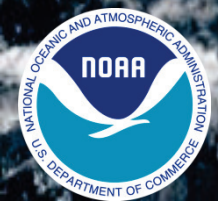# Forecast Challenges of the 2017 Hurricane Season and NHC Priorities for 2018

Michael J. Brennan, Mark DeMaria, Eric S. Blake, Richard J. Pasch, Andrew Penny

Annual HFIP Meeting
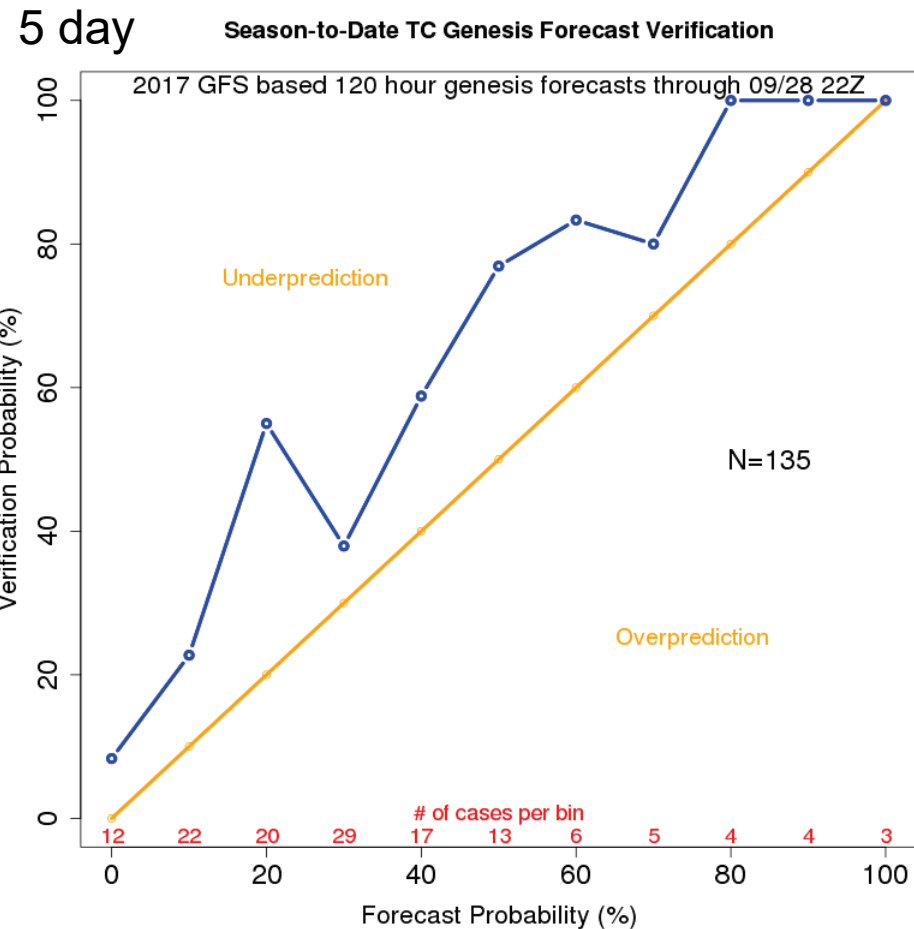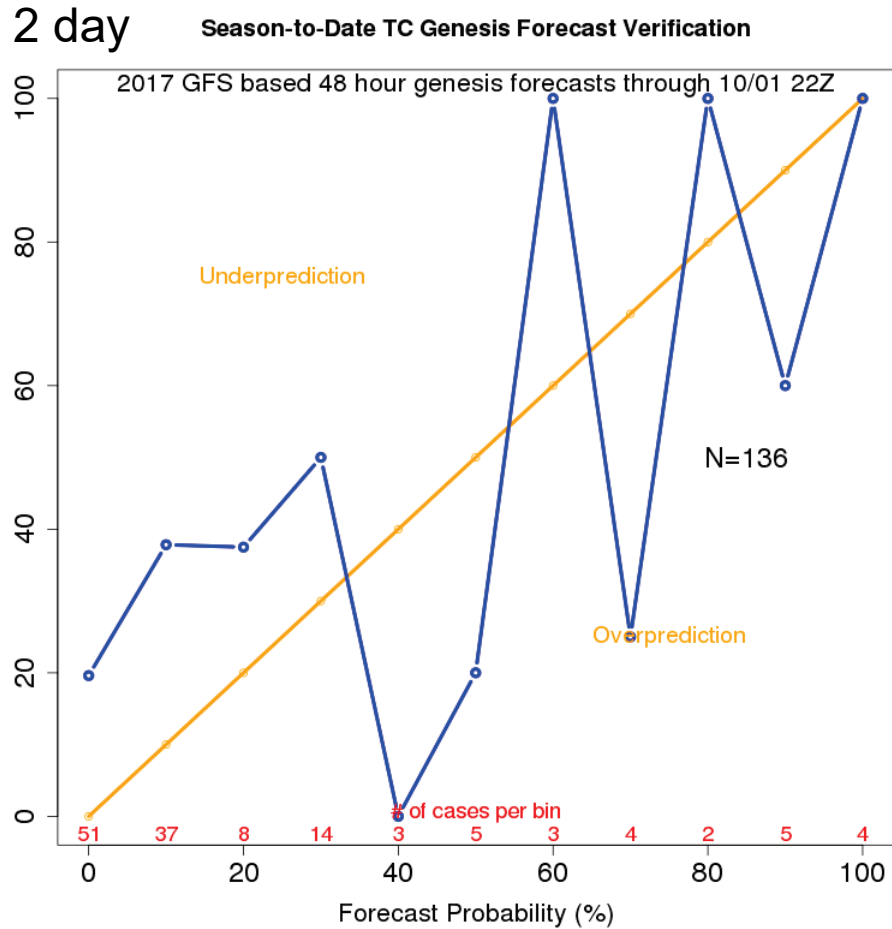
8 November 2017

Outline

- Forecast Challenges
  - Genesis
  - Rapid Intensification
  - Structural Changes
- Model Performance
  - HMON, HWRF, COAMPS-TC
- NHC Modeling Priorities for 2018

GFS Genesis Problems

- 2017 GFS had issues with under-predicting genesis at longer time ranges in both basins

  - Atlantic: GFS hit 3 of 16 genesis events at 120 h (19%)

  - East Pacific: GFS hit 7 of 18 genesis events at 120 h (39%)

- GFS forecast only half of Atlantic TC formations 48 h in advance

- East Pacific better in the short range – GFS hit 13 out of 18 events at 48 h (72%)

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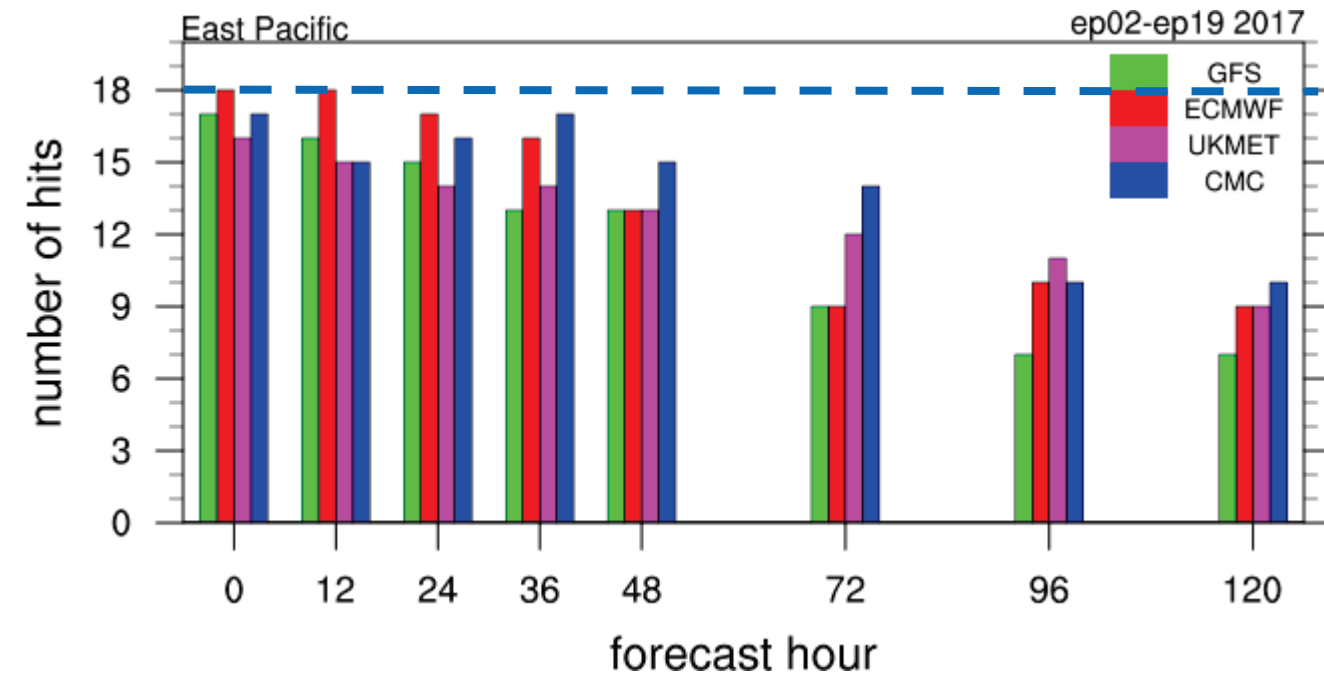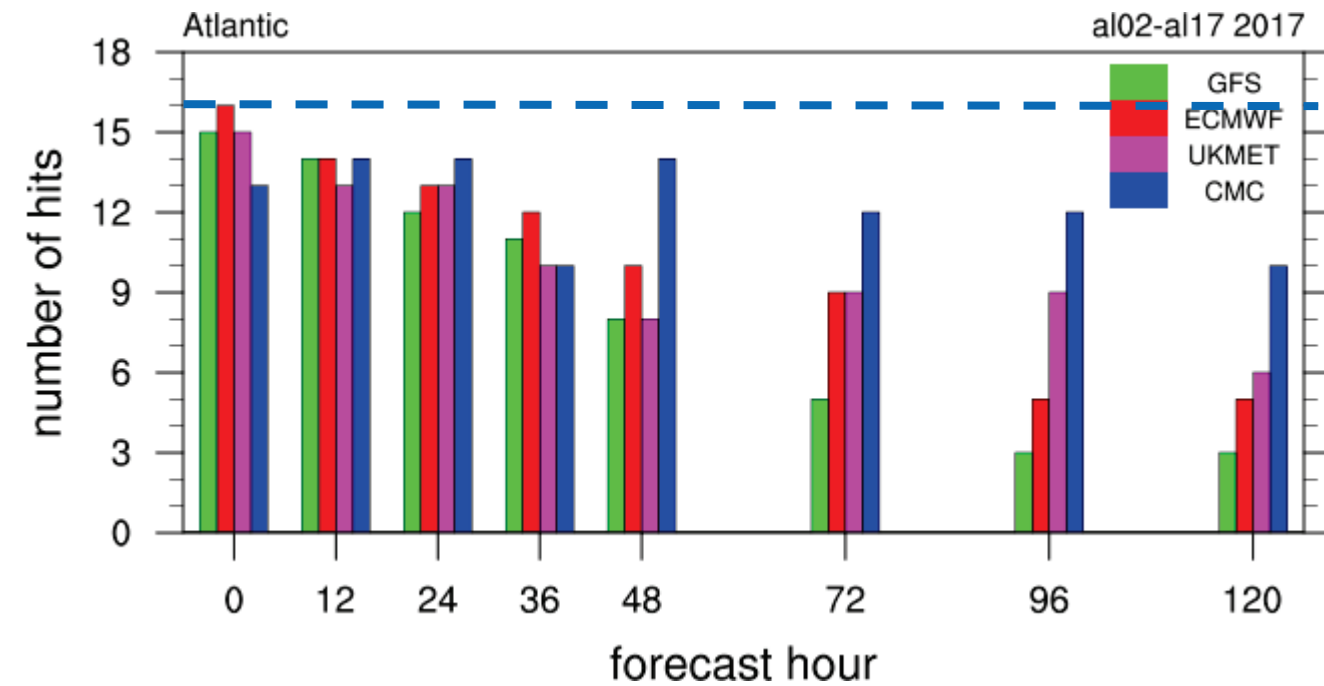
Atlantic GFS Genesis Forecasts

2 day

Season-to-Date TC Genesis Forecast Verification

2017 GFS based 48 hour genesis forecasts through 10/01 22Z

5 day

Season-to-Date TC Genesis Forecast Verification

2017 GFS based 120 hour genesis forecasts through 09/28 22Z

2-day "High" Forecasts
GFS: 15
NHC: 45

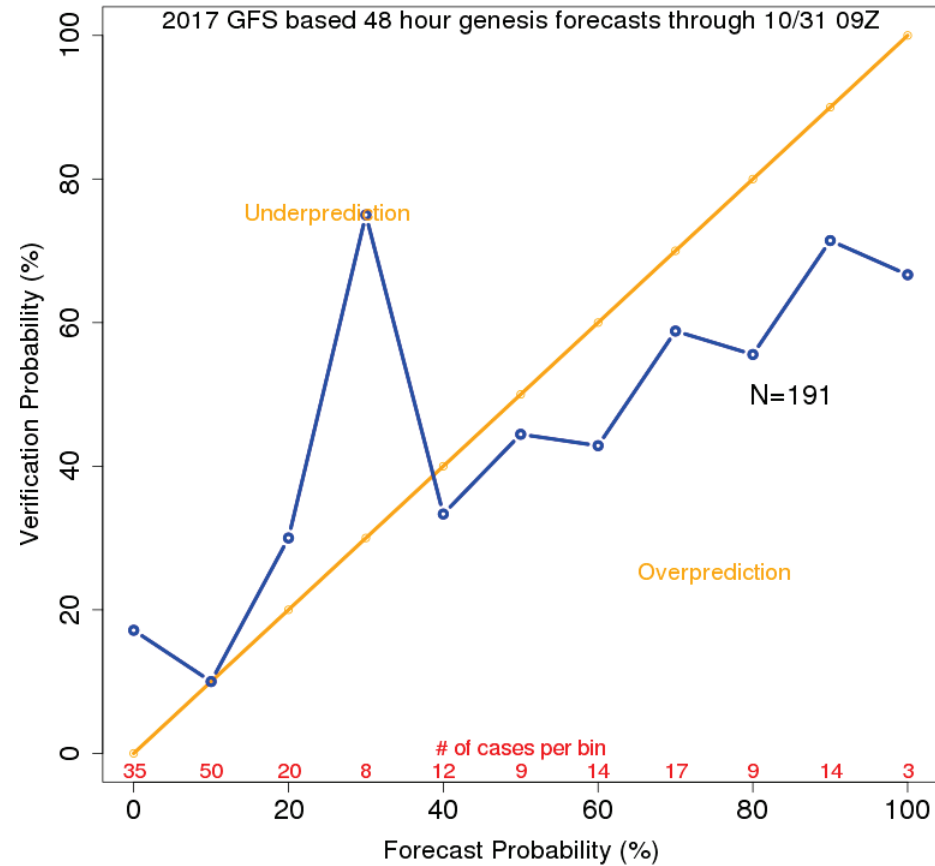5-day "High" Forecasts
GFS: 16
NHC: 89

Preliminary results courtesy of Dan Halperin

- 2-day GFS genesis forecasts had a lot of noise – low probabilities had an under-forecast bias; sample quite small at 40% and above
- 5-day results smoother, but persistent 10-20% under-forecast bias for most probabilities
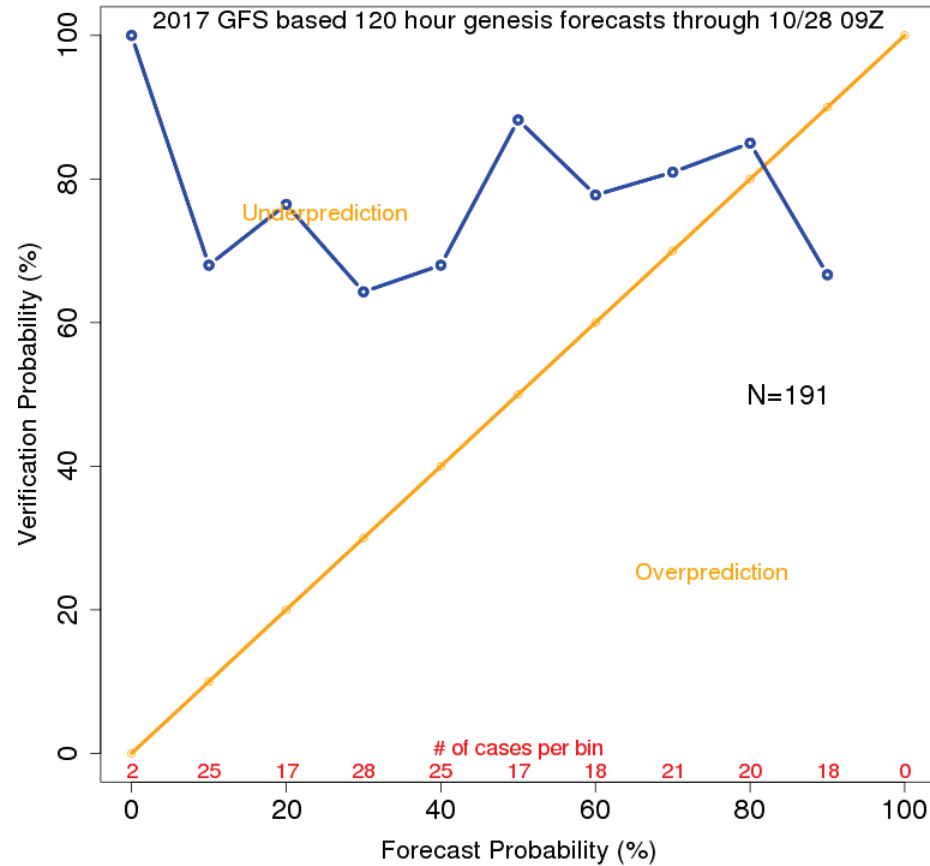
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East Pacific GFS Genesis Forecasts

