

# A NMME-based Hybrid Prediction System for Atlantic Hurricane Season Activity

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40<sup>th</sup> CDPW - Denver, Colorado

29 October, 2015



# Hybrid Prediction Procedure/Motive

- Multiple-linear regression relationships established between combinations of observed/forecast atmospheric/oceanic states and seasonal hurricane activity.

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.

- **Can NMME forecast inputs improve upon single GCM inputs for hybrid forecasting of seasonal hurricane activity?**
  - “Hybrid”: Statistical model with dynamical model predictors



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## Increased likelihood of below-normal Atlantic hurricane season

### Updated outlook calls for 90 percent probability of below-normal season

August 6, 2015

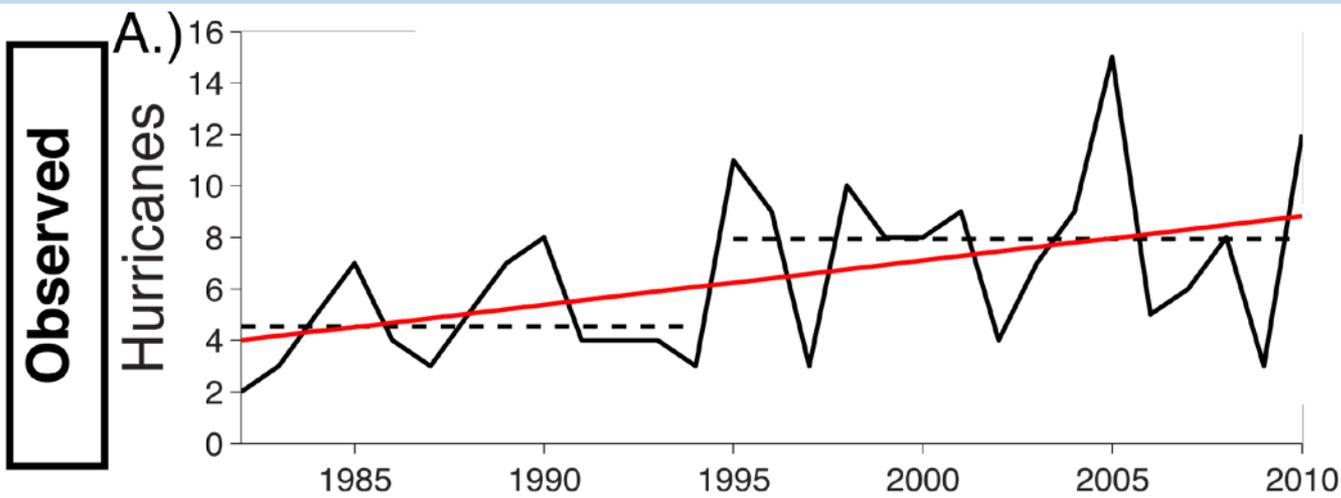
The NOAA Climate Prediction Center's updated [2015 Atlantic Hurricane Season Outlook](#) calls for a 90 percent chance of a below-normal hurricane season. A below-normal season is now even more likely than [predicted in May](#), when the likelihood of a below-normal season was 70 percent.

"Tropical storms and hurricanes can and do strike the United States, even in below-normal seasons and during El Niño events," said Gerry Bell, Ph.D., lead seasonal hurricane forecaster with [NOAA's Climate Prediction Center](#). "Regardless of our call for below-normal storm activity, people along the Atlantic and Gulf coasts should remain prepared and vigilant, especially now that the peak months of the hurricane season have started."

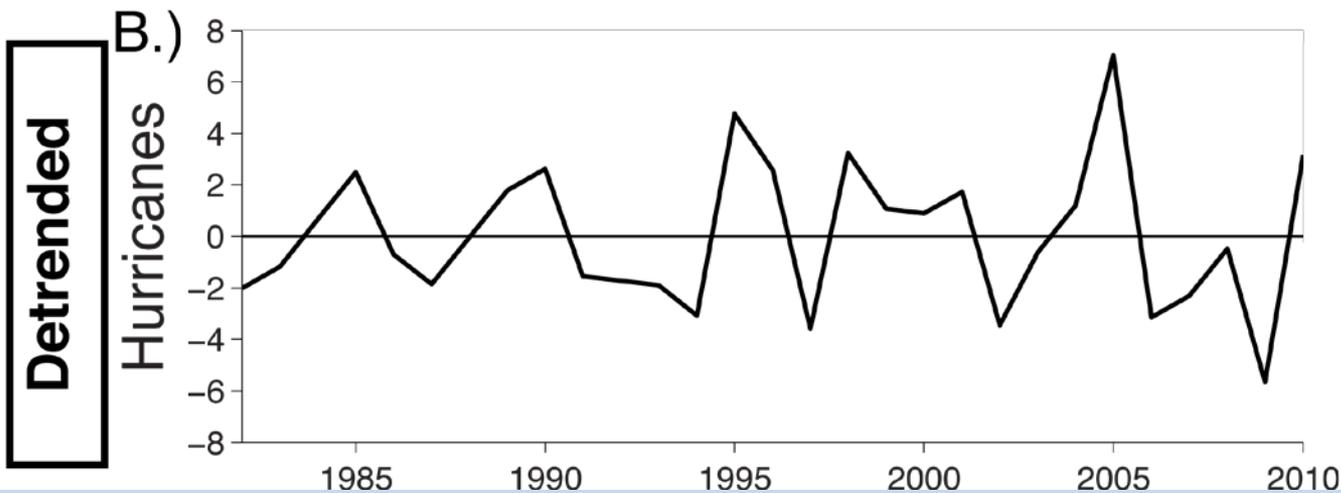
Two tropical storms already have struck the United States this year. Ana made landfall in South Carolina in May, and Bill made landfall in Texas in June.



