

Dynamic Hurricane Prediction with the NCEP CFS CGCM

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CLIVAR Hurricane Workshop

June 5, 2013

Outline

- CFS in the NOAA Hurricane Season Outlooks
 - Introduction to NOAA Hurricane Season Outlooks using the 2013 Season
 - T382 version of CFS for hurricane season prediction
 - Analysis of tropical storm statistics and performance
- CFS in the CPC Global Tropics Hazards Outlook
 - Introduction to CPC Global Hazards Outlook
 - CFSv2 45-Day Hindcasts
 - Analysis of storm statistics
 - Future plans

NOAA Hurricane Season Outlook for the Atlantic and Eastern North Pacific basins

- Outlooks have been issued since 1998
- Probabilistic season types - above, near, and below normal
- Ranges in the number of named storms, hurricanes, and major hurricanes
- Range in the ACE index (% of median)
- Consensus prediction prepared by 7 HSO forecasters based on all forecasts generated with statistical and dynamical tools; 2 from CPC, 4 NHC and 1 AOML



NOAA 2013 Hurricane Season Outlooks

<u>Season and Activity Type</u>	<u>Atlantic Outlook</u>	<u>E. Pacific Outlook</u>
Chance Above Normal	70%	10%
Chance Near Normal	25%	35%
Chance Below Normal	5%	55%
Named Storms (NS)	13-20	11-16
Hurricanes (H)	7-11	5-8
Major Hurricanes (MH)	3-6	1-4
ACE (% Median)	120%-205%	60%-105%

On May 23, NOAA released the 2013 Outlooks. We are predicting an above average year for the Atlantic and a below average year for the Eastern Pacific.

Model Summary: May 2013 Atlantic Outlook

Model	Named Storms	Hurricanes	Major Hurricanes	ACE (% Median)
CPC Regression:	14-18 (16)	7-9 (8)	3-4.5 (3.75)	140-170 (155)
CPC Binning : Nino 3.4+SSTA	7.9-21.5 (14.7)	4.2-11.5 (7.85)	2.1-5.9 (4)	69-217 (143)
CPC Binning ENSO+SSTA	10.1-21 (15.55)	5.2-11.7 (8.45)	2.8-5.9 (4.35)	106-229 (167)
CFS: Hi-Res T-382 (bias corrected)	14.4-17.4 (15.9)	5.2-11.2 (8.2)		119-206 (163)
CFS V2 Hybrid: 1	11-15 (13)	6-8 (7)	3-4 (3.5)	103-156 (130)
CFS V2 Hybrid: 2	12-16 (14)	6-9 (7.5)	3-4 (3.5)	112-169 (141)
CFS V2 Hybrid: 3	12-16 (14)	6-9 (7.5)	3-4 (3.5)	110-170 (140)
GFDL Hybrid		6-11 (8.4)		
ECMWF:	7.3-14.5 (10.9)	4.1-10.1 (7.1)		64-141 (103)
EUROSIP:	7.6-14.4 (11)			
UKMET				
Guidance Mean	10.7-17.1 (13.9)	5.5-9.9 (7.8)	2.8-4.7 (3.8)	103-182 (143)

Dynamic Hurricane Season Prediction with the T382 CFS

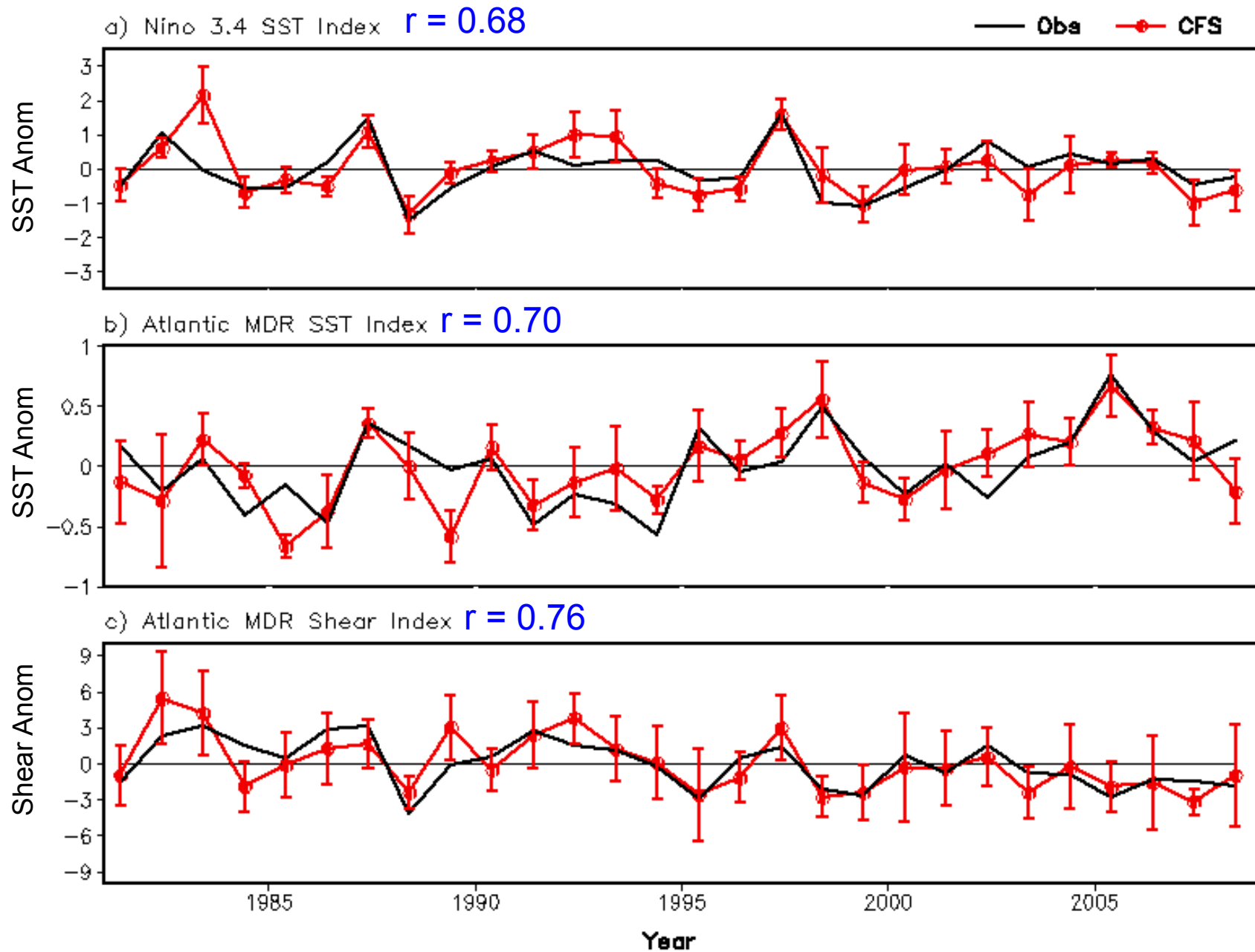
The T382 CFS Hindcast Experiments

- Experimental hurricane season prediction project initiated as an internal Climate Testbed (CTB) project in 2007 as a collaborative effort between the NCEP CPC and EMC
- AGCM - 2007 operational NCEP GFS in T382/L64 resolution
LSM - Noah LSM
OGCM - GFDL MOM3
- Historical case study performed for 1981-2008: All runs initialized with NCEP/DOE R2 and NCEP GODAS. Initial conditions at 00Z, April 19-23. Forecasts extend to December 1. Output every 6 hours.
- Tropical cyclone detection and tracking method based on Carmago and Zebiak (2002)

