Improvements and Extensions to an Existing Probabilistic TC Genesis Forecast Tool Using an Ensemble of Global Models

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Prior JHT Project (FY13-15)

Prior project goals (FY13-15)

- Verify TC genesis forecasts from global model output and record relevant variables over the AL and EP basins since 2004.

- Use the archived model forecasts as a training dataset to develop logistic regression equations that yield probabilistic TC genesis guidance.

- Apply the regression equations to real-time global model output.

- Produce graphical and text based products in real-time to NHC forecasters.

Review of prior work

- Developmental dataset created from archive of forecast output from global models.
  - GFS, UKMET, CMC included.
  - Archive of ECMWF forecasts available, but real-time model fields inaccessible.
  - Archive of NAVGEM forecasts too short to develop regression equations (at the time).
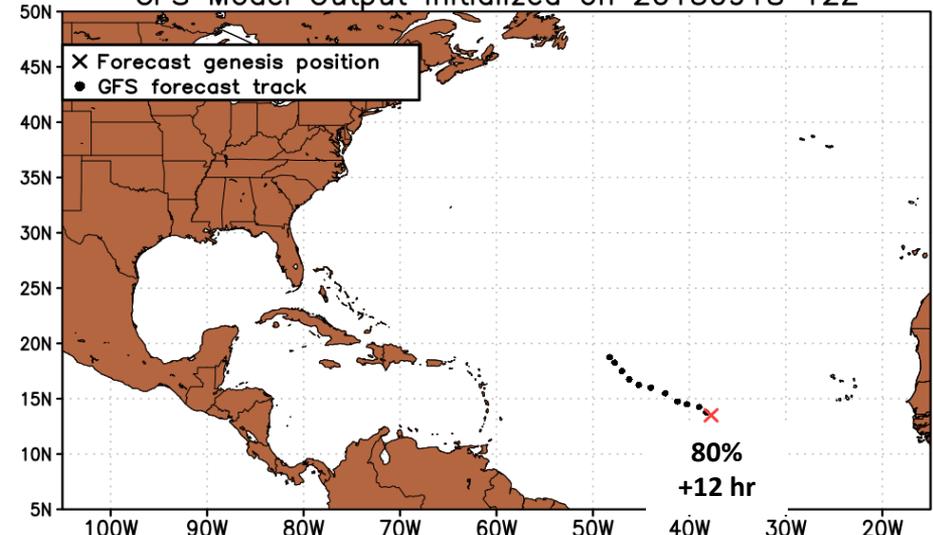
Review of prior work

- Probabilistic 2- and 5-day TC genesis forecasts calculated using the regression equations for the AL and EP basins.

Experimental Probability of TC Genesis
at Anytime Within 48 Hours
GFS Model Output Initialized on 20150825 12Z
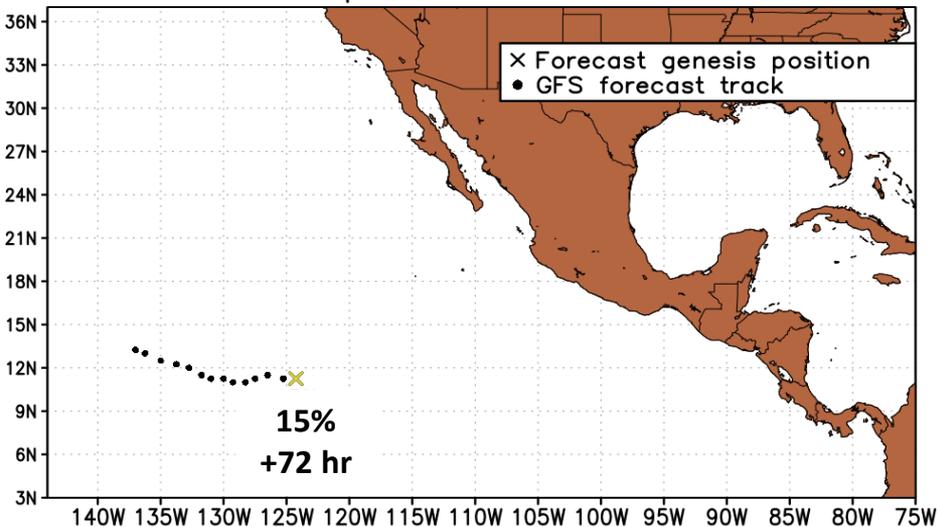
× Forecast genesis position
• GFS forecast track

15%
+72 hr

http://moe.met.fsu.edu/modelgen

Experimental Probability of TC Genesis
at Anytime Within 120 Hours
GFS Model Output Initialized on 20150918 12Z

× Forecast genesis position
• GFS forecast track

80%
+12 hr

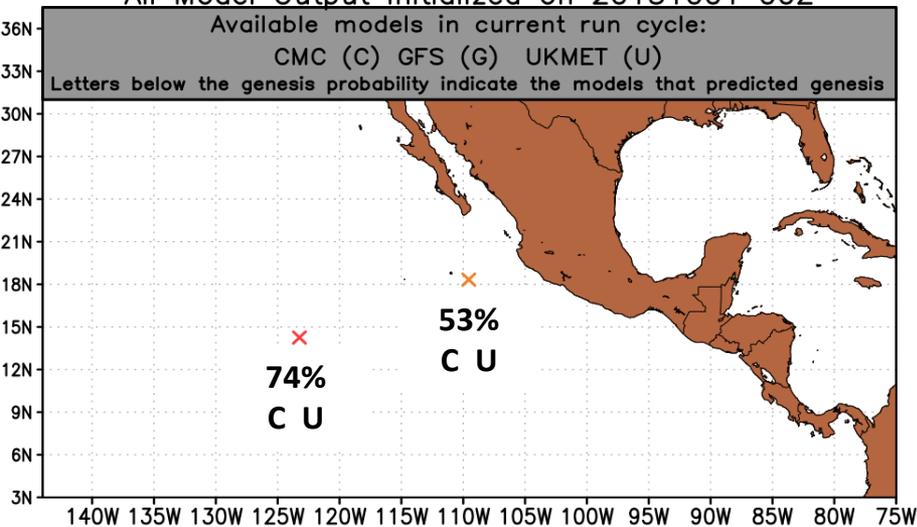http://moe.met.fsu.edu/modelgen
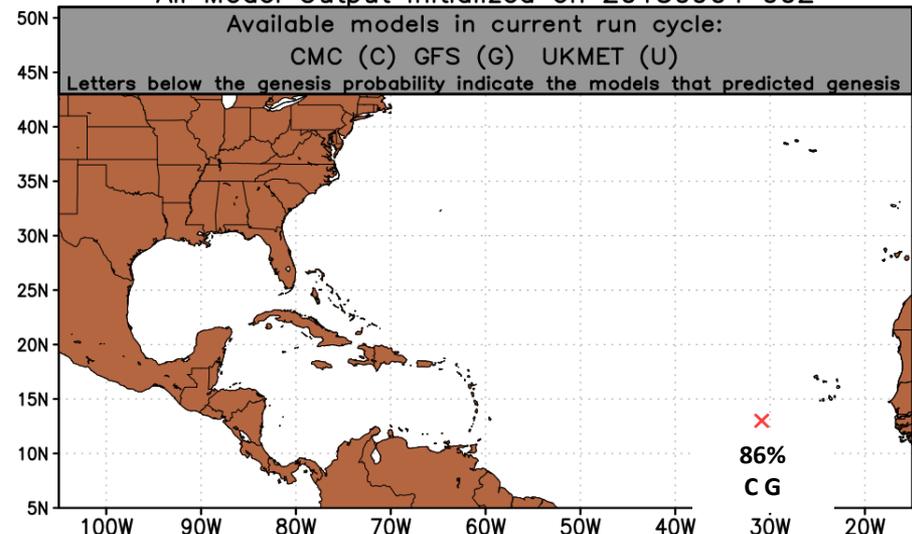
Review of prior work

- Consensus regression equation developed to provide one probability of genesis when multiple models predicted the same genesis event.

Experimental Probability of TC Genesis at Anytime Within 48 Hours
All Model Output Initialized on 20151001 00Z
Available models in current run cycle:
CMC (C) GFS (G) UKMET (U)
Letters below the genesis probability indicate the models that predicted genesis

53% C U
74% C U

http://moe.met.fsu.edu/modelgen

Experimental Probability of TC Genesis at Anytime Within 120 Hours
All Model Output Initialized on 20150904 00Z
Available models in current run cycle:
CMC (C) GFS (G) UKMET (U)
Letters below the genesis probability indicate the models that predicted genesis

86% C G

http://moe.met.fsu.edu/modelgen

Review of prior work

- Verification revealed well-calibrated forecasts in forecast probability intervals > 50%.

