Tropical cyclone genesis:
Verifying historical forecasts and developing a statistical model from NWP output

Dan Halperin, Bob Hart, Henry Fuelberg, Josh Cossuth

Florida State University

4 March 2014

I

Background

▸ Prior research verified TC genesis forecasts out to 5 days in 5 global models over the NATL and EPAC during 2004-2012.

  ▸ CMC, ECM, GFS, NGP, UKM

▸ Halperin, D.J., H.E. Fuelberg, R.E. Hart, J.H. Cossuth, P. Sura, and R.J. Pasch, 2013: An evaluation of tropical cyclone genesis forecasts from global numerical models. *Wea. Forecasting,* **28**, 1423-1445.

▸ Current research objective: Develop probabilistic forecasts of TC genesis based on global model output.

Motivation

00Z06OCT2013 cmc MSLP (mb) T=174 h

Which lows are TCs?
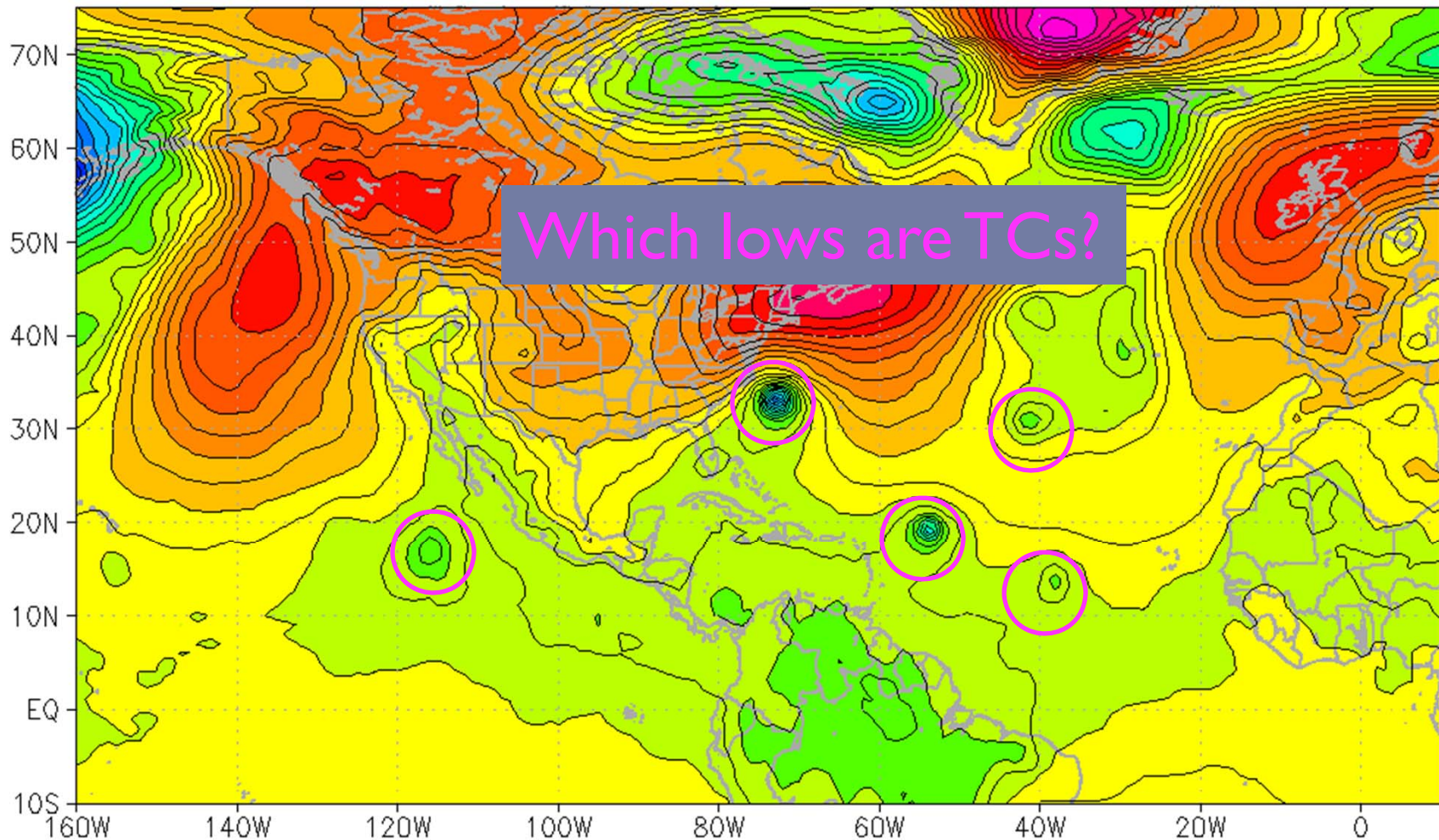
Prior Research

Summary of prior results

▸ Models' performance:

    ▸ has generally improved since 2004.

    ▸ is better in the EPAC on average due to larger probability of detection values.

    ▸ varies among different subregions in the NATL.

    ▸ expectedly decreases with increasing forecast hour.

▸ The best performing model varies from year to year and basin to basin.
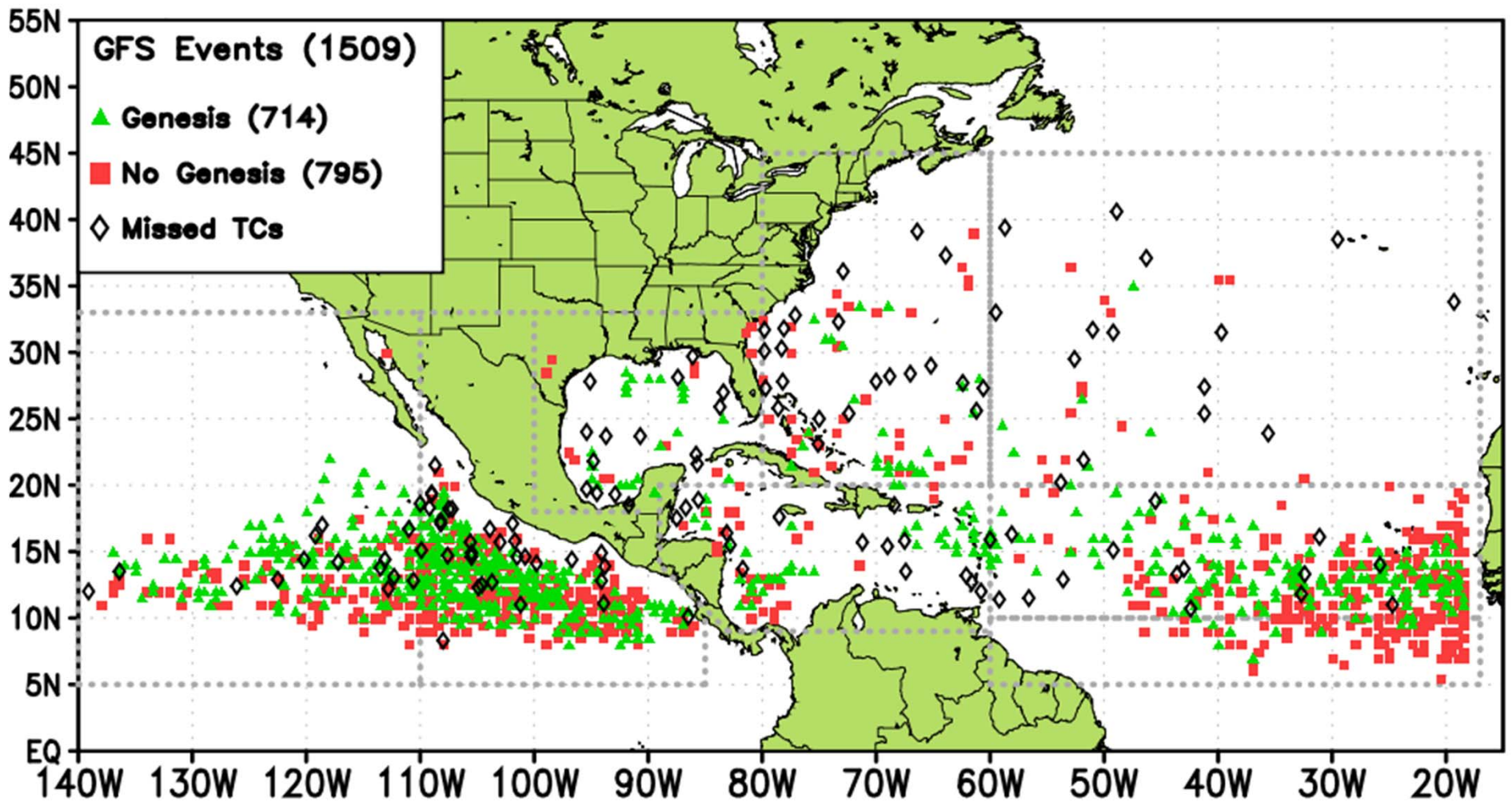
Model Performance Comparison (2007-2012 Average)
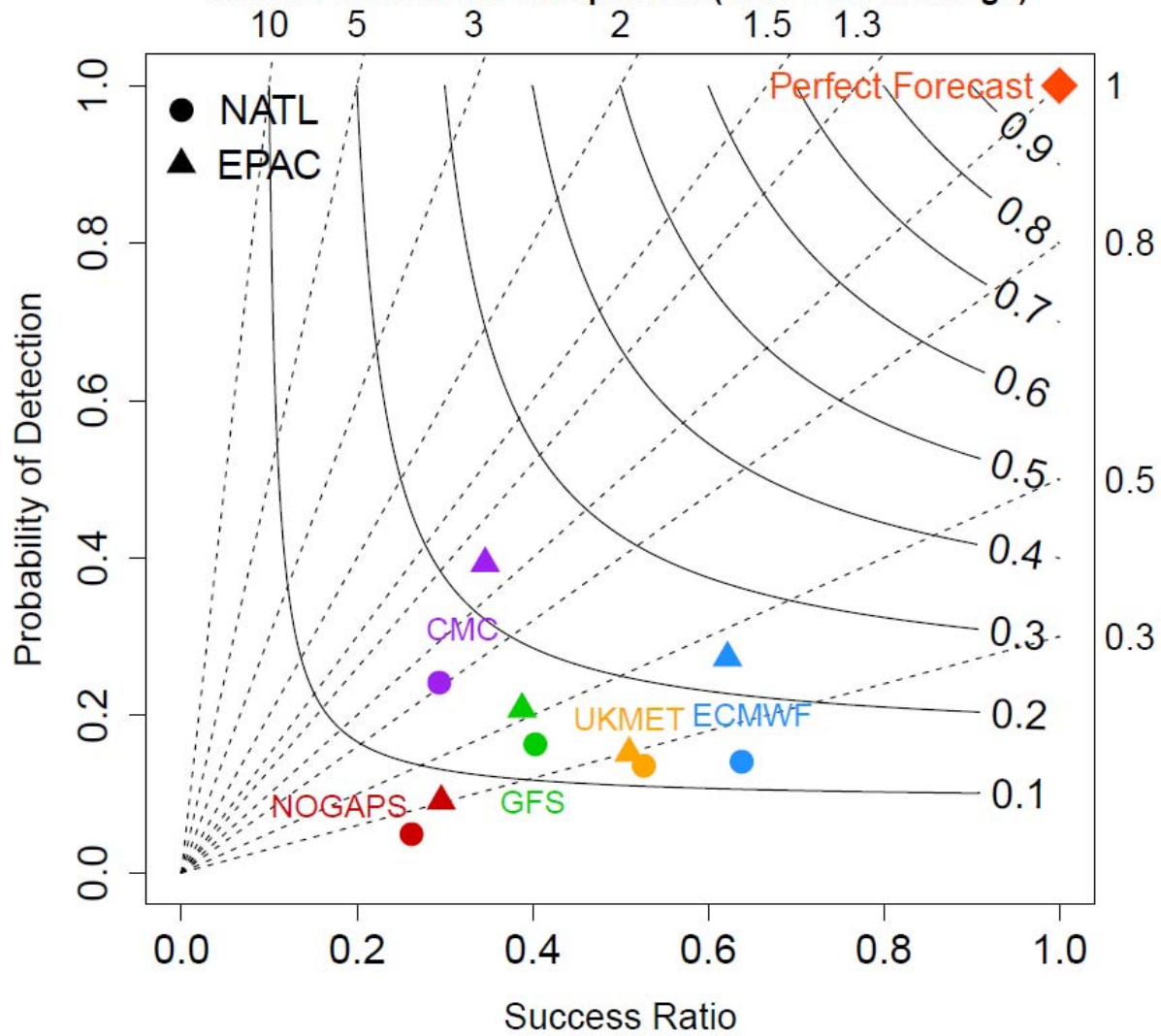