Detection & Tracking Method

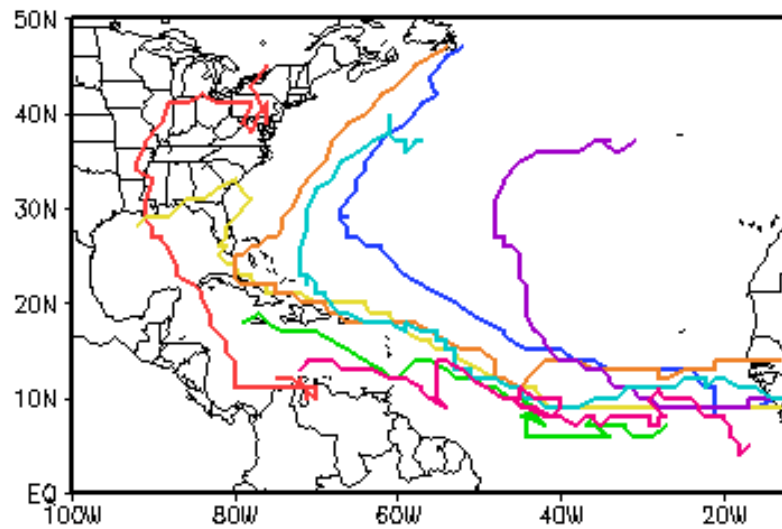
- Method based on Camargo & Zebiak (2002)
 - Point must meet 7 criteria to be considered a storm
 - Tracked forward and backward in time following vorticity maxima
- Detection thresholds unique to CFS at T382, created using 5-member hindcasts for 1981-2008
- Observations from the HURDAT and JTWC Best Track Datasets
- Tropical depressions and subtropical storms are not included in storm counts.

