Improvements and extensions to an existing probabilistic TC genesis forecast tool using an ensemble of global models

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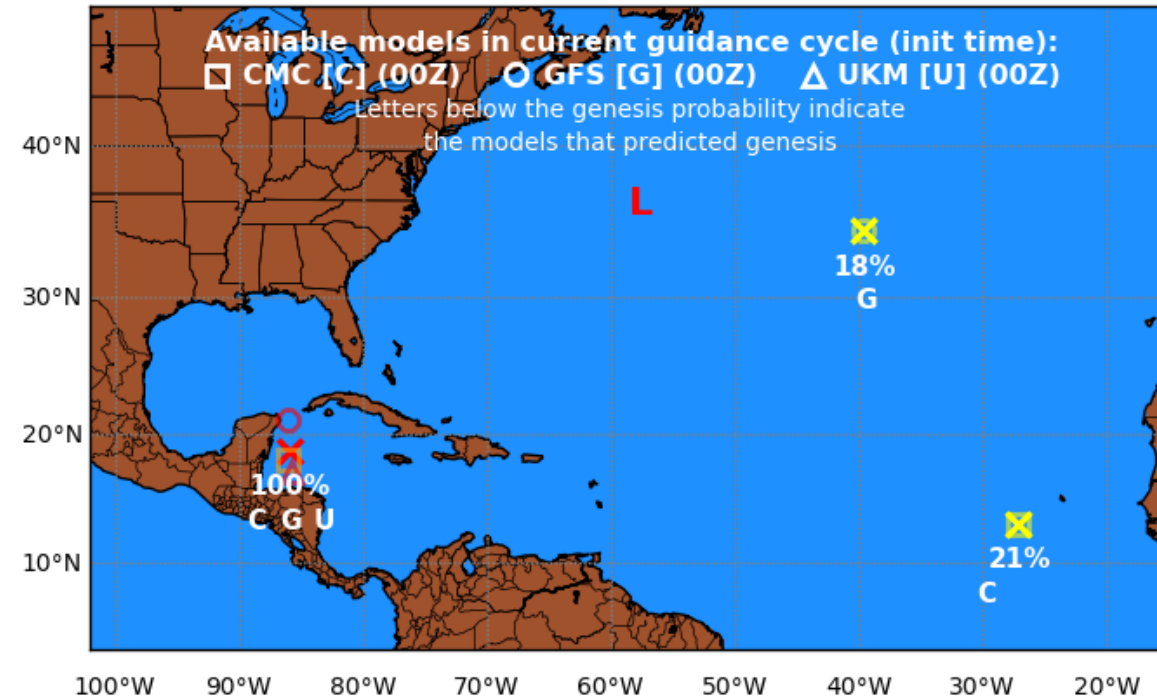[2]Florida State University, Tallahassee, FL

13 March 2019
73rd Interdepartmental Hurricane Conference

Project goals

- 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 fvGFS.
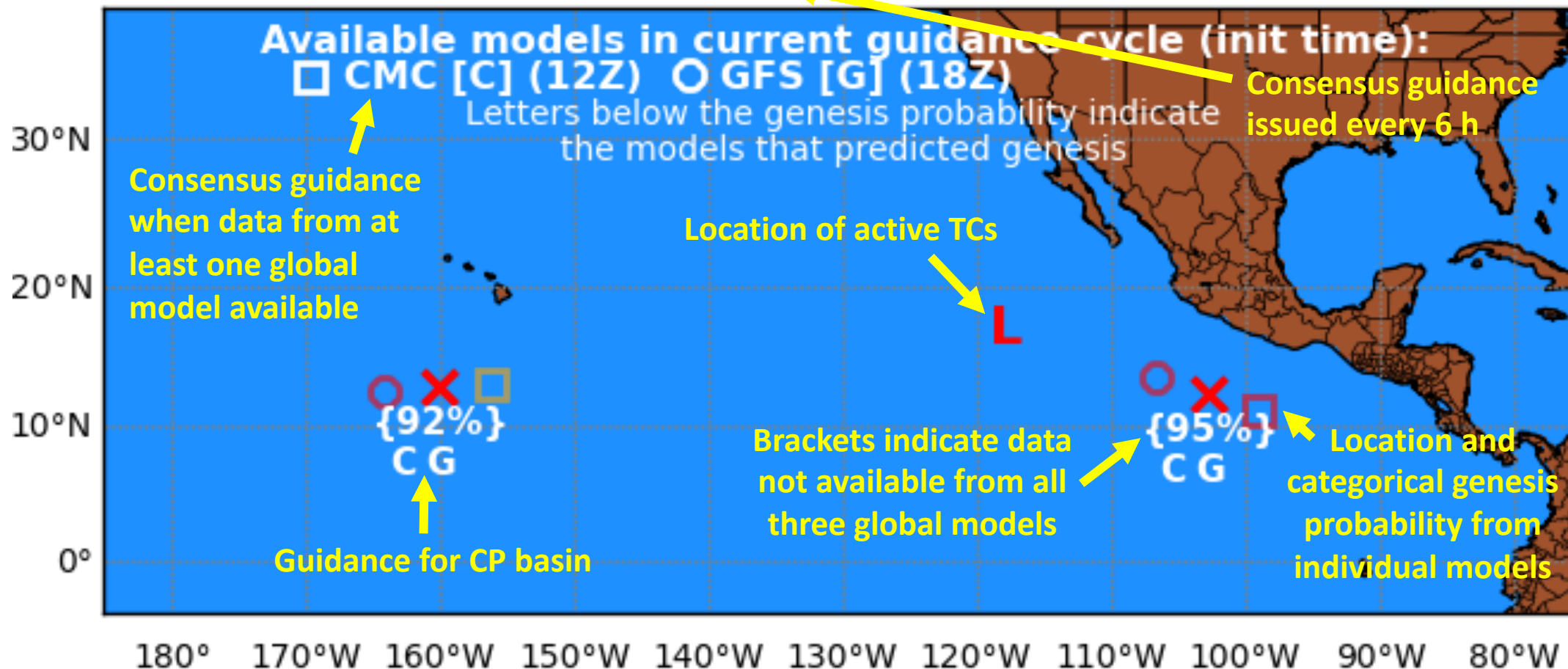
- Update/re-calibrate regression equations.

