# 2018 Hurricane Model Implementations Briefing to EMC:

## *Much improved operational forecast guidance for global tropical cyclones*

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(on behalf of the EMC Hurricane Project Teams)

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in collaboration with
HRD, DTC, NHC, GFDL, ESRL, CCU, OU and others.

# FY18 NCEP Operational Hurricane Models (proposed)

I. 2018 HWRF v12.0.0

II. 2018 HMON v2.0.0

# Proposed 2018 HWRF V12.0.0

# Scope of FY18 HWRF Upgrades

## ➢ System & Resolution Enhancements

- Framework upgrade to HWRFV3.9.1 with bug fixes
- T&E with 2017 GFS IC/BC
- Increase horizontal resolution to 1.5/4.5/13.5 km, with adjusted domain sizes for d01, d02 and d03
- Increase vertical resolution for non-NHC basins to 75 levels
- Code optimization (IBM analyst)

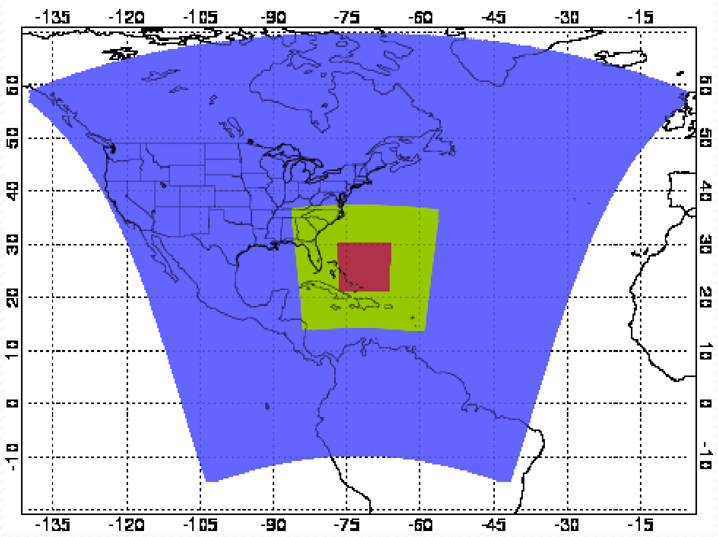
## ➢ Physics Advancements

- Radiation, RRTMG- cloud overlap (DTC)
- ~~Updates/options for PBL schemes (GFSEDMF changes for in-cloud mixing; YSU)~~
- ~~Update/tune scale-aware SAS scheme or adopt G-F cumulus scheme~~

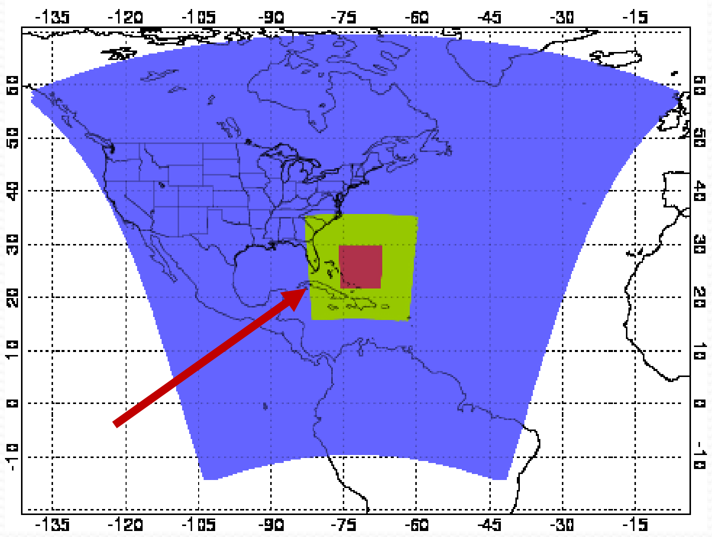
Items in Red: first time in 2018

# Adjusted Domain Sizes for 2018 HWRF with Higher Horizontal Resolution

**H217**



H218



| | H217 |
|---|---|
| Res: | 2/6/18 km |
| d01: | 288 x 576 (77.7º) |
| d02: | 265 x 532 (23.9º) |
| d03: | 235 x 472 ( 7.1º) |

| | H218 |
|---|---|
| Res: | 1.5/4.5/13.5 km |
| d01: | 390 x 780 (77.2º) |
| d02: | 268 x 538 (17.8º) |
| d03: | 268 x 538 ( 5.9º) |

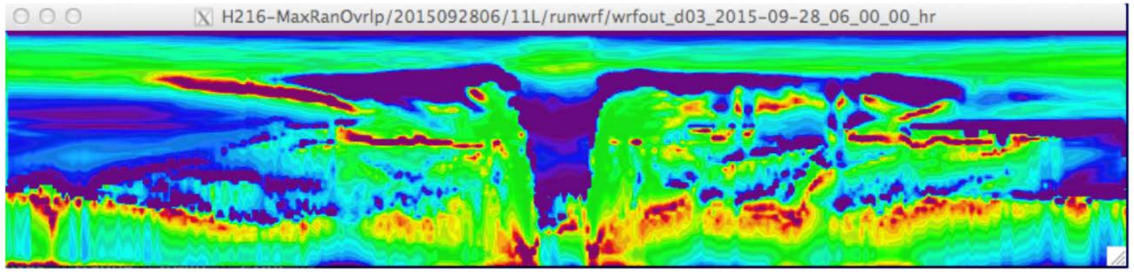
# RRTMG Sub-Grid Cloud Options:
# Cloud Overlap vertical correlation of fractional clouds

"**Maximum-random**" (Previous method)
- Continuous cloud layers overlap as much as possible; blocks of cloud layers with clear between are oriented randomly

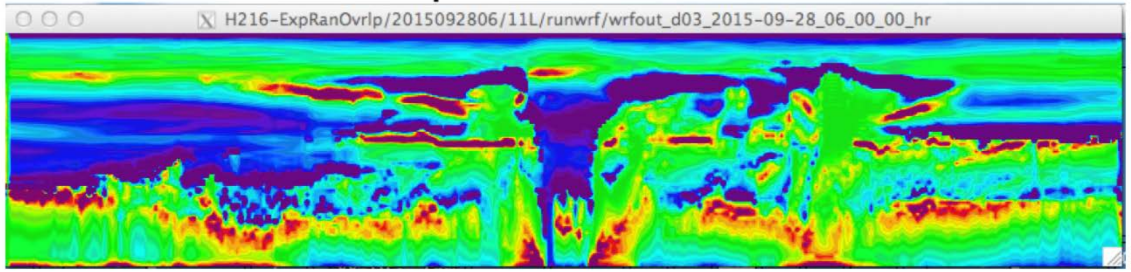
"**Exponential-random**" (New method)
- Continuous cloud layers use overlap that transitions exponentially from maximum to random with distance through clouds, blocks of cloud layers with clear between are oriented randomly
- Constant decorrelation length ($Z_0$ = ~1-2 km) controls rate of exponential transition

## Radiative Heating Rates - LW

**Maximum-Random**




**Exponential-Random**

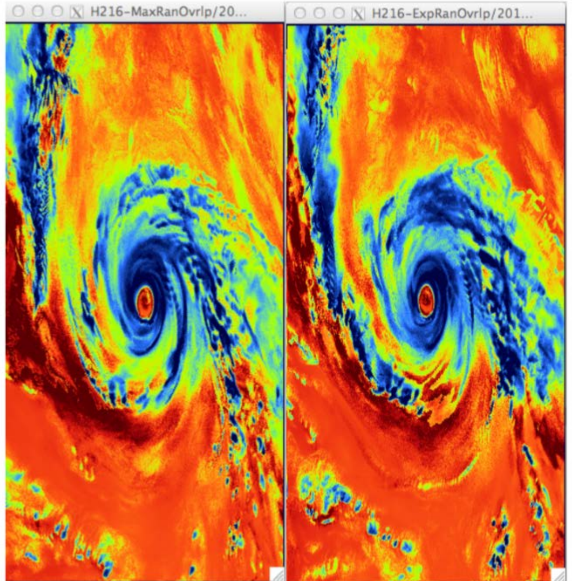



K/day

**Vertical West-East slice: Through Joaquin eye**

## Radiative Heating Rates - SW

**Maximum-Random** **Exponential-Random**




K/day



**Inner grid at ~900 hPa, Joaquin**

**-- details by Iacono & Henderson (AER, DTC visitor program)**

# Scope of FY18 HWRF Upgrades

## ➢ Initialization/Data Assimilation Improvements

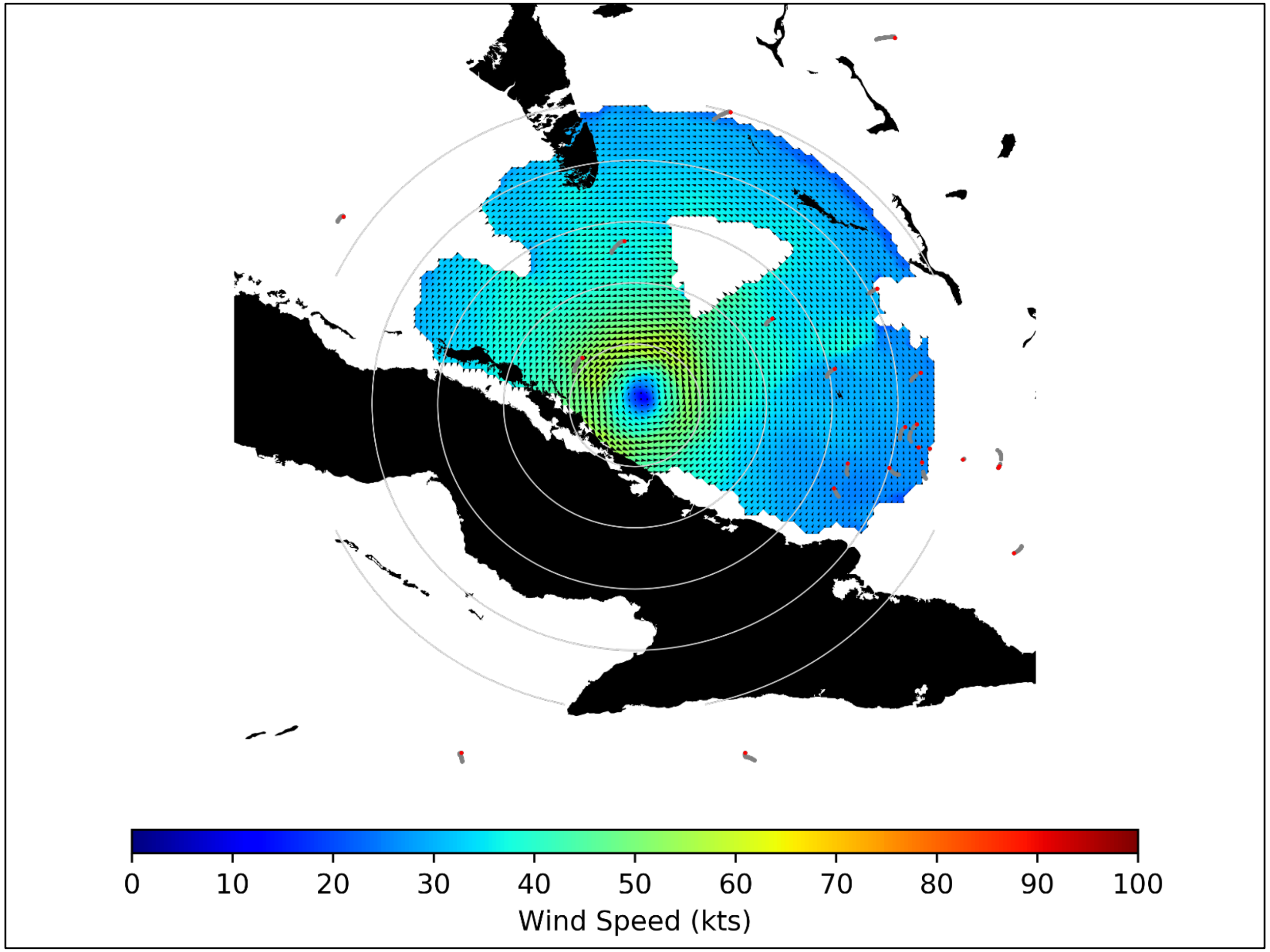
- Stochastic physics for DA ensembles
- GSI upgrades, changes (disable SSMI Channel 2)
- Admit new data sets (GOES-16 AMV's, NOAA-20, SFMR, Dropsonde drifts, TDR from G-IV)
- ~~Extend DA to Western Pacific Basin~~
- ~~Use full ensemble co-variances~~

## ➢ Coupling and other upgrades

- Unified HMON/HWRF coupler
- Use of double precision coordinates in coupler for moving nests
- Add ocean coupling (HYCOM) for Southern Hemisphere basins
- Wave initial conditions from global wave model

Items in Red: first time in 2018

# Estimating Dropsonde Drift for Hurricane Irma

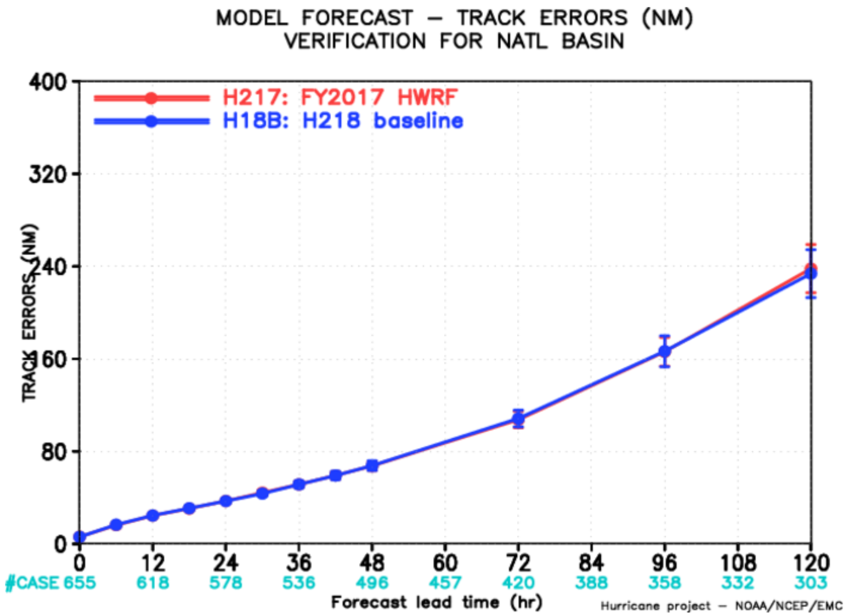


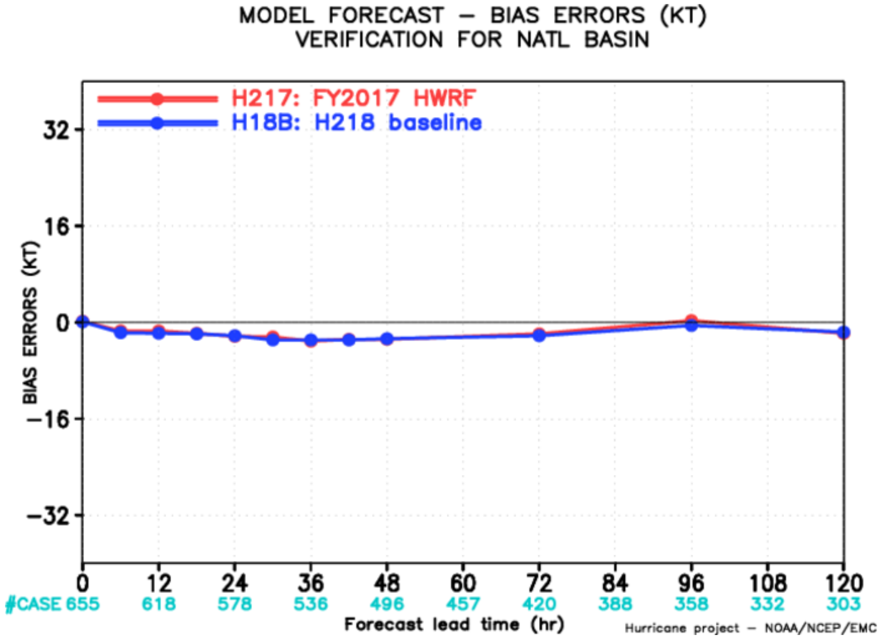

The column integrated observed radar winds (shaded) and wind vectors (arrows), and the dropsonde release locations (red), and subsequent computed dropsonde advection trajectories (grey) for TC Irma (2017) 08 September. The winds correspond to the NOAA 42 mission commencing 1710 UTC 08 September and ending 0123 UTC 09 September. The depicted dropsondes are those that occurred during the NOAA 42 mission as well as both NOAA 49 and USAF 308 missions during the same time period.

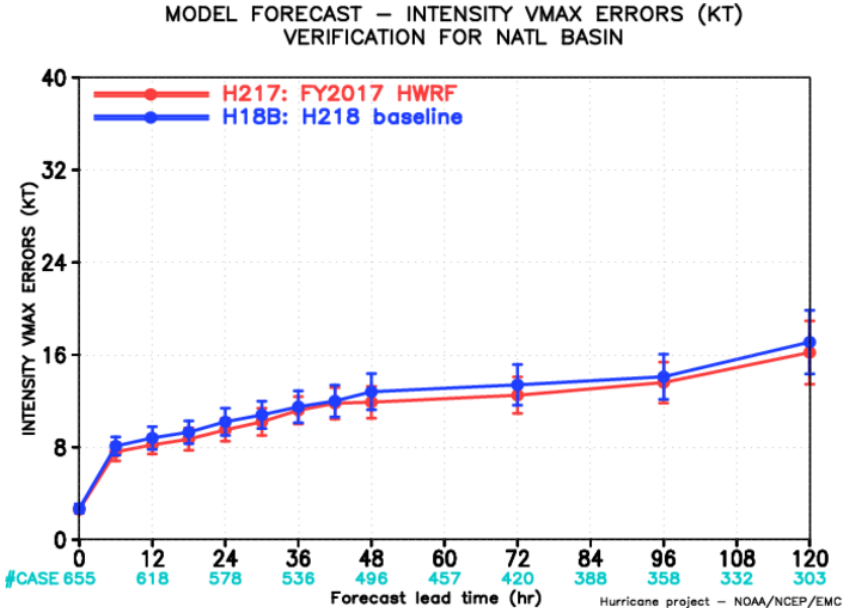
# 2018 HWRF Configurations (for NATL & EPAC)

- H217: FY17 HWRF using 2017 GFS
- H18B: baseline experiment
    - Framework and GSI upgrades
    - Unified HWRF/HMON coupler

# H18B Performance: Track and Intensity Errors



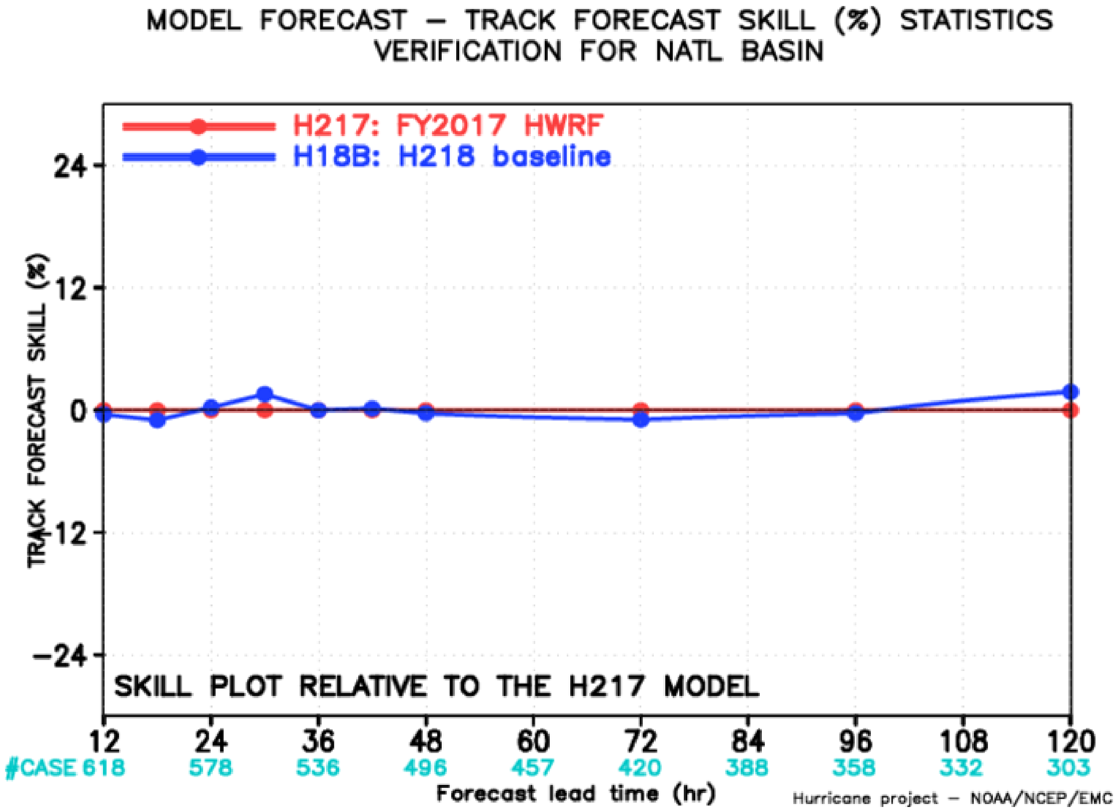



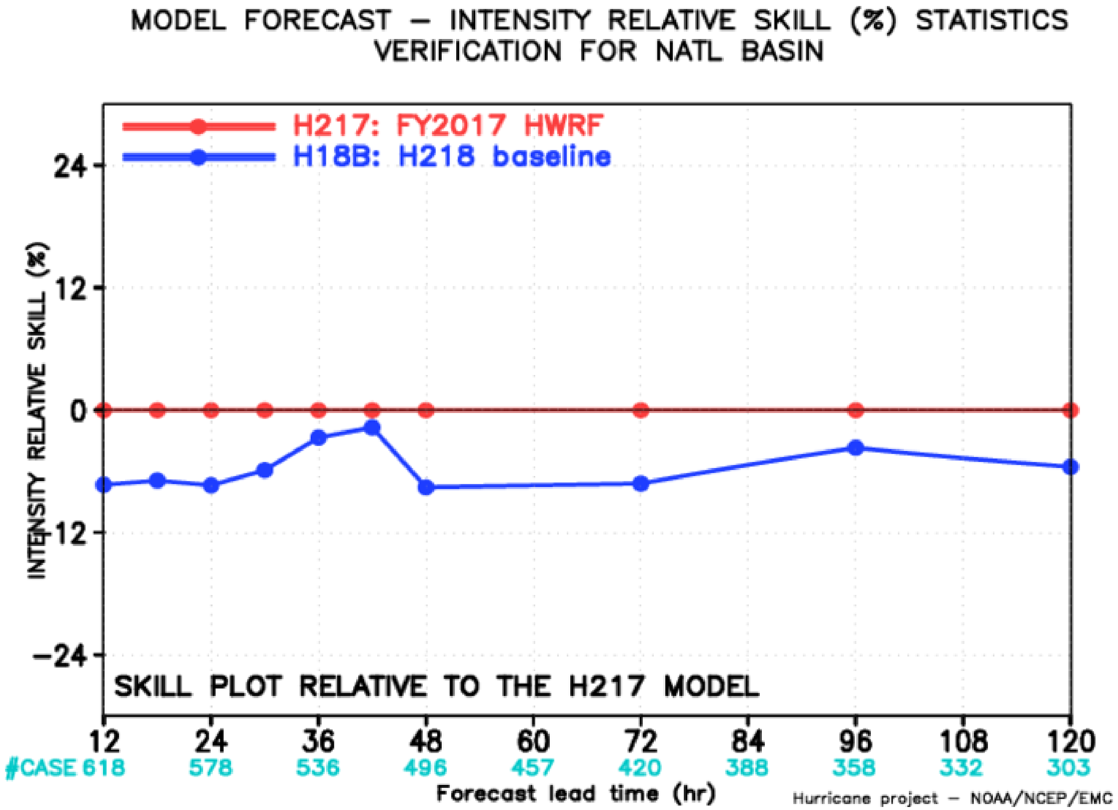




H18B has very similar track and intensity bias errors compared to H217.

But H18B does have larger intensity errors.

# H18B Performance: Track and Intensity Skill




Track skill for H18B is neutral with respect to H217 but intensity is considerably behind. The intensity skill is degraded by almost 8% at Days 1 and 2. Intensity skill remain behind by more than 5% at Days 3 and 5.