Adapted from Halperin et al. (2017)
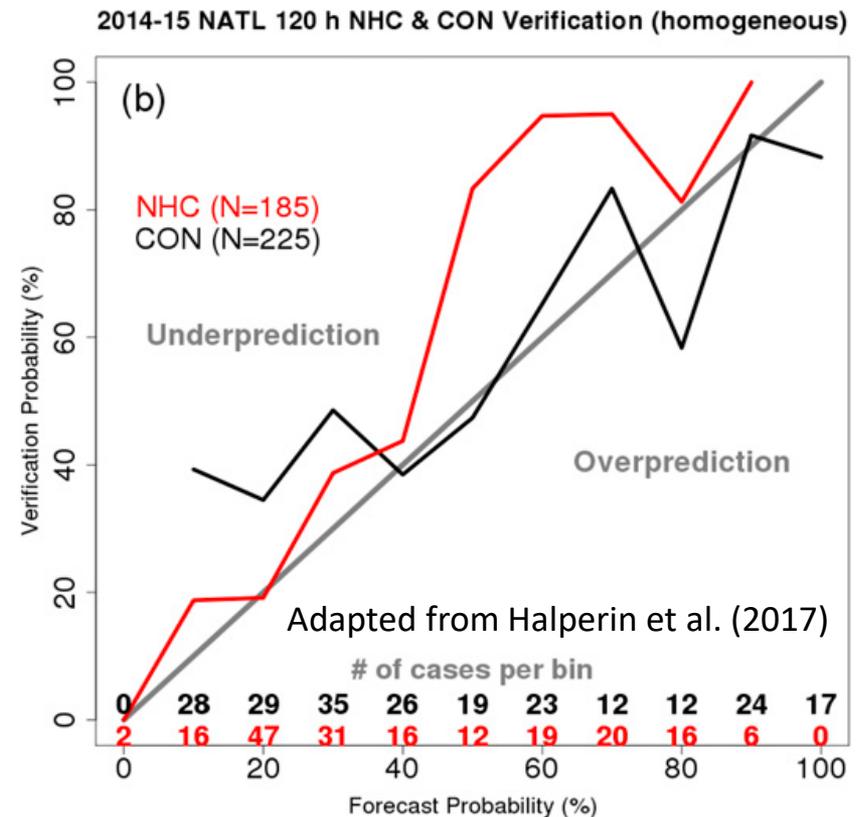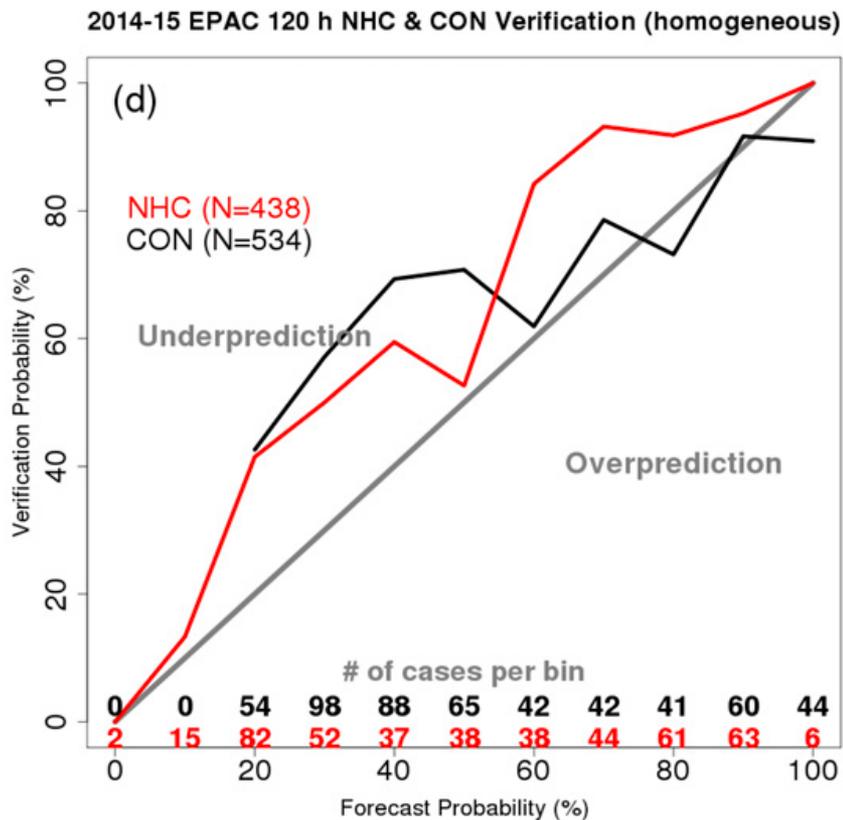
Issue: Consensus tracker

- Existing consensus tracking algorithm unable to correctly group TC genesis events with different forecast genesis times.

Experimental Probability of TC Genesis at Anytime Within 120 Hours
All Model Output Initialized on 20140820 12Z

http://moe.met.fsu.edu/modelgen
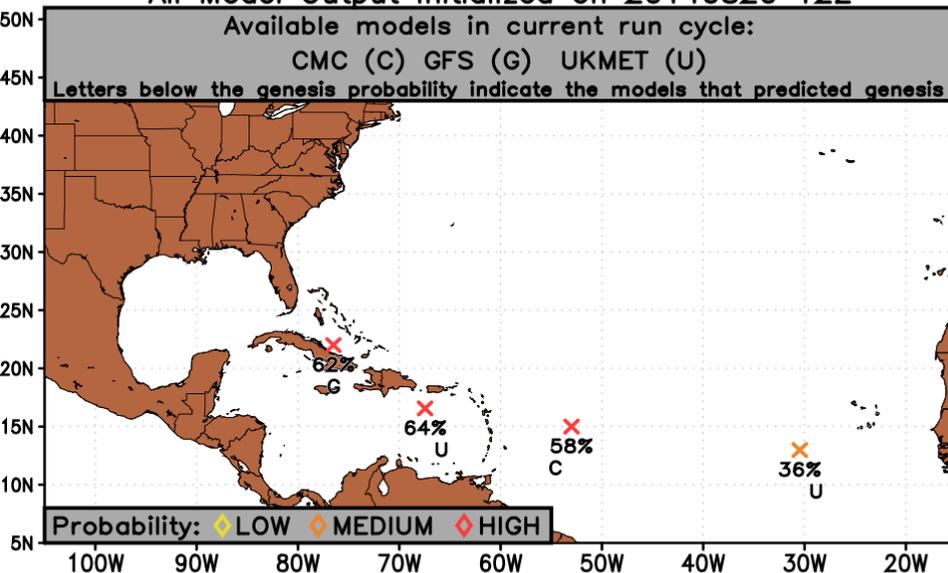
Experimental 5-Day Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida
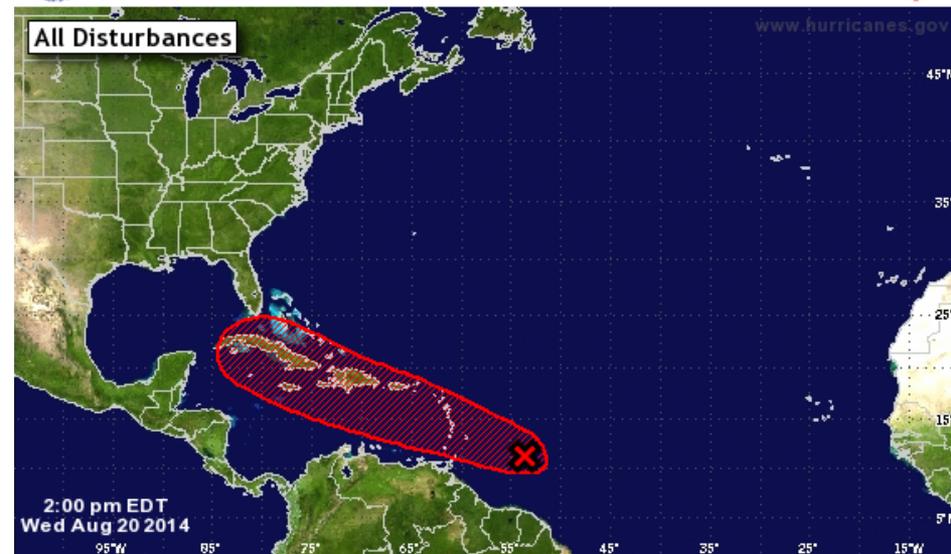
Tropical Cyclone Formation Potential for the 5-Day Period Ending 2:00 pm EDT Mon Aug 25 2014
Chance of Cyclone Formation in 5 Days: ▢ Low < 30% ▢ Medium 30-50% ▮ High > 50%
X indicates current disturbance location; shading indicates potential formation area.

Issue: High-latitude events

- Many Best-Track TC genesis events poleward of 25°N were not detected using our tracker.

- Anecdotally it appeared that the thickness threshold criterion was often not met for these higher-latitude TC genesis events.

- This is reasonable since the number of actual genesis events at higher latitude is small and the optimization of thresholds would target the higher frequency lower latitude events.