NOAA has issued annual Atlantic Hurricane Season Outlooks since 1998  
First issued in May, revised in August



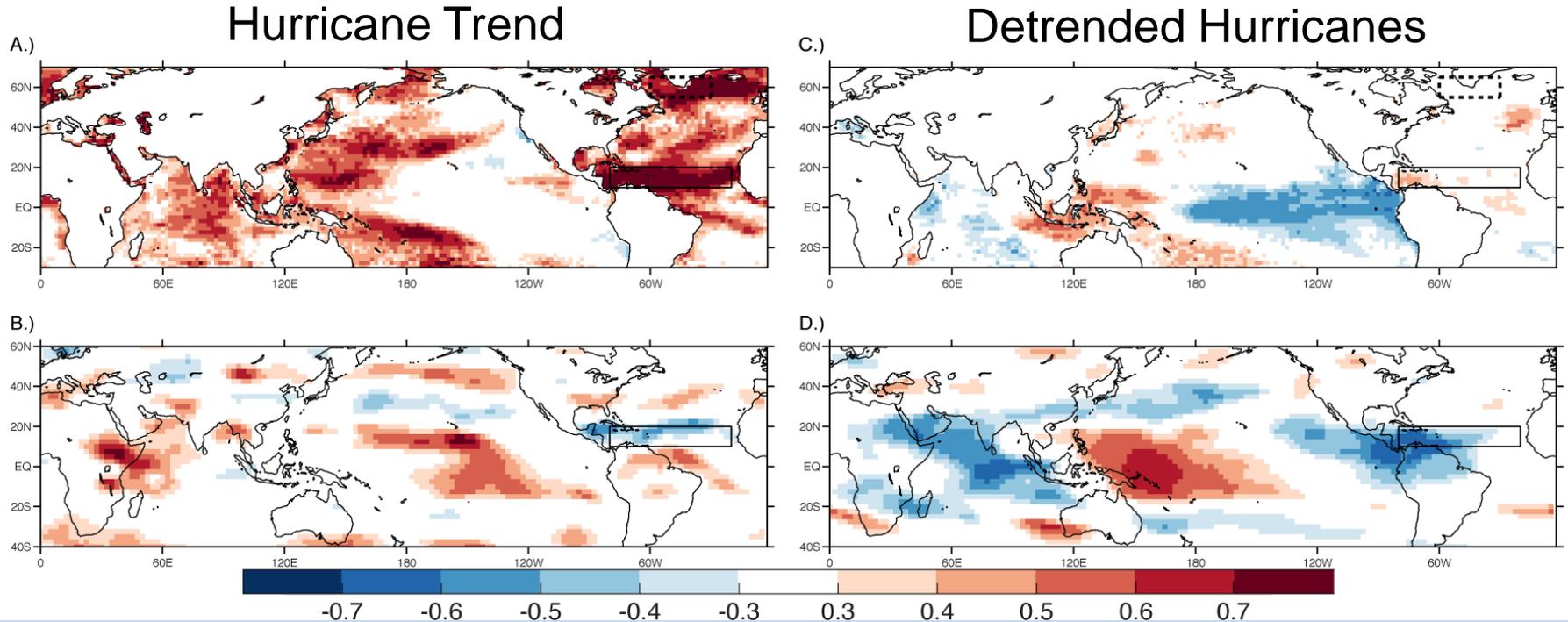
S. Dev: 3.2



S. Dev: 2.8

- Increasing trend over 1982-2010; “jump” from 1995-onward.
- Interannual variability accounts for 77% of variance.

# SST and Wind Shear Correlations with Annual Atlantic Hurricane Activity



CFSR August-October Mean; 1982-2010

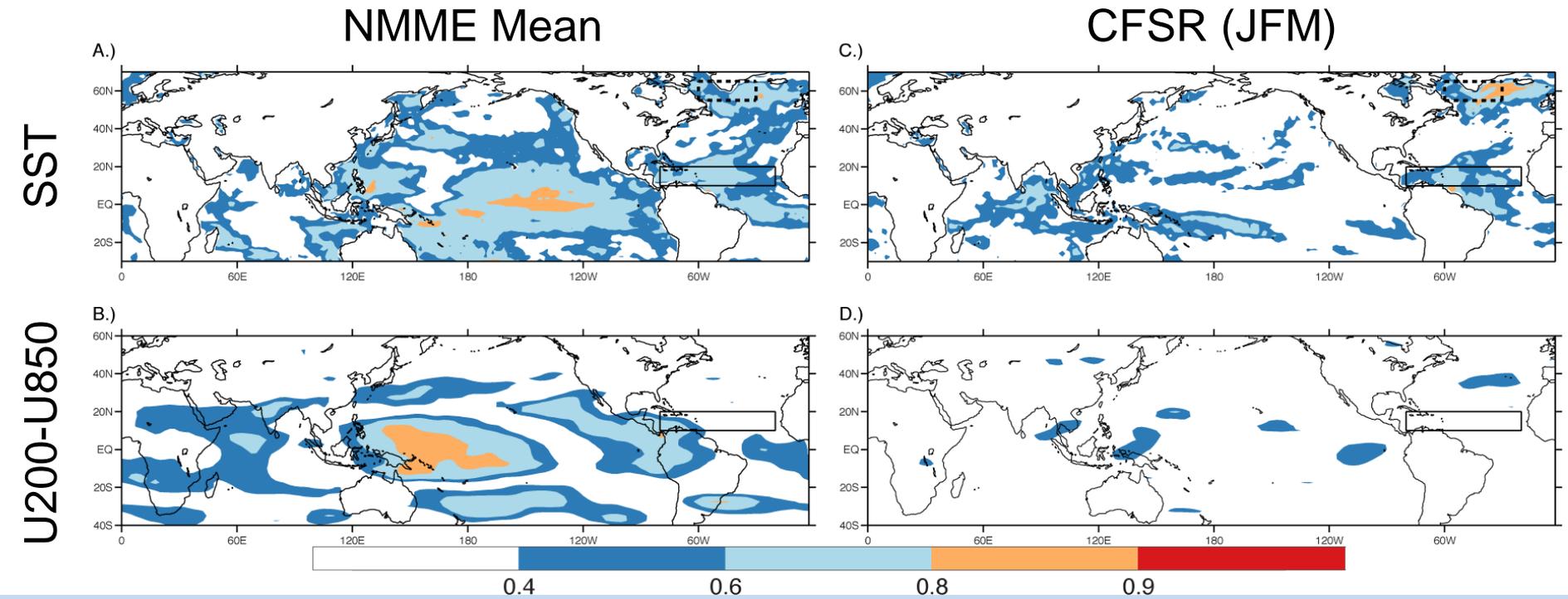
Dashed line: N. Atlantic (NATL); 55-65°N, 30-60°W

