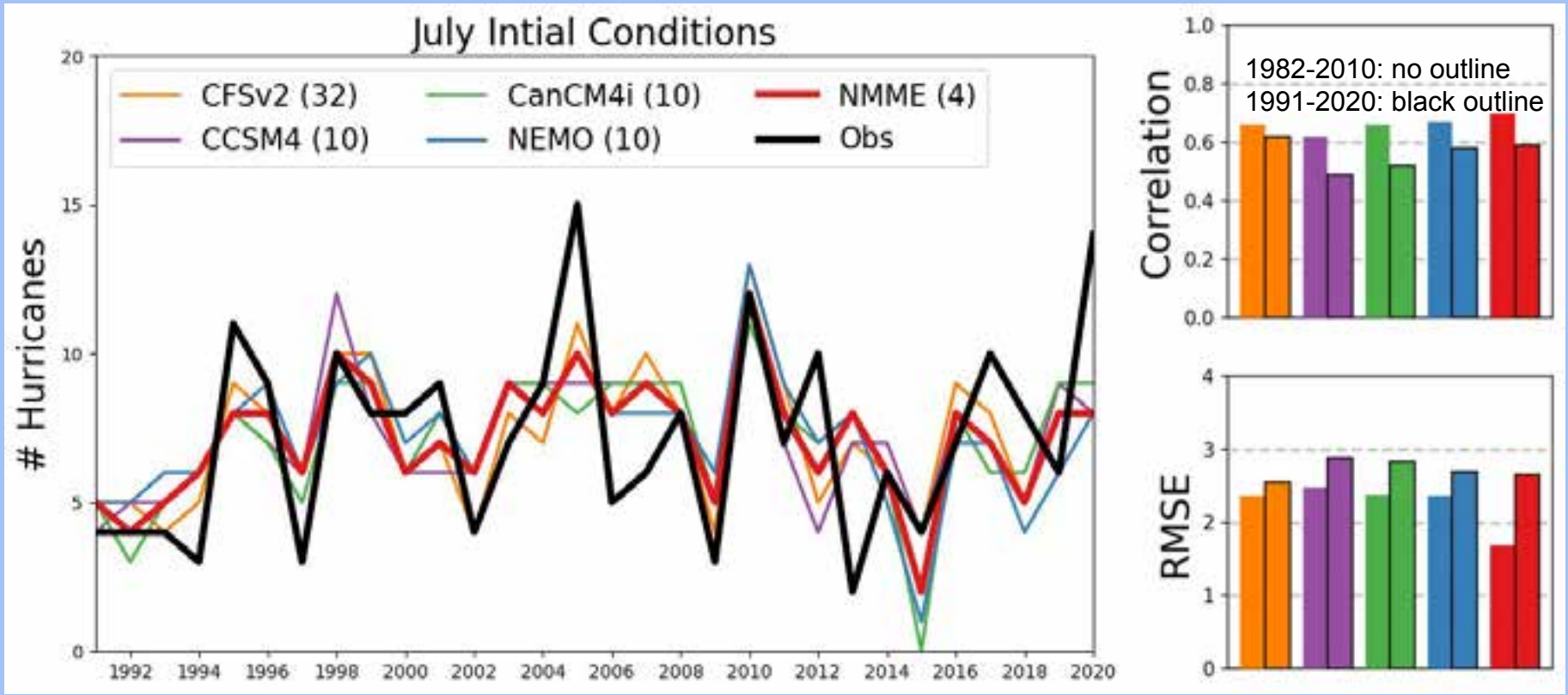
Canadian model contributions again apparent with higher ACs across the MDR.

Cross-validation performance

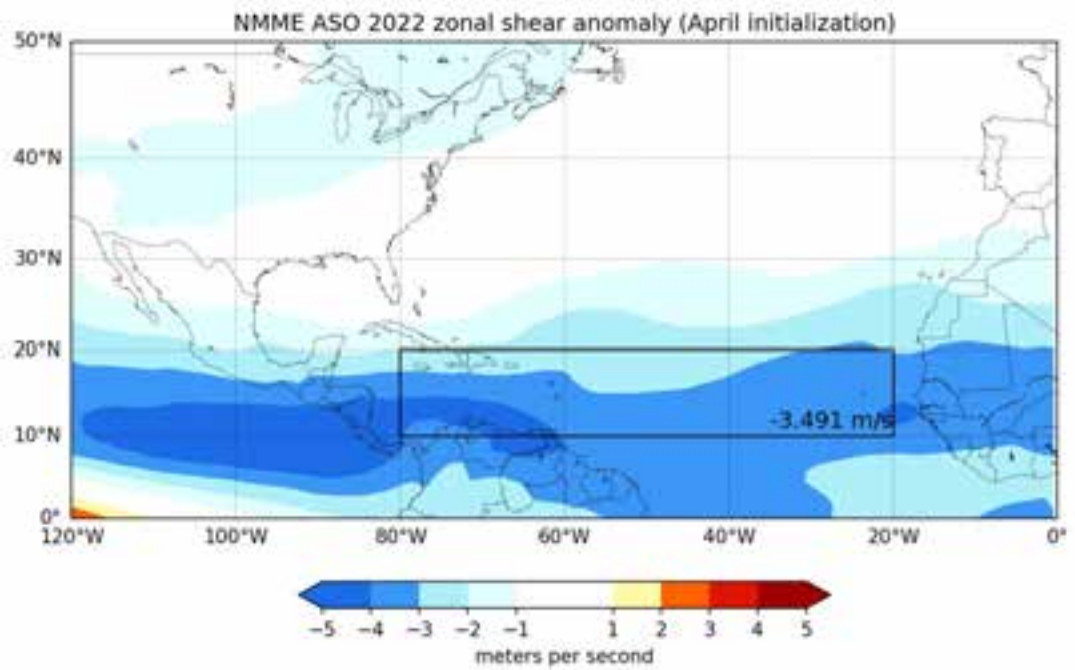


Cross-validation performed via leaving one year out

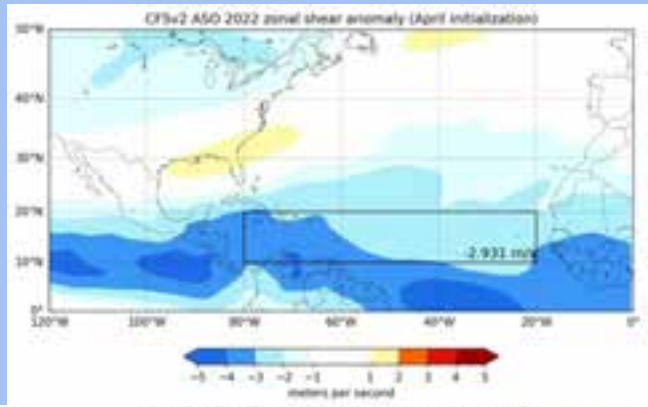
Cross-validation performance

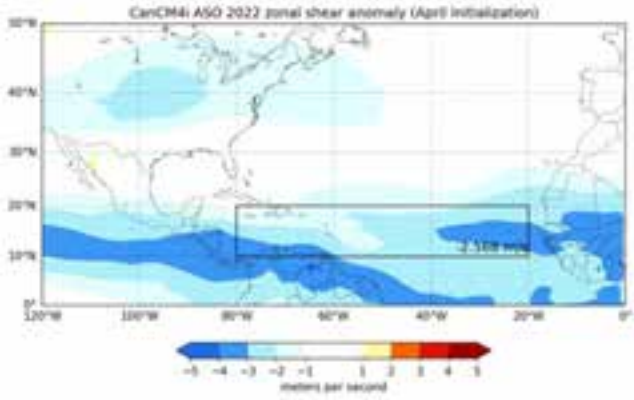


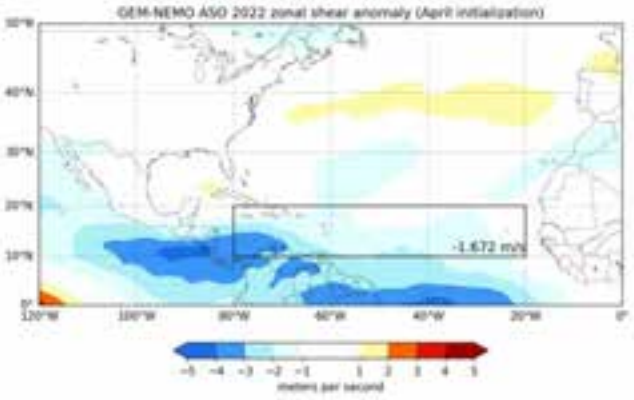
Cross-validation performed via leaving one year out

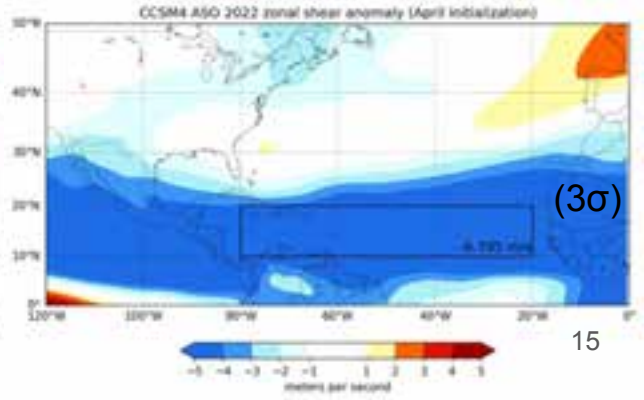


- Forecast zonal wind shear anomalies with respect to 1991-2020 model climatologies.
- Box indicates MDR domain, with the number being its areal average.