Review of prior work

- The guidance products from the FY13-15 JHT project received favorable reviews with respect to forecast benefit and product efficiency.

- Given the aforementioned areas for improvement and some technical incompatibilities, a new proposal was submitted to JHT for FY17-19.

Current JHT Project (FY17-19)

Current project goals (FY17-19)

- Build on the success and constructive forecaster feedback from the FY13-15 JHT award.

- Enhance consensus tracker algorithm.

- Increase probability of detection for TC genesis events in the subtropics.

- Test feasibility of new datasets (NAVGEM).

- Extend guidance to the CP basin.

- Verify TC genesis forecasts from FV3 GFS.

Summary of technical accomplishments in first six months

- *moe.met.fsu.edu/modelgen* maintained very reliably to provide real-time guidance (except for multi-day power outages due to Hermine and Irma).

- Rewrote scripts to ingest/process the UKMET data files in GRIB2 format and with much higher resolution.

- Filled in data gaps in GFS, UKMO, and NAVGEM from tapes at FSU and other resources.

- Developmental dataset ready for transfer to NHC, per their request.

- Began converting scripts originally written in GrADS and R to Python.

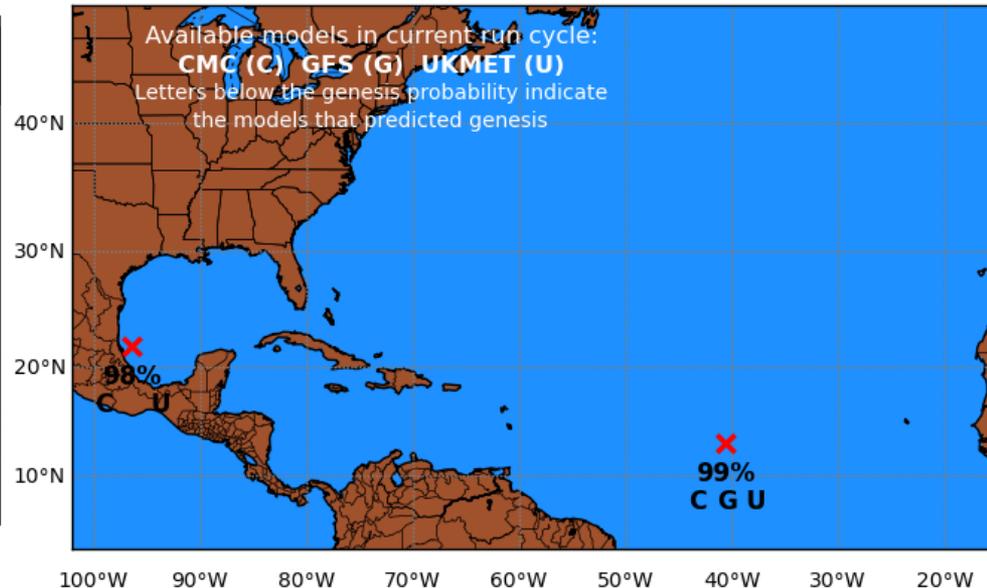# Summary of technical accomplishments in first six months

- All graphics converted to Python.

Experimental Probability of TC Genesis at Anytime Within 120 Hours
All Model Output Initialized on 20160905 00Z
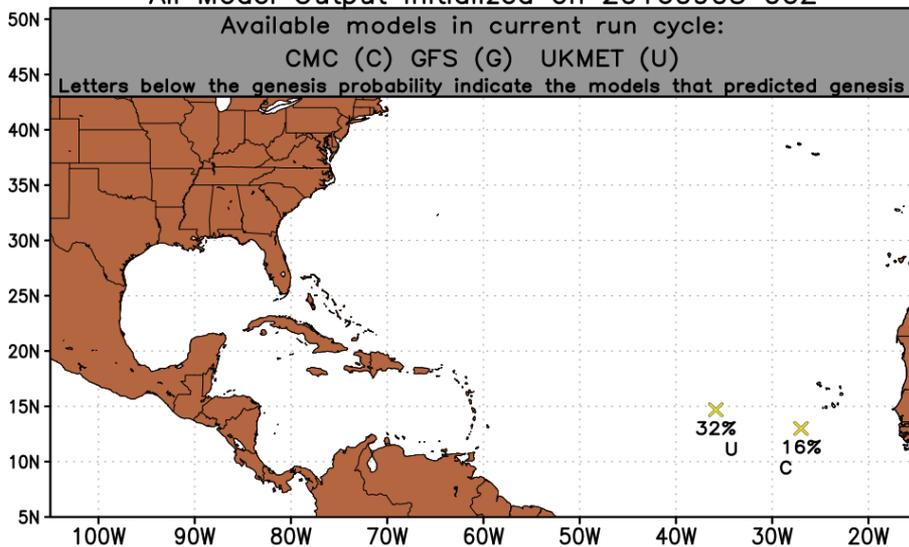
Experimental 0-120 h TC genesis probability
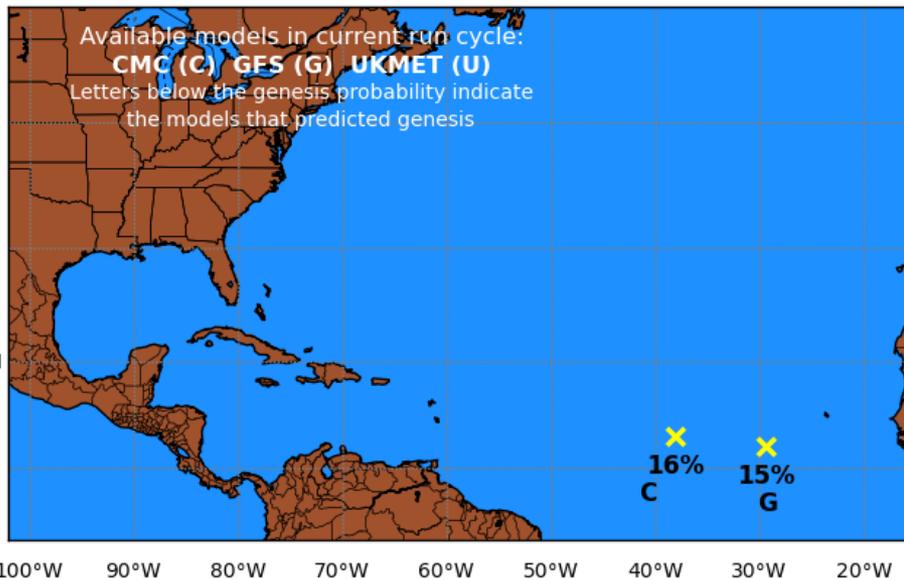CON model output initialized 2017-09-05 00Z

http://moe.met.fsu.edu/modelgen

New consensus tracker

- Consensus tracker updated to account for genesis location differences due to forecast genesis time differences.
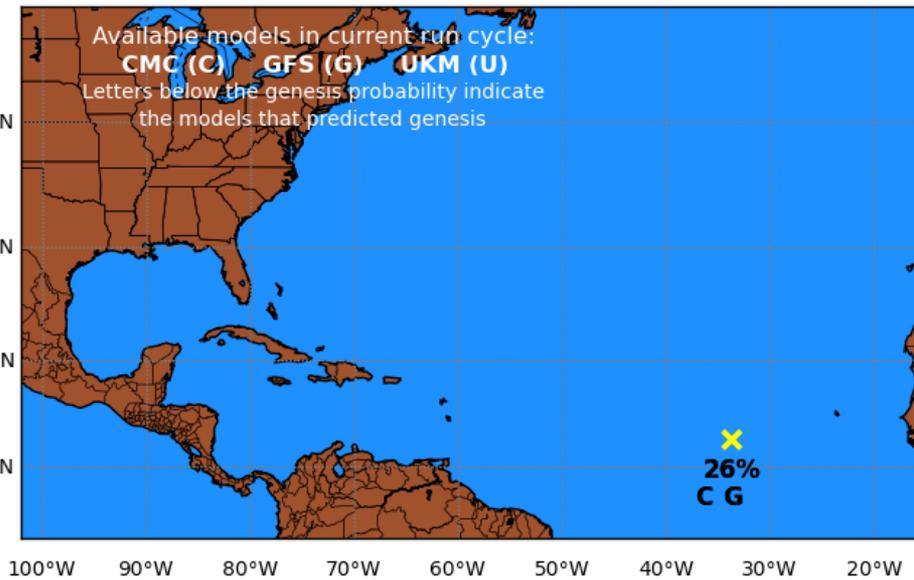
Output from old consensus tracker

Experimental 0-120 h TC genesis probability
CON model output initialized 2017-09-07 12Z

Available models in current run cycle:
CMC (C)   GFS (G)   UKMET (U)
Letters below the genesis probability indicate
the models that predicted genesis

16%
C

15%
G

http://moe.met.fsu.edu/modelgen

Output from new consensus tracker

Experimental 0-120 h TC genesis probability
CON model output initialized 2017-09-07 12Z