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

# CPC's NMME-based Hybrid Prediction System

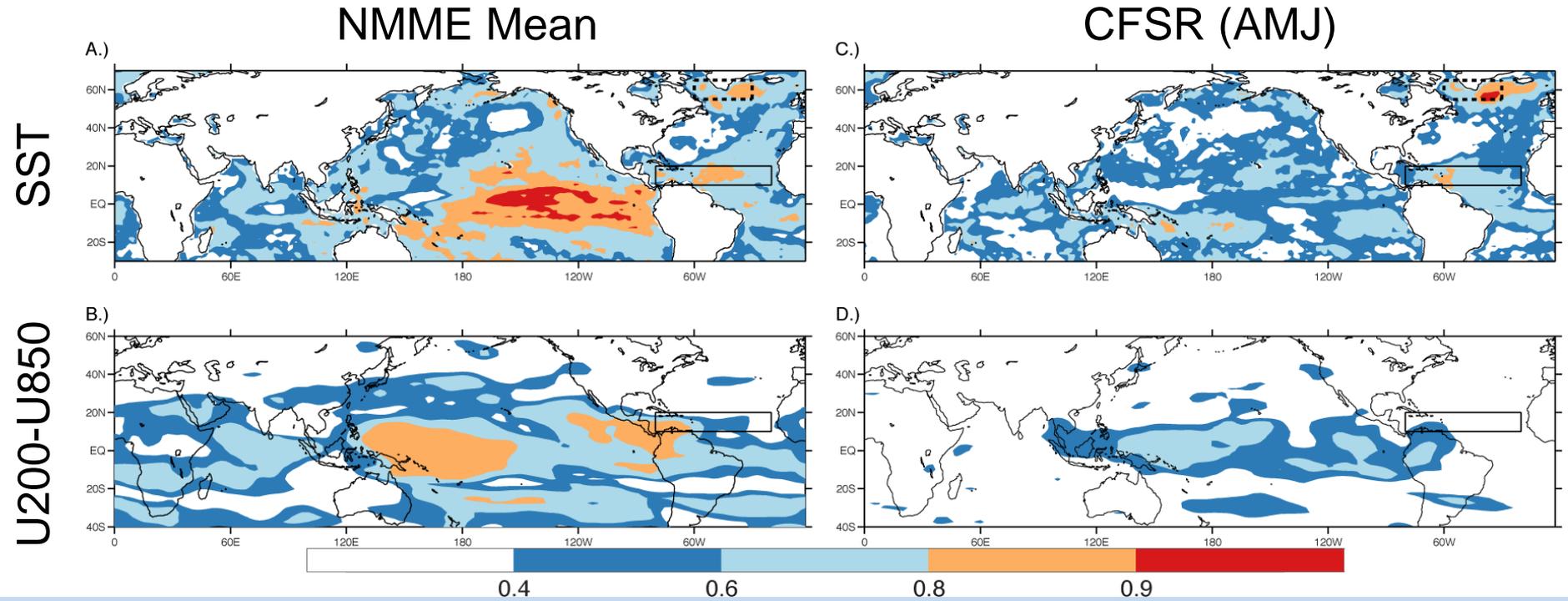
- Initial conditions: **April**, May, June, **July**
- Predictors:
  - Forecast ASO wind shear ( $u_{200}-u_{850}$ ) over the MDR
  - Observed 3-month mean preseason SST over the NATL
- Anomalous predictions added to two climatologies:
  - Method 1: 1982-2010 mean
  - Method 2: 1982-1994 (inactive era), 1995-2010 (active era)
- Predictands (seasonal total): tropical storms, **hurricanes**, major hurricanes, % of median ACE index
- 1982-2010 Hindcast (cross-validation):
  - Member GCMs: CanCM3 (10), CanCM4 (10), CCSM4 (10), CFSv2 (12)
  - NMME mean averaging 4 GCM outputs; equal weight

