Dynamical-Statistical Seasonal Prediction of Atlantic Hurricane Activity at NCEP
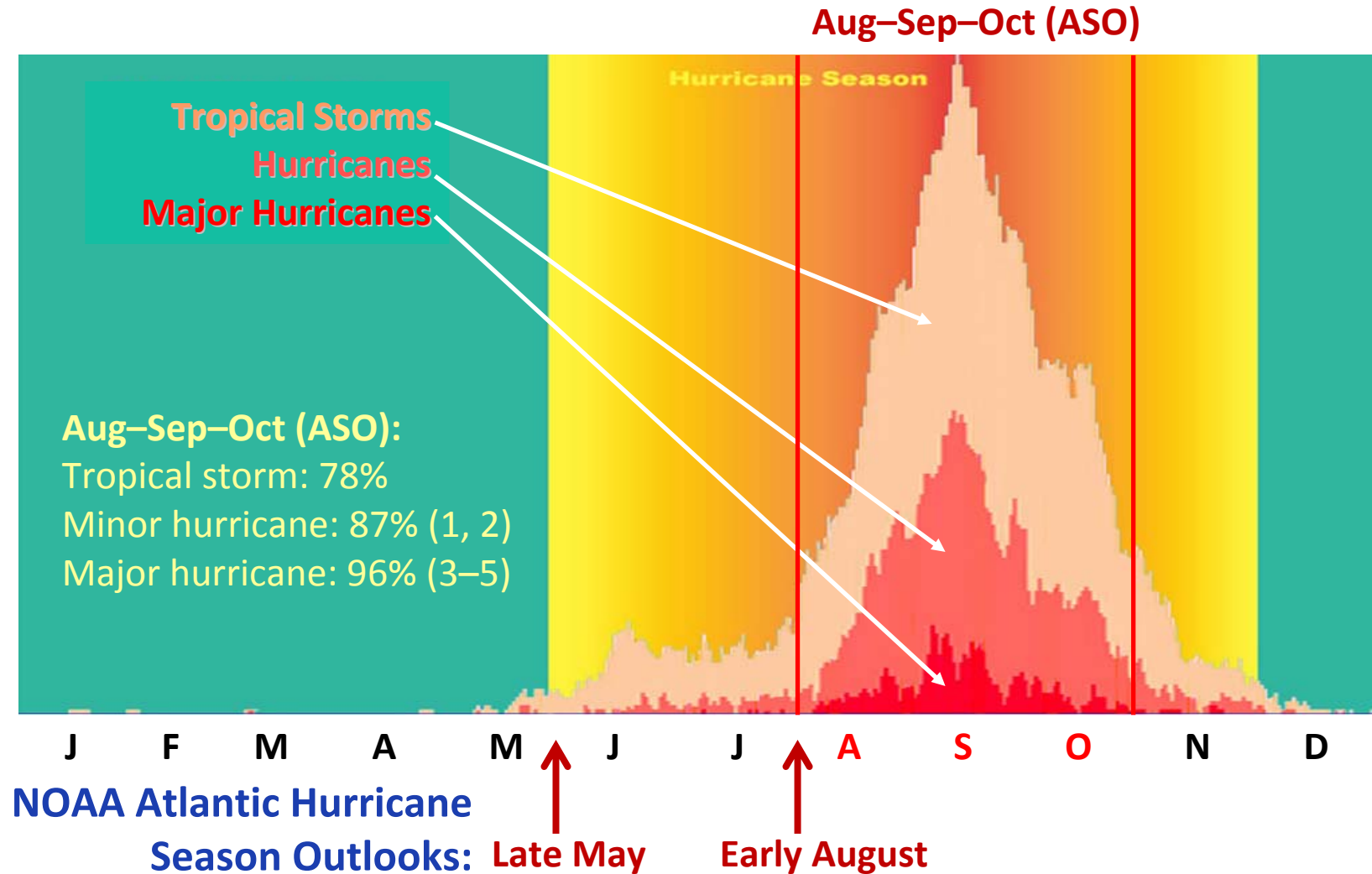
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Atlantic Hurricane Season
June 1 – November 30

Aug–Sep–Oct (ASO)

Hurricane Season

Tropical Storms
Hurricanes
Major Hurricanes

Aug–Sep–Oct (ASO):
Tropical storm: 78%
Minor hurricane: 87% (1, 2)
Major hurricane: 96% (3–5)