2 day

Season-to-Date TC Genesis Forecast Verification

2017 GFS based 48 hour genesis forecasts through 10/31 09Z

5 day

Season-to-Date TC Genesis Forecast Verification

2017 GFS based 120 hour genesis forecasts through 10/28 09Z

2-day "High" Forecasts
GFS: 43
NHC: 52

5-day "High" Forecasts
GFS: 59
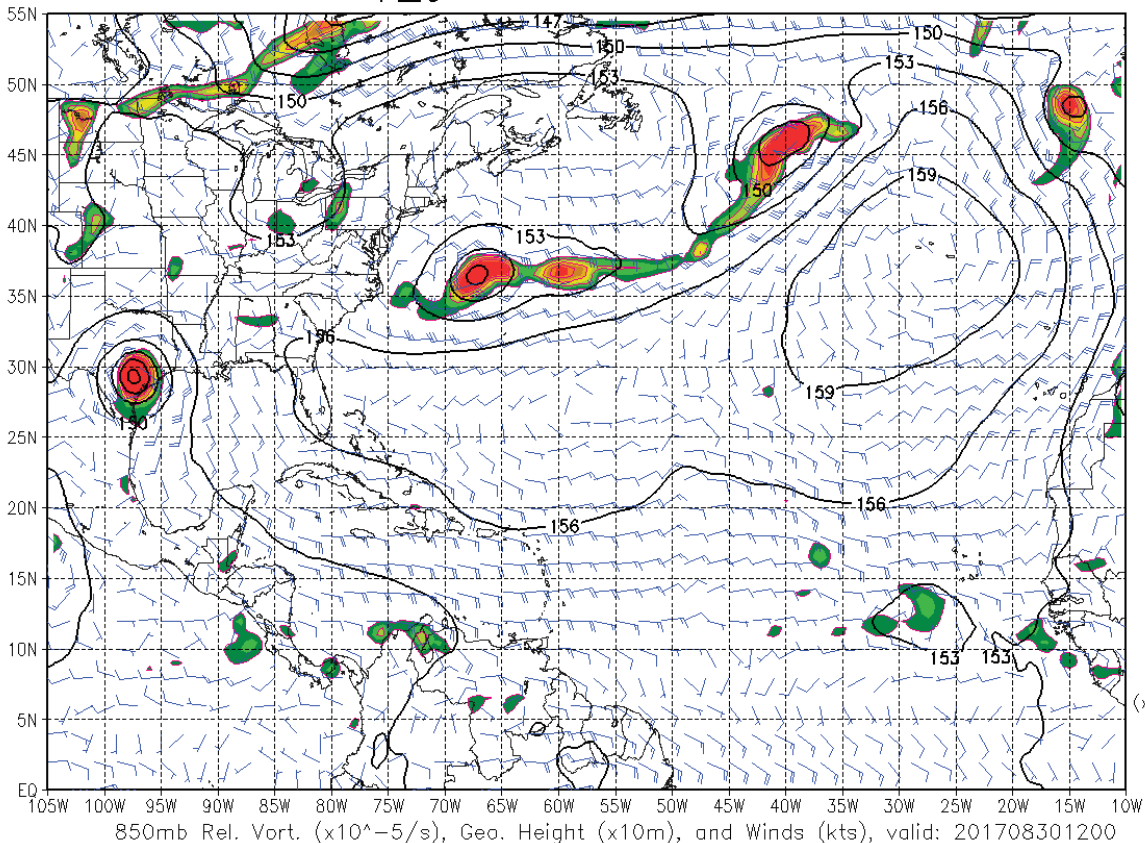NHC: 111

Preliminary results courtesy of Dan Halperin

- 2-day GFS genesis forecasts generally OK, but a big low bias around 30%
- 5-day results terrible – huge under-forecasts at low to medium probability ranges!

GFS Genesis Example – Irma
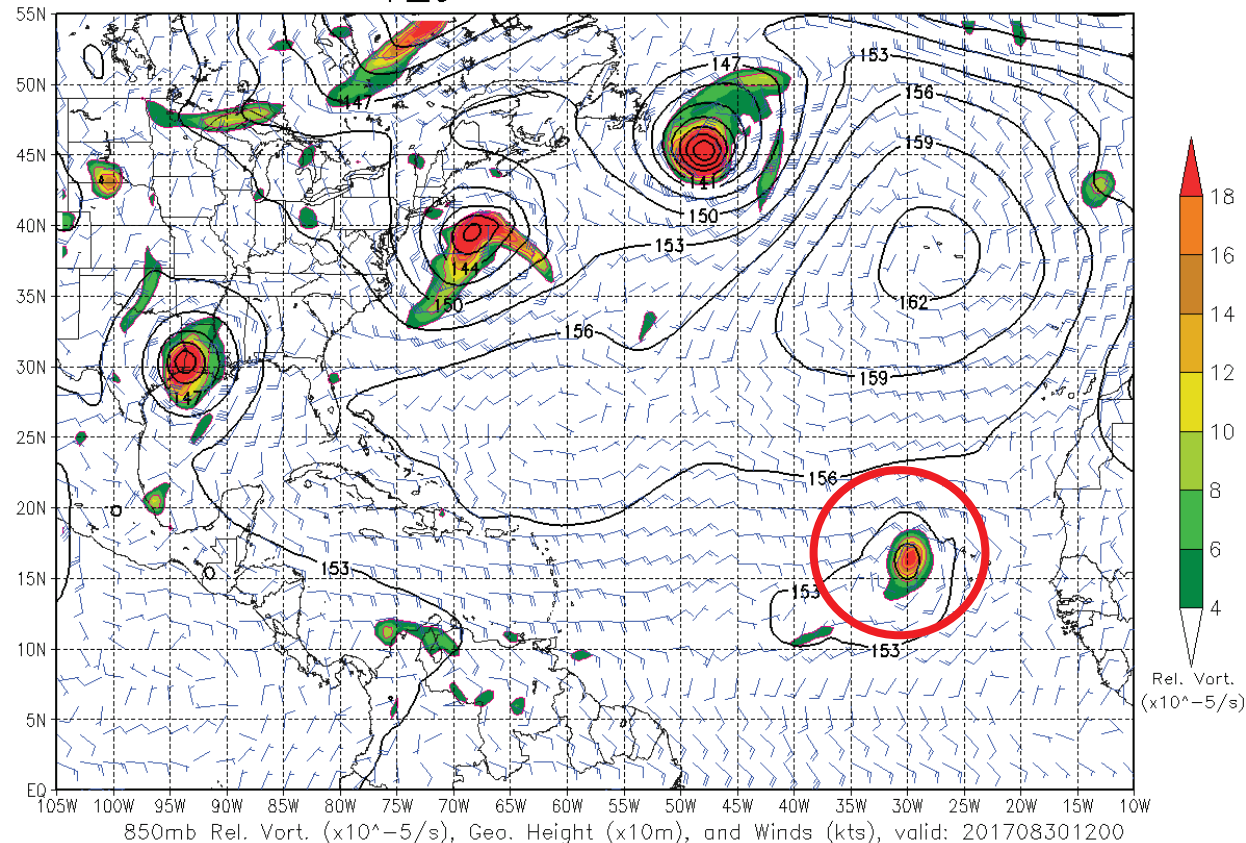

Verifying Analysis – 12 UTC 30 August 2017

NCEP op_gfs – 2017082512 – F120

NCEP op_gfs – 2017083012 – F000

850mb Rel. Vort. (x10^−5/s), Geo. Height (x10m), and Winds (kts), valid: 201708301200

850mb Rel. Vort. (x10^−5/s), Geo. Height (x10m), and Winds (kts), valid: 201708301200

Hurricane Forecast Improvement Program

Experimental Product

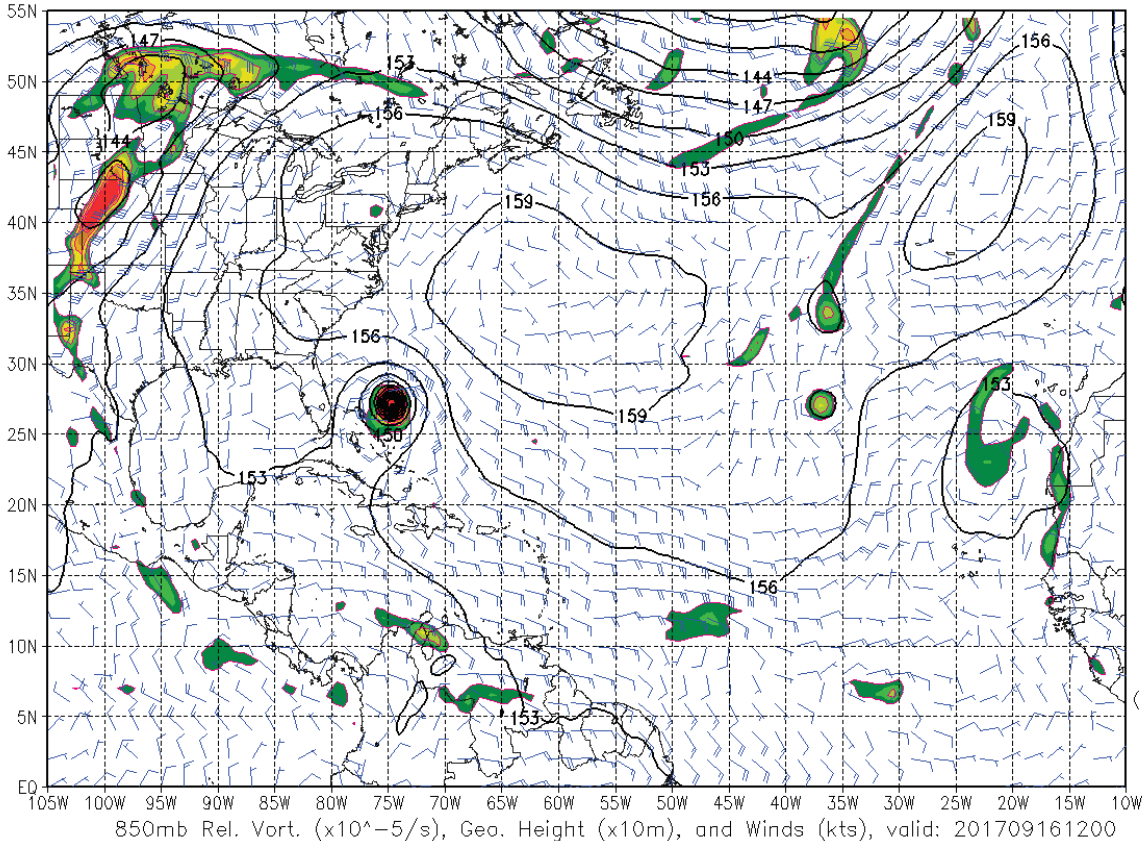Hurricane Forecast Improvement Program

Experimental Product

Some signal early (4-5 days), but signal weakened inside of 60 hours until genesis

Annual HFIP Meeting

GFS Genesis Example – Maria
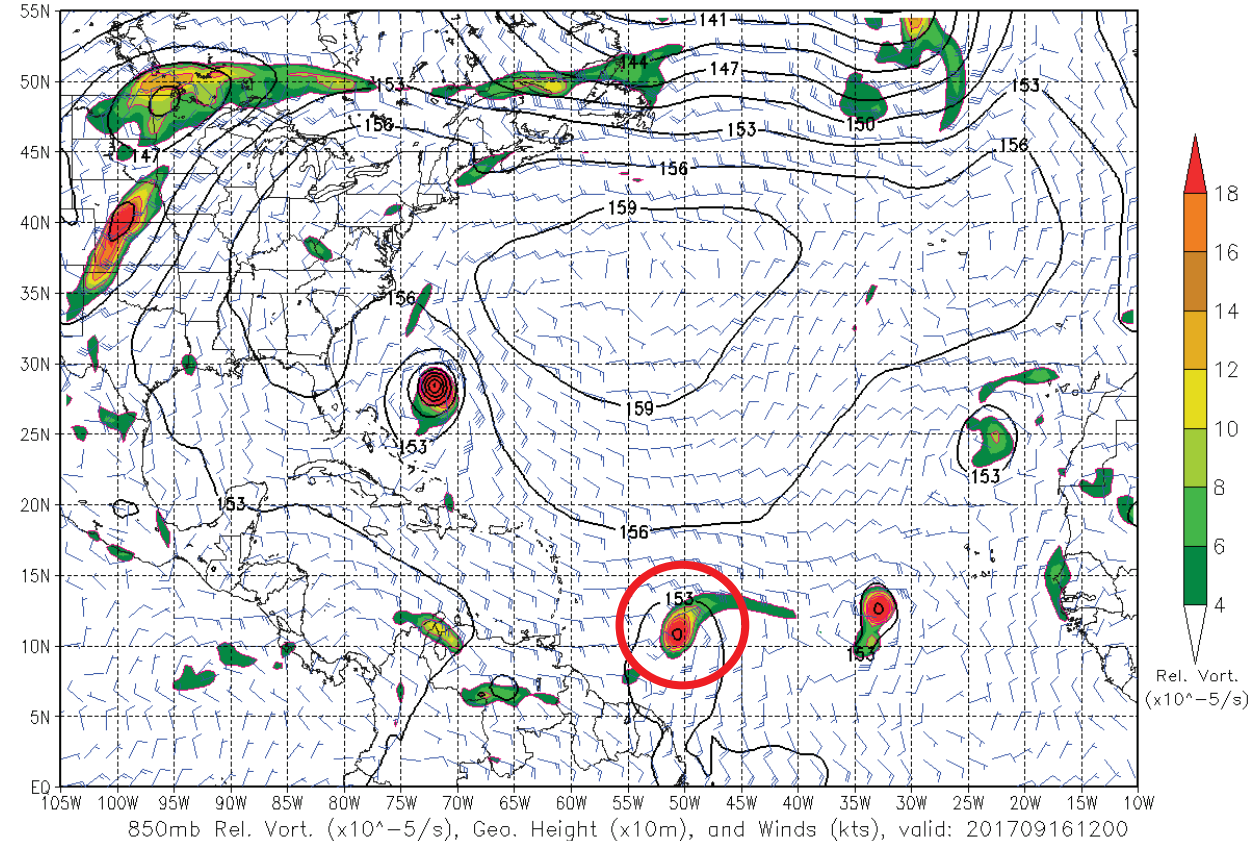

Verifying Analysis – 12 UTC 16 September 2017

NCEP op_gfs – 2017091112 – F120

NCEP op_gfs – 2017091612 – F000

850mb Rel. Vort. (x10^-5/s), Geo. Height (x10m), and Winds (kts), valid: 201709161200

