TAOS Review 2018

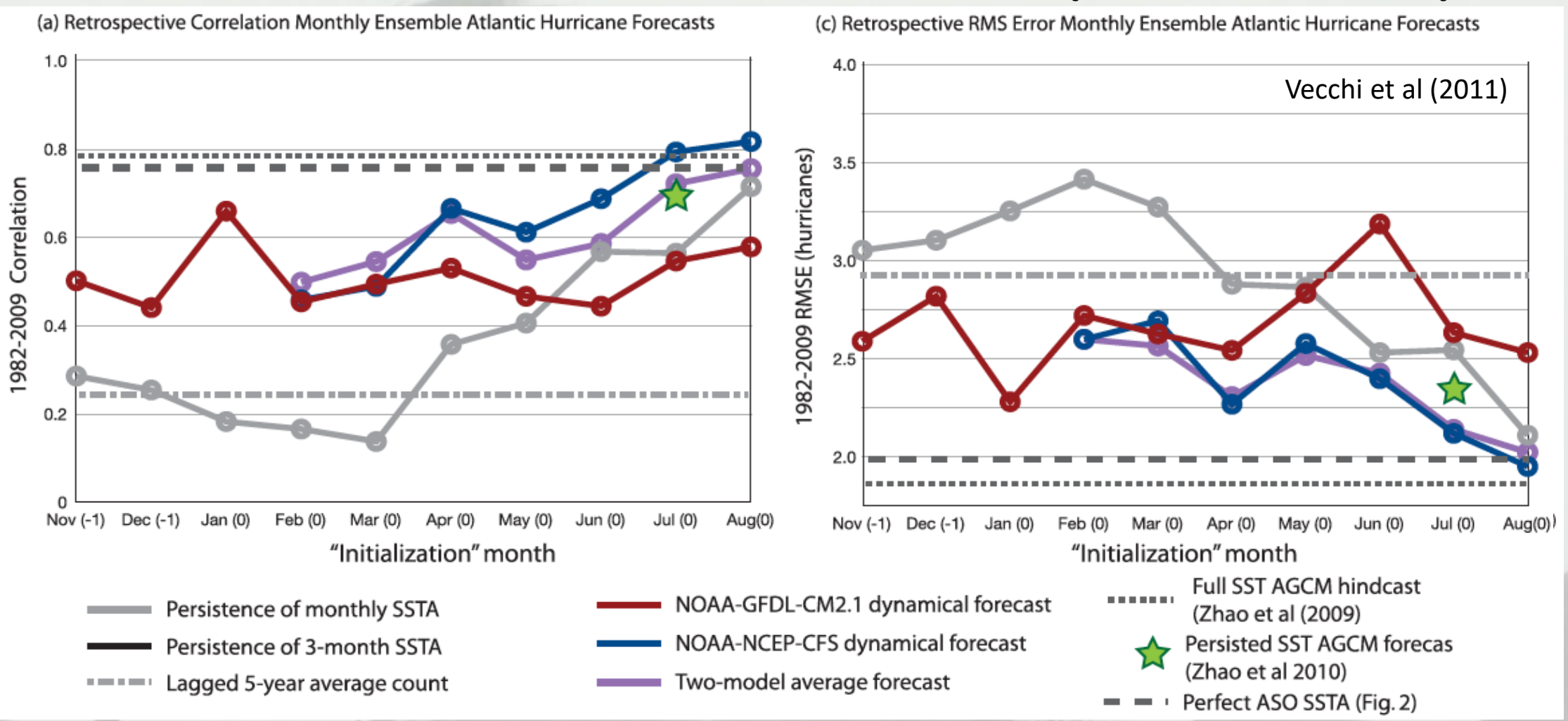
2017 Atlantic Season Review and
Ocean Observation Requirements
for Improved NHC Forecasts

Scott Stripling
TAFB/NHC
Ping Chang
Texas A & M

Atlantic Seasonal Forecasts

- **Basis for Seasonal Forecasts**
  - Large-scale atmospheric environment conducive for tropical cyclones, including background vorticity, vertical wind shear, mid-level moisture, SST and stability of atmospheric column, is modulated by modes of climate variability (ENSO, AMM/AMO, etc)
  - Seasonal predictability of these modes leads to seasonal predictability of tropical cyclones
- **Techniques**
  - Statistical Models (CSU forecast, Gray, 1984; Klotzbach and Gray, 2009, TSR forecast, Lee and Saunders, 2006)
  - Dynamical General Circulation Models (e.g., Vitart et al. 2007)
  - Hybrid Statistical-dynamical models (e.g., Wang et al. 2009; Vecchi et al. 2011)

Seasonal Forecast Verfication (1981-2009)



Challenges

- Model biases – Cold SST bias in the North Tropical Atlantic
- Longer-lead-time forecast – Forecast skills need to be improved at long lead times
- Track and landfall forecast – NOAA currently does not produce seasonal outlook for track and landfall