# 2018 HWRF Configurations (for NATL & EPAC)

- H217: FY17 HWRF using 2017 GFS
- H18B: baseline experiment
  - Framework and GSI upgrades
  - Unified HWRF/HMON coupler
- H8SC: H18B + horizontal resolution changed to 13.5/4.5/1.5 km
- HP2H: H8SC + modified d02, d03
  - Cloud overlap modifications in RRTMG
- HP3H: HP3H + data assimilation upgrades
- **H218:** HP3H + adjustment to horizontal diffusion parameters
  - **Proposed FY18 HWRF configuration**

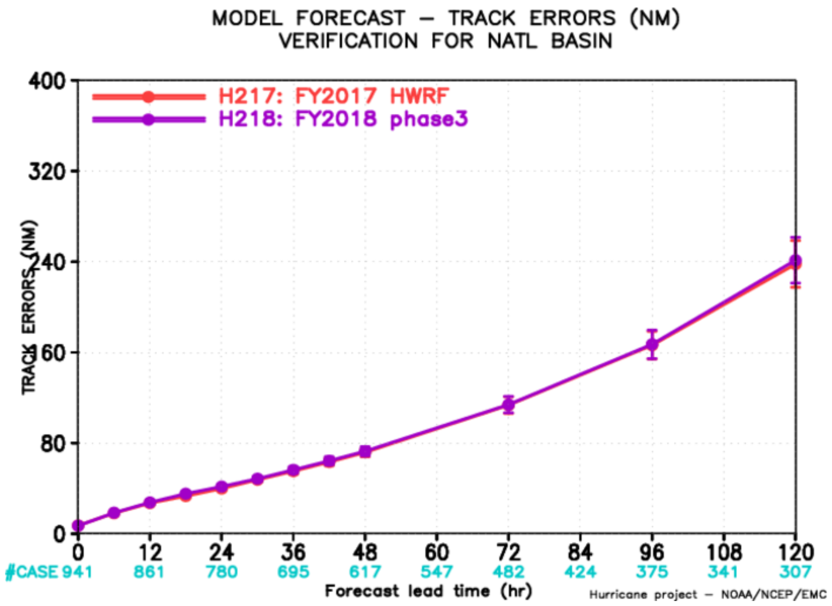
# HWRF Upgrade Plan for 2018 Implementation

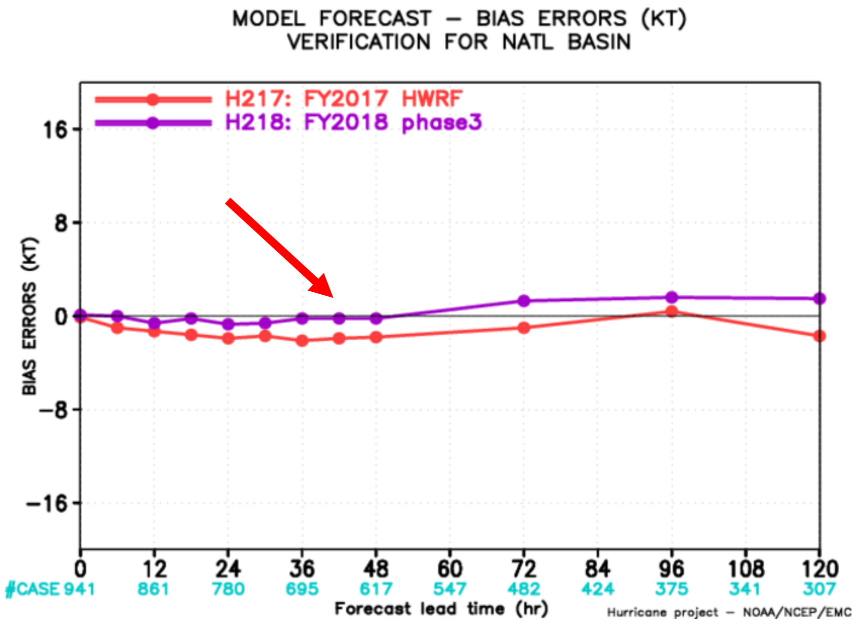
***Multi-season Pre-Implementation T&E***

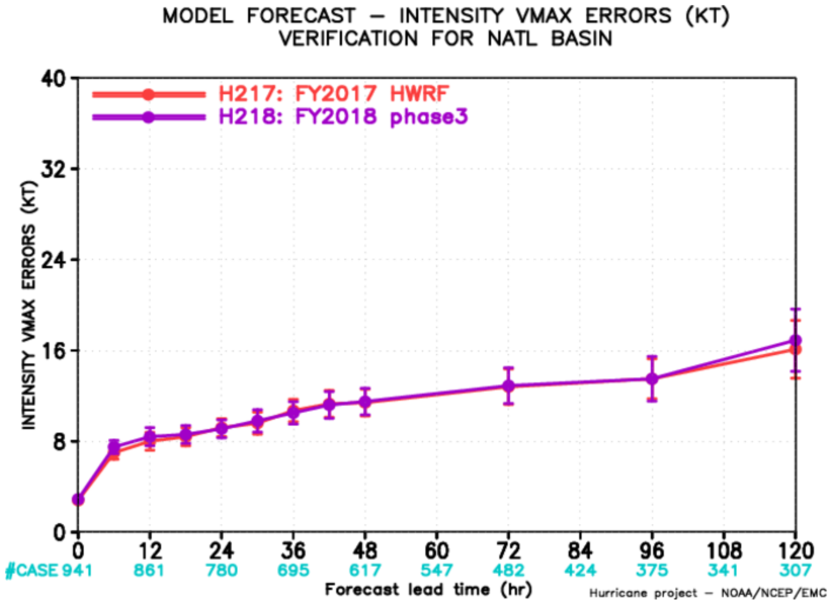
| | Model upgrades | High resolution | Physics and DA upgrades | | Combined |
|---|---|---|---|---|---|
| | **Baseline (H18B)** | **H8SC** | **Physics (HP2H)** | **Data Assimilation (HP3H)** | **H218** |
| **Description** | 1. Framework upgrade to HWRFV3.9a;<br>2. GSI upgrades;<br>3. Unified Coupler. | Baseline + Higher horizontal resolution (1.5/4.5/13.5 kms) | Cloud overlap; PBL changes | Add dropsonde drifts; add SFMR, G-IV TDR; Stochastic physics DA | Baseline + all physics changes + all DA upgrades + adjusted diffusion coeffecients |
| **Cases** | Three-season 2015-2017 simulations in NATL cases (~1000) | Priority cases for 2015-2017 retrospectives in NATL (~1000 ) | Priority cases for 2015-2017 retrospectives in NATL (~1000 ) | Priority cases for 2015-2017 retrospectives in NATL/EPAC (~2000 ) | **Three-season 2015-2017 retrospectives ~3000 simulations in all TC basins** |
| **Platform** | WCOSS/Jet | WCOSS Cray | WCOSS/Jet | WCOSS/Jet | **WCOSS Cray/Jet** |

# HWRF (H218) Verification for Atlantic Storms (2015-2017)

# H218 Performance (NATL Basin): Track and Intensity Errors



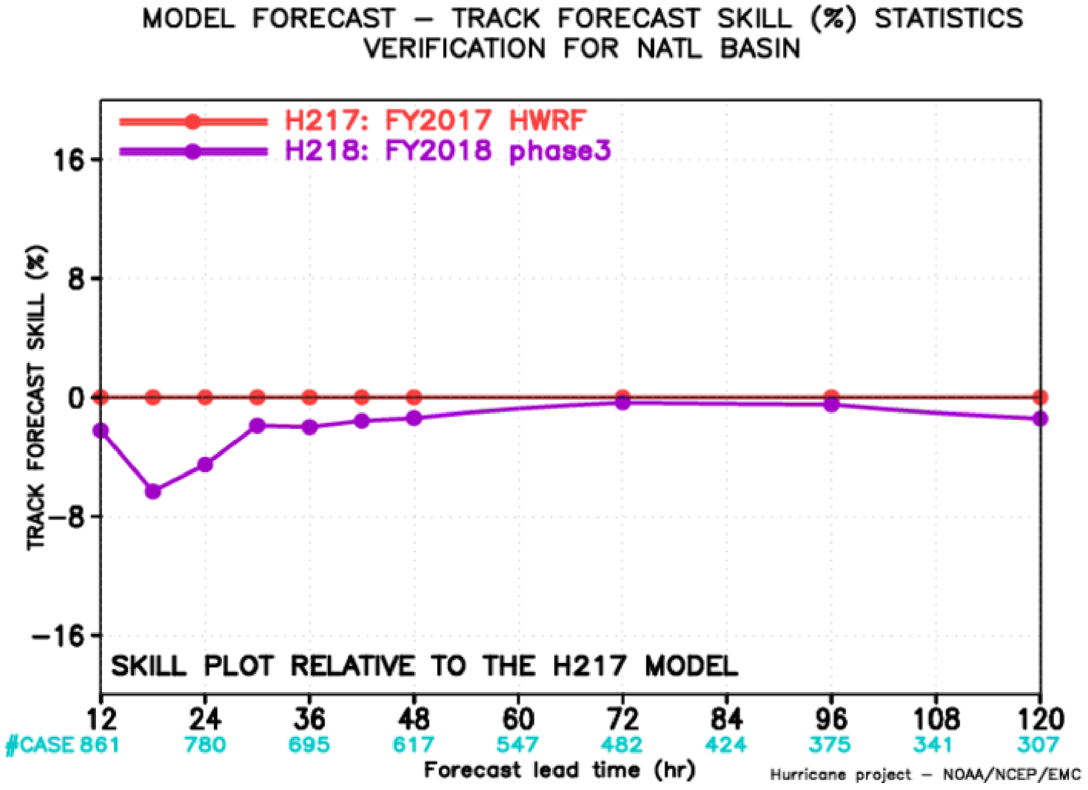



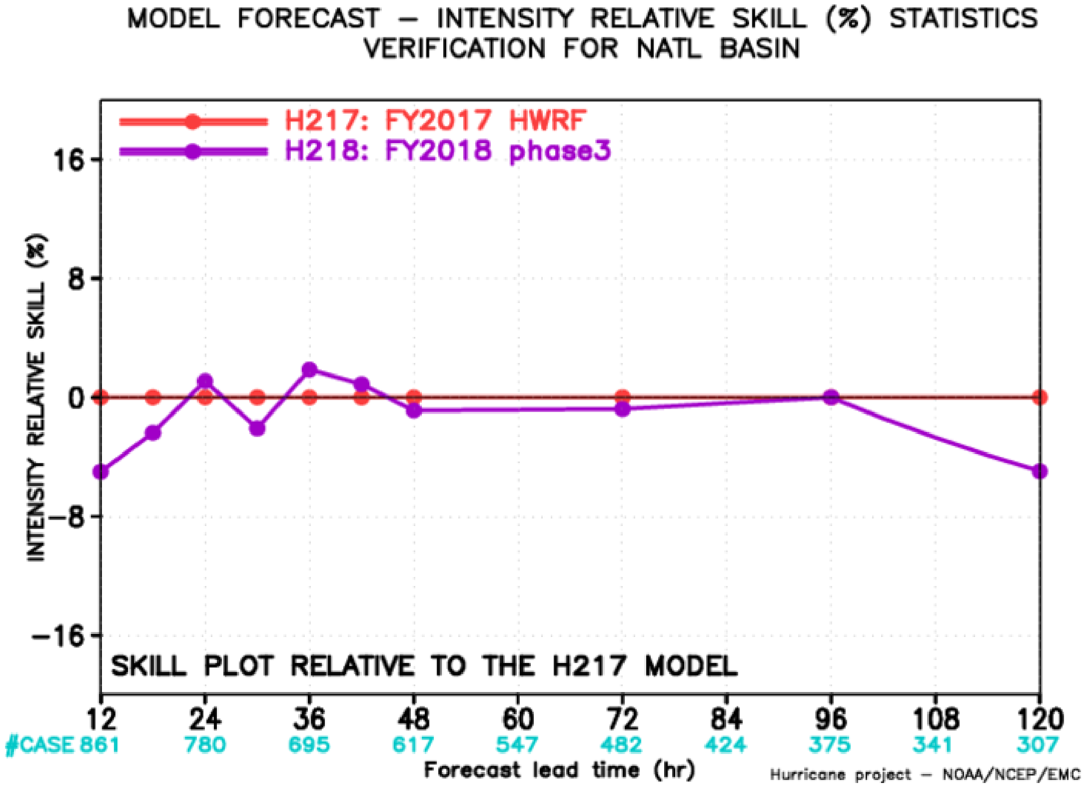




H218 has very similar track errors compared to H217. H218 has also similar intensity errors which is a significant improvement over H18B.

H218 has significantly lower bias errors as compared to H217.

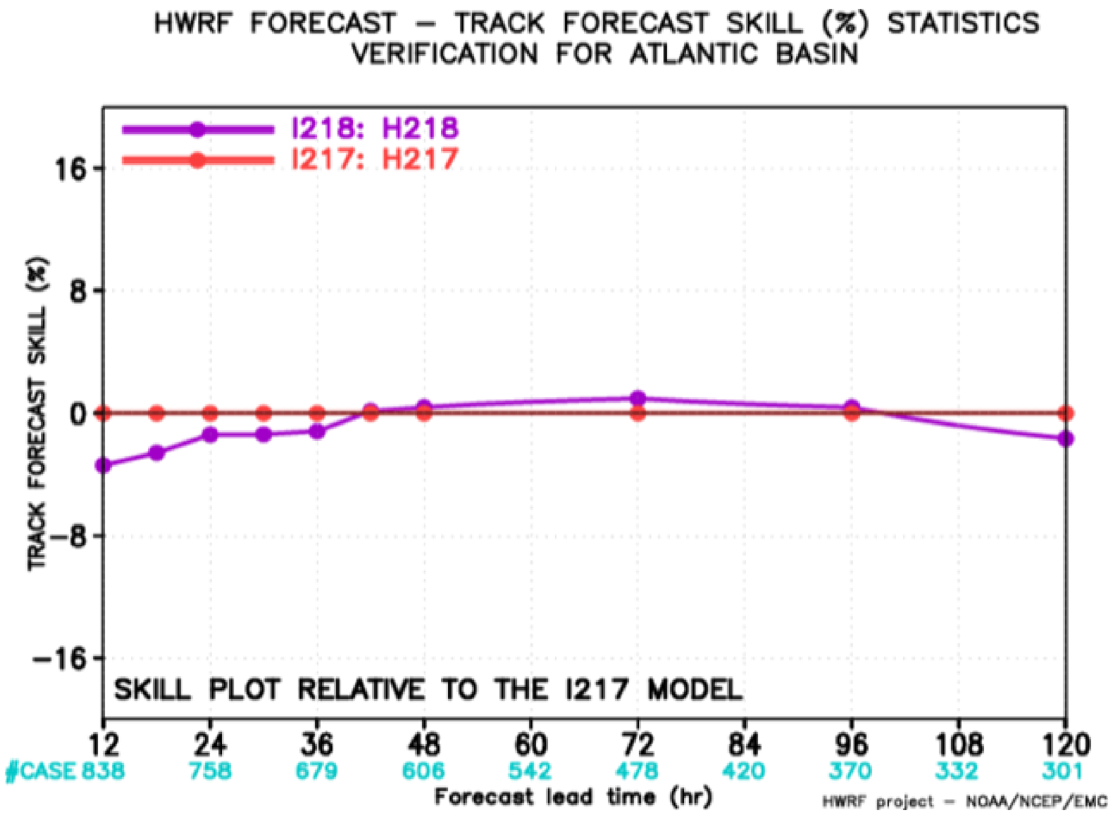
# Track and Intensity Skills: NATL Basin (Late Model)

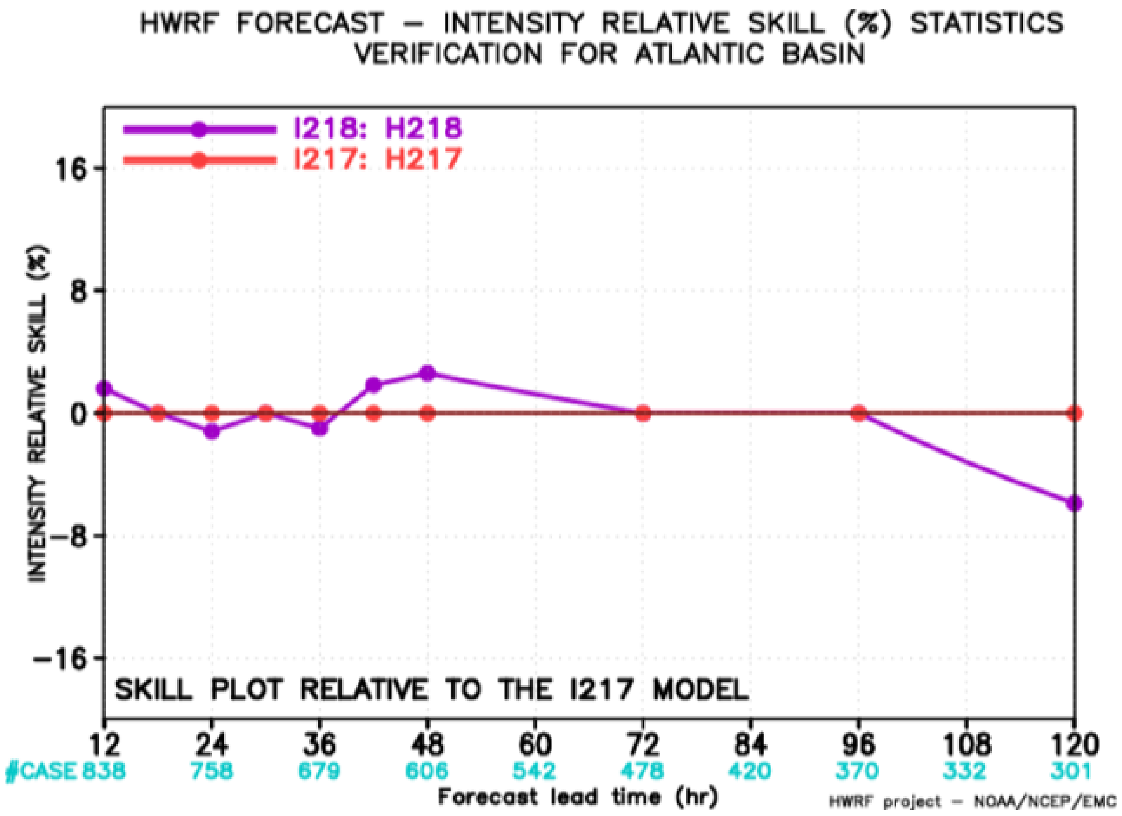



Track skill for H218 is neutral compared to H217 after 30 hrs. Intensity shows some improvements (< 2%) in the first 2 days but lower skill at Day 5. Overall both are close to neutral.

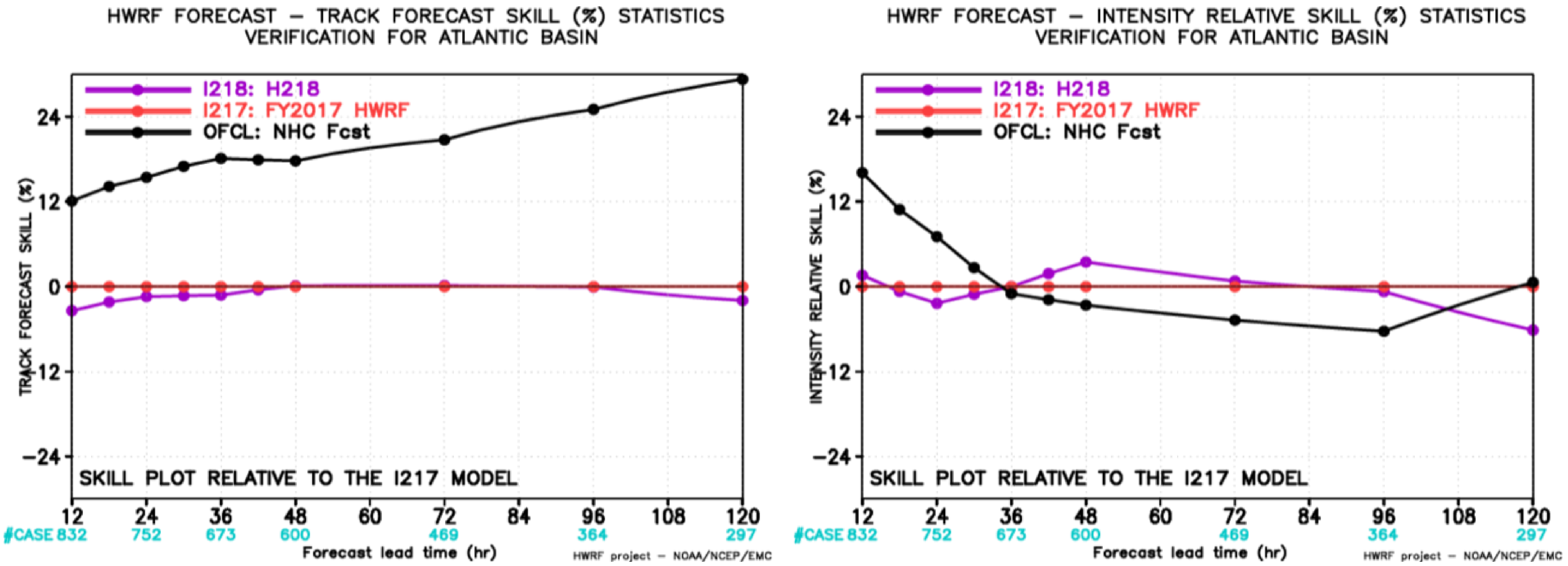
# Track and Intensity Skills: NATL Basin (Early Model)



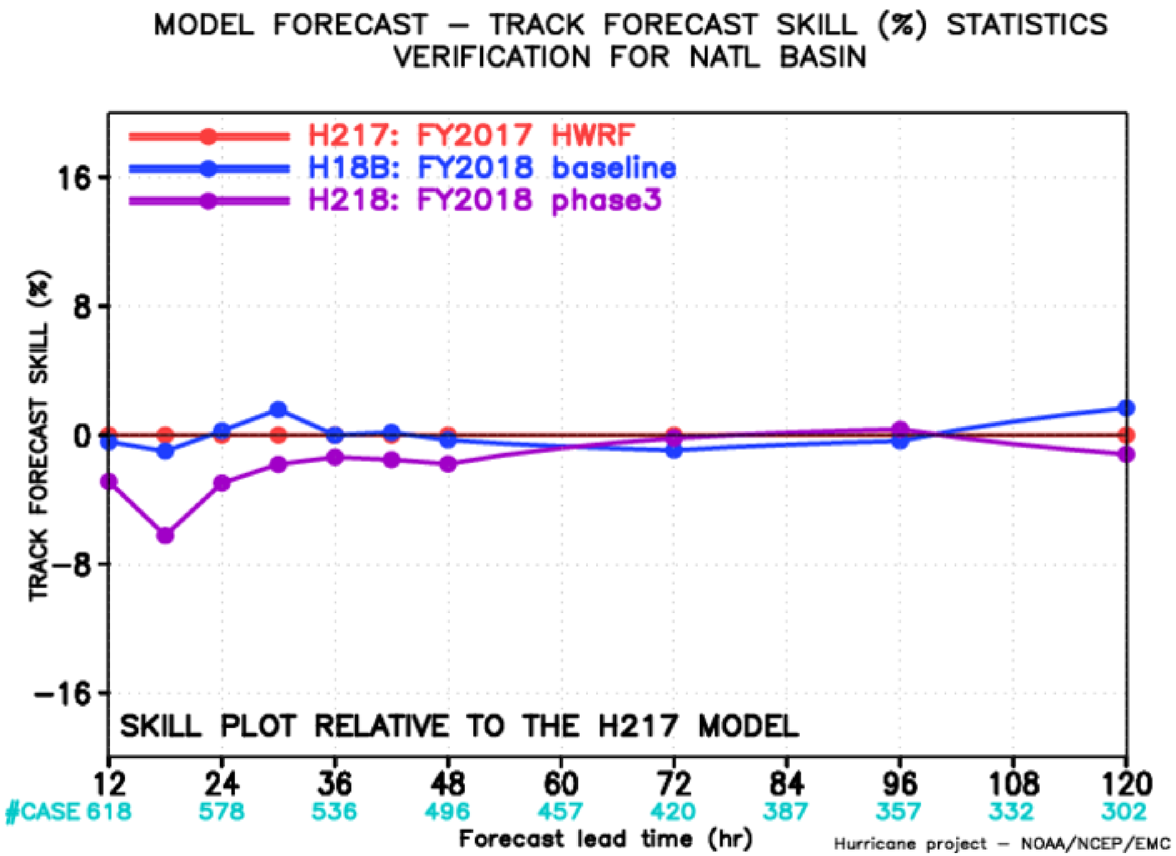

Track skill for H218 is neutral with respect to H217 results. Intensity skill is neutral to positive through Day 4 but negative at Day 5.

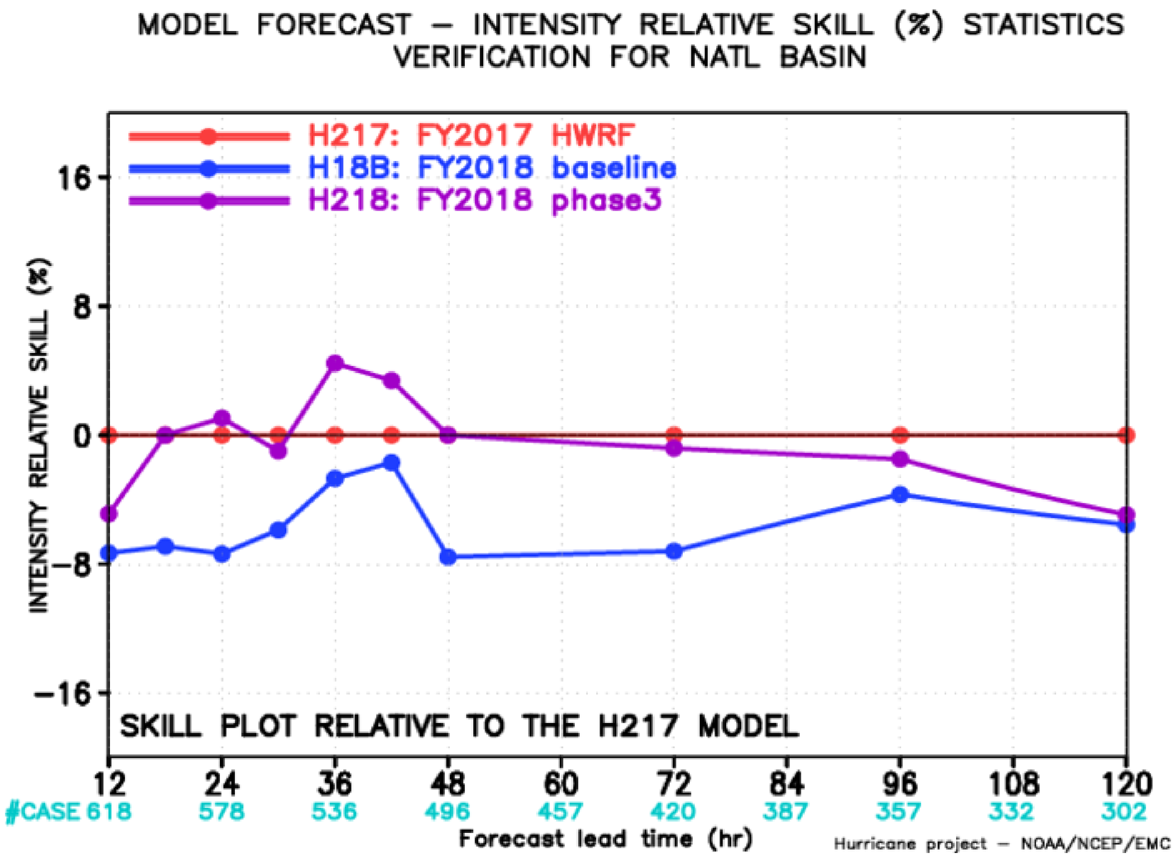
# Track and Intensity Skills: NATL Basin (Early Model)




Track skill for H218 is neutral with respect to H217 results. Intensity skill is neutral to positive through Day 4 but negative at Day 5. H218 beats official intensity forecasts between hrs 36 and 108.