850mb Rel. Vort. (x10^-5/s), Geo. Height (x10m), and Winds (kts), valid: 201709161200

Hurricane Forecast Improvement Program   Experimental Product

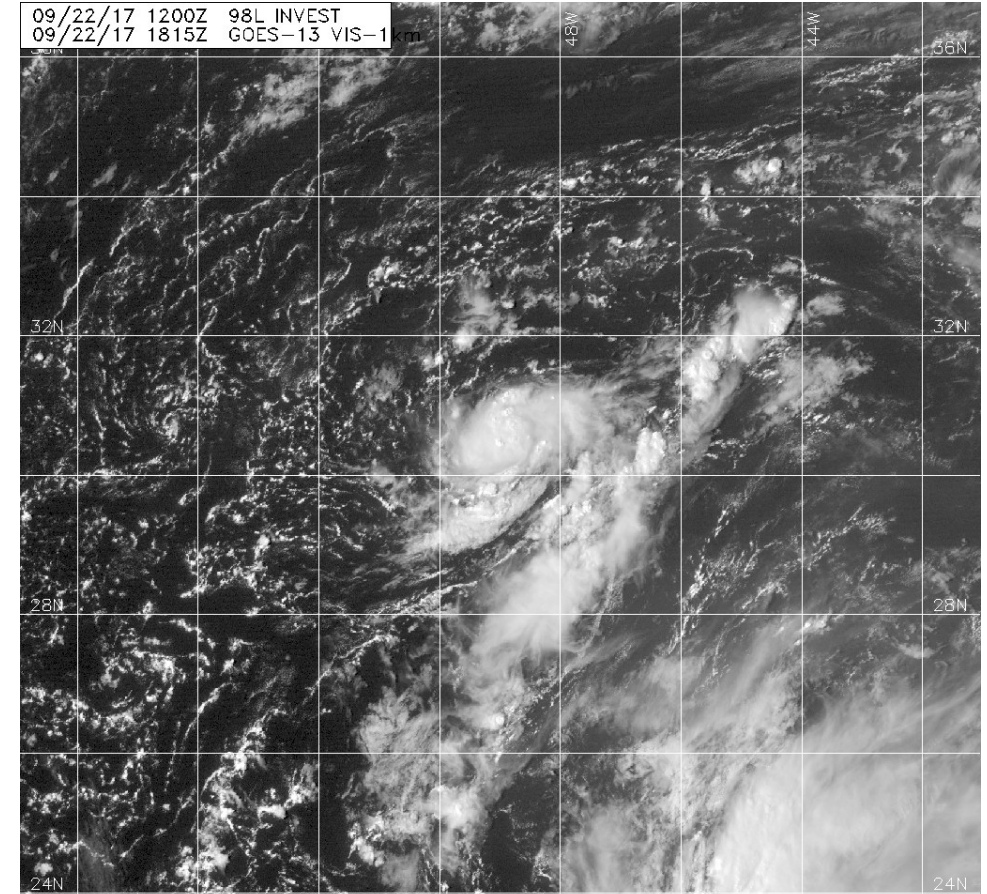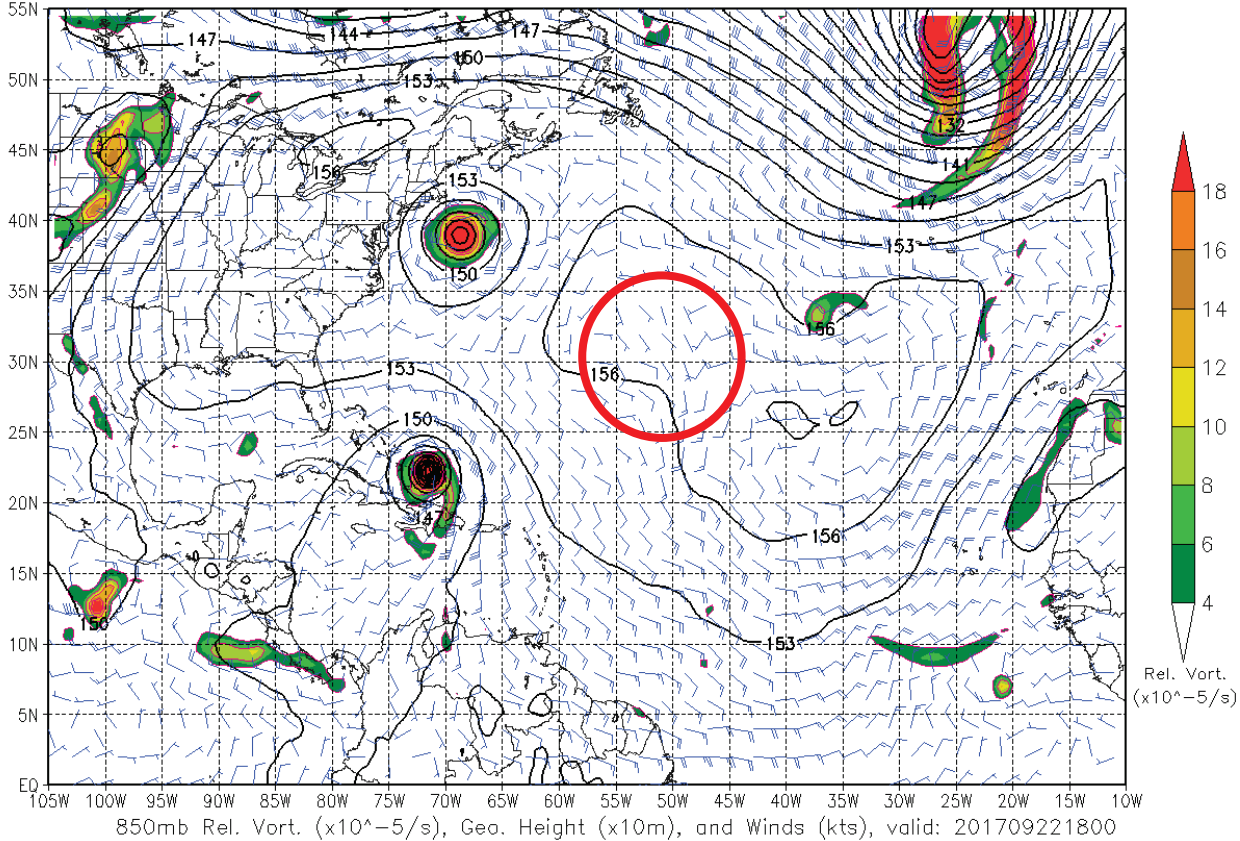Hurricane Forecast Improvement Program   Experimental Product

Weak/No signal until 42 h prior to genesis

GFS Genesis Example – Lee (Genesis #2)

GOES-13 Visible Imagery – 1815 UTC 22 September 2017


Little/No Signal Prior to Genesis

Rapid Intensification

- Rapid intensification was more frequent than average in the Atlantic in 2017
  - 24 h: 39 observed RI cases (≥ 30 kt) out of 312 total (9.6%)
    - HWRF: 6 correct, 1 false alarm
    - LGEM: 2 correct
    - NHC: 6 correct, 1 false alarm
  - 48 h: 24 observed RI cases (≥ 55 kt) out of 253 total (9.5%)
    - HWRF: 2 correct, 3 false alarms
  - 72 h: 13 observed RI cases (≥ 65 kt) out of 208 total (6.3%)
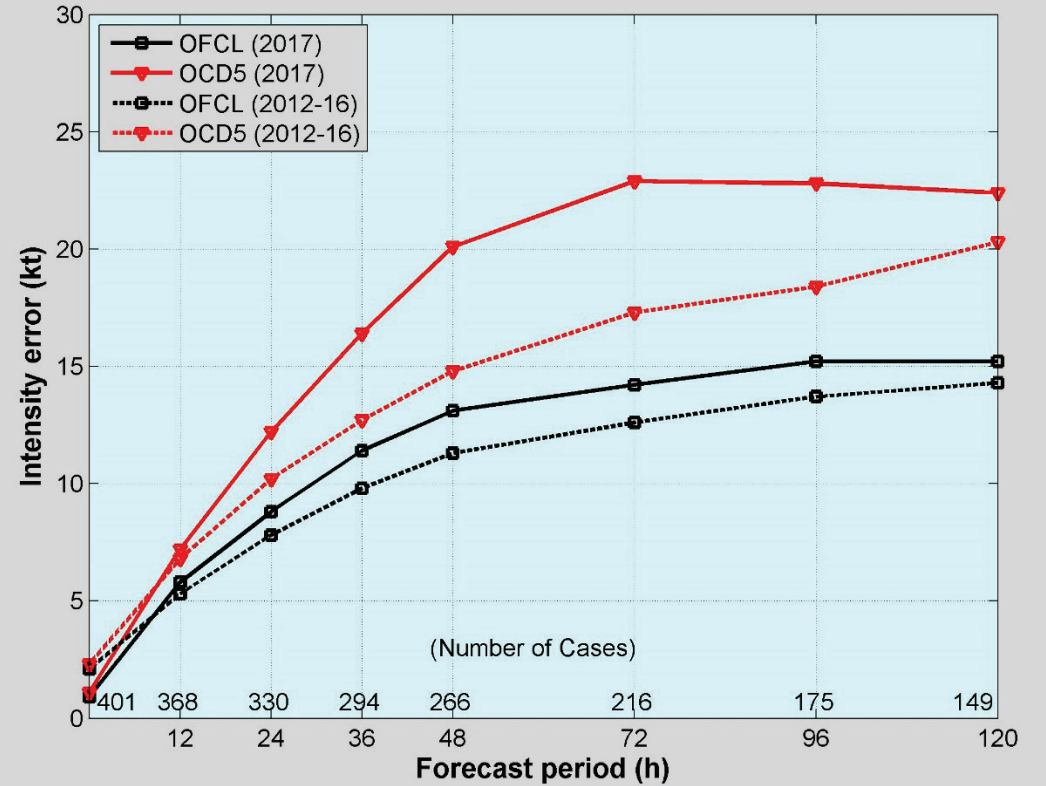   - HWRF: 4 correct, 5 false alarms
    - NHC: 1 correct

2017 Atlantic OFCL Errors
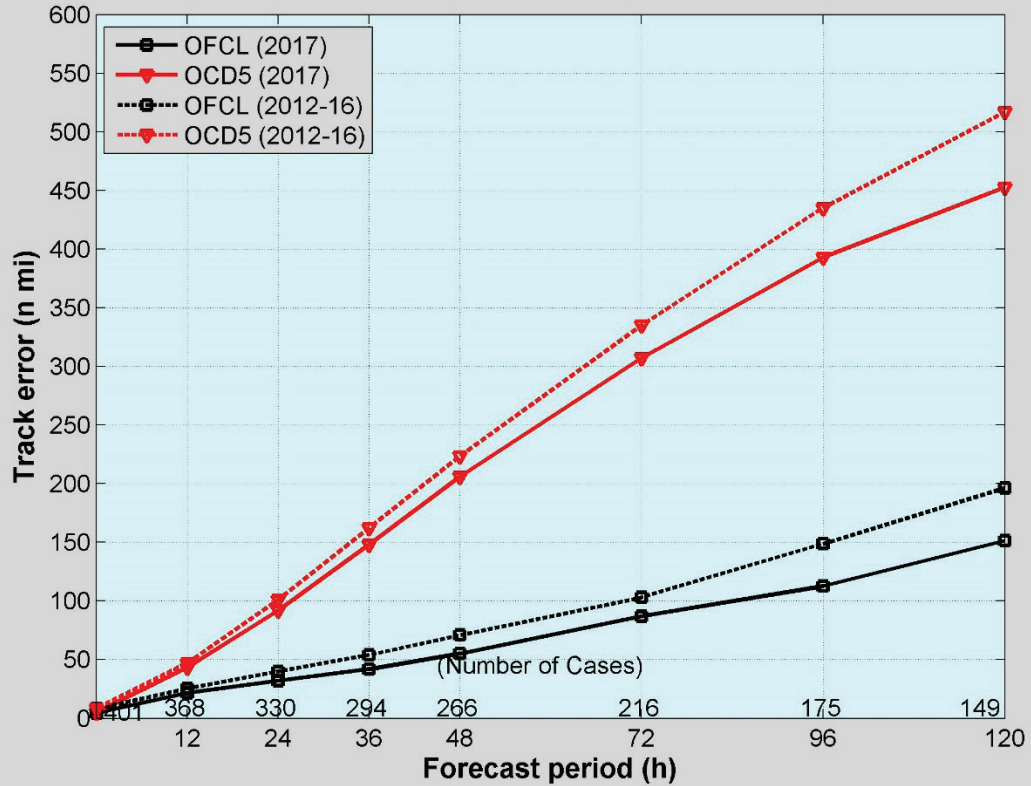
Track

Intensity

Rapid Intensification – Harvey

Obj. Aid Time Intensity for 09L for 082312
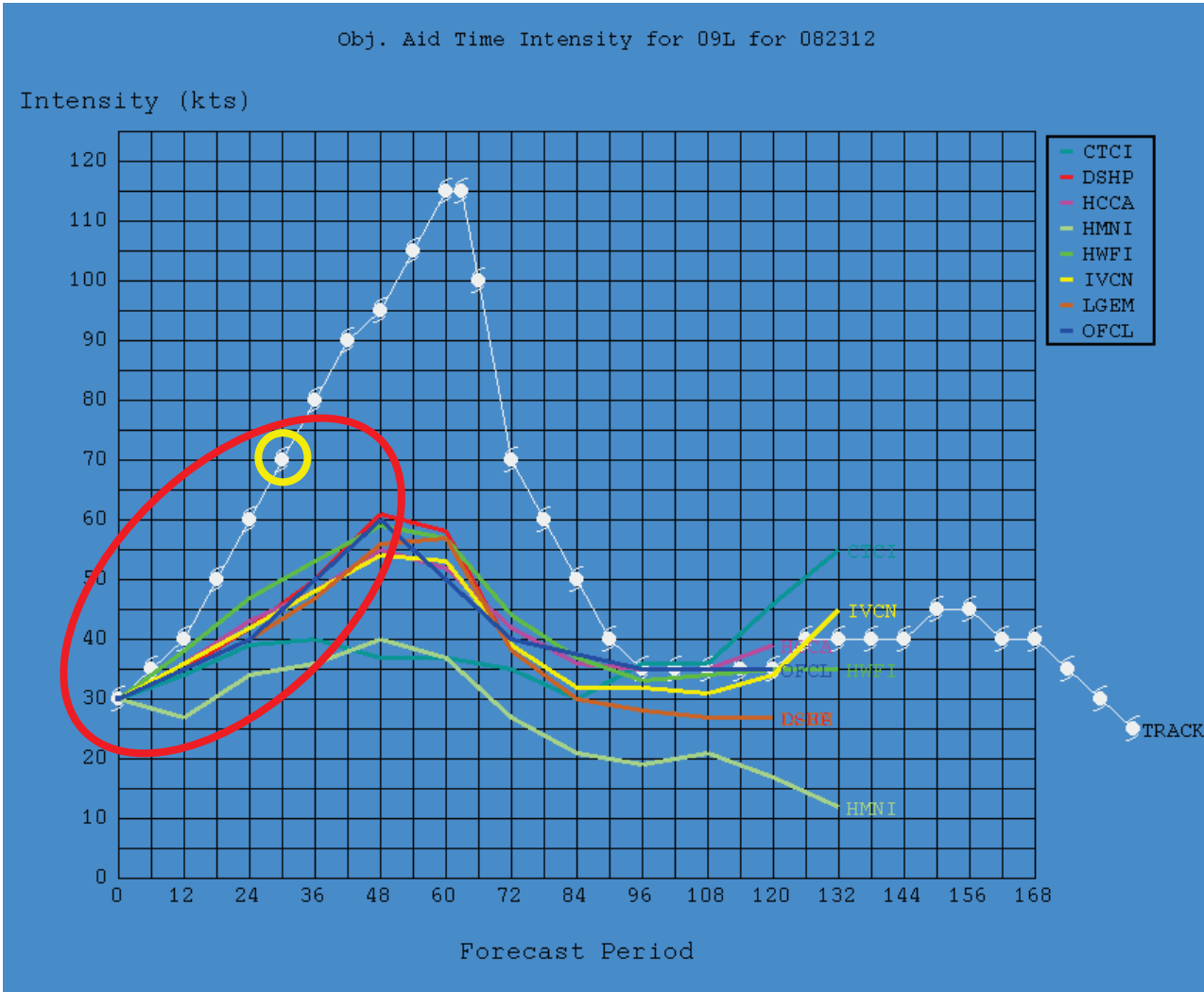
- Intensity guidance from first forecast when Harvey regenerated in the Gulf of Mexico (12Z 23 August 2017)