Available models in current run cycle:
CMC (C)   GFS (G)   UKM (U)
Letters below the genesis probability indicate
the models that predicted genesis
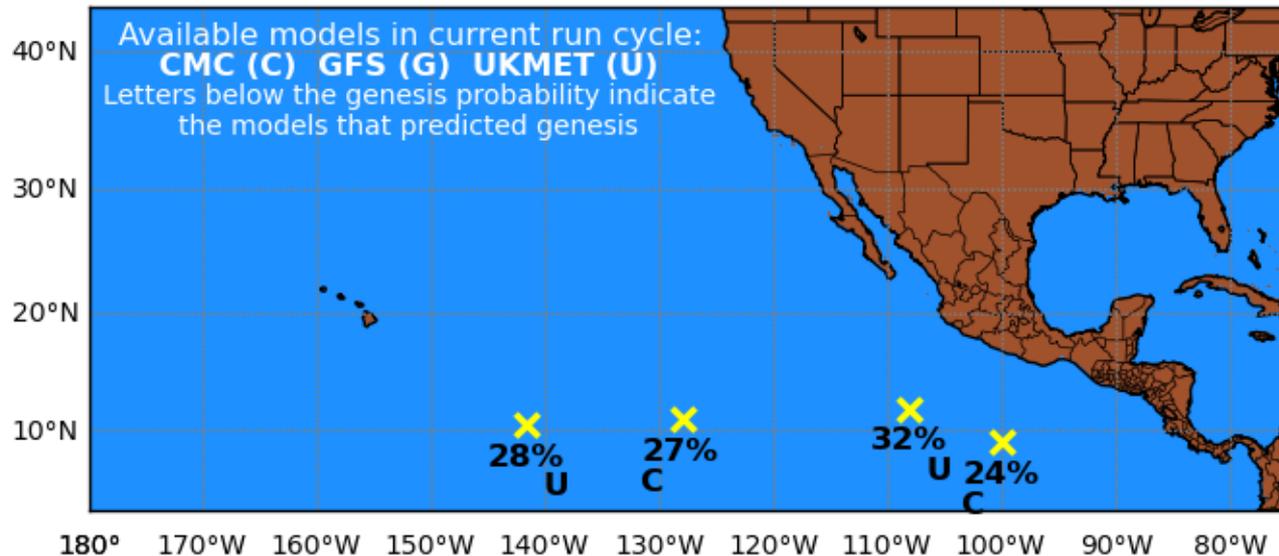
26%
C G

http://moe.met.fsu.edu/modelgen
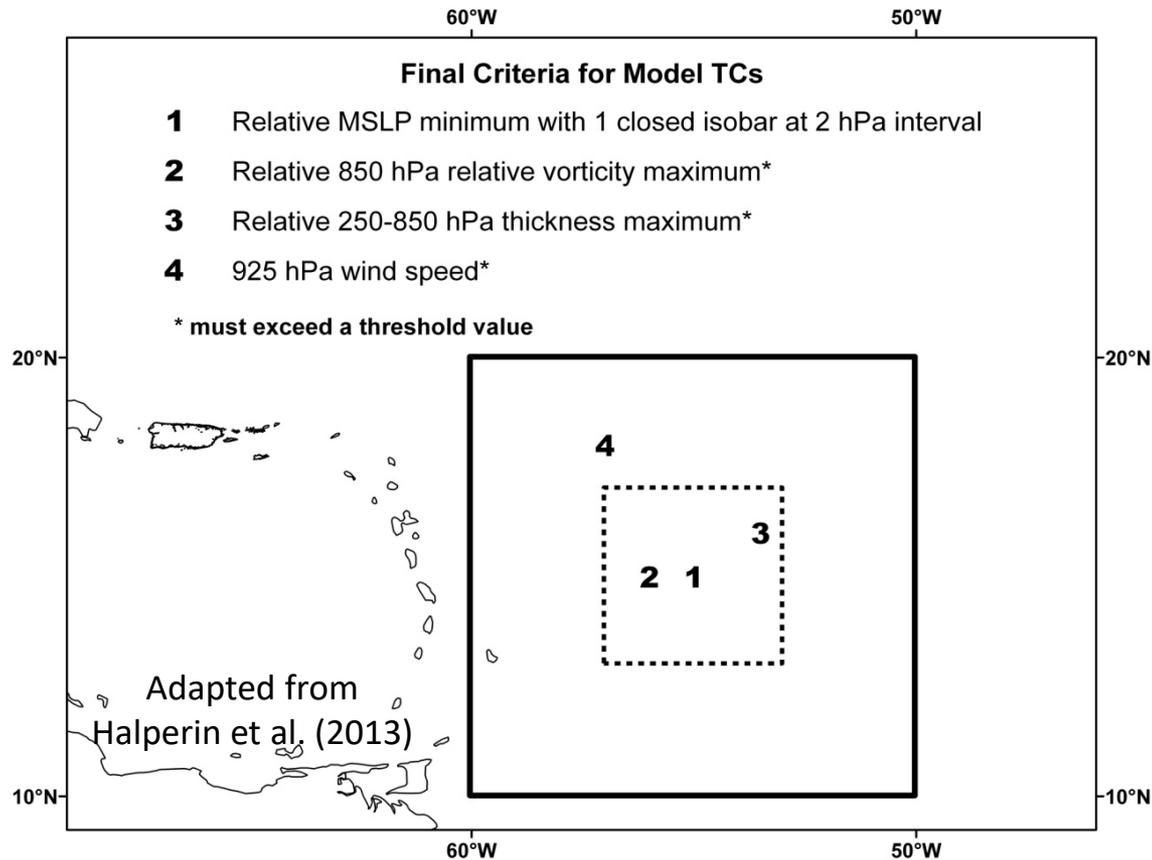
Extended guidance to CP basin

- Uses EP regression equations.
- Additional development planned.

Experimental 0-120 h TC genesis probability
CON model output initialized 2017-07-04 00Z

Available models in current run cycle:
CMC (C) GFS (G) UKMET (U)
Letters below the genesis probability indicate
the models that predicted genesis

28% U
27% C
32% U
24% C

http://moe.met.fsu.edu/modelgen

TC genesis criteria

Final Criteria for Model TCs

1   Relative MSLP minimum with 1 closed isobar at 2 hPa interval

2   Relative 850 hPa relative vorticity maximum*

3   Relative 250-850 hPa thickness maximum*

4   925 hPa wind speed*

* must exceed a threshold value

Adapted from
Halperin et al. (2013)

Criteria 1-4 must be satisfied for at least 24 consecutive hours in the forecast cycle.

TC genesis criteria
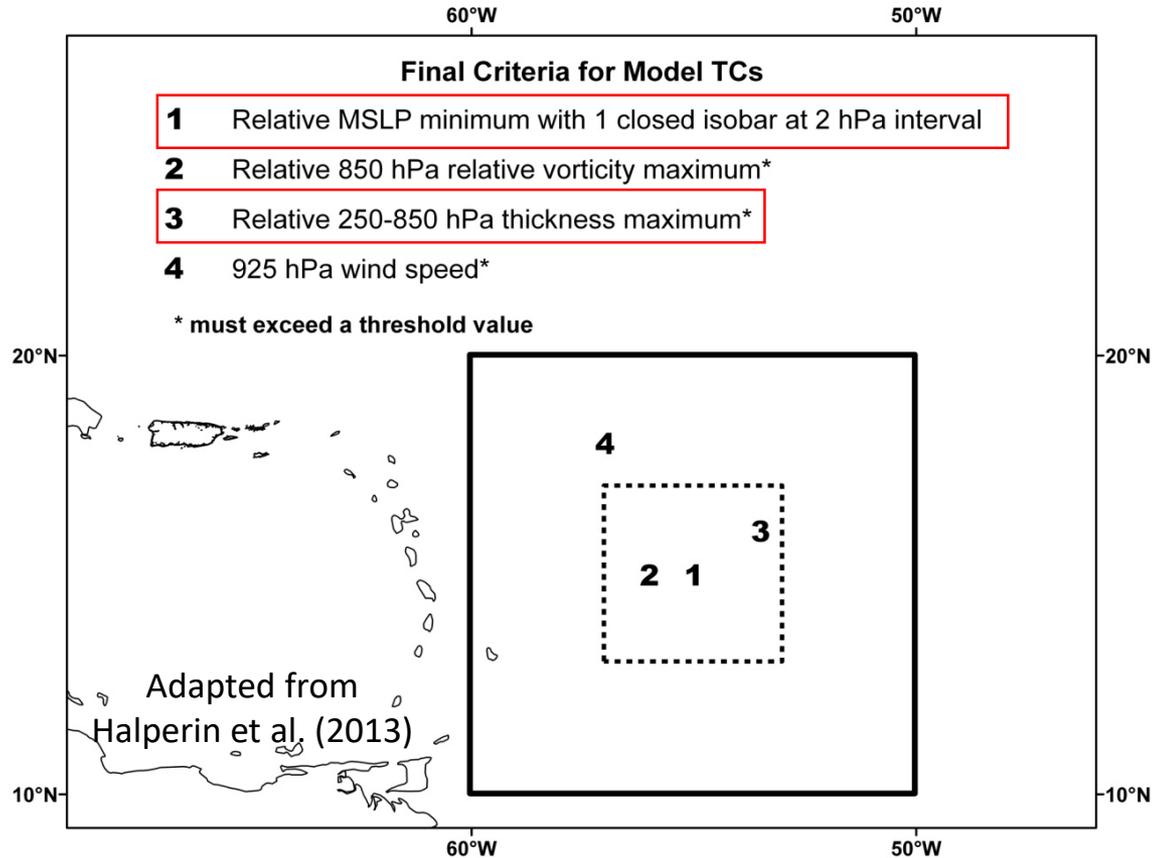
Adapted from Halperin et al. (2013)