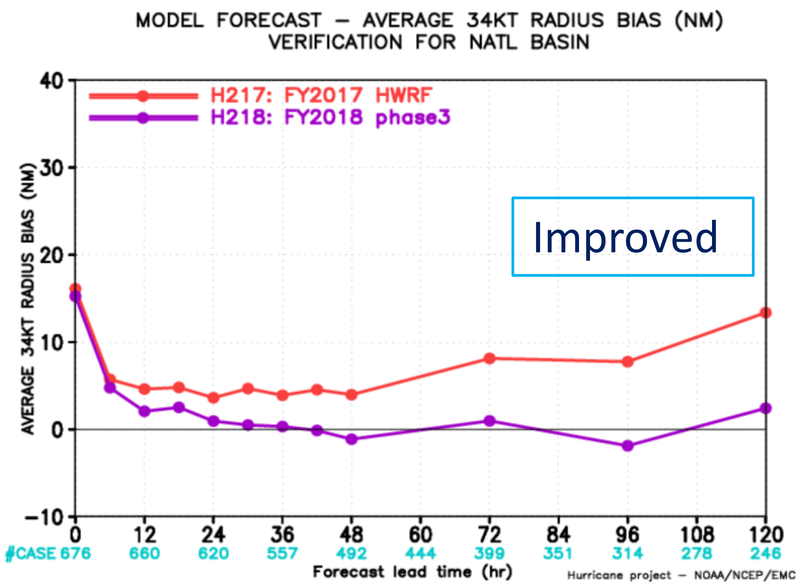
# H218 and H18B vs H217 (NATL Basin): Track and Intensity Skills

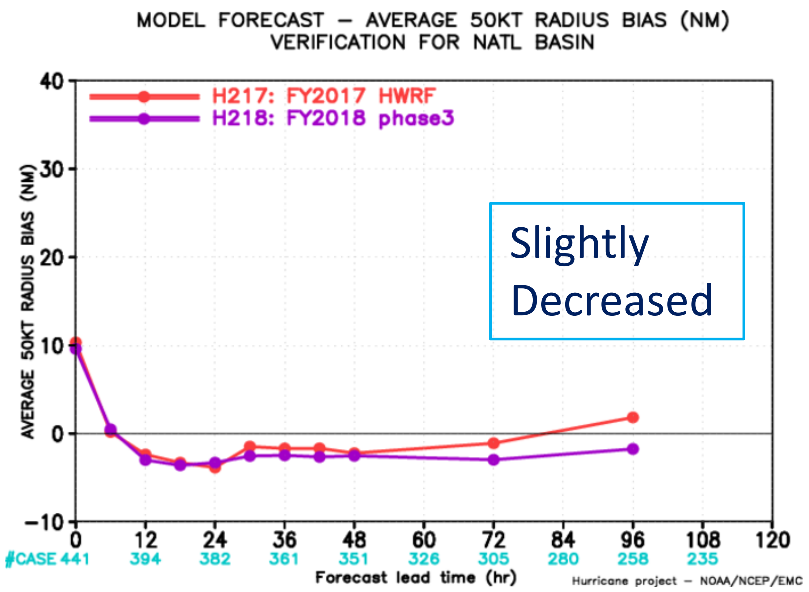


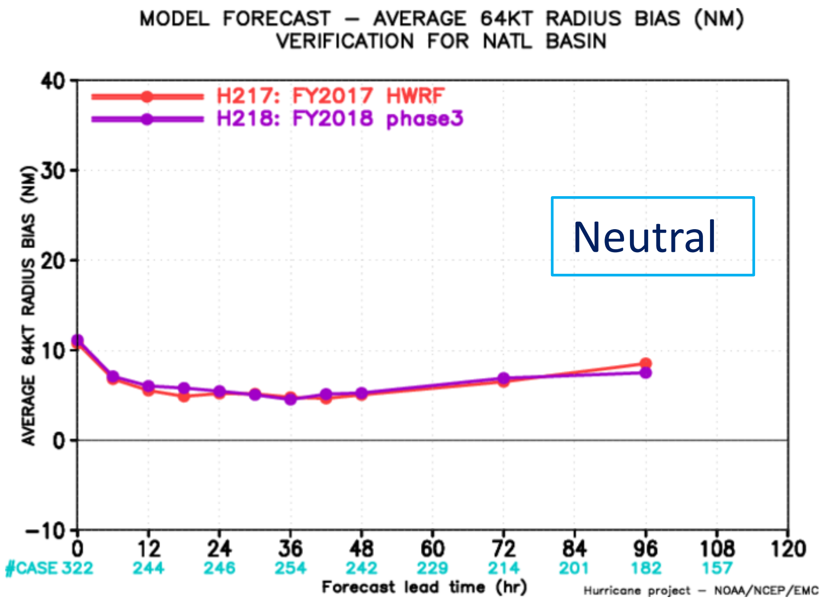



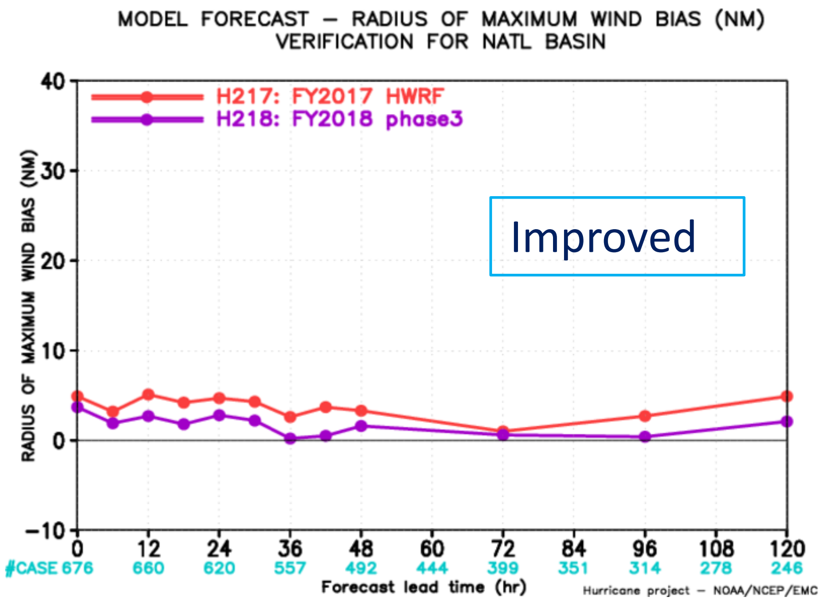

Track skill for H218 and H18B are very similar and neutral with respect to H217. For this homogenous sample, intensity skill of H218 is significantly ahead of H18B at all lead times.

# H218 Performance (NATL Basin): Storm Size Improvements

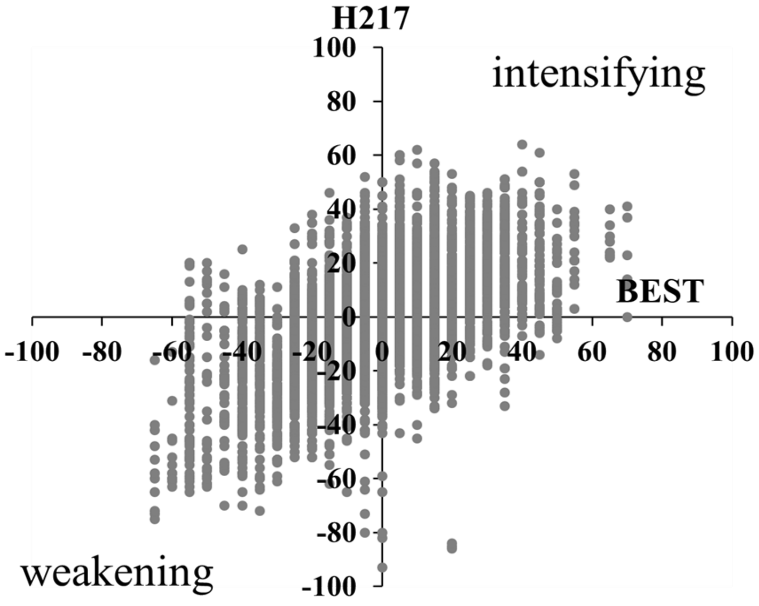


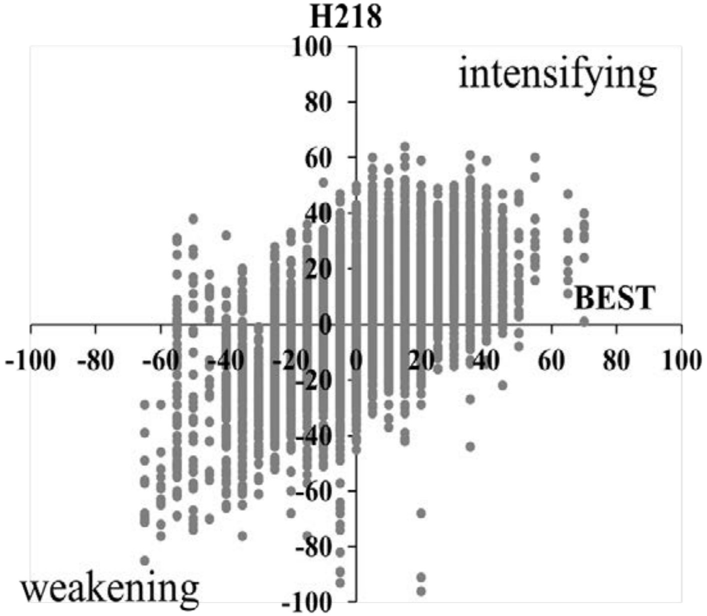



# H218 Performance (NATL Basin): RI performance




| OBS / H217 | Yes | No |
|---|---|---|
| Yes | 79 | 261 |
| No | 396 | 7894 |

POD = 16.6%
FAR = 76.8%

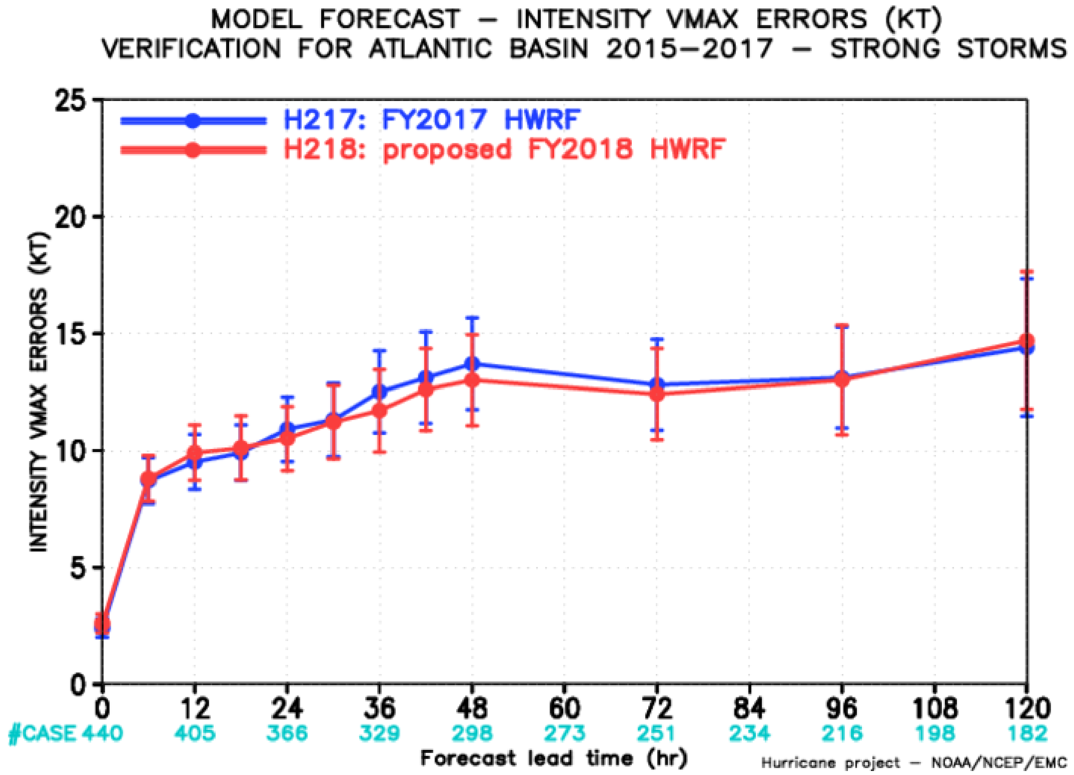


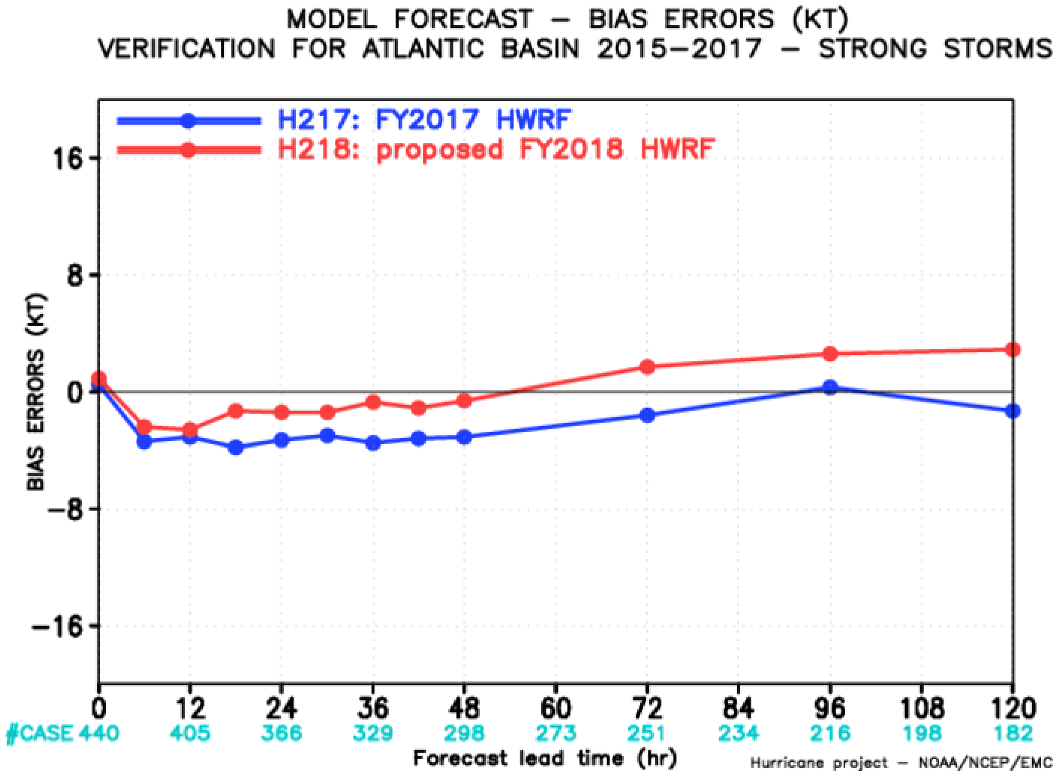

| OBS / H218 | Yes | No |
|---|---|---|
| Yes | 92 | 356 |
| No | 368 | 7959 |

POD = 20.0%
FAR = 79.5%

While POD is improved for H218, FAR is also increased as compared to H217.

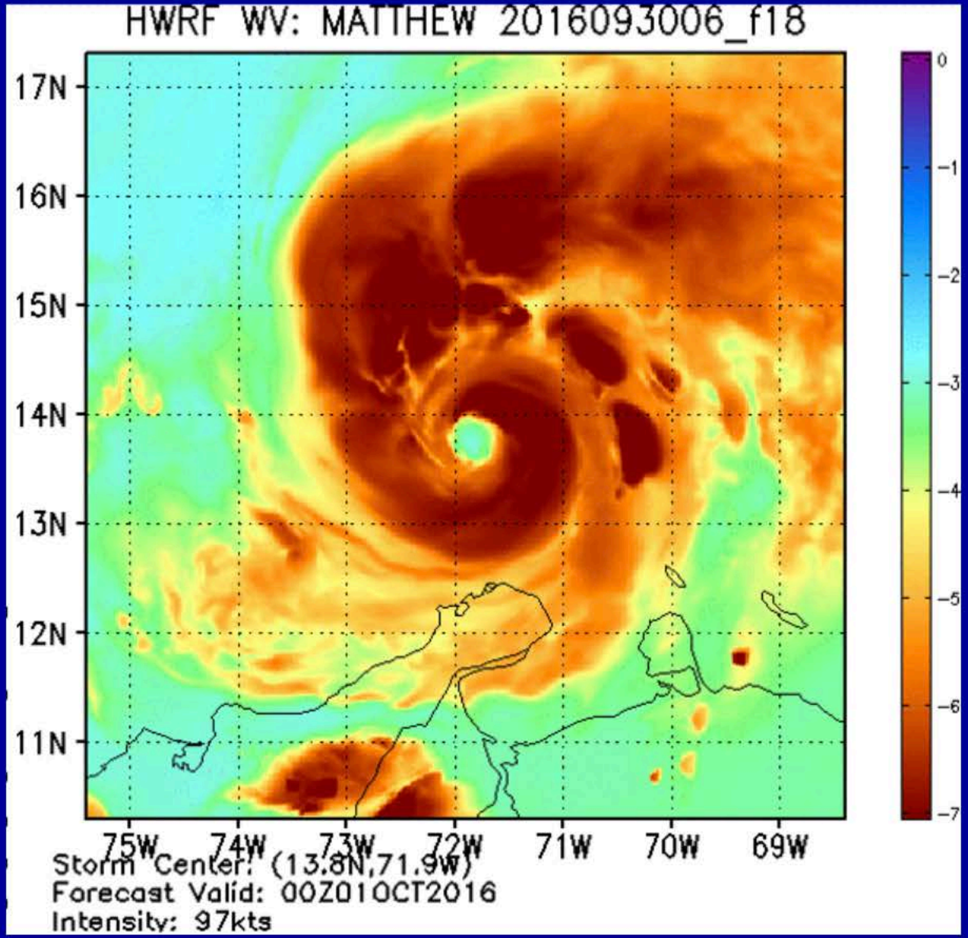
# Intensity skill improvements for NATL basin (2015-2017)
# (Strong Storms > 50 kt)



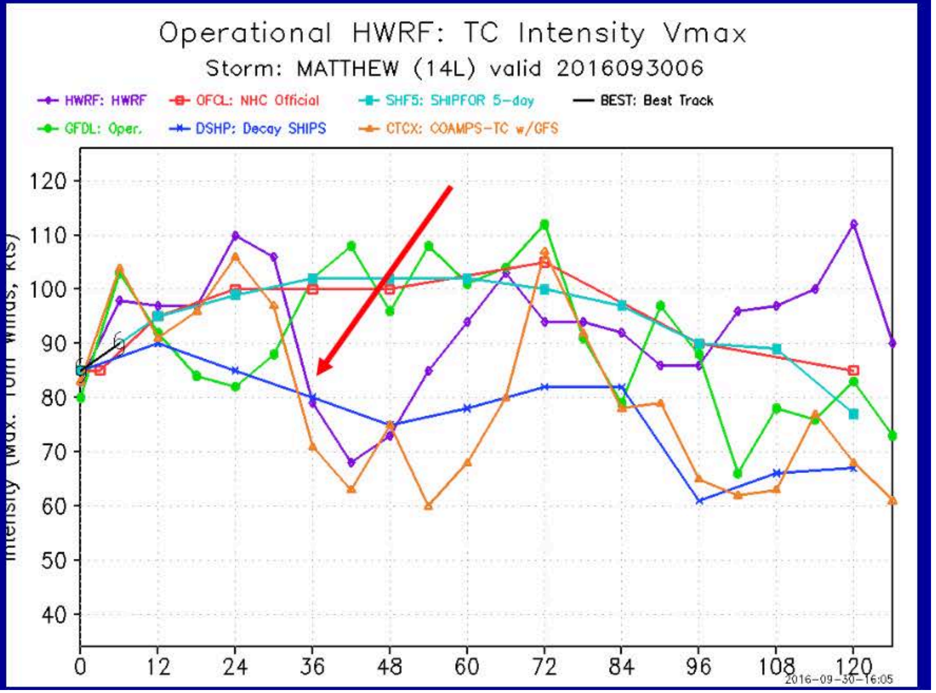




Intensity errors are reduced for H218 for strong storms between Days 1 and 4 as compared to H217 for the NATL basin. Bias errors are also reduced up to Day 3 but become positive for Days 4 and 5.

# Collapse of inner core of Matthew in HWRF




For some HWRF forecasts of Matthew when it was over the Caribbean, the eyewall unrealistically collapsed. This had to have an effect on the model-predicted intensity.