- Actual intensity increased 30 kt in 24 h and 65 kt in 48 h

- No guidance showed Harvey reaching hurricane intensity before landfall

  - Landfall intensity 115 kt (cat 4)
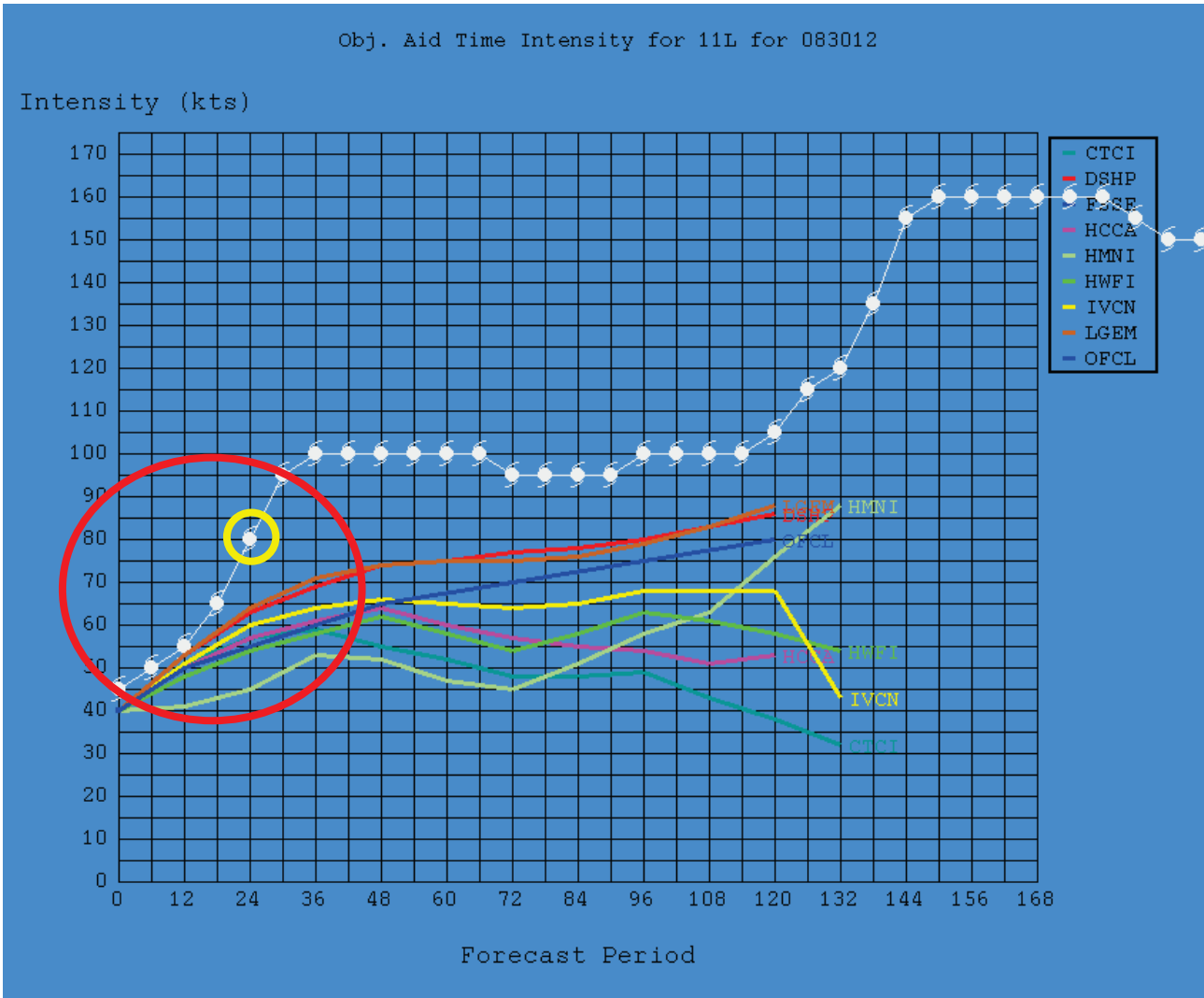
Rapid Intensification – Harvey


Obj. Aid Time Intensity for 09L
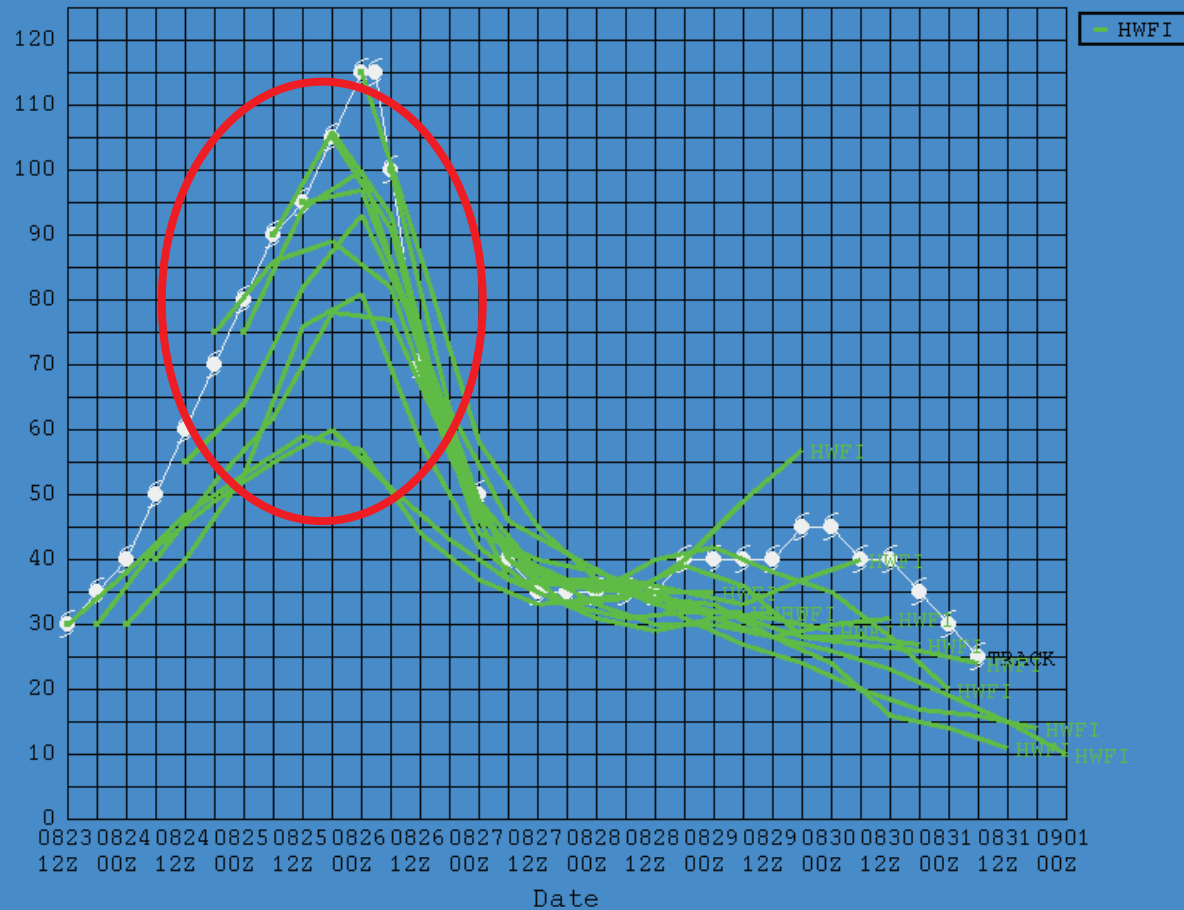
- HWRF consistently underestimated the development rate of Harvey in the Gulf, even once rapid intensification began

- 24-h bias for HWFI in Harvey through landfall was -17.5 kt (8 cycles) and -34.5 kt at 48 h (4 cycles)

Rapid Intensification – Irma
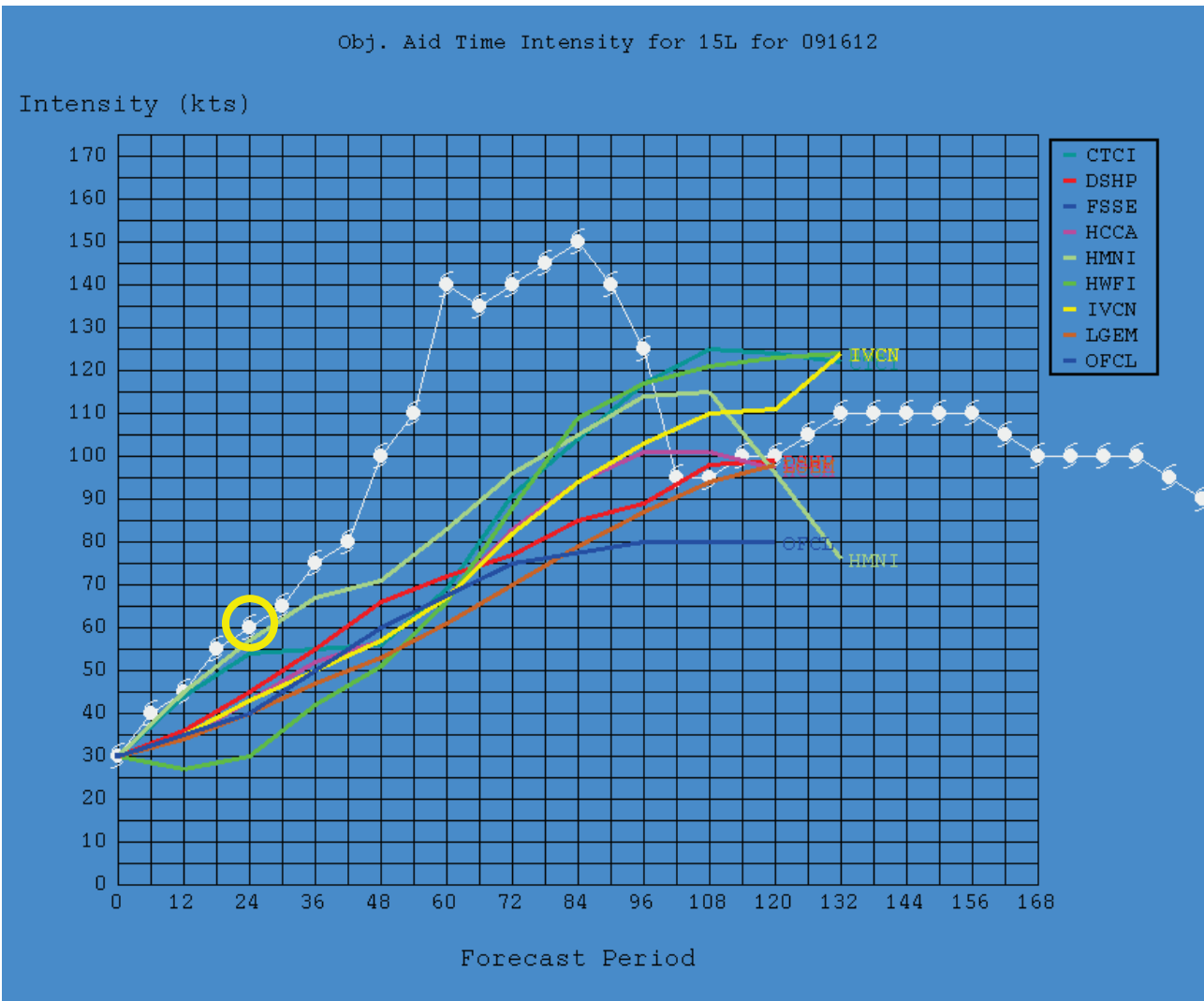

Obj. Aid Time Intensity for 11L for 083012

- For Irma's first RI instance, intensity guidance showed about 5-25 kt of strengthening, but storm intensified by 40 kt (12Z cycle on 8/30)

Rapid Intensification – Irma

Obj. Aid Time Intensity for 11L for 090500
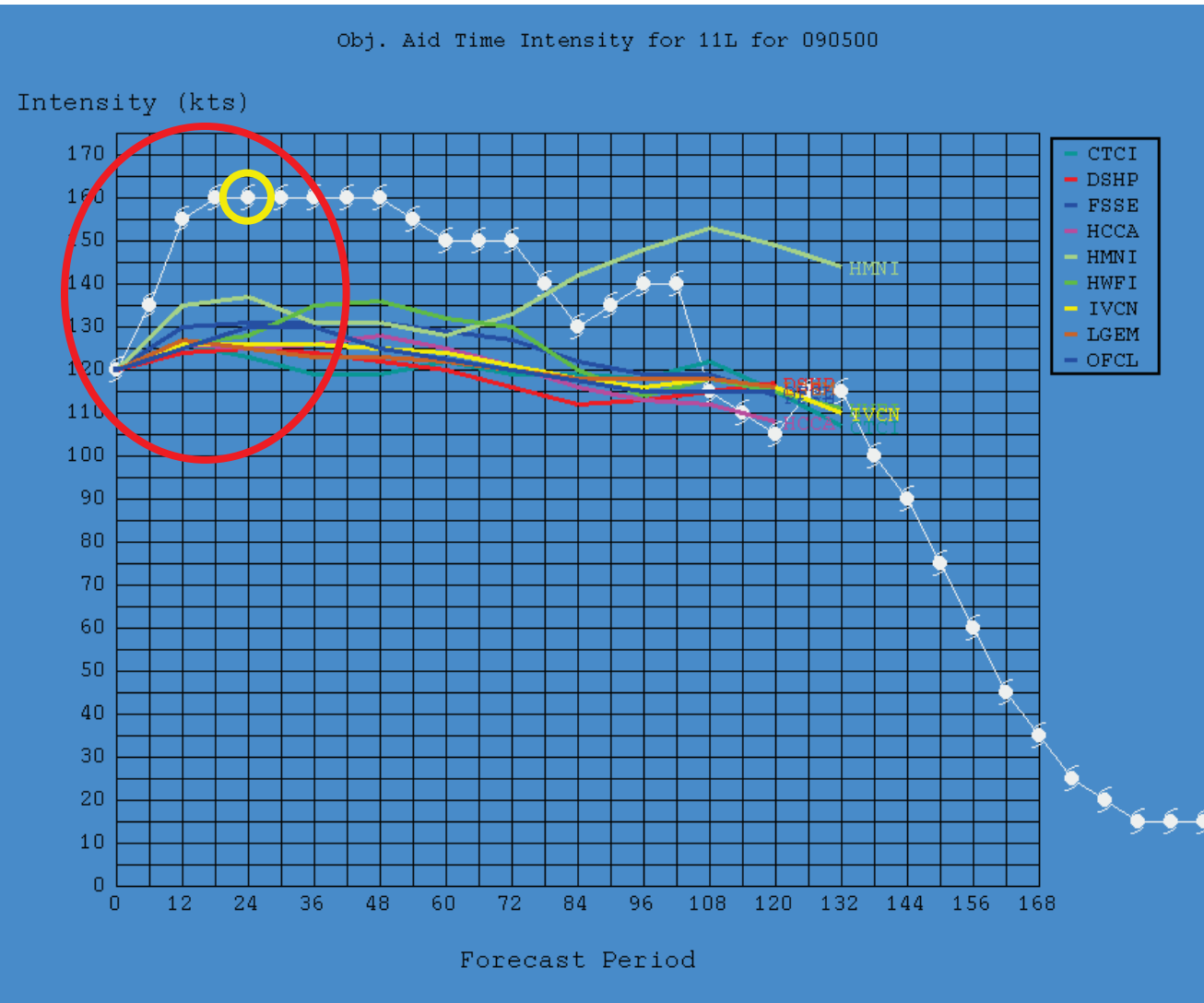
- Irma's second round of RI to category 5 intensity was very poorly predicted by all guidance, even within 6 h of RI event beginning (00Z cycle on 9/5)
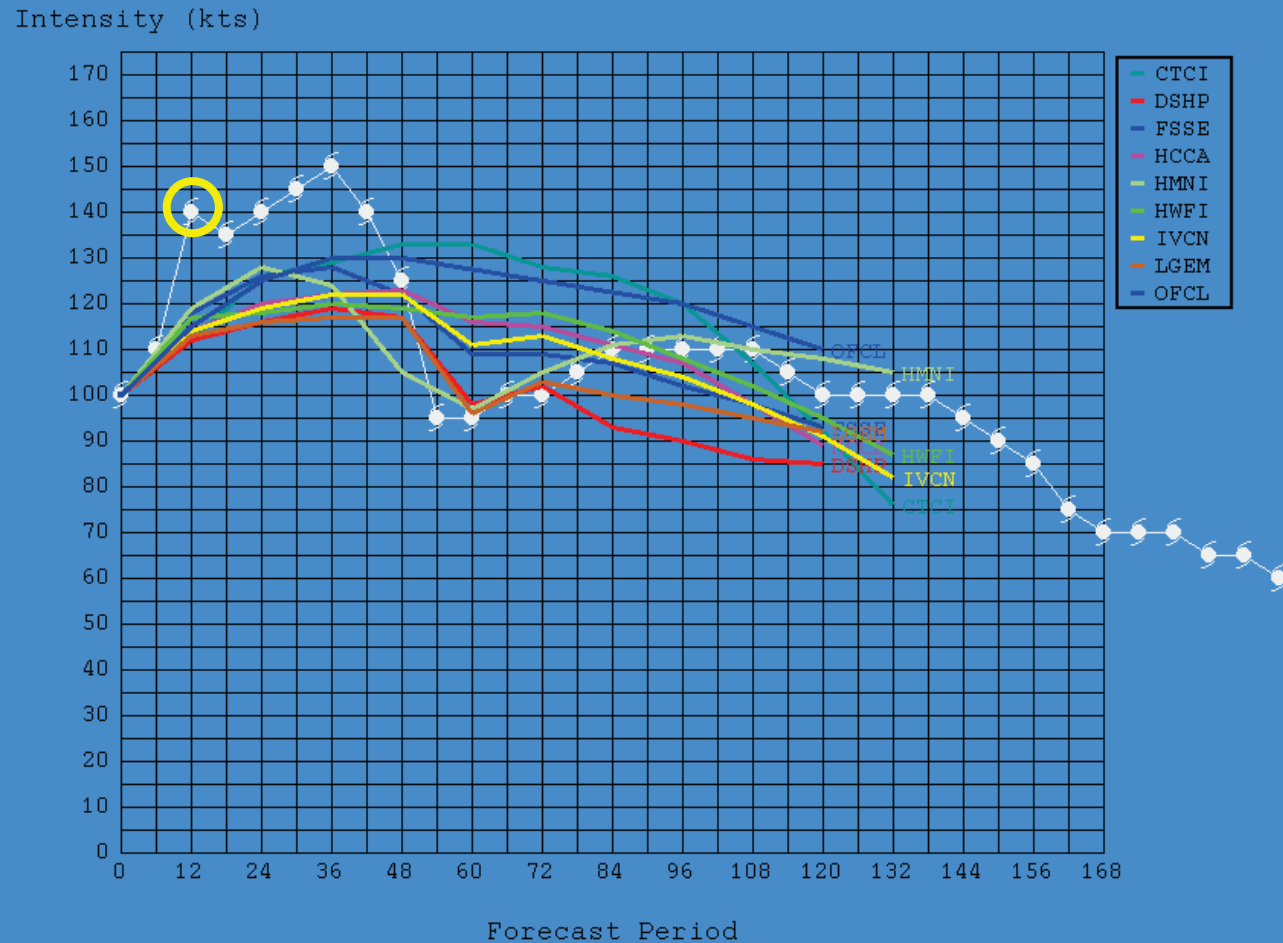
Rapid Intensification – Maria

