Plans for Operational Hurricane Modeling at NCEP/EMC in FY17

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Environmental Modeling Center

NOAA / NWS / NCEP

NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

Outline

- 2017 HWRF Baseline configuration
- Preliminary HWRF Baseline test results
- HWRF upgrades and results
- 2017 HMON configuration and preliminary results
- Current and future plans

FY17 HWRF v11.0.0
Implementation plans

FY17 HWRF Baseline Configuration

➢ System & Resolution Enhancements

- T&E with new 2017 NEMS GFS IC/BC
- Upgrade dynamic core from WRF3.7.a to WRF3.8 (with multiple bug fixes)
- Consider storm's meridional movement when determining parent domain center
- Reduce coupling time step from 9min to 6 min for both waves and ocean
- Increase vertical resolution from 24 to 40 levels for POM with reduced time step
- New Tracker (from GFDL)
- Increase vertical resolution to 75 vertical levels and 10-hPa top, with adjusted domain sizes for d02 (256 x 472) and d03 (256 x 472) (H216: 288 x 576)

➢ Initialization/Data Assimilation Improvements

- Improve vortex initialization (new composite storm vortex)
- GSI code upgrades; new data sets for GSI (hourly shortwave, clear air water vapor and visible AMV's, GH changes, G –IV TDR data)
- Fully Cycled EnKF two-way hybrid DA when TDR data is available
- Change in blending threshold (to 65 Kt)
- HDOBS data assimilation

-- Green: **Included in Baseline**

-- Orange: **Tested Separately**

FY17 HWRF Baseline Configuration

➢ Physics Advancements

- Bug fix for 10 meter wind (already in HWRFV3.8a)
- Update F-A Microphysics
- Updates to scale-aware SAS
- Updates to RRTMG (partial cloudiness)
- Update convection with G-F cumulus scheme

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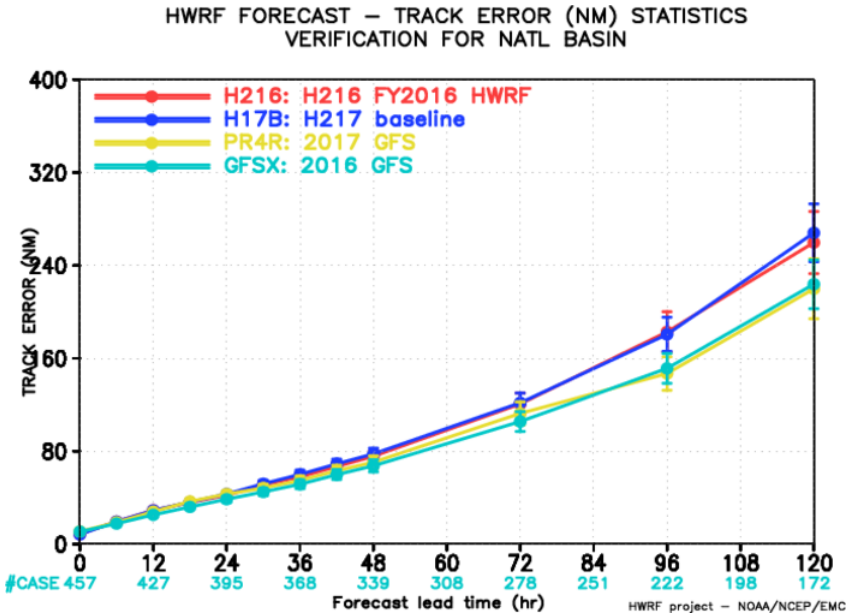
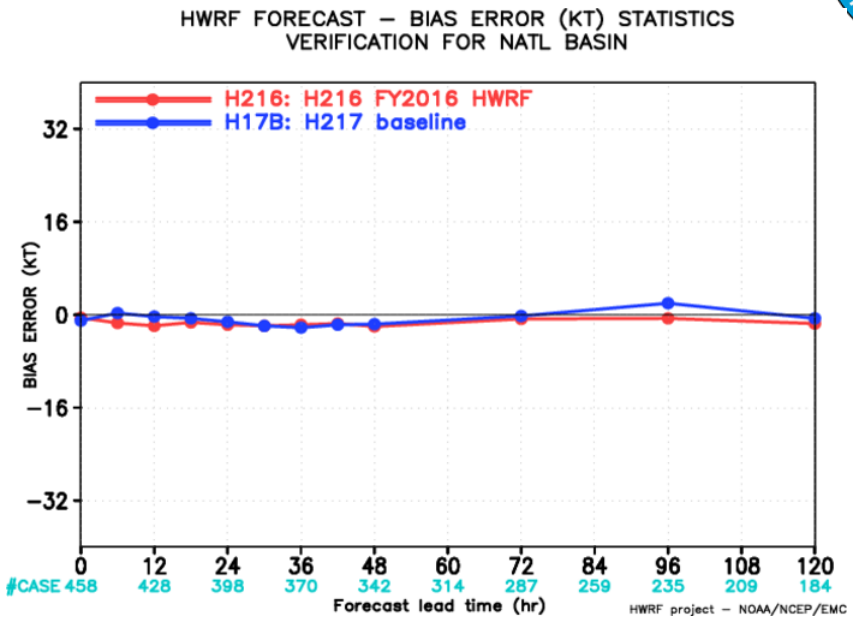
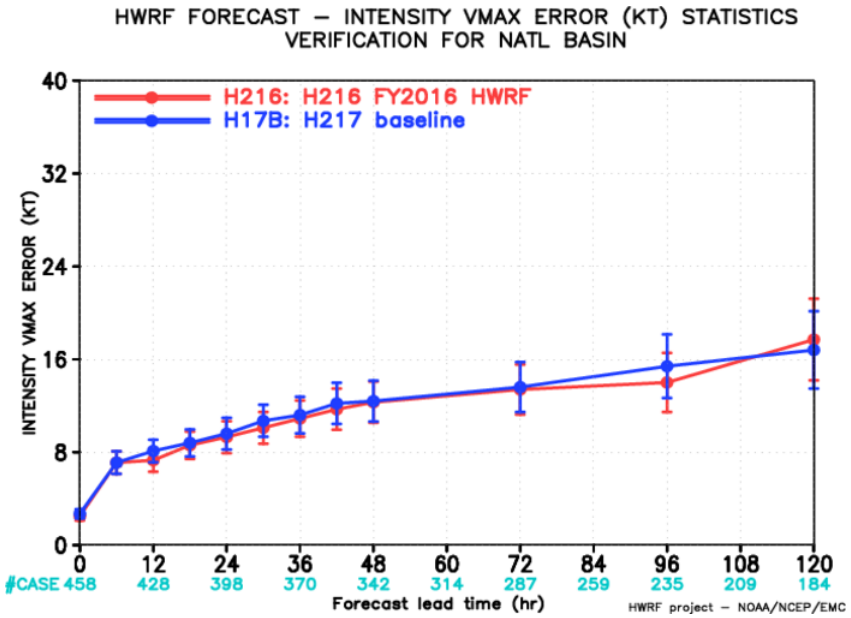
2017 HWRF Baseline Performance: North Atlantic Basin