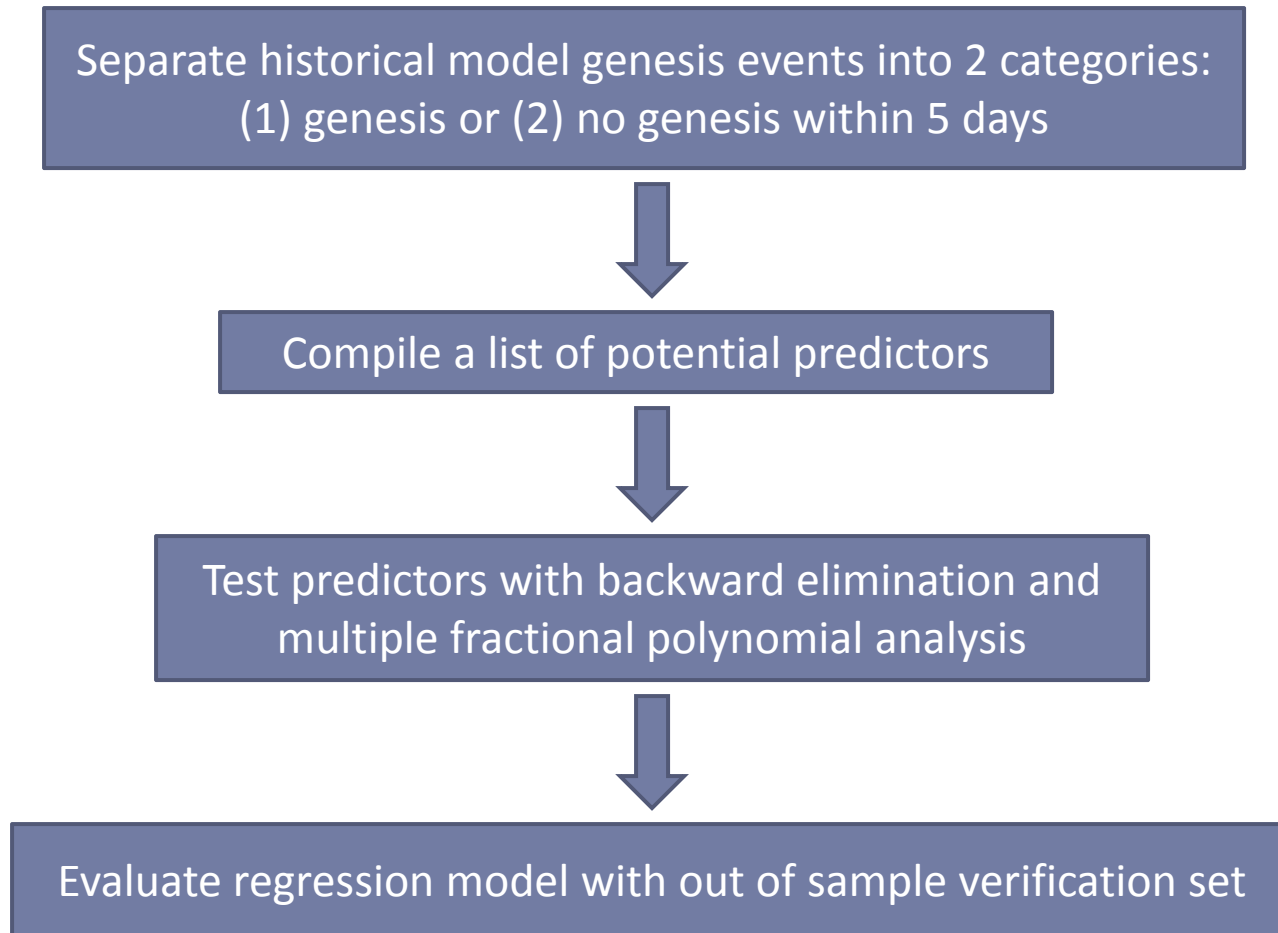$$SR = 1 - \frac{FA}{Hit + FA} \qquad POD = \frac{Hit}{Hit + Miss} \qquad Bias = \frac{Hit + FA}{Hit + Miss} \qquad CSI = \frac{Hit}{Hit + FA + Miss}$$