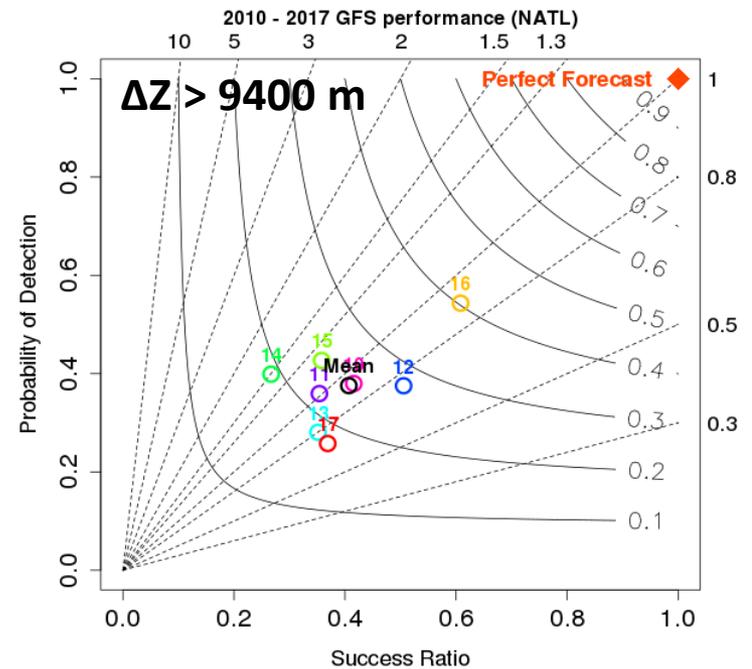Criteria 1-4 must be satisfied for at least 24 consecutive hours in the forecast cycle.
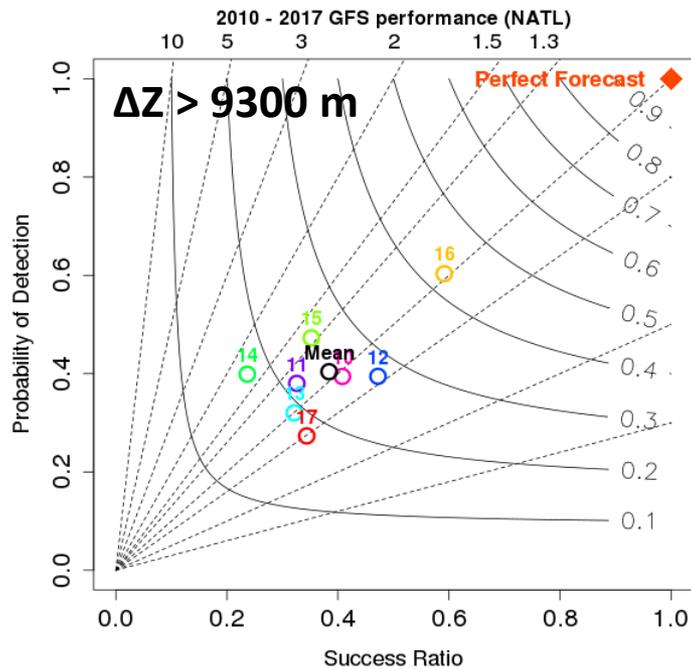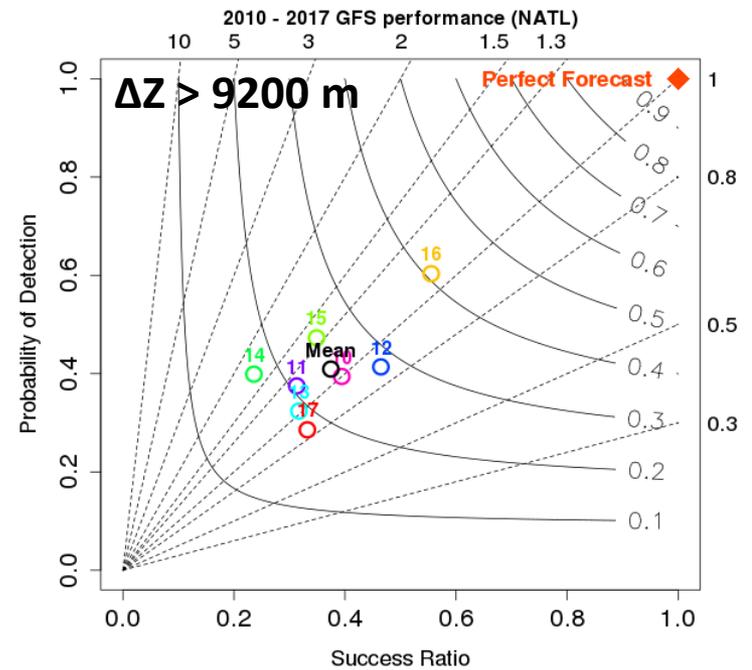