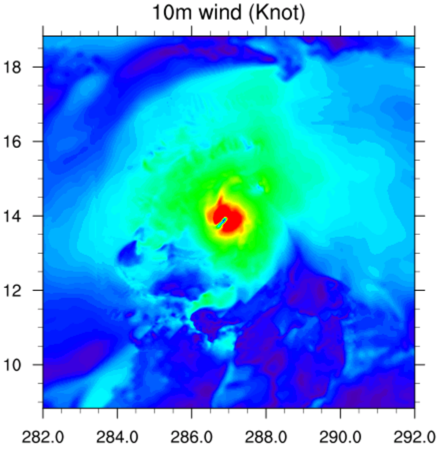

- Continue diagnostics to help identify areas for HWRF improvement

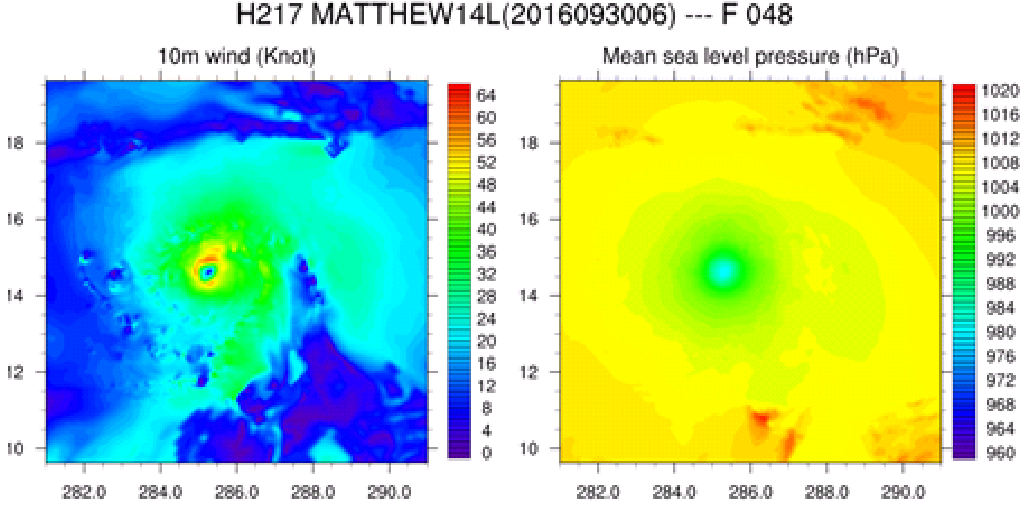
…Case studies…

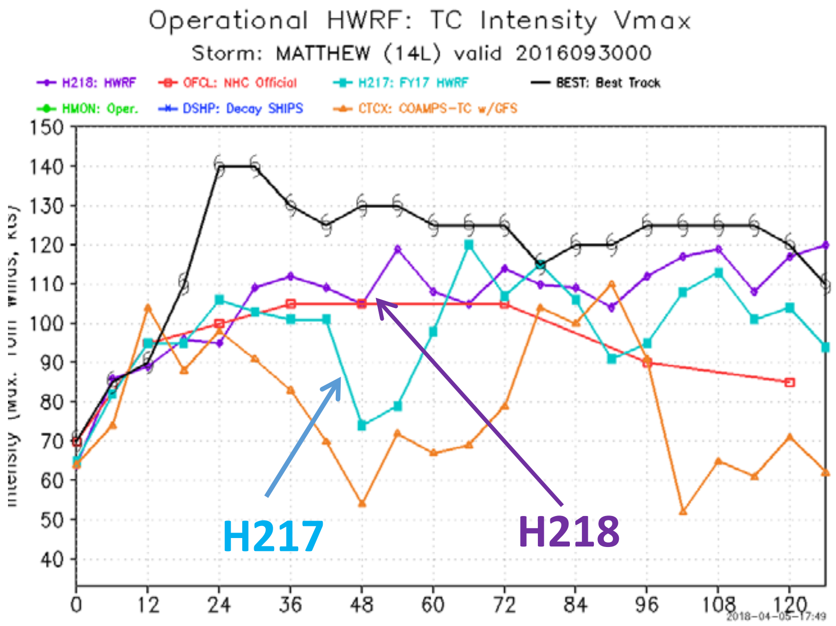
Blake et al. HFIP meeting, 01/2017

# Intensity Oscillations Improved in H218

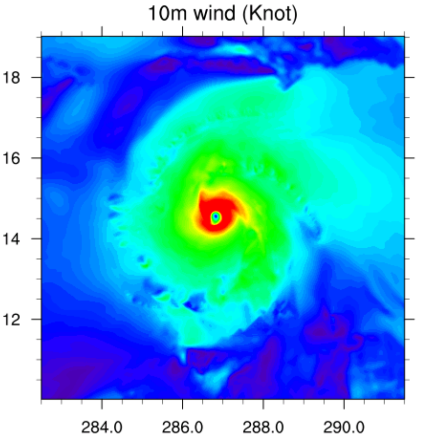
H217 V10m F036

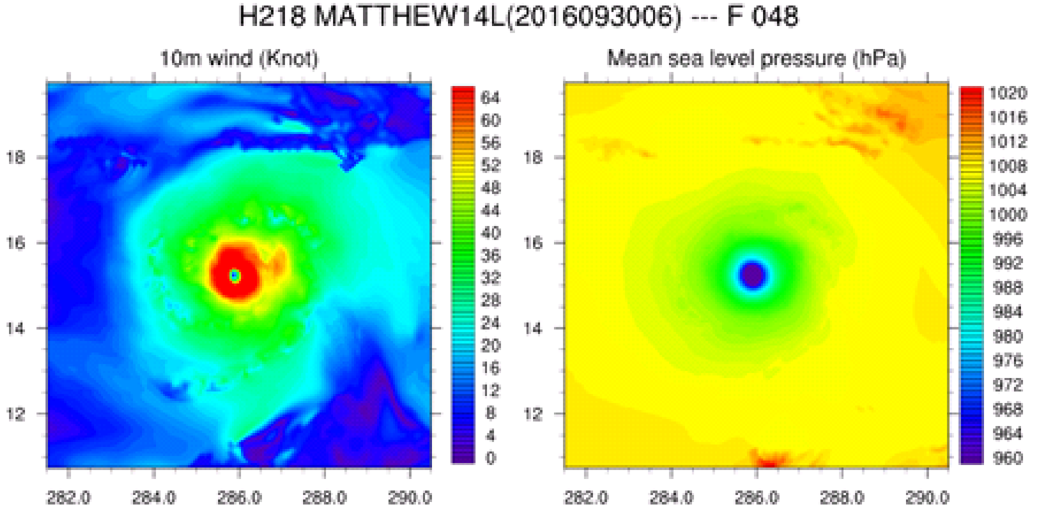


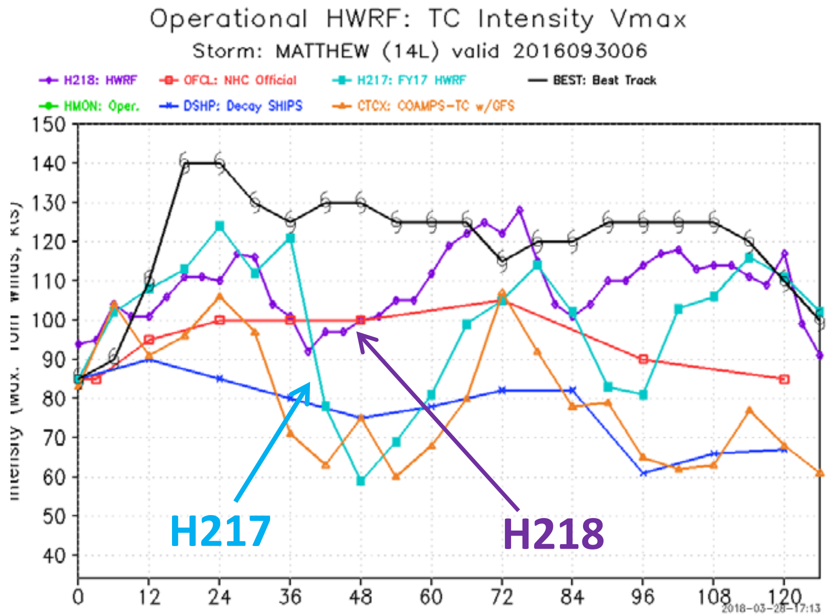



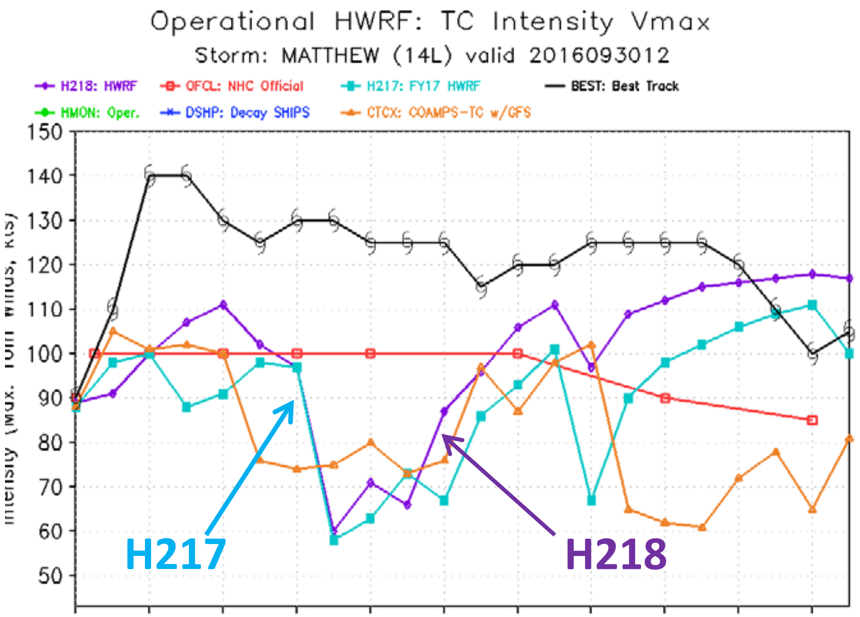

H218 V10m F036

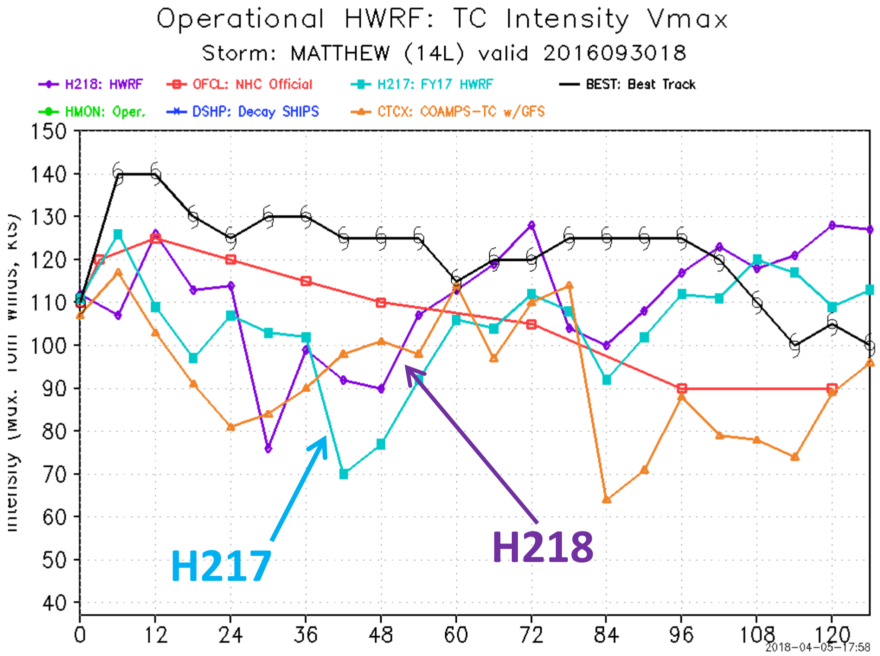


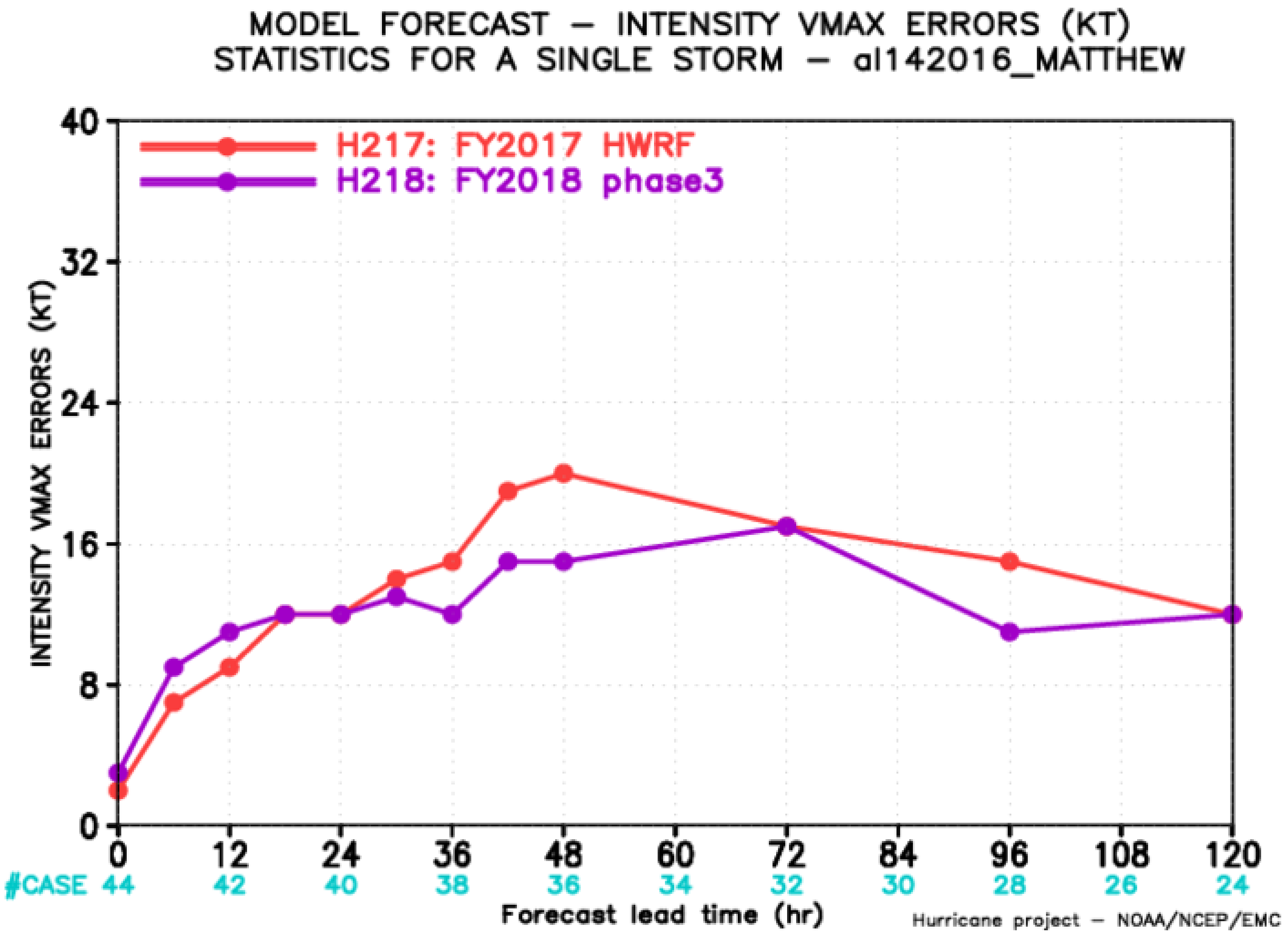



# Even though not eliminated, overall errors are reduced.



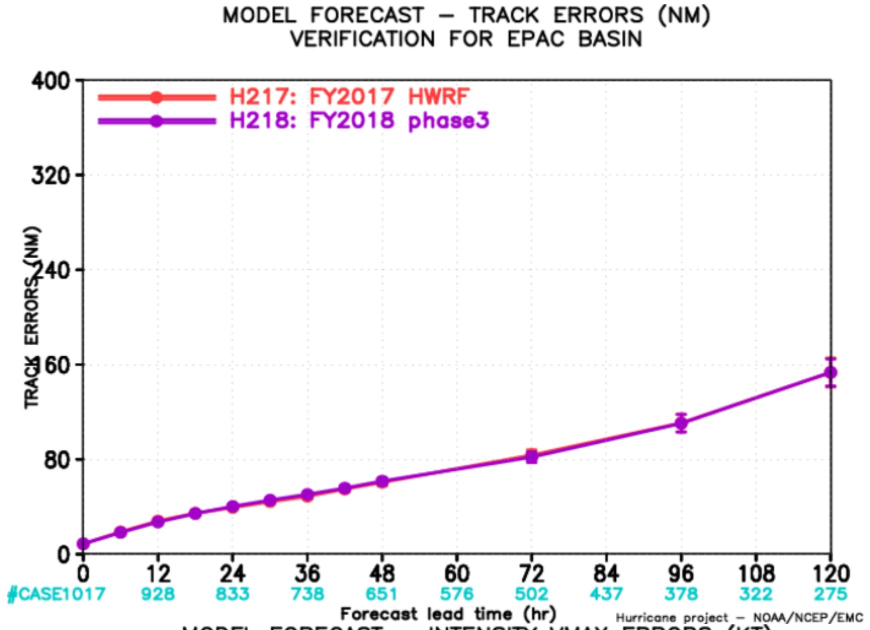



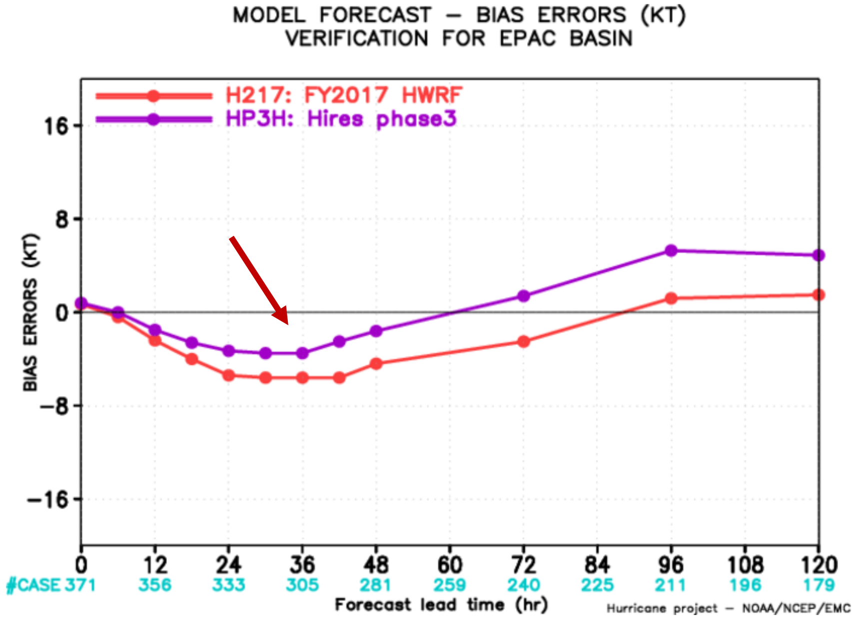



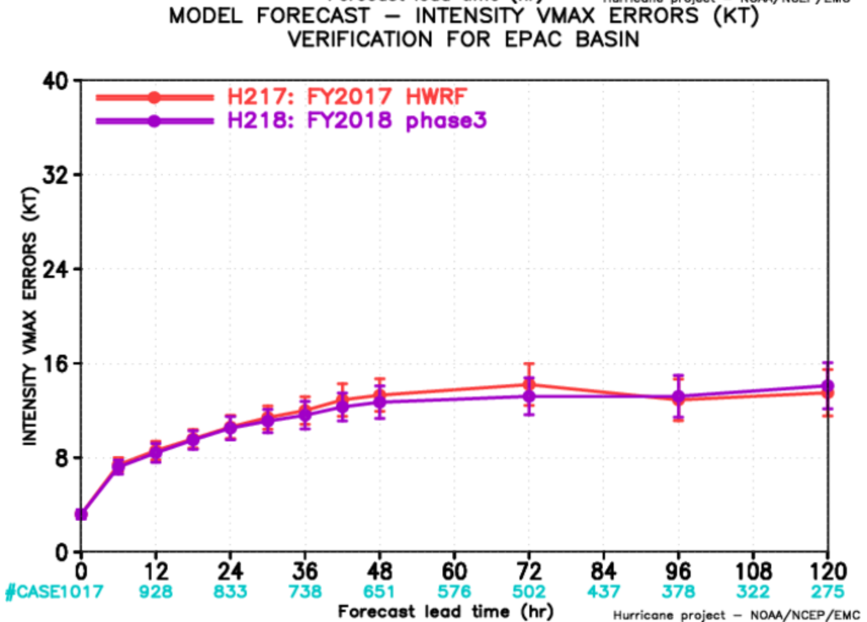

H218 intensity errors significantly reduced for Hurricane Matthew beyond Day 1.

# HWRF (H218) Verification for East Pacific Storms (2015-2017)

# H218 Performance (EPAC Basin): Track and Intensity Errors



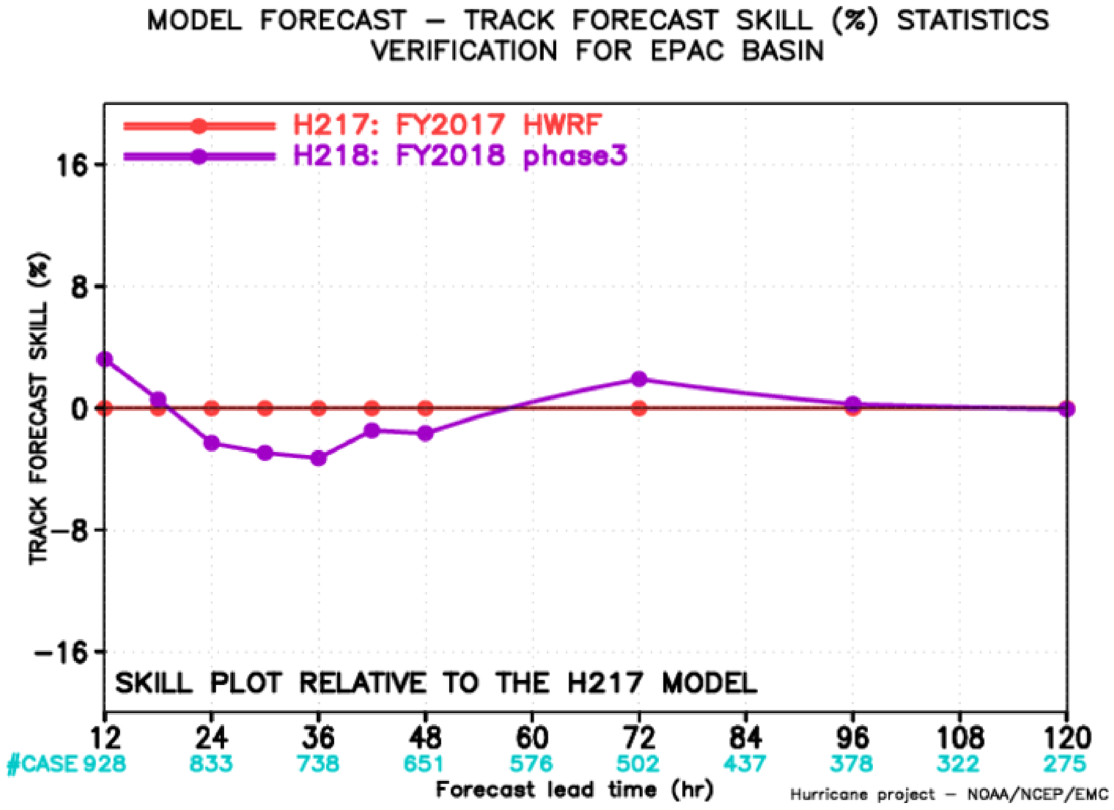



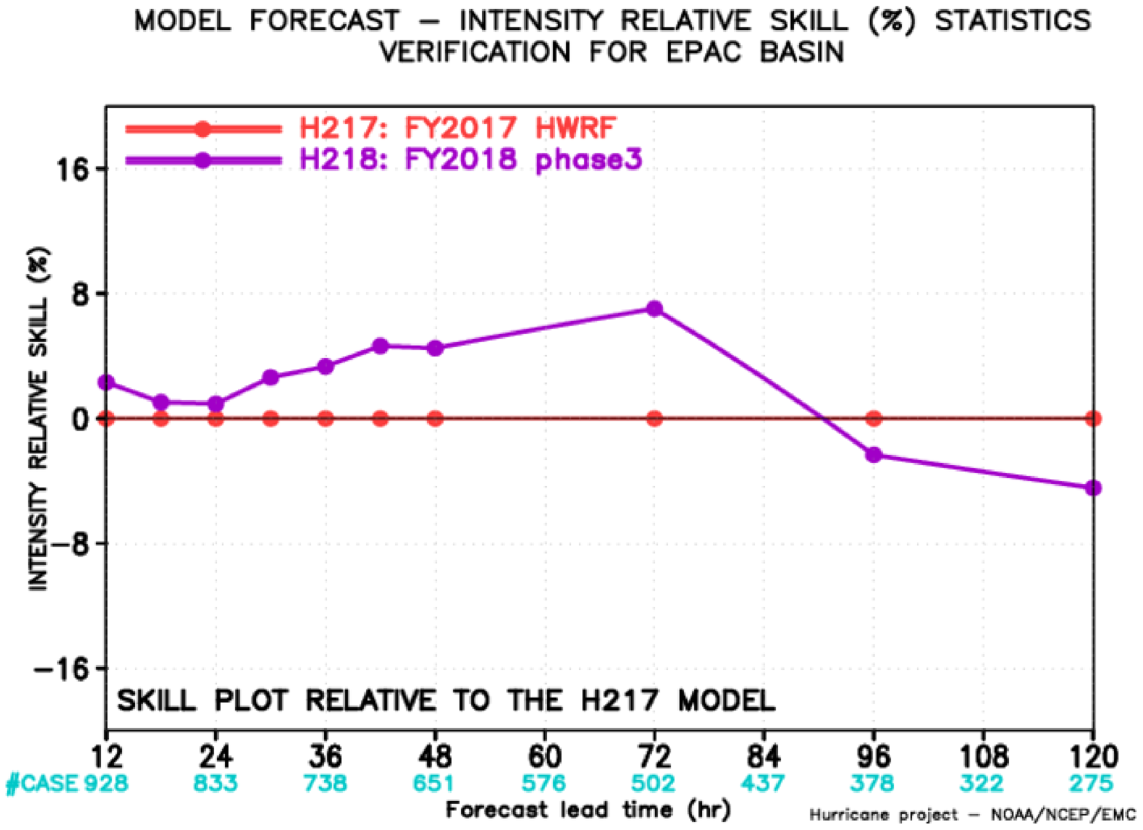




H218 has very similar track errors as compared to H217. The intensity errors are smaller up to Day 4 and then larger for Days 5.

H218 has lower bias errors for the first 3 days but larger positive bias for Days 4 and 5.

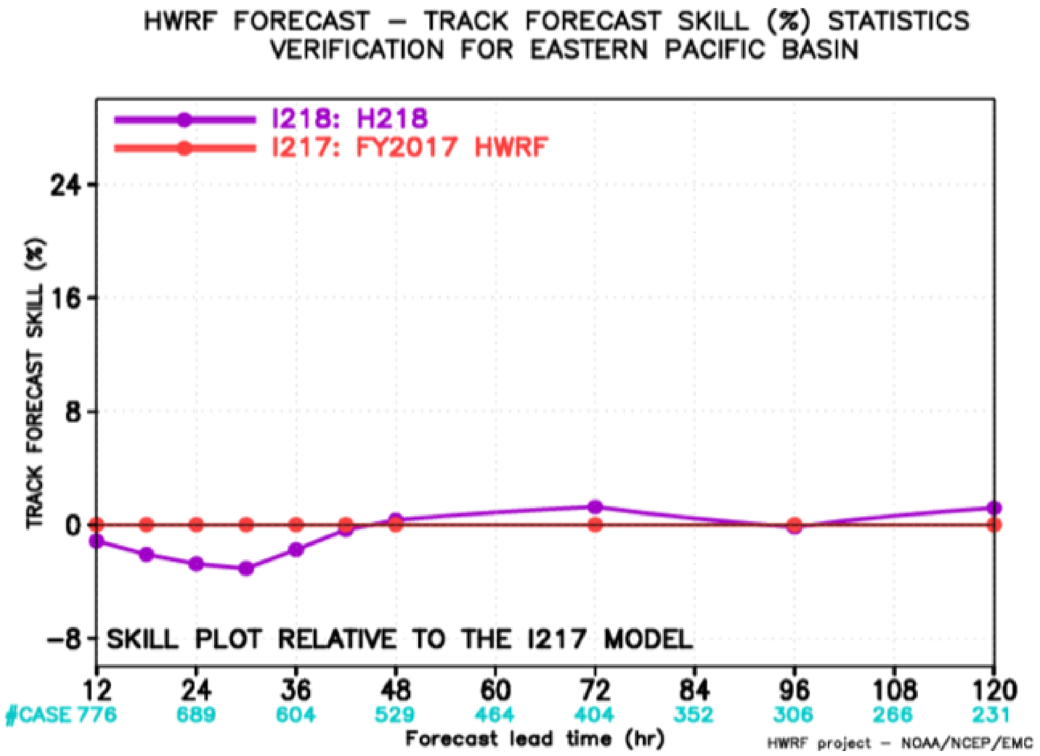
# Track and Intensity Skills for EPAC Basin (Late Model)

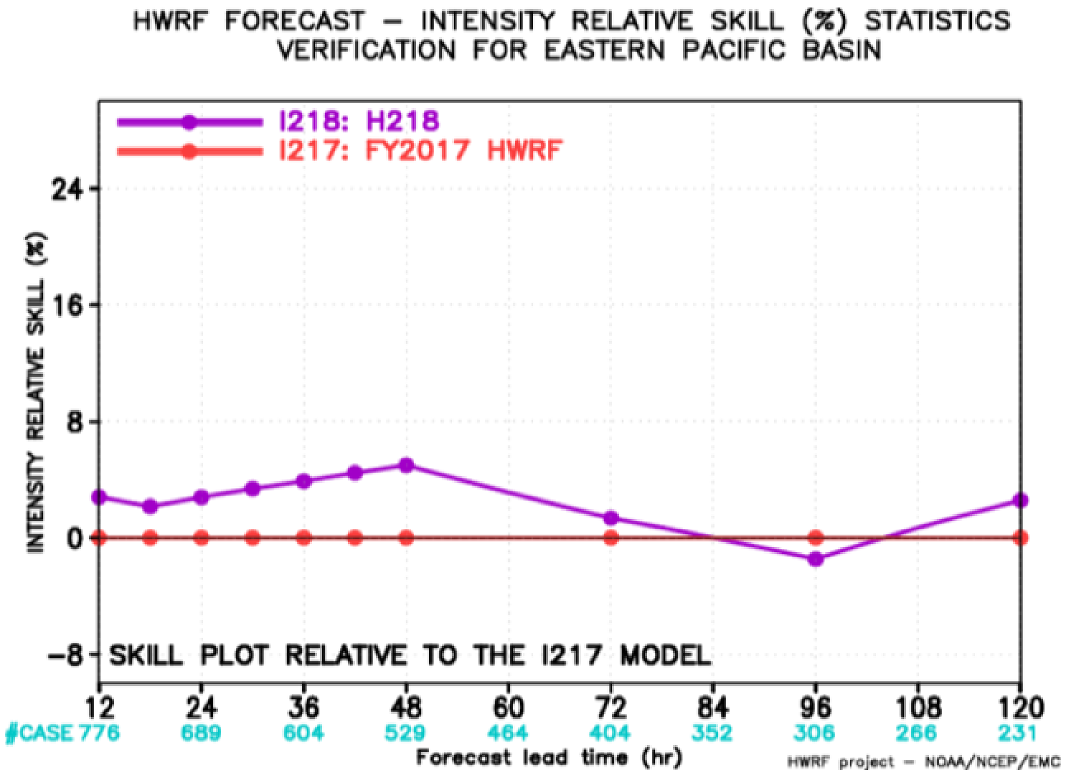



Track skill is slightly reduced for the first 2 days but is ahead for longer lead times after hr 60. Intensity skill is positive for early lead times and improved by almost 8% by Day 3. It is somewhat reduced for longer lead times.

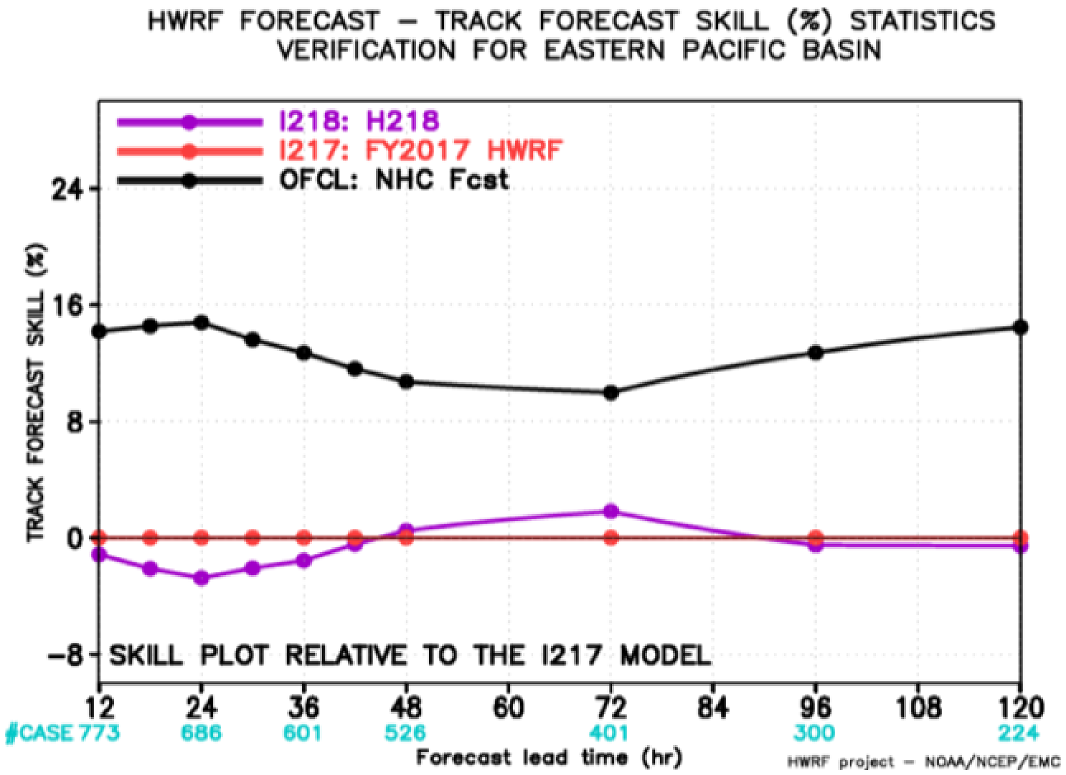
# Track and Intensity Skills for EPAC Basin (Early Model)

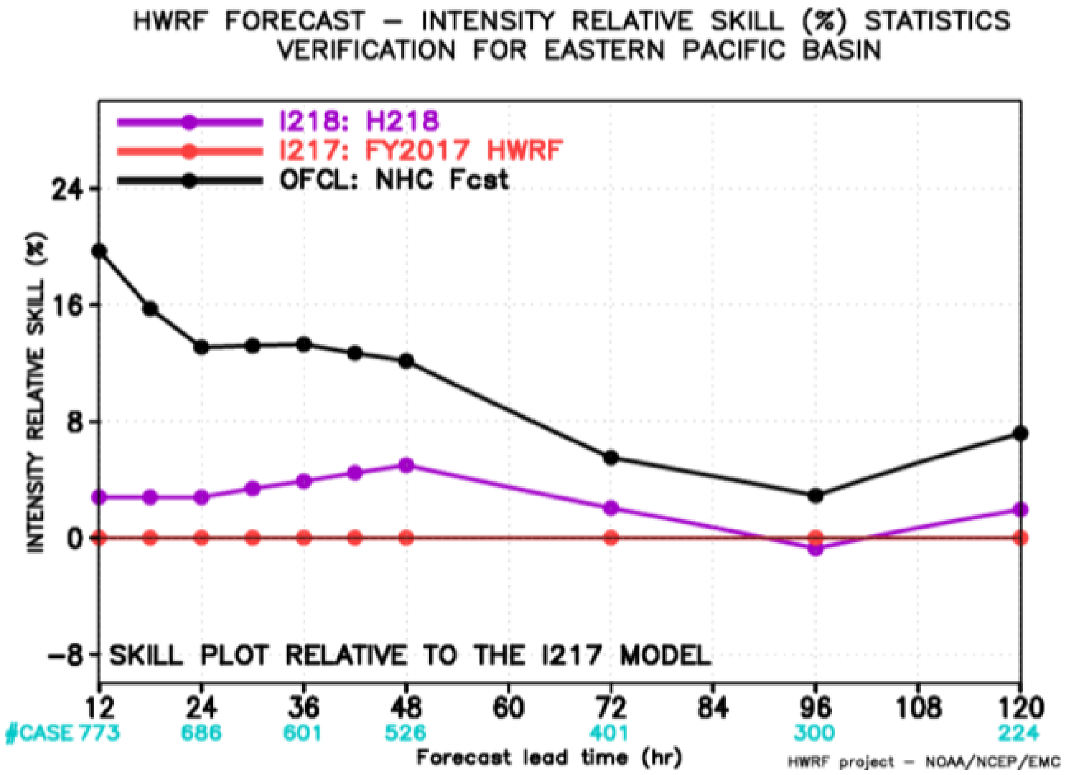



Track skill is negative for early lead times through hr 36 but positive after that, overall neutral with respect to H217 results. Intensity skill is positive at all lead times other than at Day 4.