Experimental 0-120 h TC genesis probability
2018-10-06 00Z consensus guidance
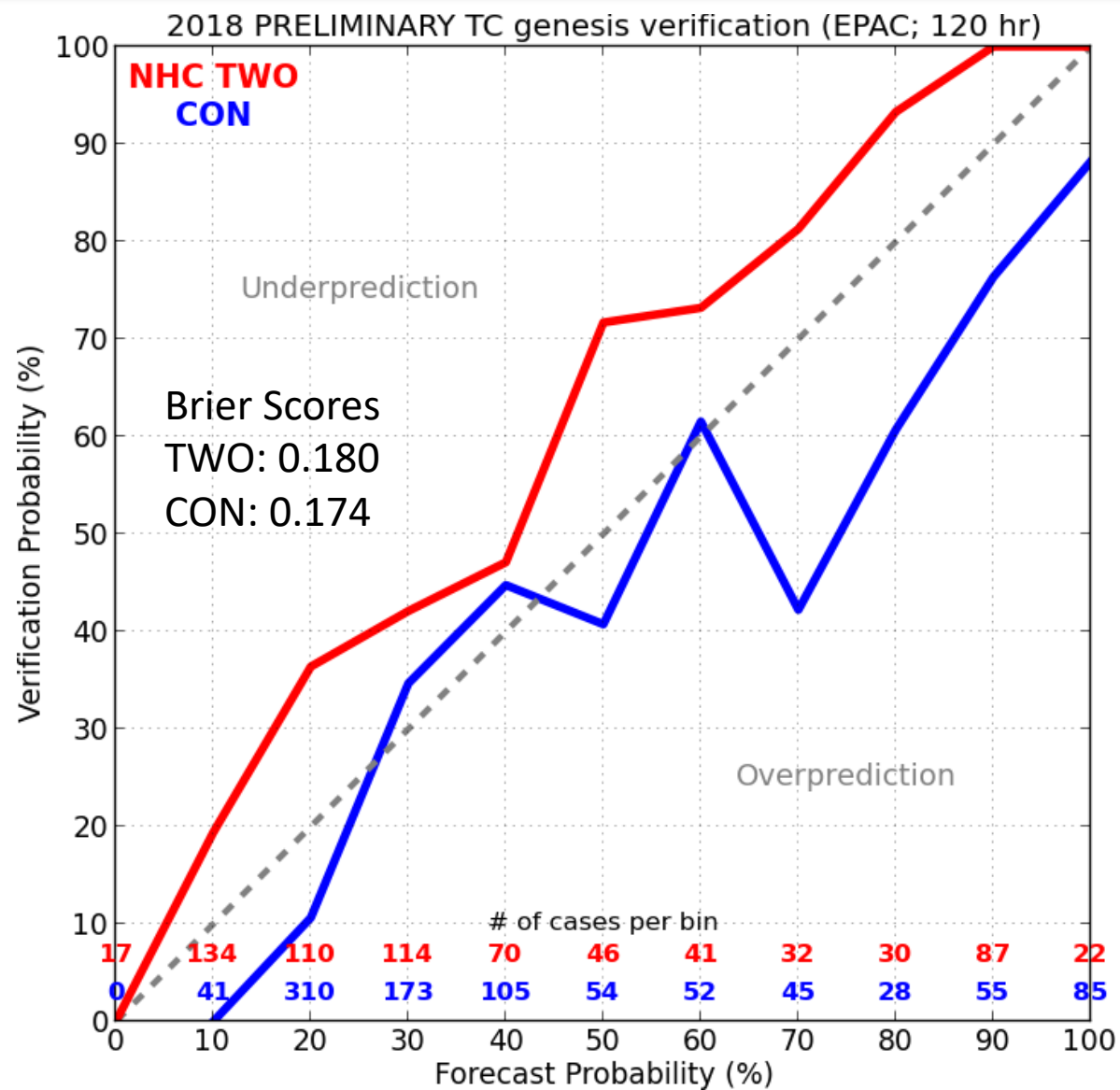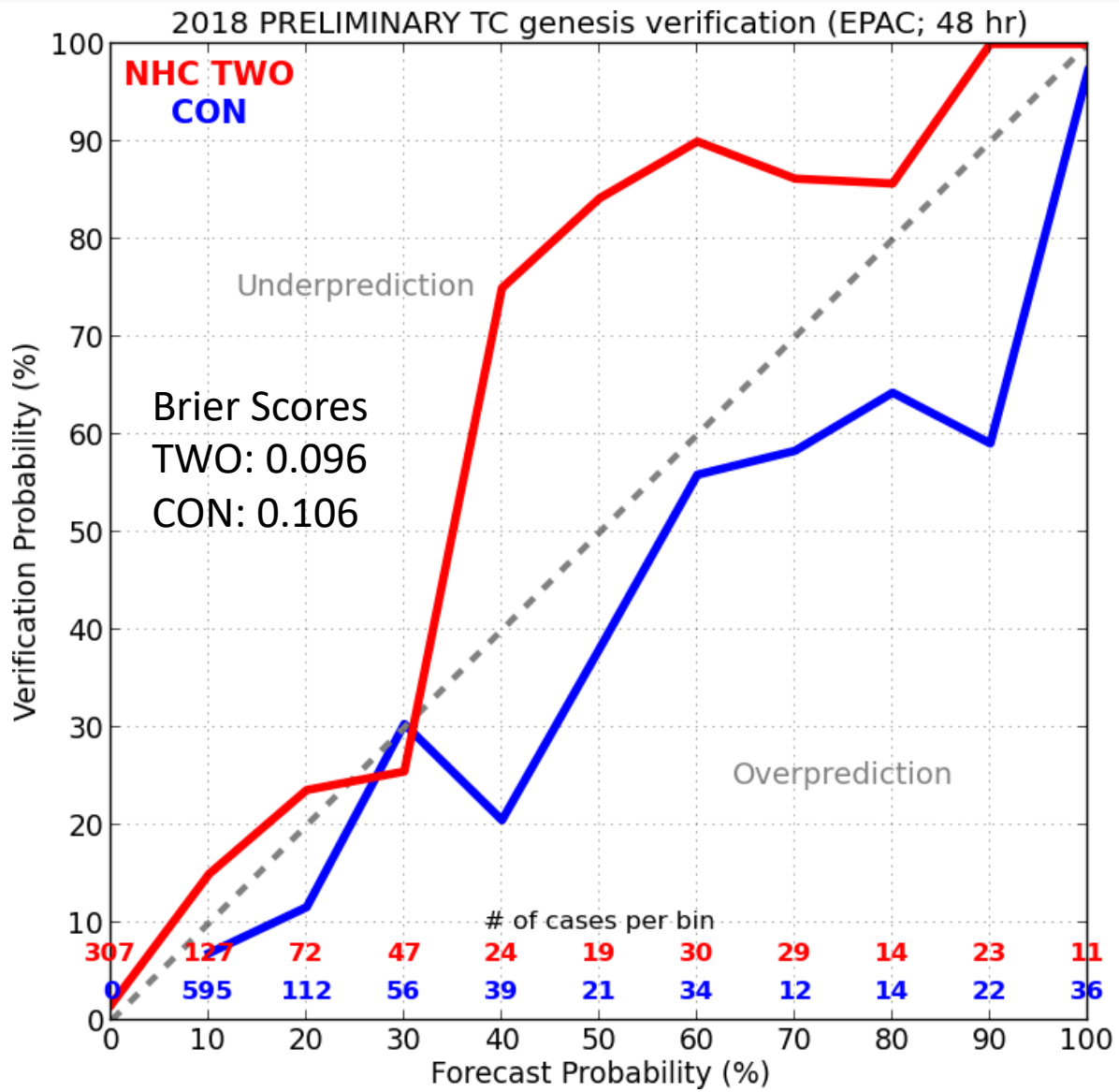
http://moe.met.fsu.edu/modelgen

2018 product enhancements

Experimental 0-120 h TC genesis probability
2018-09-28 18Z consensus guidance

Consensus guidance issued every 6 h

Available models in current guidance cycle (init time):
□ CMC [C] (12Z) ○ GFS [G] (18Z)
Letters below the genesis probability indicate the models that predicted genesis

Consensus guidance when data from at least one global model available

Location of active TCs

{92%}
C G

{95%}
C G

Brackets indicate data not available from all three global models

Location and categorical genesis probability from individual models

Guidance for CP basin

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

2018 Forecast Verification

EPAC: NHC low bias, CON high bias

2018 PRELIMINARY TC genesis verification (EPAC; 48 hr)

NHC TWO
CON

Brier Scores
TWO: 0.096
CON: 0.106

Underprediction

Overprediction

Verification Probability (%)

# of cases per bin

| 307 | 127 | 72 | 47 | 24 | 19 | 30 | 29 | 14 | 23 | 11 |
| 0 | 595 | 112 | 56 | 39 | 21 | 34 | 12 | 14 | 22 | 36 |

Forecast Probability (%)

2018 PRELIMINARY TC genesis verification (EPAC; 120 hr)

NHC TWO
CON

Brier Scores
TWO: 0.180
CON: 0.174

Underprediction

Overprediction

Verification Probability (%)

# of cases per bin

| 17 | 134 | 110 | 114 | 70 | 46 | 41 | 32 | 30 | 87 | 22 |
| 0 | 41 | 310 | 173 | 105 | 54 | 52 | 45 | 28 | 55 | 85 |

Forecast Probability (%)

NATL: NHC low bias, CON high bias

2018 PRELIMINARY TC genesis verification (NATL; 48 hr)

NHC TWO
CON

Underprediction

Brier Scores
TWO: 0.156
CON: 0.143

Overprediction

Verification Probability (%)

Forecast Probability (%)

# of cases per bin

| 250 | 85 | 60 | 34 | 21 | 21 | 12 | 23 | 11 | 14 | 4 |
| 0 | 148 | 56 | 32 | 26 | 20 | 10 | 11 | 6 | 7 | 6 |

2018 PRELIMINARY TC genesis verification (NATL; 120 hr)

NHC TWO
CON

Underprediction

Brier Scores
TWO: 0.239
CON: 0.245

Larger than normal overprediction

Overprediction

Verification Probability (%)

Forecast Probability (%)

# of cases per bin

| 32 | 155 | 99 | 54 | 34 | 54 | 25 | 25 | 13 | 40 | 4 |
| 0 | 32 | 67 | 46 | 45 | 21 | 27 | 16 | 14 | 30 | 24 |

What happened?