J F M A M J J A S O N D

NOAA Atlantic Hurricane
Season Outlooks: Late May   Early August

NOAA Atlantic Hurricane Season Outlooks

❑ **Outlooks have been issued since 1998**

❑ **Season types: above, near, and below normal**

❑ **Ranges in the numbers of tropical storms, hurricanes, and major hurricanes**

❑ **Range in the ACE index**

❑ **Consensus seasonal prediction based on all forecasts generated with**

➢ **Statistical tools**
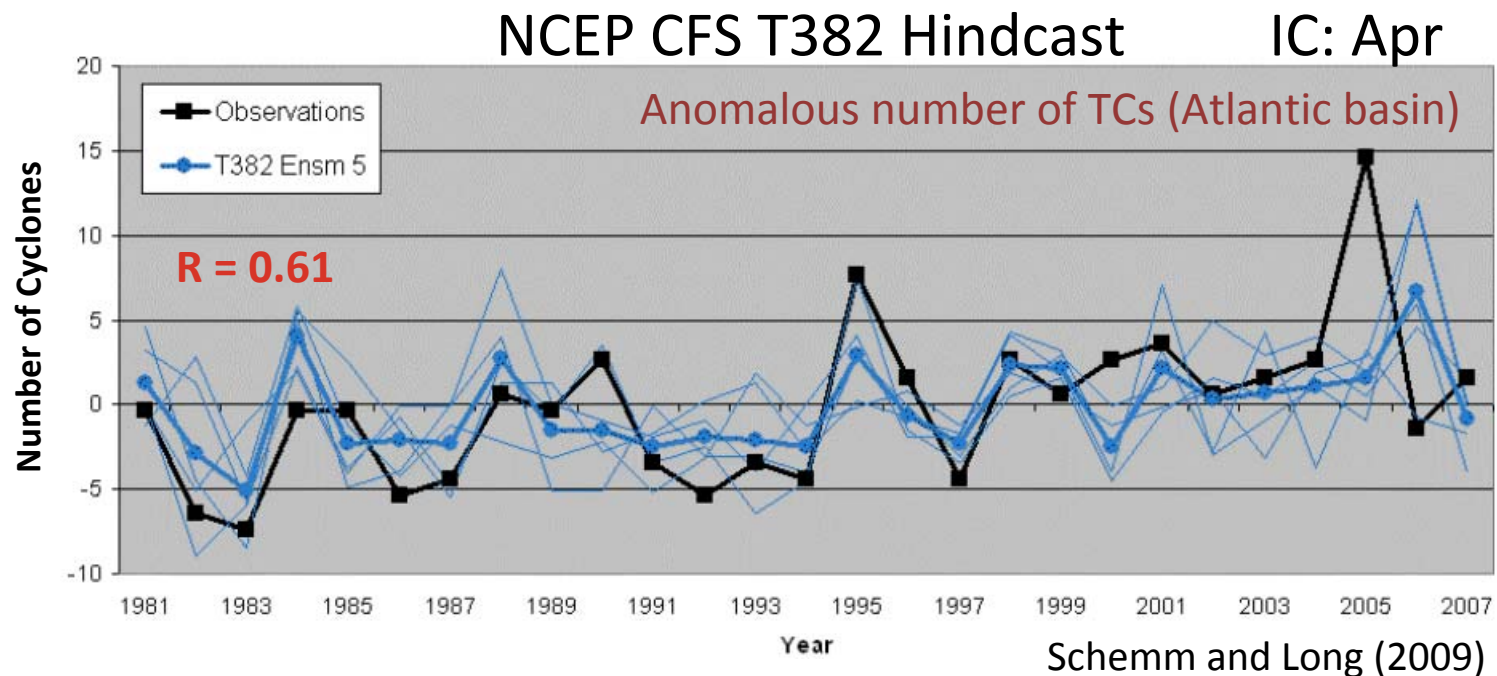➢ **Dynamical models**
➢ **Dynamical-statistical approaches**

Statistical model

❑Using observed *preseason* SST/atmos. circulation as predictors
❑Based on *lagged* relationships:
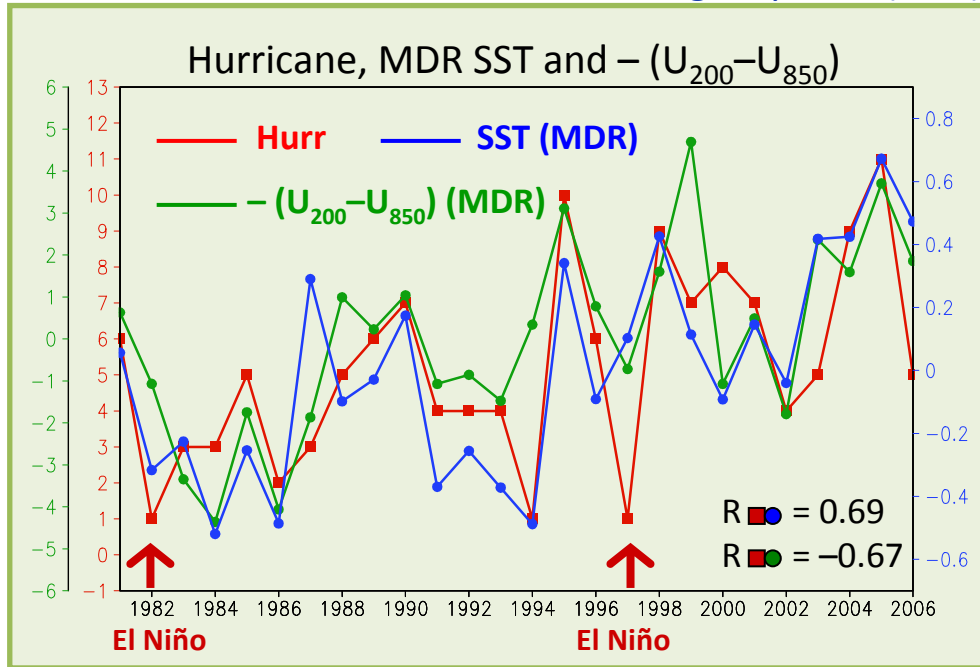
Seasonal hurricane activity ⟷ Preseason ocn/atmos