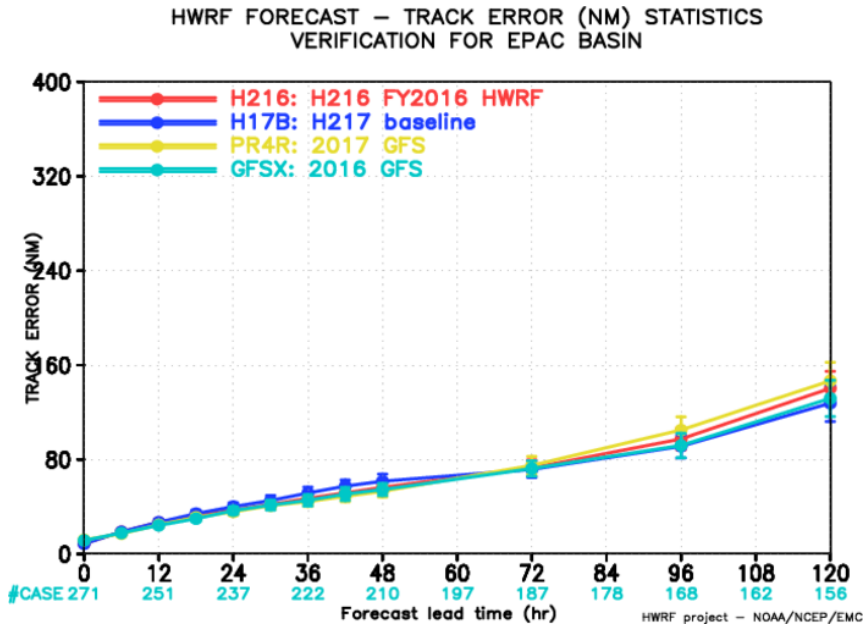


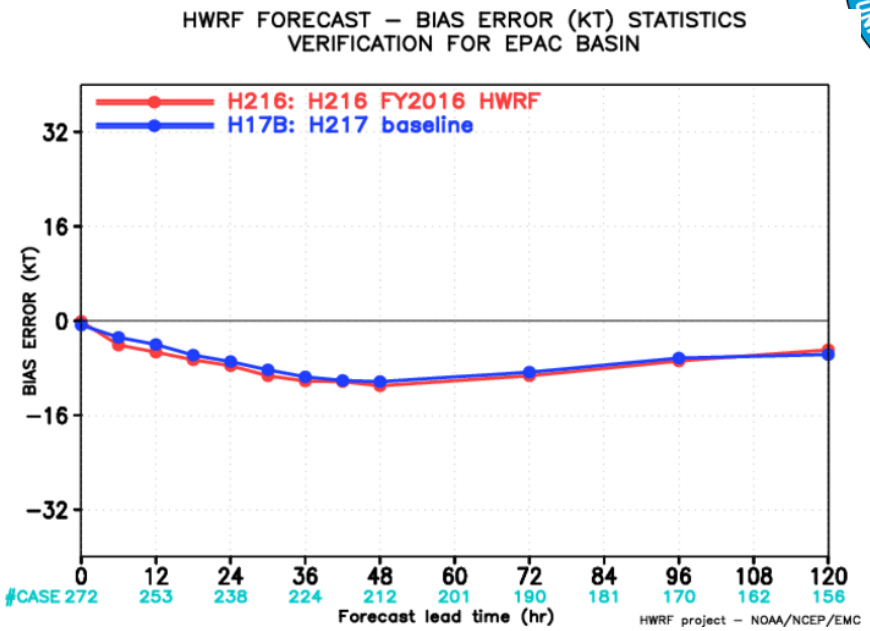


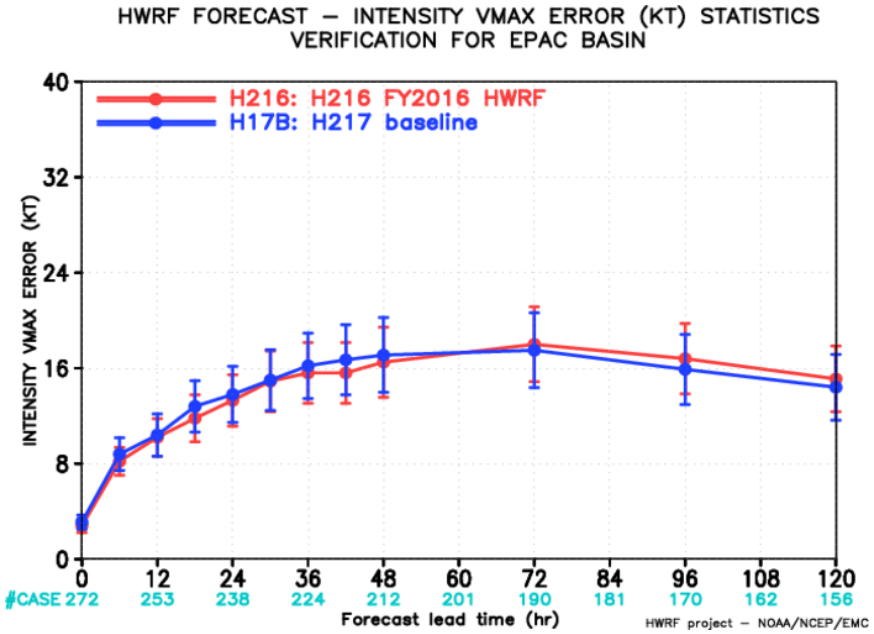


- 2017 HWRF baseline experiments are mostly neutral in the North Atlantic basin as compared to H216 for track, intensity and bias.
- Track errors are larger as compared to GFS (both 2016 and 2017) for long-lead times.

2017 HWRF Baseline Performance: North East Pacific Basin







- 2017 HWRF baseline performance remains neutral for East Pacific basin as well.
- Early lead-time are slightly negative while longer-lead times are positive for both track and intensity.

FY17 HWRF Initialization/Data Assimilation Improvements

- Improve vortex initialization (new composite storm vortex)
- GSI code upgrades; new data sets for GSI (hourly shortwave, clear air water vapor and visible AMV's, GH changes, G –IV TDR data)