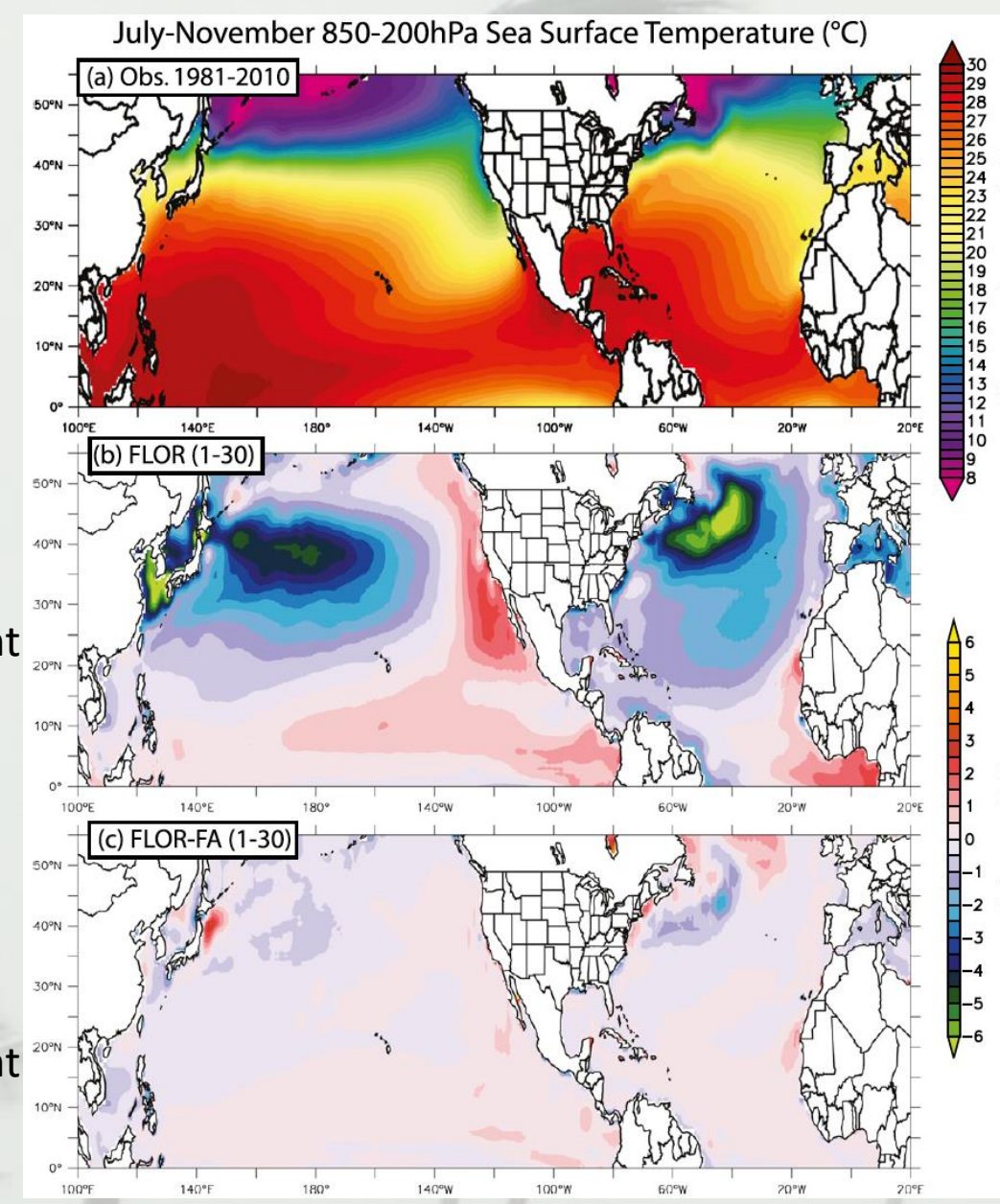
Model Bias Issues

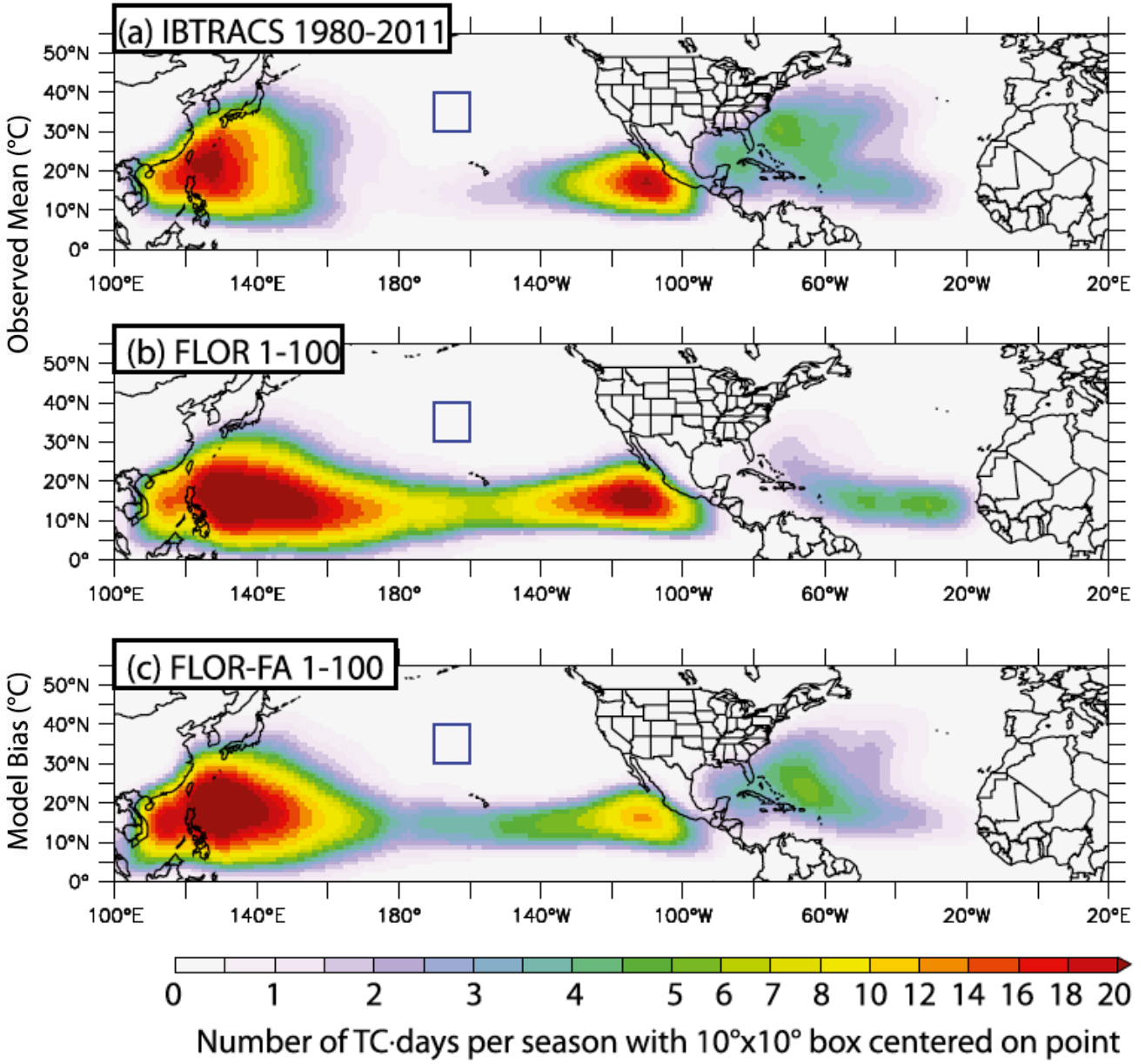
Vicchi et al. 2014

Obs

No Flux Adjustment

With Flux Adjustment





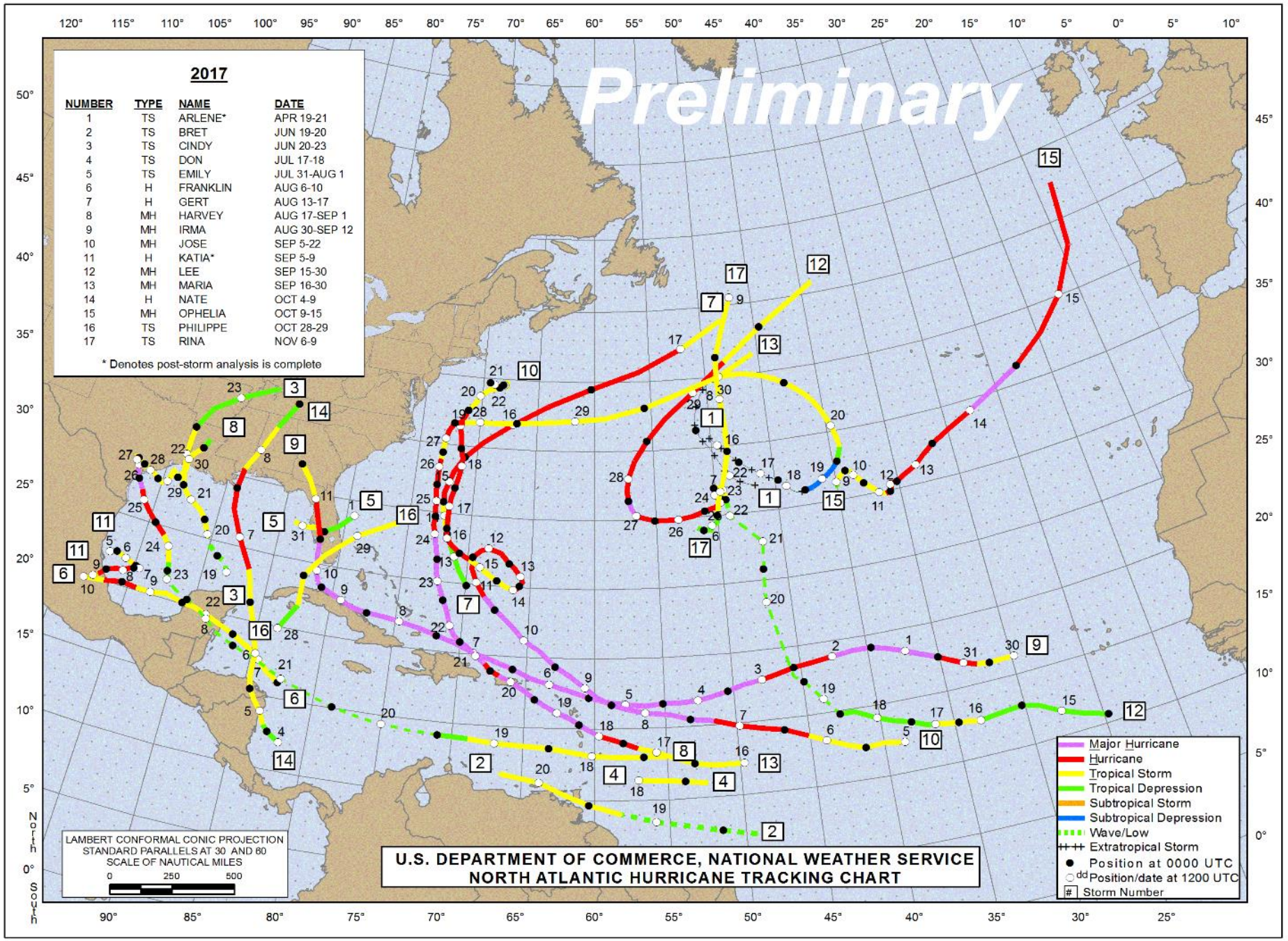
2017 Atlantic Hurricane Season

YEAR-END SUMMARY

SEASONAL OUTLOOK	ACTUAL
Named storms: 14 - 19	Named storms: 17
Hurricanes: 5 - 9	Hurricanes: 10
Major Hurricanes: 2 - 5	Major Hurricanes: 6

Be prepared: Visit hurricanes.gov and follow @NWS and @NHC_Atlantic on Twitter.