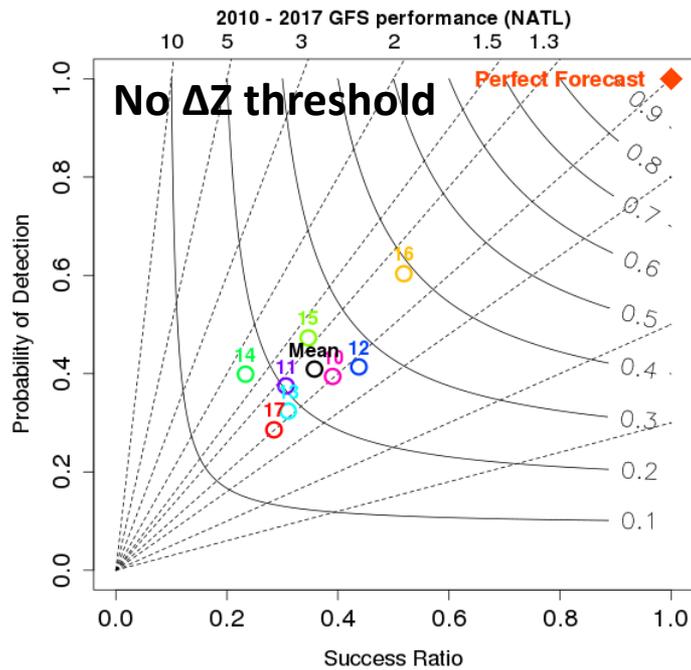
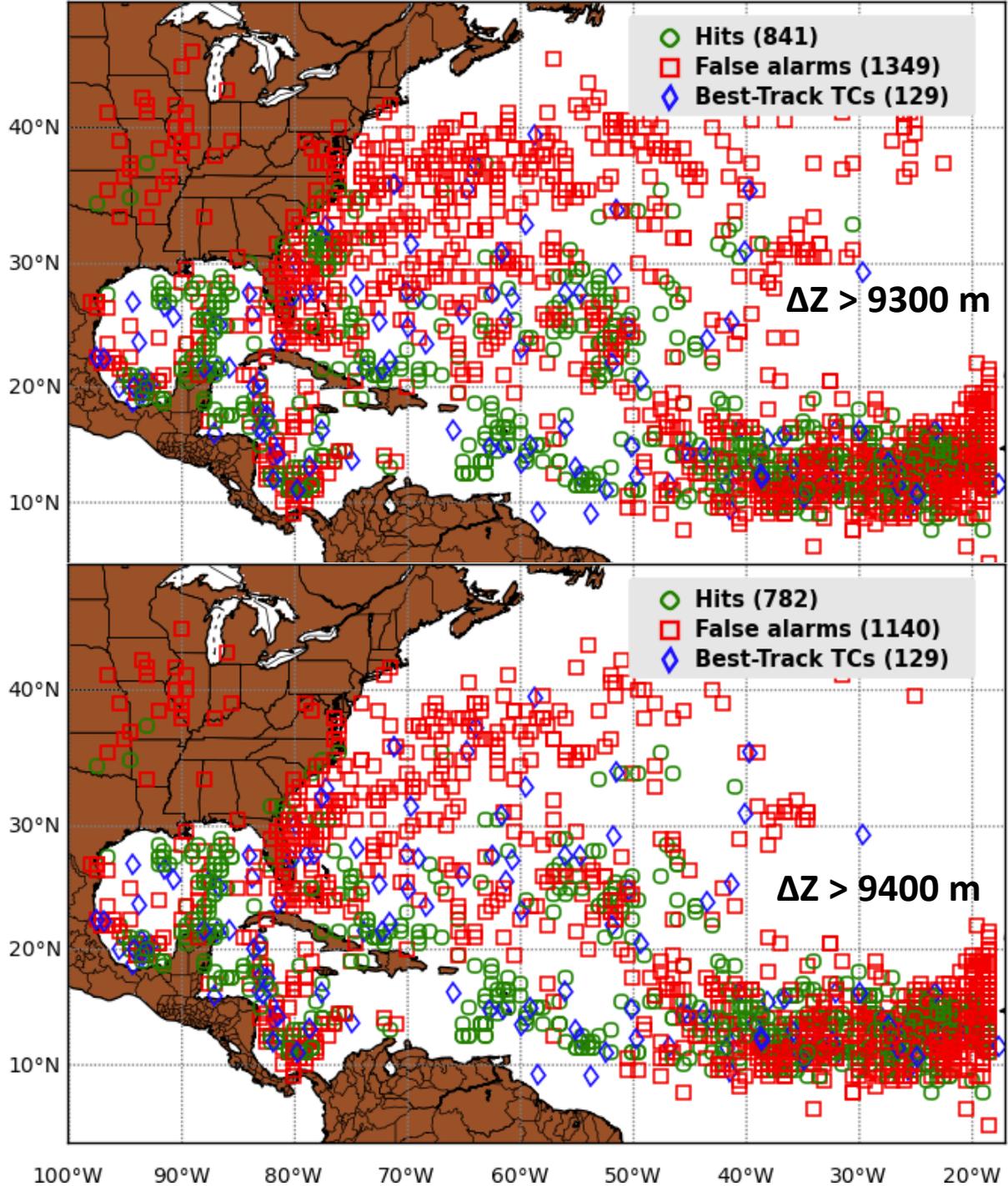## Performance Diagram
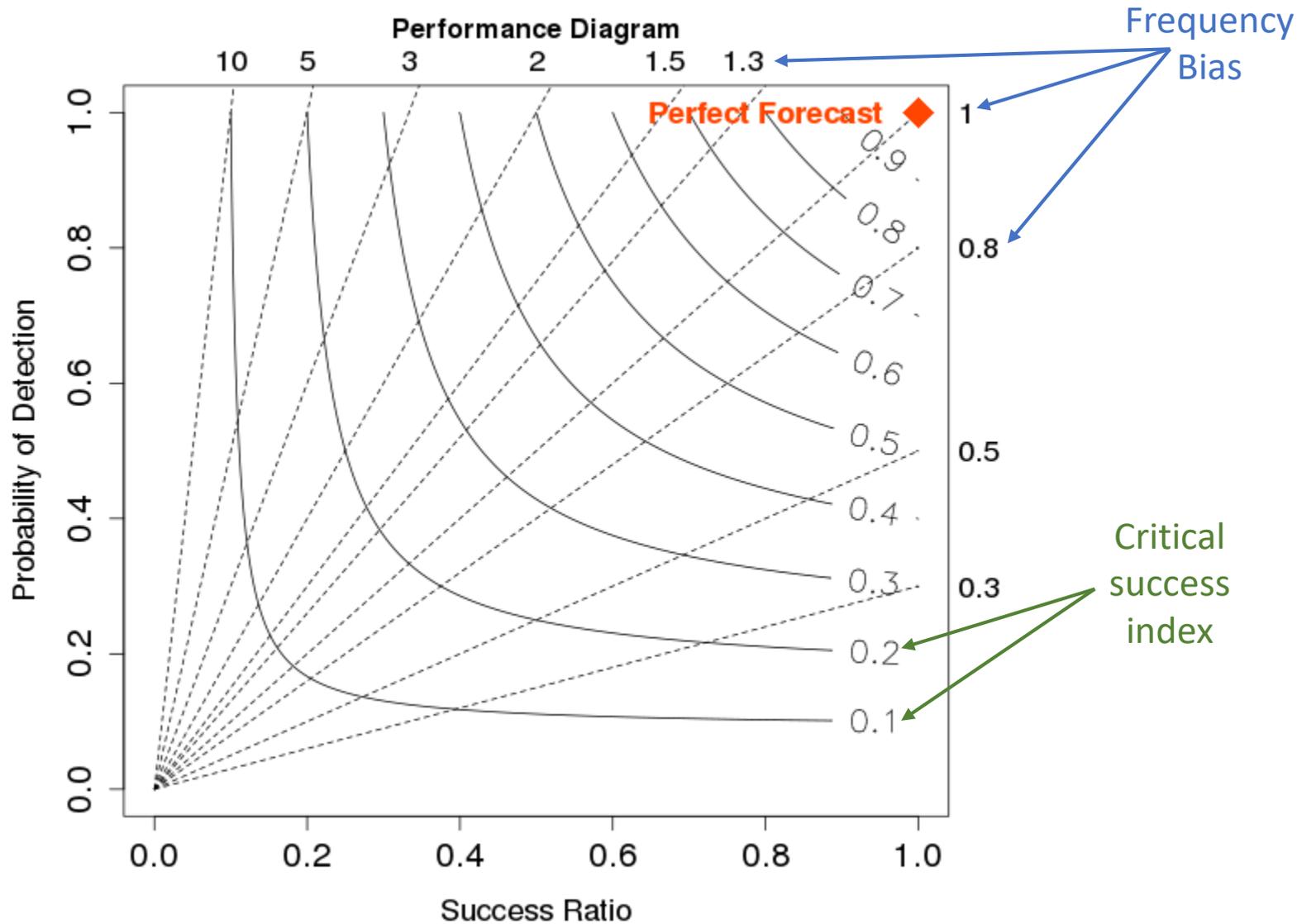
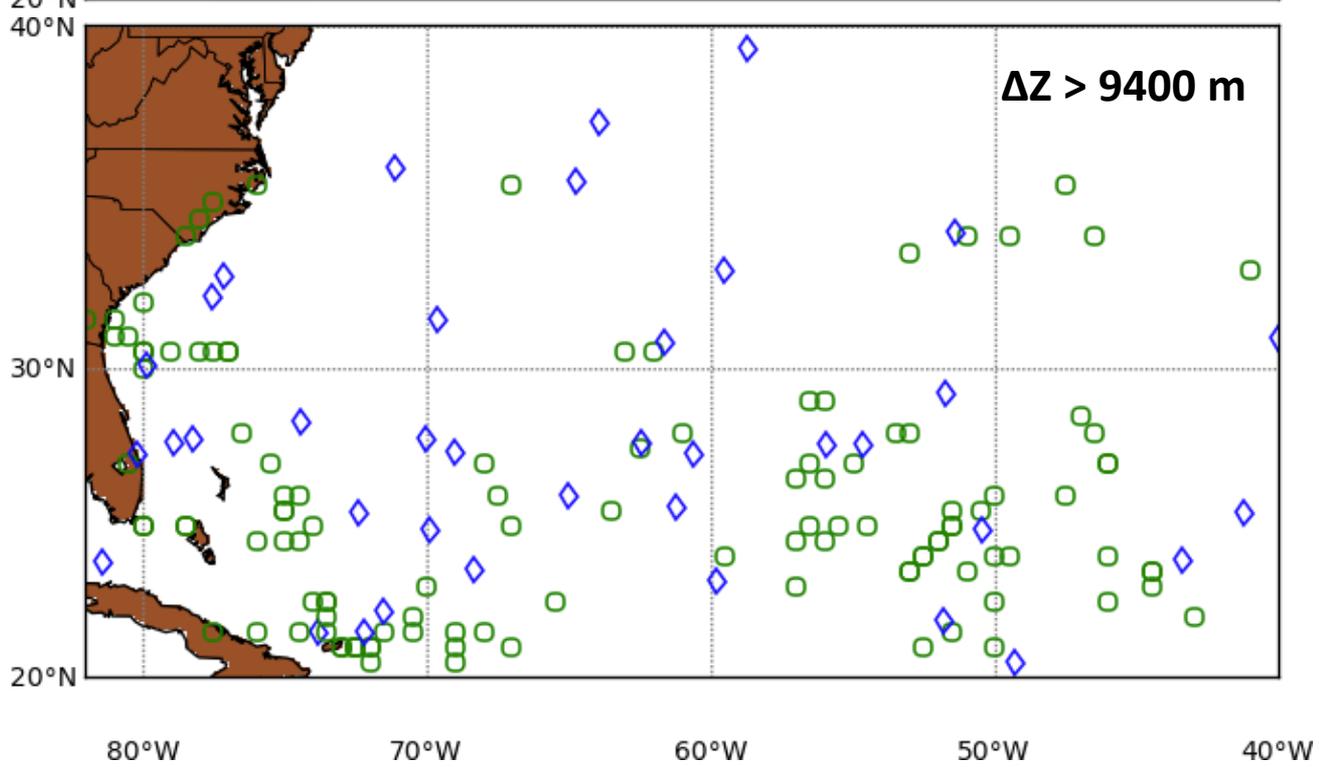$$SR = 1 - \frac{FA}{Hit + FA}$$