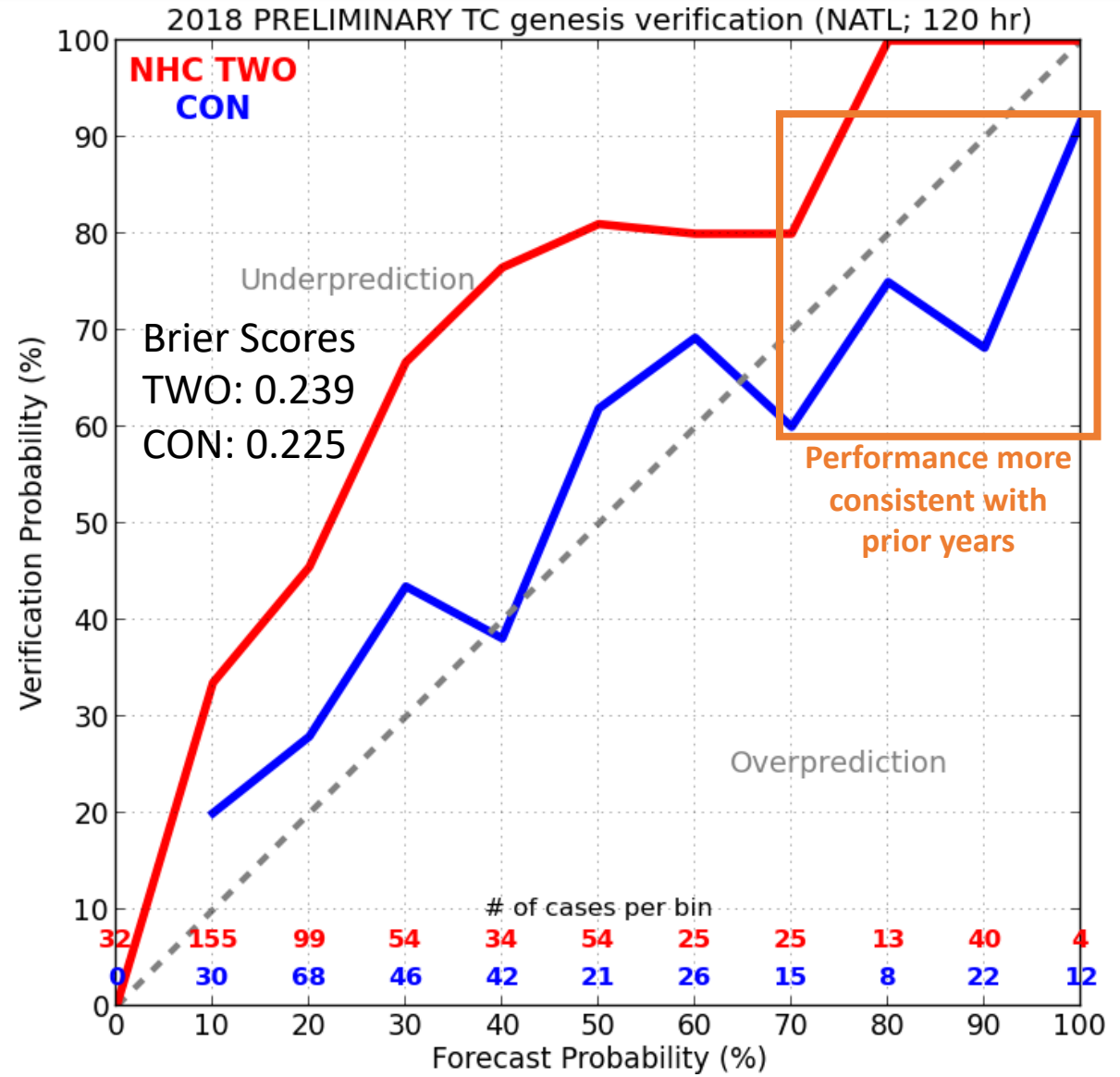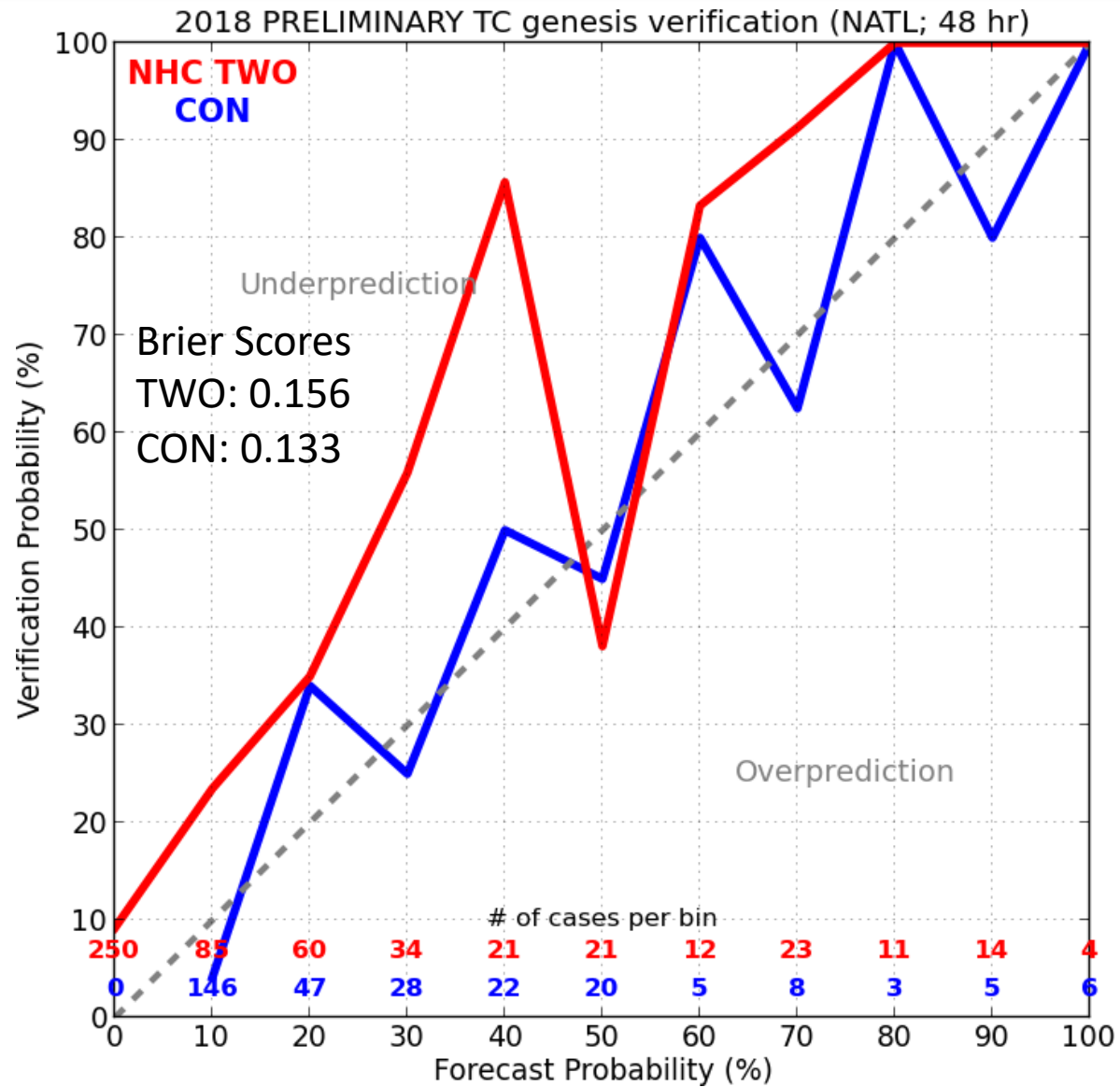2018 CON based 120 hour genesis forecasts through 12/31 12Z
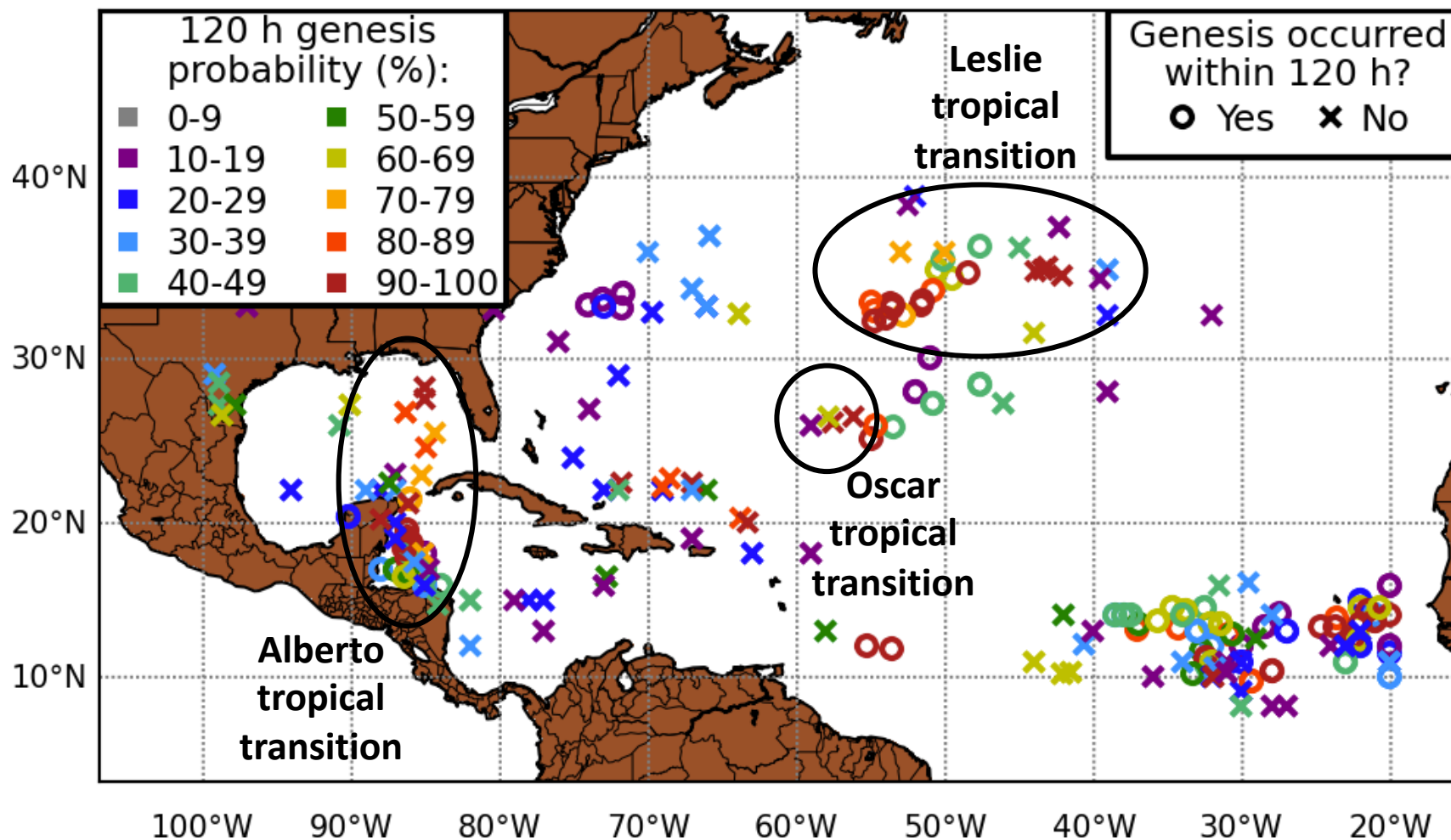
Alternate universe: Genesis time is time of first (sub)tropical depression or storm