Dynamical model

❑High-resolution models for tracking hurricanes

NCEP CFS T382 Hindcast   IC: Apr

Anomalous number of TCs (Atlantic basin)

R = 0.61

- Observations
- T382 Ensm 5

Y-axis: Number of Cyclones (20, 15, 10, 5, 0, -5, -10)
X-axis: Year (1981, 1983, 1985, 1987, 1989, 1991, 1993, 1995, 1997, 1999, 2001, 2003, 2005, 2007)

Schemm and Long (2009)

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Hurricane, MDR SST and $- (U_{200}-U_{850})$

Legend: Hurr; SST (MDR); $-(U_{200}-U_{850})$ (MDR)

$R \, \blacksquare\bullet = 0.69$

$R \, \blacksquare\bullet = -0.67$

El Niño   El Niño

Atlantic Hurricane
Main Development Region

MDR

Strong instantaneous relationships

Seasonal hurricane activity ⟷ SST and wind shear
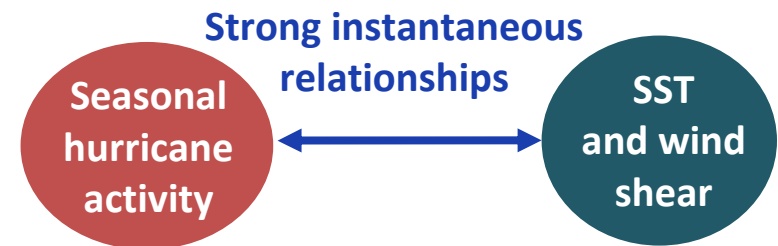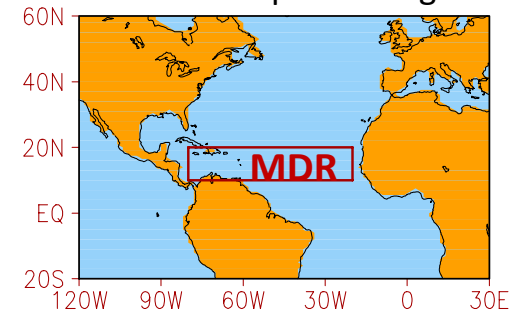
Question: **Can we predict Atlantic hurricane season using CFS' dynamical seasonal forecast of large-scale variables?**

Similar dynamical-statistical approaches could also be used for other quantities, e.g., precipitation and temperature over Eurasia (if NAO or some circulation indices can be better predicted with dynamical models).

Hybrid Dynamical–Statistical Model

➢ using simple linear/multiple linear regression
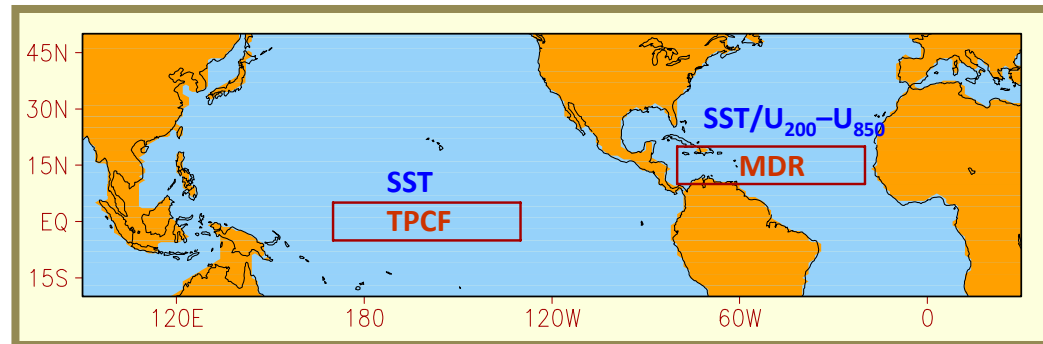➢ based on the relationship between

CFS predicted <u>ASO</u> atmos/ocean conditions **&**	**Observed seasonal total number of hurricanes**

26-year CFS hindcast

Predictors:

$SST/U_{200}-U_{850}$
MDR
SST
TPCF

45N 30N 15N EQ 15S
120E 180 120W 60W 0

Prediction:

Total number of hurricanes for target season

Data

Observations

- Hurricanes: NOAA Atlantic Hurricane Database Reanalysis Project
- SST: NOAA Optimum Interpolation SST version 2 (OISST v2)
- U_{200} and U_{850}: NCEP–DOE Reanalysis (R2)