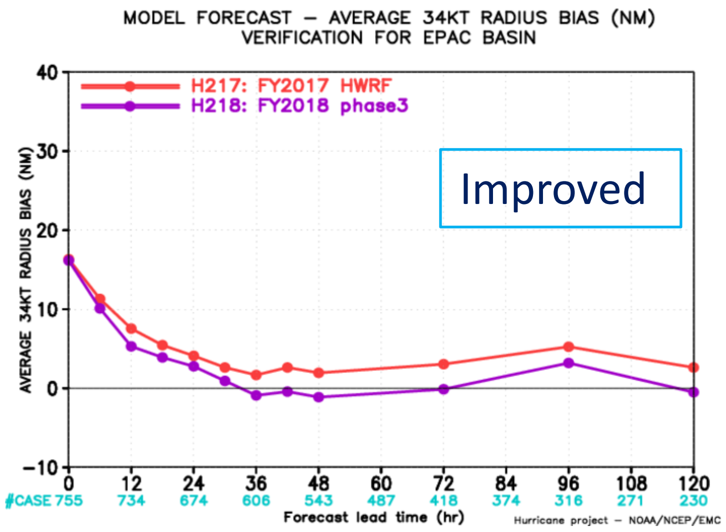
# Track and Intensity Skills for EPAC Basin (Early Model)

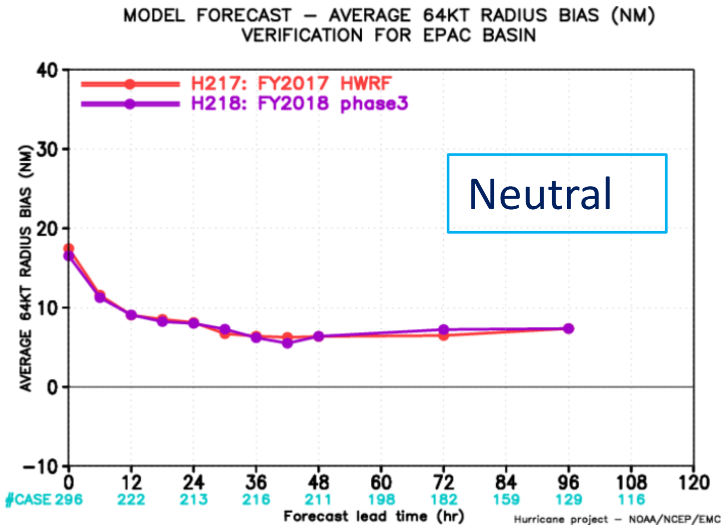


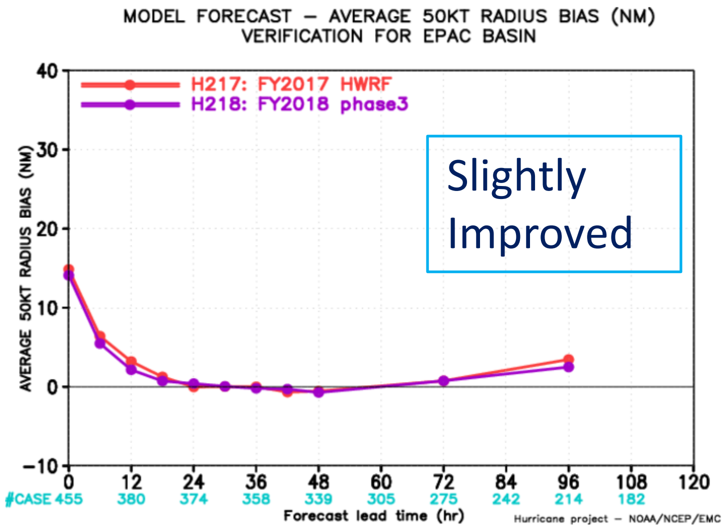



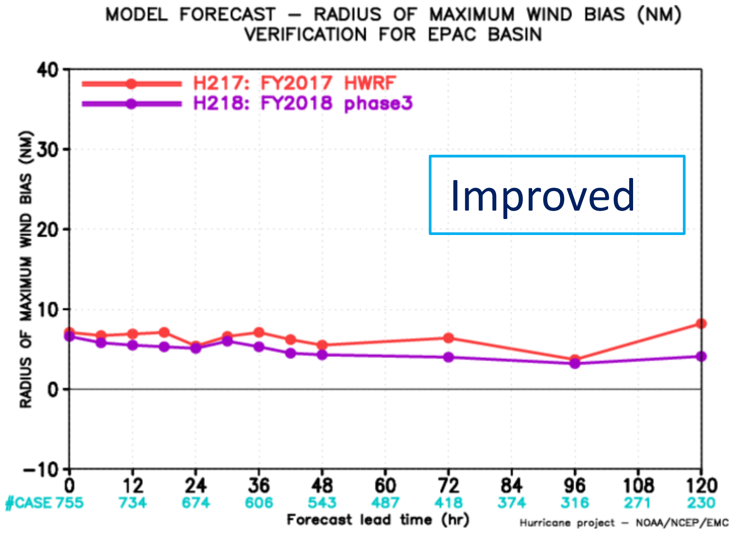

Official track and intensity skills are ahead of H218 but the gap has narrowed for intensity for longer lead times.

# H218 Performance (EPAC Basin): Storm Size Improvements

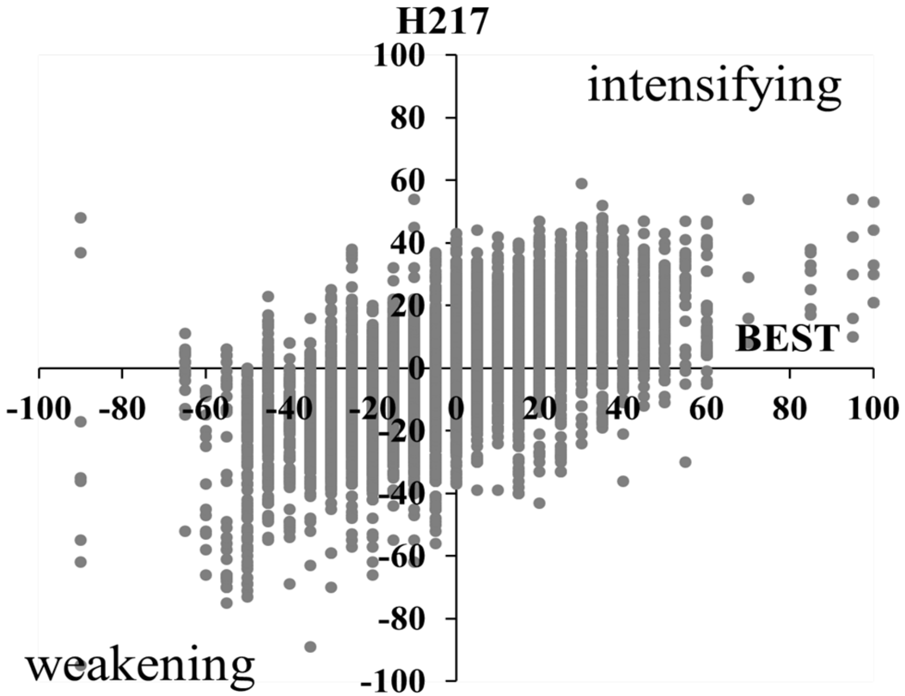


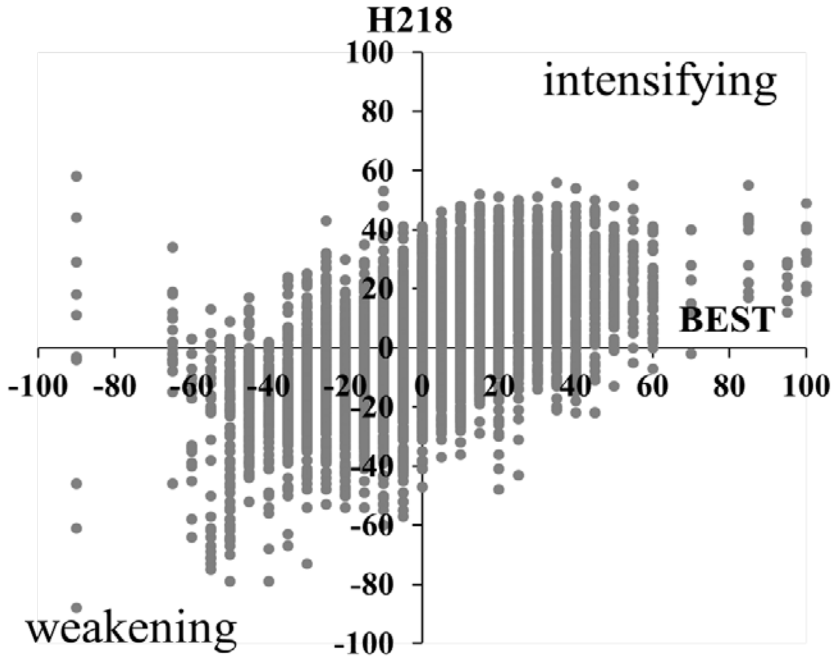



# H218 Performance (EPAC Basin): RI performance




| OBS / H217 | Yes | No |
|---|---|---|
| Yes | 93 | 166 |
| No | 647 | 7114 |

POD = 12.6 %
FAR = 65.6%

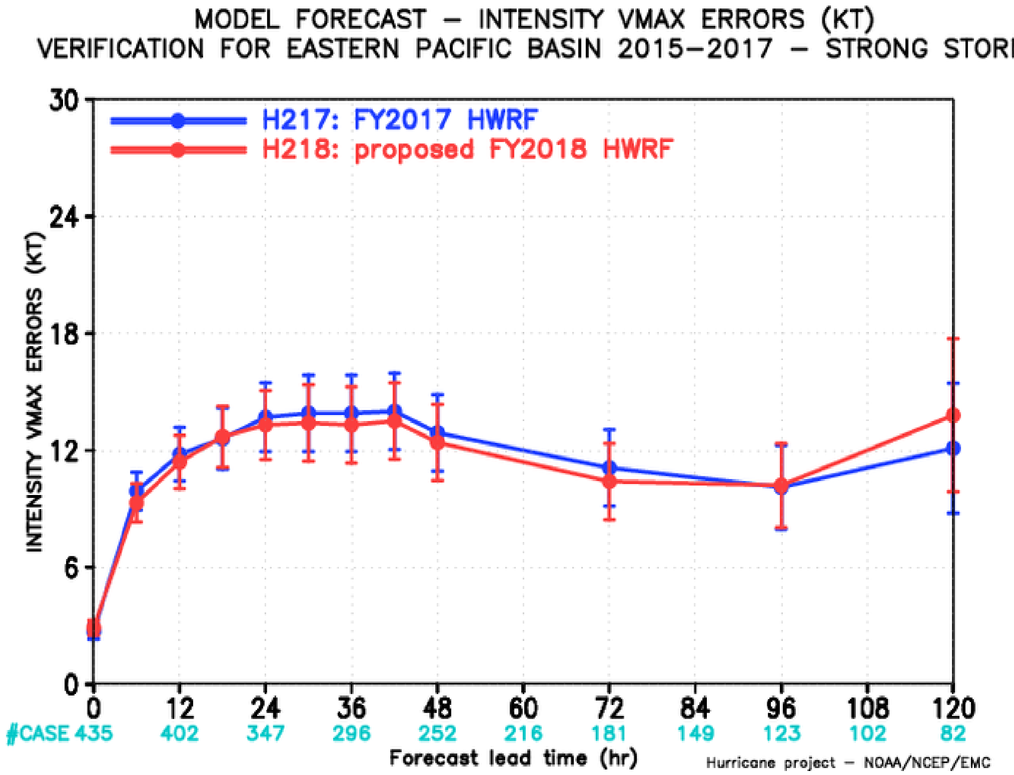


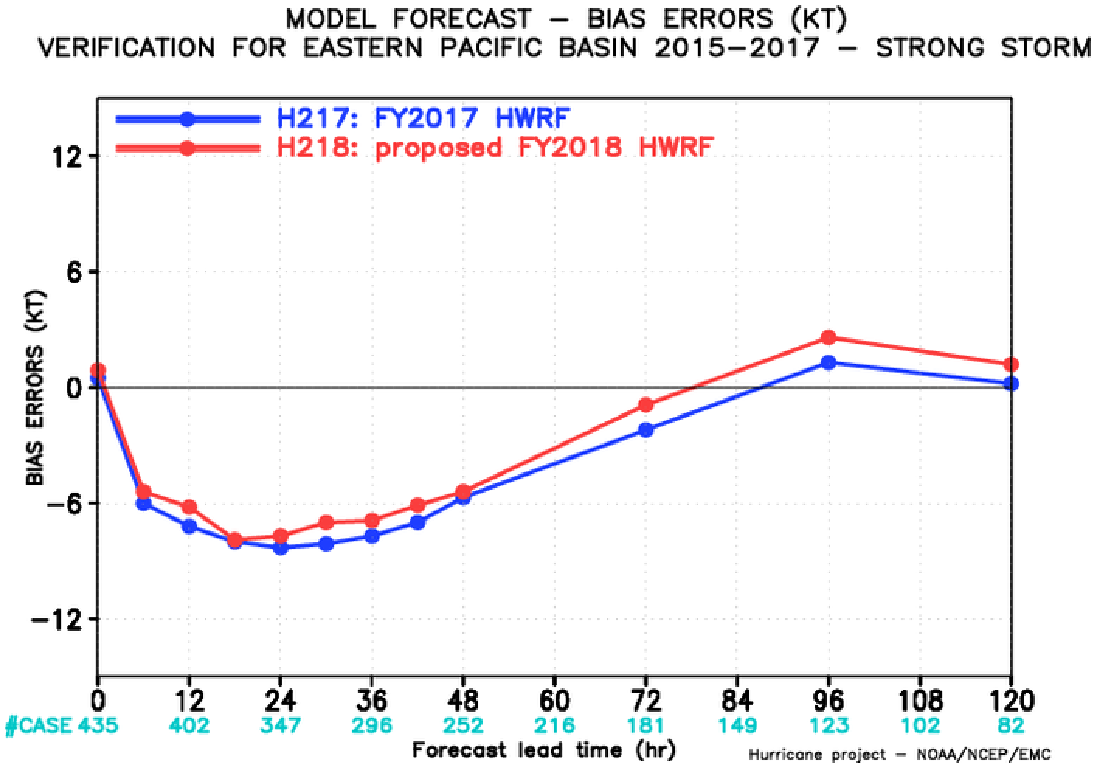

| OBS / H218 | Yes | No |
|---|---|---|
| Yes | 113 | 293 |
| No | 668 | 7699 |

POD = 14.5 %
FAR = 72.2%

Similar to NATL basin, POD is improved for H218 but FAR is also increased.

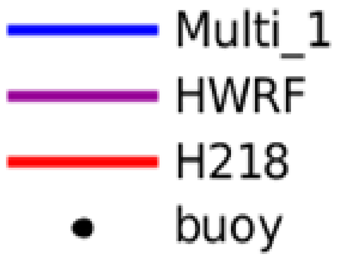
# Intensity skill improvements for EPAC basin (2015-2017)
# (Strong Storms > 50 kt)



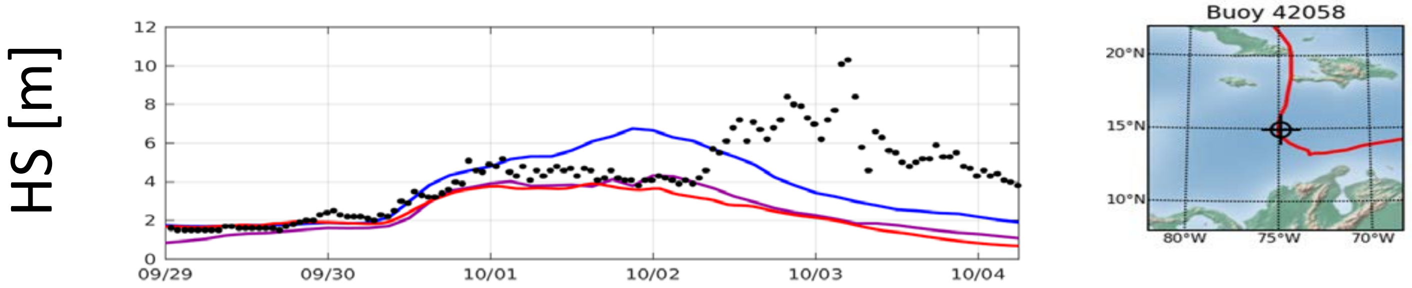

Intensity errors are reduced for H218 for strong storms between upto Day 4 as compared to H217 for the EPAC basin. Bias errors are also reduced up to Day 3 but then become positive for Days 4 and 5.

# WAVEWATCH III results for Hurricane Matthew (14L2016) with H218 (One way coupled)

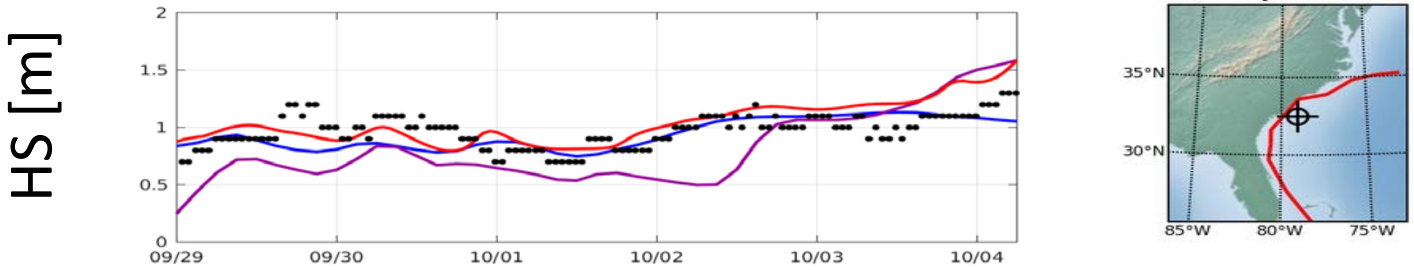



In H218 the initial condition for WW3 comes from Multi_1 (Global Wave Model). The effect of the initial condition in Buoy 41004 is evident for 12+ cycles whereas for Buoy 42058, the effect of the initial condition is evident for fewer cycles since the wind speeds are stronger and their is faster spin-up of the waves.

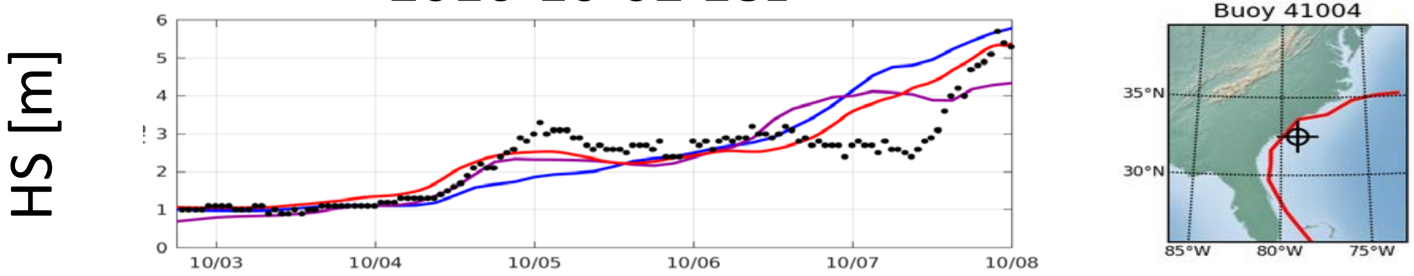
2016-09-29 00z



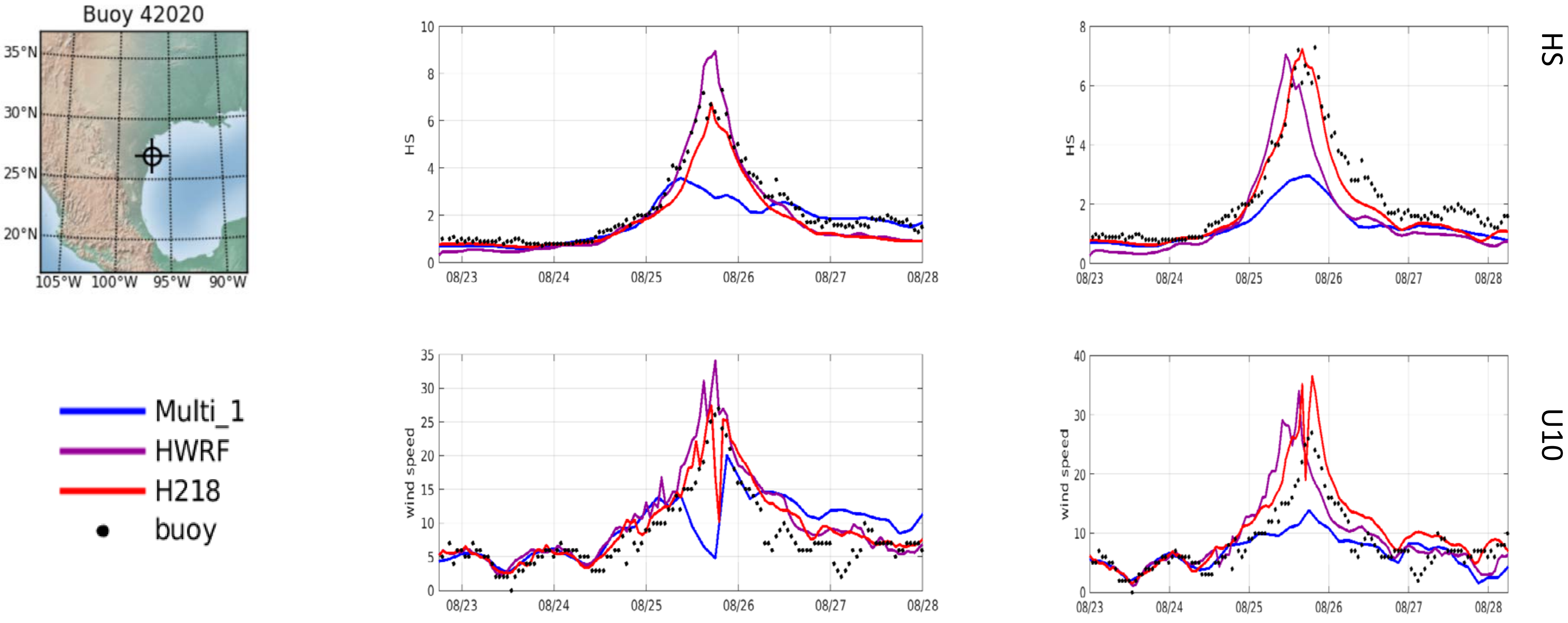

2016-09-29 00z




2016-10-02 18z



# WAVEWATCH III results for Hurricane Harvey (09L2017) with H218
# (One way coupled)




2017-08-22 18z

2017-08-23 00z

# Operational HWRF Configurations: 2017 (top) vs. 2018 (bottom)

| Basin | Ocean | Data Assim | Ensemble | Vertical | Model Top | Horizontal Resolution |
|---|---|---|---|---|---|---|
| NATL | 3D POM GDEM | Always | TDR self-cycled | 75 level | 10 mbar | 18/6/2 kms |
| EPAC | 3D POM RTOFS | Always | TDR self-cycled | 75 level | 10 mbar | 18/6/2 kms |
| CPAC | 3D POM RTOFS | None | None | 75 level | 10 mbar | 18/6/2 kms |
| WPAC | 3D HYCOM | None | None | 61 level | 10 mbar | 18/6/2 kms |
| NIO | 3D HYCOM | None | None | 61 level | 10 mbar | 18/6/2 kms |
| SIO | None | None | None | 43 level | 50 mbar | 18/6/2 kms |
| SPAC | None | None | None | 43 level | 50 mbar | 18/6/2 kms |
| NATL | 3D POM GDEM | Always | TDR self-cycled | 75 level | 10 mbar | **13.5/4.5/1.5 kms** |
| EPAC | 3D POM RTOFS | Always | TDR self-cycled | 75 level | 10 mbar | **13.5/4.5/1.5 kms** |
| CPAC | 3D POM RTOFS | None | None | 75 level | 10 mbar | **13.5/4.5/1.5 kms** |
| WPAC | 3D HYCOM | None | None | **75** level | 10 mbar | **13.5/4.5/1.5 kms** |
| NIO | 3D HYCOM | None | None | **75** level | 10 mbar | **13.5/4.5/1.5 kms** |
| SIO | **3D HYCOM** | None | None | **75** level | **10** mbar | **13.5/4.5/1.5 kms** |
| SPAC | **3D HYCOM** | None | None | **75** level | **10** mbar | **13.5/4.5/1.5 kms** |