# April Initial Condition ASO Anomaly Correlations



	NMME	Persistence
NATL SST	0.69	0.74
MDR Shear	0.41	0.02

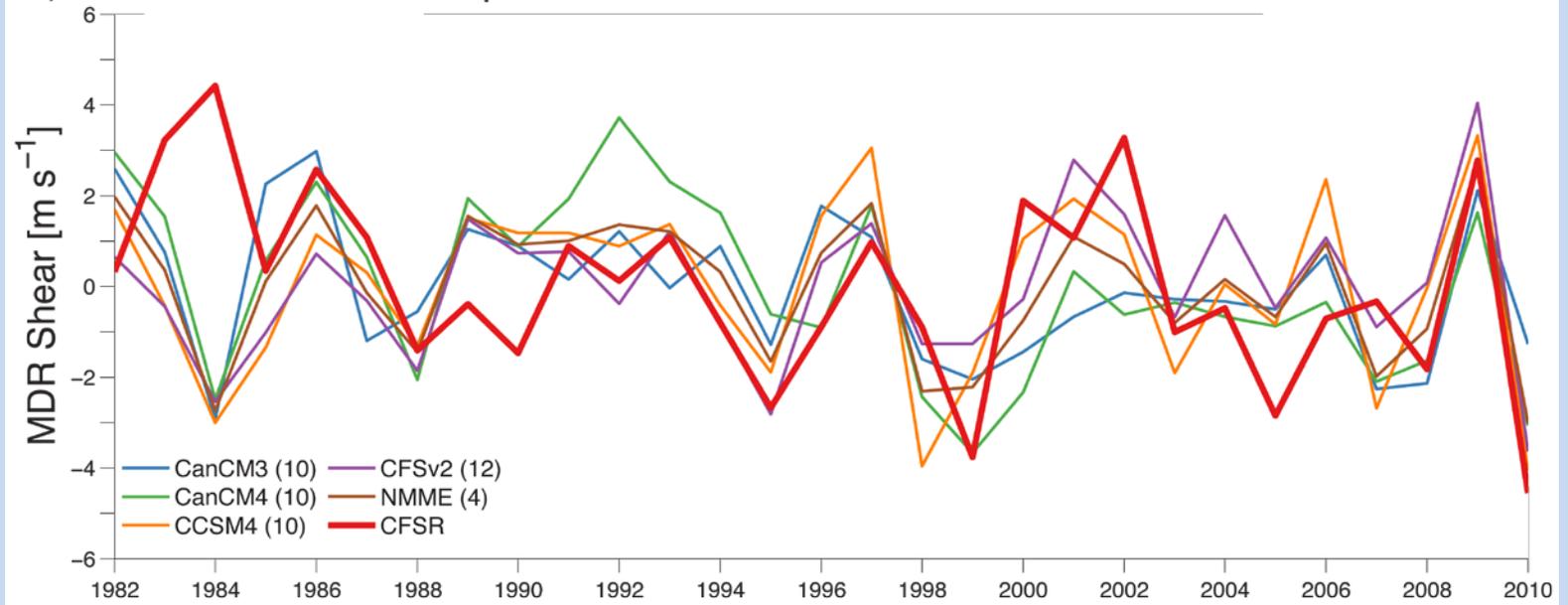
# July Initial Condition ASO Anomaly Correlations



	NMME	Persistence
NATL SST	0.80	0.90
MDR Shear	0.66	0.32

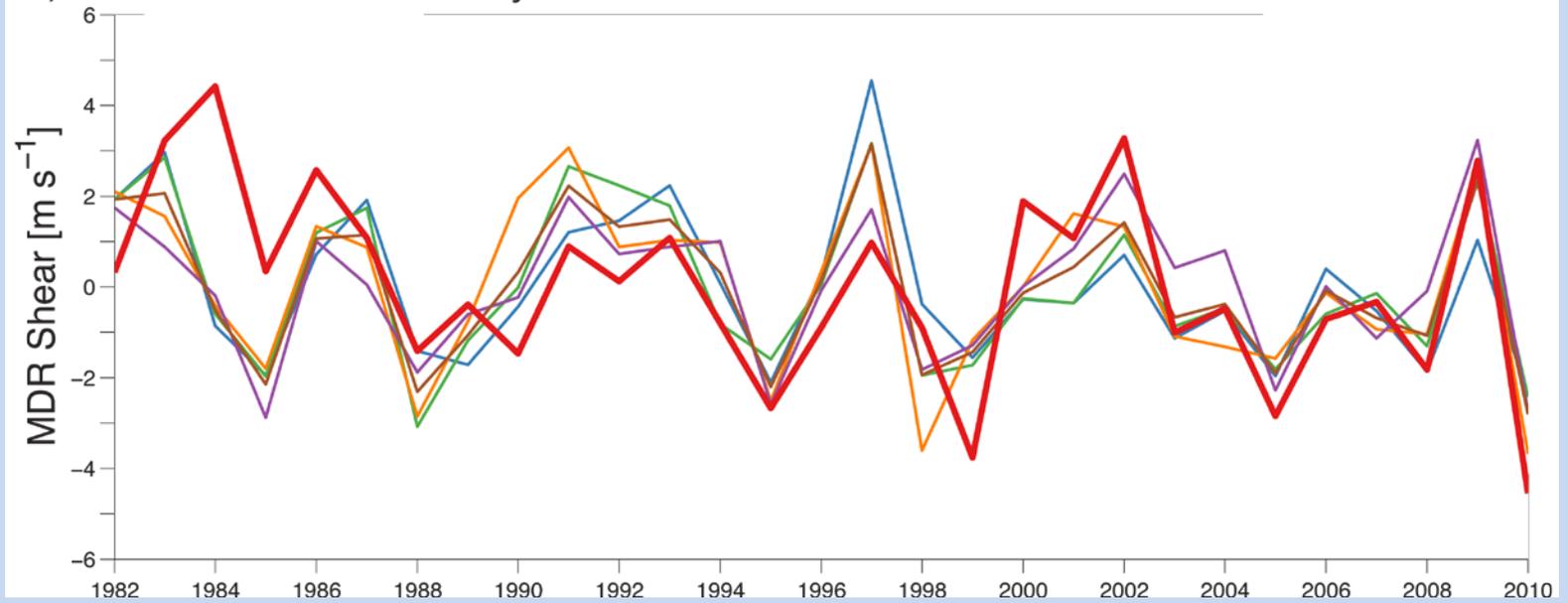
A.)

