

New Challenges and Expectations of Dynamical Seasonal Prediction of Tropical Cyclones

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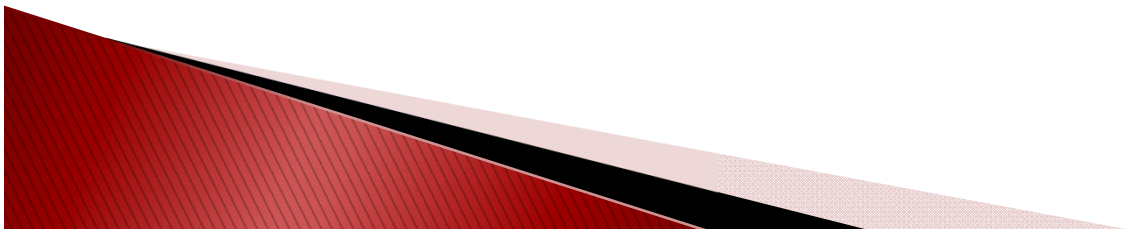
NOAA/Geophysical Fluid Dynamics Laboratory
Princeton, NJ

2014 Tropical Cyclone Research Form/68th IHC



Outlines

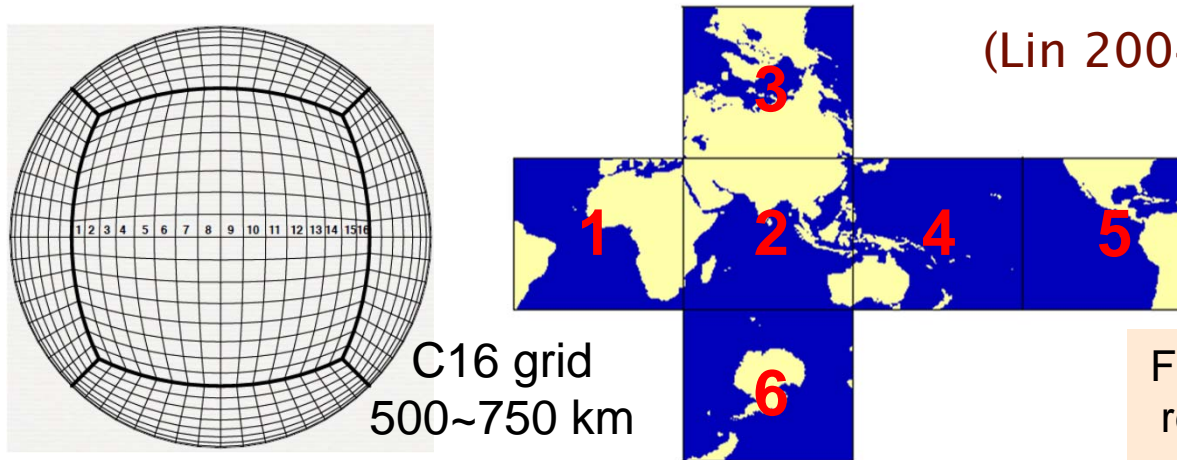
- ▶ **Seasonal TC prediction of GFDL/HiRAM**
 - **1990–2010: Remarkably skillful!**
(Chen and Lin 2011, 2013)
 - **2011–2013: New Challenges!**



The GFDL High-Resolution Atmospheric Model (HiRAM)



- ▶ Finite-volume dynamical core on the cubed-sphere grid



(Lin 2004; Putman and Lin 2007)

C16 grid
500~750 km

Flexible resolution: designed for resolution between 1– 100 km, capable of direct cloud simulation.

- ▶ The configuration used for TC seasonal prediction:
 - C360L32 ~ globally 25km horizontal resolution with model top at 1hPa
 - A non-intrusive shallow convective scheme is used to replace the traditional deep convective parameterization.
 - A PDF based 6-category bulk cloud microphysics scheme is adopted

Gird	Avg. Δx	Equiv. $\Delta \phi$
C16	625 km	5.5
C48	210 km	2
C90	110 km	1
C180	55 km	0.5
C360	25 km	0.25
C720	12 km	0.125
C2560	4 km	0.035