- Fully Cycled EnKF two-way hybrid DA when TDR data is available
- Change in blending threshold (to 65 Kt)
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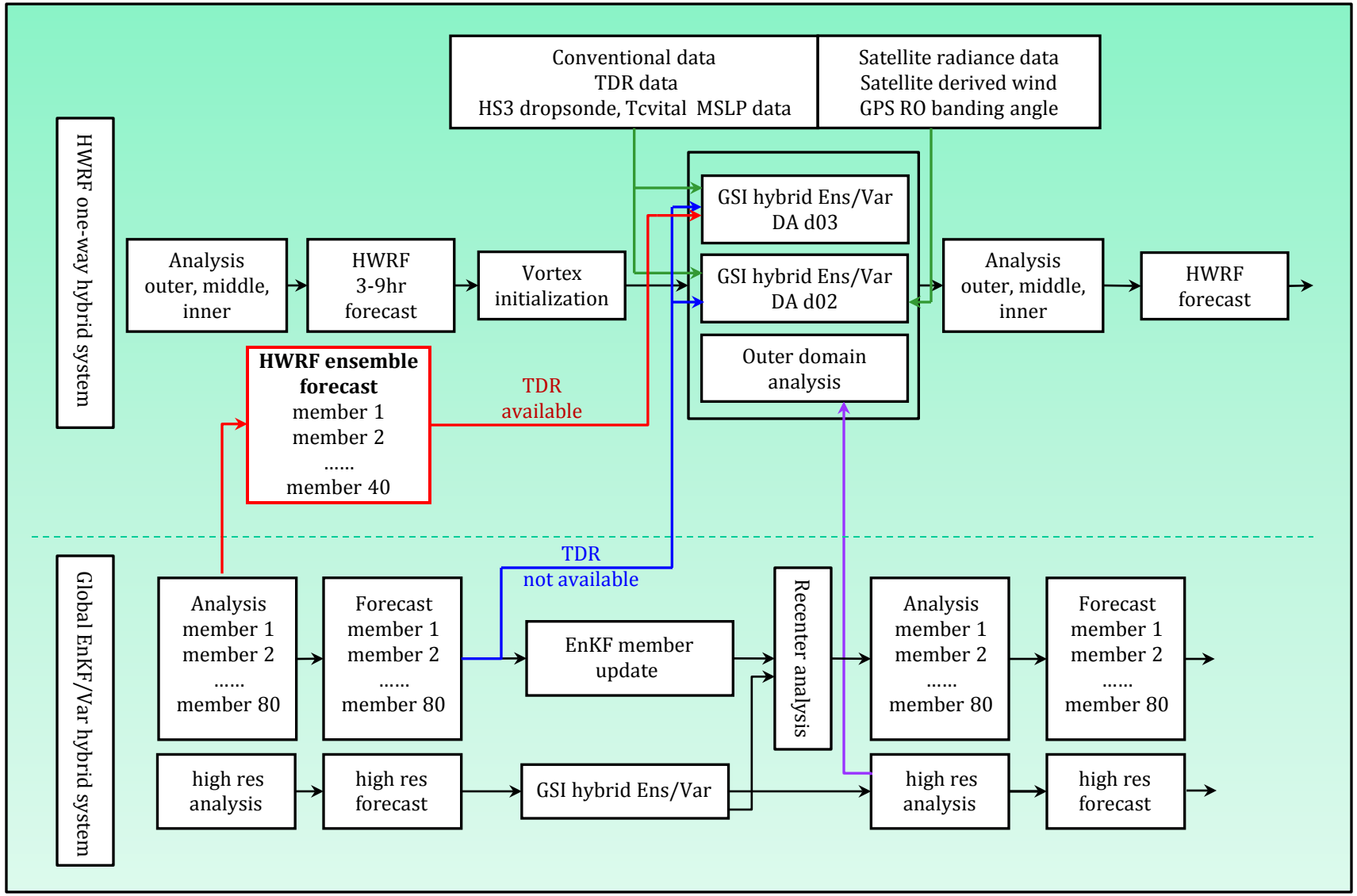
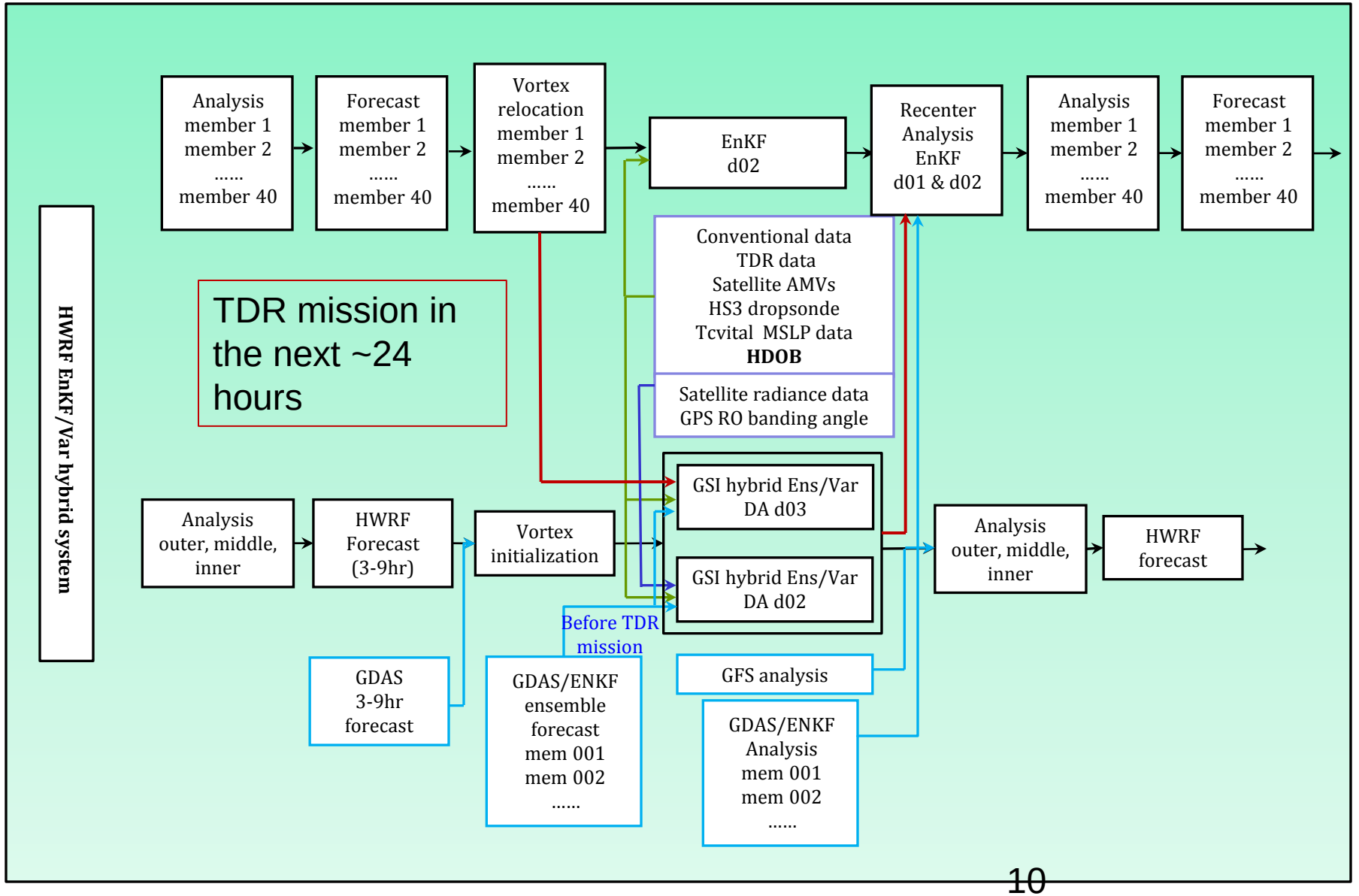
2016 HWRF Hybrid Data Assimilation System