T382 CFS – Indices for JJAS

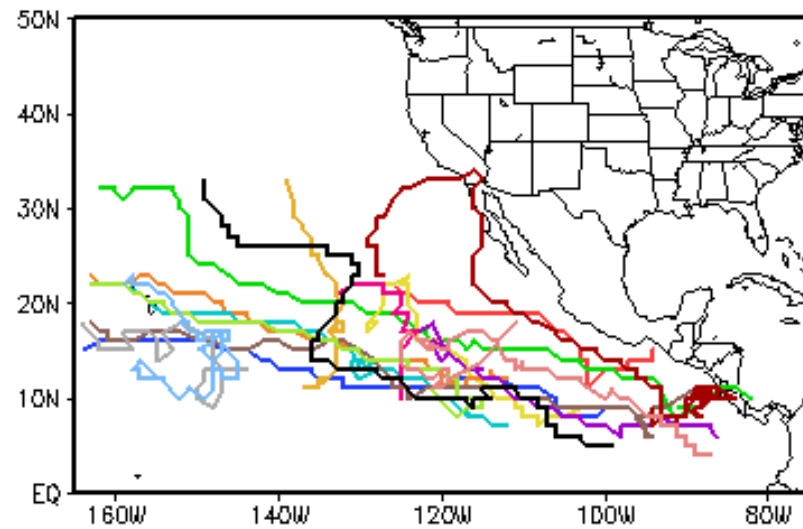


Examples of Storm Tracks for 4 NH Basins

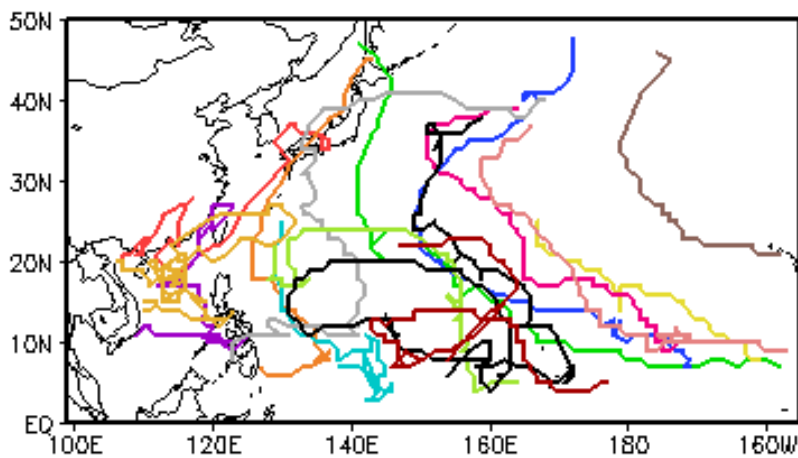
Atlantic



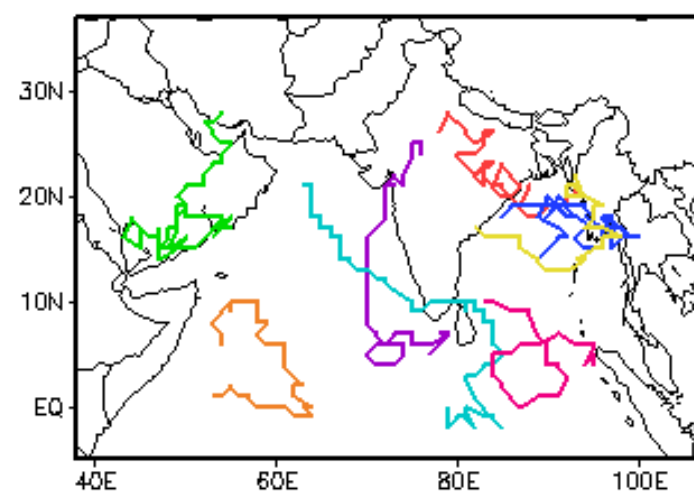
Eastern North Pacific



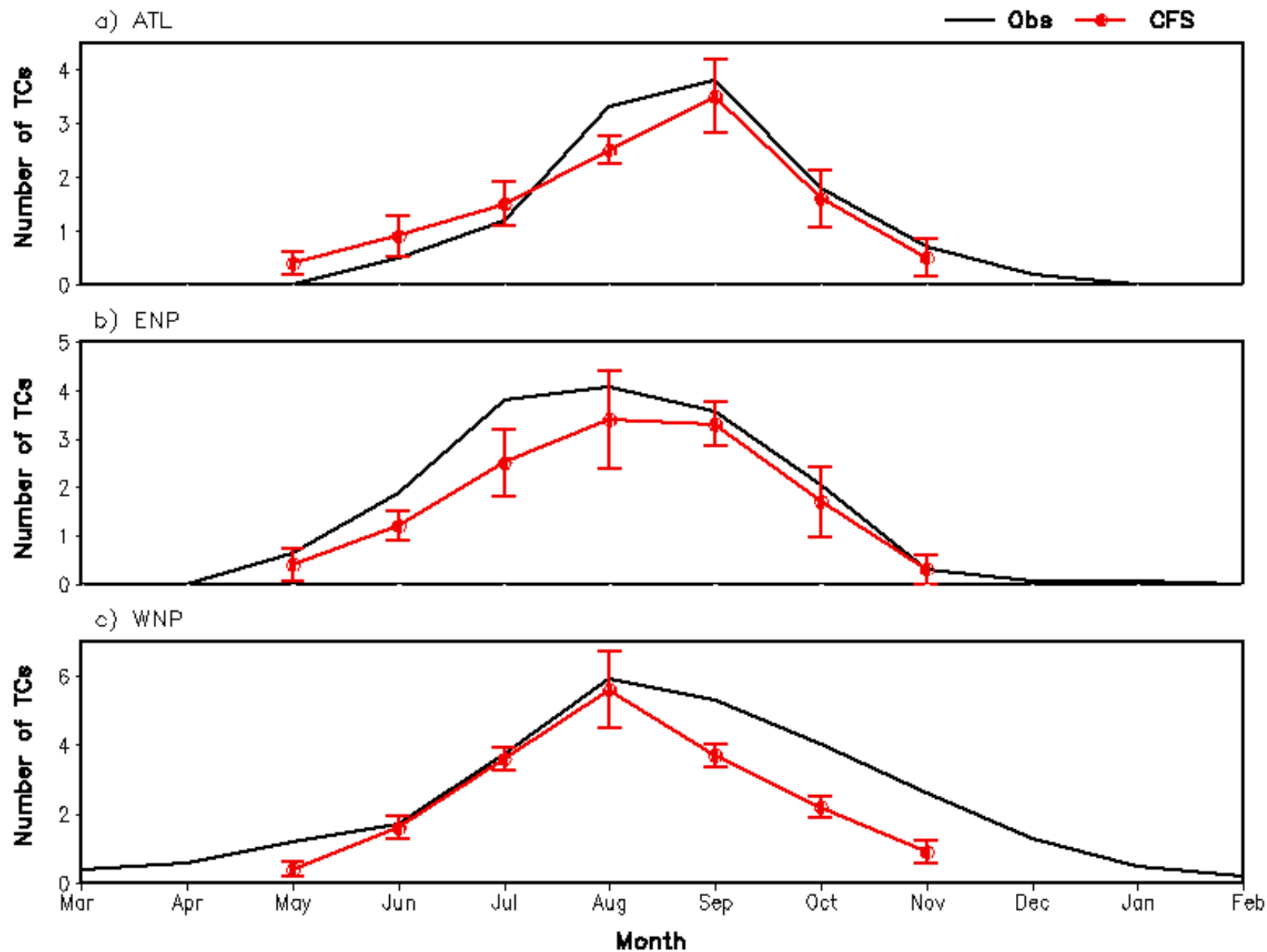
Western North Pacific



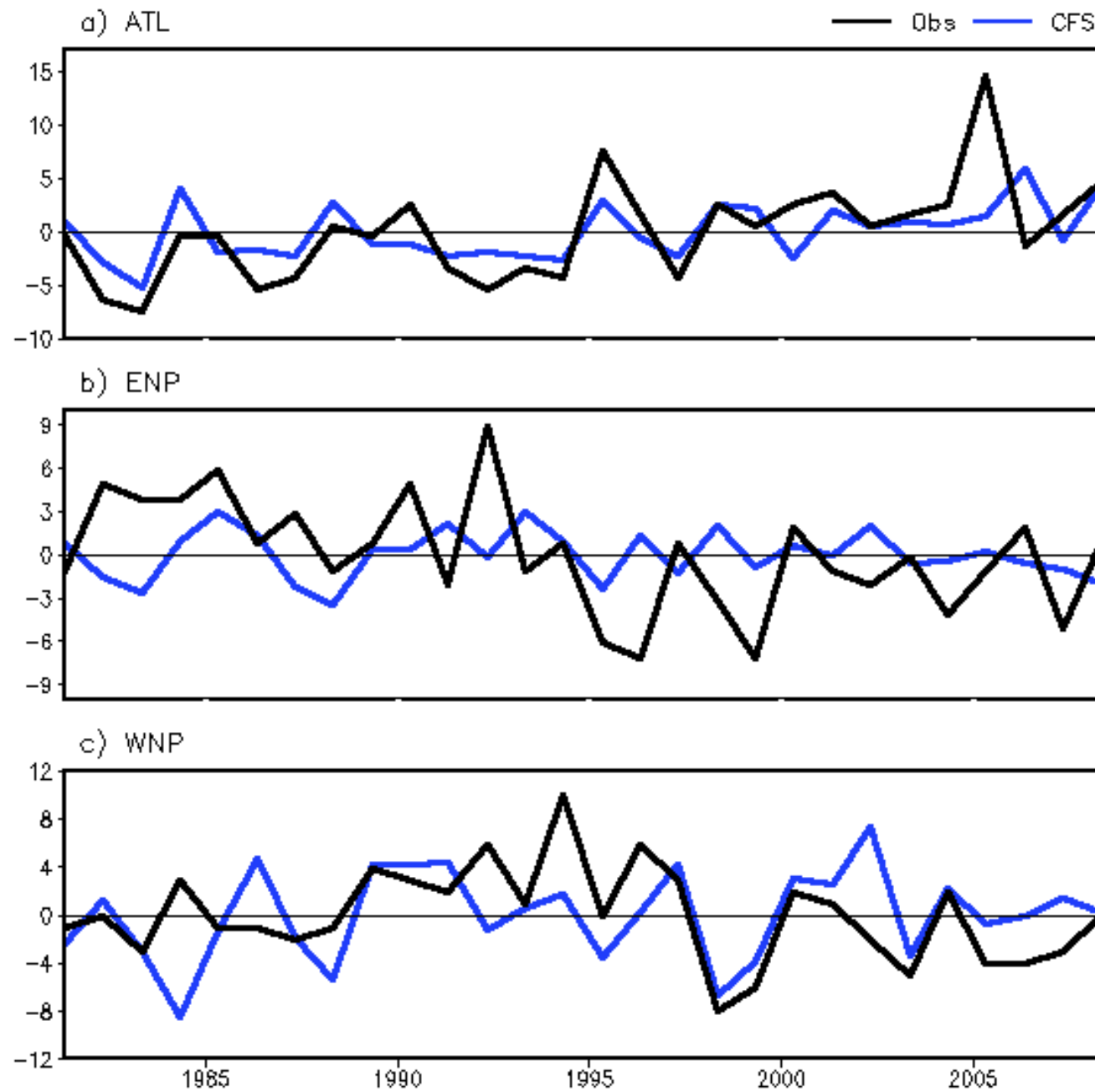
North Indian



T382 CFS – Seasonal Cycle of TCs



Interannual Variability



**Spearman
Rank
Correlation**

$r=0.63$

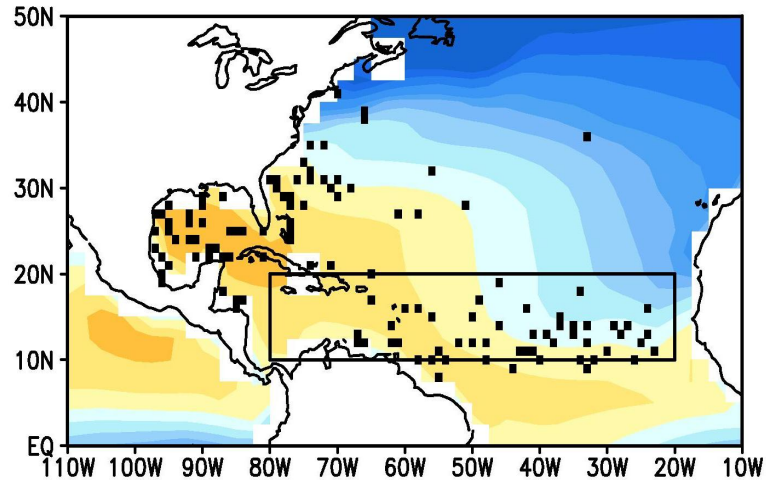
$r=-0.07$

$r=0.43$

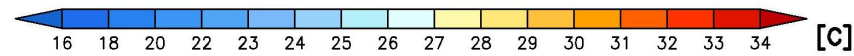
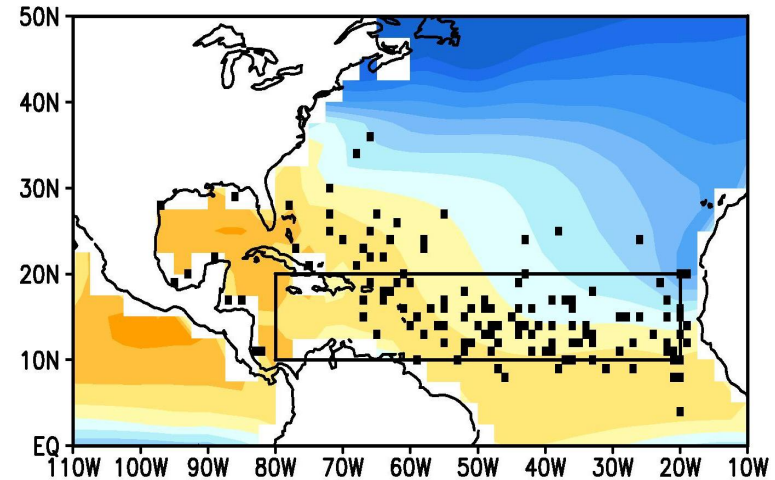
*** Bold = significant**