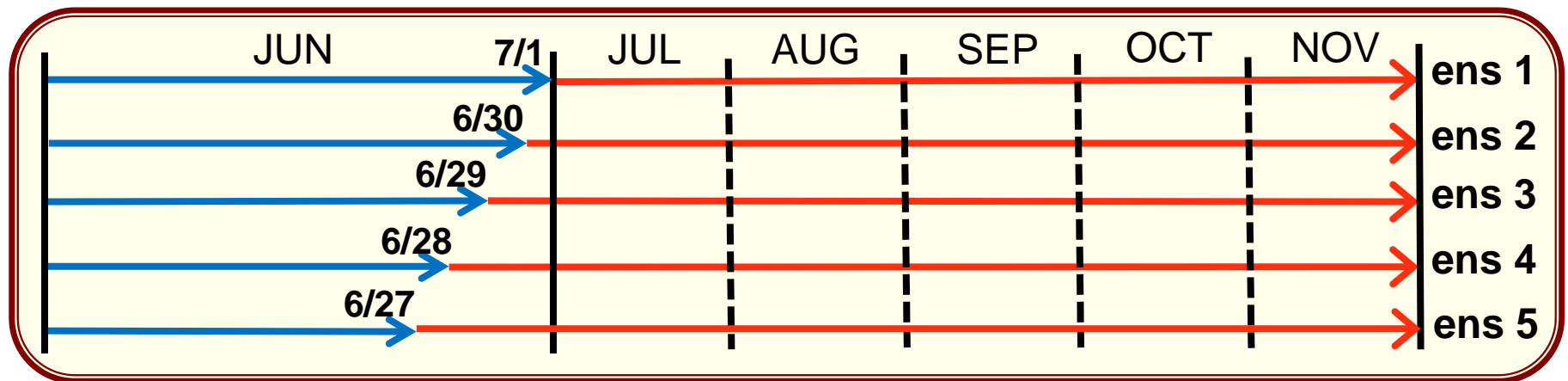
Methodology



- ▶ The Northern Hemisphere Hurricane season: July-November
- ▶ The Persistent SSTA assumption:

$$SST(t) = SST(t)_{climatology} + SST_{anomaly}(t = t_0)$$

- ▶ 5 ensemble members (one-day-lagged initial condition)



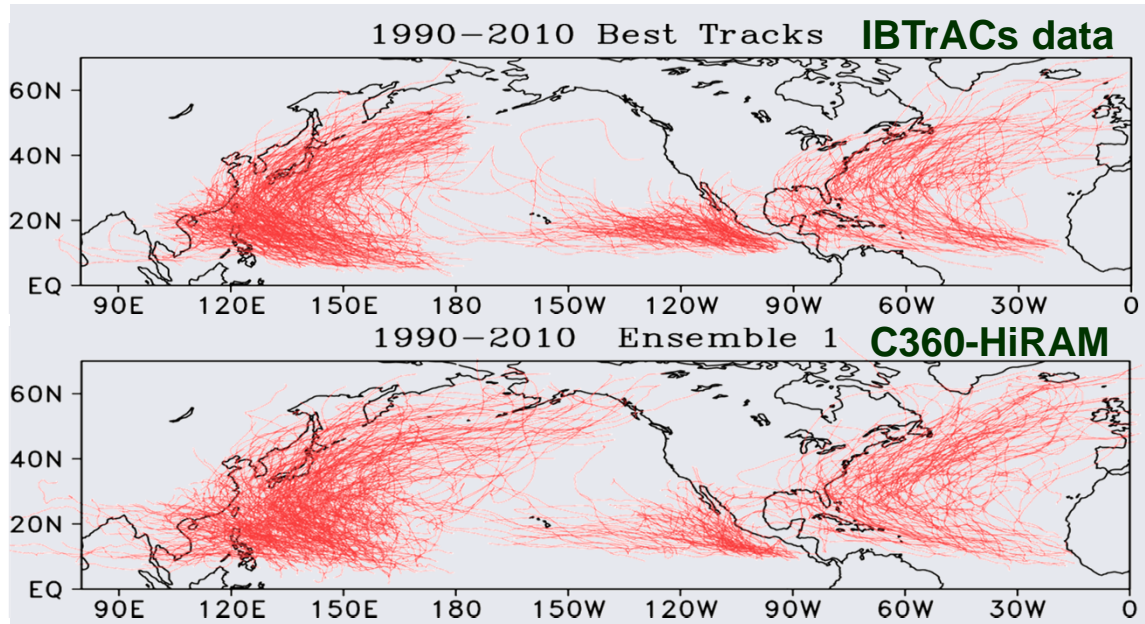
Initialization

- The **3-D wind** and **temperature** are nudged toward **NCEP analysis data**
- The **cloud micro physics** and **land surface** are considered spun-up.

free model forecast to 1st December

- **The GFDL vortex tracker** (Marchok 2002)
- **The GFDL new simple tracker** (Developer: L. Harris)