2018 CON based 120 hour genesis forecasts through 12/31 12Z
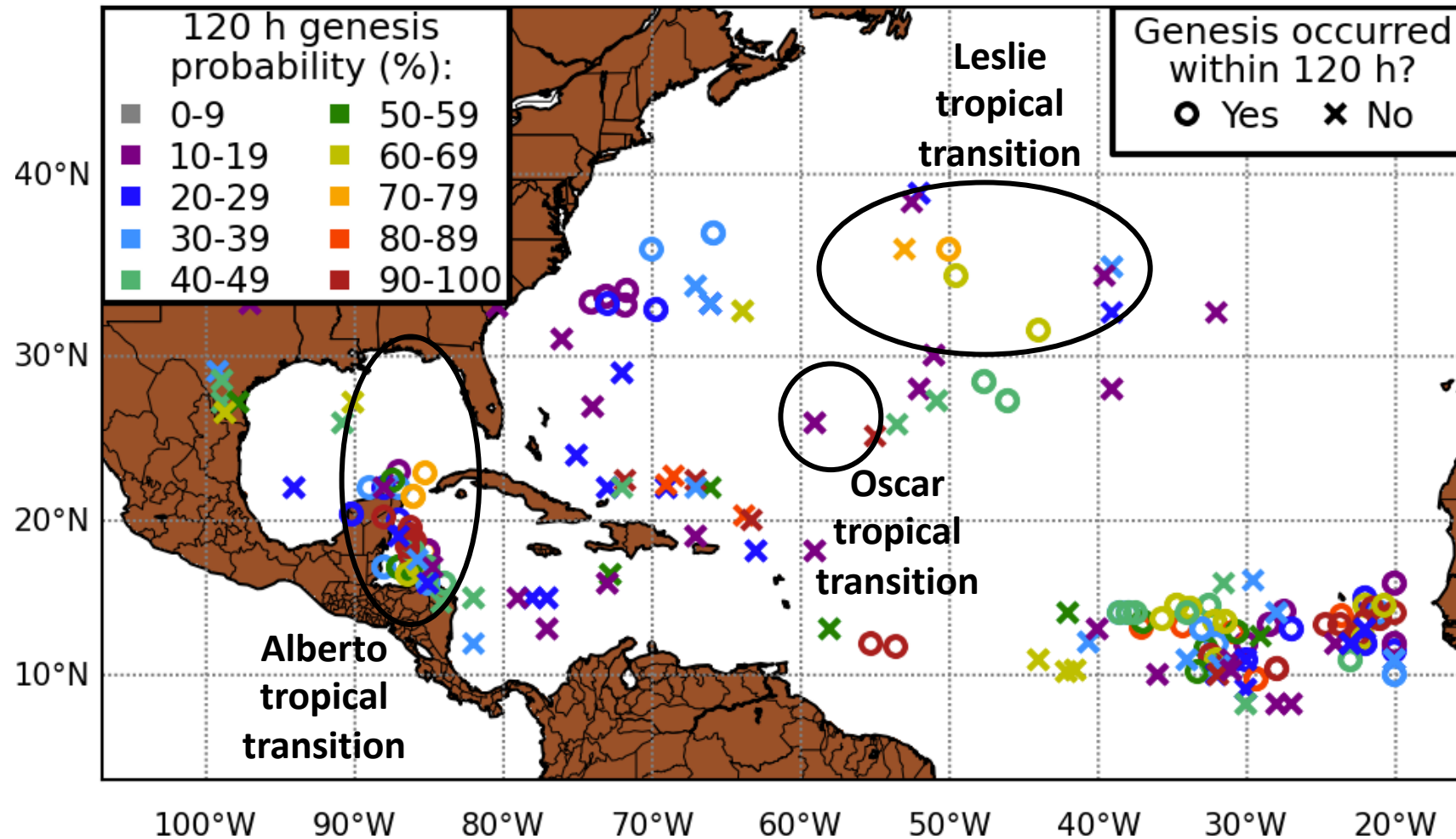
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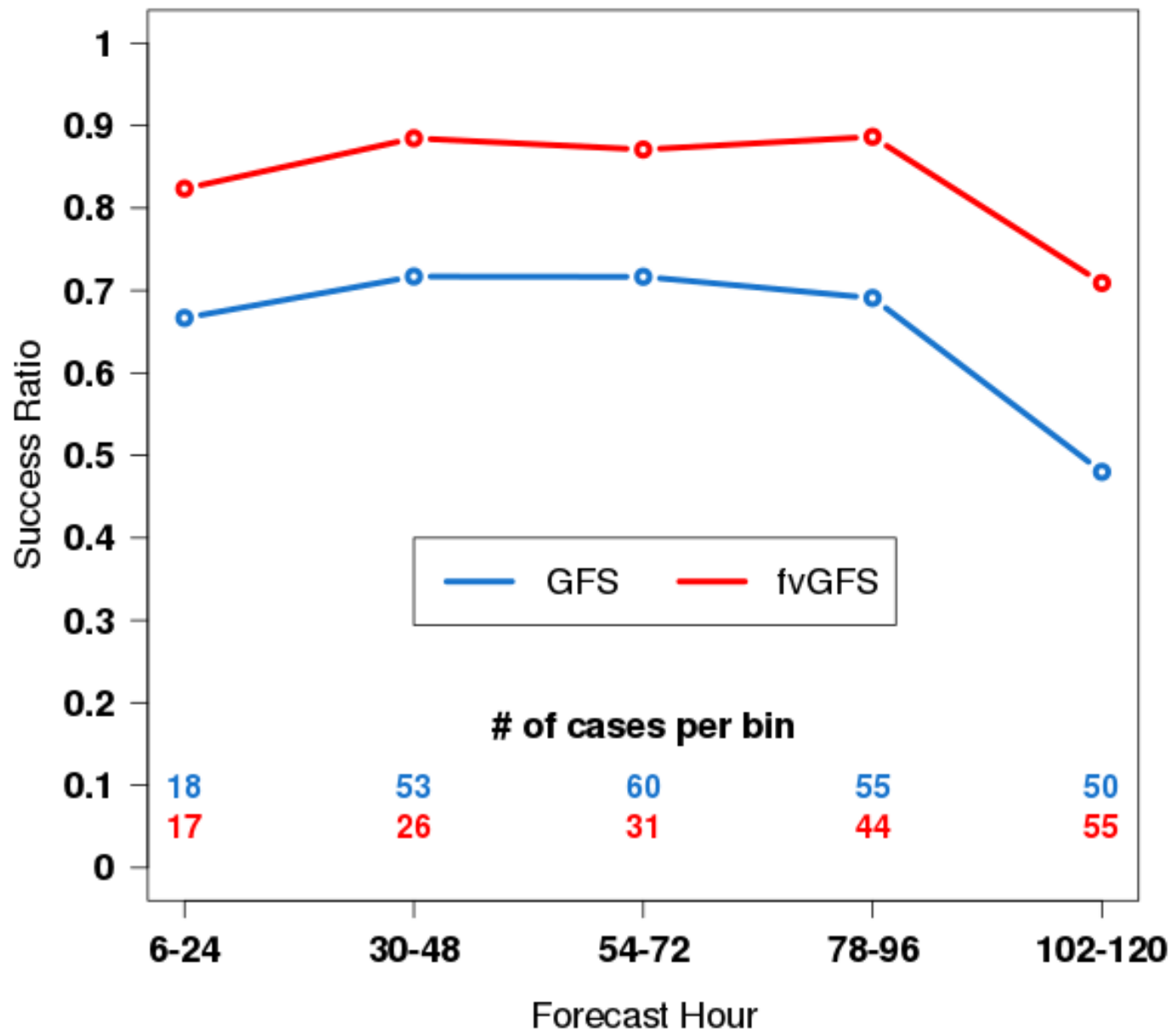