$$POD = \frac{Hit}{Hit + Miss}$$

$$Bias = \frac{Hit + FA}{Hit + Miss}$$

$$CSI = \frac{Hit}{Hit + FA + Miss}$$

Top left panel: 2010 - 2017 GFS performance (NATL)

No ΔZ threshold

Perfect Forecast ◆

x-axis: Success Ratio
y-axis: Probability of Detection

Top right panel: 2010 - 2017 GFS performance (NATL)

ΔZ > 9200 m

Perfect Forecast ◆

Bottom left panel: 2010 - 2017 GFS performance (NATL)

ΔZ > 9300 m

Perfect Forecast ◆

Bottom right panel: 2010 - 2017 GFS performance (NATL)

ΔZ > 9400 m

Perfect Forecast ◆

2010 – 2017 GFS TC genesis forecasts

Legend (top panel):
- Hits (841)
- False alarms (1349)
- Best-Track TCs (129)

ΔZ > 9300 m

Legend (bottom panel):
- Hits (782)
- False alarms (1140)
- Best-Track TCs (129)

ΔZ > 9400 m

ΔZ > 9300 m

ΔZ > 9400 m
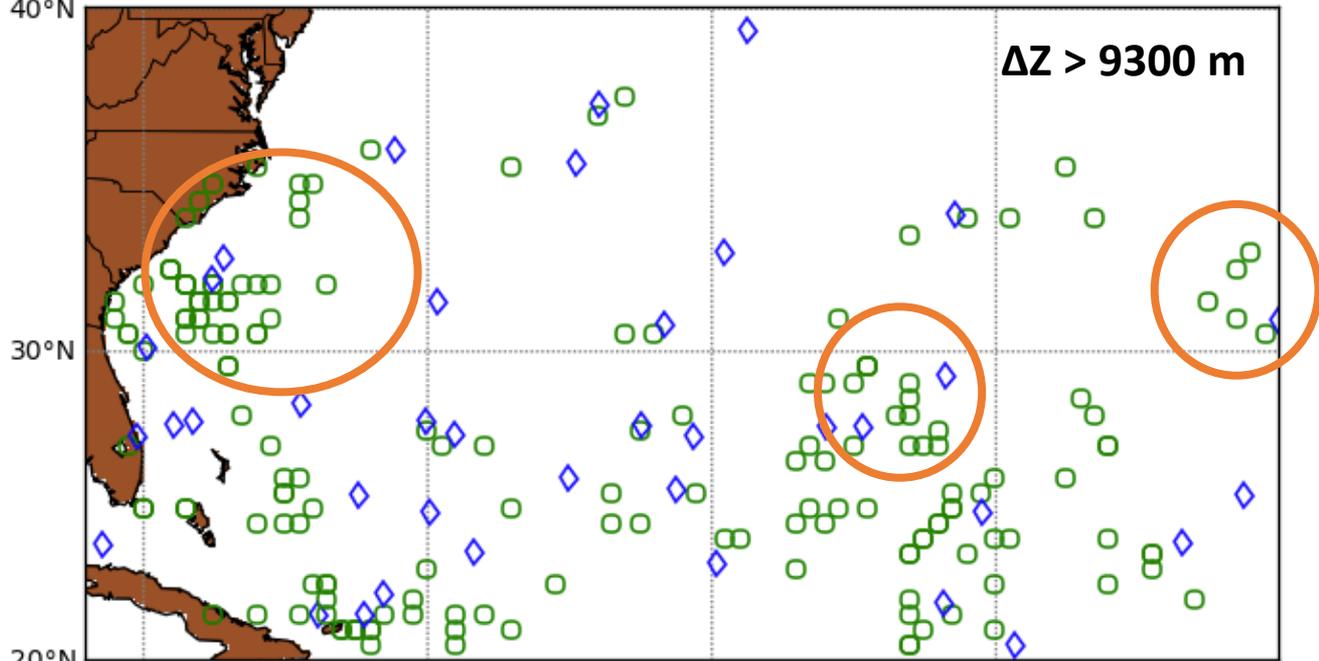
Plans for 2018

- Continue providing real-time guidance at http://moe.met.fsu.edu/modelgen.

- Re-calculate logistic regression equations.

- Develop and implement NAVGEM-based guidance.

- Implement new consensus tracker.

- Provide parallel guidance products with experimental TC genesis criteria.

- Present updated results at AMS Tropical Conference in April.

- Solicit feedback from NHC during and after TC season.

Extras

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** Tropical Disturbance #3 Information **
  ** GFS output initialized 2014072412 **

**GENESIS PREDICTED?      YES, at forecast hour 66**
```

TIME (hr)	48	54	60	66	72	78	84	90
GEN PROB (%)	14							
CRIT MET?	Y	N	N	Y	Y	Y	Y	Y
LAT (N)	10.50	10.50	11.00	11.00	11.00	11.50	11.50	11.50
LON (W)	119.50	120.00	120.50	121.50	123.00	123.50	124.50	125.00
925VMAX (m/s)	14.00	13.58^	13.36^	15.14	15.40	15.54	15.32	14.66
850RV (*10^-5 1/s)	25.52	22.87	22.27	22.22	19.21	18.64	18.62	18.99
250-850 THCK (m)	9495	9506	9509	9504	9503	9507	9512	9507
SFC LH FLUX	144.43	150.54	150.16	156.04	157.92	156.68	148.75	149.13
850RVPERT	25.52	22.87	22.27	22.22	19.21	18.64	18.62	18.99