Seasonal Hurricane Prediction during 1990–2010

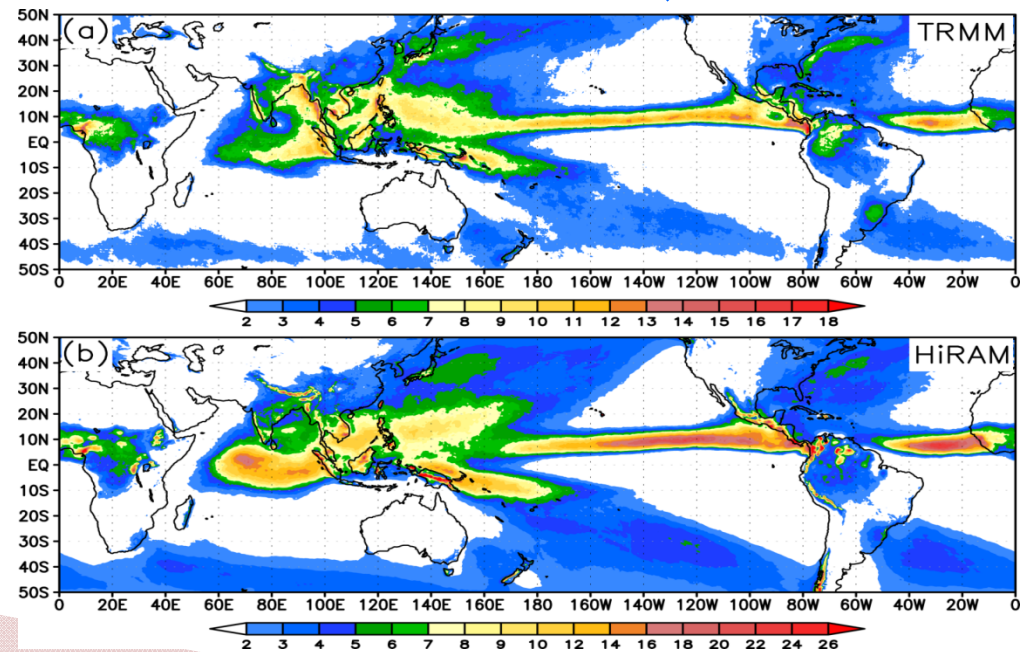


Model Predicted climatology

The average surface precipitation (mm/day) in ASO during 1998–2010

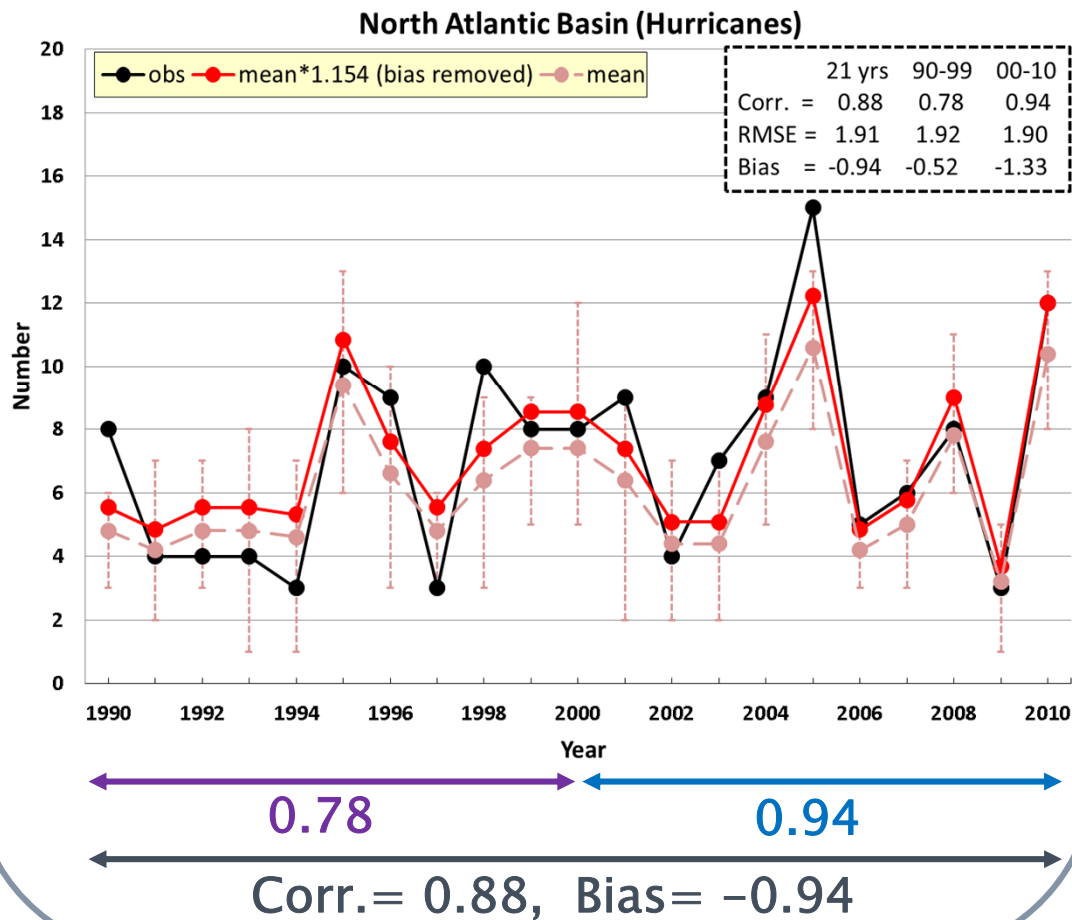


Hurricane/Typhoon occurrence



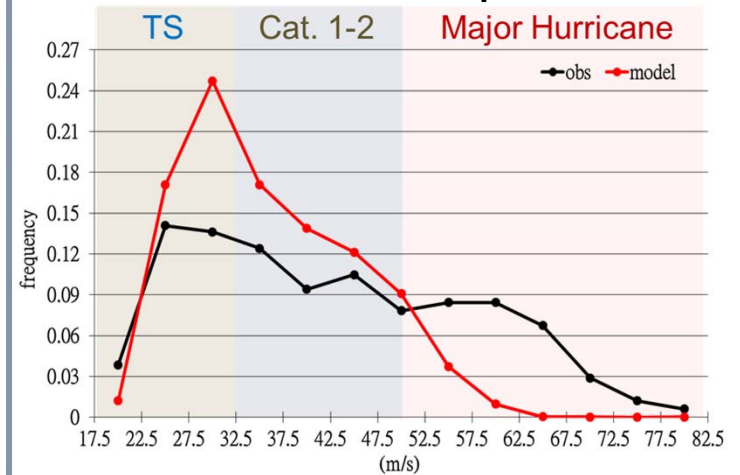
Seasonal Hurricane Prediction during 1990–2010