November 30, 2017


Preliminary
2017
NUMBER TYPE NAME DATE
1 TS ARLENE* APR 19-21
2 TS BRET JUN 19-20
3 TS CINDY JUN 20-23
4 TS DON JUL 17-18
5 TS EMILY JUL 31-AUG 1
6 H FRANKLIN AUG 6-10
7 H GERT AUG 13-17
8 MH HARVEY AUG 17-SEP 1
9 MH IRMA AUG 30-SEP 12
10 MH JOSE SEP 5-22
11 H KATIA* SEP 5-9
12 MH LEE SEP 15-30
13 MH MARIA SEP 16-30
14 H NATE OCT 4-9
15 MH OPHELIA OCT 9-15
16 TS PHILIPPE OCT 28-29
17 TS RINA NOV 6-9
* Denotes post-storm analysis is complete
LAMBERT CONFORMAL CONIC PROJECTION
STANDARD PARALLELS AT 30 AND 60
SCALE OF NAUTICAL MILES
0 250 500
U.S. DEPARTMENT OF COMMERCE, NATIONAL WEATHER SERVICE
NORTH ATLANTIC HURRICANE TRACKING CHART
Major Hurricane
Hurricane
Tropical Storm
Tropical Depression
Subtropical Storm
Subtropical Depression
Wave/Low
Extratropical Storm
Position at 0000 UTC
dd Position/date at 1200 UTC
Storm Number

Harvey - $125 Billion

KCRP - CORPUS CHRISTI, TX
08/25/2017 02:00:24 GMT
LAT: 27/47/02 N
LON: 97/30/38 W
ELEV: 45 FT
VCP: 21

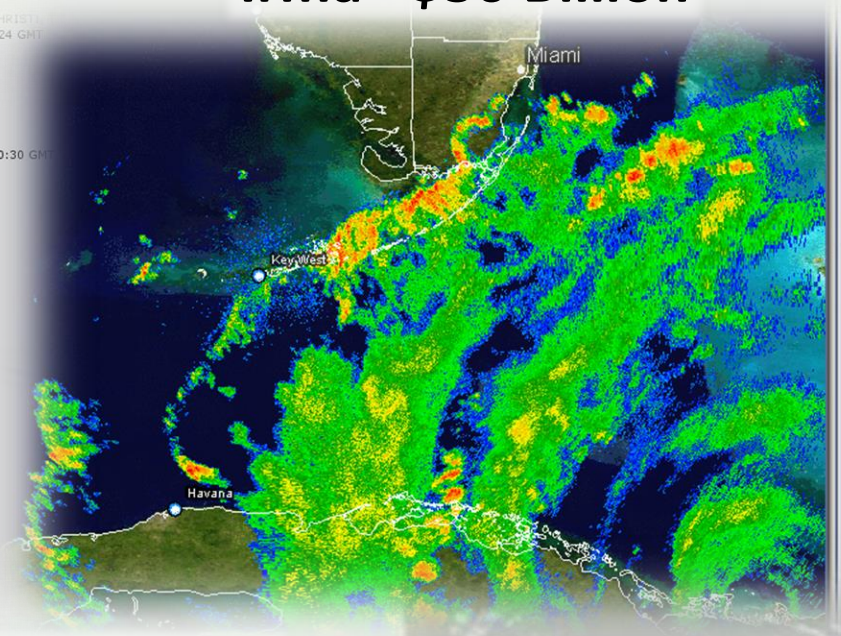
REFLECTIVITY
ELEV ANGLE: 0.51
SWEEP TIME: 02:00:30 GMT

Legend: dBZ

75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25

RF

Irma - $50 Billion



KBYX - KEY WEST, FL
09/09/2017 09:05:28 GMT
LAT: 24/35/48 N
LON: 81/42/11 W
ELEV: 08 FT
VCP: 212

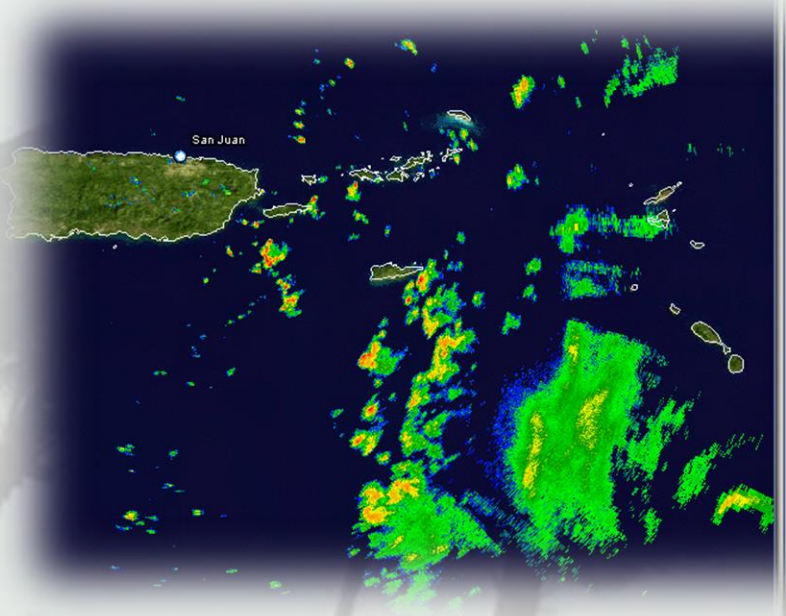
REFLECTIVITY
ELEV ANGLE: 0.47
SWEEP TIME: 09:05:31 GMT

Legend: dBZ

75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25

RF

Maria - $90 Billion



TJUA - SAN JUAN, PR
09/19/2017 11:02:21 GMT
LAT: 18/07/02 N
LON: 66/04/42 W
ELEV: 2794 FT
VCP: 21

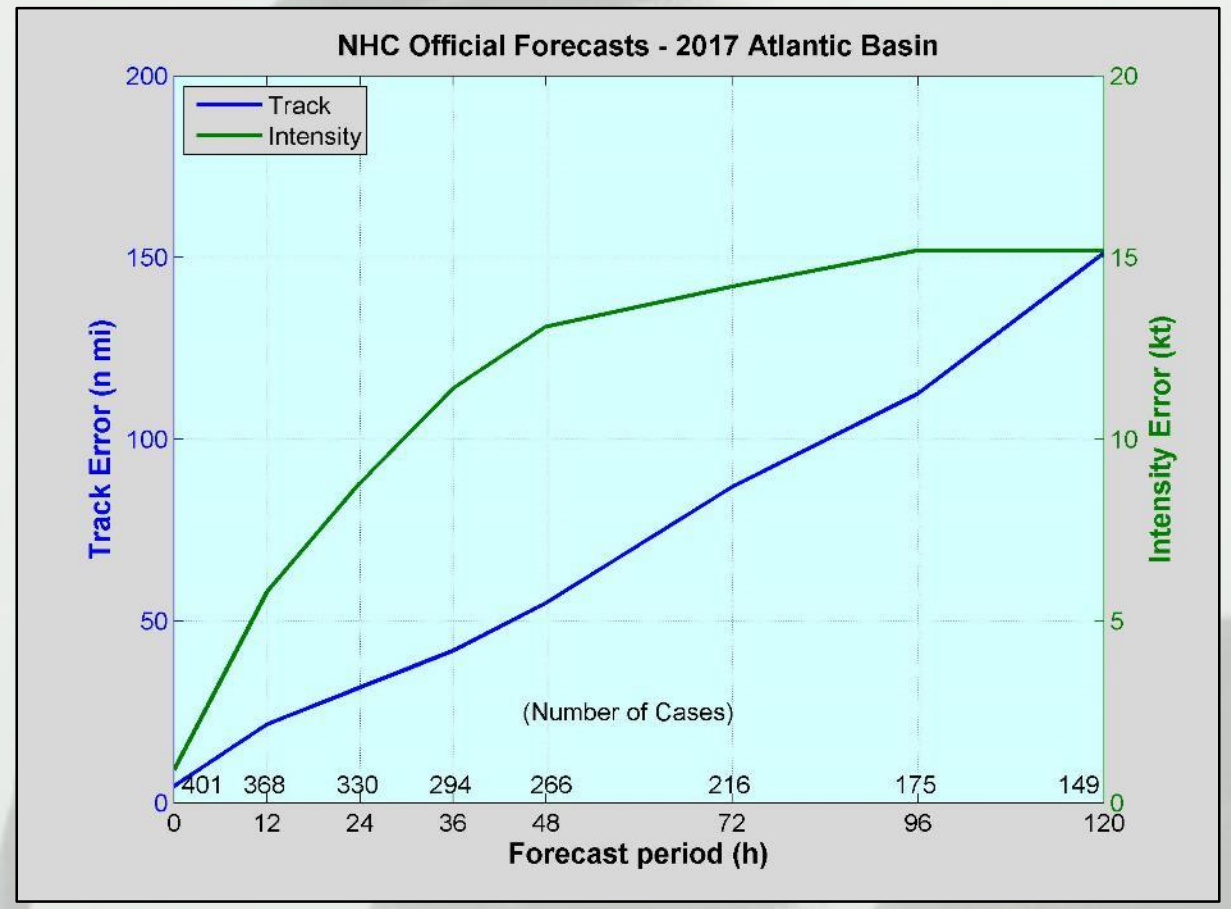
REFLECTIVITY
ELEV ANGLE: 0.52
SWEEP TIME: 11:02:27 GMT