April Prediction for 2022

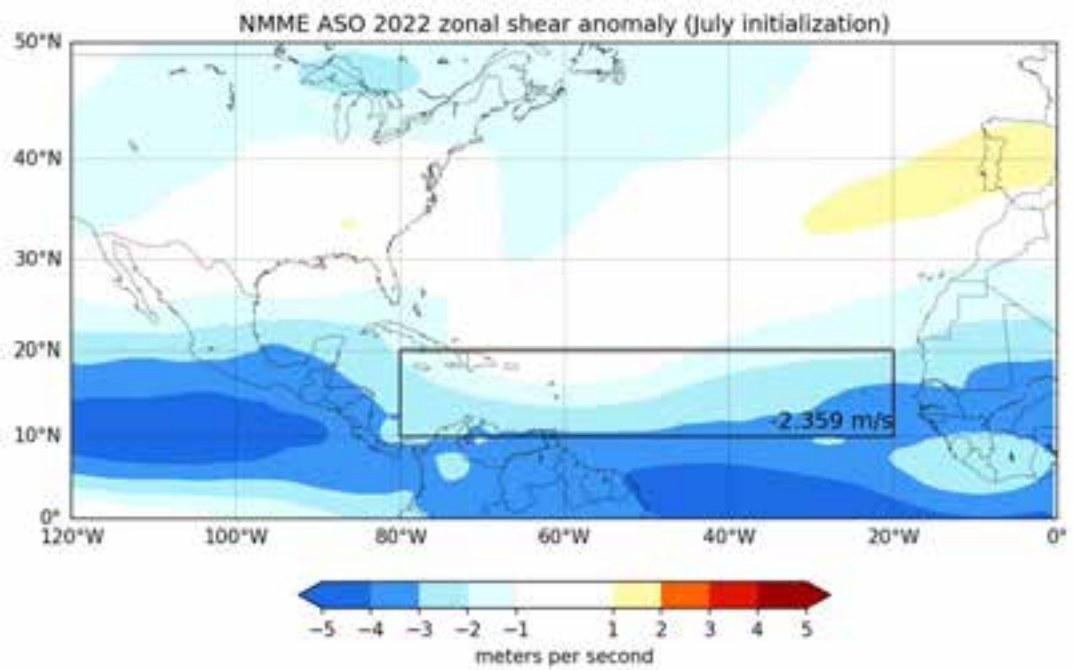
Predictors: Forecast ASO MDR shear anomaly and observed JFM NATL SST

	Hurricanes	Named Storms	M. Hurricanes	% Median ACE
CanCM4i (10)	10 (9-11)	18 (16-19)	5 (4-5)	193 (168-219)
GEM-NEMO (10)	9 (8-10)	15 (14-16)	4 (3-4)	161 (142-181)
CCSM4 (10)	12 (11-14)	22 (20-25)	5 (5-6)	238 (207-270)
CFSv2 (32)	10 (9-11)	18 (17-20)	4 (4-5)	187 (166-209)
NMME (4)	10 (9-11)	18 (17-20)	5 (4-5)	196 (171-220)

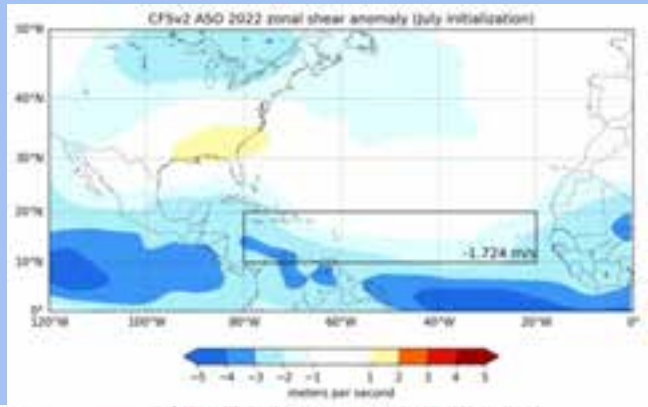
To date (10/24): 5 hurricanes, 11 named storms, 2 major hurricanes, 84.1 ACE (87% median)

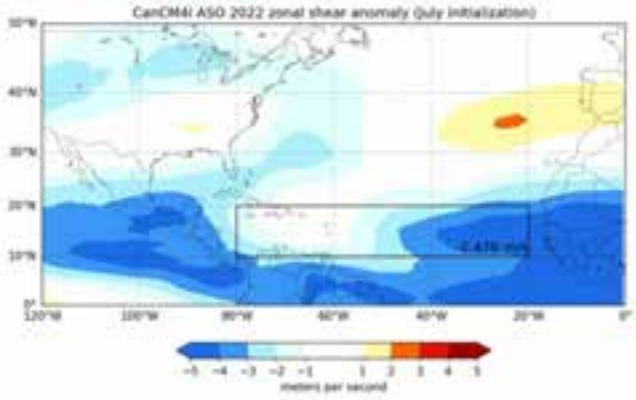
	Hurricanes	Named Storms	M. Hurricanes	% Median ACE
CanCM4i (10)	0 10 90	0 10 90	0 20 80	0 0 100
GEM-NEMO (10)	0 50 50	0 60 40	0 60 40	0 0 100
CCSM4 (10)	0 0 100	0 0 100	0 0 100	0 0 100
CFSv2 (32)	0 16 84	0 6 94	0 19 81	0 0 100
NMME (4)	0 19 81	0 19 81	0 25 75	0 0 100

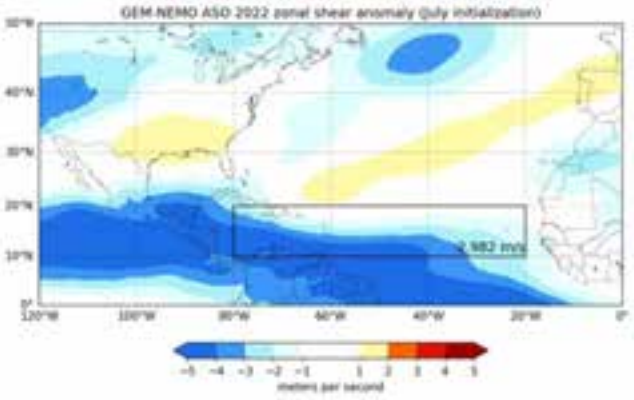
% Below normal % Near normal % Above normal

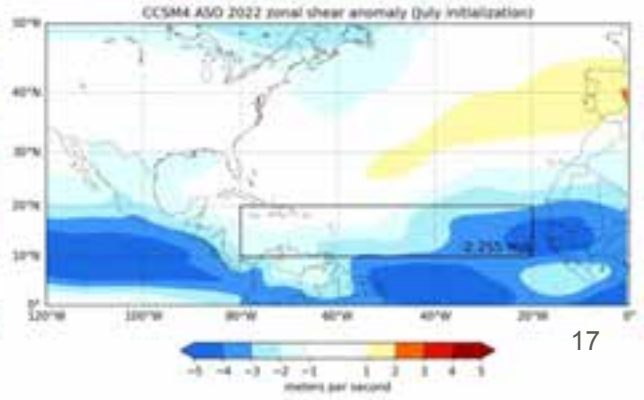


- Forecast zonal wind shear anomalies with respect to 1991-2020 model climatologies.
- Box indicates MDR domain, with the number being its areal average.