April IC: ASO Anomalous MDR wind shear

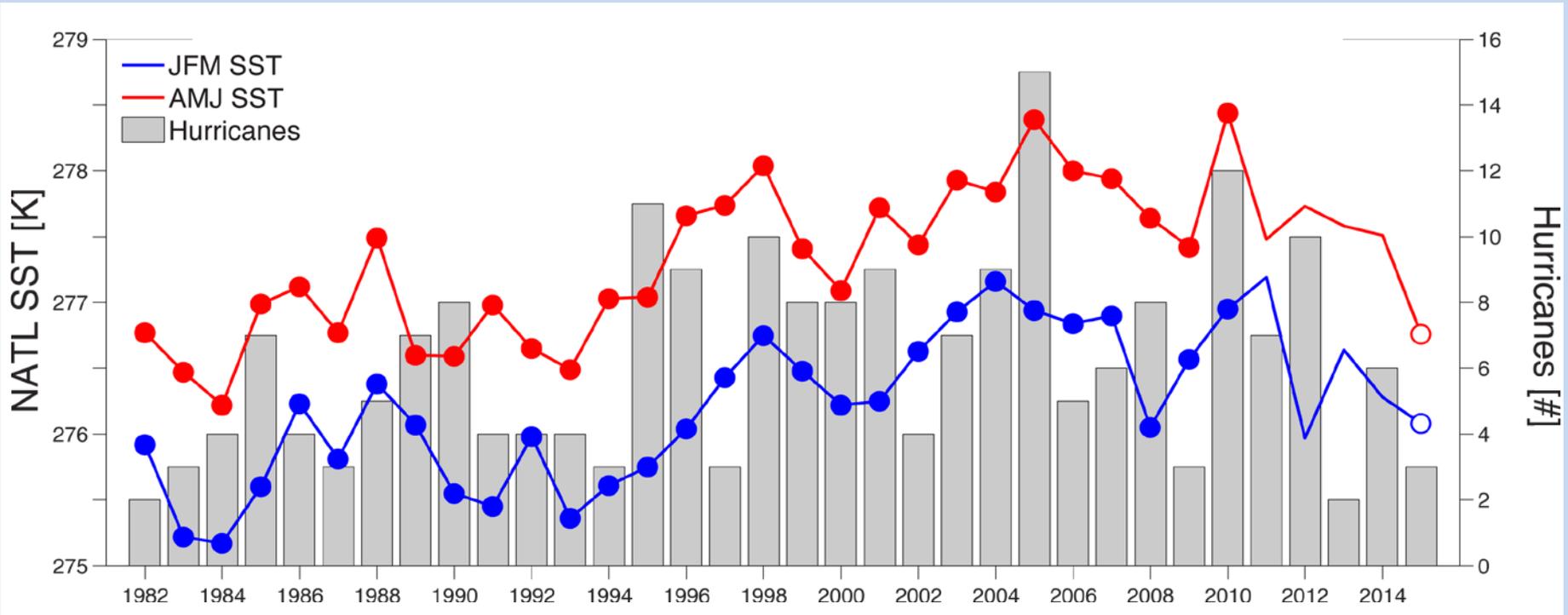


B.)

July IC: ASO Anomalous MDR wind shear



# Observed NATL 3-month mean preseason SST



● 1982-2010 (Hindcast)  
○ 2015 (Forecast)

Correlations (1982-2010): 0.43; 0.57

# Seasonal Hurricane Count Hindcast Performance: GCM Statistics

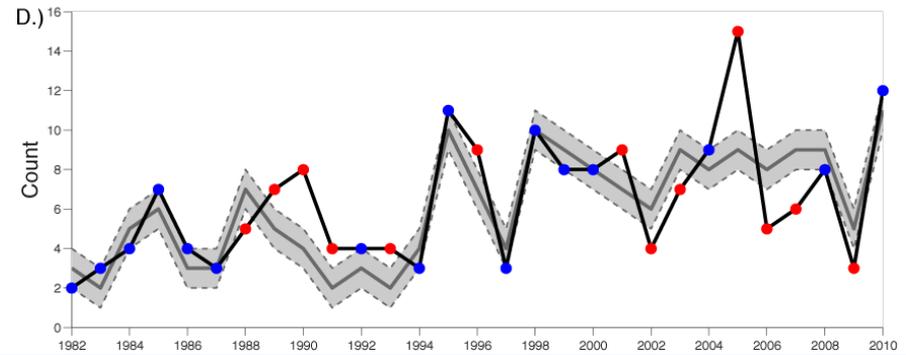
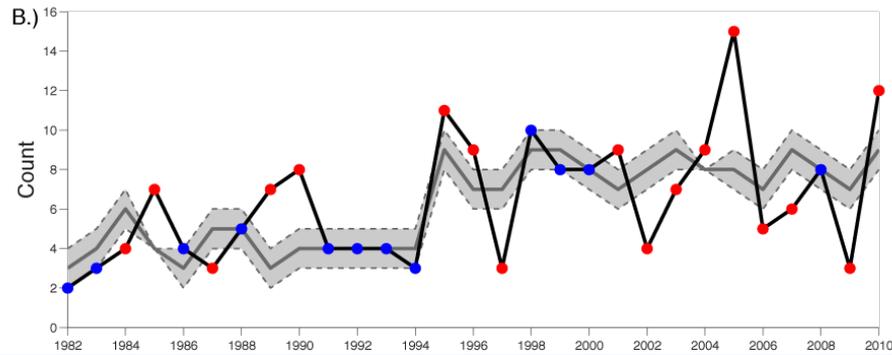
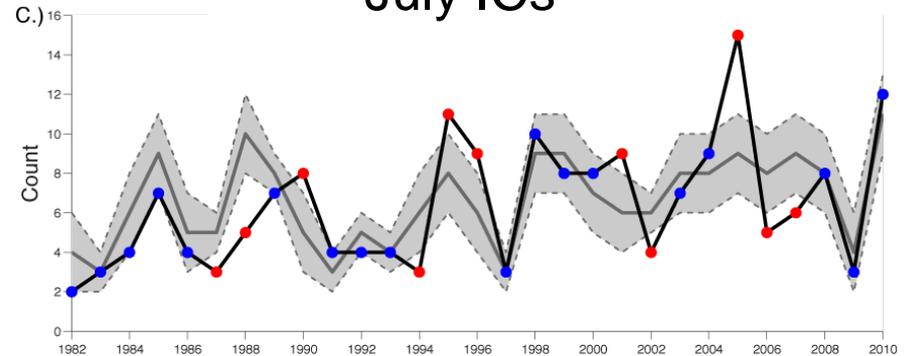
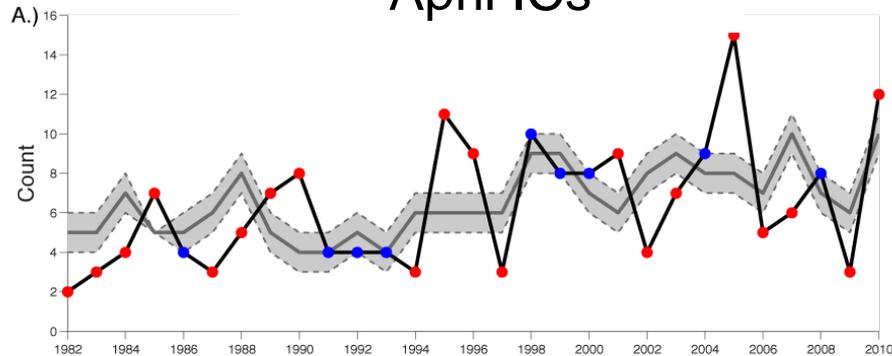
<b>Method 1</b>		CanCM3 (10)	CanCM4 (10)	CCSM4 (10)	CFSv2 (12)	NMME (4)
April IC	Corr	0.42	0.47	0.46	0.46	0.49
	RMSE	2.87	2.80	2.80	2.80	2.27
July IC	Corr	0.67	0.66	0.62	0.67	0.71
	RMSE	2.36	2.37	2.47	2.36	1.76