Obj. Aid Time Intensity for 15L for 091612

- For first Maria forecast, HMON and COAMPS-TC captured initial 24-h of strengthening, but no guidance had second round of RI to Cat 4/5 range
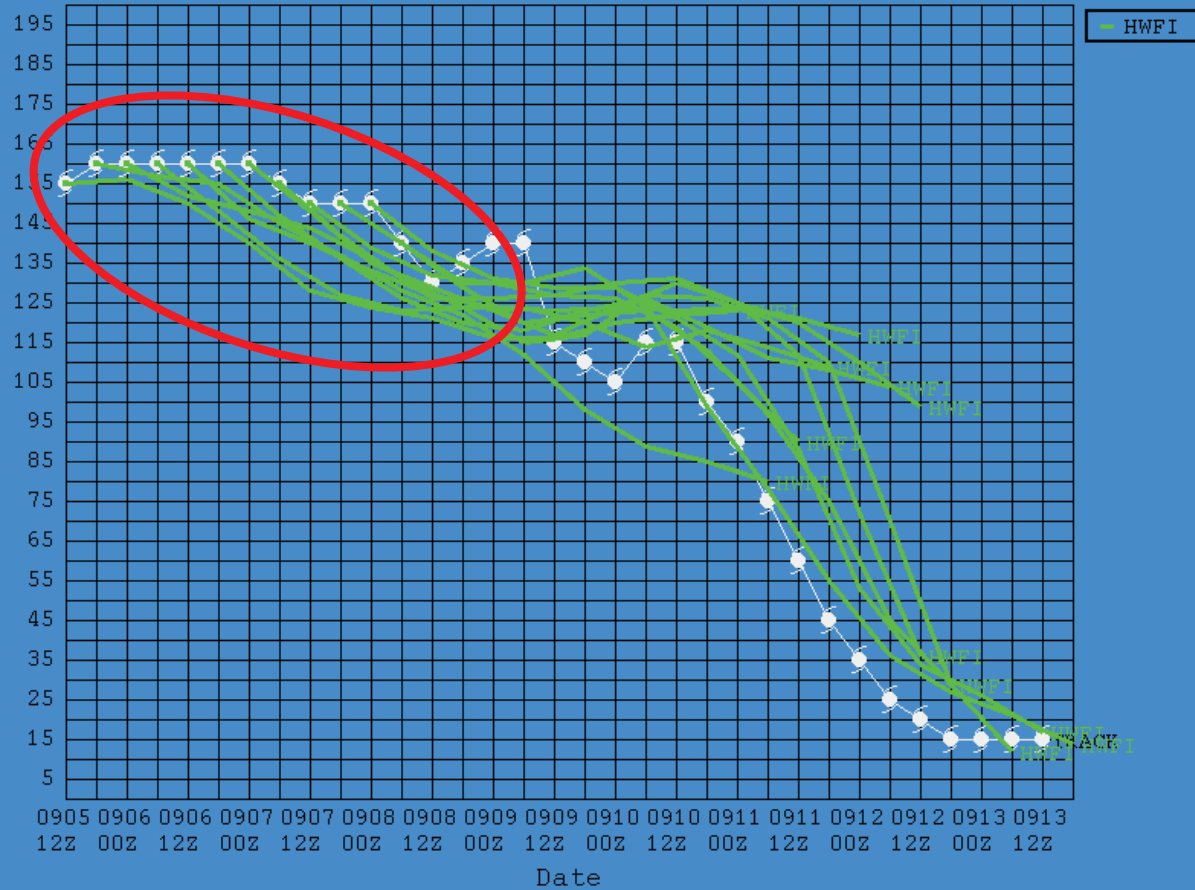
Rapid Intensification – Maria

- Just prior to second RI instance, guidance showed at most 25-30 kt of strengthening in 24 h, when 40 kt of intensification occurred in just 12 h

Long Duration Cat 5 – Irma

Obj. Aid Time Intensity for 11L

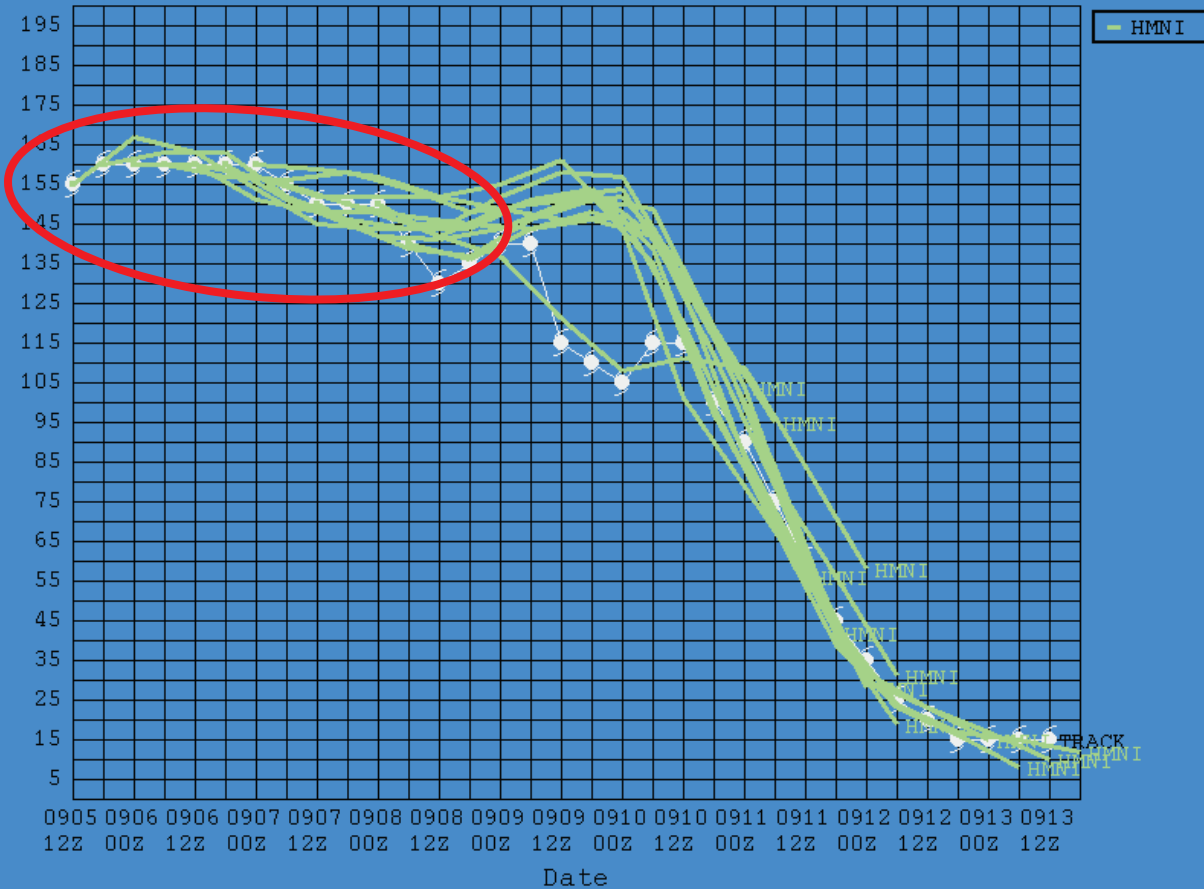- HWRFI continually weakened Irma once it became a cat 5
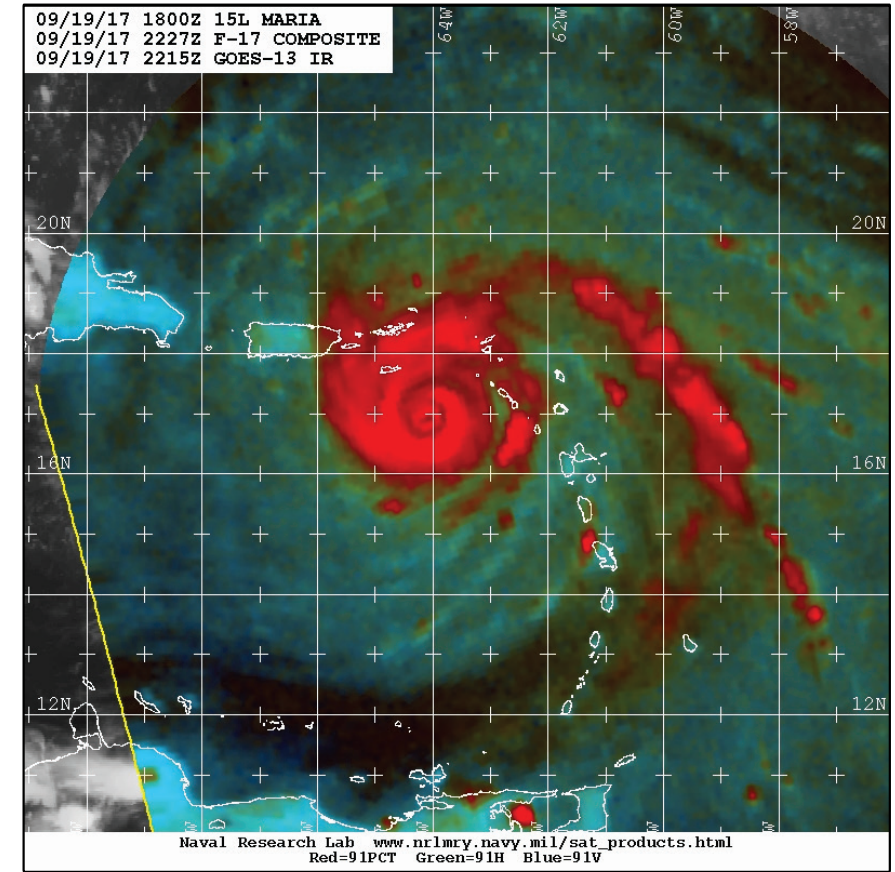
Long Duration Cat 5 – Irma
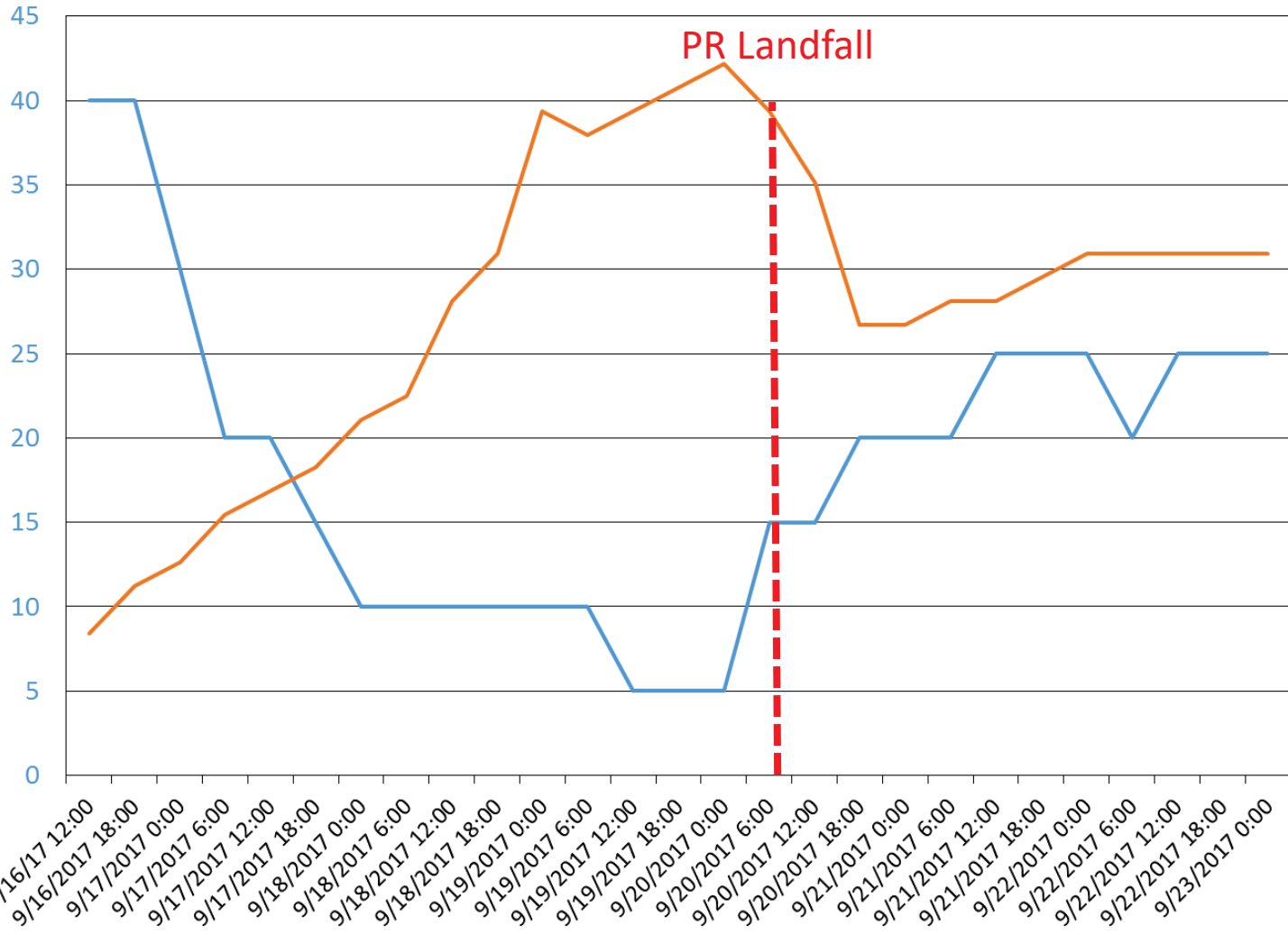