# Summary

- Further enhancements suggested for 2018 operational HWRF include:
  - Upgrades in model components consistent with observations, data assimilation improvements including GSI and improved ocean initializations.
- H218 retrospective evaluation of 2015-2017 hurricane seasons (total 941 verifiable cycles in NATL, 1017 in EPAC) demonstrated neutral to improved forecasts compared to FY17 operational HWRF (H217) and significantly improved over the baseline H18B driven by 2017 GFS;
- Results from H218 for the Atlantic basin and the North East Pacific suggested modest improvement compared to H217 for intensity (< 5%) and neutral performance for tracks;
- Results suggest reduction in intensity errors and bias for strong storms (initial intensity > 50 kts) for both (NATl, EPAC) basins;
- Storm size errors and bias were significantly reduced for both basins at all lead times;

# Summary (cont.)

- The one –way coupled WaveWatch III in H218 gives better results for Significant Wave Heights as compared to 2017 operational HWRF;
- Evaluation metrics in the skill space confirmed some positive improvements from H217;
- Horizontal and vertical high resolution, and ensemble based inner-core DA pave way for the planned future Hurricane Analysis and Forecast System (HAFS), while also bringing immediate benefits in the operations;
- Centralized HWRF Development Process for both research and operations with community involvement is critical for making further enhancements;
- Seek more direct engagement of HFIP supported researchers for active participation in model evaluation, enhancements and future R2O;
- **Full credit to the entire EMC Hurricane team, HRD team and DTC team for another successful execution of pre-implementation T&E for implementing improved HWRF model in operations.**

# What it takes in operations to run 2018 HWRF

- Resource requirements:
  - FY18 HWRF H218: 1944 cores or 81 nodes on Cray (increased from 63 nodes for FY17 HWRF but maximum storm slots decreased to 7 from 8, total resource increase 12.5% for HWRF)
  - Run maximum seven storms in all global basins simultaneously.
  - No changes in delivery time (before t+6);

# IT Testing (completed)

| Test Objective | Comment |
|---|---|
| Missing GDAS EnKF members (total 80 mem) | if Nmissing >= 40, hybrid EnKF/GSI<br>else conventional GSI |
| TDR (Tailed Doppler Radar) test | GSI will be done w/wo TDR for D03 |
| Missing ICs from GDAS data | HWRF fails with proper error message |
| Missing BCs from GFS data | HWRF fails with proper error message |
| Missing previous cycle’s 6-hr forecast output | HWRF runs to completion in cold start mode |
| Zero length data files for GSI | Initialization and analysis runs to completion |
| Missing input data files for GSI | Initialization and analysis runs to completion |
| Missing loop current for ocean initialization | POM runs to completion using climatology |
| Failed ocean initialization | HWRF runs in un-coupled mode |
| Tracker fails to identify initial storm location | Swath generator fails with proper error message |
| **Test at least one storm in each basin** | **HWRF runs to completion** |
| Cross dateline and Greenwich test | Make sure HWRF model and scripts properly handle the specially situations. |
| Bugzilla Entries | Addressed |

# Operational Resources for Hurricane Modeling (maximum per storm forecast)

| Operational System | 2017 (nodes/slots) | 2018 (nodes/slots) | Comments |
|---|---|---|---|
| HWRF | 63/8 | 81/7 | Max # of storms decreased by 1 |
| HMON | 26/5 | 26/5 | No change, uses much less resources than HWRF |
| **TOTAL** | **89/13** | **107/12** | Overall **10%** resource increase with 12 slots |

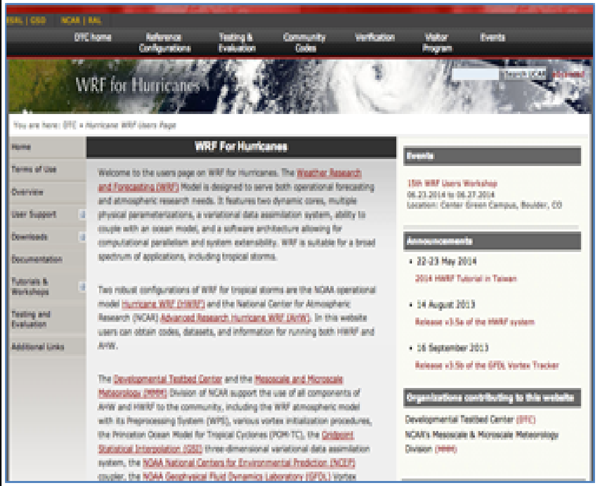
# HWRF as a unique global tropical cyclone model

***Operational Real-time forecast guidance for all global tropical cyclones in support of NHC, JTWC and other US interests across the Asia Pacific, North Indian Ocean and Southern Hemisphere ocean basins***

NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

## Developmental Testbed Center Support

www.dtcenter.org/HurrWRF/users




- Yearly releases, code downloads, datasets, documentation, helpdesk
- 700 registered users
- Stable, tested code
- Benchmarks available
- Support to HWRF developers in code management

**Current release:** HWRF v3.5b (2013 operational with several patches)

**Next:** HWRF v3.6a (2014 operational) 08/2014, concurrent with operational implementation

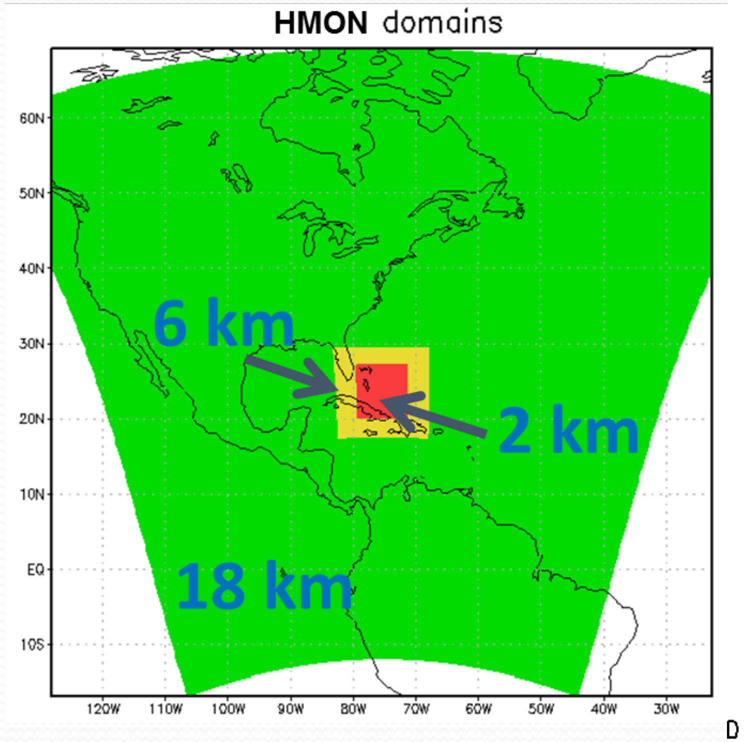
DTC Developmental Testbed Center

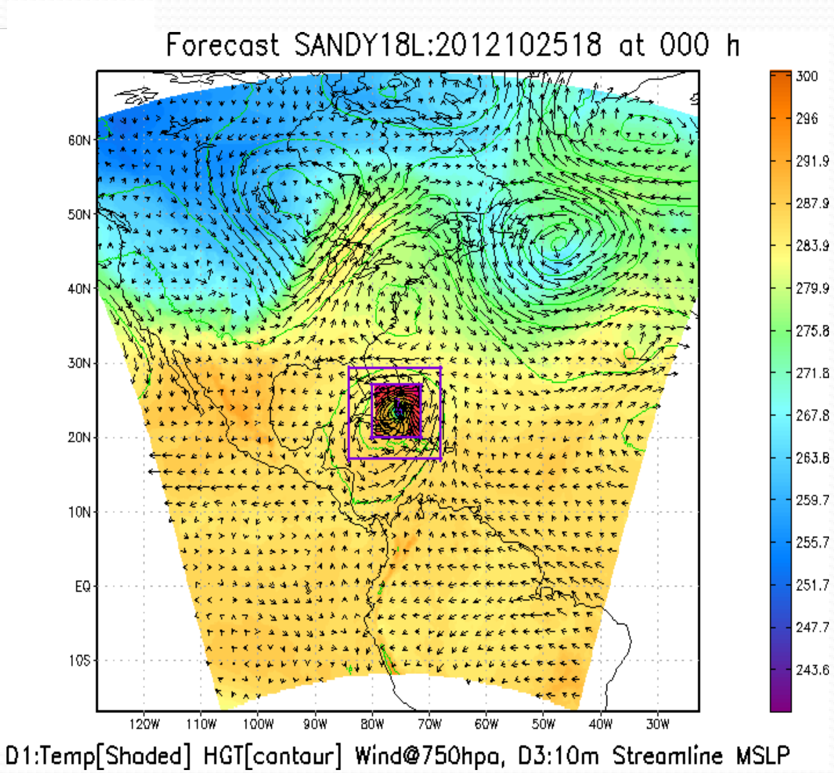
***Continue the community modeling approach for accelerated transition of research to operations***

***International partnerships for accelerated model development & research***

# Proposed 2018 HMON V2.0.0

# HMON: Hurricanes in a Multi-scale Ocean coupled Non-hydrostatic model




**Operational HMON :**
First version implemented in 2017 (by replacing legacy GFDL Hurricane Model)

**HMON:** Implements a long-term strategy at NCEP/EMC for multiple static and moving nests globally, with one- and two-way interaction and coupled to other (ocean, wave, land, surge, inundation, etc.) models using NEMS-NUOPC infrastructure.

# Scope of FY18 HMON Upgrades

## ➢ System & Resolution Enhancements

- Upgrade to the latest NMMB dynamic core with bug fixes
- Increase vertical levels from 42 to 51
- NMMB Dycore optimization (IBM analyst)
- Change diffusion parameterization

## ➢ Initialization/Data Assimilation Improvements

- Updated composite vortex
- Change co-ordinates for VI

## ➢ Physics Advancements

- Use scale-aware SAS scheme
- Update momentum and enthalpy exchange coefficients(Cd/Ch)
- Use GFS-EDMF PBL scheme
- ~~Explore use of MYJ surface layer + MYJ PBL~~

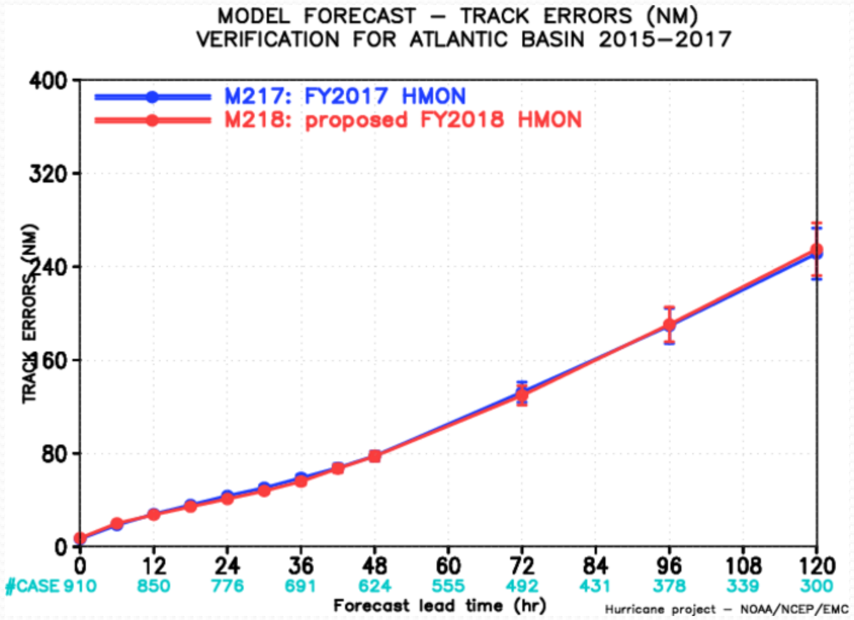
## ➢ Coupling Upgrades

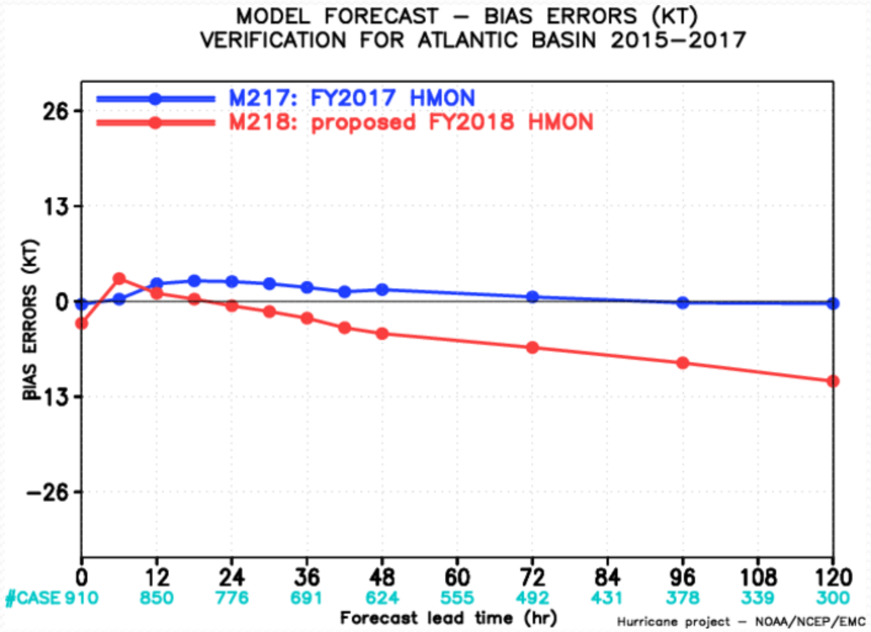
- Add HYCOM coupling in NATL basin
- Use unified HWRF/HMON coupler

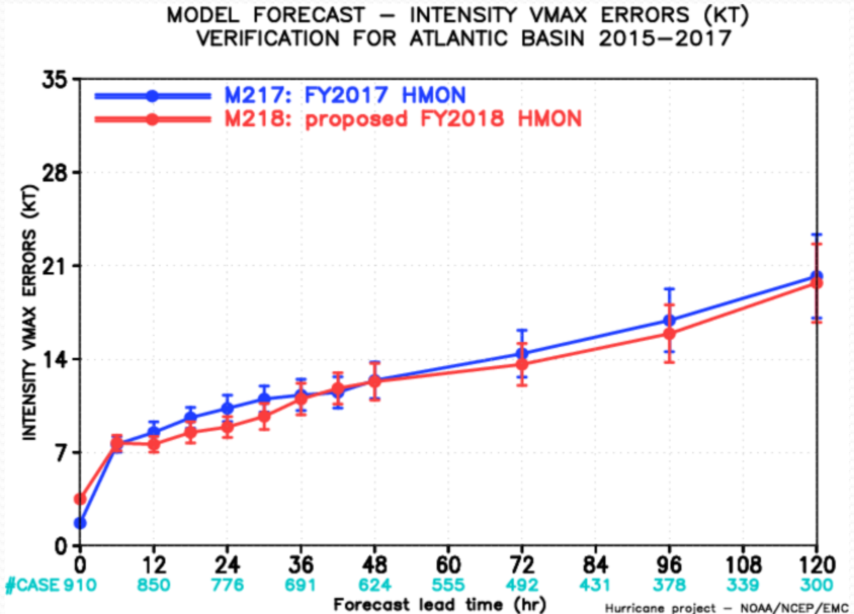
Items in Red: first time in 2018

# HMON (M218) Verification for North Atlantic Storms
# (2015-2017)

# Track and Intensity errors for NATL basin (2015-2017) (Late Model)

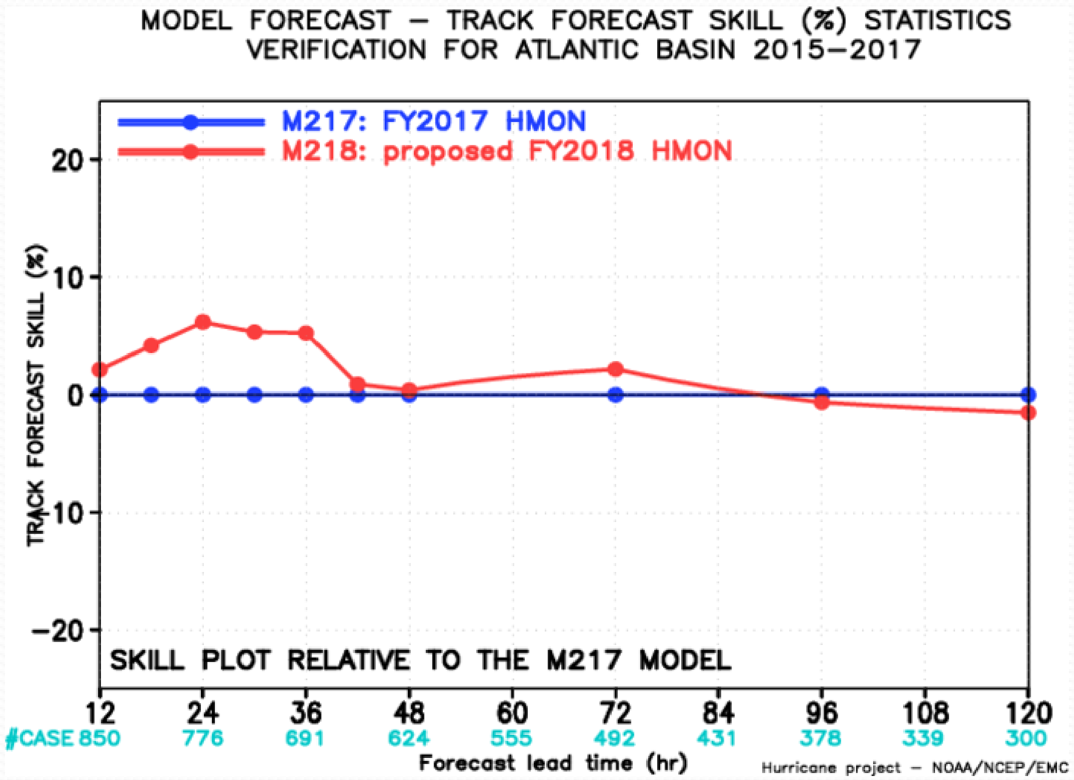


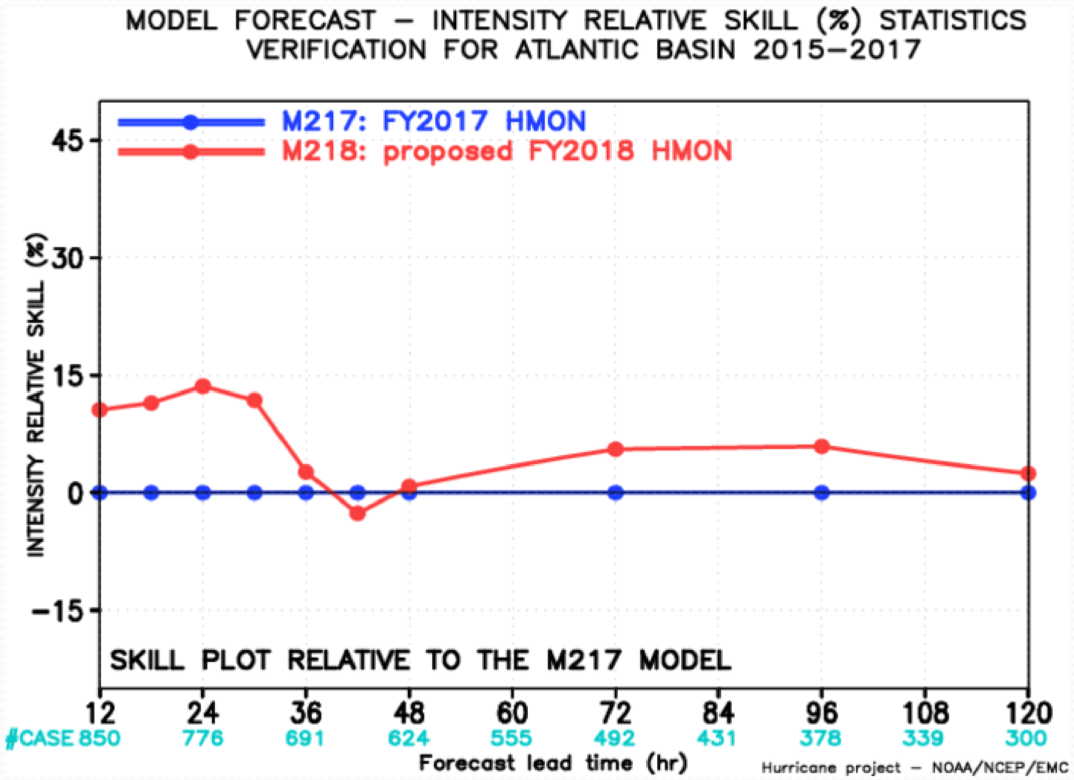




Track errors are very similar to operational FY2017 HMON (M217) but there is a significant improvement in reduction of intensity errors for all lead times. Intensity bias is negative as compared to M217 because of active ocean coupling introduced for M218.

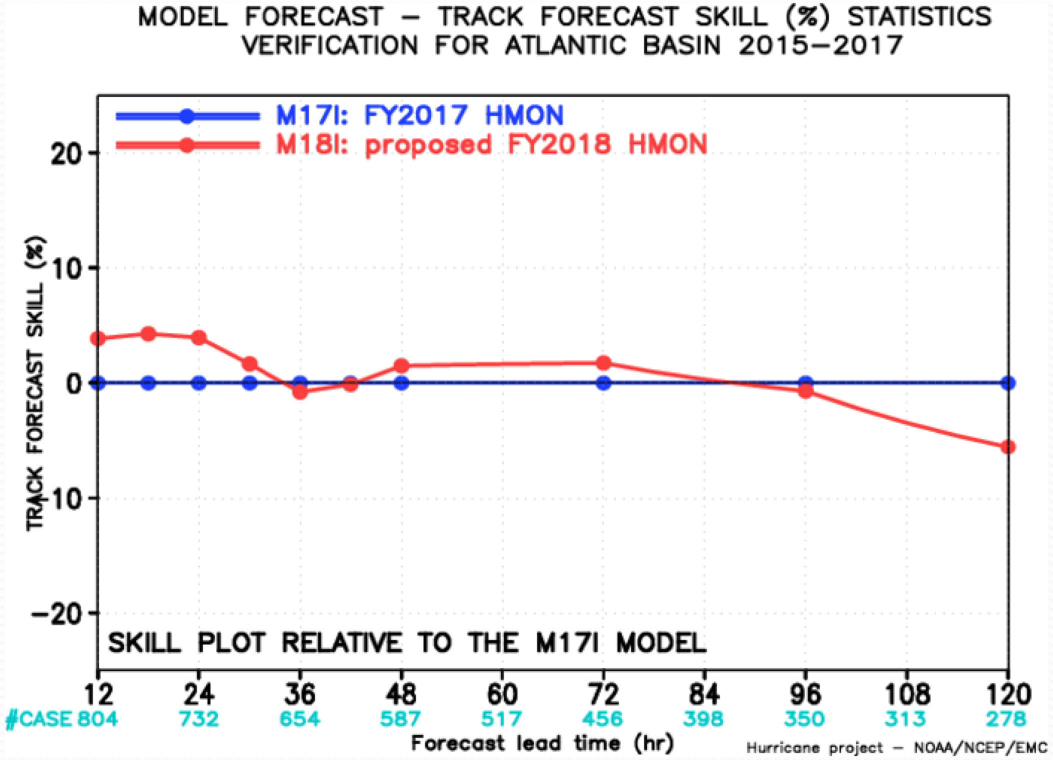
# Track and Intensity skill for NATL basin (2015-2017)
# (Late Model)

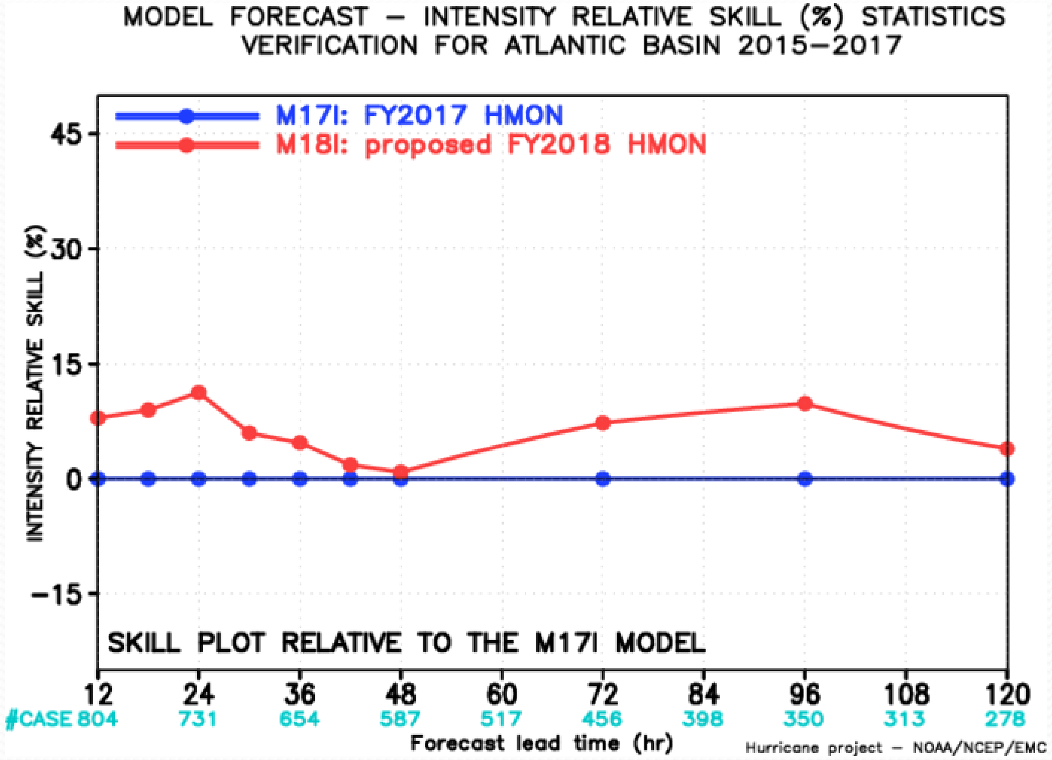



There is improvement in track skill for the early lead times of around 6% (at hr 24) while it is mostly neutral beyond day 2. Intensity skill improvements are significant at early lead times (~ 15%) and then again for late lead times at Days 3 and 4 of about 6-7%.