Storm Counts

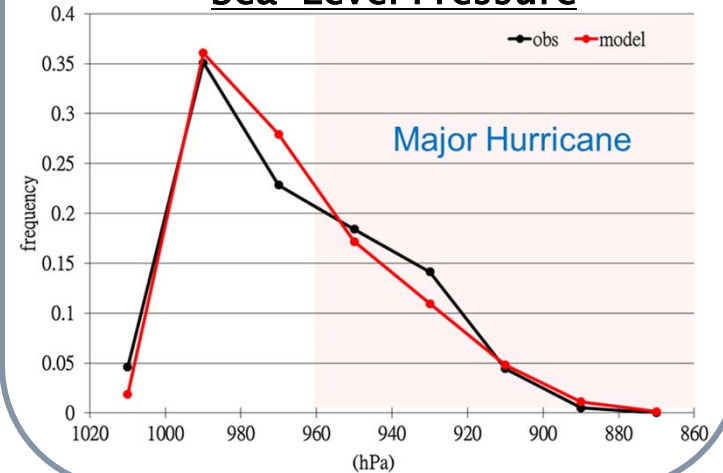


Storm intensity

PDF characterized by
10-m wind speed

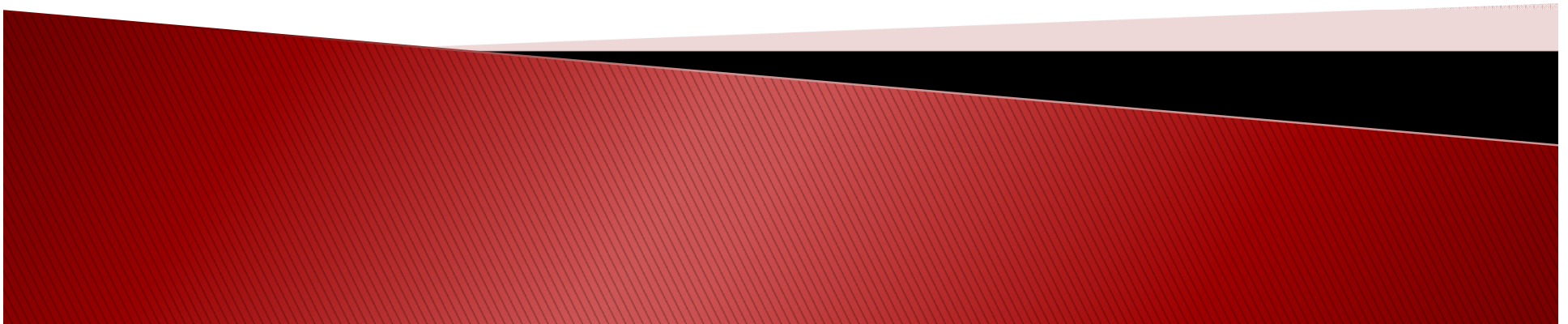


PDF characterized by
Sea-Level Pressure



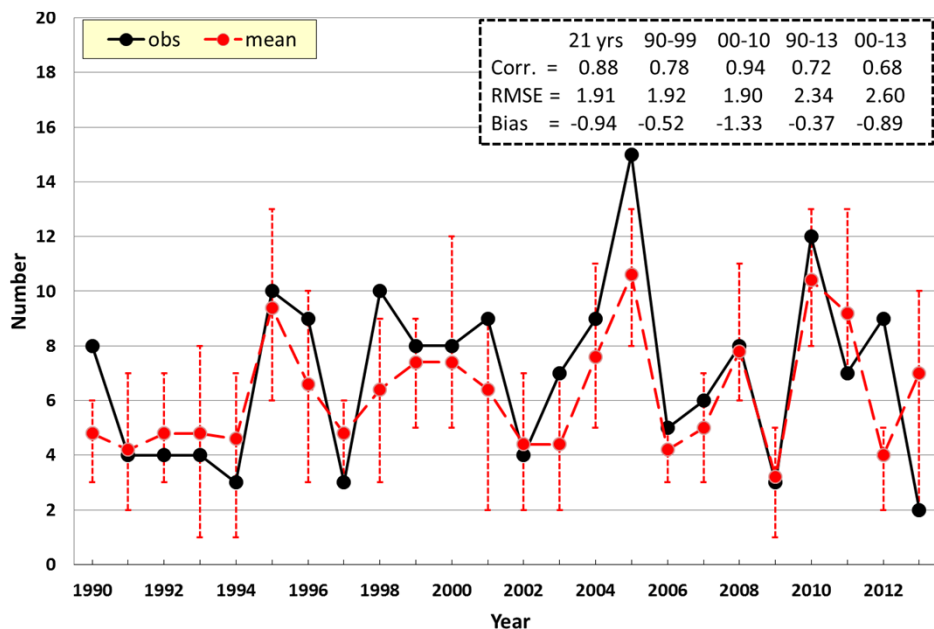


What's the skill if we extend forecasts
to 2011–2013?