CFS hindcast for ASO

- CFS: Fully coupled dynamical seasonal prediction system
- 15 ensemble members of 9-month forecasts
- 26 years, 1981 – 2006
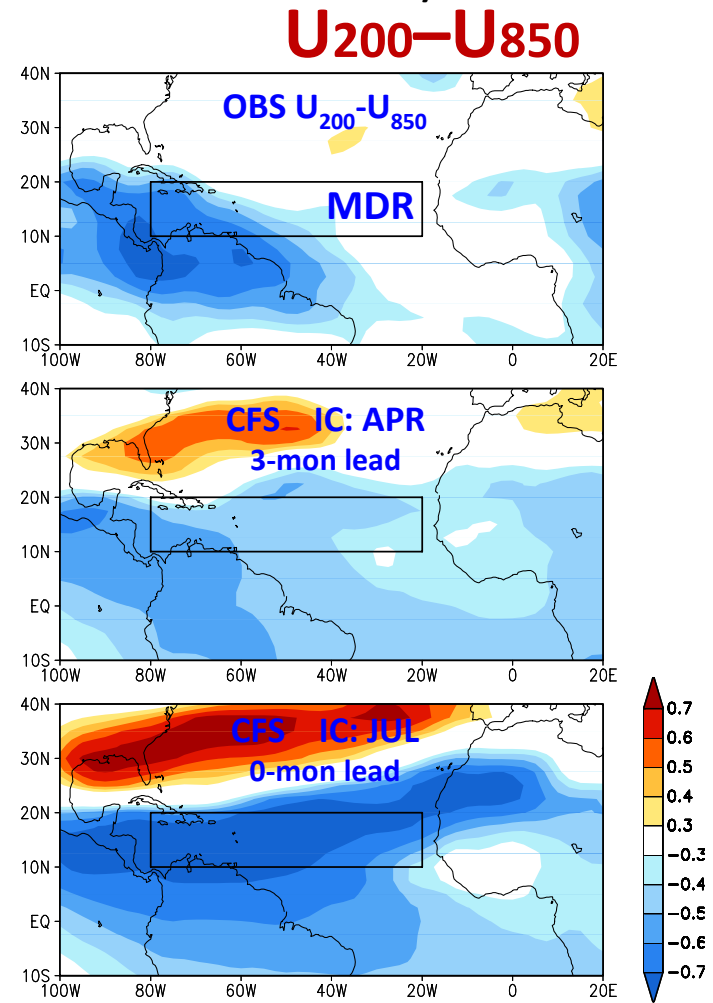
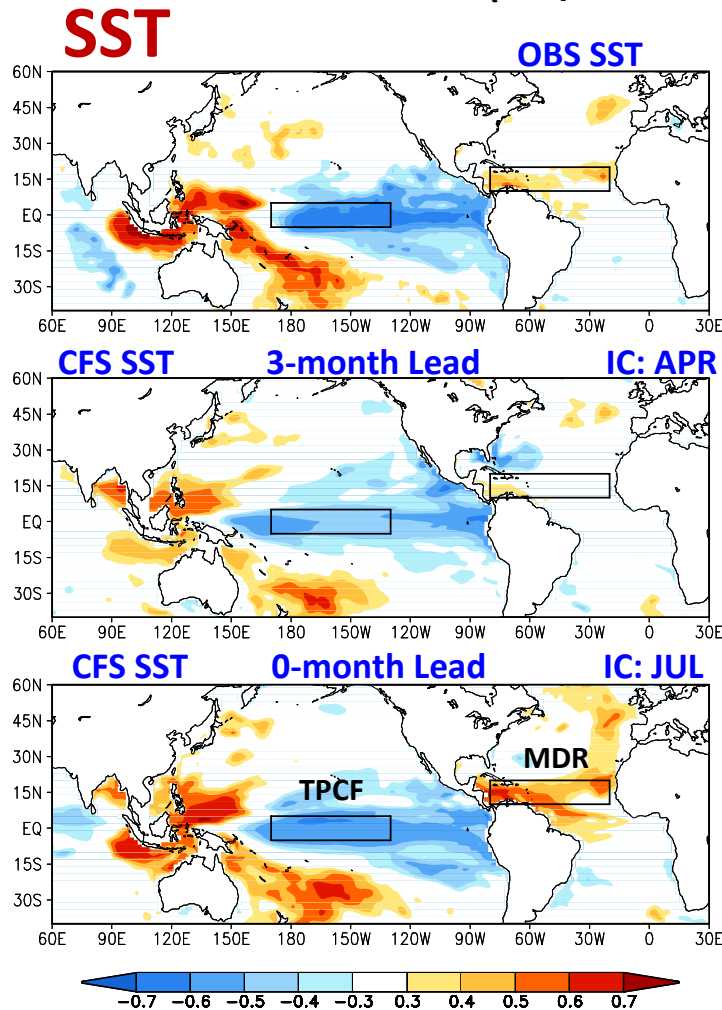# CFS Forecast Skill for ASO SST and Wind Shear