<b>Method 2</b>		CanCM3 (10)	CanCM4 (10)	CCSM4 (10)	CFSv2 (12)	NMME (4)
April IC	Corr	0.44	0.52	0.61	0.60	0.56 (3)
	RMSE	2.92	2.96	2.50	2.51	2.03
July IC	Corr	0.76	0.75	0.69	0.79	0.78 (2)
	RMSE	2.17	2.16	2.38	1.91	1.57

# Seasonal Hurricane Count Hindcast Performance: NMME Uncertainty

April ICs

July ICs

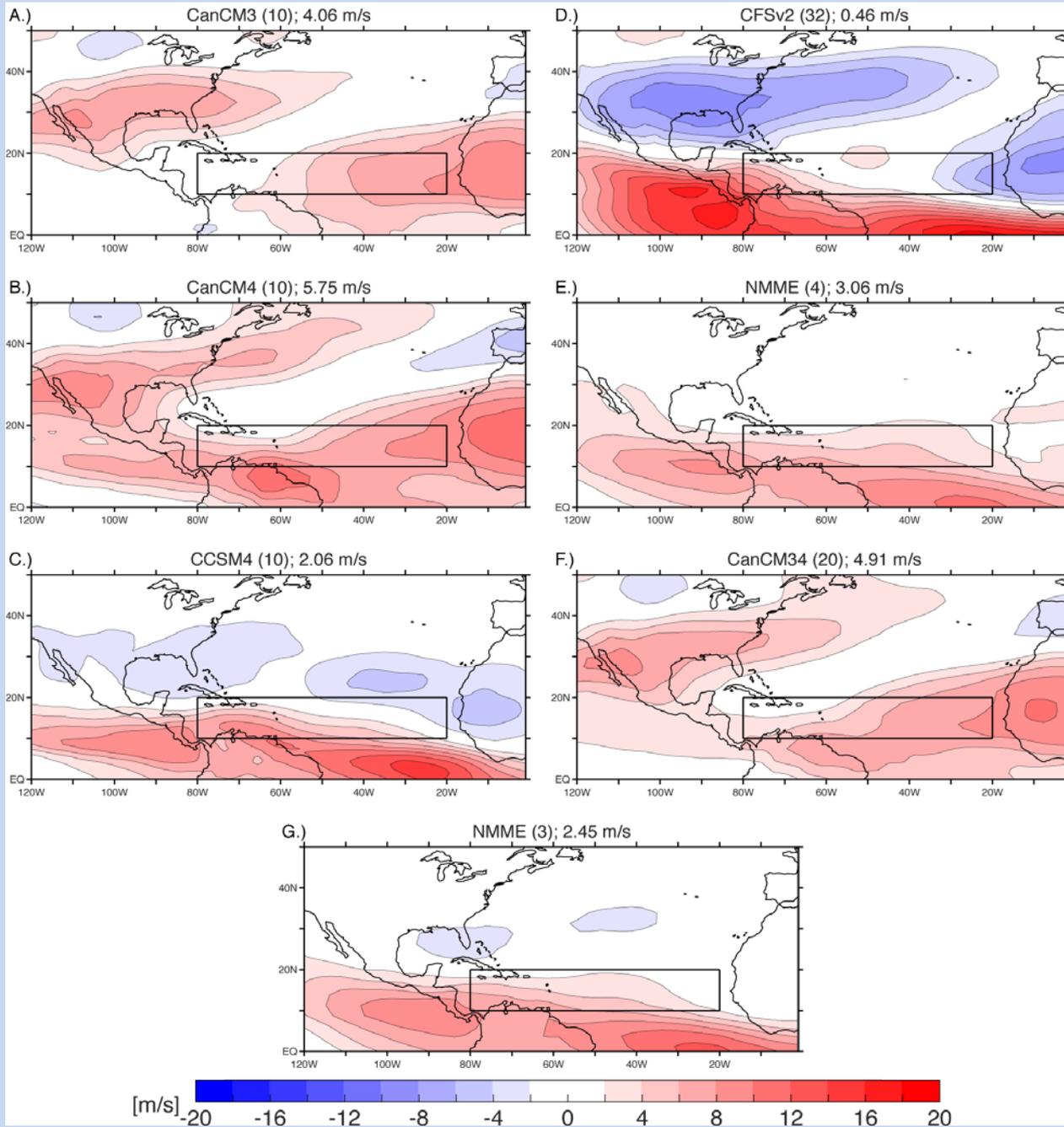


Envelope:  $\pm 1$  standard deviation

April Initial Conditions		July Initial Conditions	
Method 1	Method 2	Method 1	Method 2
31% within	41% within	62% within	56% within

**2015 NMME EXPERIMENTAL  
HYBRID PREDICTION**