Legend: dBZ

75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25

RF

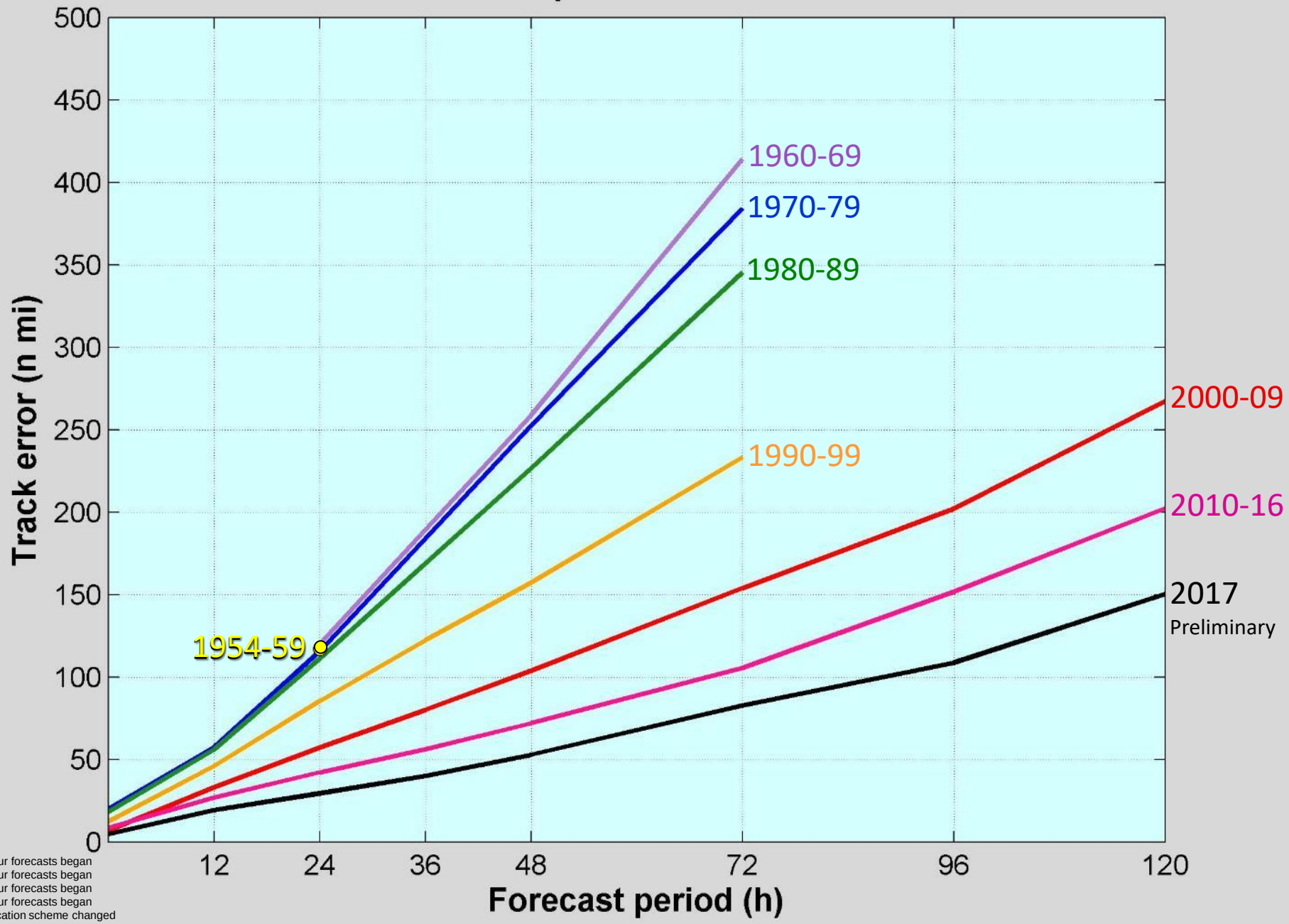
2017 NHC Forecast Track Verification



VT (h)	NT	TRACK (n mi)	INT (kt)
000	401	4.5	0.9
012	368	21.6	5.8
024	330	31.6	8.7
036	294	41.8	11.3
048	266	55.0	13.0
072	216	86.9	14.2
096	175	112.6	15.1
120	149	151.1	15.2

Values in red exceed all-time records.

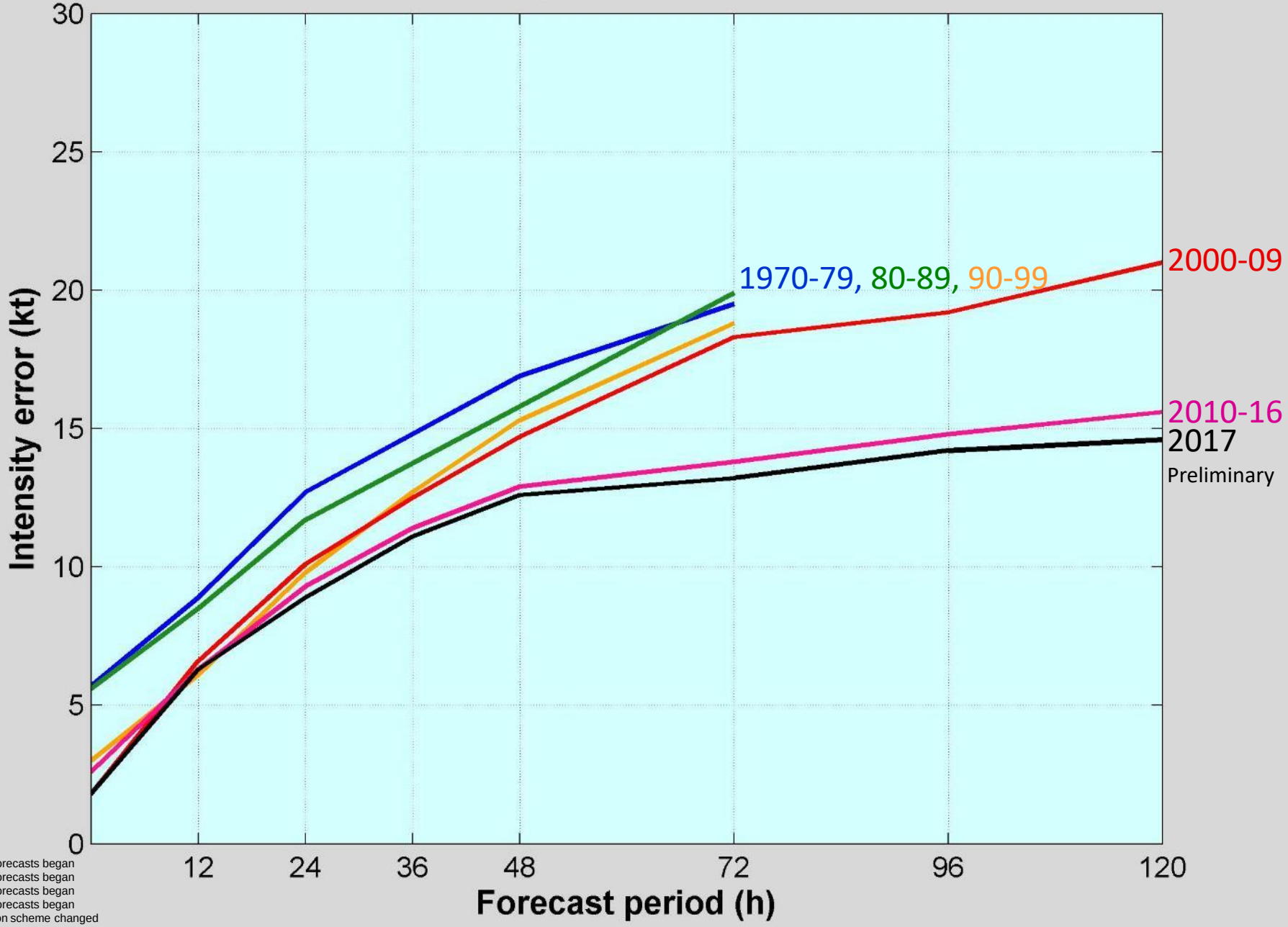
NHC Official Average Track Errors
Atlantic Basin Tropical Storms and Hurricanes



1954: 24 hour forecasts began
1961: 48 hour forecasts began
1964: 72 hour forecasts began
1967: 12 hour forecasts began
1970: Verification scheme changed
1988: 36 hour forecasts began
2001: 96 and 120 hour forecasts began (became public in 2003)

Source: NHC ENR/JPC 1/2018

NHC Official Average Intensity Errors
Atlantic Basin Tropical Storms and Hurricanes