Anomaly Correlation (CFS ensm15, OBS)
ASO 1981–2006
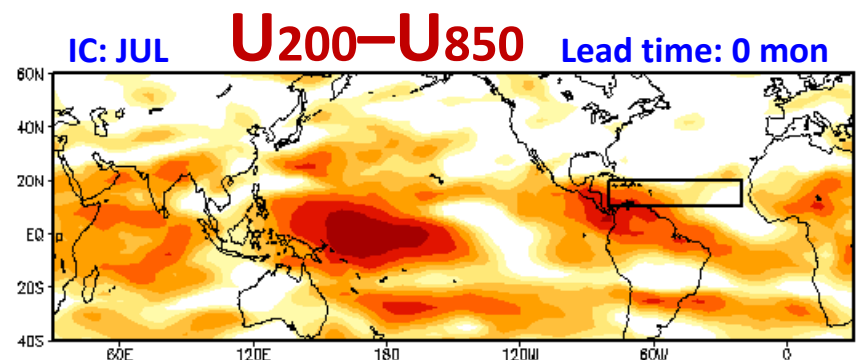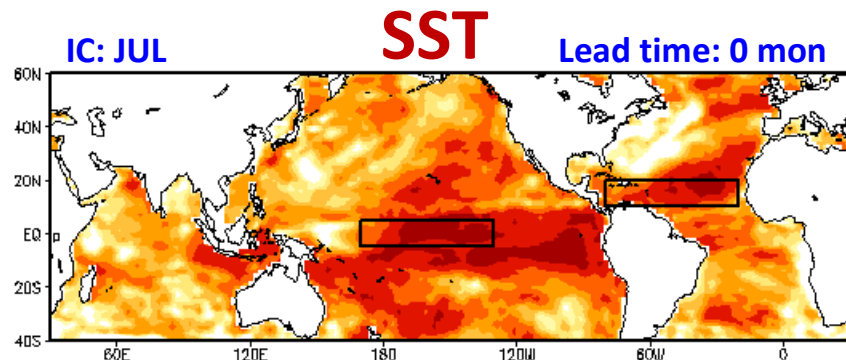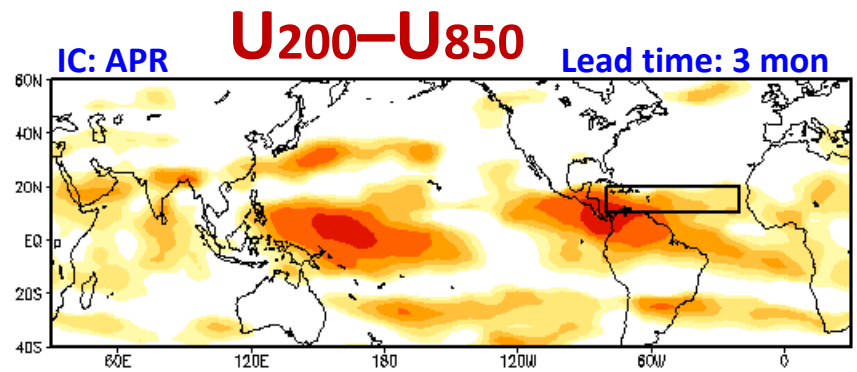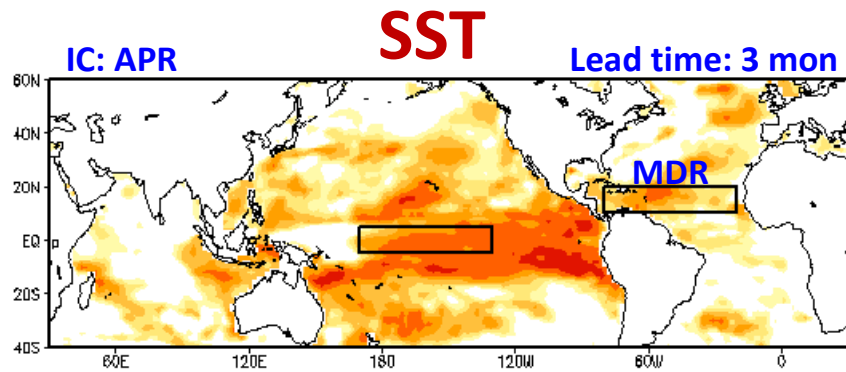
CFS: 15-member ensemble