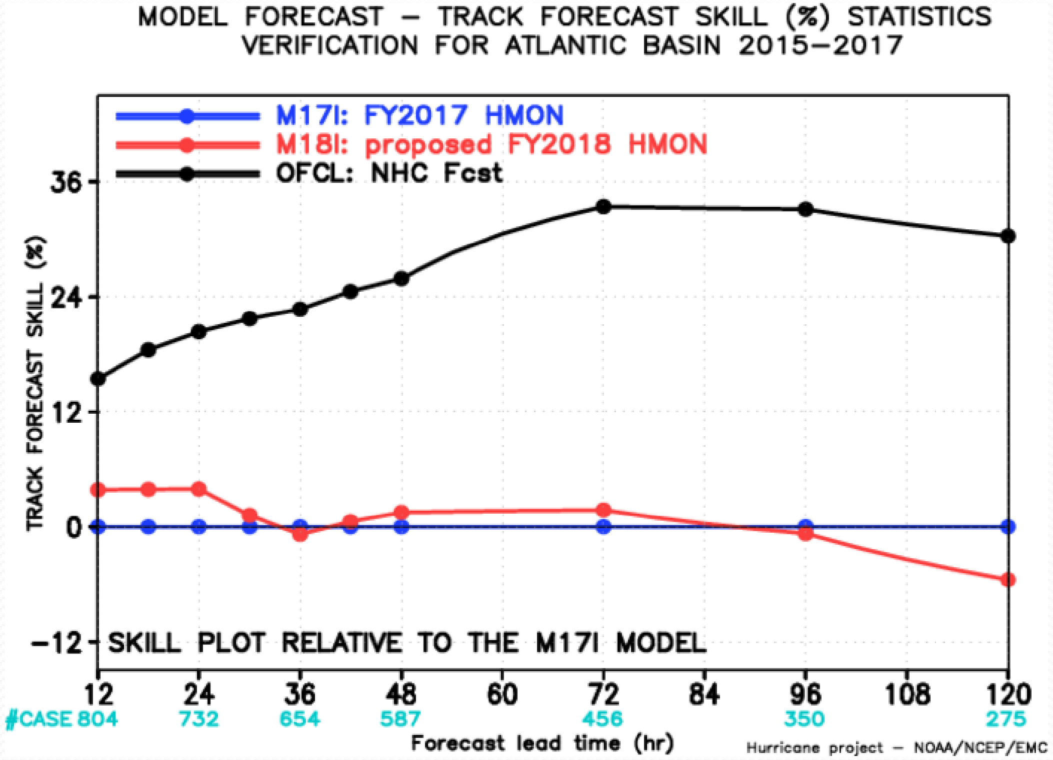
# Track and Intensity skill for NATL basin (2015-2017) (Early Model)

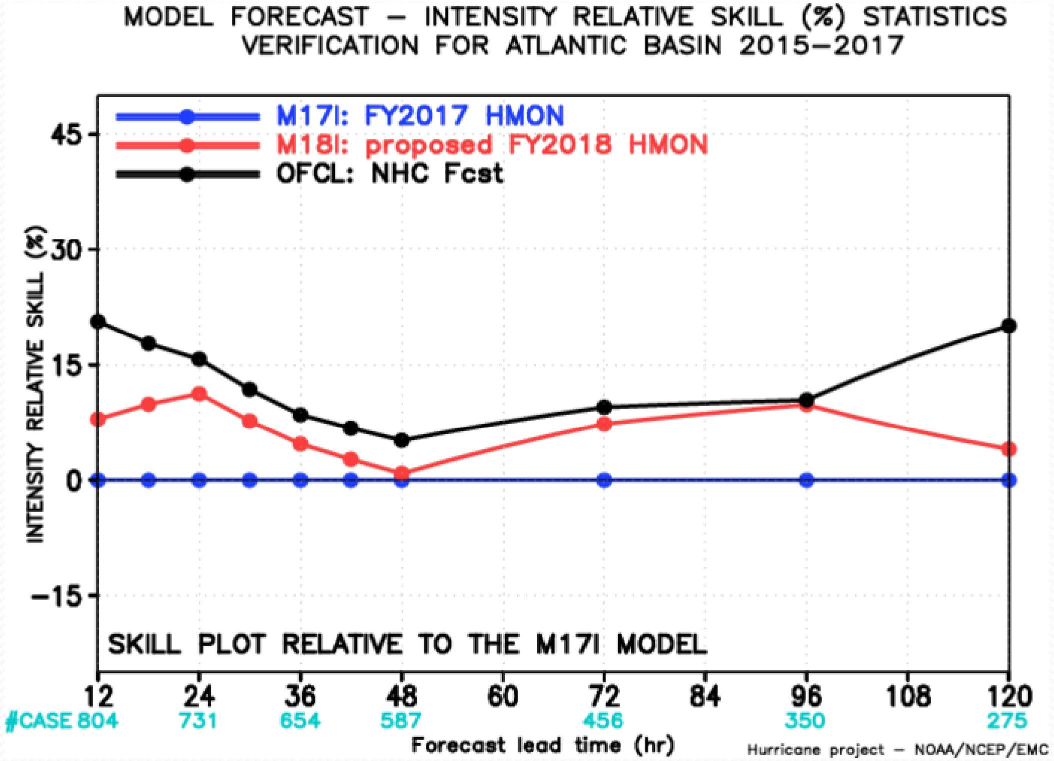



There is improvement in track skill for the early lead times of around 5% (at hr 24) while it is mostly neutral beyond day 2 with some degradation at Day 5 . Intensity skill improvements are significant at early lead times ( > 10%) and then again for late lead times at Days 3 and 4 of about 10%.

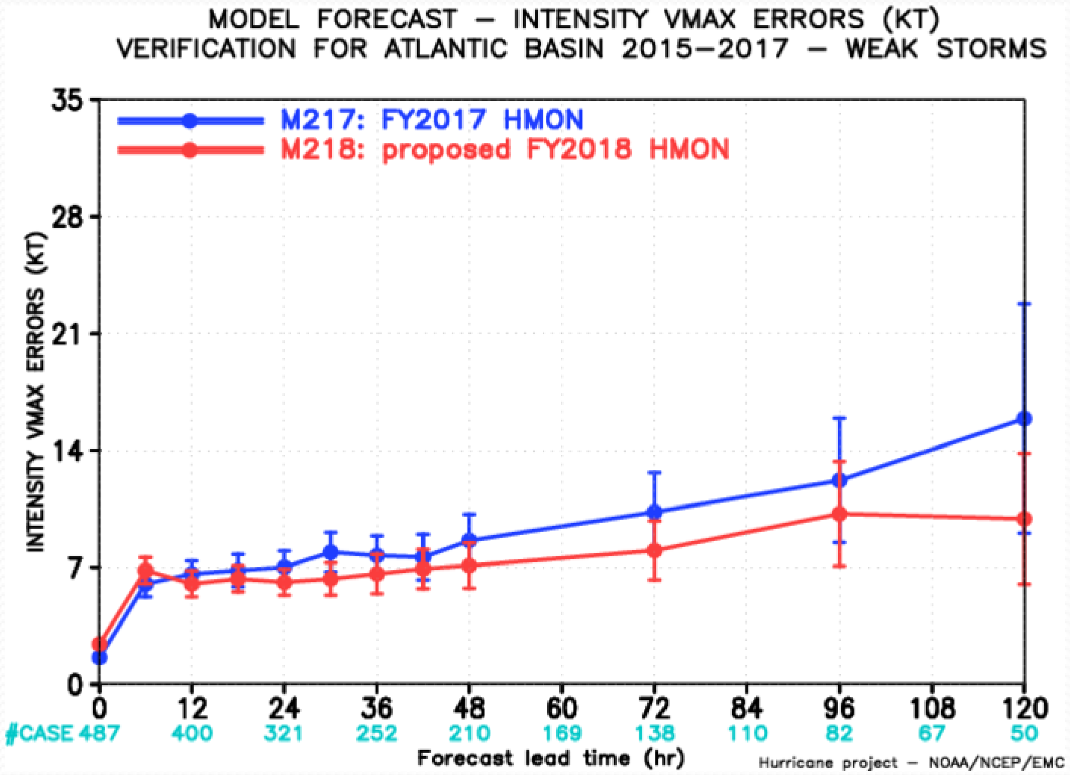
# Track and Intensity skill for NATL basin (2015-2017)
# (Early Model)

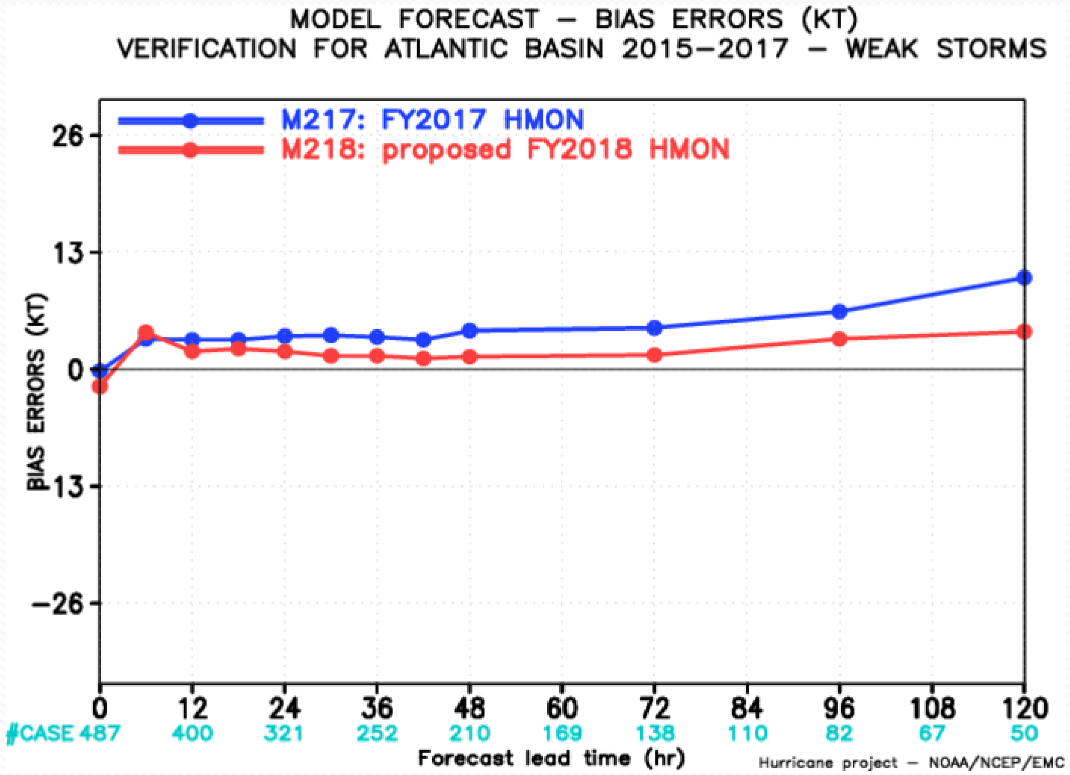



Improvements in track and intensity skill as compared to the official skill over the FY2017 HMON.

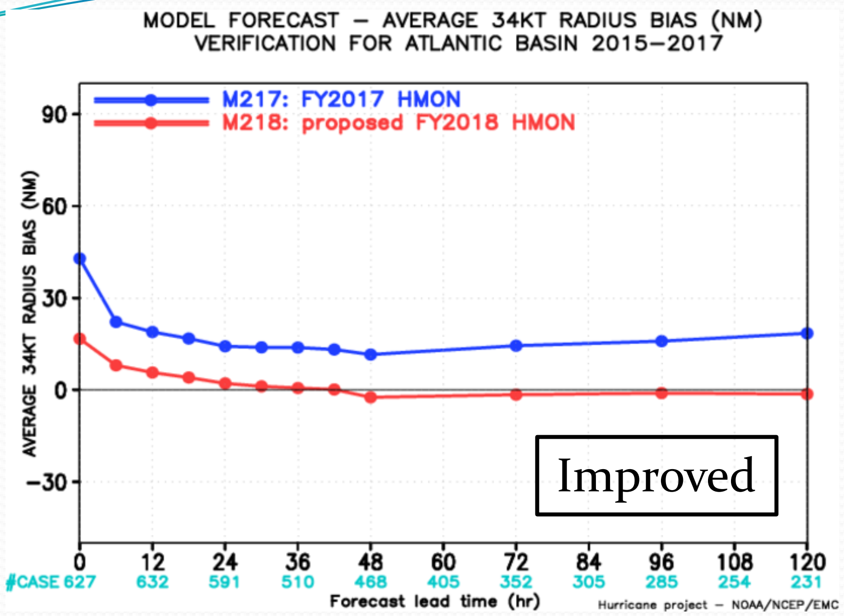
# Intensity skill improvements for NATL basin (2015-2017)
# (Weak Storms < 50 kt)

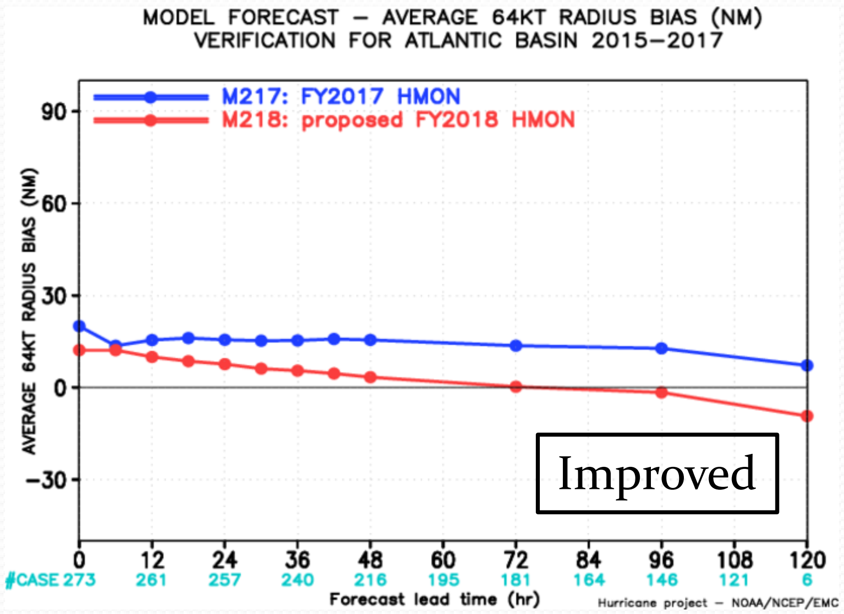


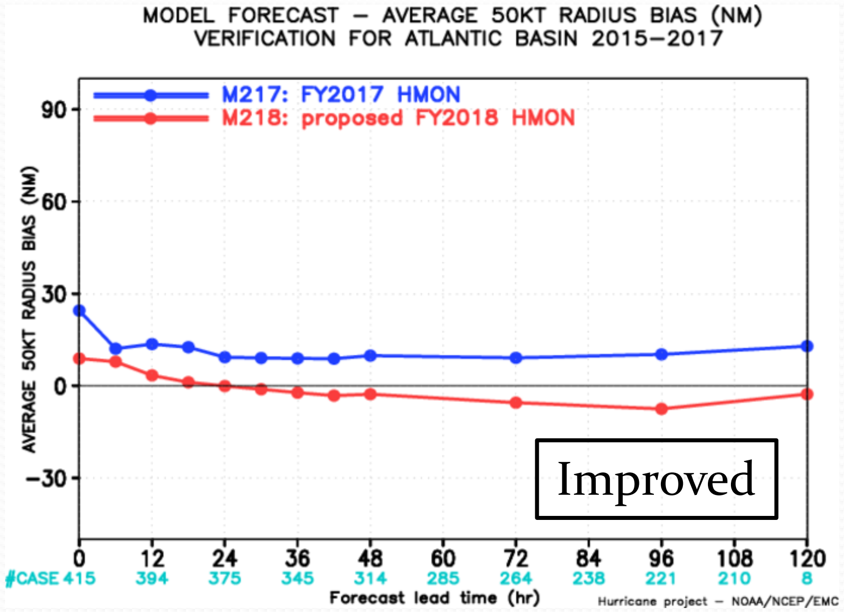



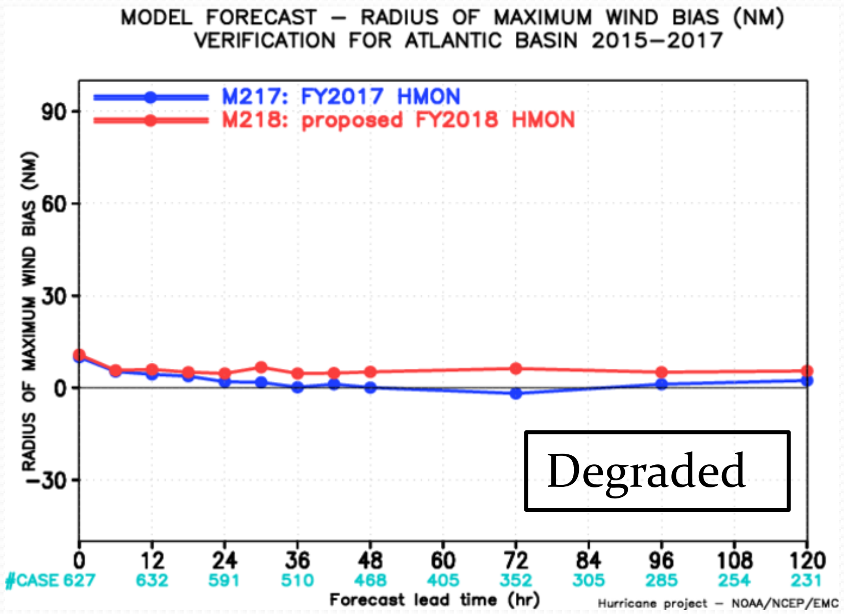

Both intensity errors and bias errors are significantly reduced for M218 for weak storms at all lead times as compared to M217 for the NATL basin.

# Storm Size Errors for NATL basin (2015-2017)



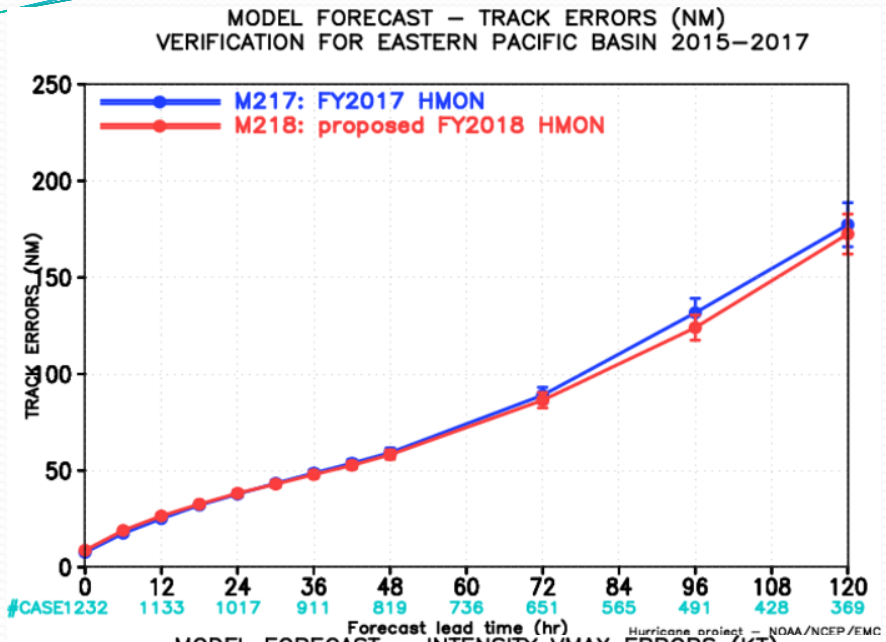



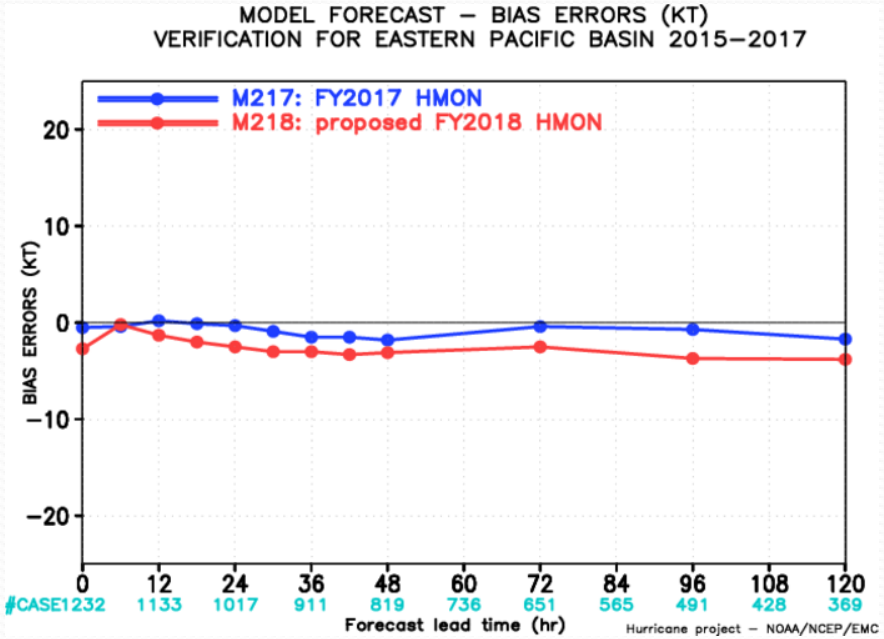



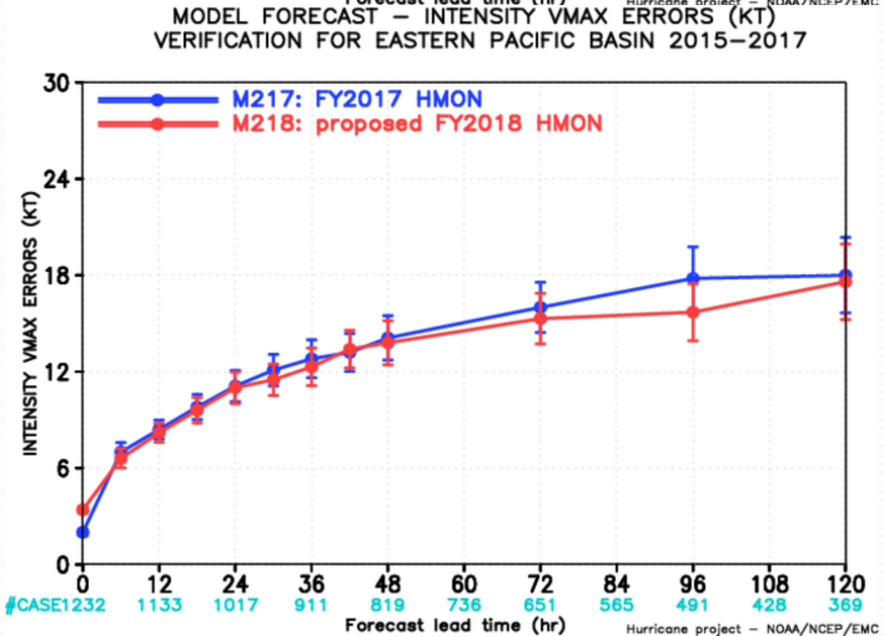



## HMON (M218) Verification for East Pacific Storms (2015-2017)

# Track and Intensity errors for EPAC basin (2015-2017) (Late Model)



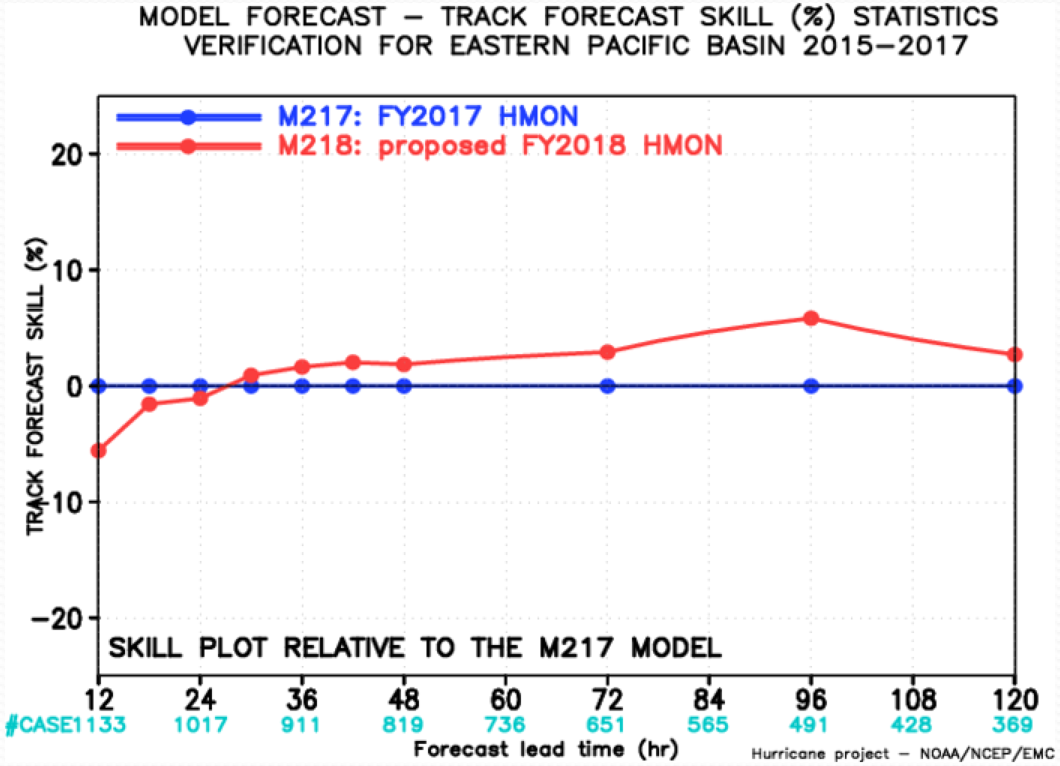



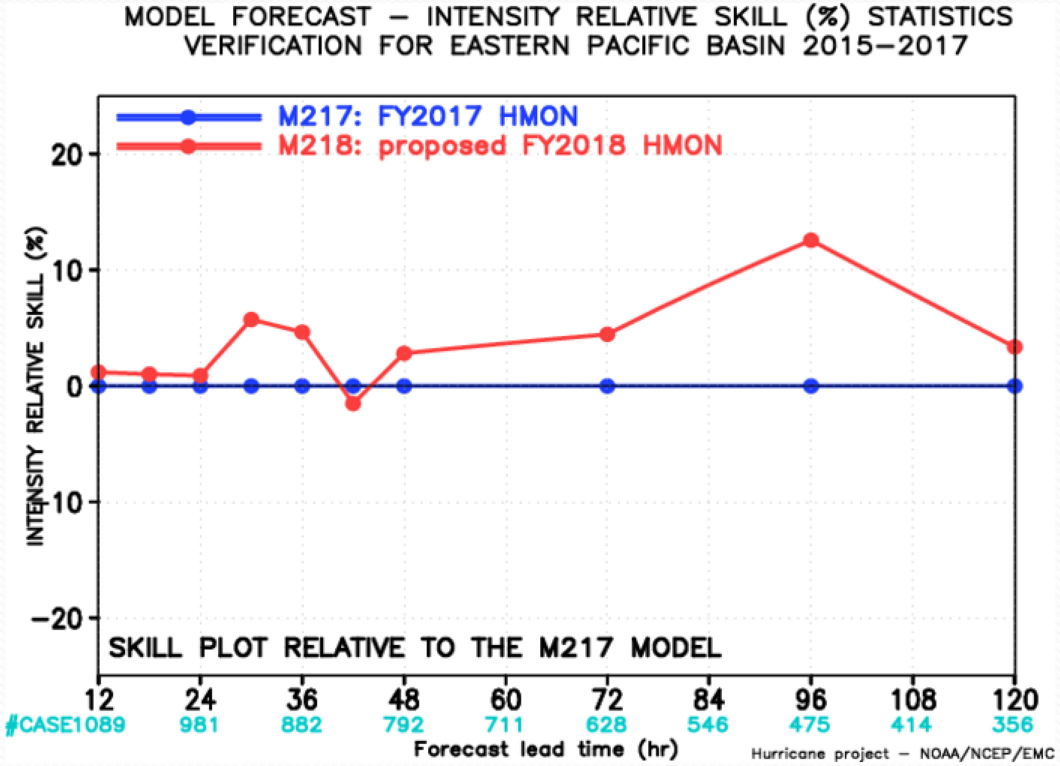




Both track and intensity errors are significantly reduced as compared to operational FY2017 HMON (M217) especially for late lead times.