Atlantic Basin SSTs and Storm Origins Climatology JJA

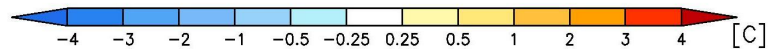
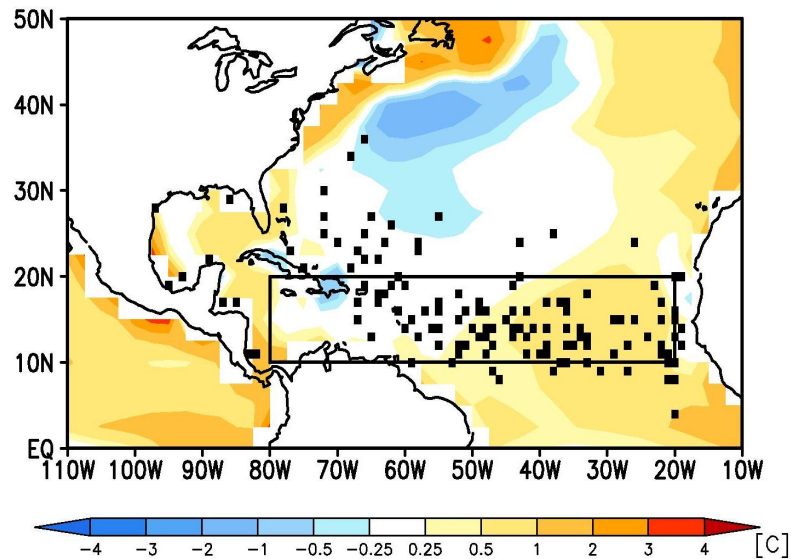
a) Observed



b) T382 5-Mem Ensm, IC=0423 Origins

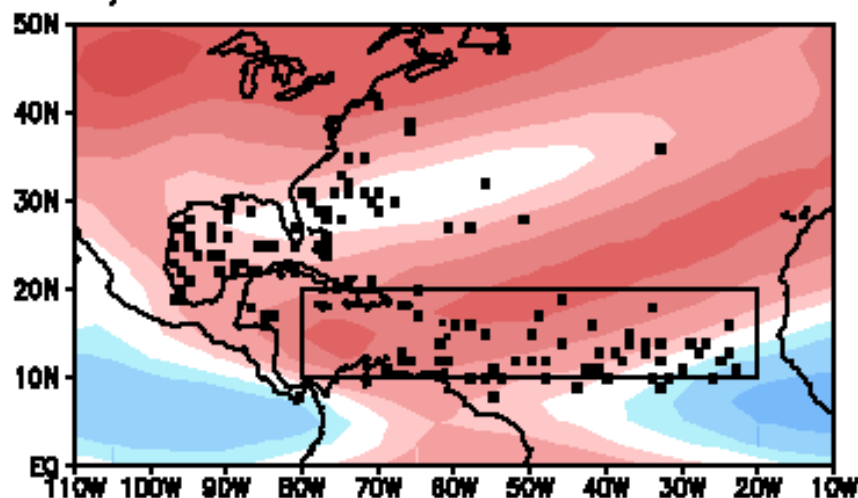


c) T382 Ensm - Obs, Bias

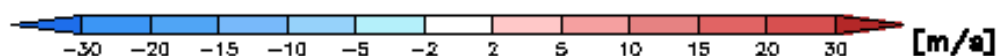
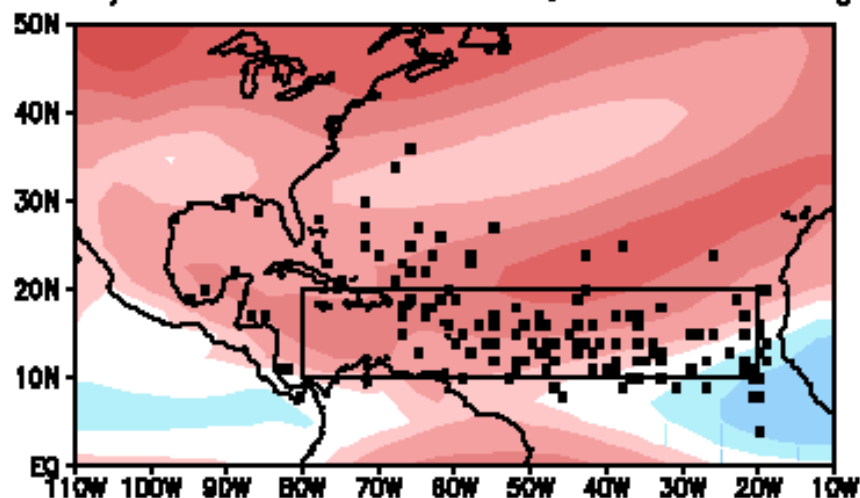


Atlantic Basin Shear and Storm Origins Climatology JJA

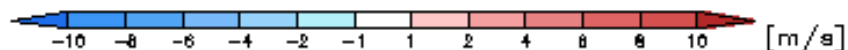
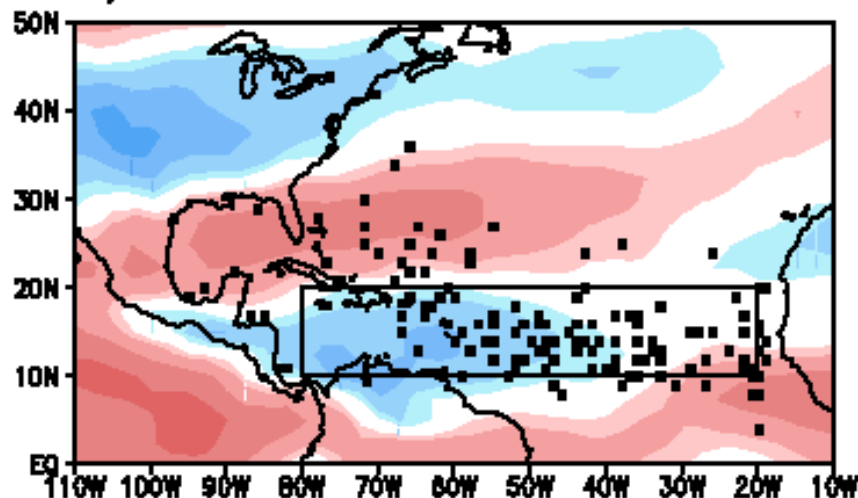
a) Observed