Relationship between Hurricane and ASO SST/Wind Shear
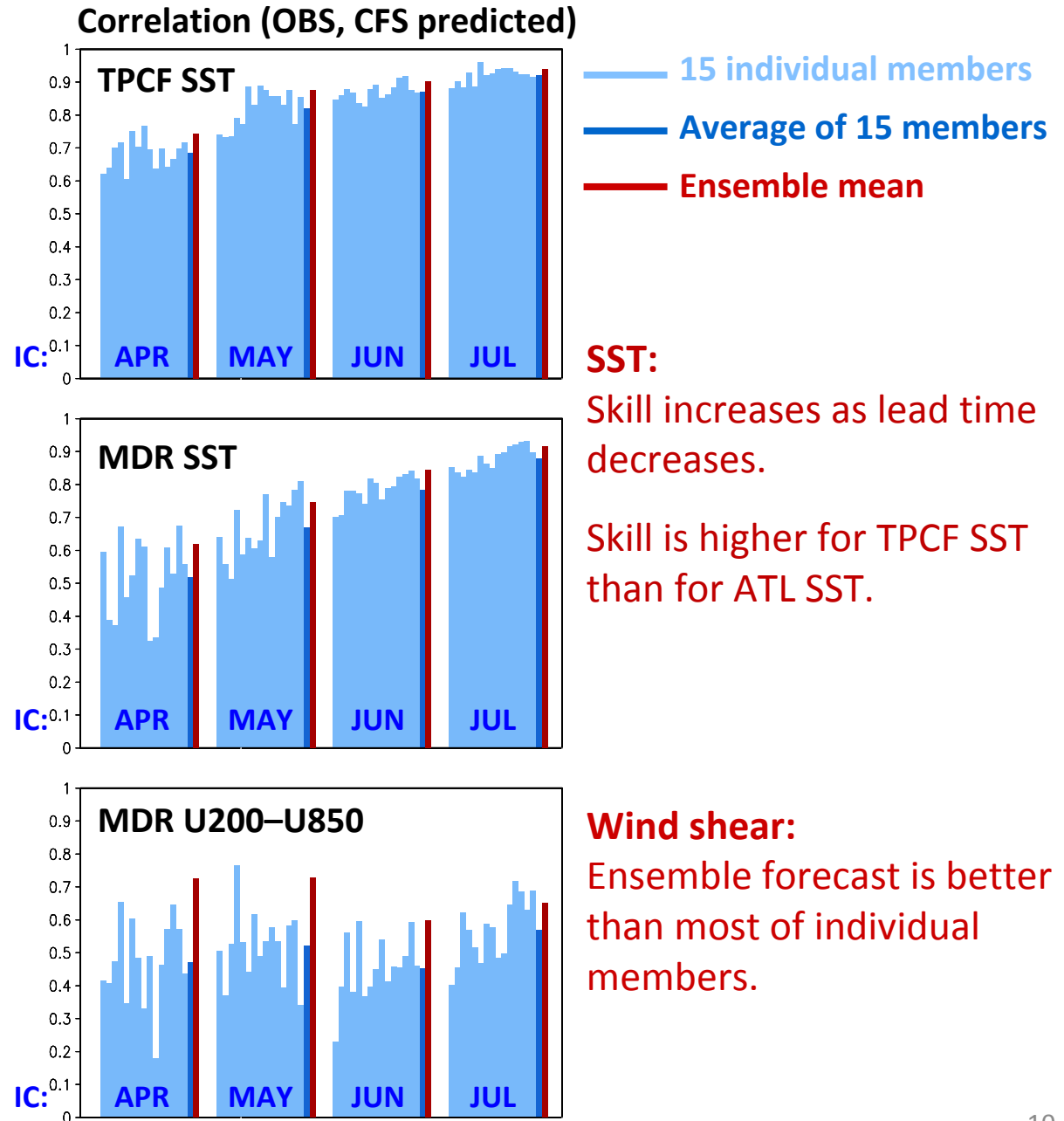
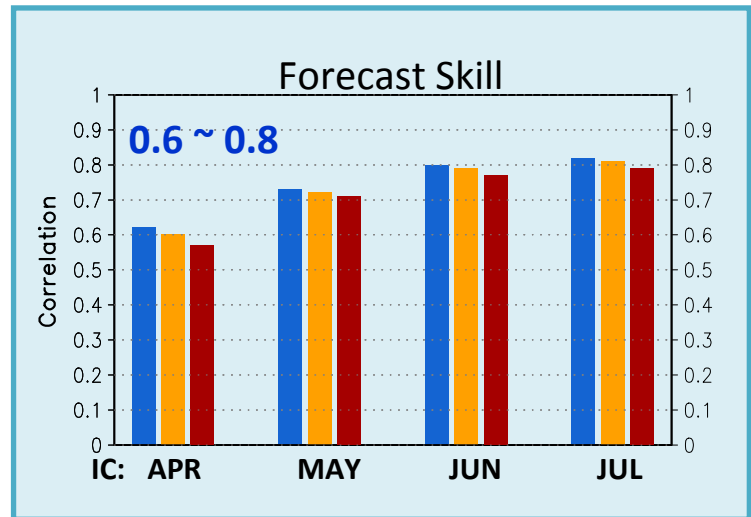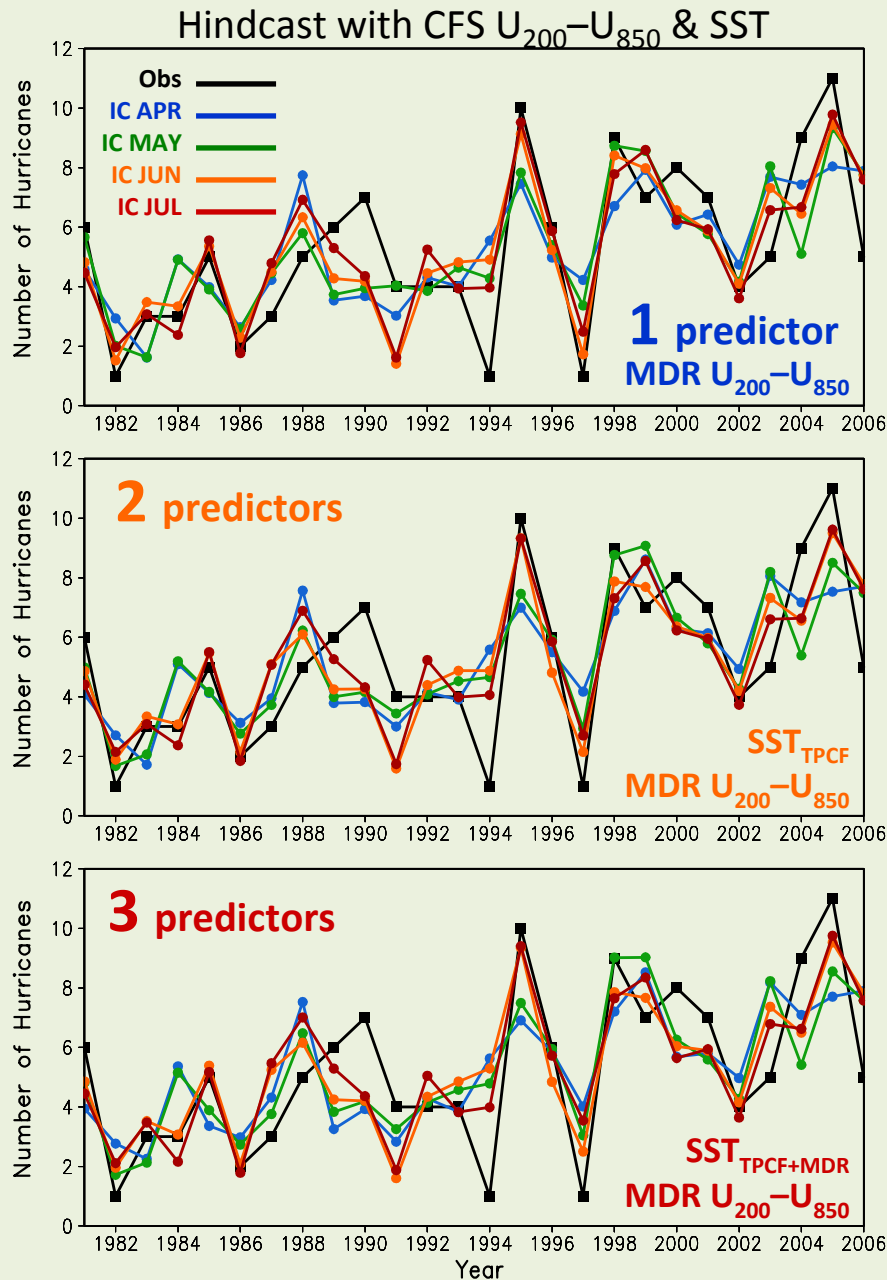## Correlation (SST/Wind shear, OBS number of hurricanes)