July Prediction for 2022

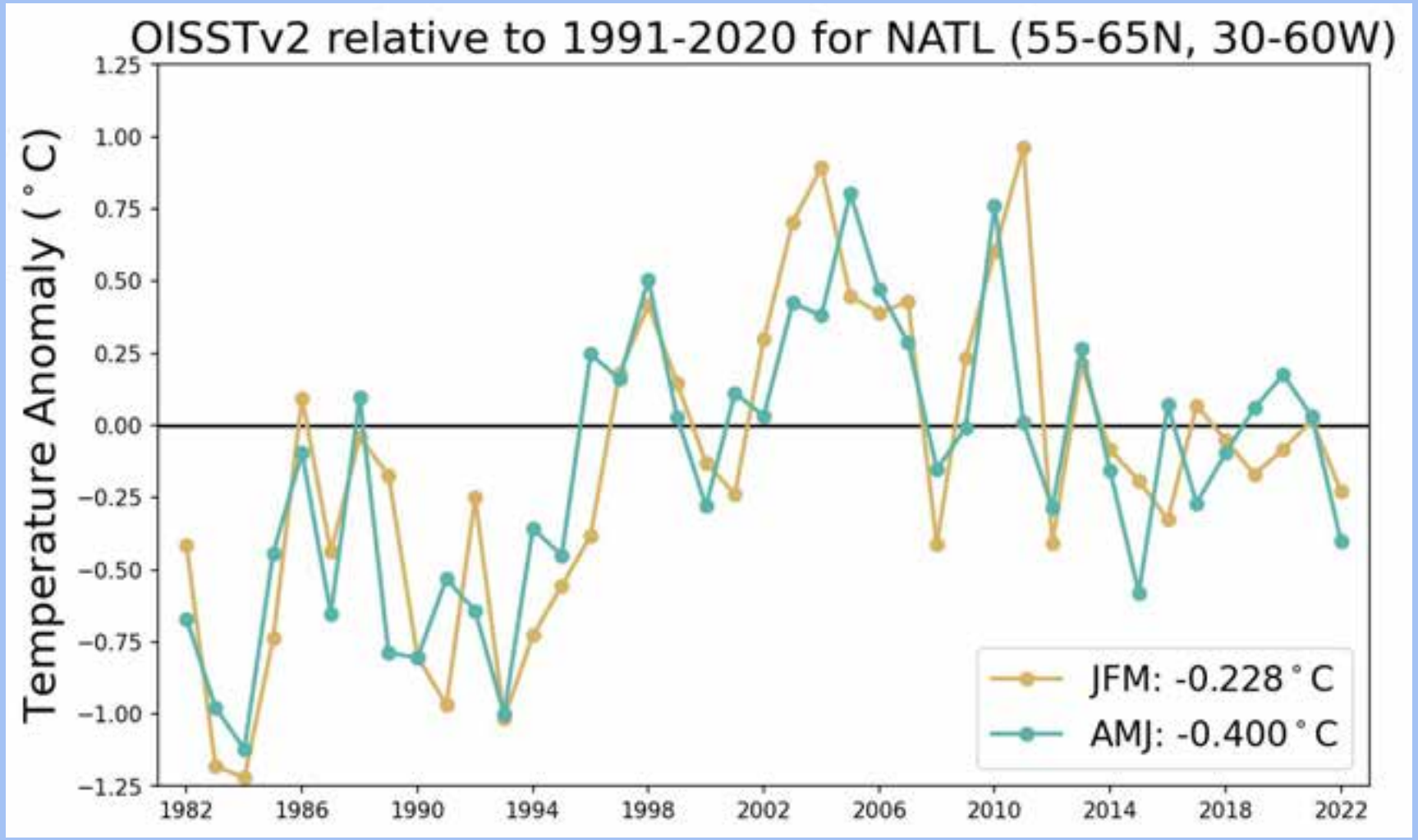
Predictors: Forecast ASO MDR shear anomaly and observed AMJ NATL SST

	Hurricanes	Named Storms	M. Hurricanes	% Median ACE
CanCM4i (10)	9 (8-10)	16 (14-18)	4 (4-5)	184 (154-214)
GEM-NEMO (10)	9 (7-10)	14 (13-15)	4 (3-5)	174 (146-202)
CCSM4 (10)	8 (7-8)	15 (14-16)	3 (3-4)	153 (139-166)
CFSv2 (32)	8 (7-8)	15 (14-16)	3 (3-4)	149 (132-165)
NMME (4)	8 (7-9)	15 (14-16)	4 (3-4)	165 (143-187)

To date (10/24): 5 hurricanes, 11 named storms, 2 major hurricanes, 84.1 ACE (87% median)

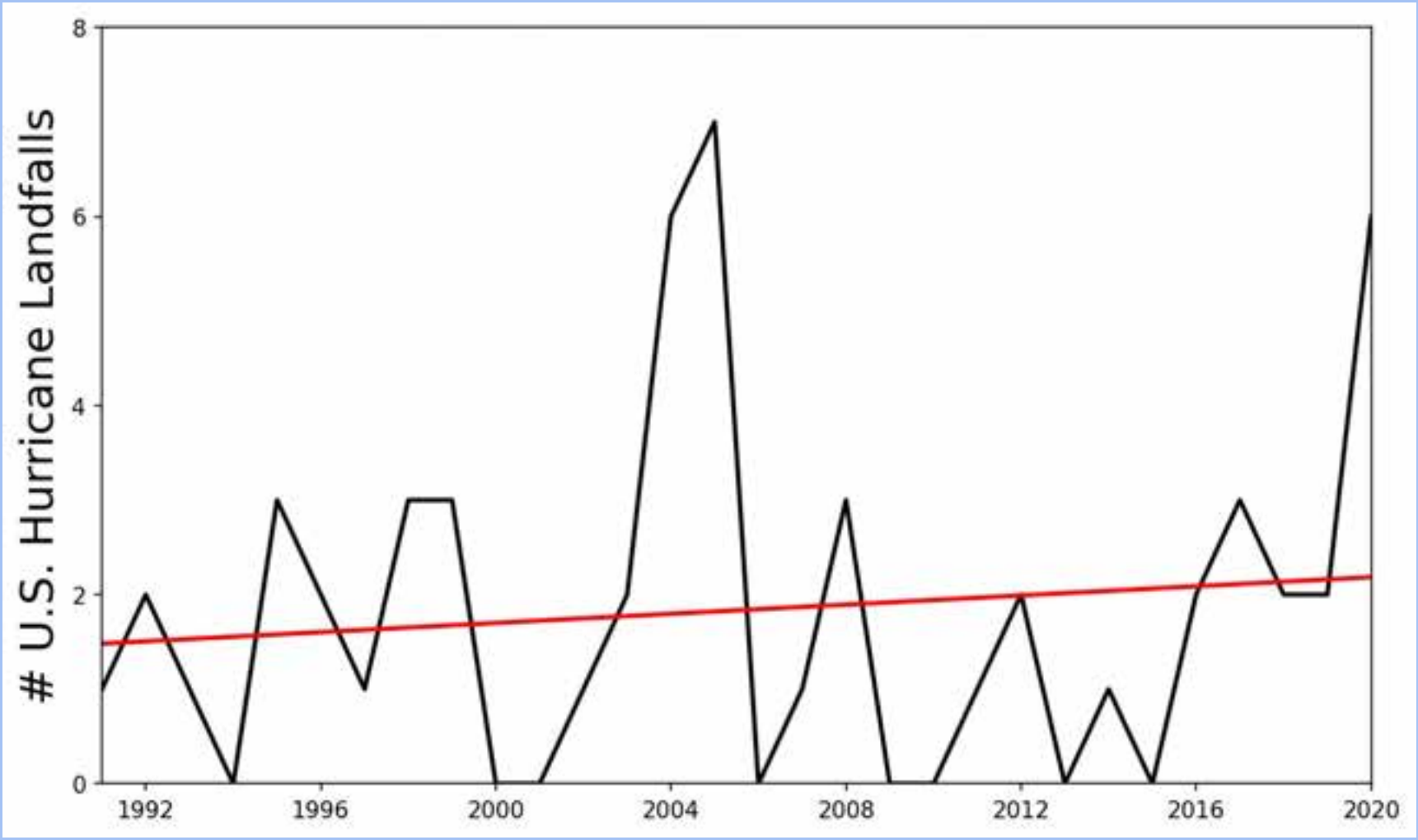
	Hurricanes	Named Storms	M. Hurricanes	% Median ACE
CanCM4i (10)	0 30 70	0 30 70	0 30 70	0 10 90
GEM-NEMO (10)	0 30 70	0 100 0	0 30 70	0 20 80
CCSM4 (10)	0 100 0	0 50 50	0 100 0	0 10 90
CFSv2 (32)	0 84 16	0 78 22	0 94 6	0 9 91
NMME (4)	0 61 39	0 65 35	0 63 37	0 12 88