# April 2015 ASO shear forecasts



Model	MDR (m s <sup>-1</sup> )
CanCM3 (10)	4.06
CanCM4 (10)	5.75
CCSM4 (10)	2.06
CFSv2 (32)	0.46
NMME (4)	3.06
CanCM34 (20)	4.91
NMME (3)	2.45

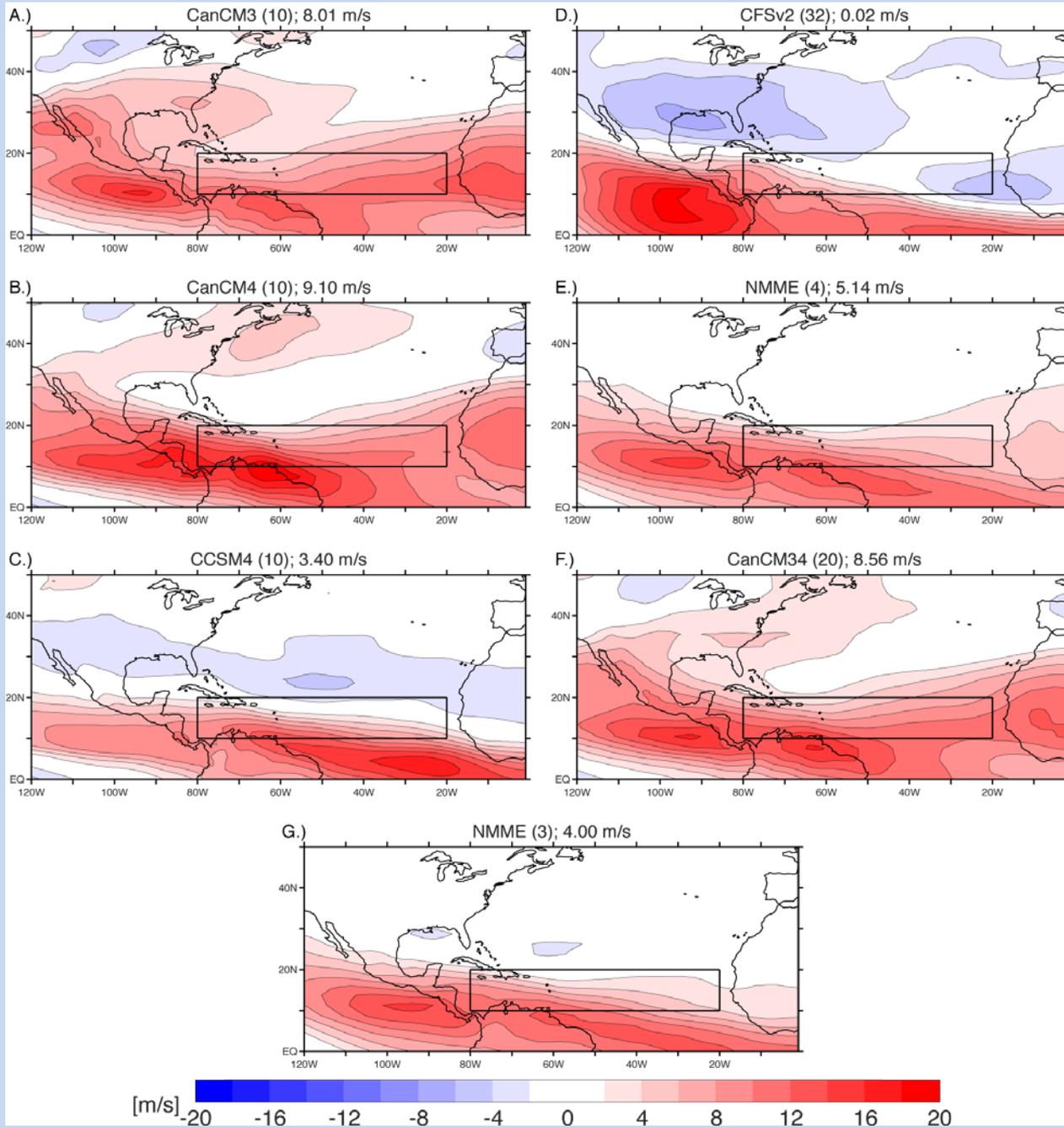
# April 2015 NMME Hybrid Forecast

GCM	Hurricanes	T. Storms	M. Hurr.	ACE (% Med.)
CanCM3 (10)	3 (1-5)	6 (1-10)	1 (0-2)	50 (5-94)
CanCM4 (10)	2 (0-3)	4 (1-6)	1 (0-1)	21 (0-45)
CCSM4 (10)	5 (4-6)	9 (8-10)	2 (2-2)	80 (64-96)
CFSv2 (32)	6 (5-7)	11 (9-13)	2 (2-3)	102 (75-128)
NMME (4)	4 (3-5)	7 (5-10)	1 (1-2)	63 (35-91)
CanCM34 (20)	3 (0-6)	5 (0-10)	1 (0-2)	42 (0-98)
NMME (3)	4 (3-6)	8 (6-11)	2 (1-2)	75 (42-108)