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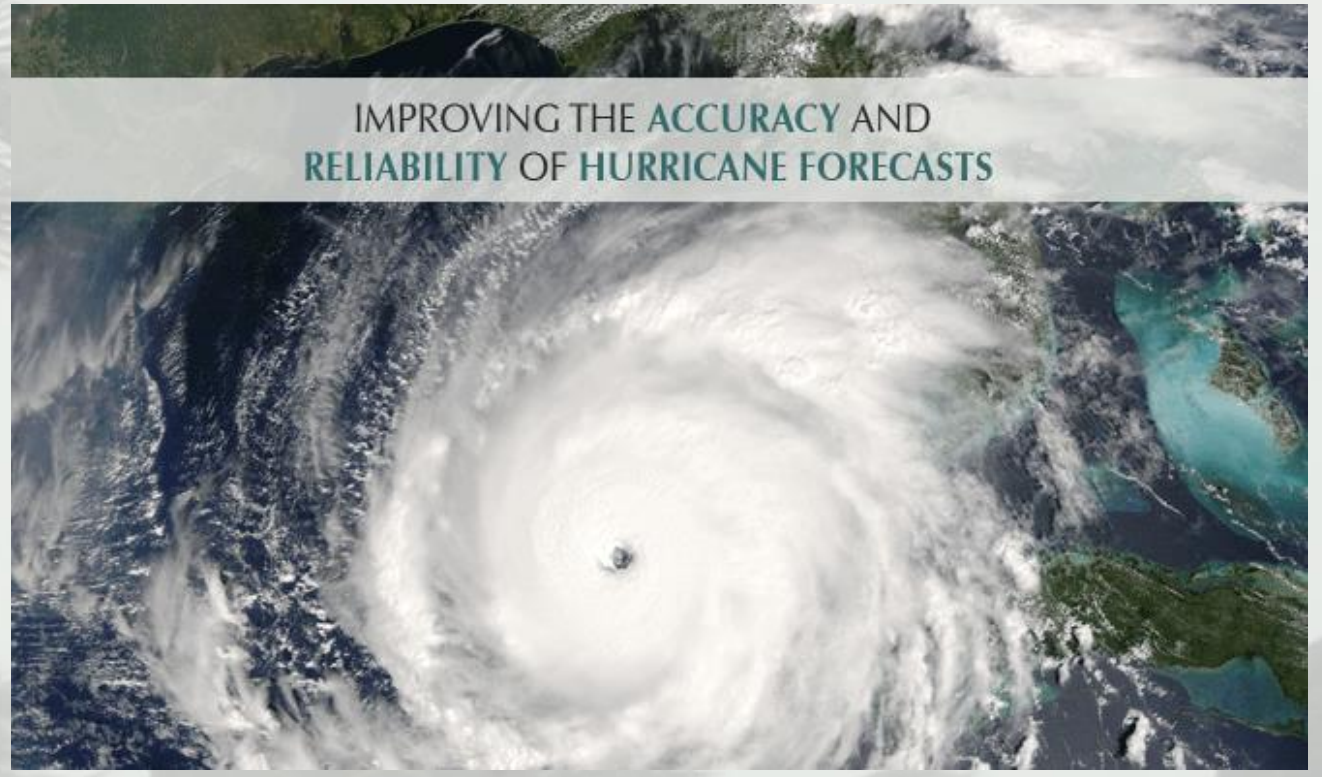
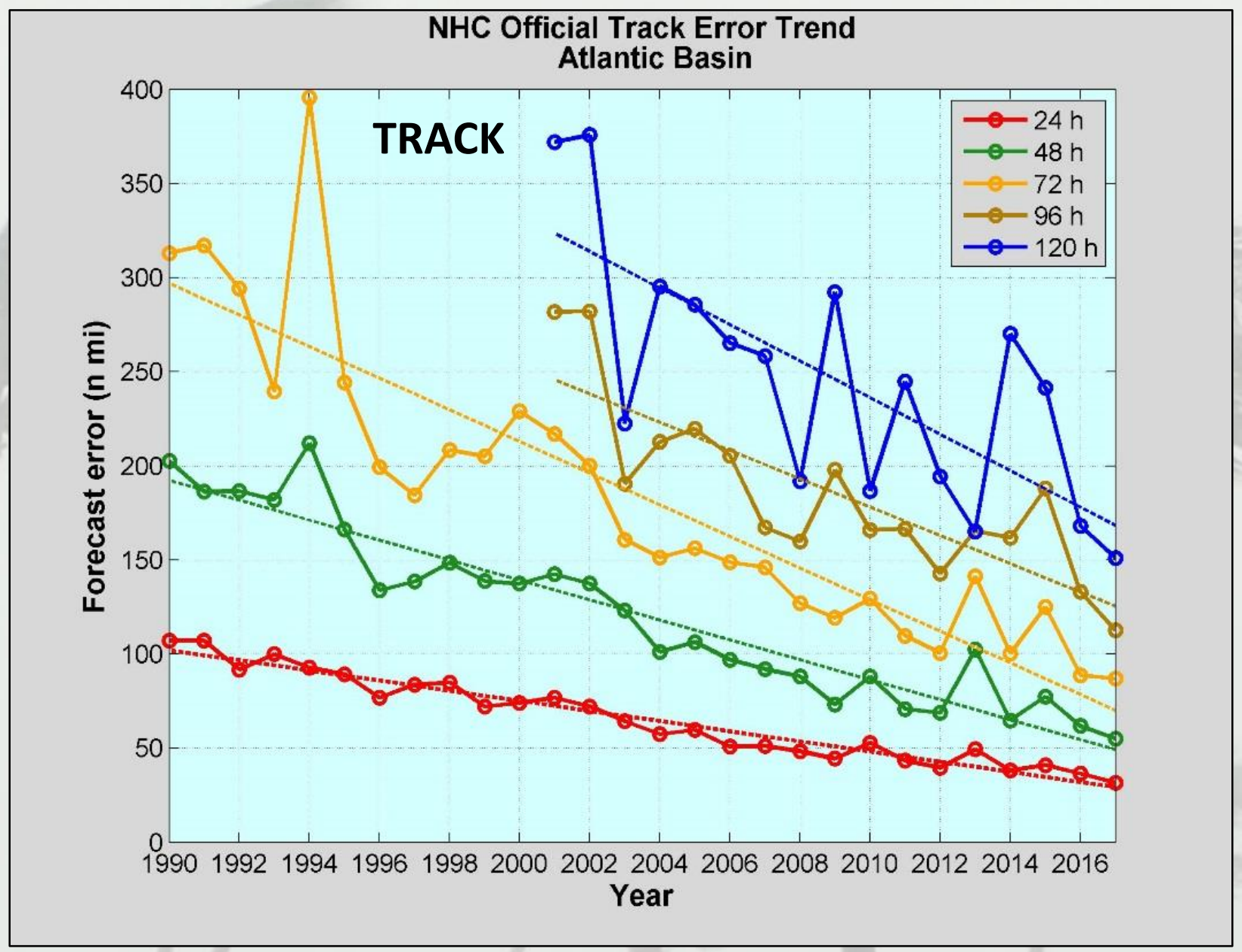
Hurricane Forecast Improvement Program

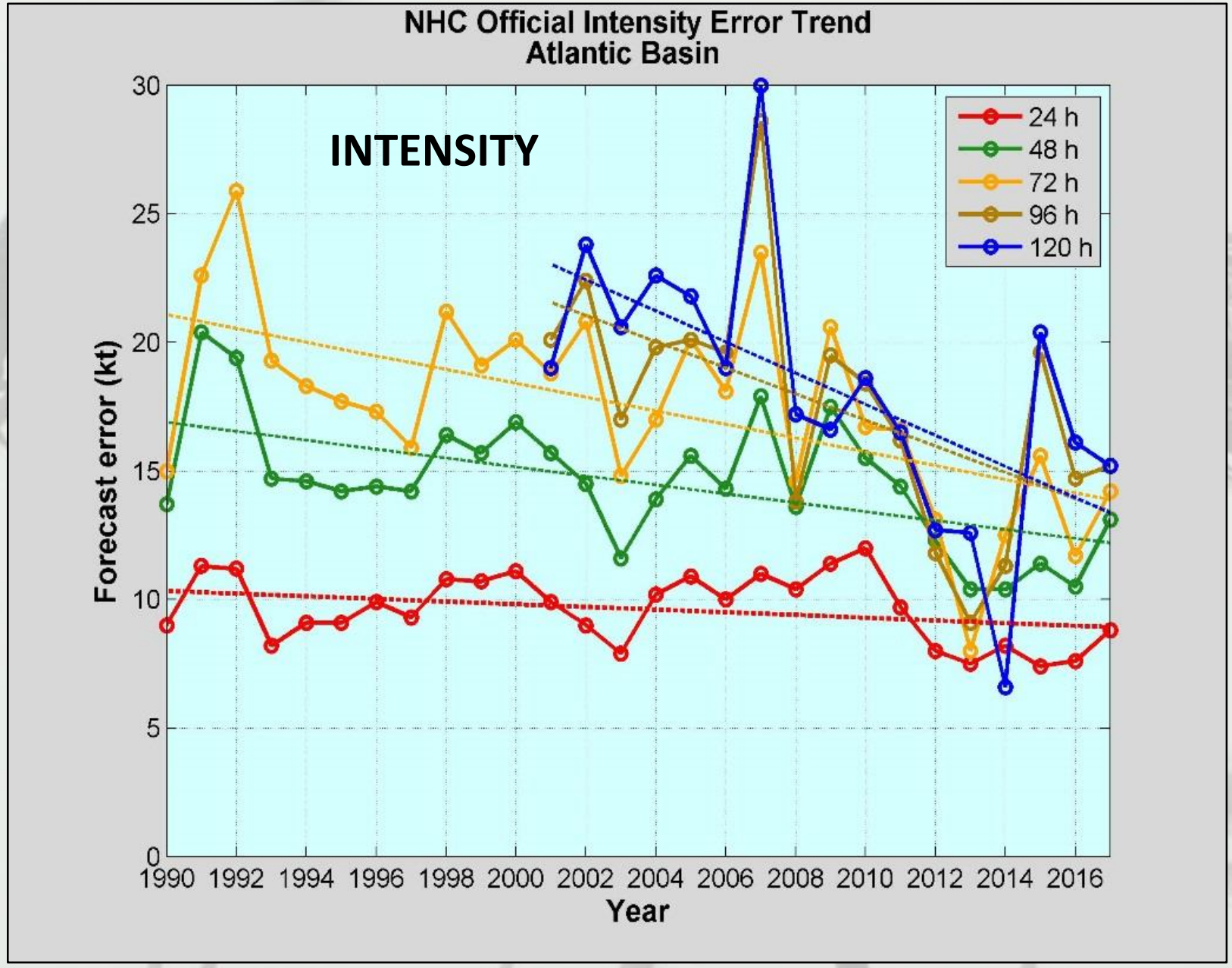
- Interagency coordinated research effort to address the challenges posed to improve guidance for hurricane track, intensity, and storm surge forecasts.
- Specific goals are to reduce the average errors of hurricane track and intensity forecasts by 20% within five years and 50% in ten years with a forecast period out to 7 days.