CFS: 15-member ensemble, 1981–2006

Three Predictors: SST_{TPCF} , SST_{MDR}, and $U_{200}-U_{850}$ in MDR
for predicting seasonal hurricane activity

CFS Forecast Skill for Three Predictors

Correlation (OBS, CFS predicted)

15 individual members

Average of 15 members

Ensemble mean

SST:
Skill increases as lead time decreases.

Skill is higher for TPCF SST than for ATL SST.

Wind shear:
Ensemble forecast is better than most of individual members.

Hindcast with CFS $U_{200}-U_{850}$ & SST

1 predictor
MDR $U_{200}-U_{850}$

2 predictors
SST_{TPCF}
MDR $U_{200}-U_{850}$

3 predictors
$SST_{TPCF+MDR}$
MDR $U_{200}-U_{850}$

Cross-validation

1981–2006

Forecast Skill

0.6 ~ 0.8

IC: APR   MAY   JUN   JUL

$U_{200}-U_{850}$ $U_{200}-U_{850}/SST_{TPCF}$
$U200-U850/SST_{TPCF} + SST_{MDR}$

At all different leads:
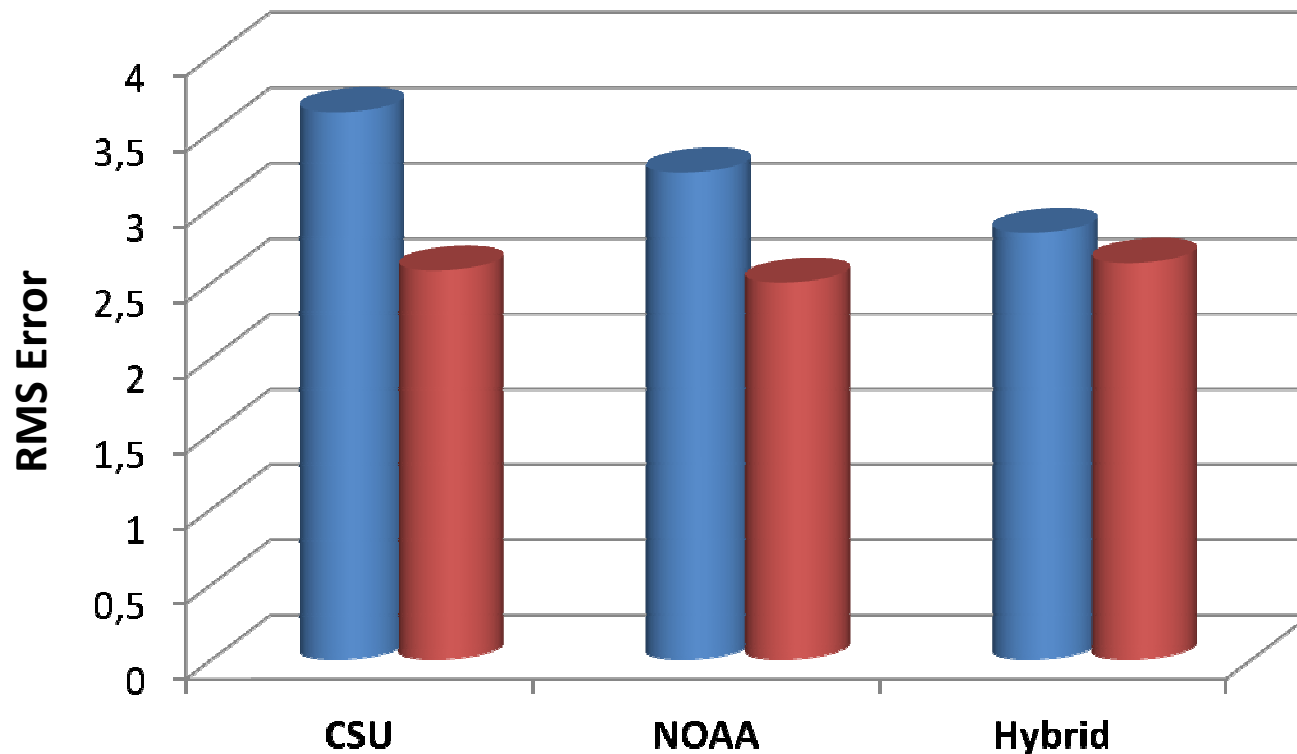**MDR wind shear → highest skill**