Obj. Aid Time Intensity for 11L

- HMON did a better job keeping Irma at Cat 5 intensity, but kept intensity too high (likely due to track that didn't interact with Cuba)

Maria – Structural Changes


Maria RMW vs. Intensity

PR Landfall

09/19/17 1800Z 15L MARIA
09/19/17 2227Z F-17 COMPOSITE
09/19/17 2215Z GOES-13 IR

Naval Research Lab   www.nrlmry.navy.mil/sat_products.html
Red=91PCT   Green=91H   Blue=91V

SSMIS Image at 0521 UTC 20 Sep. 2017

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Model Performance

HMON – Atlantic Track

- HMON track errors were 10-30% larger than HWRF through day 4
- HMON was not included in the TVCN multi-model track consensus in 2017, but it would have degraded it by up to 7% (at 72 h)

2017 Atlantic Track Forecast Error

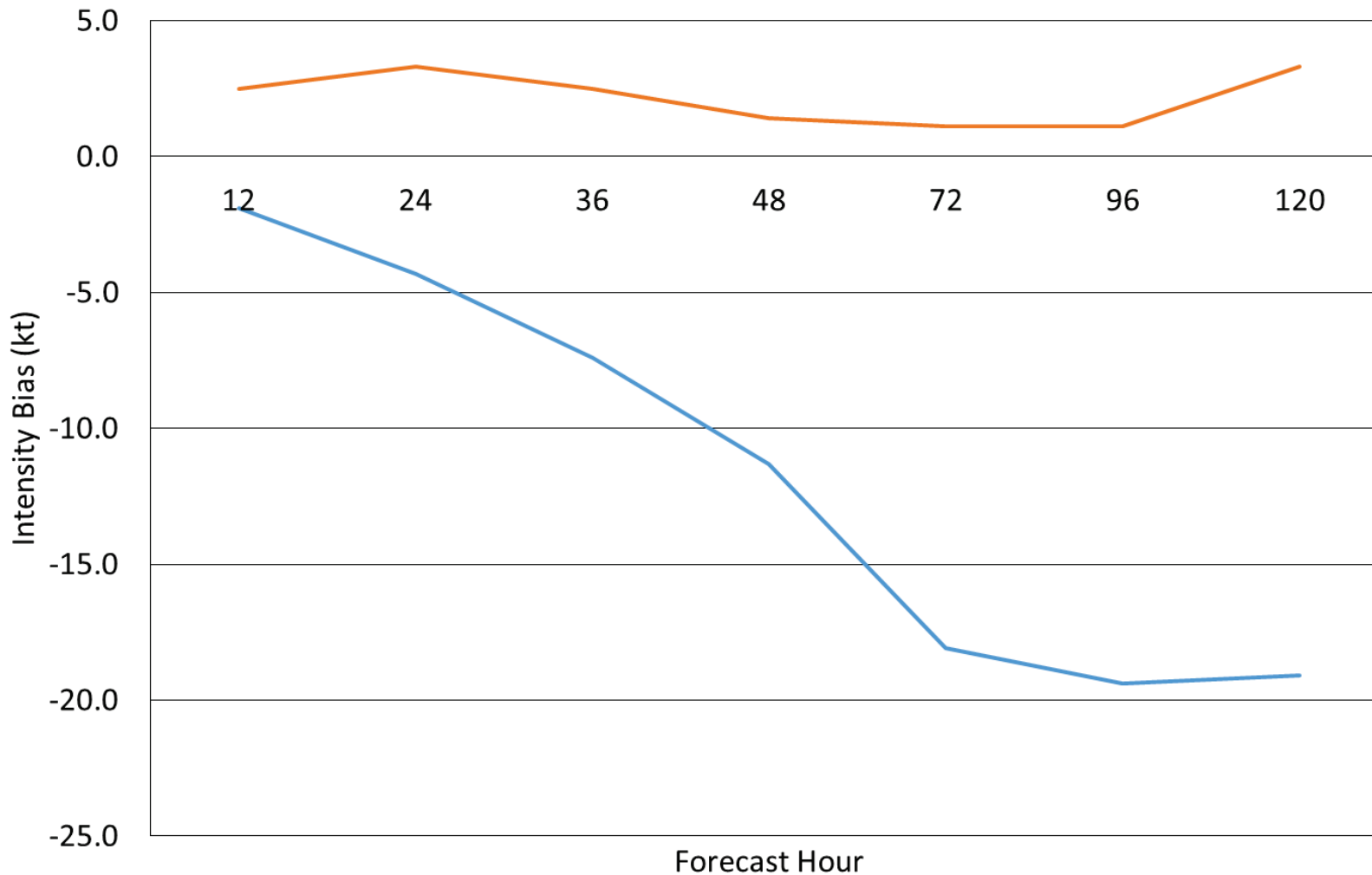2017 Atlantic Track Forecast Error
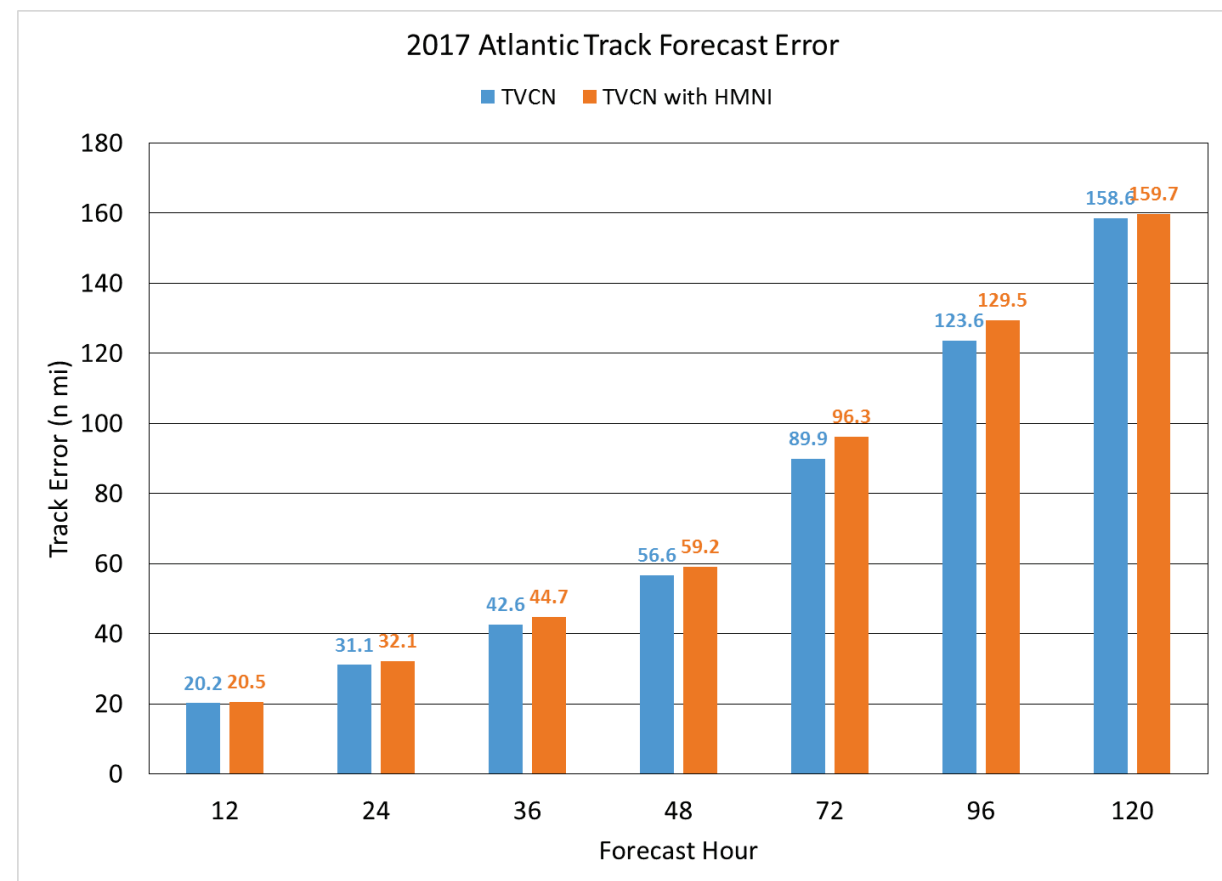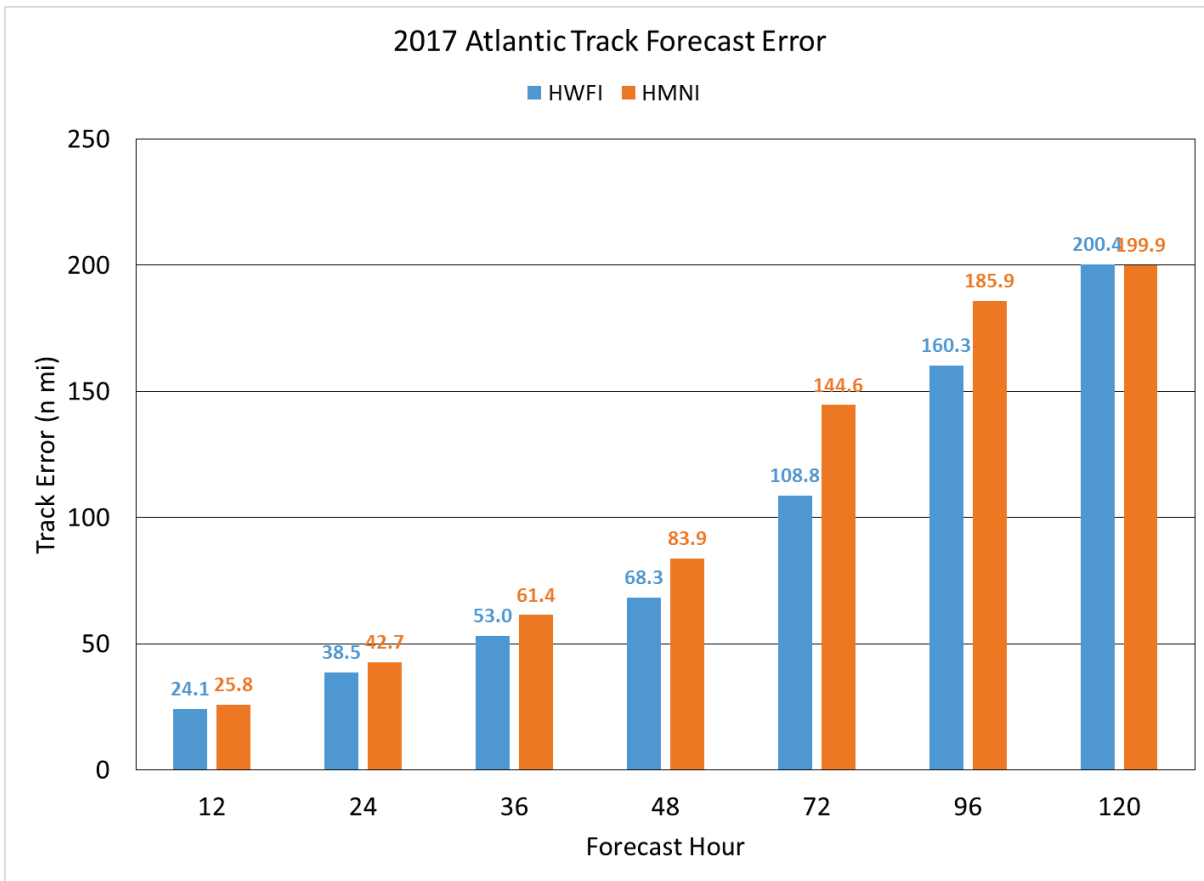
HMON – Atlantic Intensity