2018 PRELIMINARY TC genesis verification (NATL; 48 hr)

NHC TWO
CON

Underprediction

Brier Scores
TWO: 0.156
CON: 0.133

Overprediction

# of cases per bin
250 85 60 34 21 21 12 23 11 14 4
0 146 47 28 22 20 5 8 3 5 6

2018 PRELIMINARY TC genesis verification (NATL; 120 hr)

NHC TWO
CON

Underprediction

Brier Scores
TWO: 0.239
CON: 0.225

Performance more
consistent with
prior years

Overprediction

# of cases per bin
32 155 99 54 34 54 25 25 13 40 4
0 30 68 46 42 21 26 15 8 22 12

fvGFS TC genesis verification

- 2015-2018 retrospective period
  - Ended mid-season 2018 (before Hurricane Michael)

- Verification compared a homogeneous set of model initializations

- TC genesis events identified in the tracker out to 120 h

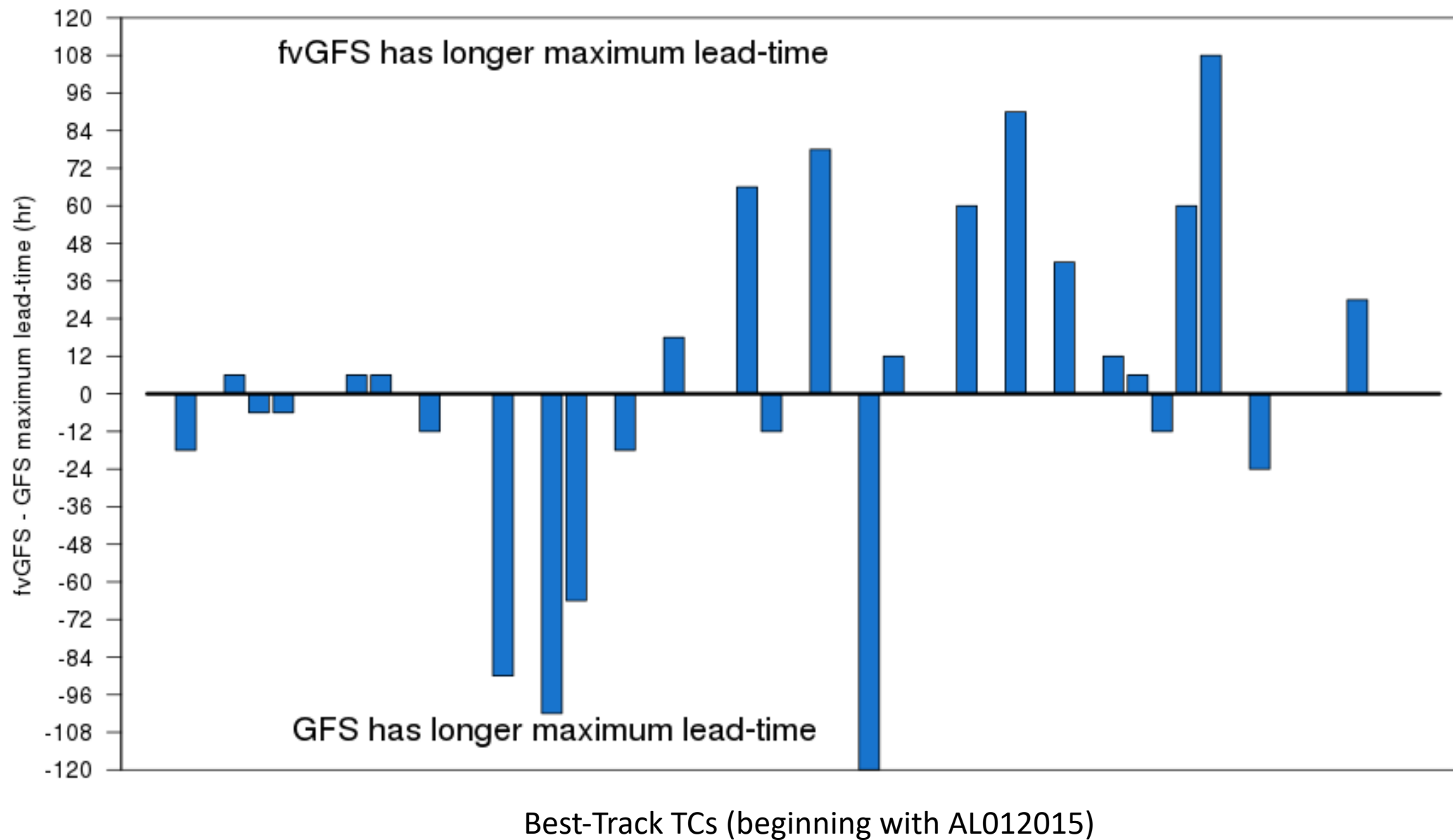- If genesis occurs within 120 h of model initialization time → "hit"
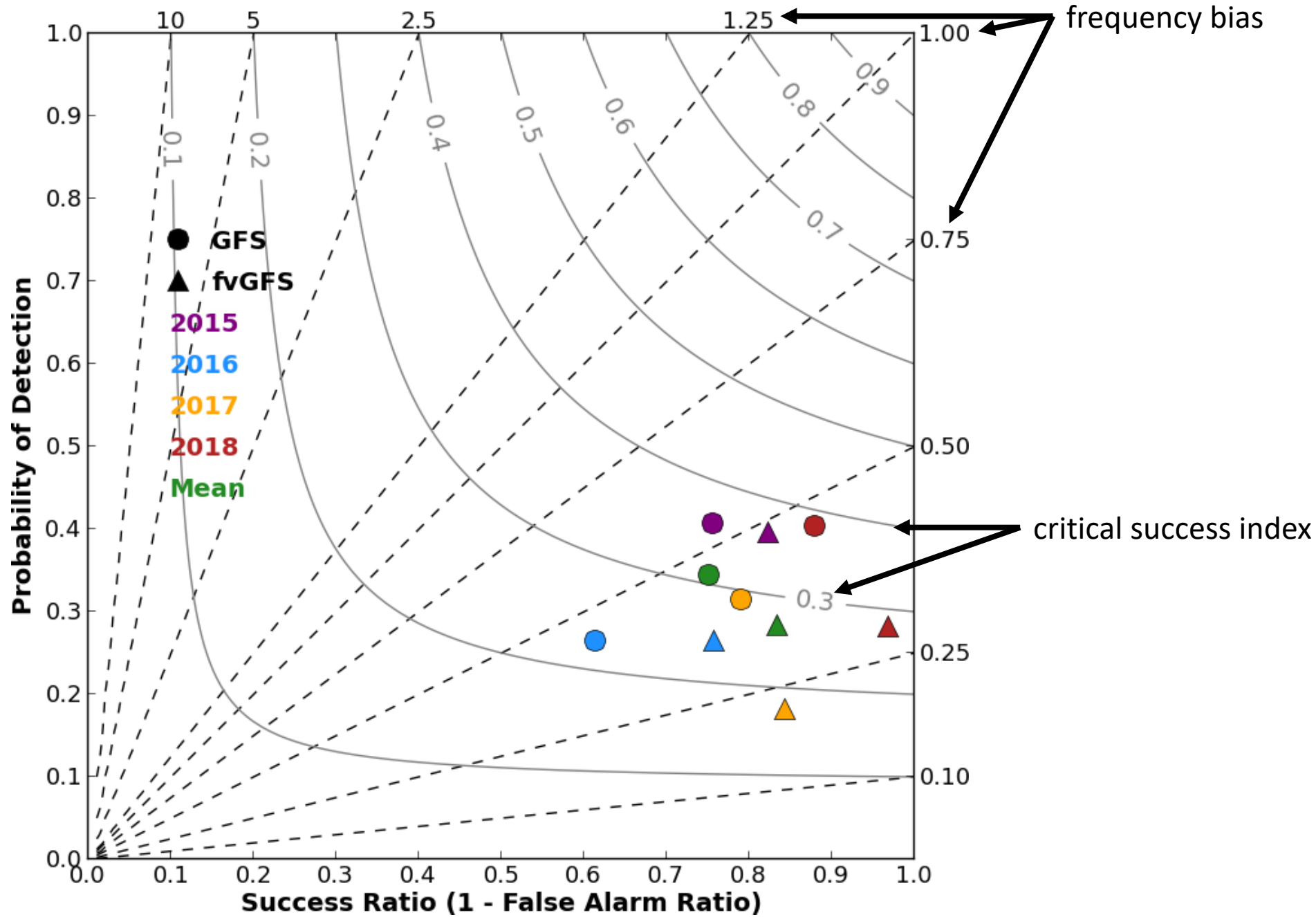
2015-2018 performance diagram (NATL)
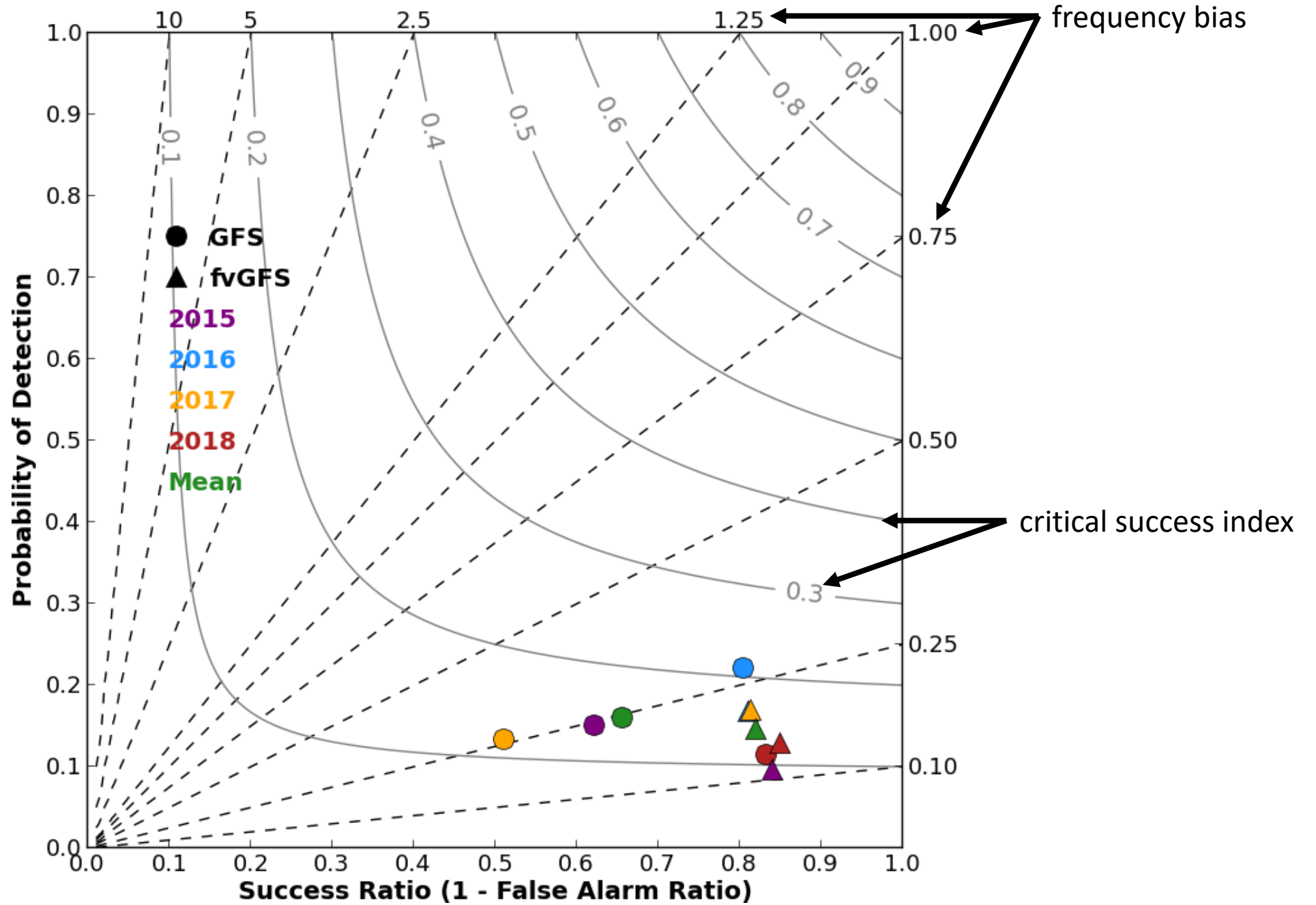
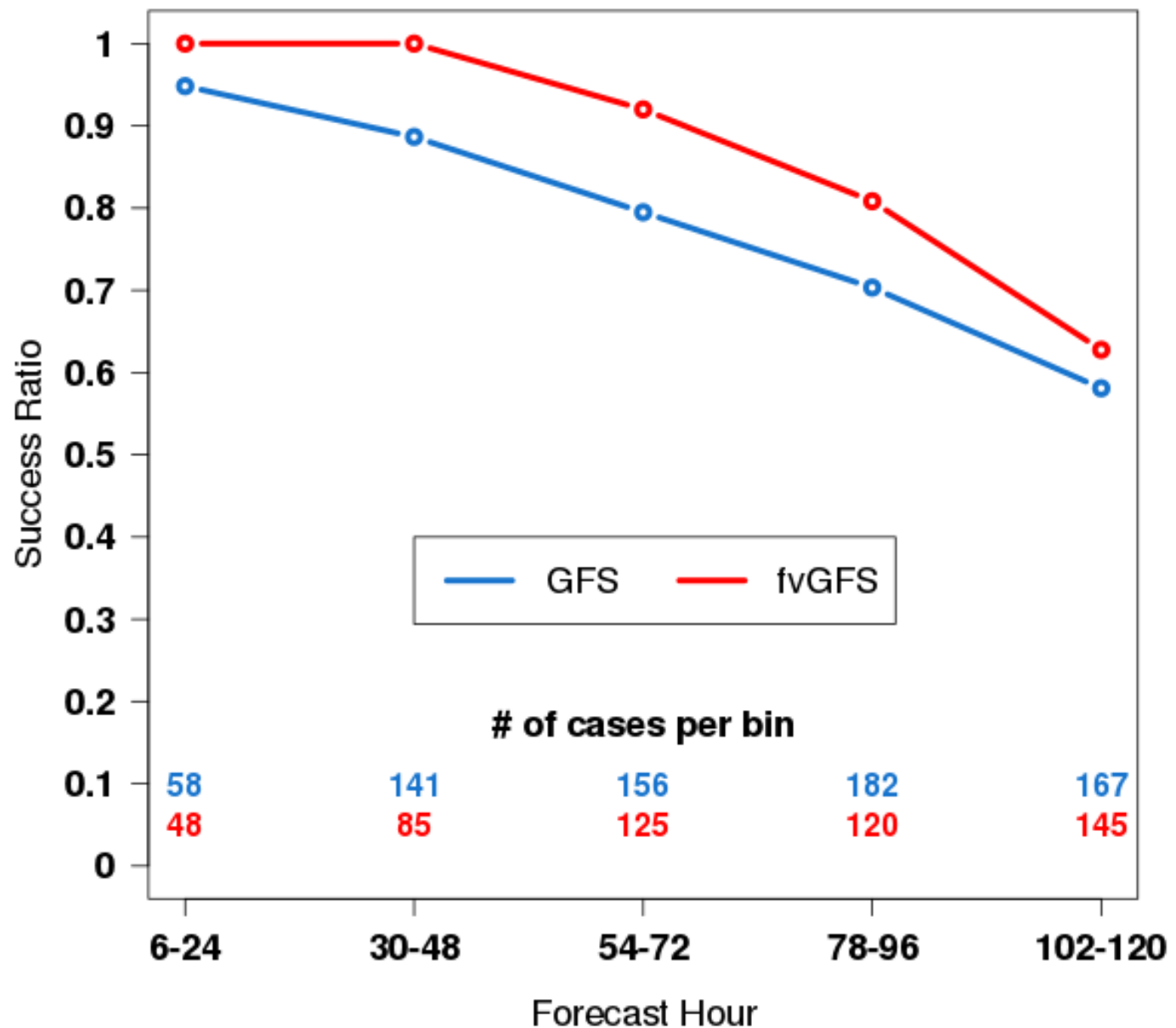**2015-2018 NATL GFS 120-h success ratio by forecast hour**