Real-time Verification: 2002–2012

Hybrid dynamical-statistical model (operational in 2008)
2002–2007: prediction mode
**2008–2012: real-time forecast**

Legend:
- Late May, 3-month lead (IC: APR)
- Early Aug, 0-month lead (IC: JUL)

Hybrid model: better forecasts at longer lead time

Summary

❑The hybrid model shows statistically significant forecast skill for seasonal Atlantic hurricane activity.

❑The model also provides operational seasonal forecasts of tropical cyclones, major hurricanes, and ACE index.

❑The model has been applied for seasonal predictions of W. Pacific typhoons and E. Pacific hurricanes.

❑The dynamical-statistical approach is a useful tool that can be applied for seasonal hydro-meteorological predictions.

Real-time Seasonal Forecast
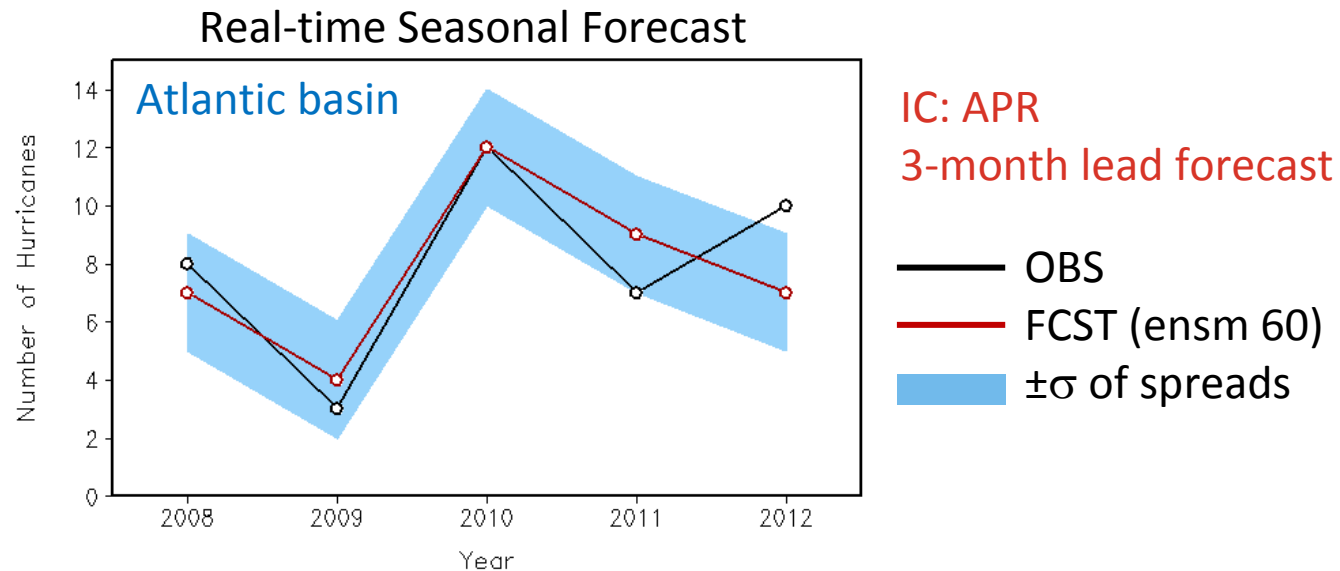
Wang et al., 2009: A statistical forecast model for Atlantic seasonal hurricane activity based on the NCEP dynamical seasonal forecast. *J. Climate*, 22, 4481–4500.

Li et al., 2013: A dynamical-statistical model for the annual frequency of western Pacific tropical cyclones based on the NCEP Climate Forecast System version 2. *J. Geophys. Res. – Atmosphere*, doi: 10.1002/2013JD020708, in press.