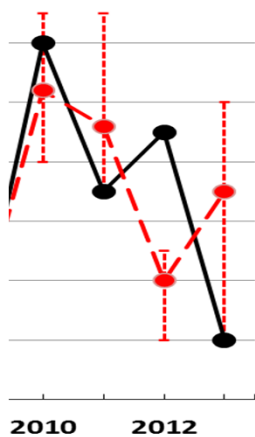
New Challenges to 2011–2013 Seasonal TC forecasts

North Atlantic Hurricanes



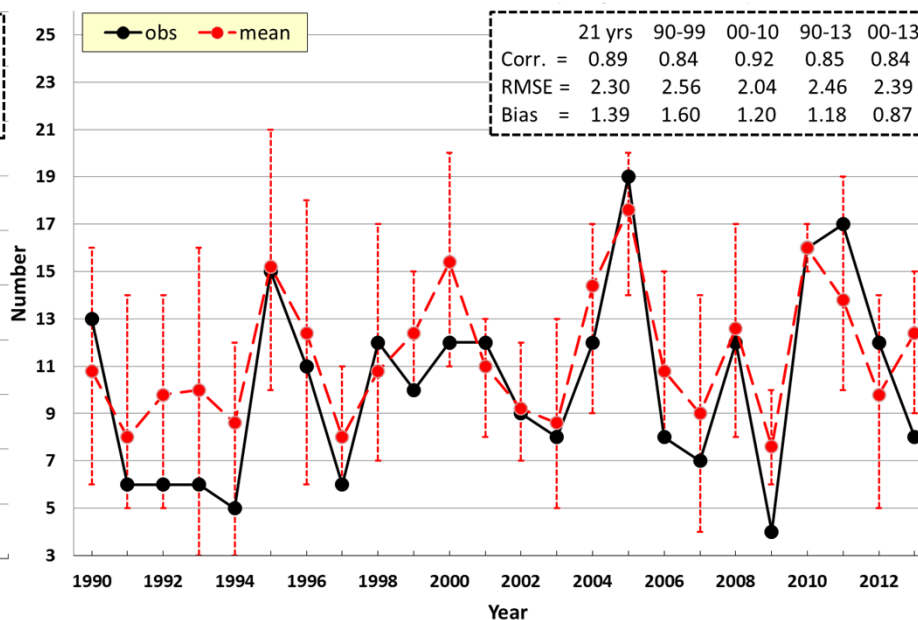
24 year: Corr.= 0.72, Bias= -0.37

14 year: Corr.= 0.68
Bias= -0.89



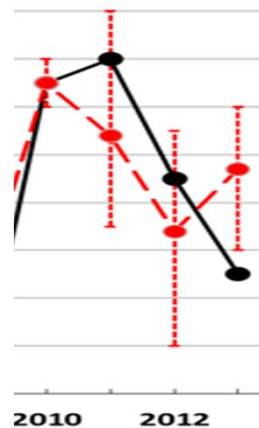
	Hurricane obs.	Hurricane model
2011	7	9.2
2012	9	4
2013	2	7