New/Recent Research

New Research Questions

▸ Prior results show spatial and temporal variations in model performance.

  ▸ Other useful variables?

  ▸ Is logistic regression suitable?

  ▸ Do the predictors make sense physically?

  ▸ Do the predictors provide insight regarding important TC genesis processes?

Logistic regression model development

Separate historical model genesis events into 2 categories:
(1) genesis or (2) no genesis within 5 days

↓

Compile a list of potential predictors

↓

Test predictors with backward elimination and
multiple fractional polynomial analysis

↓

Evaluate regression model with out of sample verification set

Initial predictor pool (not comprehensive)

- forecast hour
- thickness (250-850 mb)
- relative vorticity (850, 700 mb)
- 925 mb wind speed
- relative humidity (600, 700 mb)
- Okubo-Weiss (850, 500 mb)
- divergence (850, 200 mb)
- Q vector convergence (200-400 mb)
- maximum potential intensity (MPI)

- latitude
- mslp
- year
- PWAT
- Julian day
- CAPE
- CIN
- ENSO index
- MJO phase

- longitude
- shear (200-850 mb)
- temperature (sfc, trop)
- lapse rate (1000-700 mb)
- | season peak – Julian day |
- % land cover
- sfc latent heat net flux
- thickness asymmetry
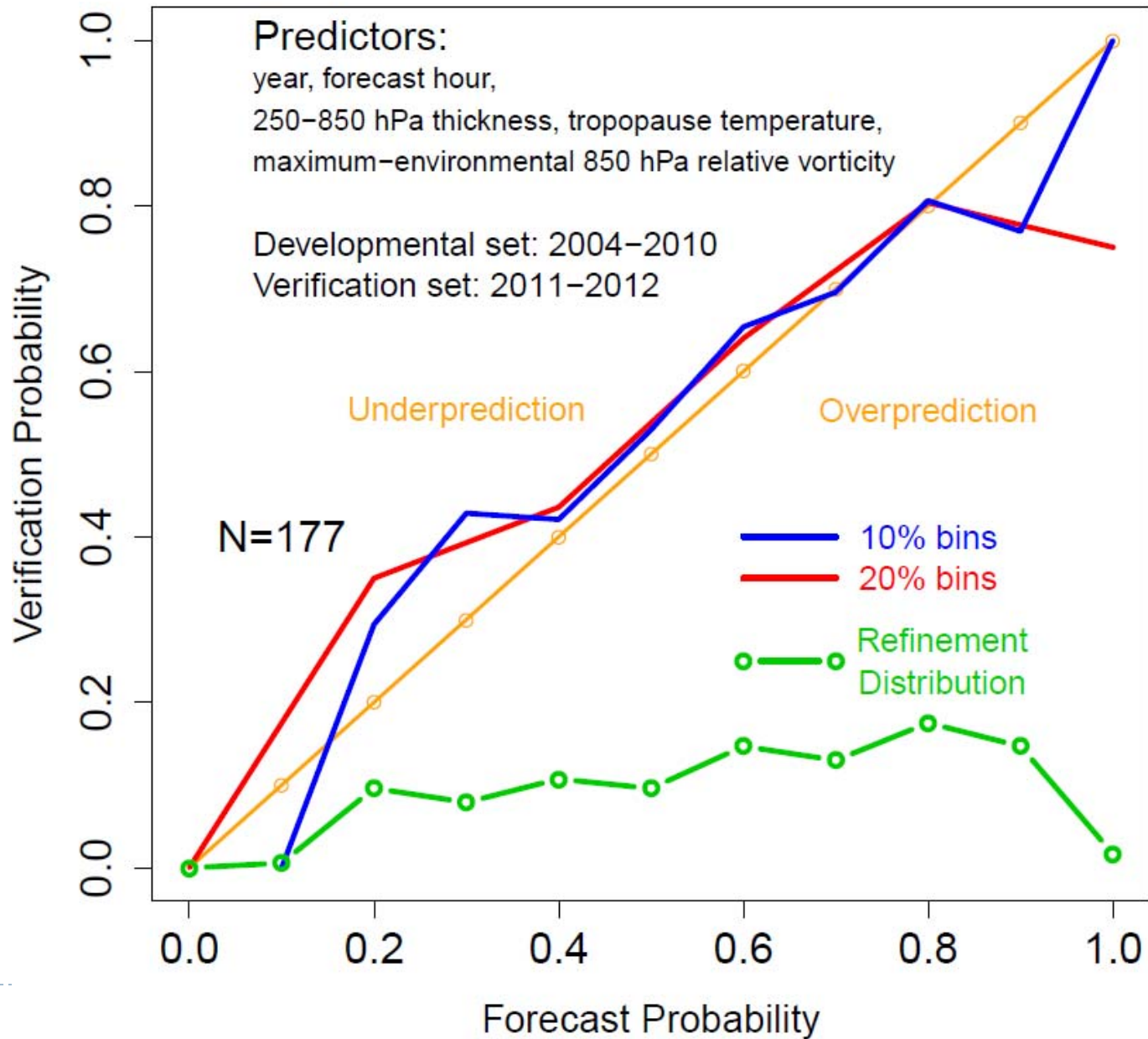- genesis in another model