- HMON intensity errors were 5-20% larger than HWRF

- HMON was not included in the IVCN multi-model intensity consensus in 2017, but it would have improved it slightly (1-3%) at most lead times
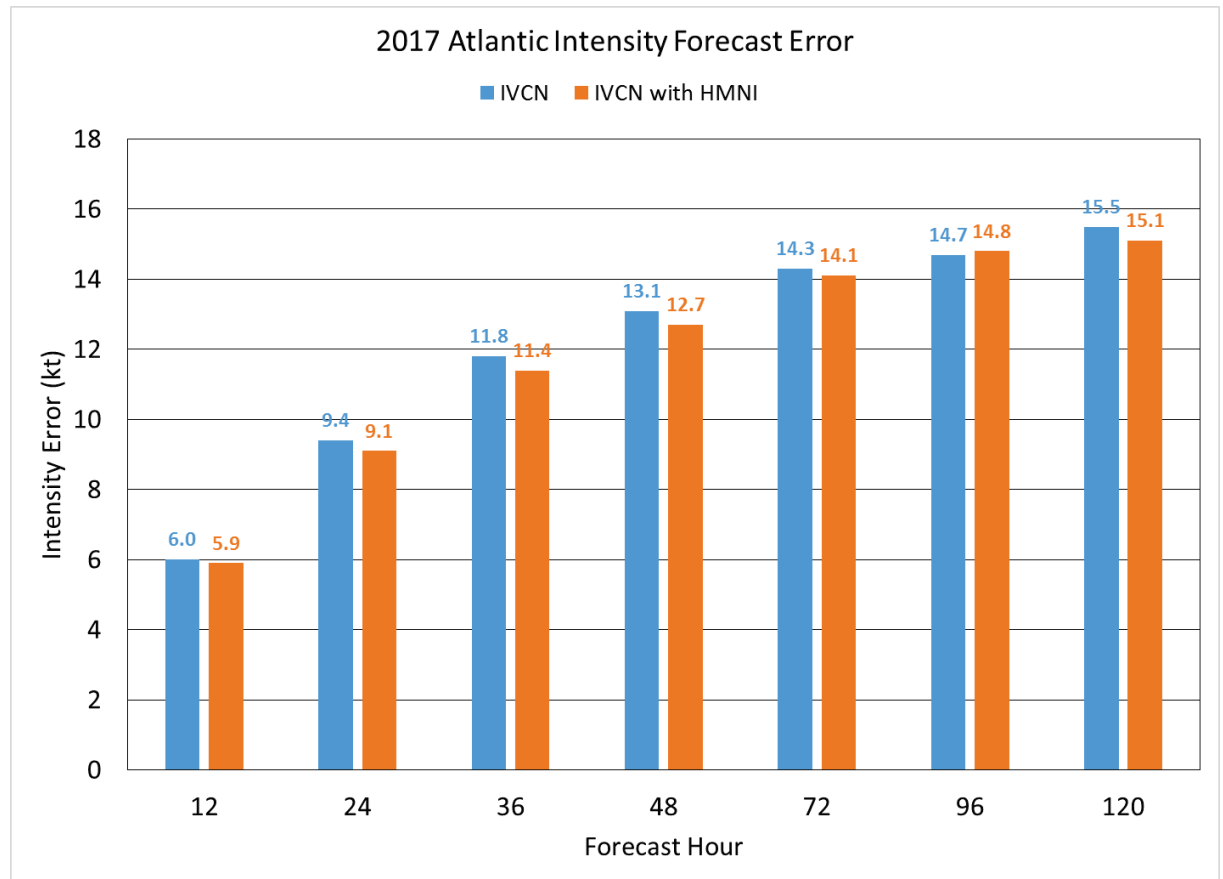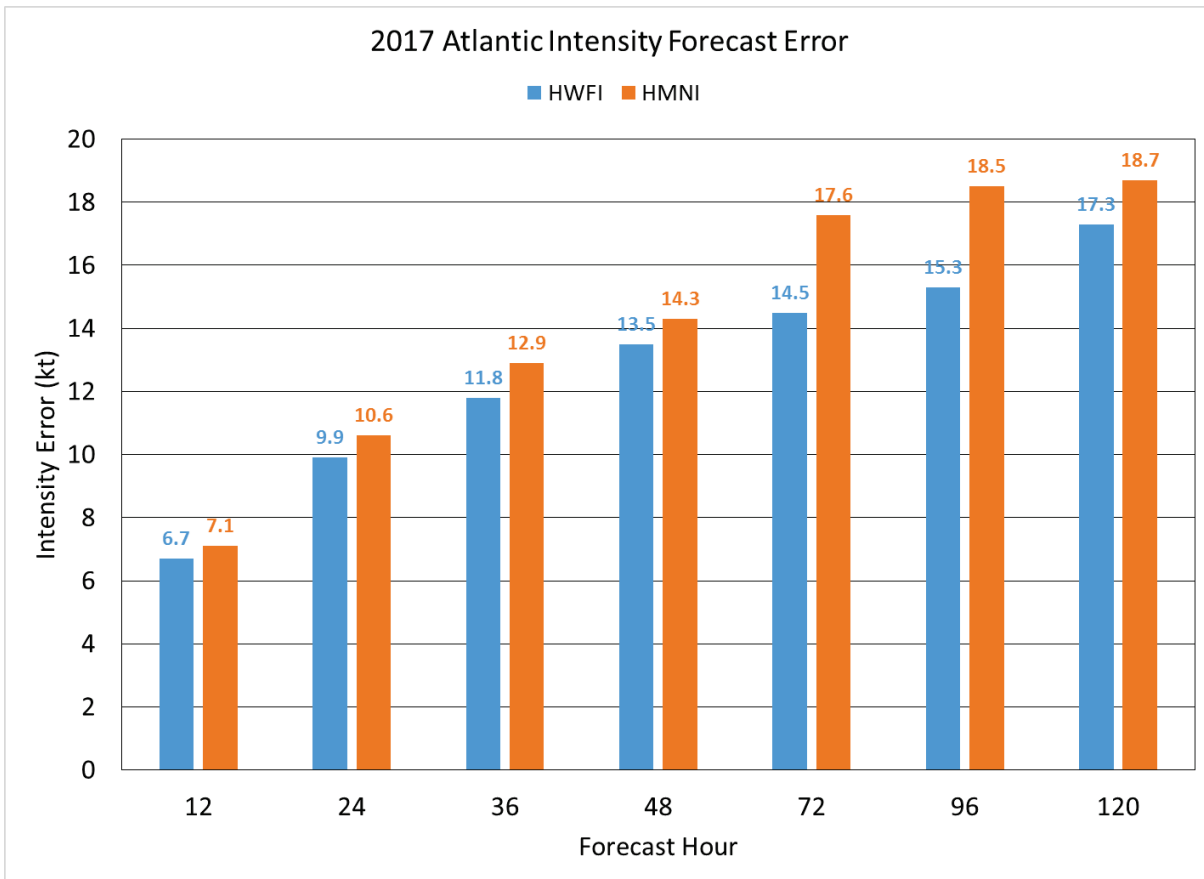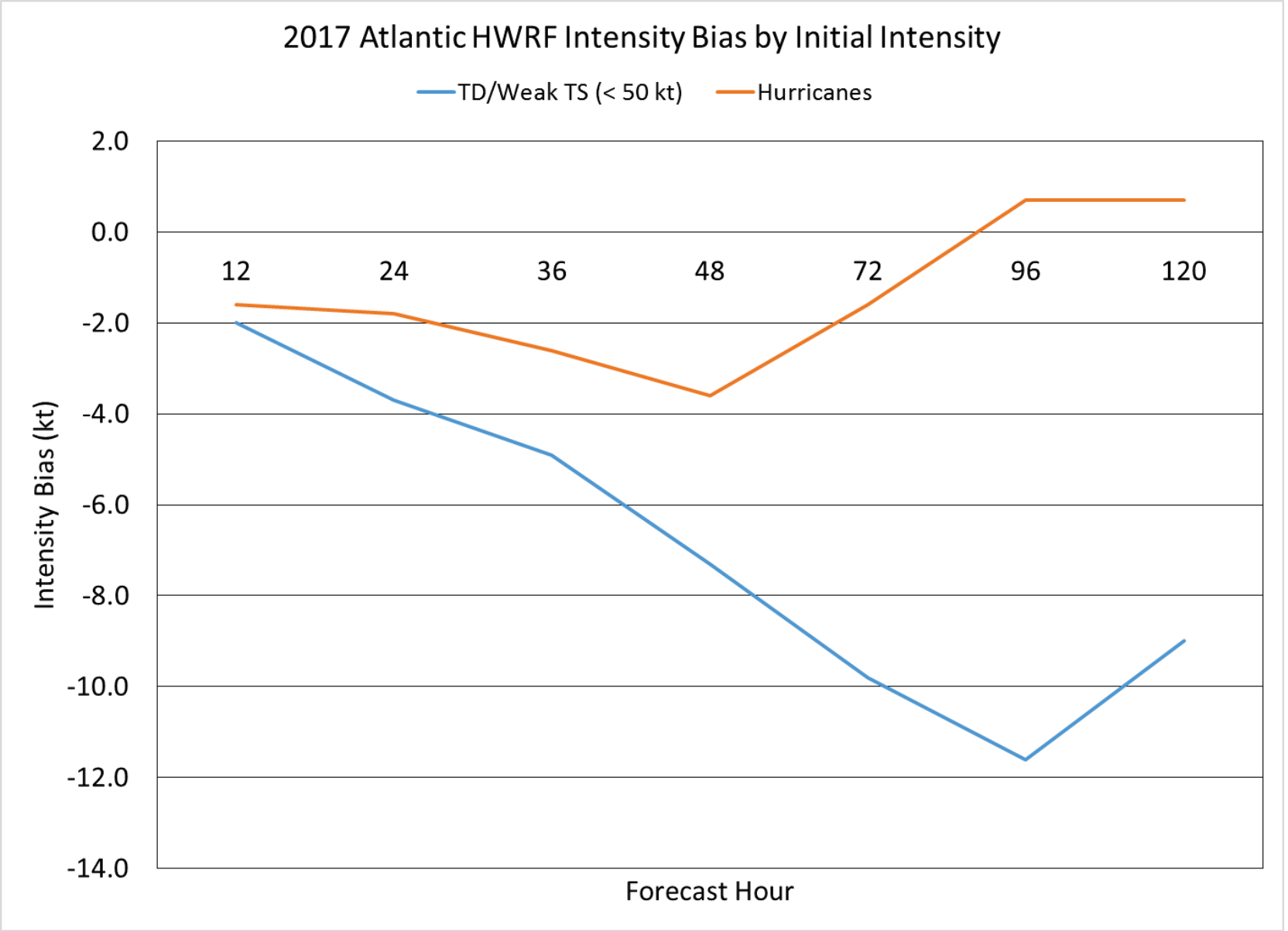
HMON Intensity Bias

2017 Atlantic HMON Intensity Bias by Initial Intensity

- For 2017 HMON had a very large low bias for systems that were < 50 kt at the initial time

- Slight high bias for systems initially at hurricane intensity

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HWRF Intensity Bias

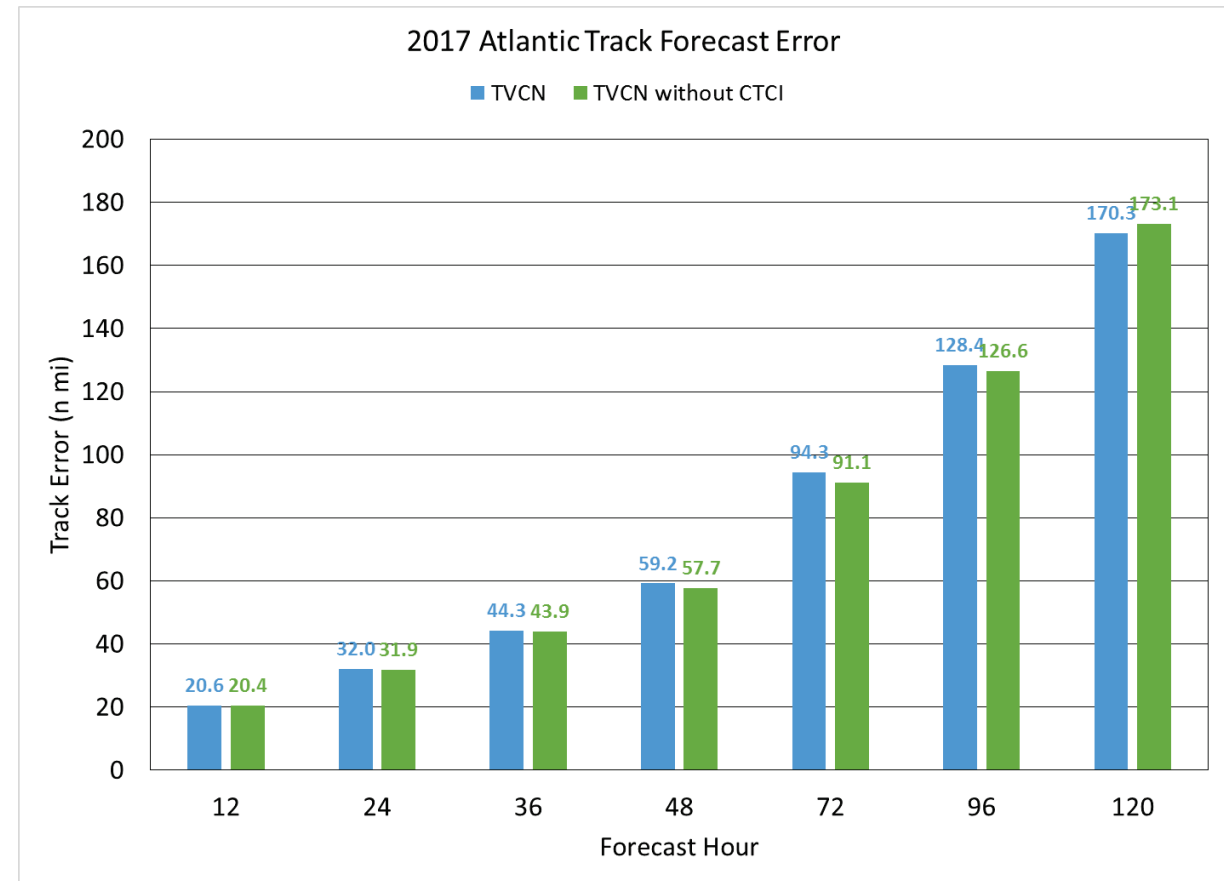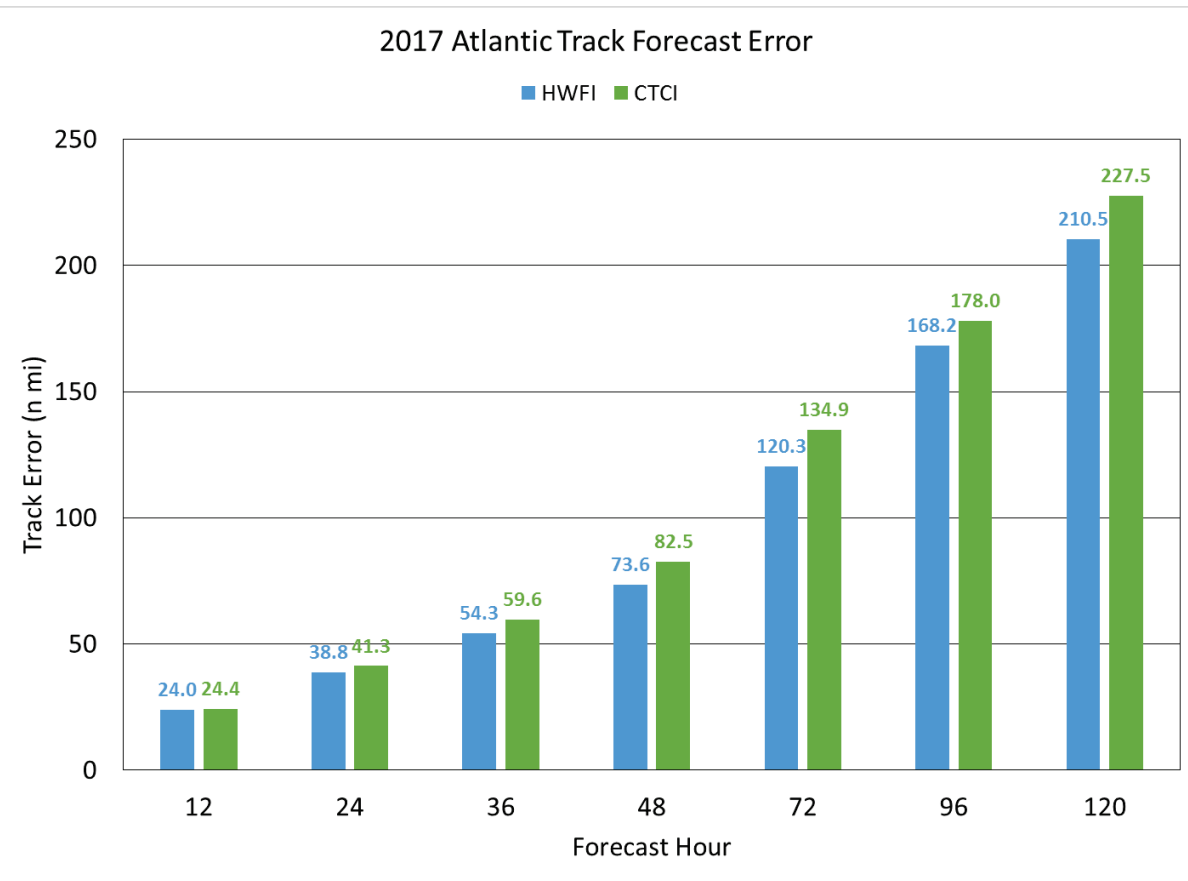2017 Atlantic HWRF Intensity Bias by Initial Intensity

- For 2017 HWRF had a large low bias for systems that were < 50 kt at the initial time

- 2-4 kt low bias through 72 h for systems that were hurricanes at the initial time, with small high bias at 96 and 120 h

COAMPS-TC – Atlantic Track

- COAMPS-TC track errors were 6–12% larger than HWRF at most lead times
- COAMPS-TC slightly degraded the TVCN multi-model track consensus through 96 h and slightly improved it at 120 h

2017 Atlantic Track Forecast Error

HWFI / CTCI

Forecast Hour	HWFI	CTCI
12	24.0	24.4
24	38.8	41.3
36	54.3	59.6
48	73.6	82.5
72	120.3	134.9
96	168.2	178.0
120	210.5	227.5