**Observed through 28 October:**

**3 hurricanes, 10 t. storms, 2 m. hurr., ~58% of median ACE**

# July 2015 ASO shear forecasts



Model	MDR (m s <sup>-1</sup> )
CanCM3 (10)	8.01
CanCM4 (10)	9.10
CCSM4 (10)	3.40
CFSv2 (32)	0.02
NMME (4)	5.14
CanCM34 (20)	8.56
NMME (3)	4.00

# July 2015 NMME Hybrid Forecast

GCM	Hurricanes	T. Storms	M. Hurr.	ACE (% Med.)
CanCM3 (10)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
CanCM4 (10)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
CCSM4 (10)	3 (2-4)	7 (6-9)	1 (1-2)	38 (16-60)
CFSv2 (32)	6 (4-7)	11 (9-13)	1 (1-2)	103 (74-132)
NMME (4)	2 (2-3)	5 (4-6)	1 (1-1)	36 (23-48)
CanCM34 (20)	1 (0-1)	2 (0-4)	0 (0-1)	6 (0-23)
NMME (3)	4 (3-6)	8 (6-11)	2 (1-2)	75 (42-108)

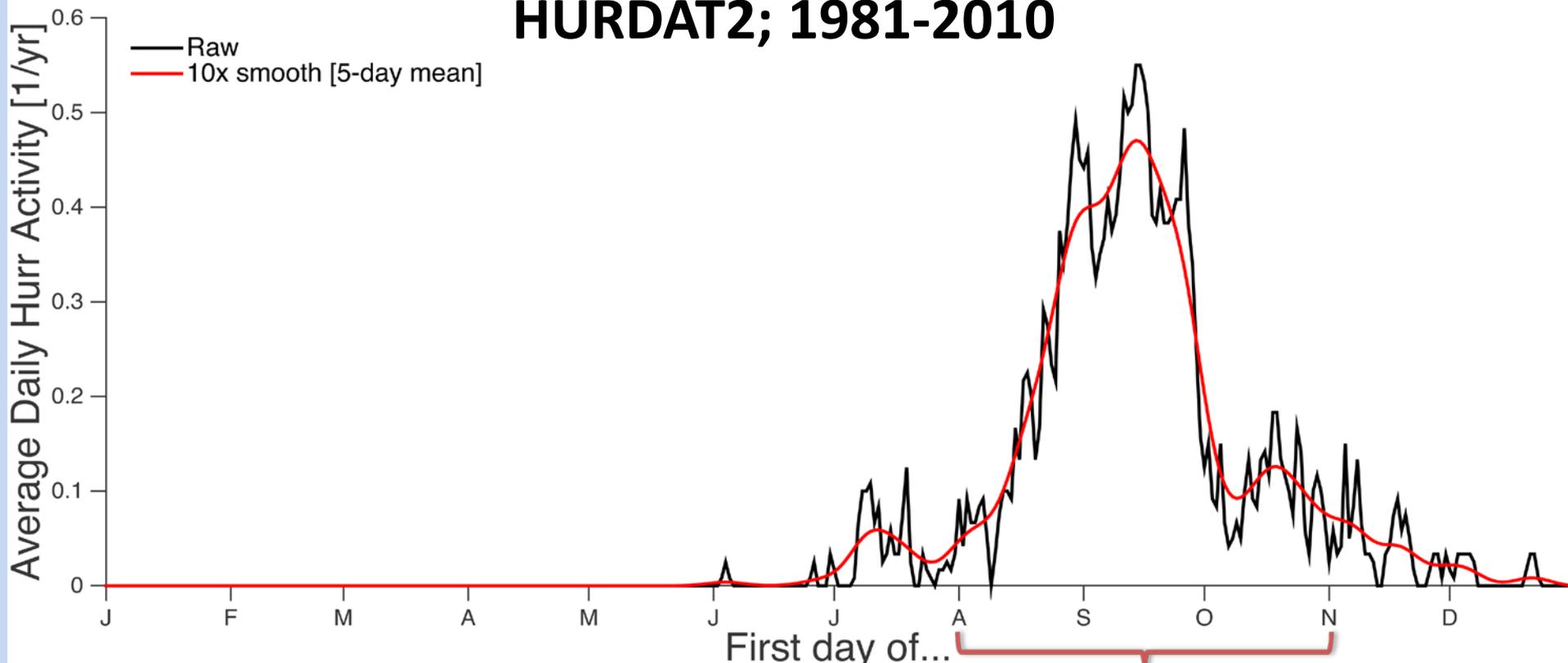
**Observed through 28 October:**

**3 hurricanes, 10 t. storms, 2 m. hurr., ~58% of median ACE**

## Summary

- NMME-based hybrid model shows promise for improving Atlantic hurricane predictions over established CFSv2 based model.
  - NMME mean 2015 forecast is on track to verify better than those based on member GCMs.
- Future plans:
  - Incorporation of GEOS-5 and CESM as data becomes available.
  - Extension to the E. Pacific basin.

# HURDAT2; 1981-2010



## Percentage activity per month

88.4%

J	F	M	A	M	J	J	A	S	O	N	D
0	0	0	0	0	0.4	4.7	23.7	51.2	13.5	5.4	1.1

## Cumulative percentage activity through month

J	F	M	A	M	J	J	A	S	O	N	D
0	0	0	0	0	0.4	5.1	28.9	80.0	93.5	98.9	100