Warm-start HWRF ensemble when TDR available

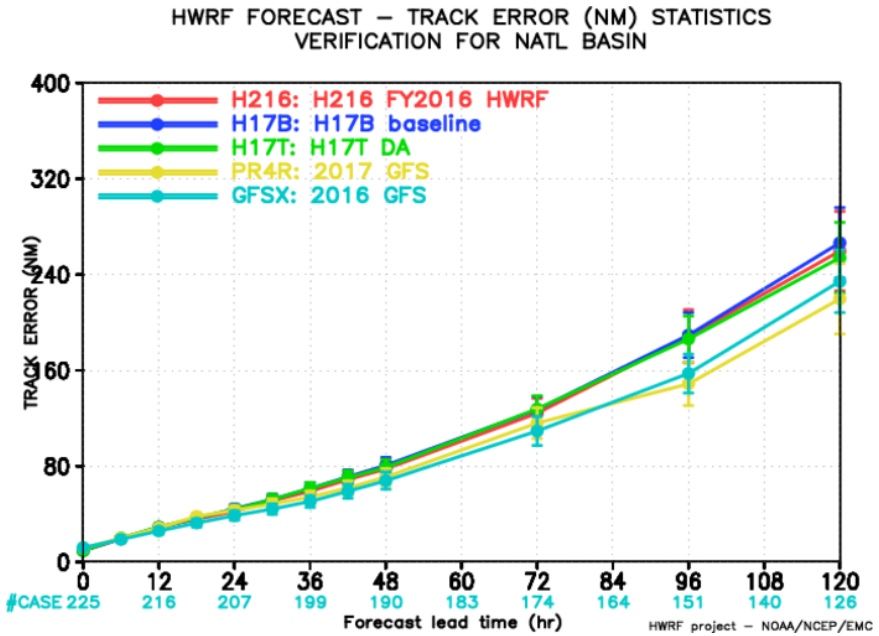


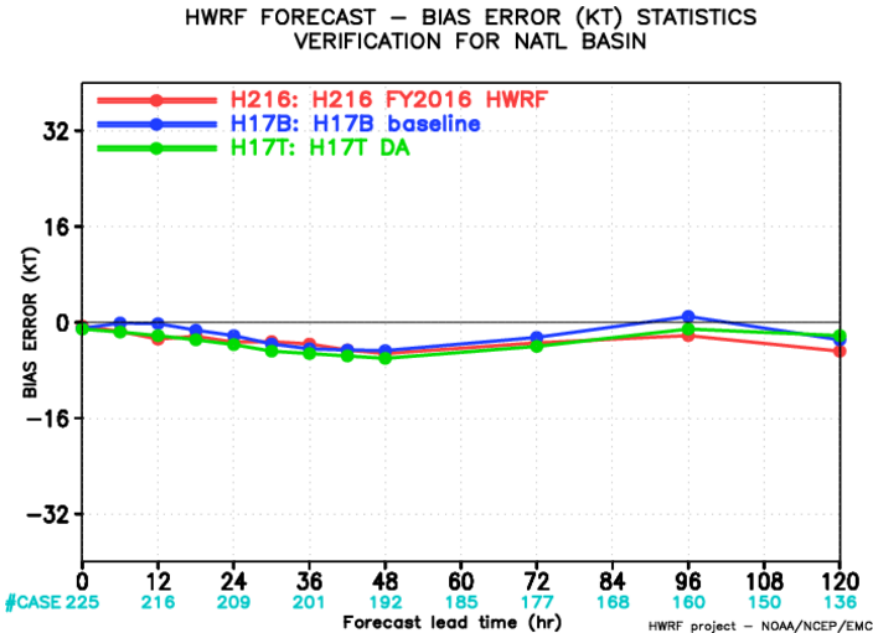
2017 HWRF Hybrid Data Assimilation System

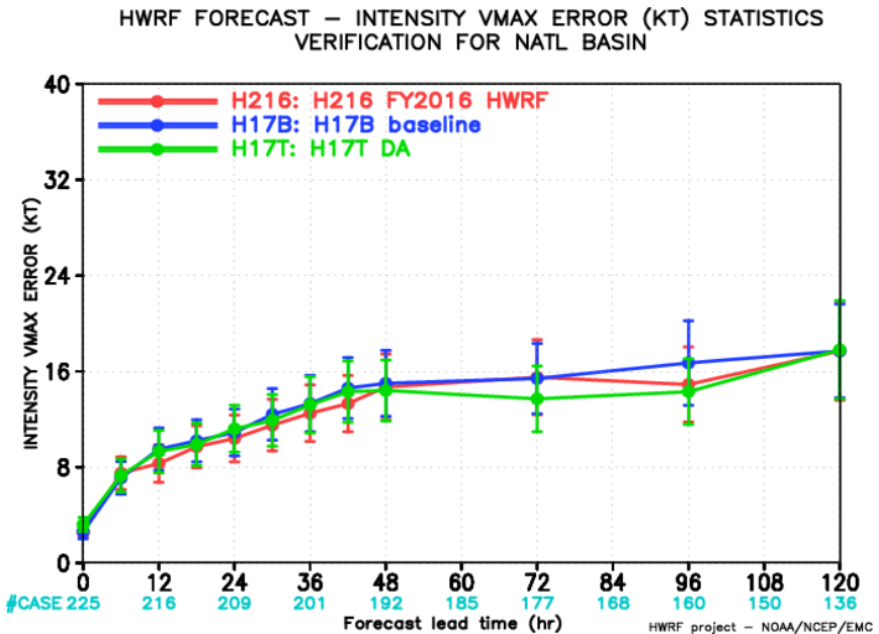
Cycled HWRF EnKF Ensemble Hybrid when TDR available



2017 HWRF DA Improvements: North Atlantic Basin







- 2017 HWRF DA upgrades show improvement in tracks for longer-lead times.
- Intensity errors are significantly less as compared to baseline and H216 from Days 2-5.
- Bias results are very similar to H17B.
- Preliminary results.

FY17 HWRF Physics Advancements

- Bug fix for 10 meter wind (already in HWRFV3.8a)

- Update F-A Microphysics
- Updates to scale-aware SAS
- Updates to RRTMG (partial cloudiness)
- Update convection with G-F cumulus scheme

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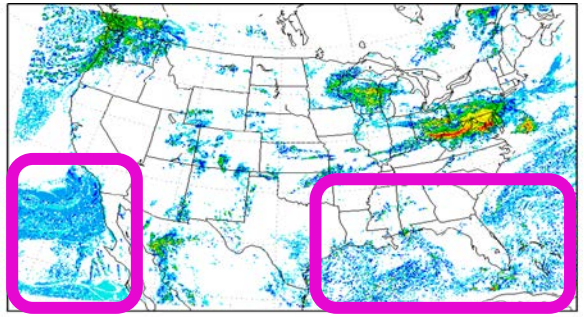
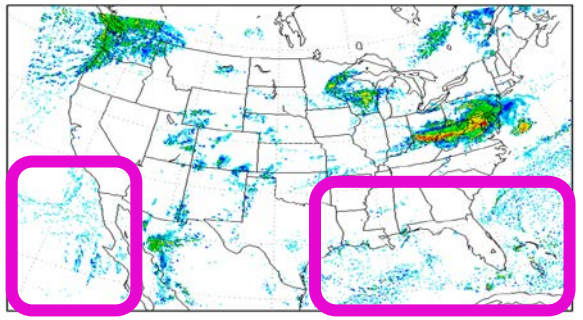
Ferrier-Aligo Microphysics Changes

Problem	Solution
High reflectivity bias in PBL clouds	Added a drizzle parameterization (allows larger number of droplets)
High reflectivity bias at anvil	Increased largest possible number concentration of snow
Lack of stratiform precipitation	Constant rain drop size during rain evaporation (reduces evaporation)

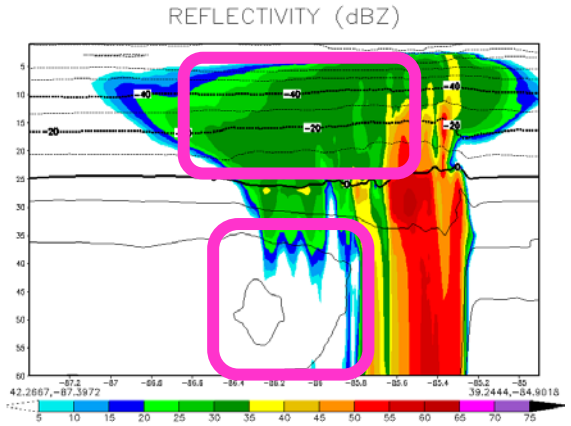
Old

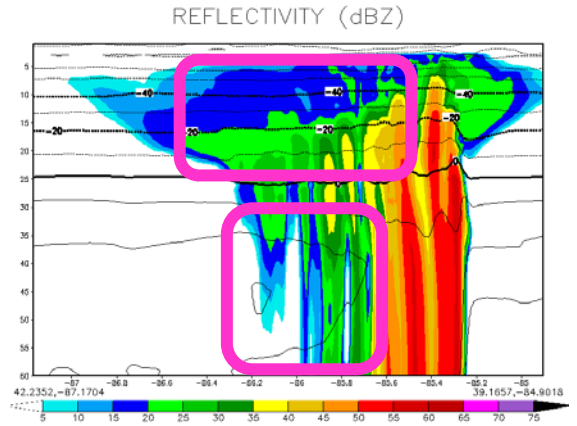
New





12Z 23 June 2016





21Z 29 June 2012

2017 HWRF Physics Advancements

- **Changes in Scale Aware SAS**

  - Updates to scale awareness
  - Decrease rate of rain conversion rate with decreasing air temperatures above freezing levels
  - Enhance entrainment in dry environments
  - Precipitation changes in shallow convection to reduce presence of low clouds
  - Changes to separation criteria between deep and shallow convection