% Below normal % Near normal % Above normal

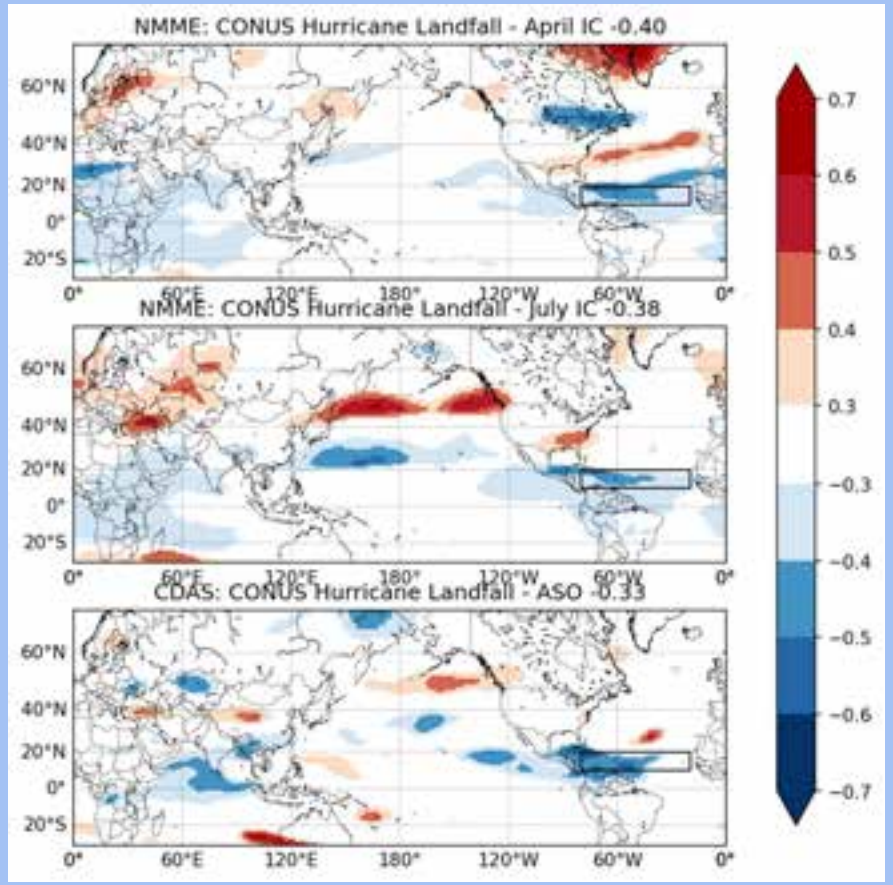

OISSTv2 relative to 1991-2020 for NATL (55-65N, 30-60W)
Temperature Anomaly (°C)
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.25
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
JFM: -0.228 °C
AMJ: -0.400 °C

Summary

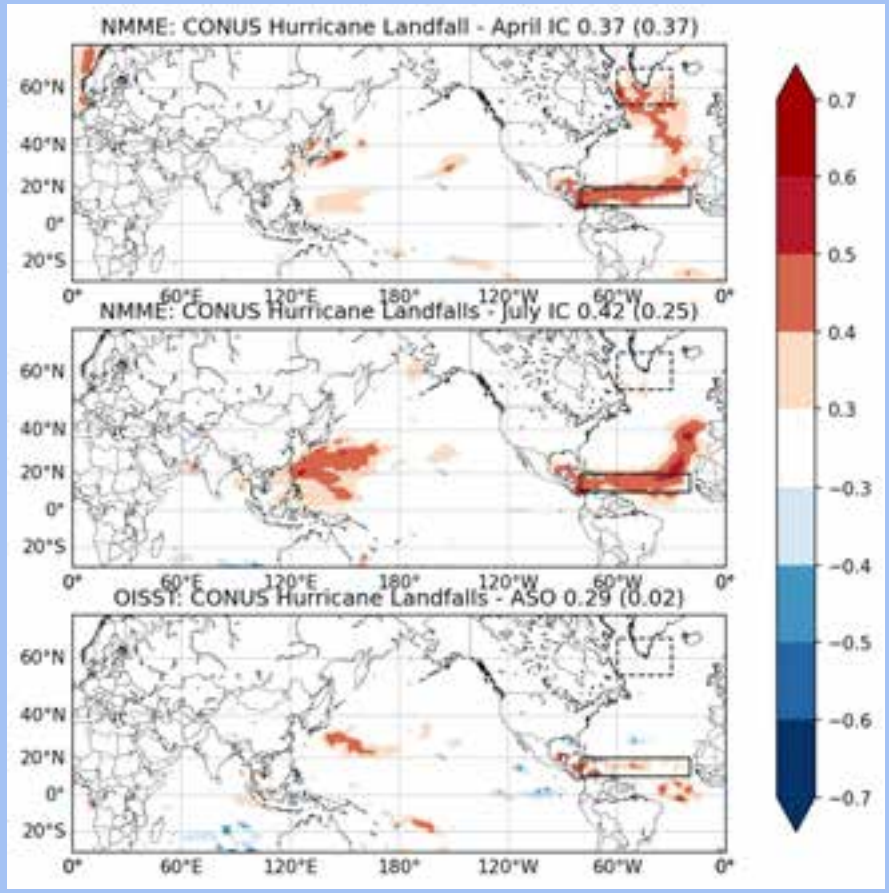
- The NMME-hybrid prediction system continues to provide skillful forecasts of seasonal Atlantic hurricane activity.
  - Interannual variability of Atlantic hurricanes has increased over the most recent base period. Despite this, improvements in model forecasts of tropical Atlantic zonal wind shear have helped maintain the performance of the NMME hybrid prediction model.
  - The Canadian model upgrades saw particular improvement in their predictive skill of MDR zonal wind shear, although with the caveat of differing base periods from their predecessors. These improvements subsequently benefitted the NMME ensemble mean prediction.
  - The 2022 outlook looks to be too high from April, but at least corrected in the right direction with the July update as forecast MDR easterly zonal wind shear anomalies relaxed, while observed preseason NATL SST continued to cool.
- Going forward, we would like to leverage this framework to look at the feasibility of landfall predictions.