Are NHC Forecasts Getting Better?



Are NHC Forecasts Getting Better?



Atlantic TC Rapid Intensification (RI)

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

Rapid Intensification

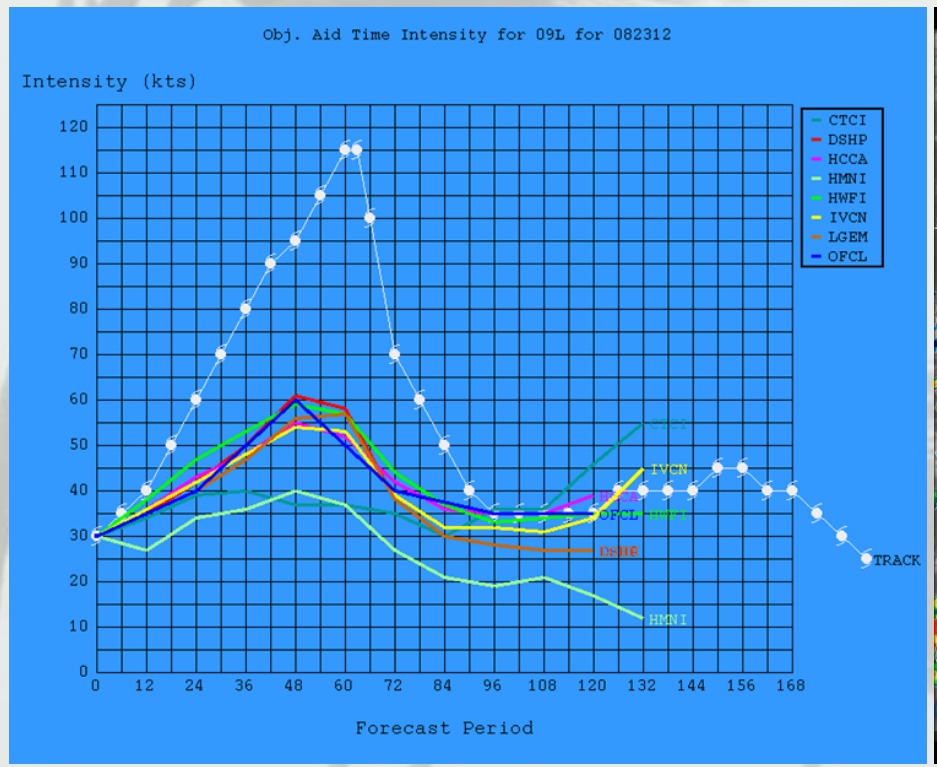
CHALLENGE

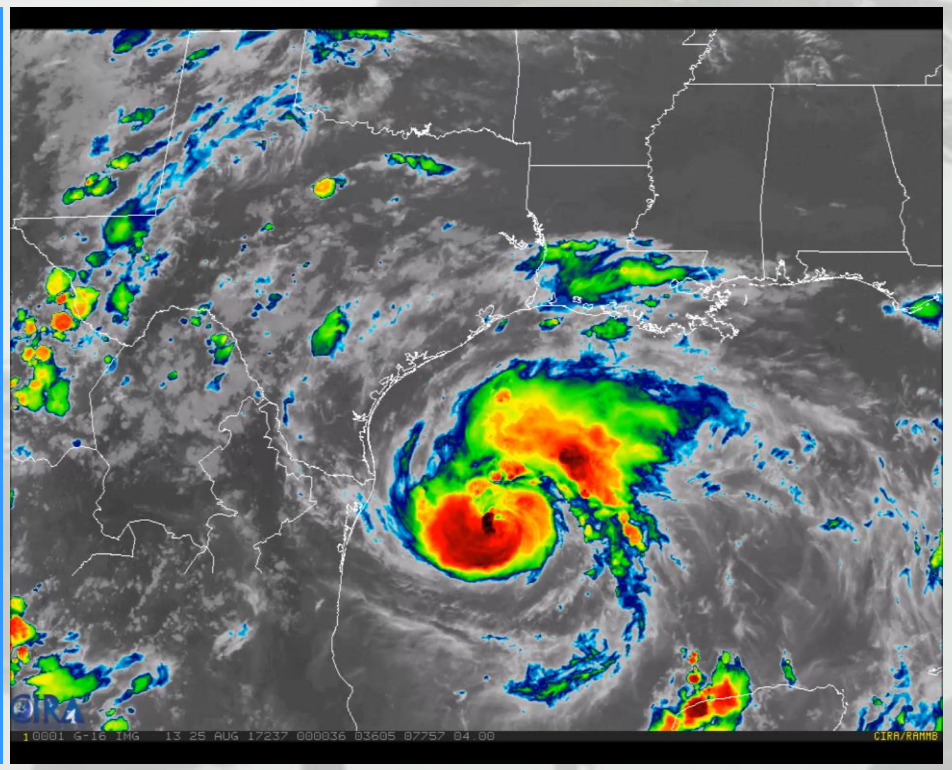
39 cases of RI observed

NHC correctly forecast 6 of them

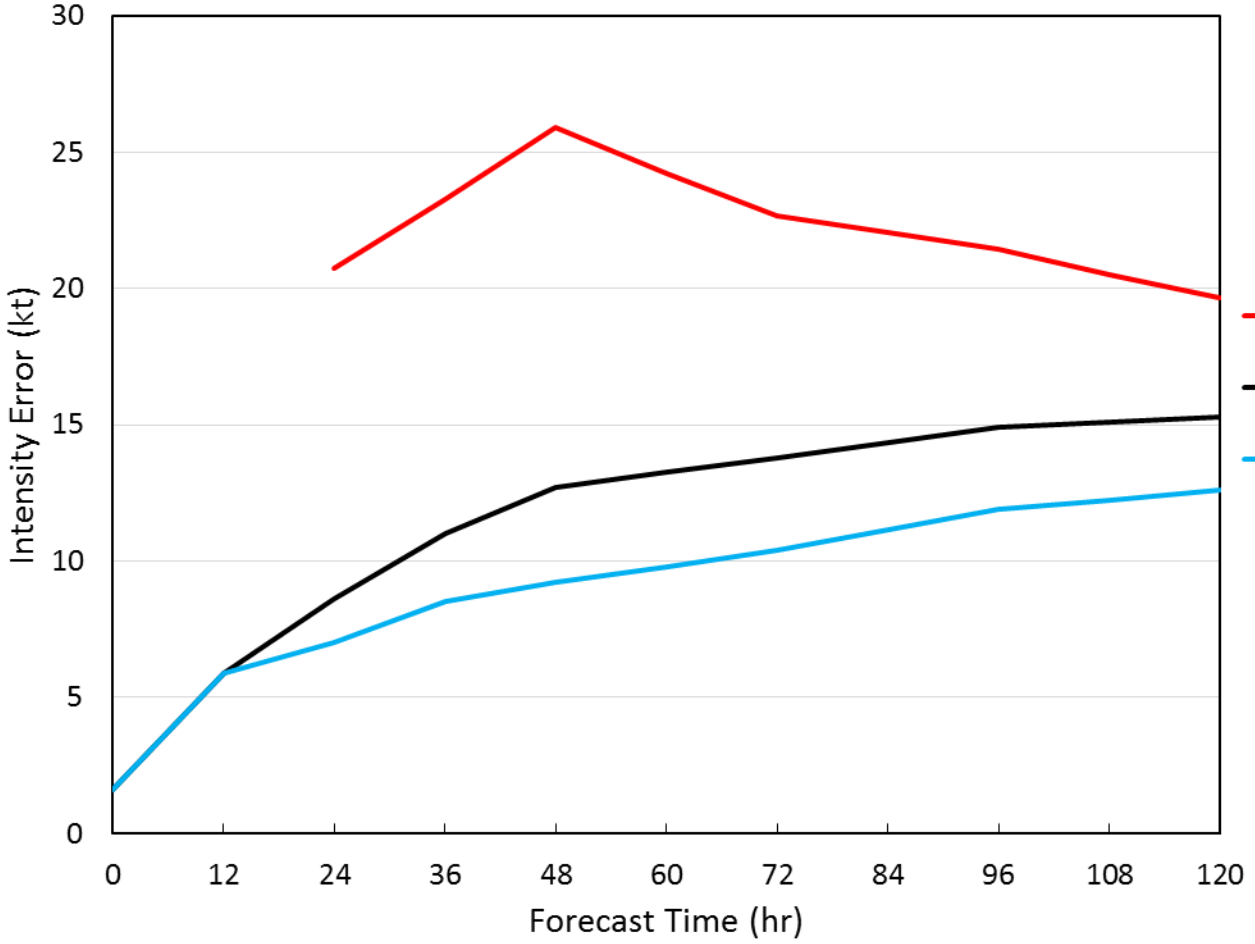
SUCCESS

