Intraseasonal Tropical Storm Prediction in the NCEP CFSv2 45-Day Forecasts

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1. Introduction

The objective of this project is to assess the ability of the NCEP Climate Forecast System Version 2 (CFSv2) 45-day forecasts to predict global tropical cyclone (TC) activity from weeks 1 to 4. These forecasts are being used to support the CPC Global Tropics Hazards and Benefits Outlook with an objective TC forecast tool.

2. Model Description

The CFSv2 is a fully coupled atmosphere-ocean-land model run operationally at the NCEP since April, 2011.

CFSv2 Components:

- Atmospheric Model: 2009 operational NCEP GFS in T126/L64 resolution
- Land Surface Model: Noah LSM
- Ocean Model: GFDL MOM4

45-Day Operational Runs:

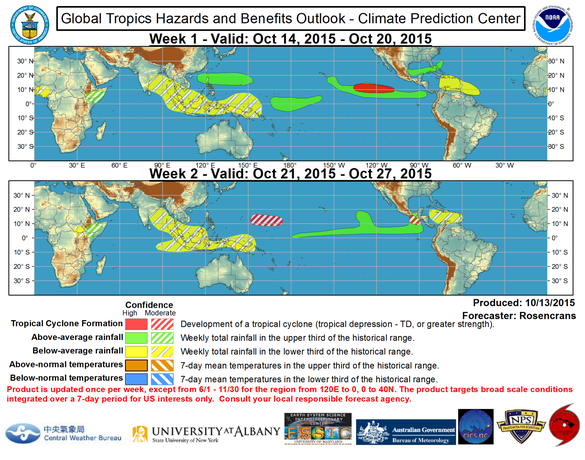
- Run 4 times daily with 4 ensemble members each
  - Initial Conditions = 00Z, 06Z, 12Z, and 18Z
  - 16 Members total per day
- Output every 6 hours

45-Day Hindcast Runs:

- Time Period: 1999-2012 (14 years)
- Run 4 times daily with 1 ensemble member each
  - Initial Conditions = 00Z, 06Z, 12Z, and 18Z
  - 4 Members total per day
- Output every 6 hours

3. Global Tropics Hazards and Benefits Outlook

- Issues Week 1 and Week 2 Forecasts for:
  - Rainfall Above/Below the Upper/Lower Third of Historical Range
  - Tropical Cyclone Formation
- Includes graphic (below) and a detailed discussion
- Released each Tuesday, with a Friday update for a limited region
  - Friday updates limited to Jun 1 – Nov 30
- Includes live briefing (via webinar), open to public



Global Tropics Hazards and Benefits Outlook graphic issued Oct 13, 2015

4. Intraseasonal Tropical Storm Prediction

Tracking

- Method based on Camargo & Zebiak (2002)*
  - Points must meet 7 criteria to be considered a cyclone
  - Tracked forward and backward in time following vorticity maxima
- Detection thresholds unique to CFSv2
  - Created using seasonal hindcast runs for 1982-2010
- Verification: HURDAT2 and JTWC Best Track Datasets
  - Tropical depressions and subtropical storms not included

Products

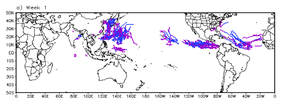
- Forecasts for storm count and storm track
- Prepared for Week 1 - Week 4
- Based on an ensemble of forecast runs:
  - Hindcast: 20-members, comprised of previous 5 day's forecasts (4 runs daily)
  - Operational: 16-members from previous day
- TC analysis performed for global ocean basins year round

* Camargo, S.J. and S. E. Zebiak, 2002: Improving the Detection and Tracking of Tropical Cyclones in Atmospheric General Circulation Models. *Weather and Forecasting*, **17**, 1152-1162.

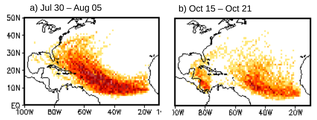
Storm Track Filtering

- CFSv2 produces a high number of False Alarms (FA), storms that do not occur in observations.
- Using storm track density values, the weekly storm track climatology and FA climatology are removed from the daily storm track density.
- Remaining track density points are considered to be forecasted TCs.

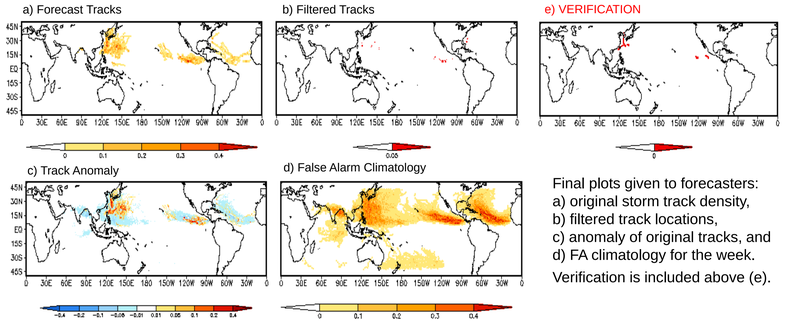
Example of Original Storm Tracks



Examples of Weekly FA Climatology



Example of Final Storm Track Density Distribution

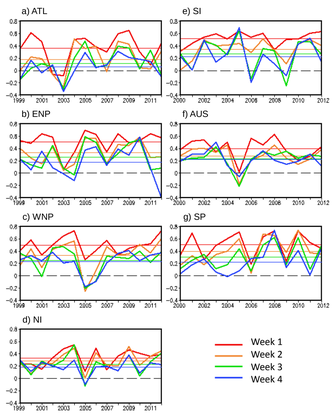


Final plots given to forecasters:
a) original storm track density,
b) filtered track locations,
c) anomaly of original tracks, and
d) FA climatology for the week.
Verification is included above (e).