U.S. Hurricane Landfalls
0
2
4
6
8
1992
1996
2000
2004
2008
2012
2016
2020

Zonal Wind Shear



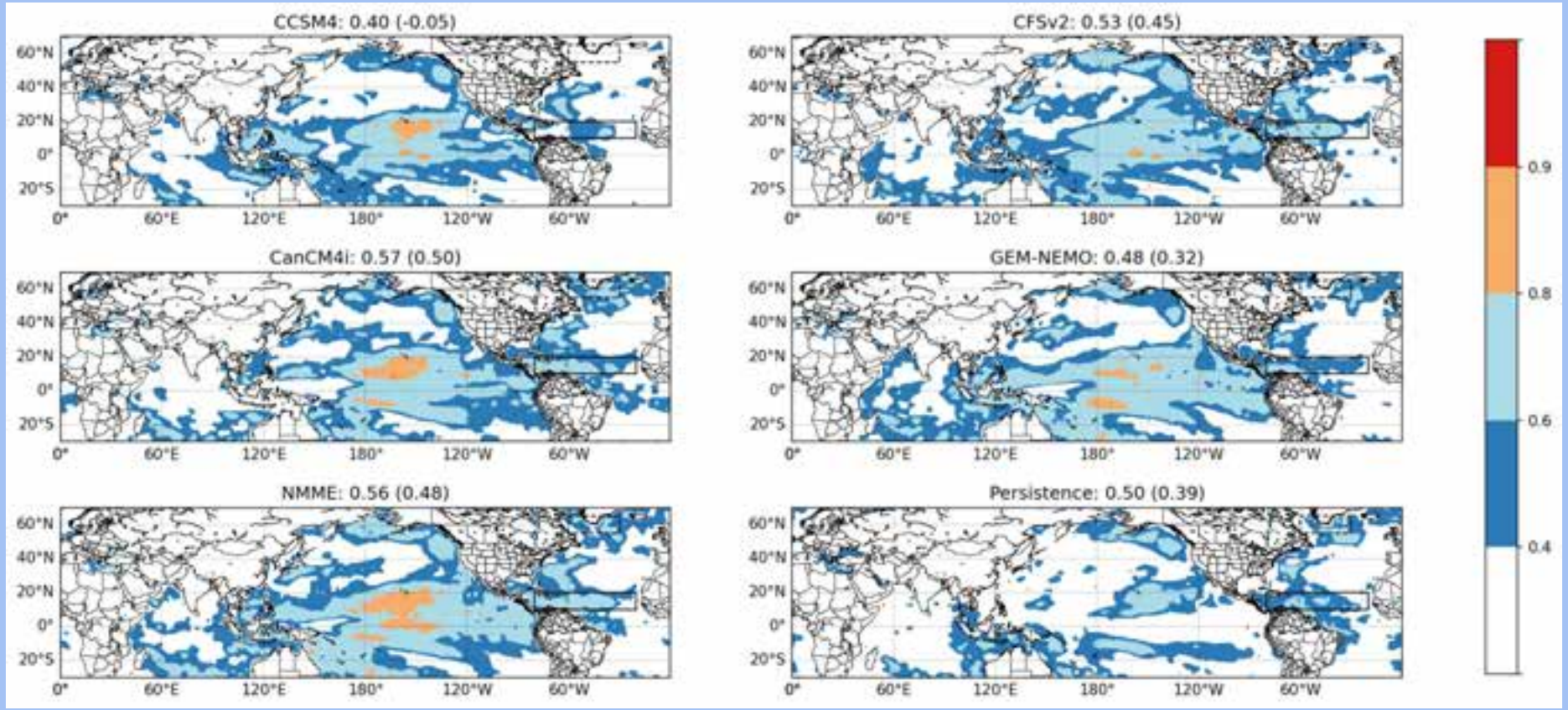
SST



Period: 1991-2020

Extra Slides

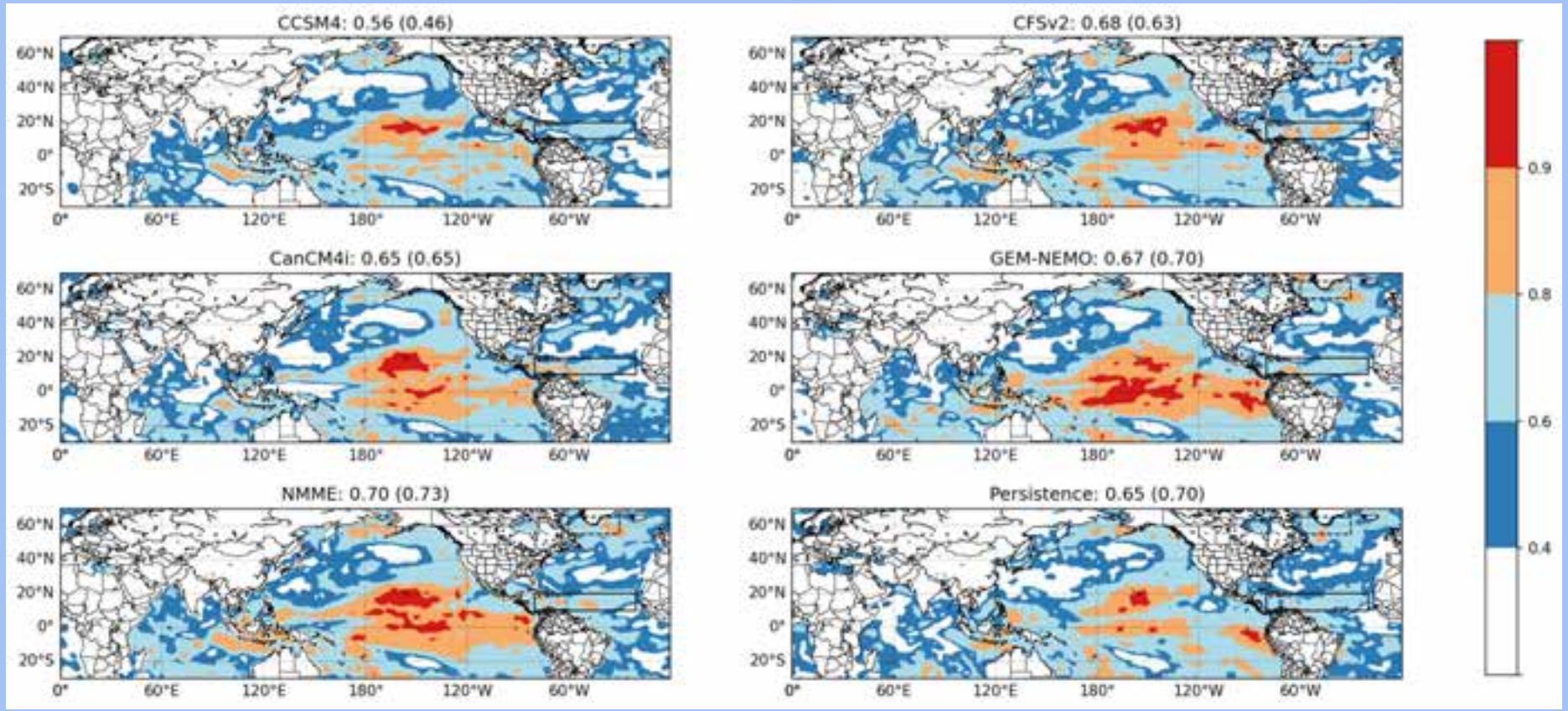
Anomaly correlations: ASO SST (April initialization)



w.r.t. OISSTv2

Title value: MDR (NATL) mean

Anomaly correlations: ASO SST (July initialization)



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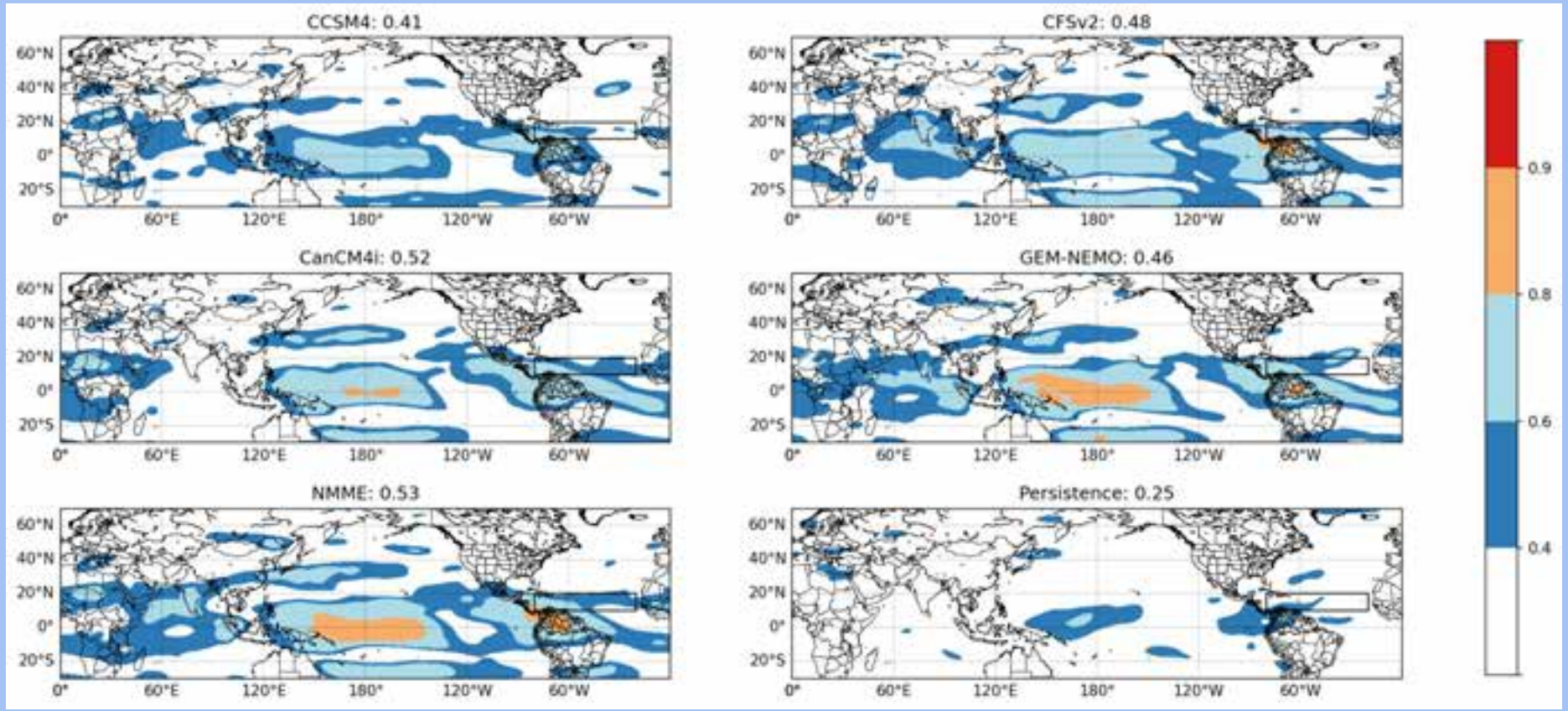
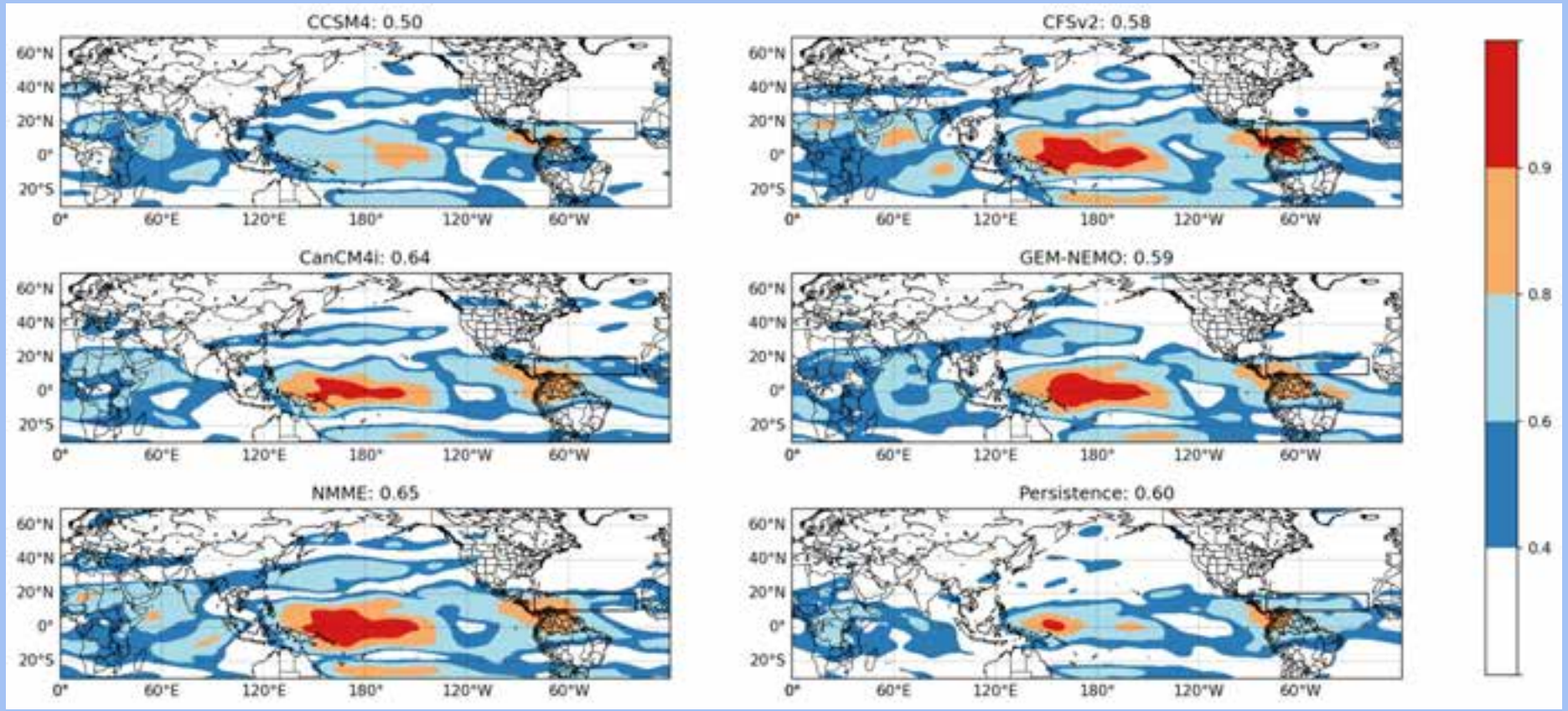
Anomaly correlations: ASO Zonal shear (April initialization)