For the first time ever, NHC forecast a storm to intensify from T.S. to major hurricane in the last 36 hours before landfall (Harvey)





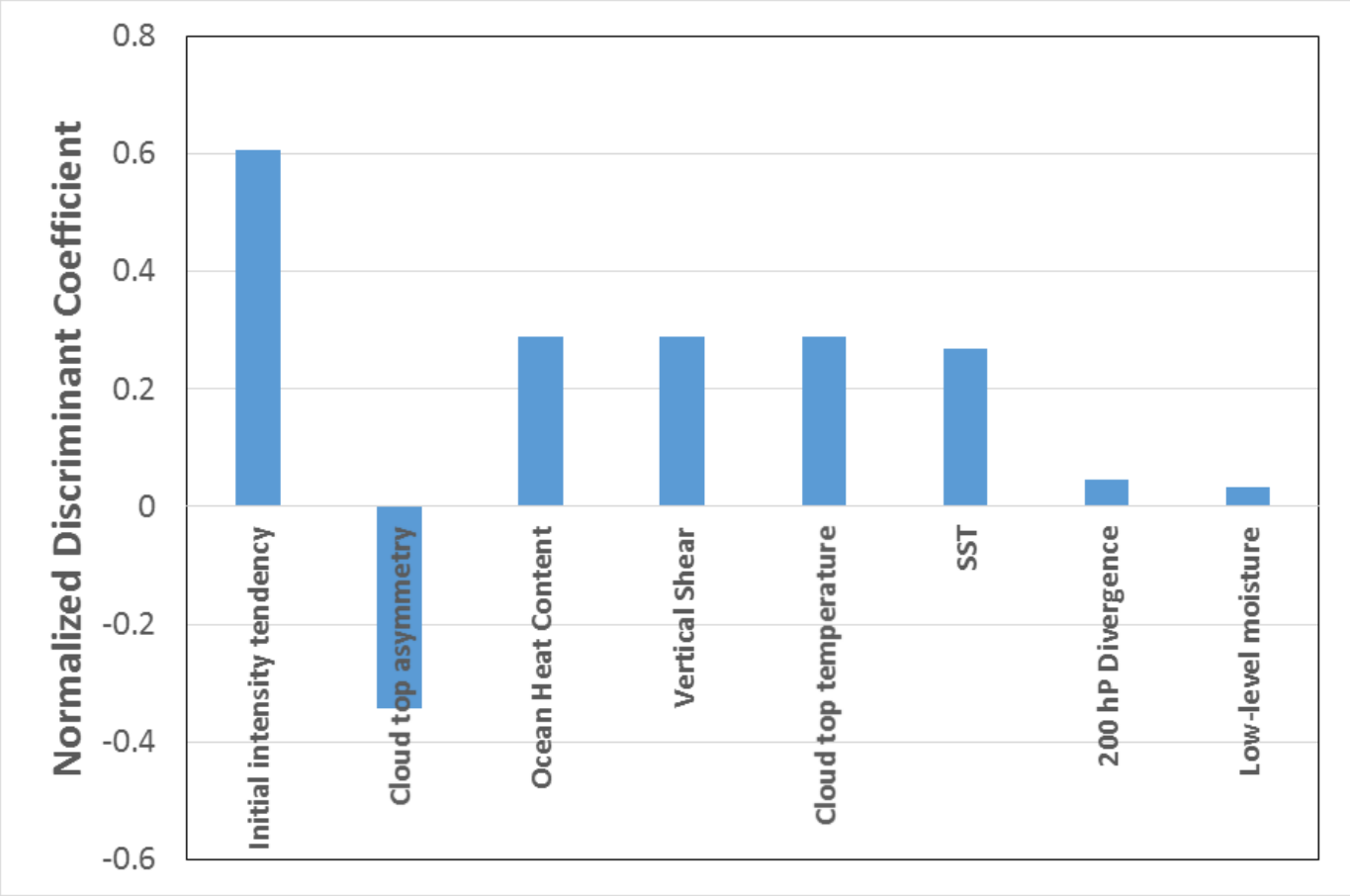
NHC 2017 Atlantic Intensity Forecast Errors Stratified by RI Occurrence



No. Cases						
-	40	54	59	62	56	58
376	343	307	277	224	178	152
376	303	253	218	162	122	94
12	24	36	48	72	96	120

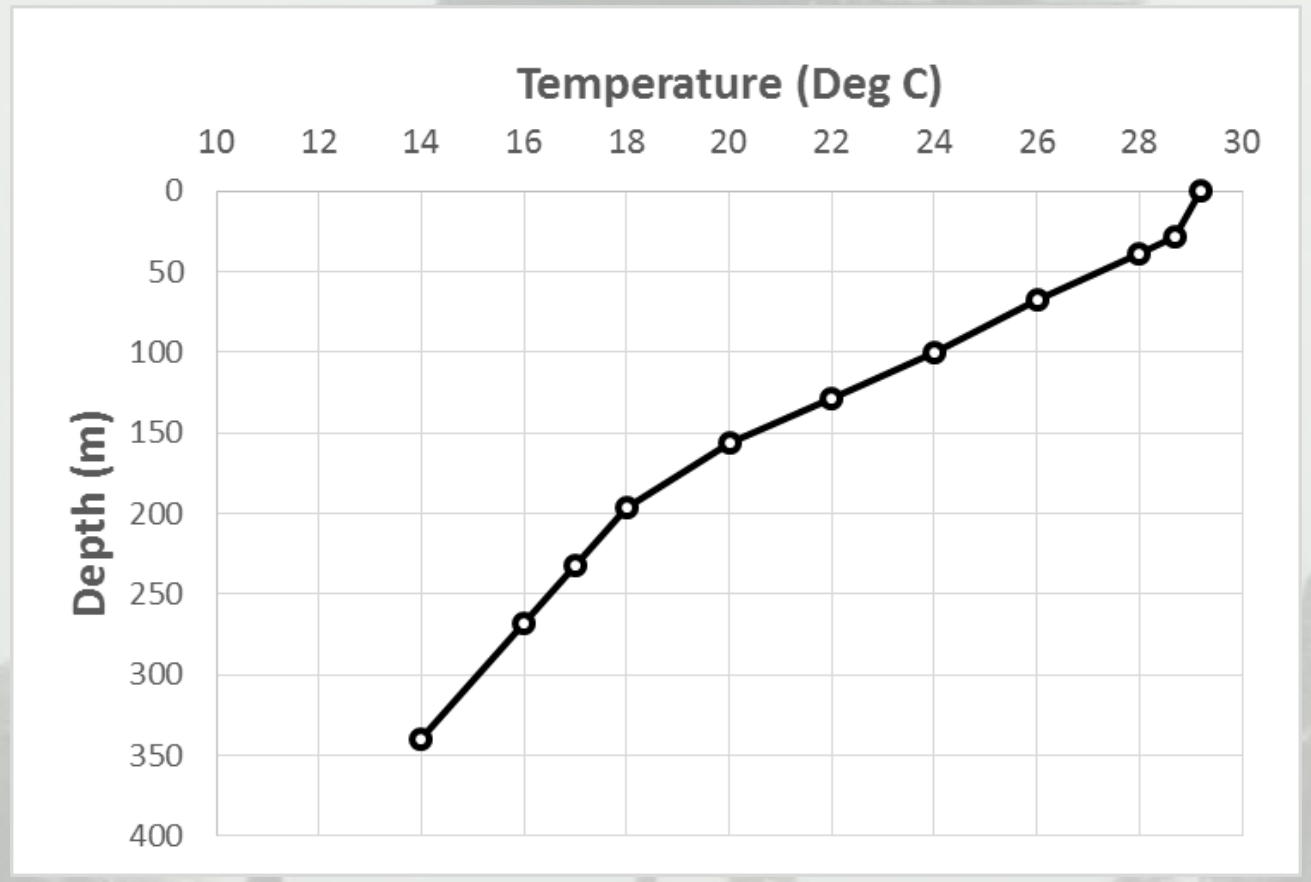
time (hr)