North Atlantic TSs



24 year: Corr.= 0.85, Bias= 1.18

14 year: Corr.= 0.84
Bias = 0.87



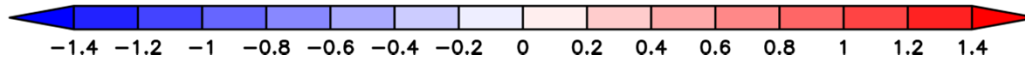
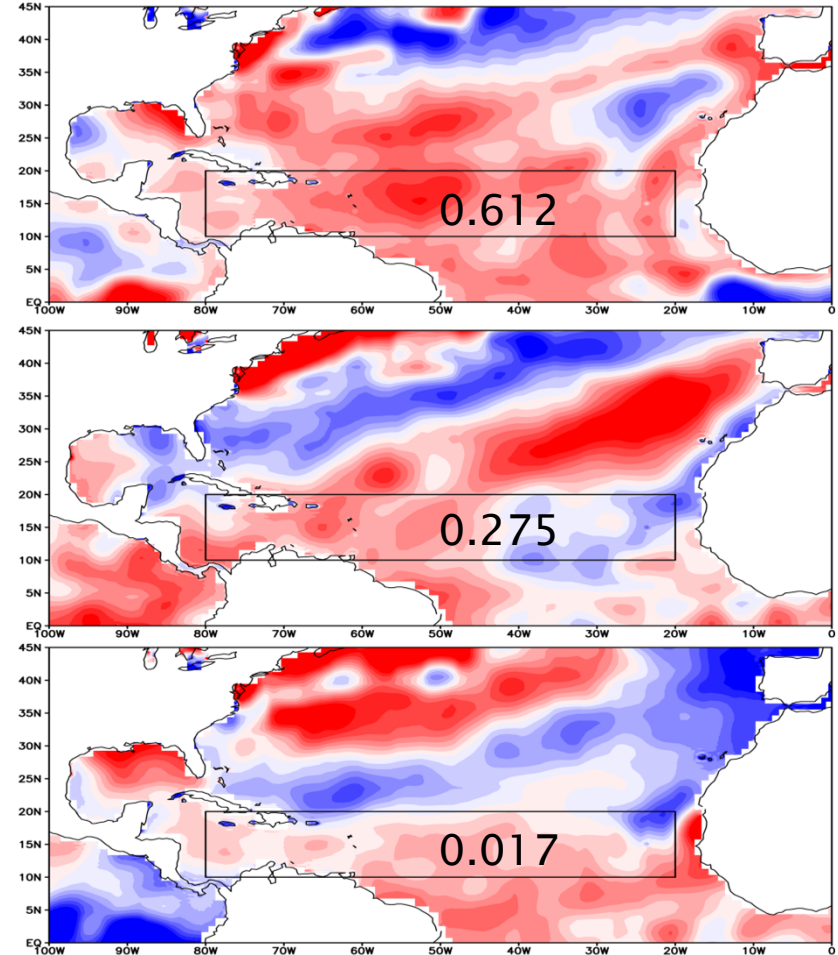
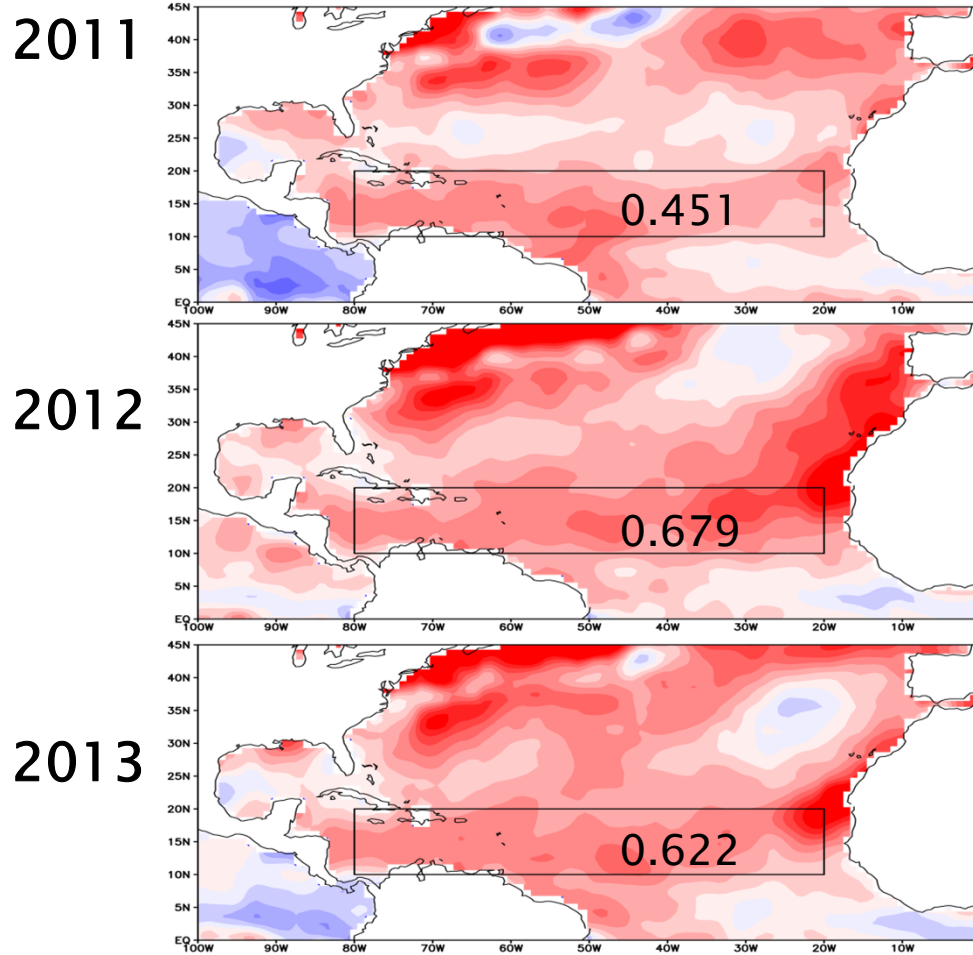
	TS obs.	TS model
2011	17	13.8
2012	12	9.8
2013	8	12.4

How's the SSTA in 2011-2013?

Hurricane number	obs.	model SSTA	model AMIP
2011	7	9.2	11.6
2012	9	4	9
2013	2	7	9.8