b) T382 5-Mem Ensm, IC=0423 Origins



c) T382 Ensm - Obs Diff



CFS Hurricane Season prediction for the 2009 – 2012 seasons

Past Forecasts and Verification; ATL

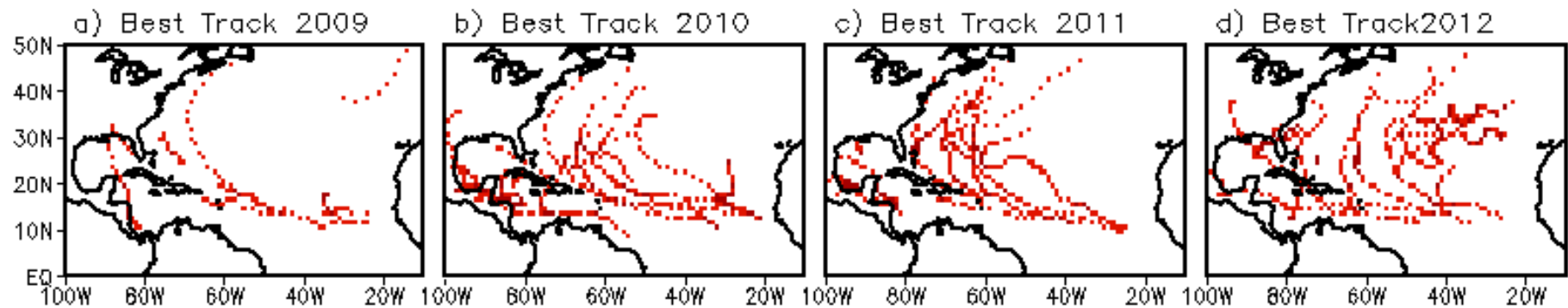
	Atlantic Basin	Tropical Storms	Hurricanes	ACE Index (% of Median)
2009	Ensemble	7.9	5.1	82.8
	Range	6 - 10	4 - 6	61 - 104
	Verification	9	3	57
2010	Ensemble	22.0	13	262.3
	Range	19 - 25	10 - 16	212 - 312
	Verification	19	12	185
2011	Ensemble	14.4	7.5	144.6
	Range	11 - 18	5 - 10	104 - 185
	Verification	19	7	134
2012	Ensemble	12.9	5.2	124.4
	Range	11 - 15	3 - 7	89 - 160
	Verification	19	10	149

Past Forecasts and Verification; ENP

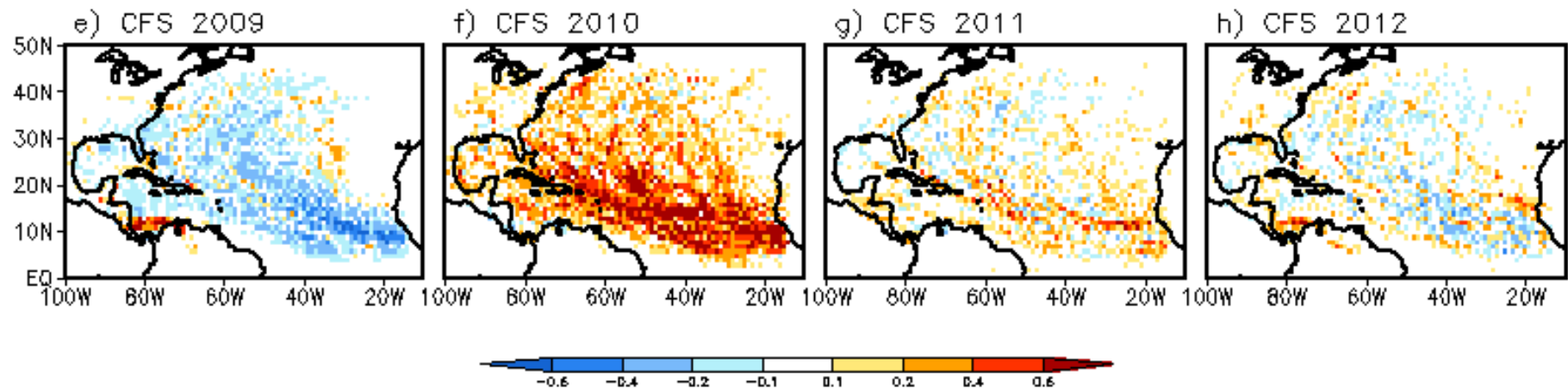
	ENP Basin	Tropical Storms	Hurricanes	ACE Index (% of Median)
2009	Ensemble	11.6	3.0	97.0
	Range	10 – 13	2 – 4	74 – 120
	Verification	17	7	99.3
2010	Ensemble	10.4	2.0	75.4
	Range	7 – 14	1 – 3	52 – 99
	Verification	7	3	29
2011	Ensemble	11.1	3.9	99.1
	Range	9 – 13	2 – 6	75 – 123
	Verification	11	10	94
2012	Ensemble	12.0	4.8	117.5
	Range	10 – 14	3 – 7	86 – 149
	Verification	17	10	78

Track Prediction (anomalous storm day density for CFS)

Observed Actual Tracks



Anomalous Storm Day Density from CFS Forecasts

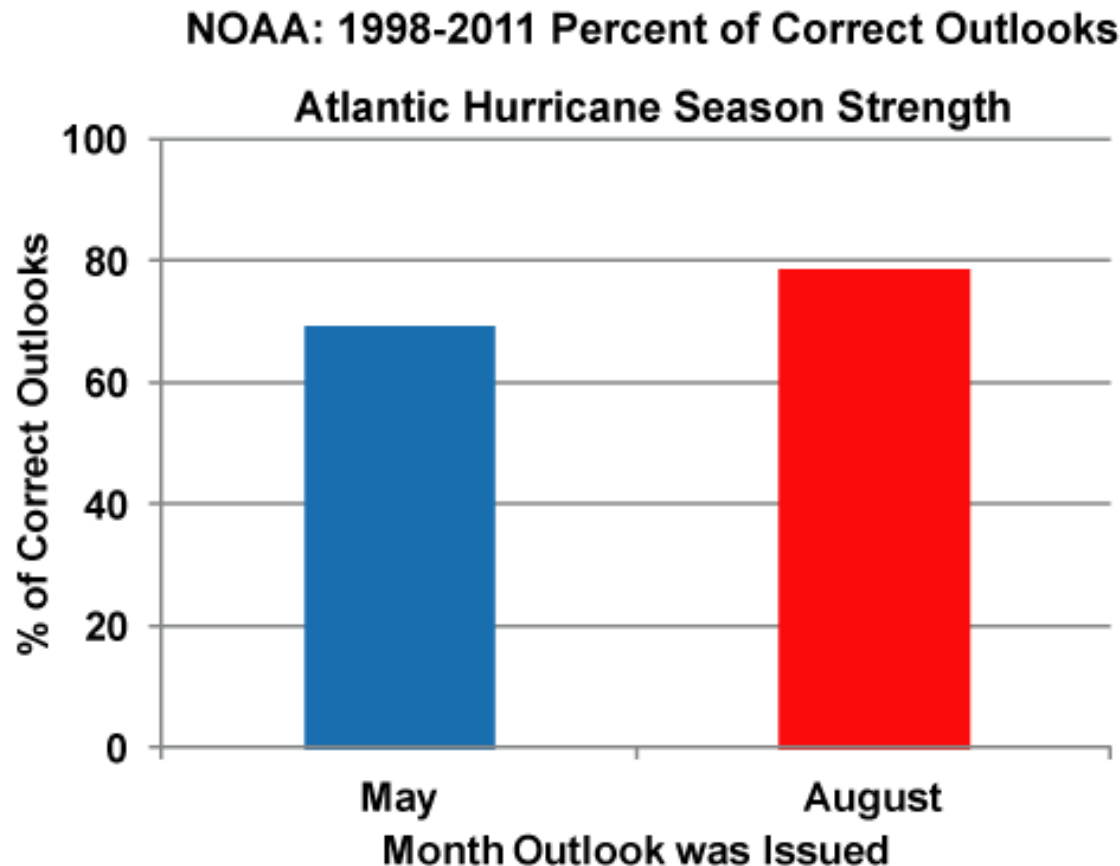




Impact of Dynamic Prediction Input on the NOAA Atlantic Hurricane Season Outlook Verifications