w.r.t. CDAS

Title value: MDR mean

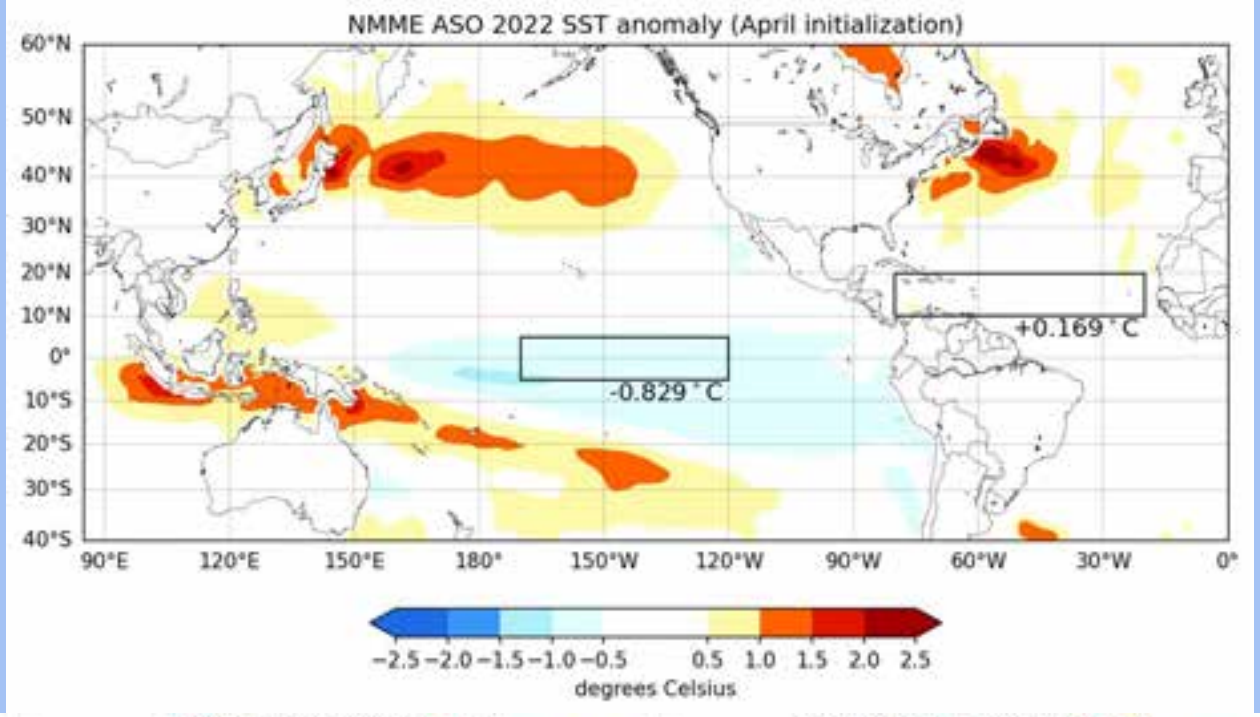
Anomaly correlations: ASO Zonal shear (July initialization)