```
^ indicates that the threshold value was not met
```
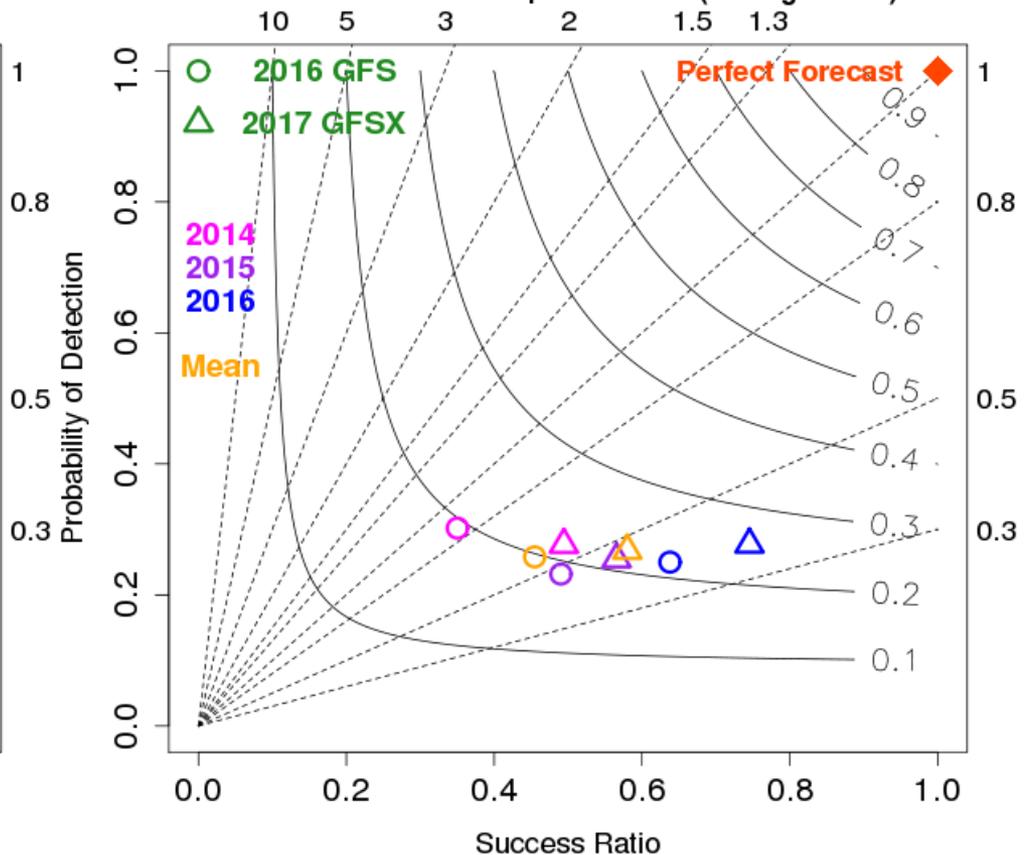

Experimental Probability of TC Genesis
at Anytime Within 120 Hours
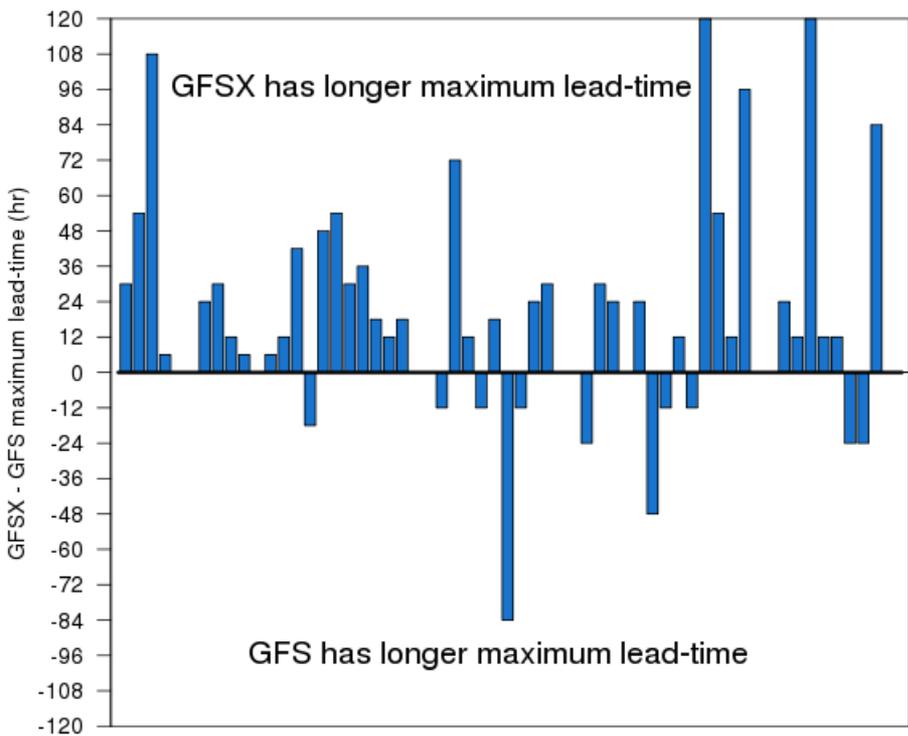GFS Model Output Initialized on 20140724 12Z
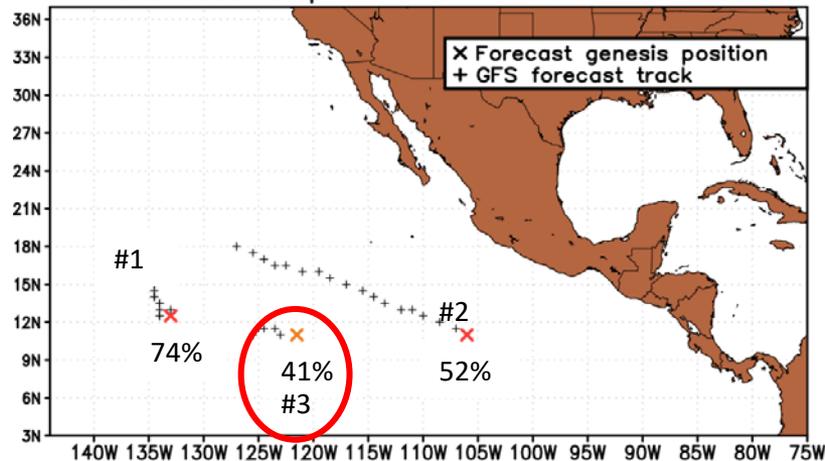
2014 - 2016 EPAC GFS performance (homogeneous)
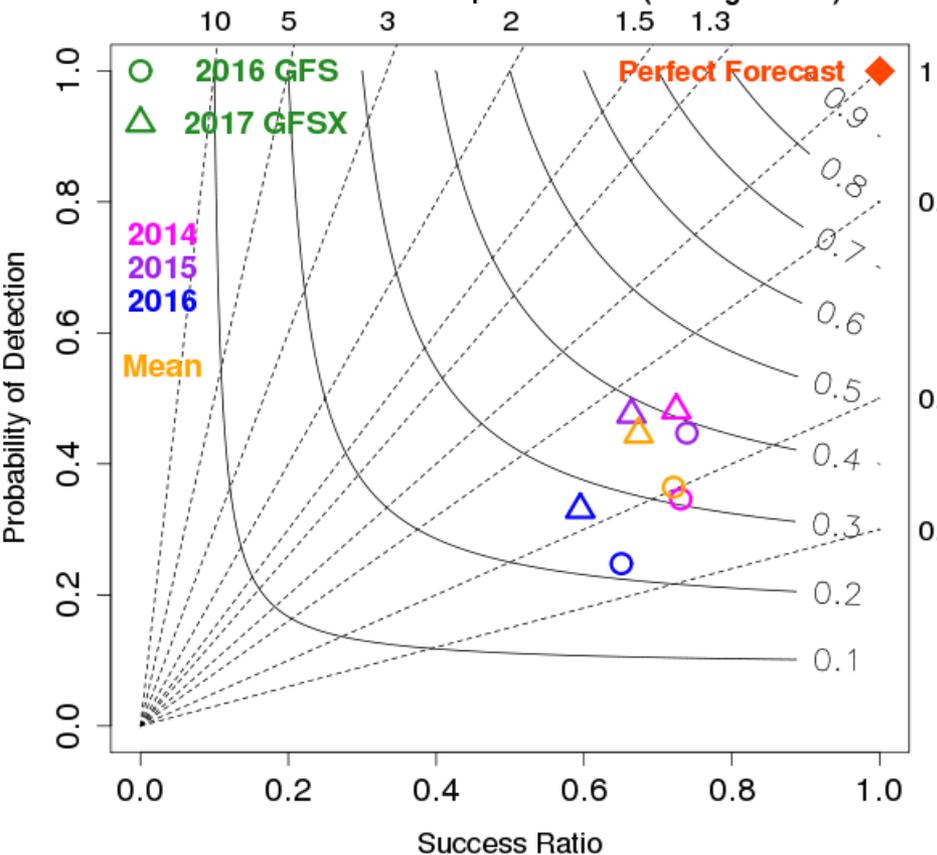
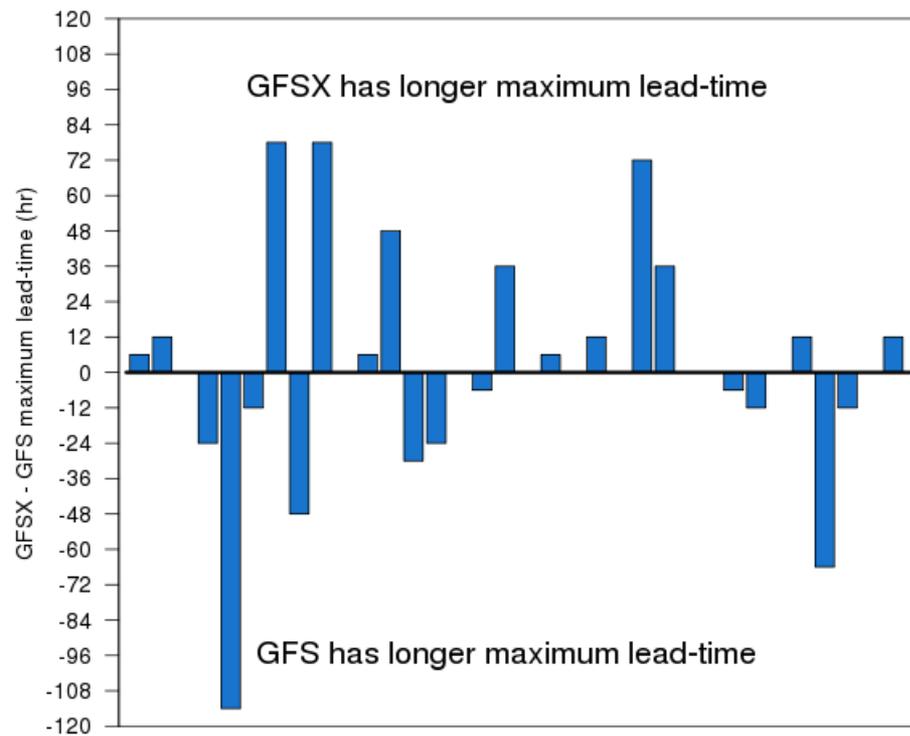2014 - 2016 NATL GFS performance (homogeneous)

Difference in maximum lead-time for each Best-Track TC (EPAC)

GFSX has longer maximum lead-time

GFS has longer maximum lead-time

GFSX - GFS maximum lead-time (hr)

Best-Track TCs

Difference in maximum lead-time for each Best-Track TC (NATL)

GFSX has longer maximum lead-time

GFS has longer maximum lead-time

GFSX - GFS maximum lead-time (hr)

Best-Track TCs