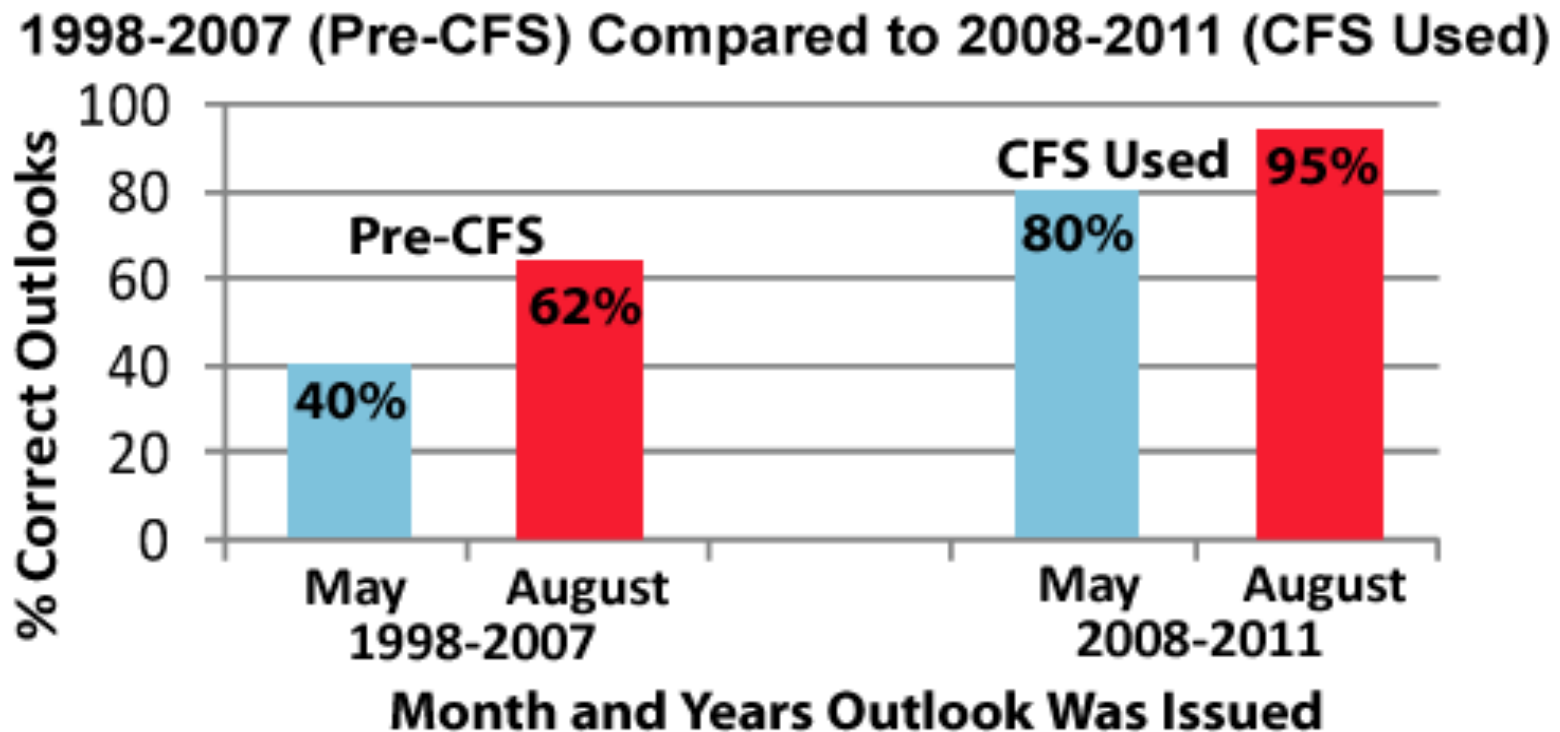
Verification for Hurricane Season Strength



NOAA's Atlantic hurricane season outlooks issued in May have correctly predicted the season strength (Above-, near-, or below-normal) 70% of the time. Outlooks issued in August were correct 79% of the time.



Atlantic Outlook Verification



The use of dynamical models since 2008, especially the CFS, has contributed to a large improvement in outlook accuracy.

Summary for Hurricane Outlooks

- CFS in T382 resolution exhibits robust climatological seasonal cycle of tropical cyclones over three NH basins.
- Warming trend and intensification of hurricane activity in the Atlantic basin captured in the CFS hindcasts.
- Fair level of skill in predicting interannual variability of seasonal storm activities for the Atlantic and West. N. Pacific basins.
- Addition of dynamical prediction tools has contributed considerably to much improved HSO performance since 2008.
- Currently exploring ways to utilize track predictions for landfall probability distribution
- Future plans include an upgrade of the hurricane season prediction system to T574 (~25 km) or higher resolution by 2015 and usage of the NOAA NMME forecast system.

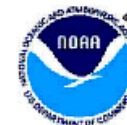
CPC Global Tropics Hazards and Benefits Outlook – Subseasonal TC Activity Analysis

CPC Global Tropics Hazards and Benefits Outlook

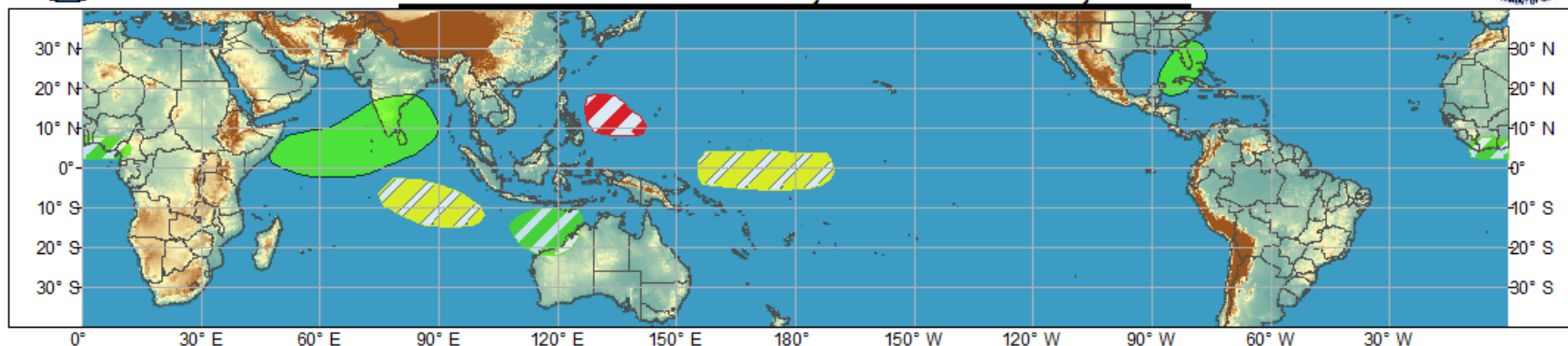
- Forecast for moderate or high confidence of:
 - TC Formation
 - Above/Below Average Rainfall
 - Above/Below Average Temperatures
- Issue forecast for Week 1 and Week 2
- Includes graphic and a detailed discussion
- Outlooks are updated each Tuesday
 - Includes live briefing (via webinar) open to public
- Currently subjective in nature and not based on an objective system
- Collaborators include
 - NHC, CPHC, JTWC, NPS, Australian Bureau of Meteorology, Taiwan Central Weather Bureau, SUNY, CICS



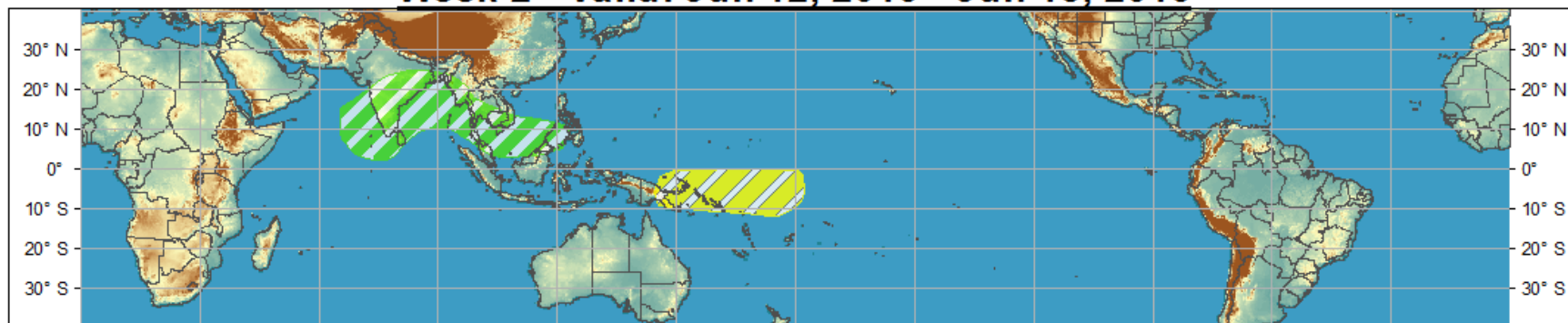
Global Tropics Hazards and Benefits Outlook - Climate Prediction Center