Normalized Discriminant Weights for NHC's Statistical Rapid Intensification Index



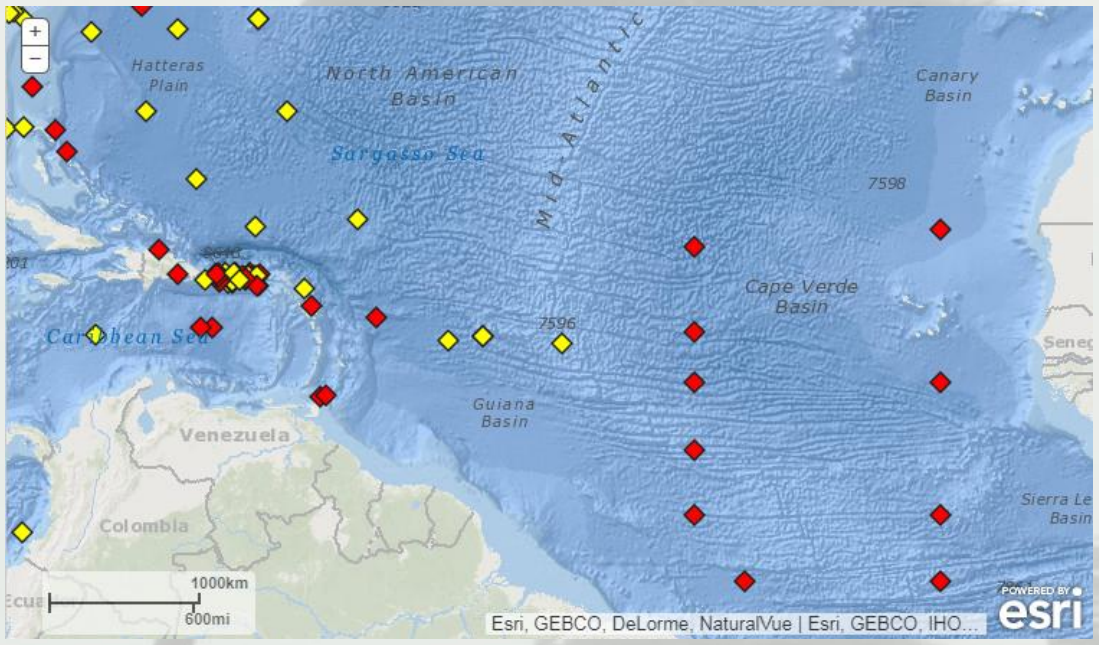
- 2 ocean predictors
  - SST and OHC
- 3 atmospheric environment predictors
  - Vertical shear
  - 200 hPa divergence
  - 850-700 hPa moisture
- 3 storm scale predictors
  - Cloud top temperature
  - Clout top temperature asymmetry
  - Intensity tendency

NCODA Ocean Temperature Profile During Hurricane Maria Rapid Intensification

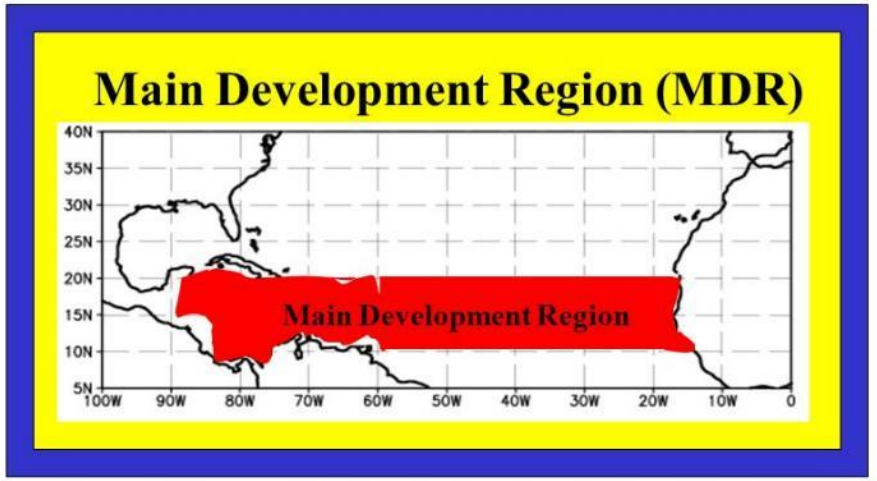


- Ocean heat content uses data down to 26 °C isotherm
  - Depth = 67 m for Maria case
- Cold wake can reduce SST by up to 5°C
  - Mixed depth for 5°C cooling ~ 220 m for Maria case
- For intensity prediction, accurate ocean temperature profiles needed to depths of ~200 to 300 m
- Will increased mixed layer depth improve forecasts?

NHC Ocean Data Needs



Increased Observations across the MDR and GOM!

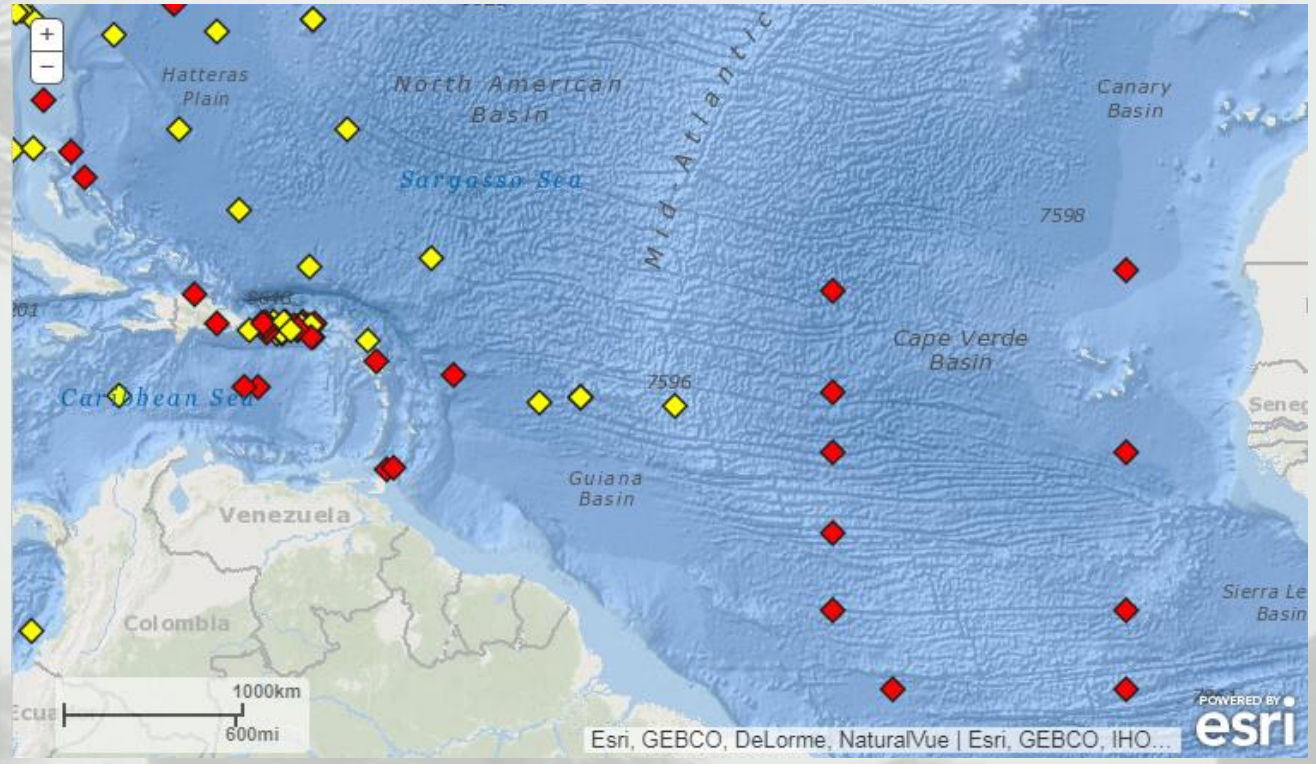


MDR is defined as tropical Atlantic and Caribbean Sea between 9°-21.5°N

During 1949-2002 Tropical Systems first named in MDR account for:
71% of the 53-year total activity measured by ACE index
55% of all hurricanes
79% of all major hurricanes
Nine-fold drop in activity in MDR between above- and below-normal seasons

NHC Ocean Data Wish List

- Increased observations across the MDR and GOM to include:
  - SST
  - Mixed Layer profiles
  - Full suite of Met data
  - Spectral Wave data
- PIRATA:
  - Higher temporal frequency of obs
  - Full suite of met data
  - T-Flex moorings
- Argos:
  - Increased surface pressure obs
- Drifting buoys



Questions - Discussion