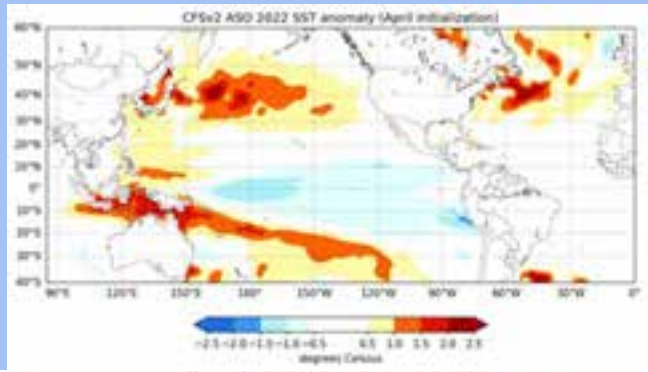


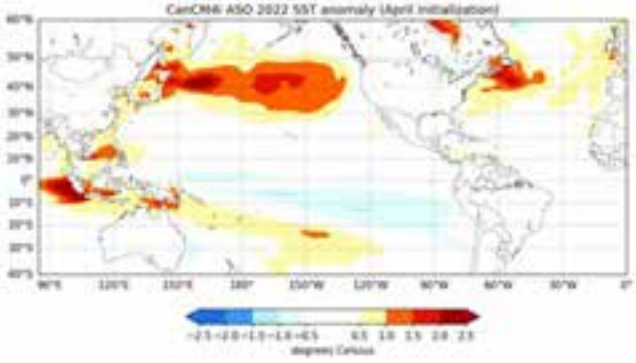
w.r.t. CDAS

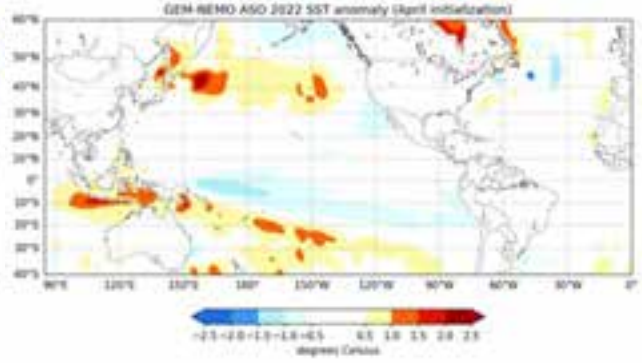
Title value: MDR mean

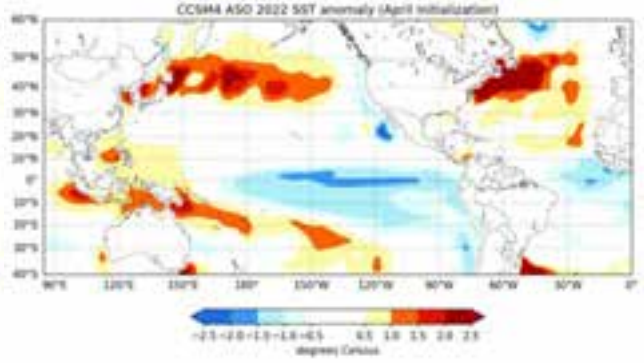
April 2022 ASO global SST forecasts



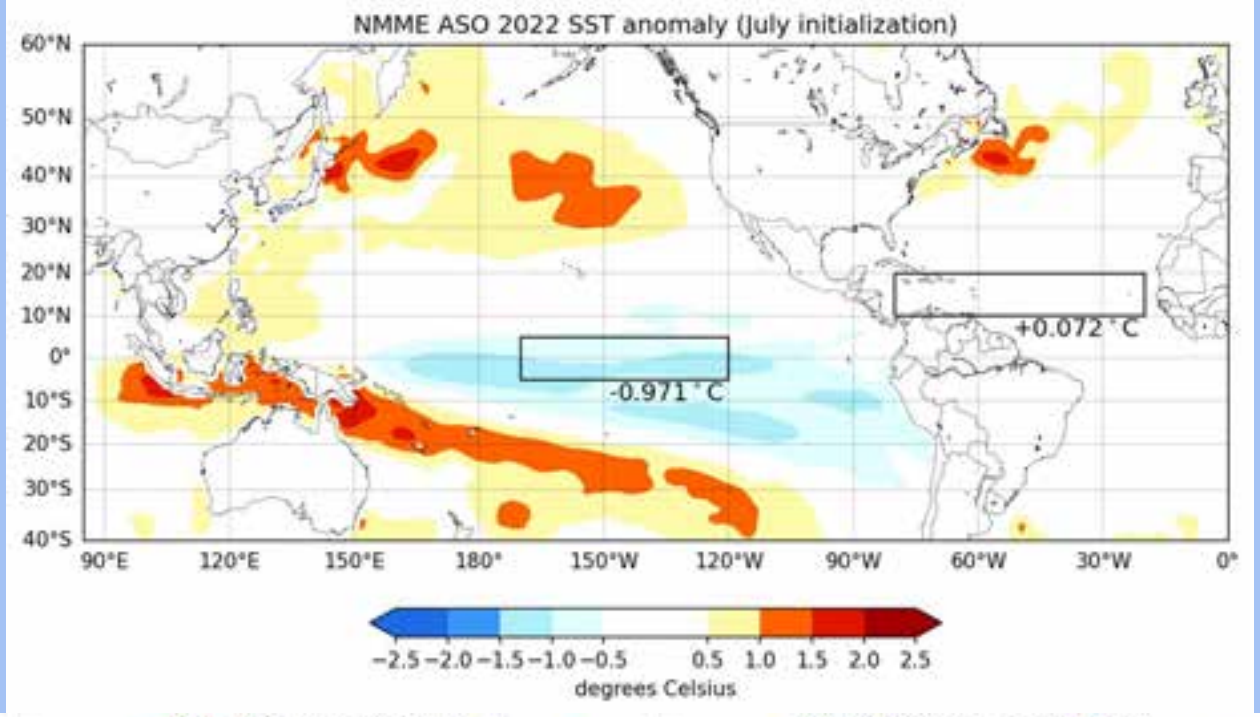


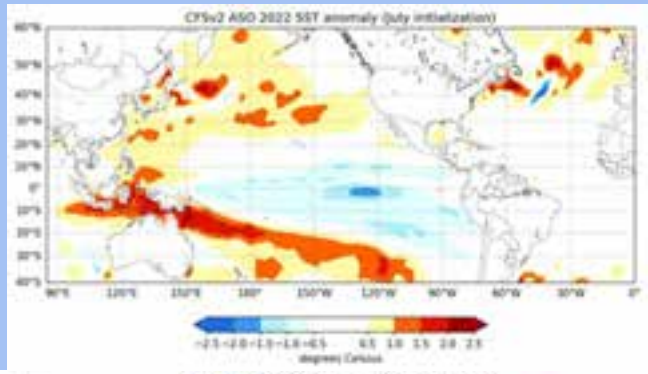


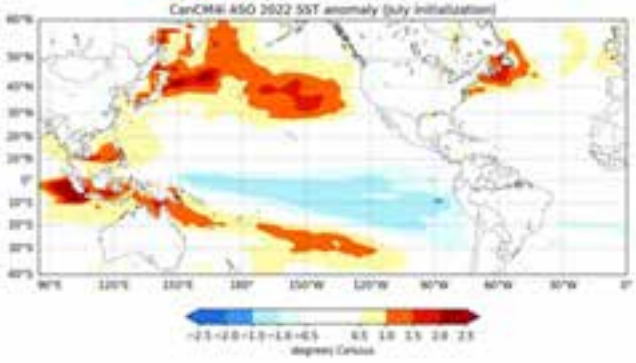


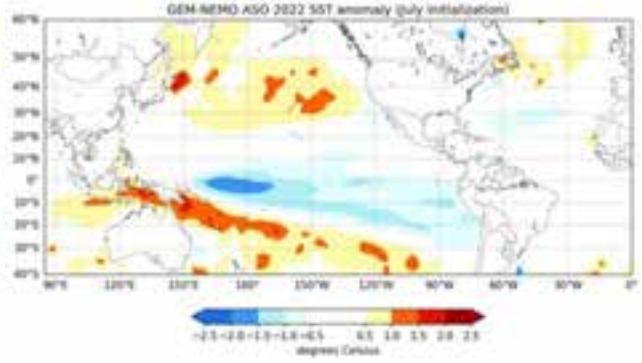


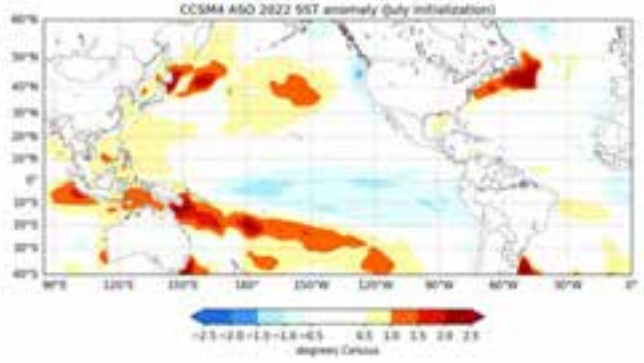
July 2022 ASO global SST forecasts







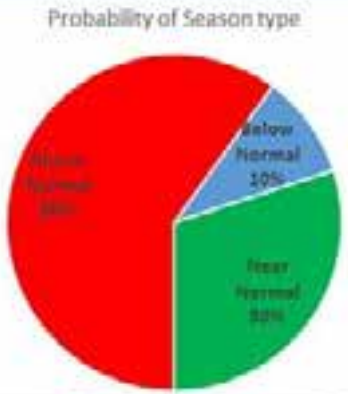




NOAA's 2022 Atlantic Hurricane Season Outlooks

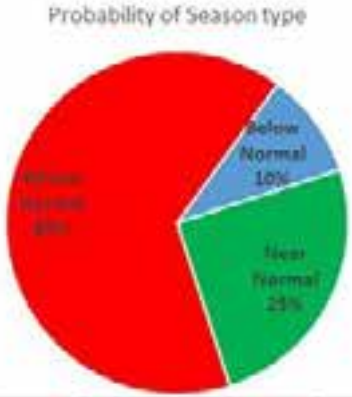
Forecasts are for the entire June-November Hurricane Season