Week 1 - Valid: Jun 05, 2013 - Jun 11, 2013



Week 2 - Valid: Jun 12, 2013 - Jun 18, 2013



Confidence
High Moderate

Produced: 06/04/2013

Forecaster: Baxter

- | | | |
|-----------------------------------|--|--|
| Tropical Cyclone Formation | | Development of a tropical cyclone that eventually reaches tropical storm/cyclone strength. |
| Above-average rainfall | | Weekly total rainfall in the upper third of the historical range. |
| Below-average rainfall | | Weekly total rainfall in the lower third of the historical range. |
| Above-normal temperatures | | 7-day mean temperatures in the upper third of the historical range. |
| Below-normal temperatures | | 7-day mean temperatures in the lower third of the historical range. |

Product is updated once per week. The product targets broad scale conditions integrated over a 7-day period for US interests only. Consult your local responsible forecast agency.



CFSv2 T126 45-Day Hindcasts

Subseasonal Tropical Storm Prediction with the CFSv2 45-Day Forecasts

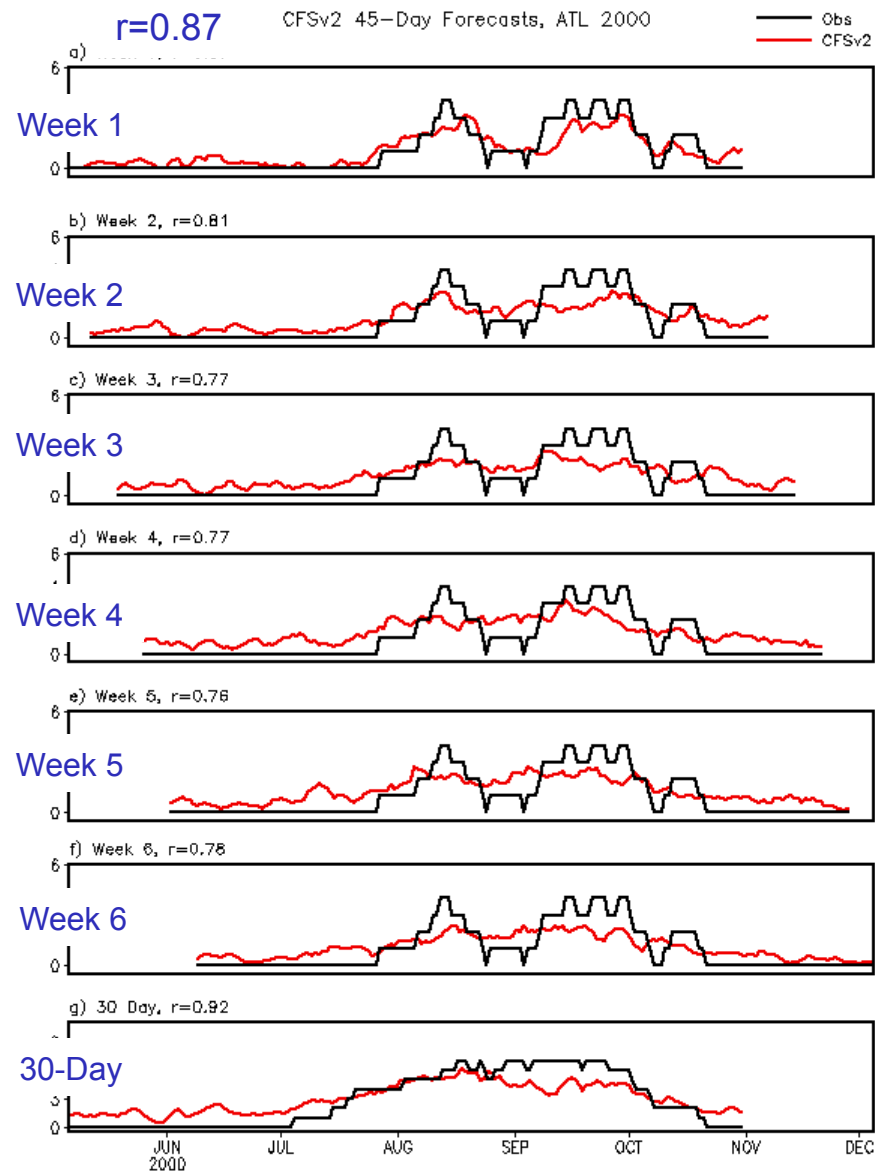
- CFSv2 operationally implemented in April, 2011
- AGCM - 2007 operational NCEP GFS in T126/L64 resolution
LSM - Noah LSM
OGCM - GFDL MOM4
- Hindcast runs for 1999-2010 with initial conditions every 6 hours at 00Z, 06Z, 12Z, and 18Z everyday. Output every 6 hours.
- Operational runs with ICs at 00Z, 06Z, 12Z, and 18Z everyday, 4 ensemble members each
- Tropical cyclone detection and tracking method based on Carmago and Zebiak (2002)

Hindcast TS Analysis for Tropical Hazards Outlook

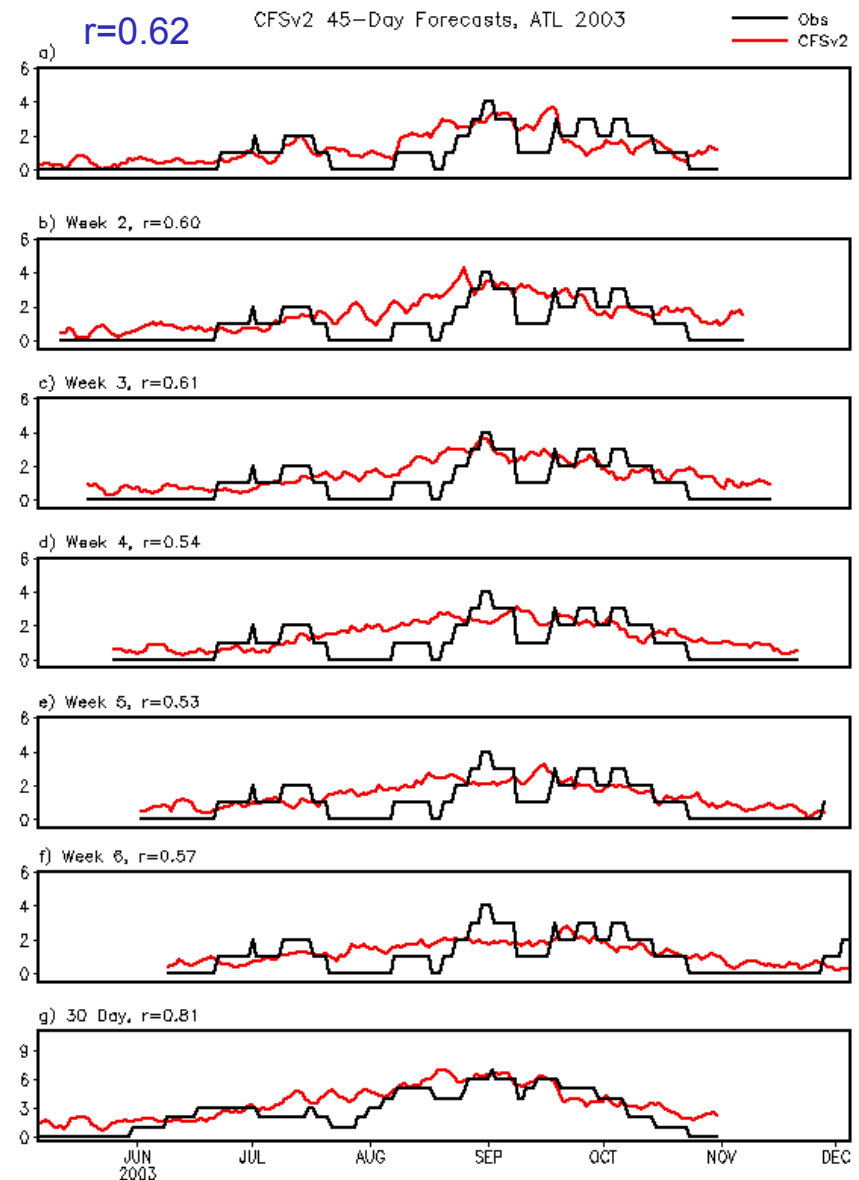
- Currently working on two possible products
 - Storm count
 - Storm genesis and track location
- These products are prepared for Week 1 through Week 6 and monthly (30-day).
- Based on a 20-member ensemble comprised of the 5 days prior to the forecast day (4 times per day)
- Currently finished with May-Oct (NH) runs, still processing Jan-Apr, Nov-Dec (SH) runs
- Hope to provide an objective tool for forecasters