Intensity bias is negative as compared to M217 but less than that for NATL basin.

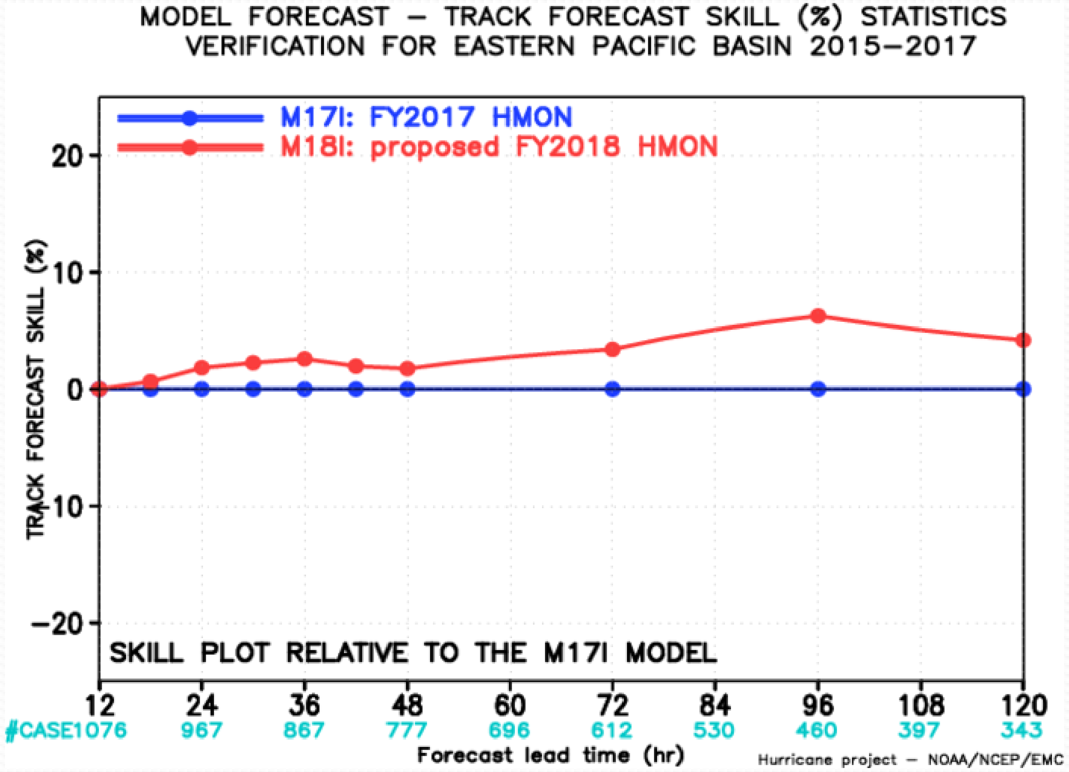
# Track and Intensity skill for EPAC basin (2015-2017)
# (Late Model)

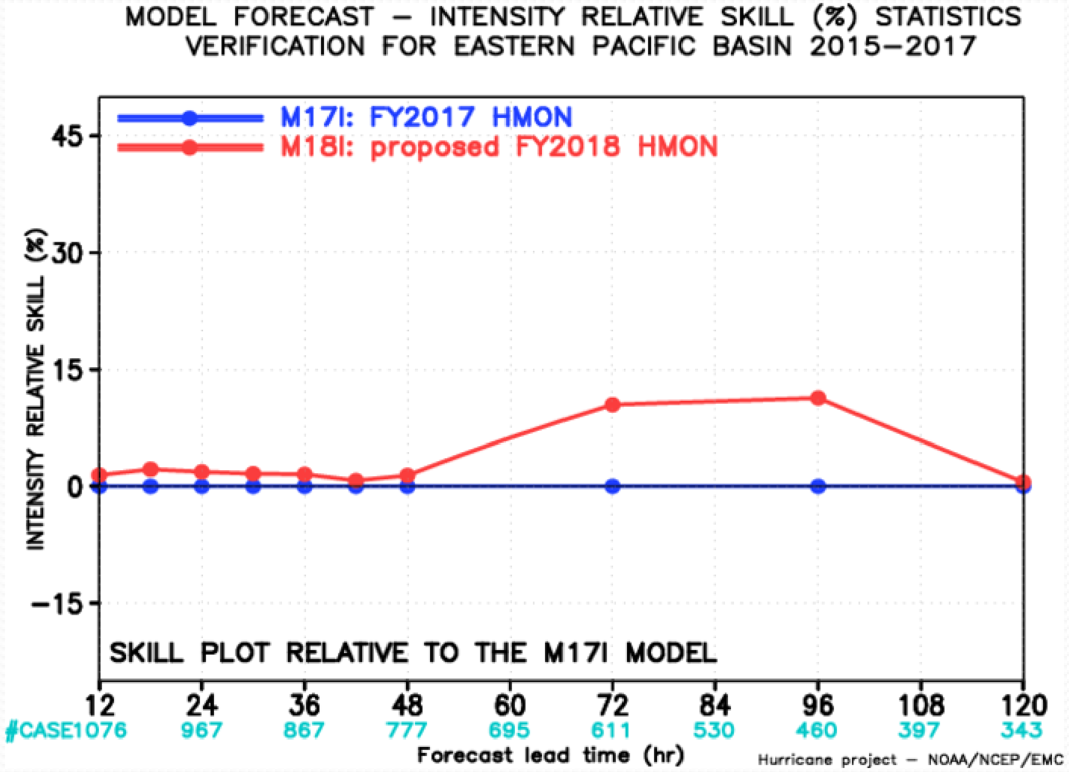



Other than for the first 24 hrs, there is improvement in track skill for all lead times which reaches around 7% at Day 4. We also find intensity skill improvements at all lead times after Day 1 with improvements peaking at day 4 (> 10%).

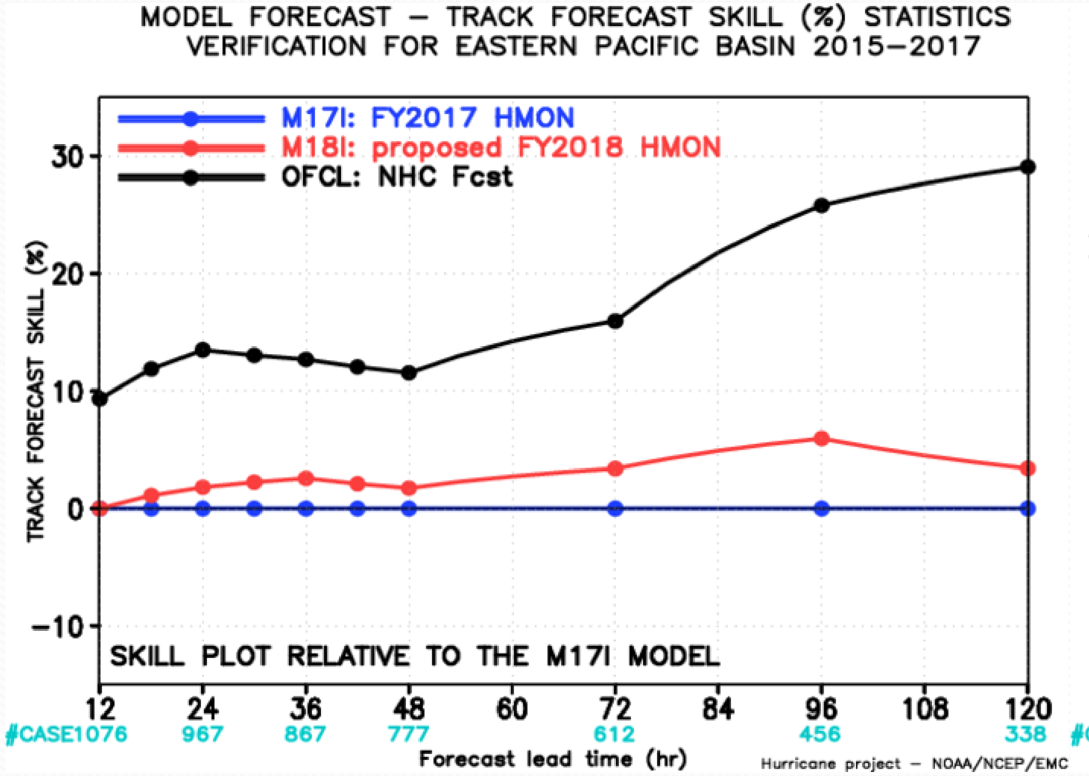
# Track and Intensity skill for EPAC basin (2015-2017)
# (Early Model)

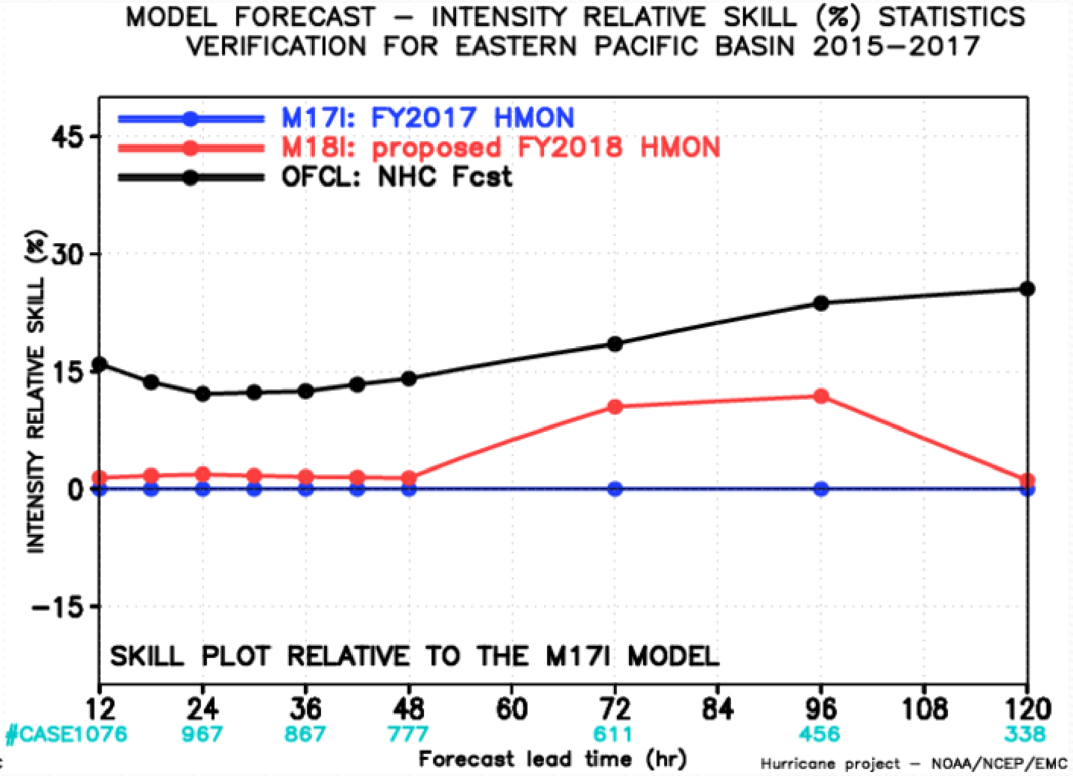



There is improvement in track skill for all lead times which reaches around 7% at Day 4. We also find intensity skill improvements at all lead times, marginal till Day 2 and significant at Days 3 and 4 ( > 10%).

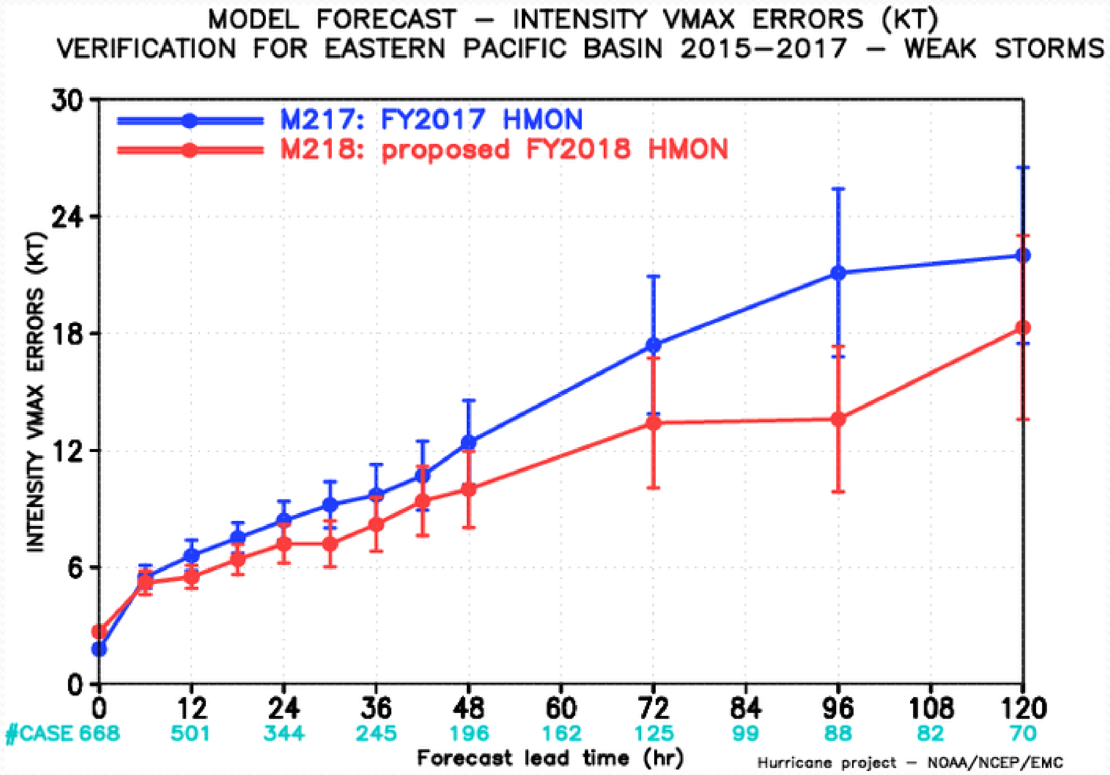
# Track and Intensity skill for EPAC basin (2015-2017)
# (Early Model)

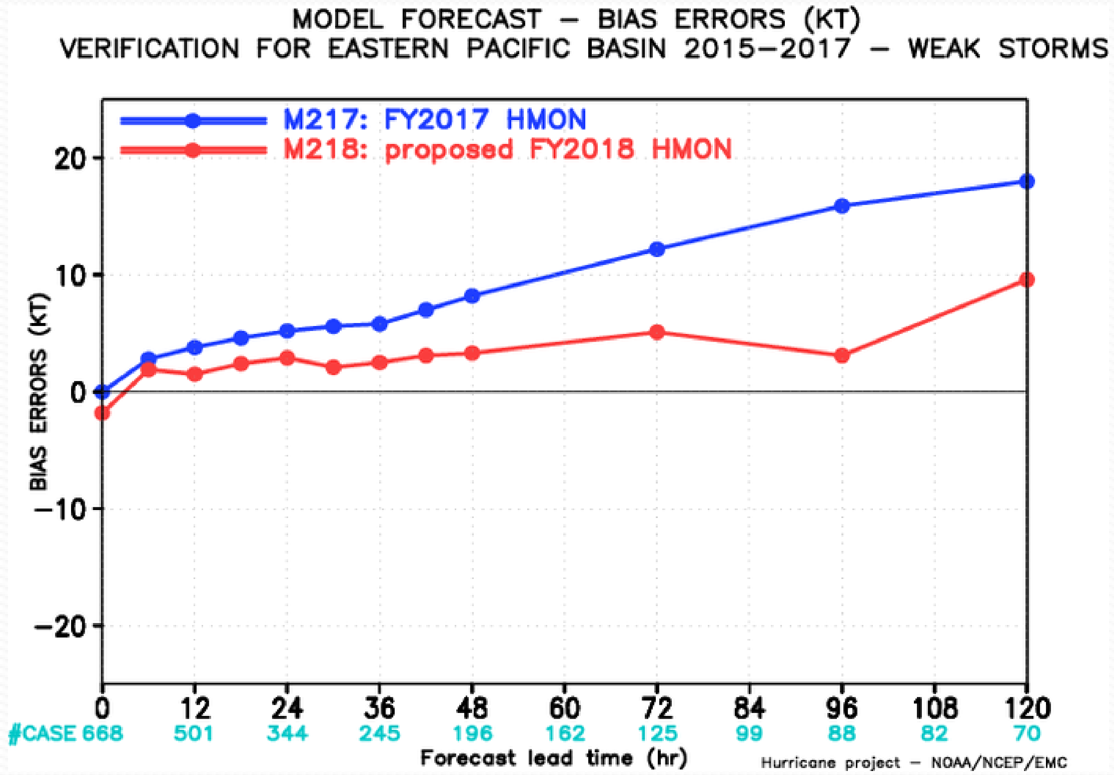



Improvements in track and intensity skill as compared to the official forecasts over the operational FY17 HMON.

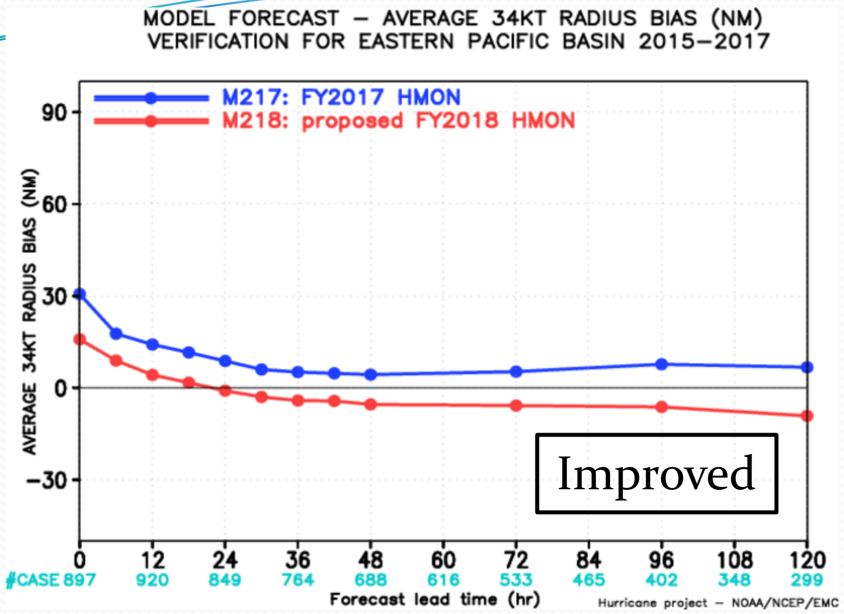
# Intensity skill improvements for EPAC basin (2015-2017) (Weak Storms < 50 kt)

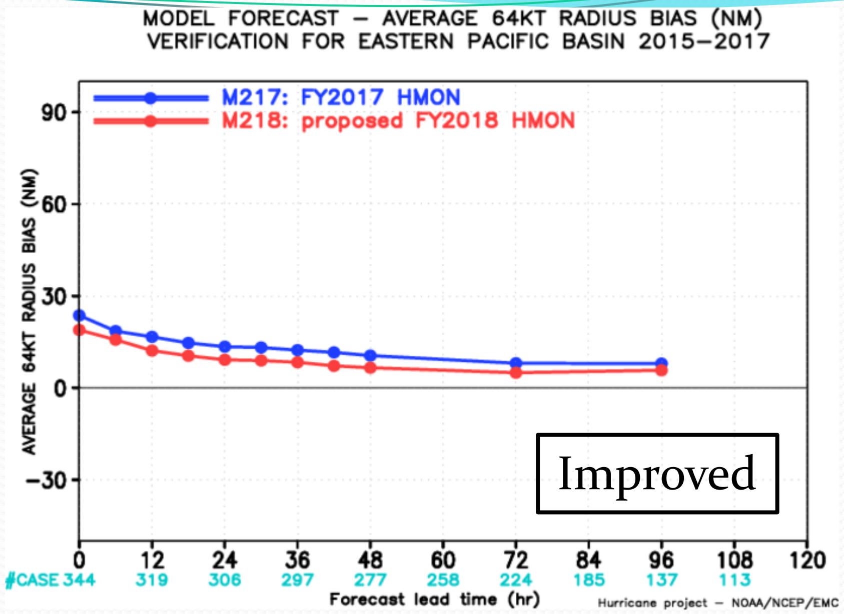


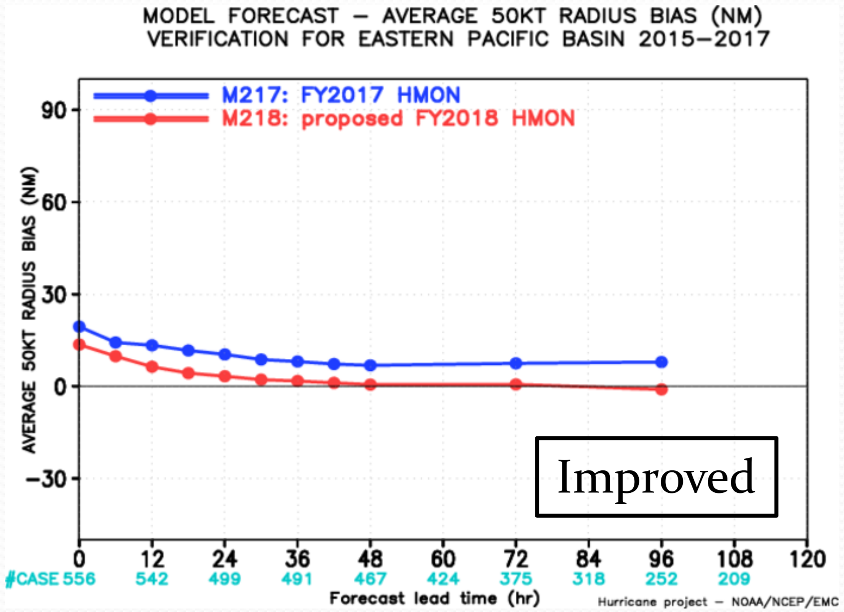



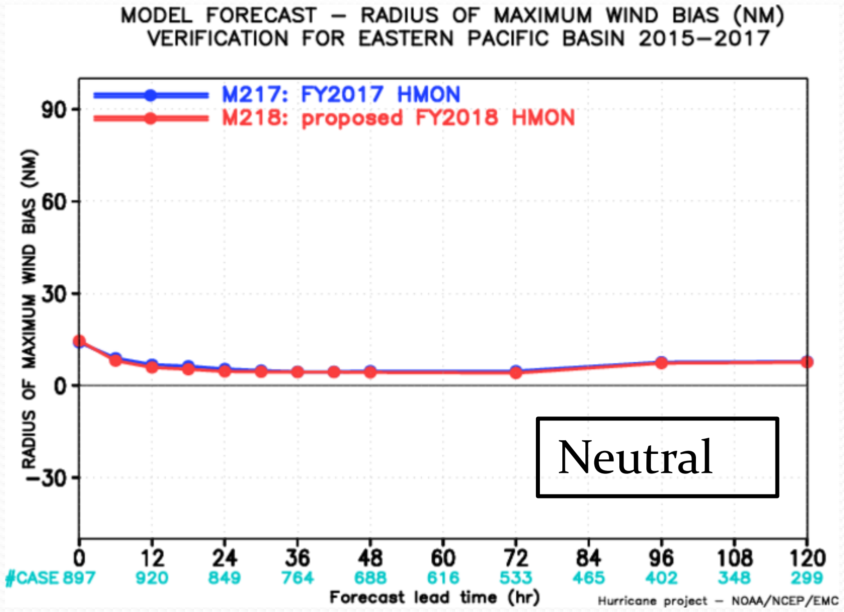

Both intensity errors and bias errors are also significantly reduced for M218 for weak storms for all lead times as compared to M217 for the EPAC basin.

# Storm Size Errors for EPAC basin (2015-2017)



# FY2018 HWRF/HMON configurations maintain diversity

Note: Items in Red are different

| | HWRF | HMON |
|---|---|---|
| Dynamic core | Non-hydrostatic, NMM-E | Non-hydrostatic, NMM-B |
| Nesting | 13.5/4.5/1.5 km; 77°/18°/6°; 75 vertical levels; Full two-way moving | 18/6/2 km; 75°/12°/8°; 51 vertical levels; Full two-way moving |
| Data Assimilation and Initialization | Vortex relocation & adjustment, Self-cycled hybrid EnKF-GSI with inner core DA (TDR) | Modified vortex relocation & adjustment, no DA |
| Physics | Updated surface (GFDL), GFS-EDMF PBL, Updated Scale-aware SAS, NOAH LSM, Modified RRTM, Ferrier | Surface (GFDL), GFS-EDMF PBL, Scale-aware SAS, NOAH LSM, RRTM, Ferrier |
| Coupling | MPIPOM/HYCOM, RTOFS/GDEM, WaveWatch-III | HYCOM, RTOFS/NCODA, No waves |
| Post-processing | NHC interpolation method, Updated GFDL tracker | NHC interpolation method, GFDL tracker |
| NEMS/NUOPC | No | Yes with moving nests |
| Computation cost for forecast job | 81 nodes in 98 mins | 26 nodes in 95 mins |

# What it takes in operations to run 2018 HMON
# (no change from 2017 operational HMON)

- Resource requirements:
  - FY18 HMON M218:  624 cores or 26 nodes on Cray
  - Run maximum five storms for 3 basins (NATL, EPAC and CPAC) simultaneously.
  - Delivery times same as HWRF (before t+6);

# IT Testing (completed)

| Test Objective | Comment |
|---|---|
| Missing ICs from GFS data | HMON fails with proper error message |
| Missing BCs from GFS data | HMON fails with proper error message |
| Missing previous cycle's 6-hr forecast output | HMON runs to completion in cold start mode |
| Failed HYCOM initialization | HMON runs in un-coupled mode |
| Tracker fails to identify initial storm location | HMON fails with proper error message |
| Test at least one storm in AL and EP basins | HMON runs to completion |
| Cross dateline and Greenwich test | Make sure HMON model and scripts properly handle the specially situations. |

# Next Steps

1. Retrospective T&E at EMC: **April 3, 2018 --- Completed**
2. Results shared with NHC: **April 4, 2018 ----- Completed**
3. NHC Evaluation: **April 5, 2018 -- Completed**
4. Briefing to EMC Director: **April 9, 2018 --- Now Completed**
5. Briefing to NCEP Director's Office: **April 12, 2018 (scheduled)**
6. Submission of Codes to NCO: ***April 13, 2018 --- Code hand-off, submission of RFC forms, release notes and flow diagram***
7. TIN for 2017 HWRF : ***May 7, 2018***
8. NCO IT Testing completed: ***June, 2018***
9. Briefing to NCEP Director's Office: ***June 20, 2018 (tentative)***
10. Implementation by NCO: ***June 26, 2018 (tentative)***