*Perturbation from environmental average and time tendencies to be tested for some variables

Selecting predictors

▸ 20 iterations of out-of-sample testing to determine significant predictors.

  ▸ Each genesis event will be used in the verification set once.

NATL		EPAC	
Forecast hour	20	Forecast hour	20
Year	20	850 mb ζ perturbation	18
250-850 mb ΔZ	20	Sfc latent heat net flux	20
Tropopause temp	20	Latitude	20
850 mb ζ perturbation	20	PWAT	16
CAPE	20	CIN	16
Sfc latent heat net flux	20		
Longitude	20		

GFS 120-h Genesis Forecasts (NATL)

Predictors:
year, forecast hour,
250–850 hPa thickness, tropopause temperature,
maximum–environmental 850 hPa relative vorticity

Developmental set: 2004–2010
Verification set: 2011–2012

Underprediction   Overprediction

N=177

— 10% bins
— 20% bins

Refinement
Distribution

GFS 120-h Genesis Forecasts (EPAC)

Predictors:
forecast hour, sin(latitude),
maximum-environmental 850 hPa relative vorticity,
surface latent heat net flux

Developmental set: 2004-2010
Verification set: 2011-2012

N=235

Underprediction   Overprediction

10% bins
20% bins

Refinement
Distribution

14

Plans for 2014

Quasi-operational testing at FSU

▸ By June, logistic regression models for GFS, UKM, and CMC should be fully developed.

▸ Real-time output will be available at http://moe.met.fsu.edu/modelgen

▸ Graphical and text bulletins will be provided.

Tropical cyclone genesis summary information
GFS initialized 2014/08/01 12 UTC

ID NUM	FHR	LAT	LON	PROB120
1	24	22.5	-60.0	63%
2	54	15.0	-108.0	45%
3	108	12.0	-30.0	24%

Experimental Probability of TC Genesis at Anytime Within 120 Hours
GFS Model Output Initialized on 20140801 12Z