August Update



Named Storms	14-20
Hurricanes	6-10
Major Hurricanes	3-5
ACE % of Median	110-190

May Outlook

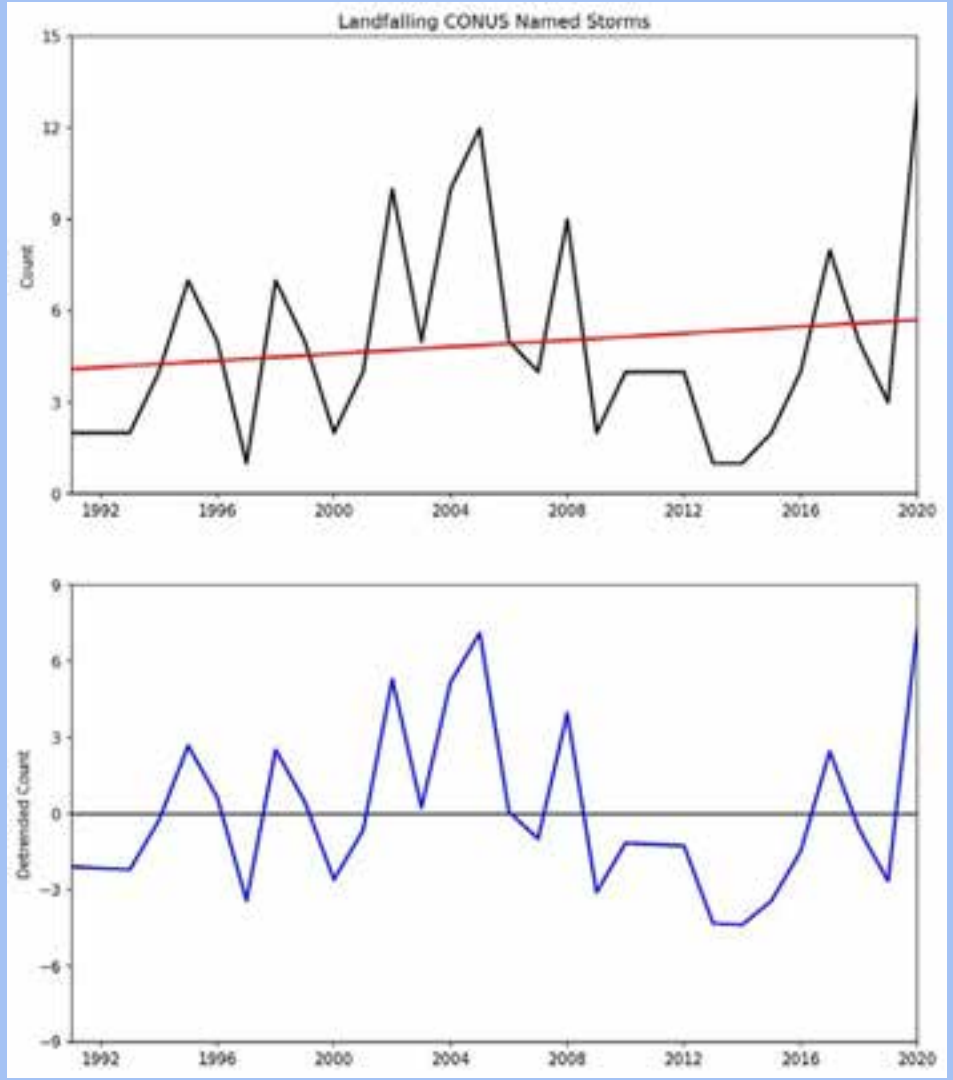


Named Storms	14-21
Hurricanes	6-10
Major Hurricanes	3-6
ACE % of Median	115-200

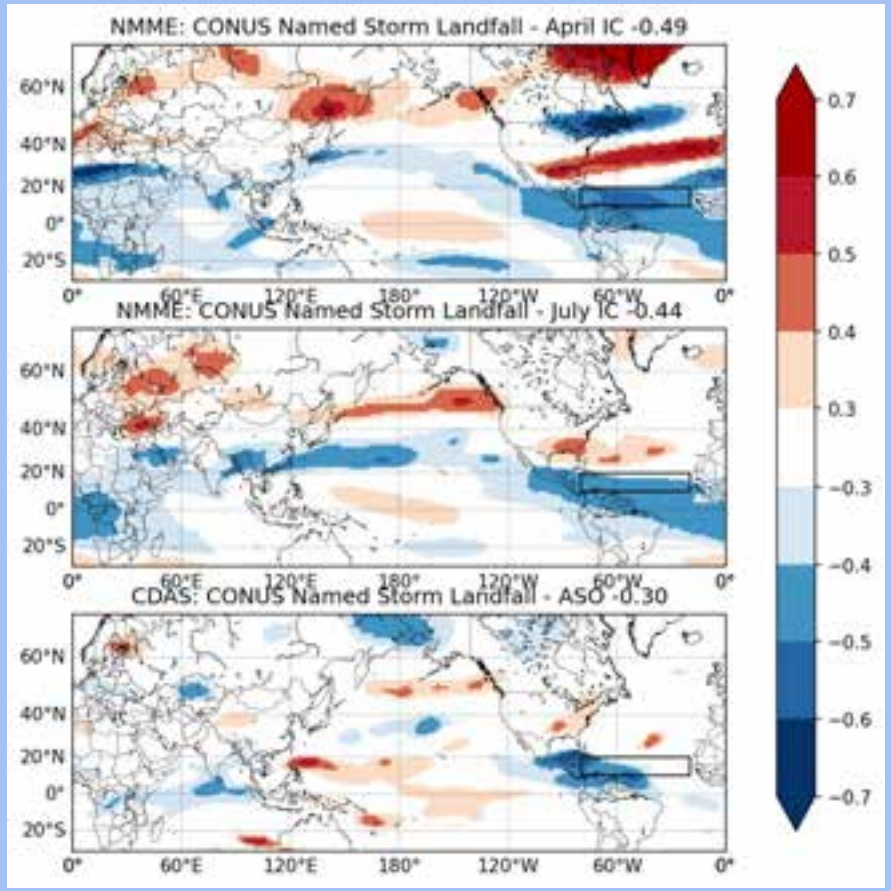
Averages

Named Storms	14
Hurricanes	7
Major Hurricanes	3
% Median ACE	100%

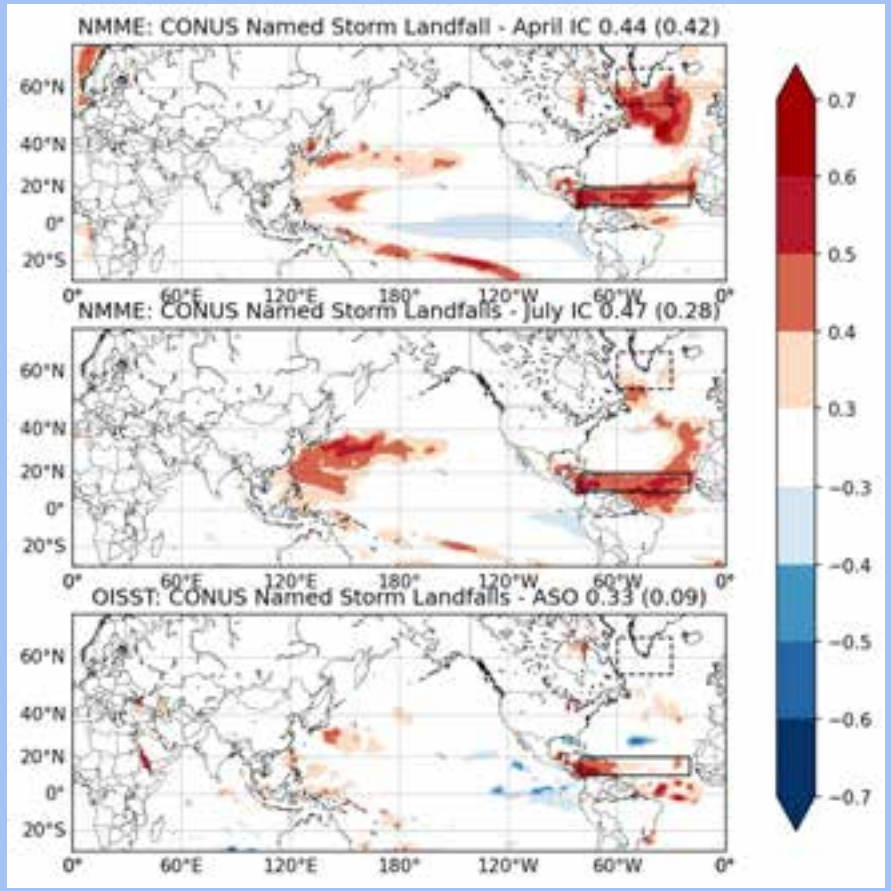
- (Left) An above-normal Atlantic hurricane season is likely (60% chance), slightly less than the May outlook (Right).
- Predicted ranges are now centered at 17 named storms, 8 hurricanes, and 4 major hurricanes, and remain above the 1991-2020 seasonal averages of 14 NS, 7 H, and 3 MH.


Landfalling CONUS Named Storms
Count
15
12
9
6
3
0
1992
1996
2000
2004
2008
2012
2016
2020
Detrended Count
9
6
3
0
−3
−6
−9
1992
1996
2000
2004
2008
2012
2016
2020

Zonal Wind Shear



SST



Period: 1991-2020