Storm Counts for Atlantic, May-Oct IC

2000

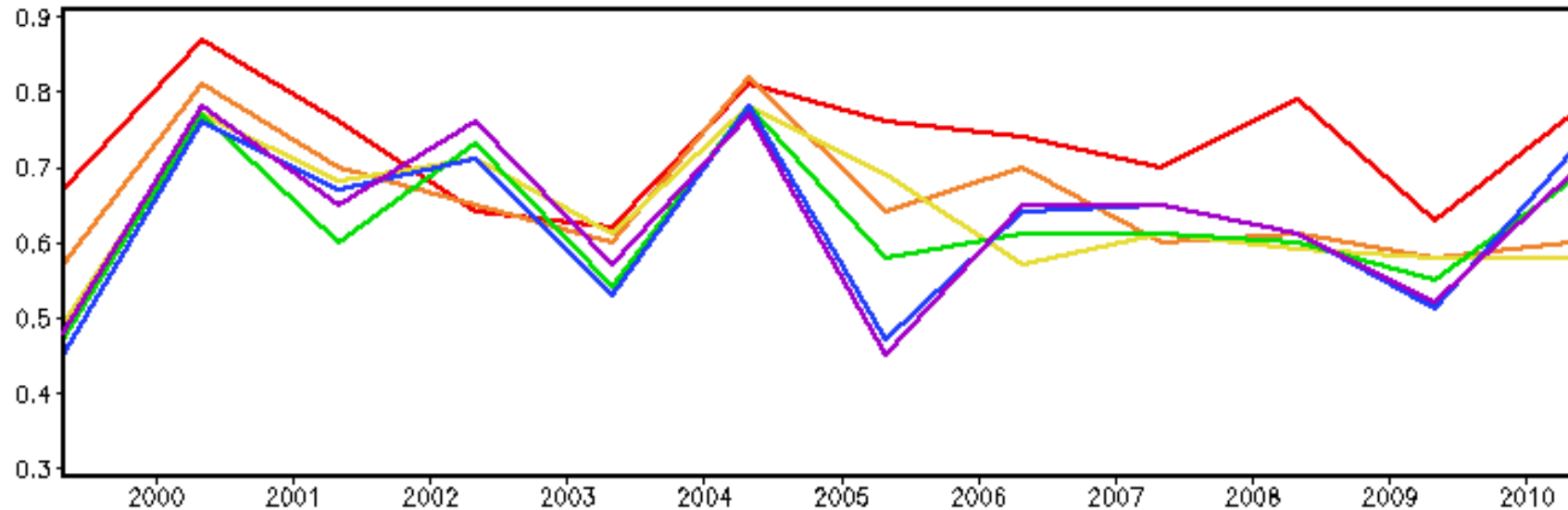


2003



Storm Count Correlations for Atlantic

Count Correlation, ATL

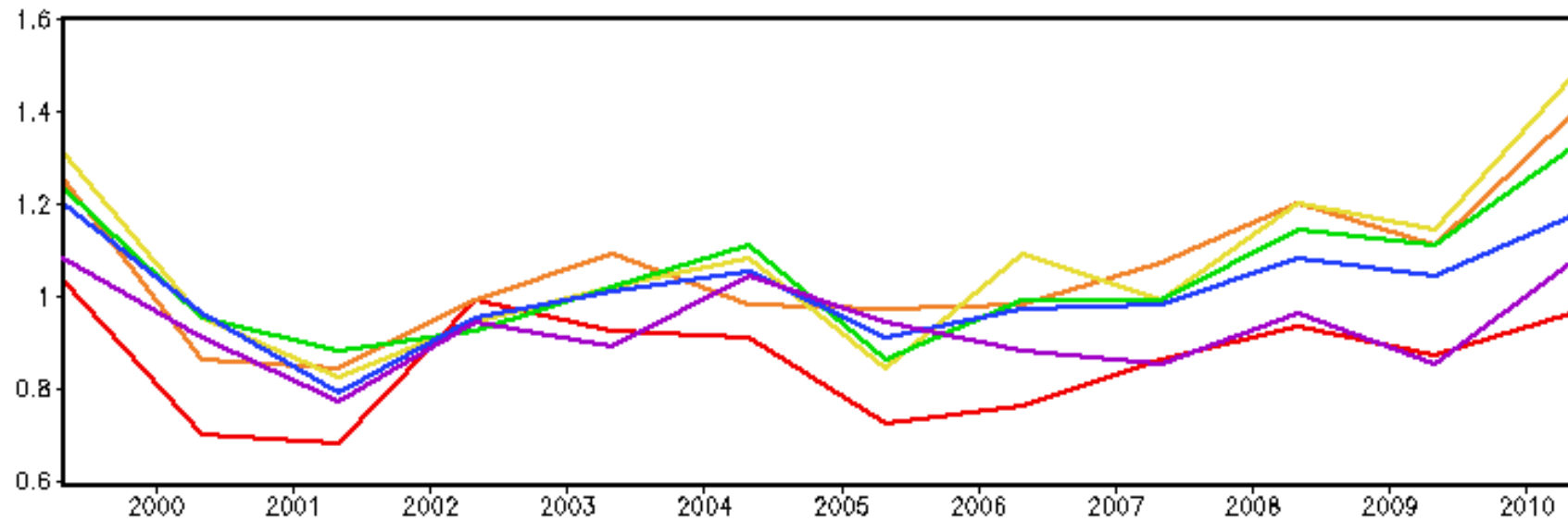


Average Means per Week

Week1 = 0.73 Week2 = 0.66 Week3 = 0.64
Week4 = 0.63 Week5 = 0.63 Week6 = 0.63

RMSE for Atlantic

RMS Error, ATL



Average Means per Week

Week1 = 0.86 Week2 = 1.06 Week3 = 1.07
Week4 = 1.04 Week5 = 1.01 Week6 = 0.93

Summary for Hazards Outlook

- New product being developed for CPC forecasters
 - Not yet in production
 - Still working on 12-year climatology for SH Summer and skill evaluation
- Will provide guidance on both storm count and location
 - Brainstorming additional products
- Operational product will be based on 16-member daily ensemble (00Z, 06Z, 12Z, and 18Z with 4 members each)