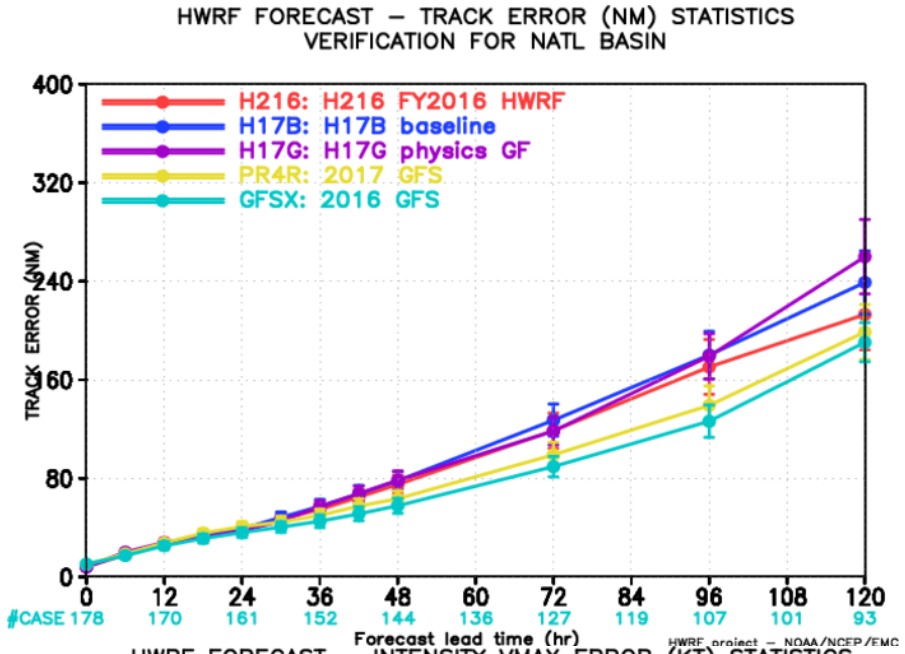
2017 HWRF Physics Advancements

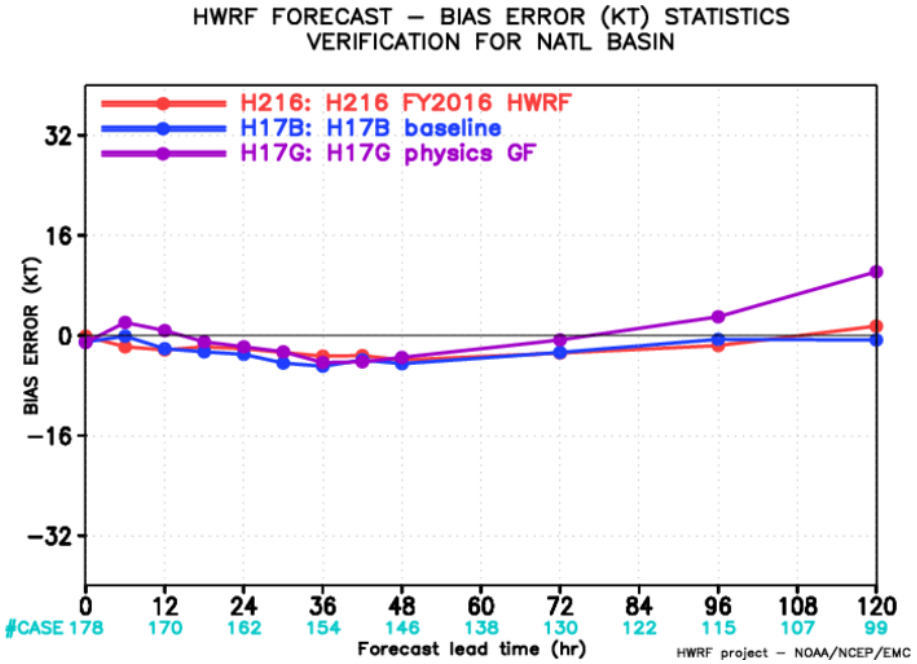
- **RRTMG Partial cloudiness modifications**
  - Adjustments to RH threshold methodology
  - Reduction in solar radiation biases over CONUS

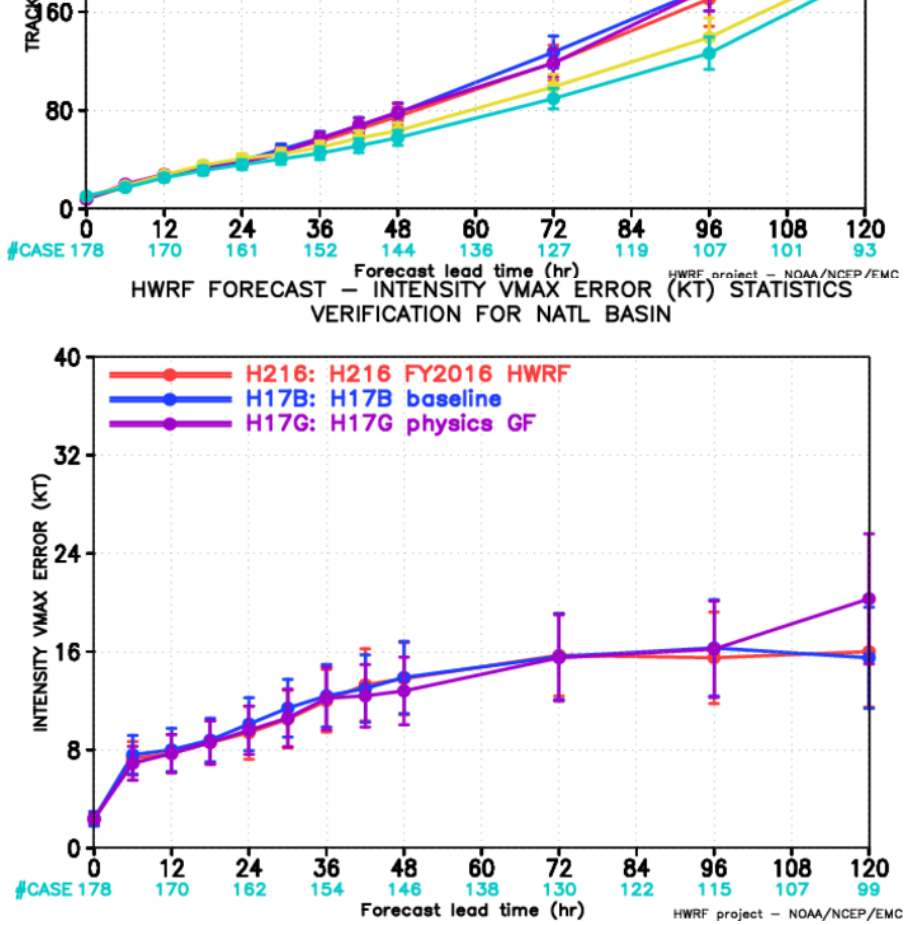
- **Grell-Freitas convective scheme implemented in HWRF**
  - NGGPS project (G. Grell and J.-W. Bao)
  - Based on Scale-aware/Aerosol-aware methods