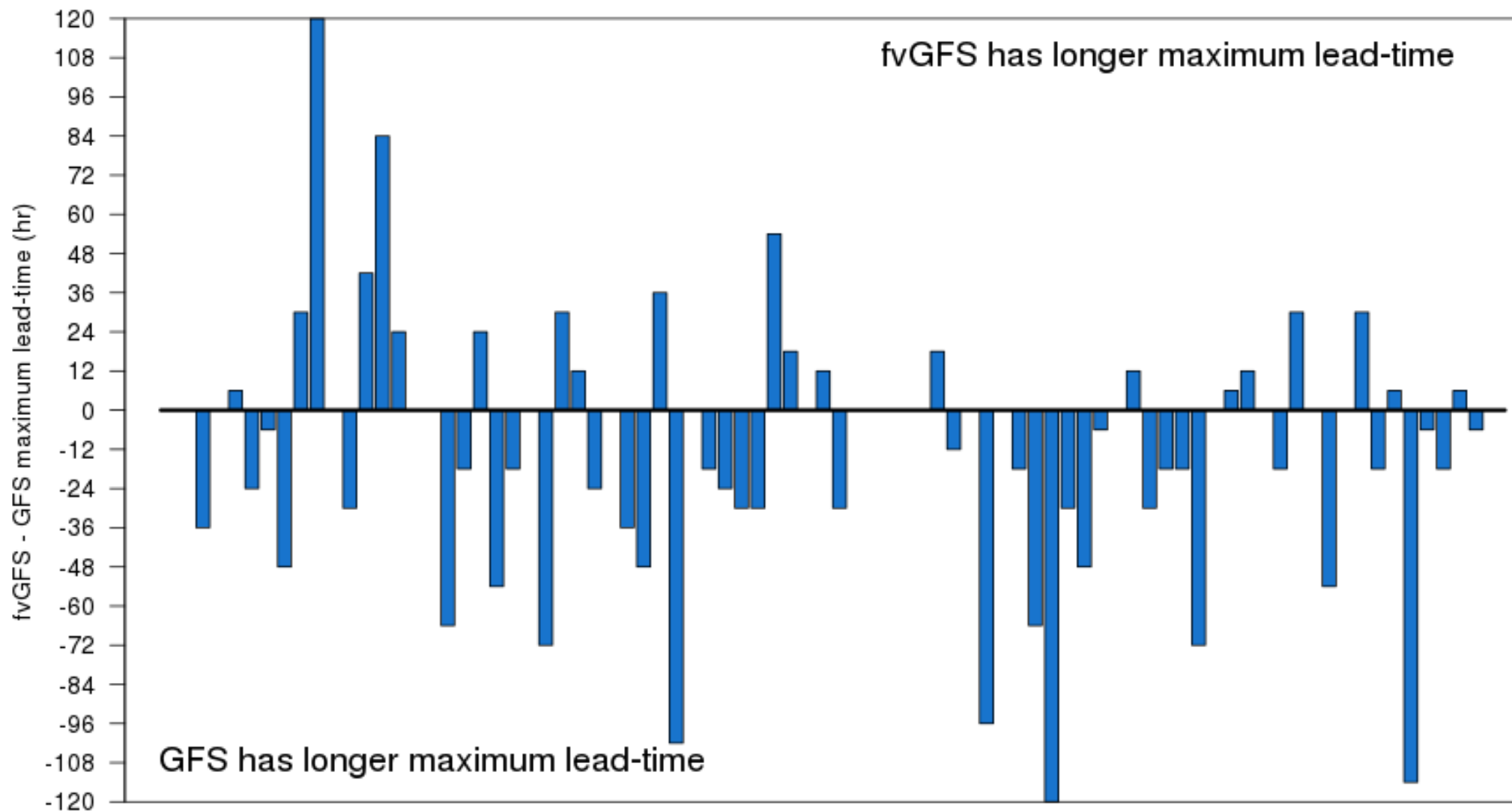Difference in maximum lead-time for each Best-Track TC (NATL)

fvGFS has longer maximum lead-time

GFS has longer maximum lead-time

fvGFS - GFS maximum lead-time (hr)

Best-Track TCs (beginning with AL012015)

2015-2018 performance diagram (EPAC)

2015-2018 EPAC GFS 120-h success ratio by forecast hour

Success Ratio (y-axis)

Forecast Hour (x-axis): 6-24, 30-48, 54-72, 78-96, 102-120

Legend: GFS (blue), fvGFS (red)

# of cases per bin

	6-24	30-48	54-72	78-96	102-120
GFS	58	141	156	182	167
fvGFS	48	85	125	120	145

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

fvGFS has longer maximum lead-time

GFS has longer maximum lead-time

fvGFS - GFS maximum lead-time (hr)

Best-Track TCs (beginning with EP012015)

Plans for 2019 (last six months of project)

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

- Determine whether the probabilities with the experimental tracker are more reliable than those with the operational tracker.

- Update/re-calibrate logistic regression equations.

- Implement NAVGEM-based guidance.

- Transfer post-season verification and development code to NHC.

- Solicit feedback from NHC through remainder of project period.

Proposed new JHT research: 2019-2021

- New JHT proposal submitted to further expand the current forecast tool now titled:

    "TCLOGG" – Tropical Cyclone Logistical Guidance for Genesis.

- The proposed new work includes:
    - Changing the GFS GRIB variable for SLP from PRMSL to MSLET
    - Further improvements for high latitude formation (and perhaps subtropicals)
    - Testing feasibility of expanding guidance to Day 6-7
    - Development of ensemble regression equations using GEFS Reforecast V2
   - Development of regression equations for "most-likely time of genesis"

Example 1 proposed new deliverable: PRMSL to MSLET

- In May 2011, NCEP began outputting a second GRIB variable for SLP (MSLET) for the GFS in addition to the NCEP standard (PRMSL).

- The MSLET variable is more consistent in method with the SLP calculation in other global models, and better exploits the improved GFS grid resolution over the past decade. There is now a sufficient archive length to use MSLET in TCLOGG.

1200UTC 18 June 2017 0.25° GFS Analysis SLP (PRMSL, hPa) of INVEST92L (pre-TC Bret); Minimum value: 1010.6hPa
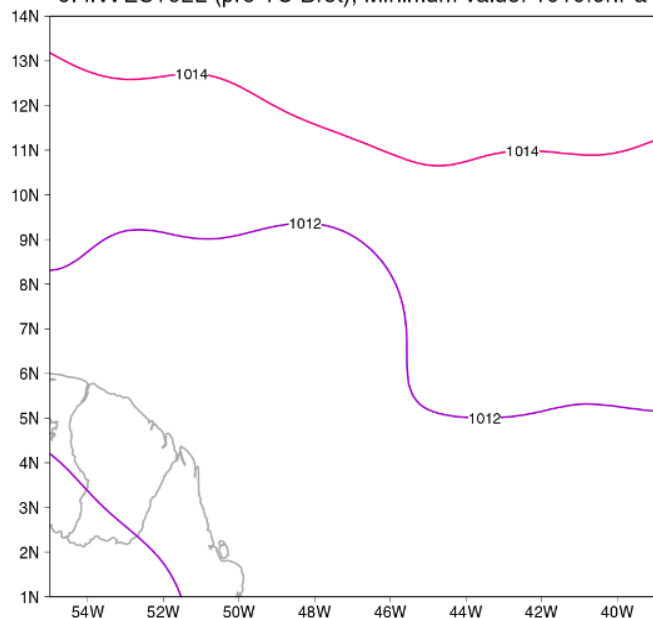
1200UTC 18 June 2017 0.25° GFS Analysis SLP (MSLET, hPa) of INVEST92L (pre-TC Bret); Minimum value: 1005.8hPa
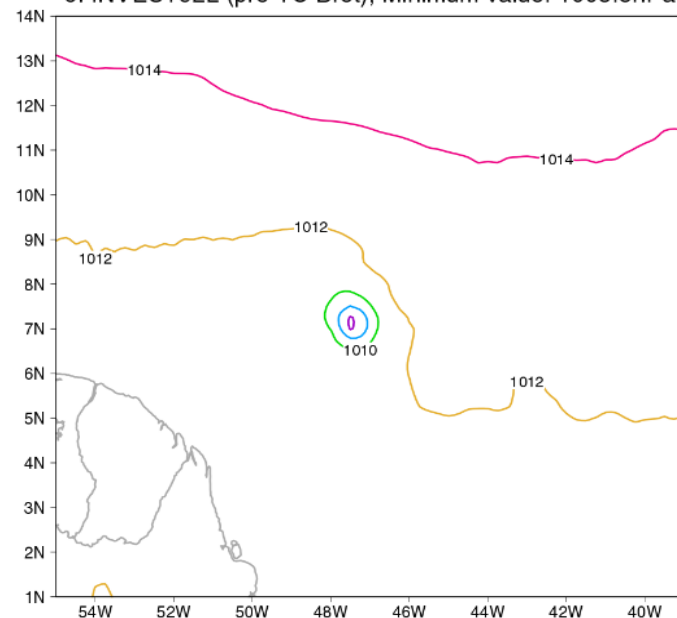
Left: A case of TC genesis illustrating the potentially dramatic impact of using PRMSL (left; open wave at 2mb contour) vs. MSLET (right; closed 1006mb low) on the identification of a closed circulation (pre-TC Bret in 2017) in the current GFS. This has a severe impact on derived TC genesis probabilities using the forecast tool described here. From Hart and Cowan (2018).

Example 2 proposed new deliverable: Most Likely Time of Genesis

- There are cases where the TC genesis time was highly model-dependent, e.g.:

| Source	CMC	GFS	UKM		Average	Verification
Genesis Fcst. Hr.	18hr	114hr	60hr		64hr	78hr
120hr Genesis Prob.	74%	75%	81%		77%	100%

- Accordingly, one proposed addition to TCLOGG is a means by which to calculate and display a "most-likely time of genesis."

- This additional information may be critical for the forecaster by helping to more precisely determine when pre-genesis watches or warnings may be required.