2017 Atlantic Track Forecast Error

TVCN / TVCN without CTCI

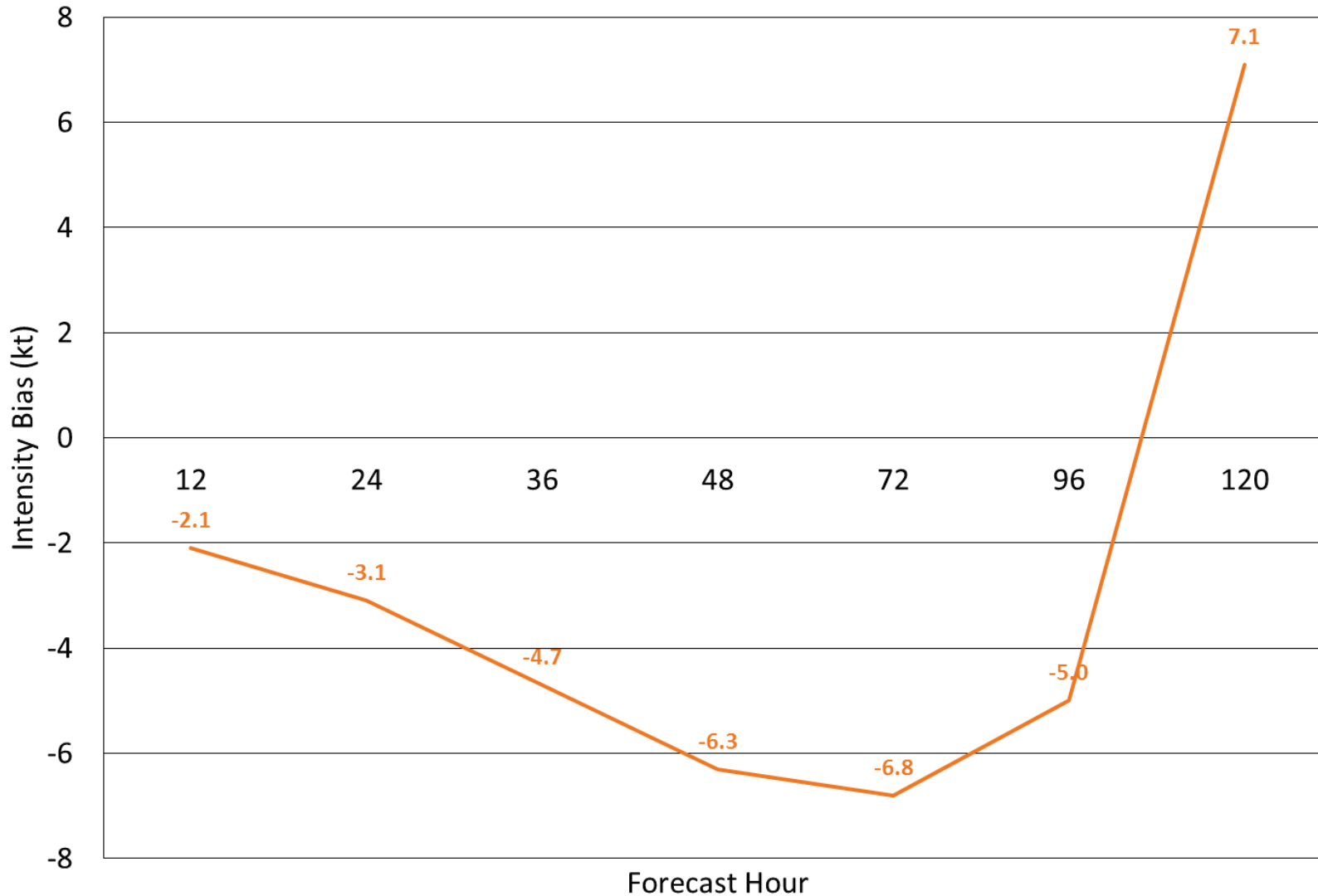| Forecast Hour	TVCN	TVCN without CTCI
12	20.6	20.4
24	32.0	31.9
36	44.3	43.9
48	59.2	57.7
72	94.3	91.1
96	128.4	126.6
120	170.3	173.1

COAMPS-TC – Atlantic Intensity

- COAMPS-TC intensity errors were 10–20% larger than HWRF through 72 h, but 5–10% smaller at days 4–5

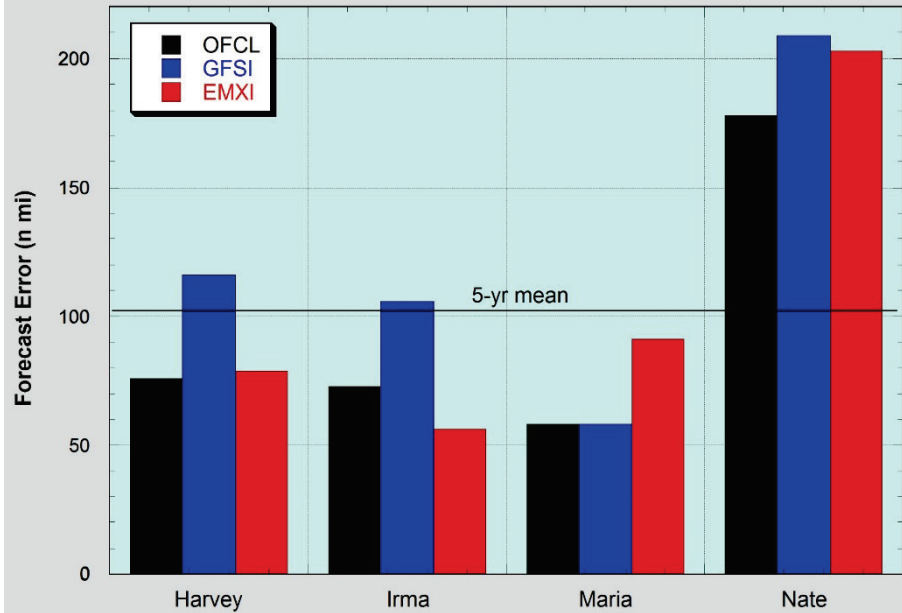- Removing COAMPS-TC from IVCN would degrade the consensus by up to 8%
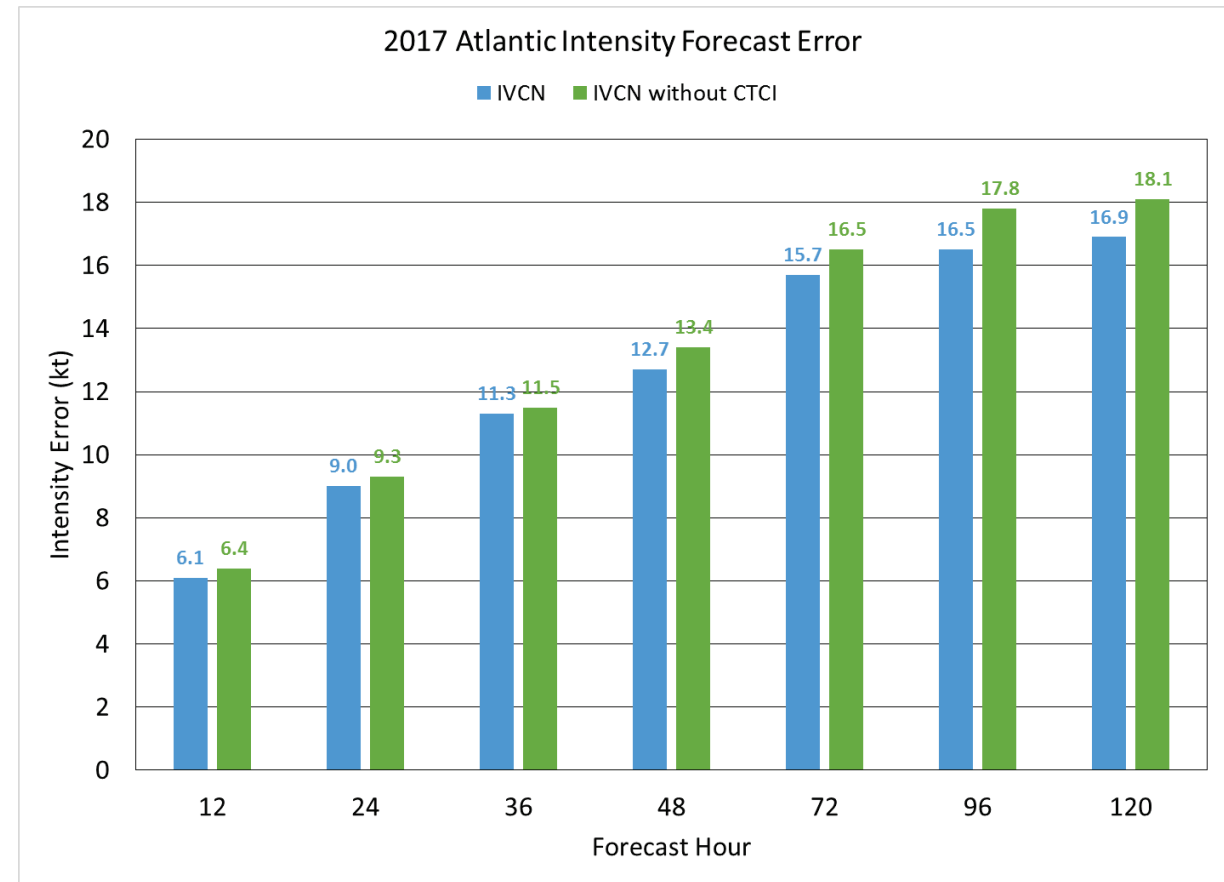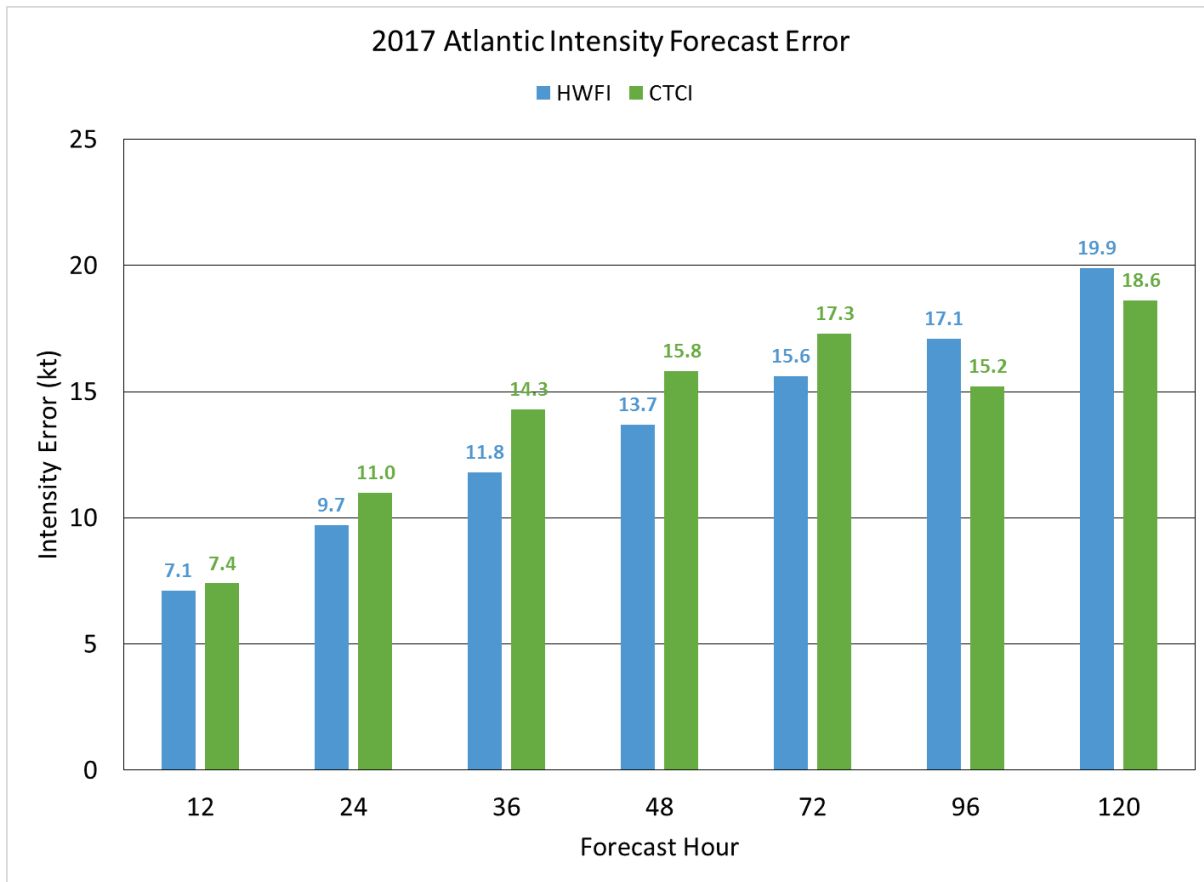
GFS Intensity Bias
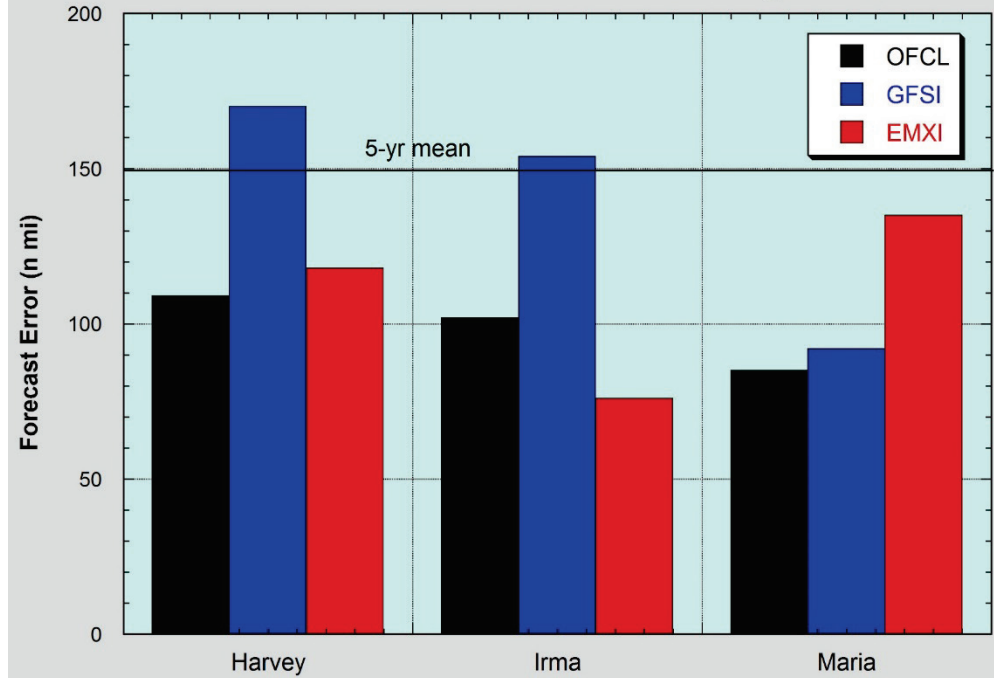

2017 Atlantic GFS Intensity Bias

- For 2017 interpolated GFS intensity (GFSI/AVNI) had an increasing low bias through 96 h

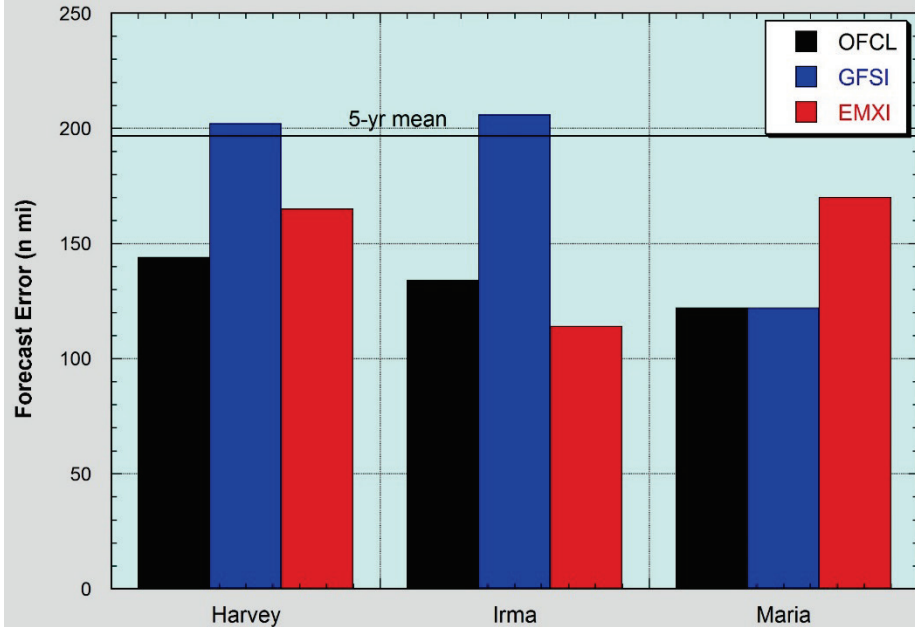- Becomes a high bias by 120 h when interpolator phase out ends

72-h Track Errors for 2017 U.S. Landfalling Hurricanes

96-h Track Errors for 2017 U.S. Landfalling Hurricanes

120-h Track Errors for 2017 U.S. Landfalling Hurricanes

For U.S. landfalling hurricanes, the GFS had larger errors than ECMWF for Harvey and Irma, but the GFS had lower errors than ECMWF in Maria

NHC Modeling Priorities for 2018

- Continue to improve HWRF, especially for RI cases
- Improve HMON so it can contribute positively to the consensus aids
  - Address significant weak bias for weaker storms
- Work towards a less under-dispersive ensemble system
- Improve GFS genesis forecasts
- Address low bias in GFS intensity forecasts
- Develop methods to assimilate GOES-16 and JPSS data
- Begin work toward extending TC intensity guidance out to 7 days