    (Grell and Freitas, 2014)

2017 HWRF Physics Advancements: North Atlantic Basin



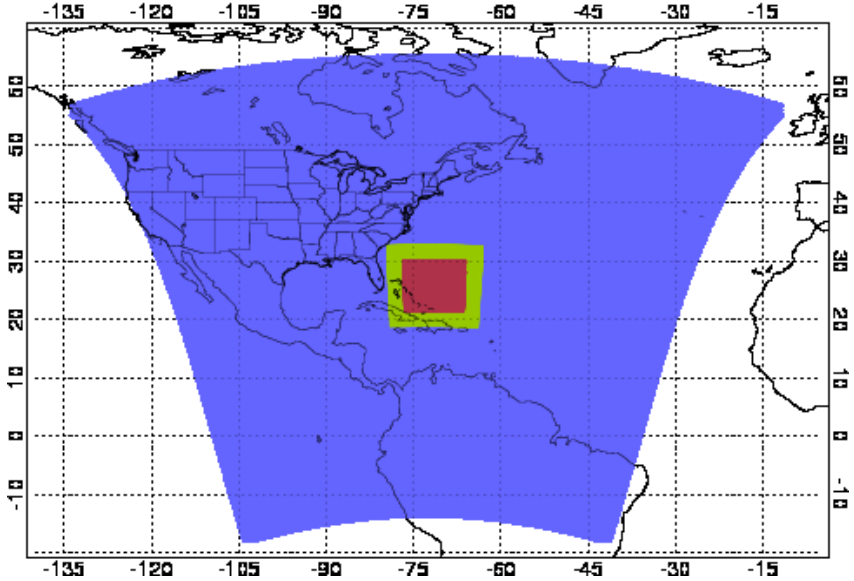




- G-F scheme gives us the best track and intensity performance at Days 2 and 3.
- Errors are somewhat larger as compared to baseline for longer-lead times especially at Day 5.
- Preliminary results.

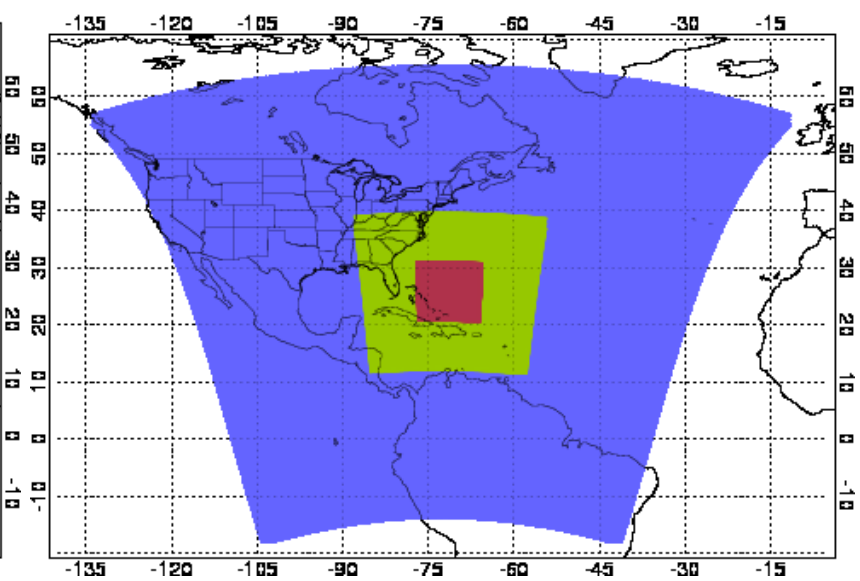
Potential Domain Size Adjustment for H217 with higher vertical resolution: Hurricane Joaquin (2015)

H215



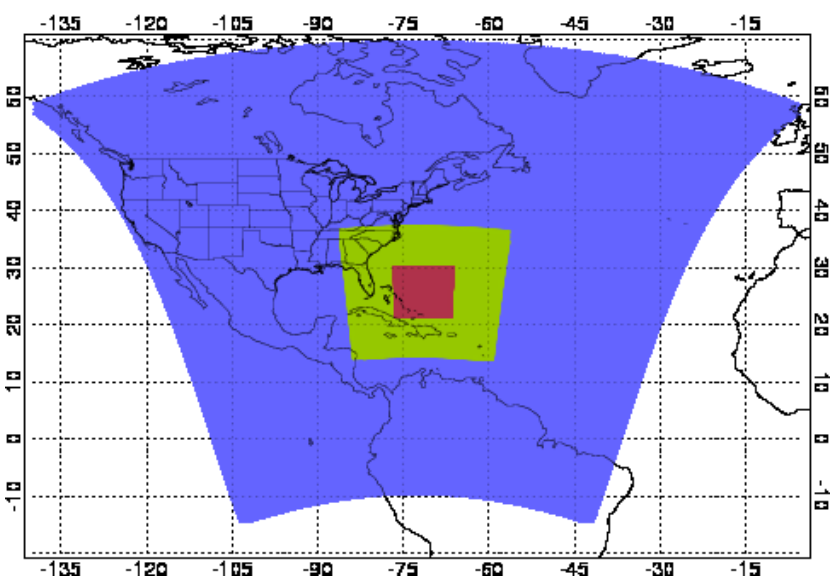
d02: 142 x 274
d03: 256 x 472
Levels: 61
Top: 2 mbar

H216



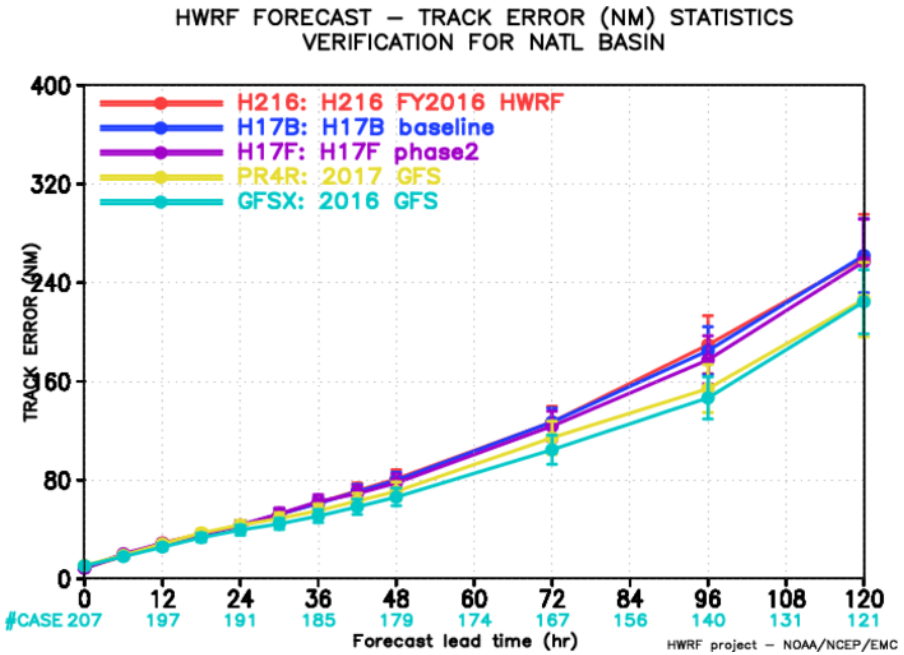
d02: 288 x 576
d03: 288 x 576
Levels: 61
Top: 2 mbar