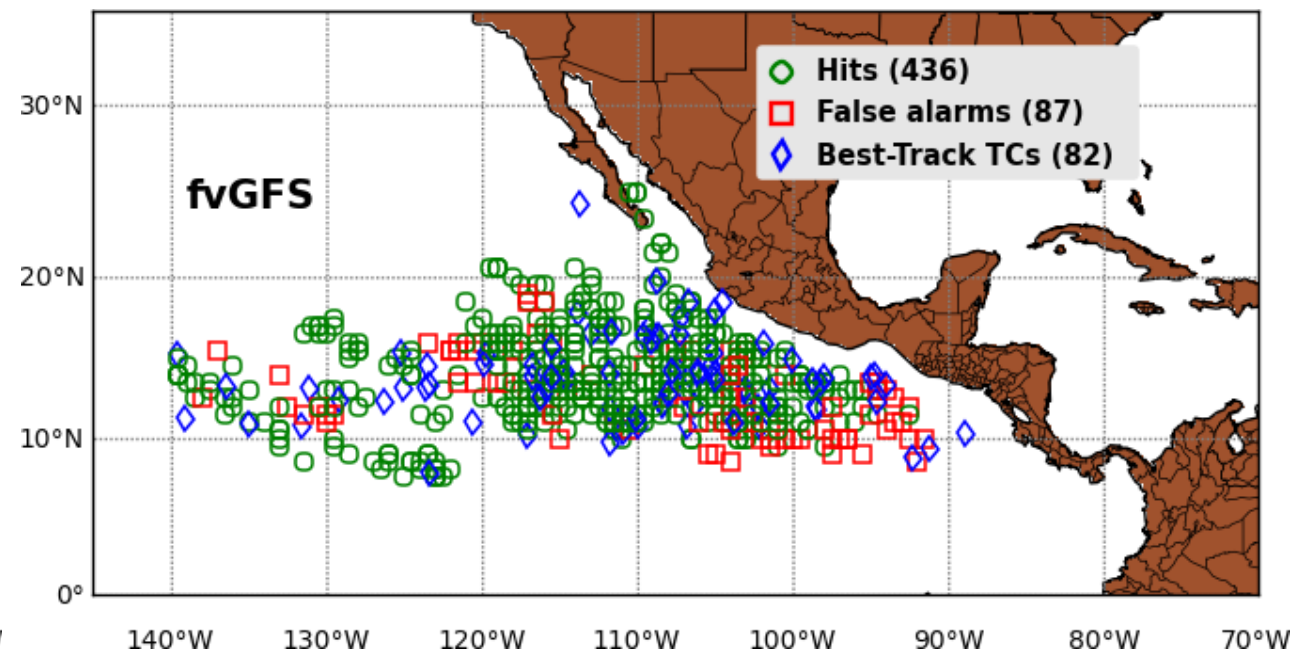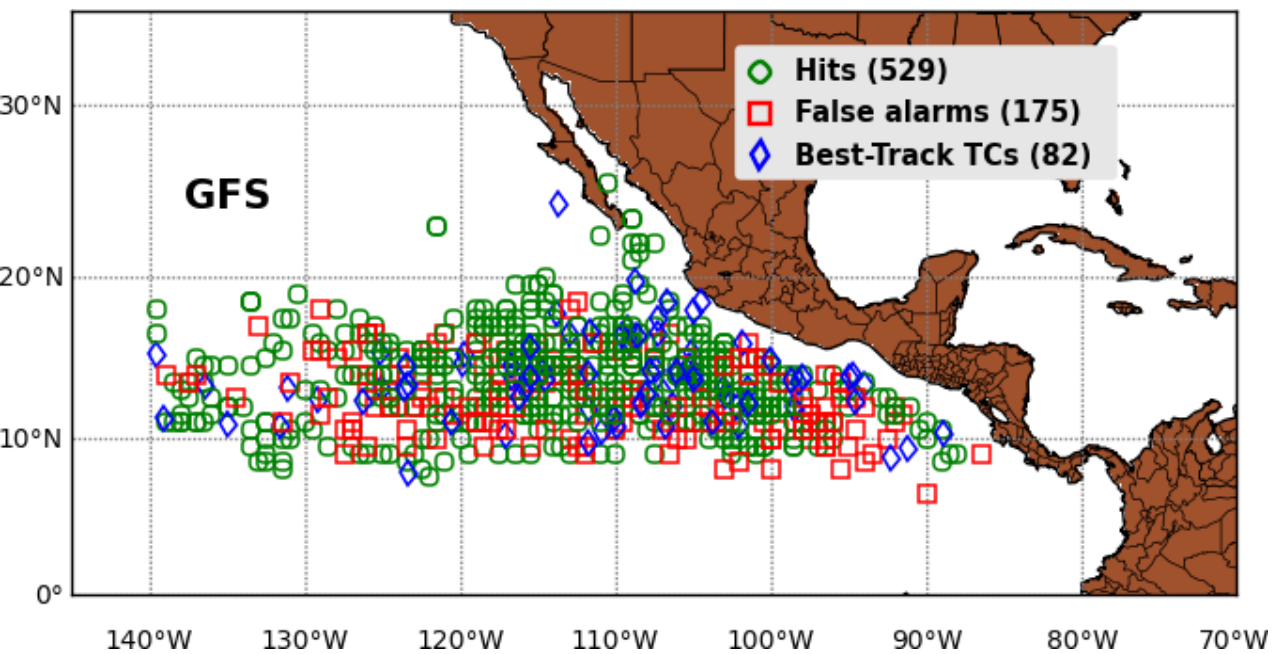# Example 3 proposed new deliverable: Use of GEFS Reforecast V2

- A significant proposed expansion for TCLOGG is to use a subset of the 30-year archive of the GEFS Reforecast v2 (GEFSRv2).

- The goal is to arrive at genesis probabilities from an ensemble prediction system with a single model configuration rather than an ensemble of unique deterministic models (the latter of which has been the focus of TCLOGG development thus far) :

  - The first approach would be to apply the GFS or fvGFS tracker and equations to the GEFSRv2 members and then calculate the mean probability of development from the latter.

  - The second approach would be to combine all the GEFSRv2 members and develop a single tracker and regression equation. We would then apply these to each member and take the mean of the resulting probabilities.

- The former approach is more straightforward whereas the latter, while time consuming, exploits more greatly the benefit of a large ensemble.

Thank you

Extra Slides
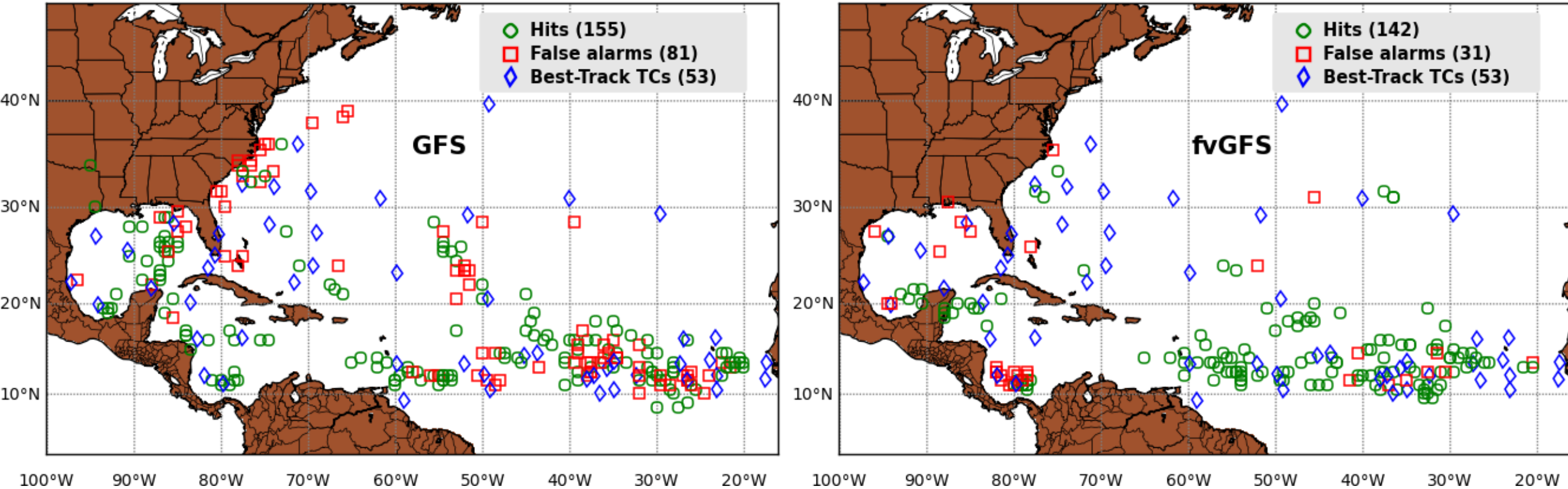
Locations of all forecast hit events, false alarm events, and actual best-track TC genesis during the 2015-2018 study period.

Locations of all forecast hit events, false alarm events, and actual best-track TC genesis during the 2015-2018 study period.