http://moe.met.fsu.edu/modelgen
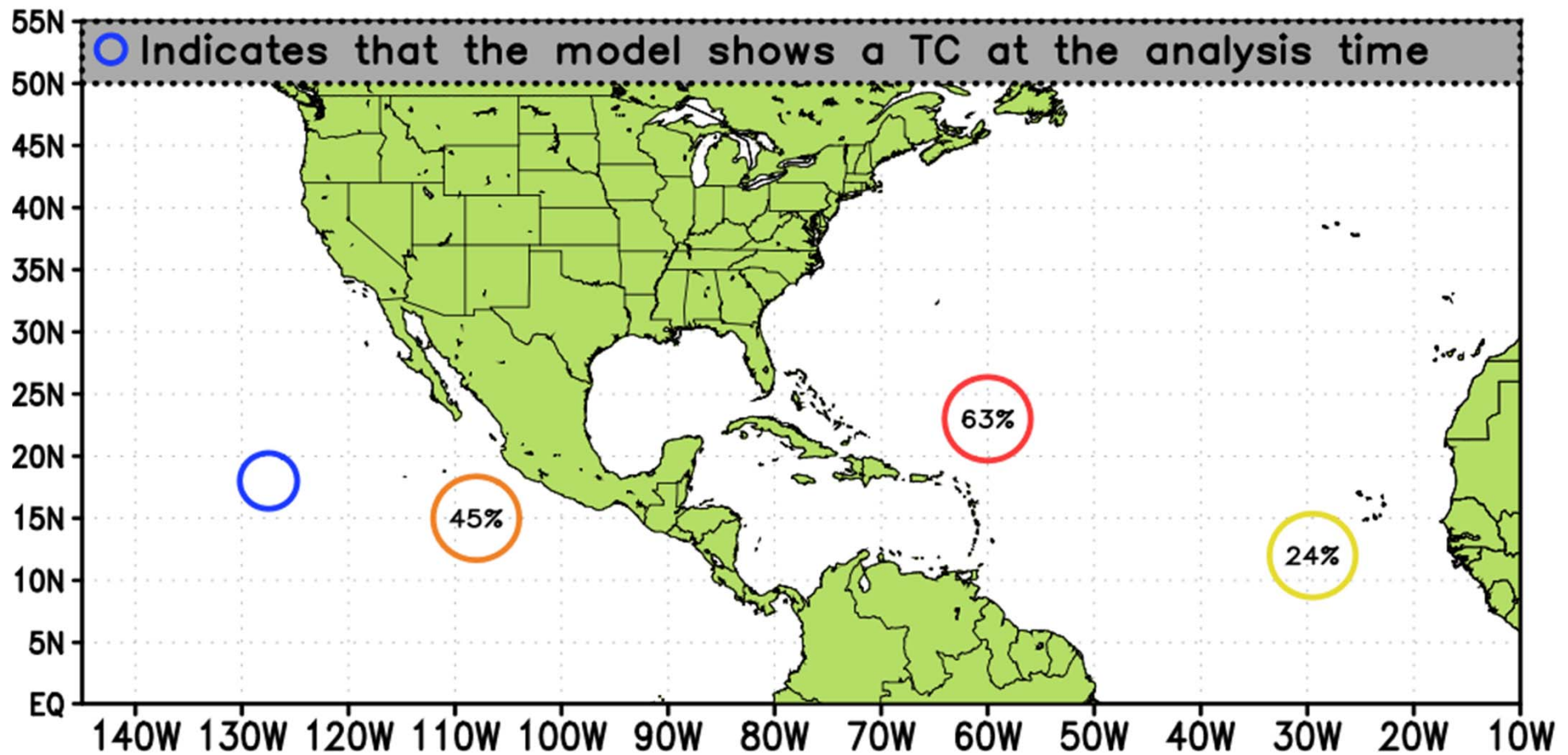
Tropical cyclone disturbance information for disturbance #1
GFS initialized 2014/08/01 12 UTC

FHR	0	6	12	18	**24**	30	36	42	48	54	60	66	72
LAT (N)	N/A	N/A	21.5	22.0	**22.5**	22.5	23.0	23.5	23.5	24.0	24.0	24.5	25.0
LON (W)	N/A	N/A	57.0	58.5	**60.0**	61.0	62.5	63.5	64.0	64.5	65.0	66.0	67.0
MSLP (hPa)	N/A	N/A	1011	1010	**1009**	1007	1004	1003	1001	1000	999	997	996
_850 RV ($*10^{-5}$ s^{-1})_	N/A	N/A	_27.6_	_28.0_	**_28.3_**	_28.9_	_28.6_	_29.2_	_28.7_	_29.6_	_29.9_	_31.5_	_33.8_
_250-850 ΔZ (m)_	N/A	N/A	9465	9470	**_9472_**	_9474_	_9479_	_9482_	_9489_	_9494_	_9498_	_9506_	_9509_
925 WIND (m s^{-1})	N/A	N/A	_21.5_	_22.3_	**_22.0_**	_22.6_	_23.4_	_24.0_	_24.7_	_23.9_	_25.6_	_28.2_	_31.2_
TTROP (K)	N/A	N/A	196.5	197	**197**	197	197	198	198.5	199	199	199	200
RV850PERT ($*10^{-5}$ s^{-1})	N/A	N/A	24.2	24.7	**25.1**	25.3	25.3	26.0	25.4	26.1	26.2	26.5	27.1