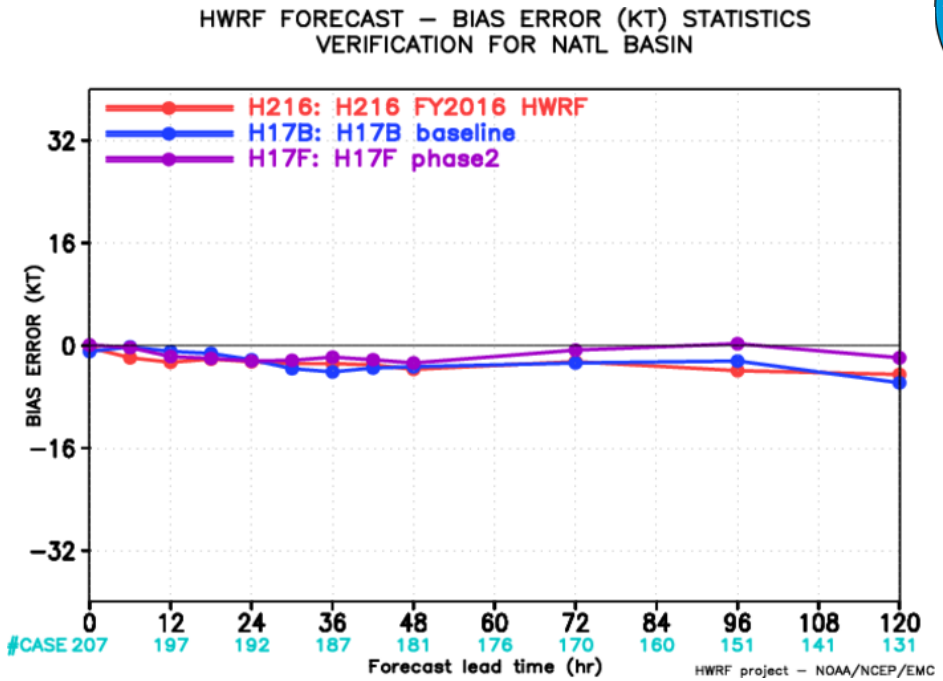
B217L

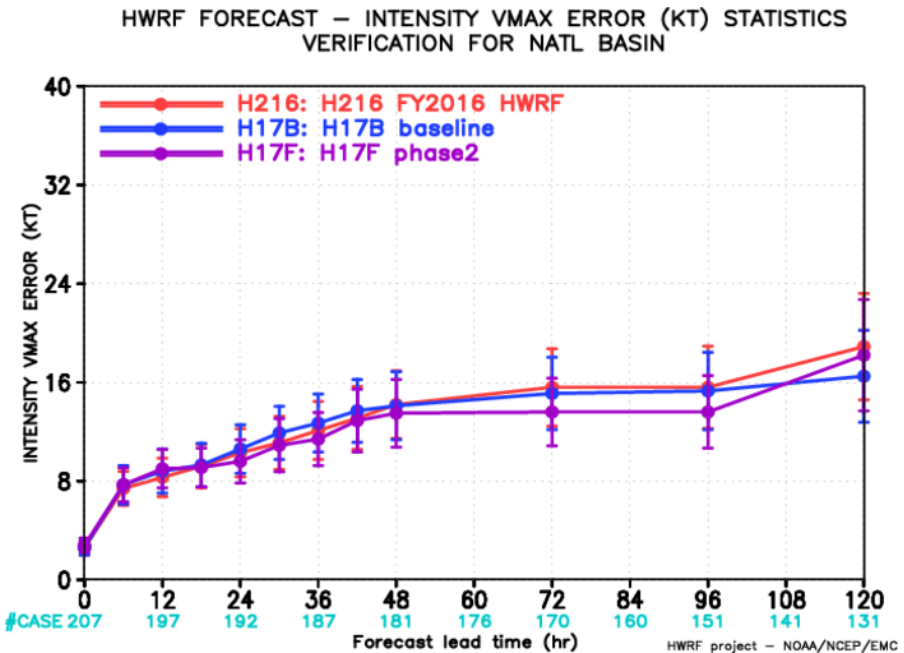


d02: 256 x 472
d03: 256 x 472
Levels: 75
Top: 10 mbar

2017 HWRF Combined Physics, DA and system changes: NATL

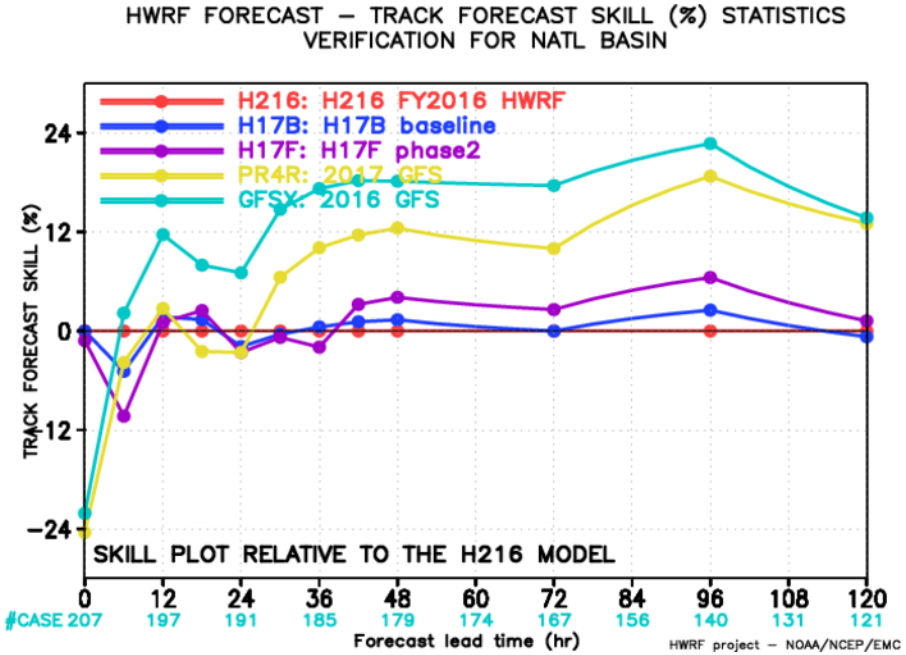


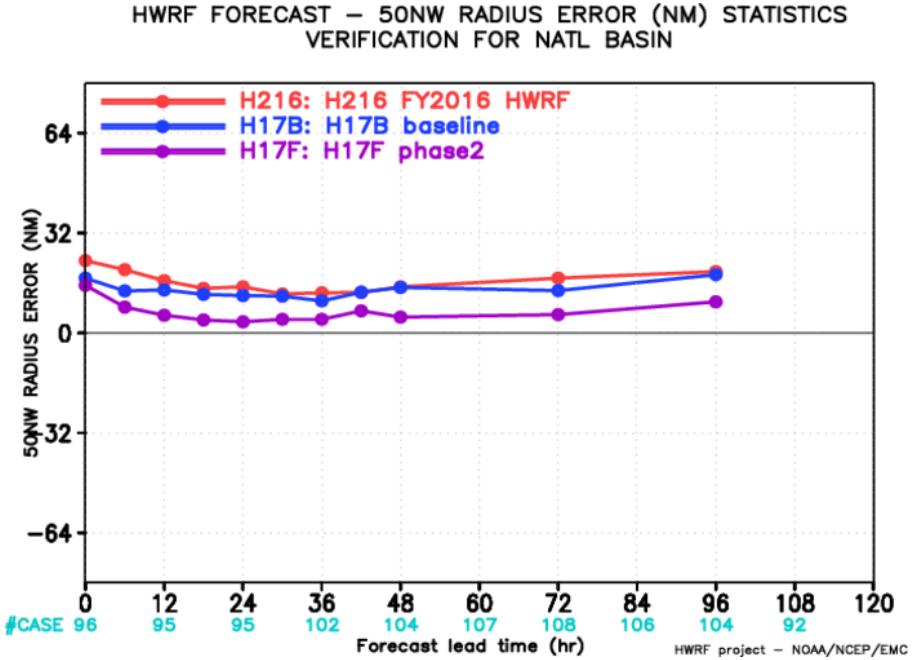


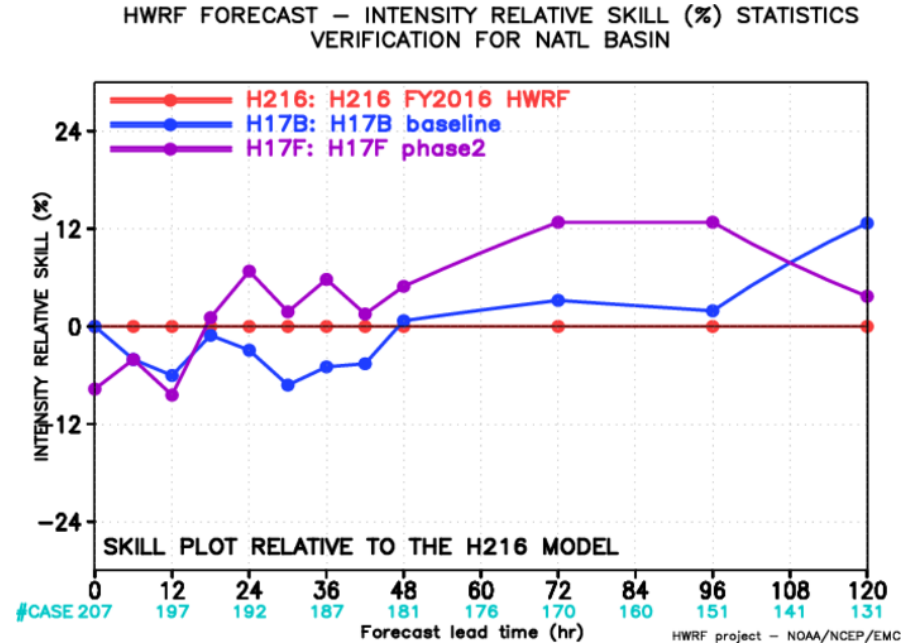


- Combined DA, Physics and system changes are giving us improvements in both track and intensity errors in the North Atlantic Basin as compared to H17B.
- Intensity and Bias errors are significantly less for longer-lead times especially at Days 3 - 5.
- Preliminary results.

2017 HWRF Combined Physics, DA and system changes: NATL