Hadley SSTA in ASO

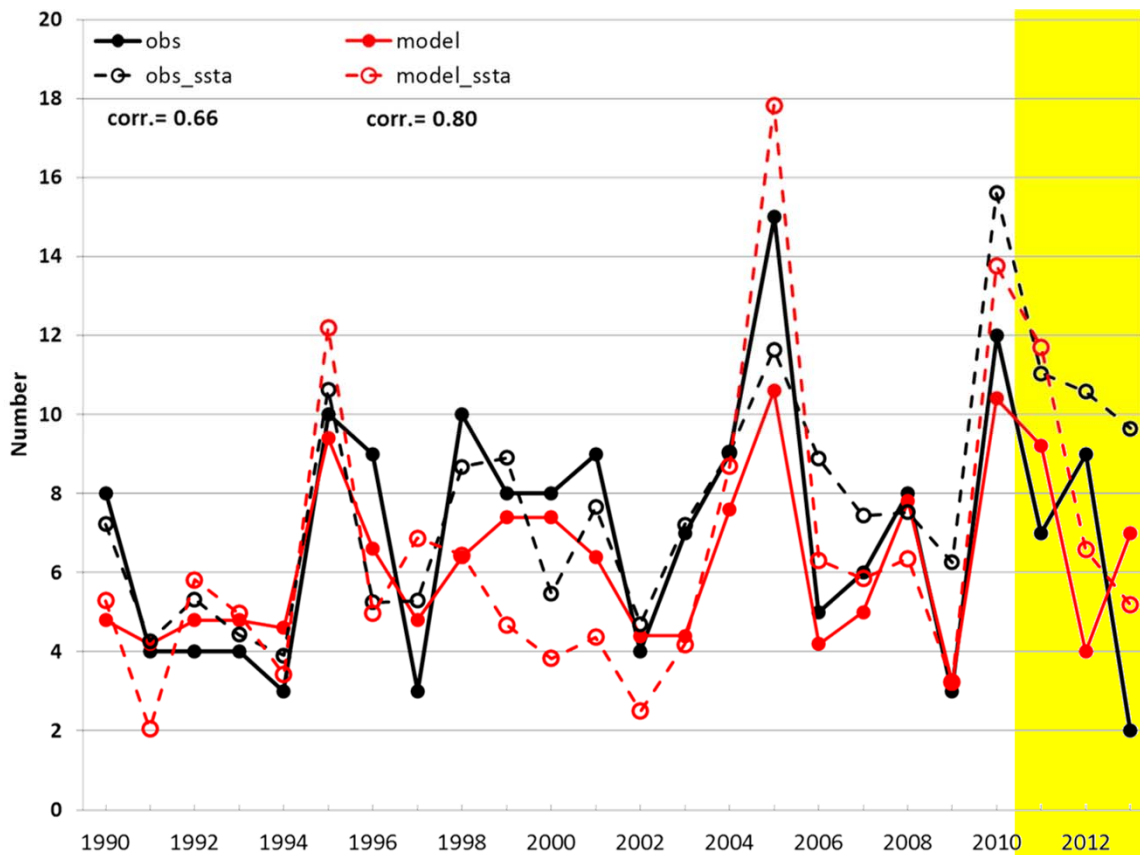
HiRAM used initial SSTA



How's the (tropical) SST in 2011–2013?

- ▶ For NA basin, the hurricane frequency is strongly correlated with the **SSTs over the MDR** versus the **average SST of the entire tropical oceans**. (Zhao et al. 2009; Vecchi and Knutson 2011; Villarini et al. 2010)

Vecchi et al. (2011) built from C180–HiRAM: $\lambda = e^{1.707 + 1.388SST_{MDR} - 1.521SST_{TROP}}$



Hurricane number	obs.	model SSTA	model AMIP
2011	7	9.2	11.6
2012	9	4	9
2013	2	7	9.8

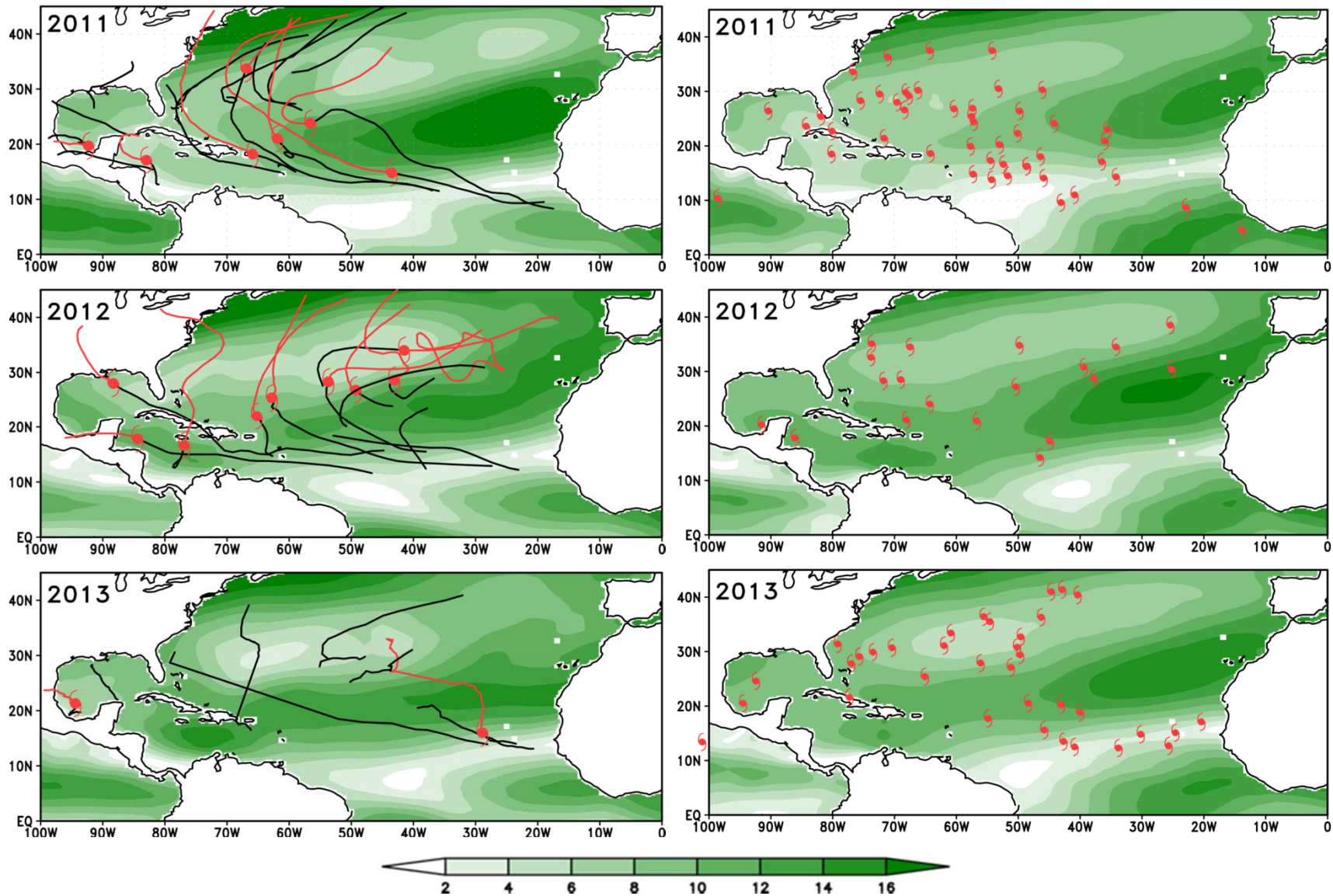
Statistical emulator	initial SSTA	mean SSTA
2011	11.69	11.0
2012	6.58	10.6
2013	5.18	9.6