This forecast for August 1, 1999 shows a high confidence for storms in the WNP, ENP and ATL basins (b). One storm in the WNP and two in the ENP verify (e).

5. Hindcast Results

Anomaly Count Correlations



Correlations are calculated during active season only.

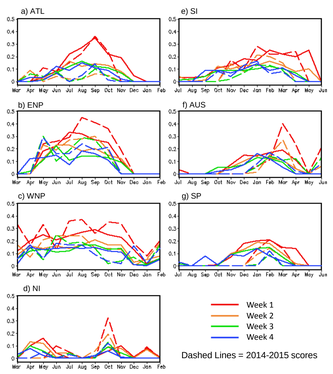
Anomaly Count Correlations:

- Based on daily storm activity
- Highest Week 1 scores = ENP, WNP, SI, and SP basins (average values between 0.50-0.52).
- ATL average correlation (0.36) brought down by two bad years (2002 and 2003).
- Skill drops with lead time, but still evident in Weeks 2-4.

Storm Track Heidke Skill Scores (HSS):

- Highest Week 1 scores = ATL, ENP and WNP basins with scores between 0.25 and 0.35 for the most active part of the season.
- SH basins show an increase in scores in the latter half of the season instead of a peak in February.
- Week 2 skill drops, but remains steady for Weeks 3-4.
- Real-time prediction scores for 2014-2015 show increased scores in most basins.

Storm Track Heidke Skill Scores

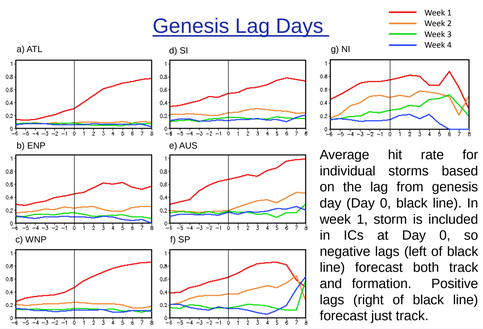


Because of the nature of the HSS, months with no storms will have a score of zero. No credit is given for correctly forecasting no storms when there are also no hits. Therefore, as expected, the scores increase with increased activity.

Genesis Lag Days:

- Uptick at Day 0 when the storm is first included in the ICs, but still considerable skill in the earlier lags.
- For week 2-4, skill drops significantly, but some basins (NI, SP) show promise in week 2.

Genesis Lag Days



Average hit rate for individual storms based on the lag from genesis day (Day 0, black line). In week 1, storm is included in ICs at Day 0, so negative lags (left of black line) forecast both track and formation. Positive lags (right of black line) forecast just track.

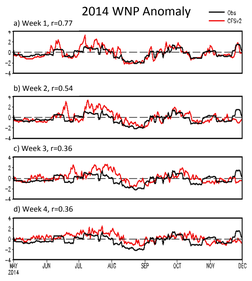
6. Real-Time Prediction

Ongoing real-time prediction began December 2013 using daily 16-member operational runs.

Anomaly Count Correlations

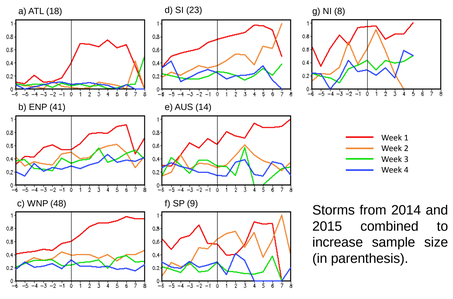
Year	Week	ATL	ENP	WNP	NI	SI	AUS	SP
2014	1	**0.56**	0.40	**0.77**	0.24	**0.72**	0.06	0.26
	2	**0.53**	**0.52**	**0.54**	0.14	**0.53**	-0.28	0.34
	3	**0.41**	**0.49**	**0.36**	0.05	0.06	-0.37	**0.37**
	4	**0.42**	**0.45**	**0.36**	-0.04	-0.13	-0.29	**0.29**
2015	1	**0.49**	**0.52**	**0.62**	**0.35**	0.35	0.37	**0.52**
	2	**0.34**	**0.42**	**0.76**	0.10	0.18	**0.32**	0.27
	3	**0.21**	**0.35**	**0.45**	-0.17	0.11	0.08	0.02
	4	**0.26**	**0.30**	**0.26**	0.00	0.18	-0.16	-0.03

Note: 2014 SH correlations are for 1/1/14-5/30/14. 2015 NH correlations are through 10/14/15.
Bold = Higher correlation versus hindcast average.



Almost all ATL, ENP and WNP correlations are higher than their average hindcast correlations, while the NI and SH basins show mostly lower skill. Higher correlations are to be expected with the shortened lead time of the ensemble members.

Genesis Lag Days



Storms from 2014 and 2015 combined to increase sample size (in parenthesis).

- Although noisier, 2014-2015 lags are similar to hindcast lags in Week1 and overall show increased skill in real-time prediction.
- Later weeks show more skill than the hindcast in all basins except ATL.
- Consistent with increased HSS.
- Although SI and AUS show relatively good skill in predicting observed storms, the count correlations are low, indicating an abundance of FAs.

7. Summary

- New product on TC intraseasonal prediction developed for CPC forecasters.
- Provides guidance on both storm count and location
  - Although skill drops with lead time, weeks 2-4 still show skill for both storm count and track.
- Real-time experimental predictions for 2014 and 2015 season show increased skill
  - Indicates predictability for ATL, ENP and WNP, while SH basins can still struggle with FAs.
- Daily updates available at: ftp://ftp.cpc.ncep.noaa.gov/llong/main.html