Meets TC criteria?   **Yes**   PROB120

Genesis at   2014-08-02 12UTC   **63%**
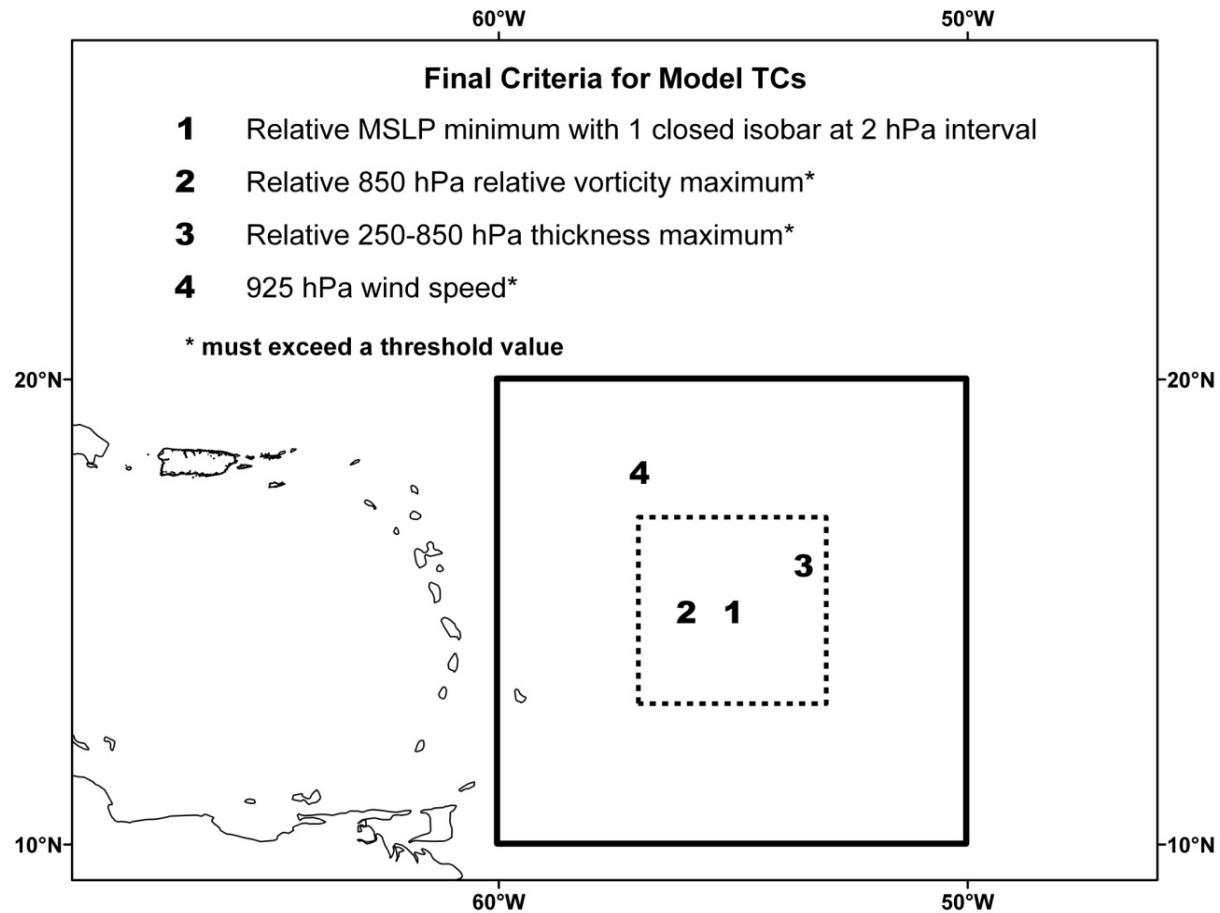
Related works to be compared to

- DeMaria et al. (2001) – TCFP

- Schumacher et al. (2009), (IHC 2013) – TCFP updates

- Marchok/HFIP

- Pratt and Evans (2009)

- Dunion et al. (IHC 2013)

Backup Slides

Model TC criteria

Criteria 1-4 must exist for at least 24 consecutive hours in the model cycle

2004−2012 GFS performance (NATL)