Other factors?

Mean wind shear speed (m/s)
between 850–200 hPa in July–October

Era Interim

HiRAM ensemble mean



Summary and Discussion



- ▶ GFDL HiRAM with 25-km resolution achieves a high forecast skill of the storm count in the NA during 1990-2010, but is experiencing challenges of recent seasons.
 - Compared to the high correlations (0.88/0.89) for the first 21 years, the correlations between observed and model predicted hurricane/TS numbers decrease to 0.72/0.85 for 1990-2013.
 - The model could not capture the trend of the hurricane number variation during 2010-2013.

- ▶ The SSTA is higher than the climatology mean value during 2013 hurricane season.
 - Both the statistical emulator and model AMIP simulation generate too many hurricanes in 2013.

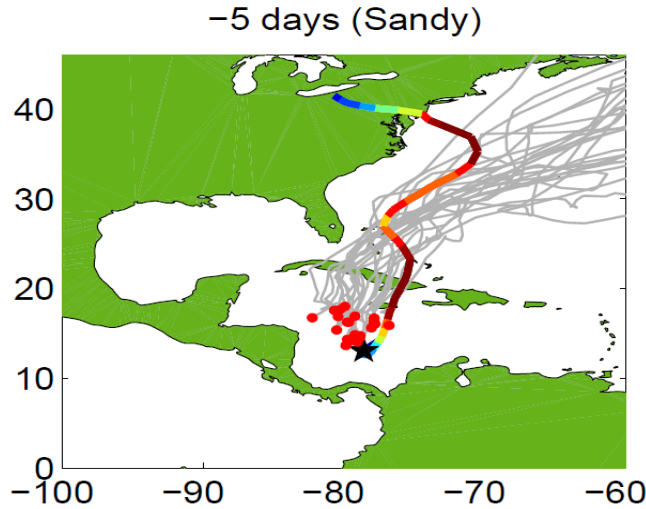
- ▶ The model overestimated the hurricane number in 2013, even though the SSTA is relatively cold at the beginning of this season.
 - The persistent SSTA assumption may not be adequate, and some other factors (e.g. aerosol effects, air-sea interaction...) may play important roles in 2013 hurricane season.

Is Super Storm Sandy Predictable?

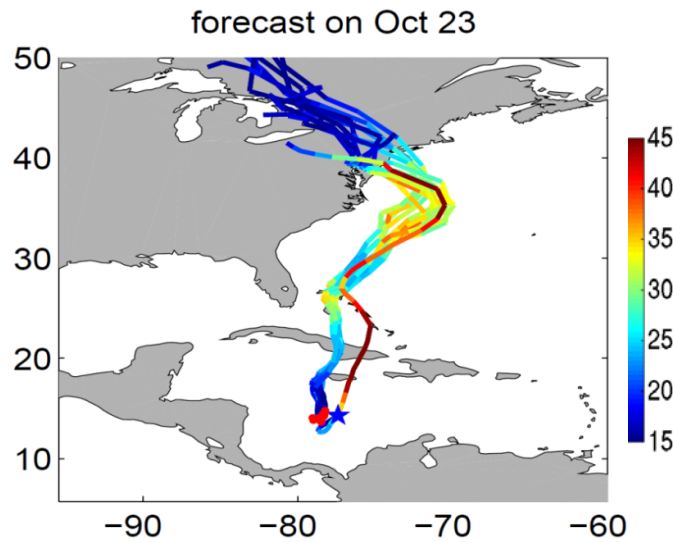
Provided by
Baoqiang Xiang
at GFDL

- ▶ GFDL CM coupled model
(c180 (50 km) AGCM + 1 degree ocean)

Genesis
forecast



a) Sandy (Oct 22 2012)



Track
forecast

d) forecast on Oct 23