- Combined DA, Physics and system changes are giving us improvements in both track and intensity errors in the North Atlantic Basin as compared to H216.
- 50 Kt radius errors are also significantly less.
- Preliminary results.

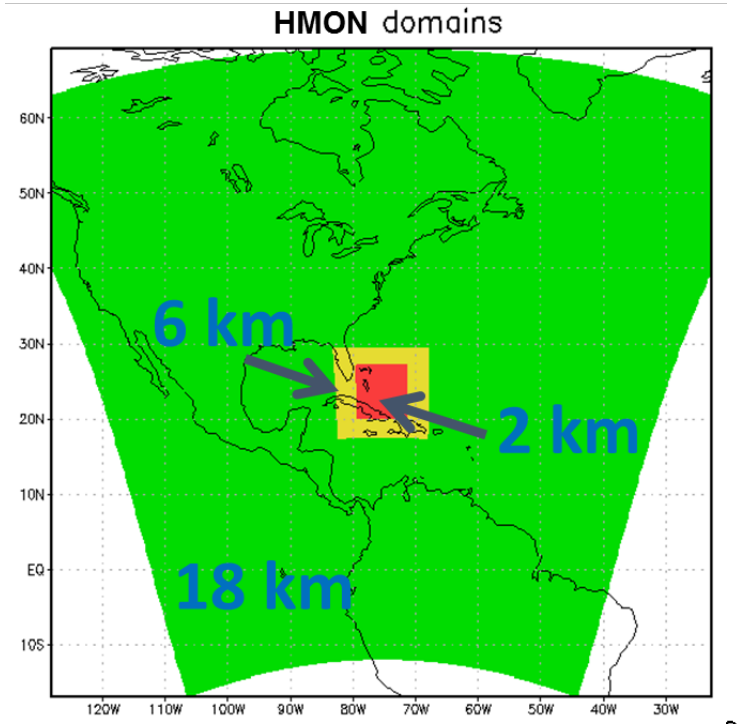
HWRF Upgrade Plan for 2017 Implementation

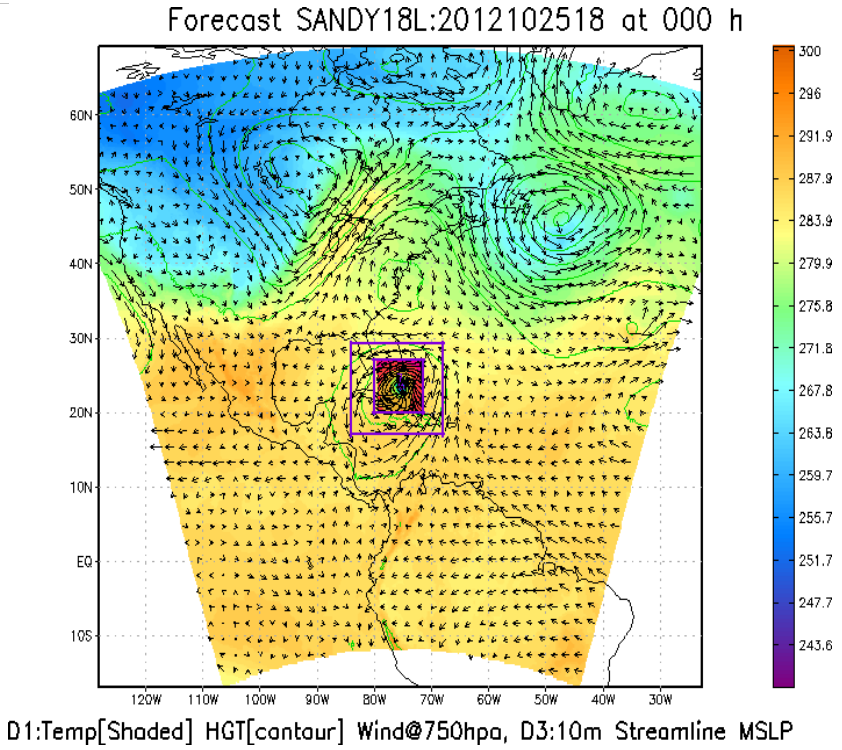
Multi-season Pre-Implementation T&E

	Model upgrades	Physics and DA upgrades		Combined
	Baseline (H17B)	**Data Assimilation changes (H17T)**	**Physics changes (H17G)**	**H217**
Description	1. Framework upgrade to HWRFV3.8a; domain center; new tracker 2. New 2017 GFS upgrade 3. U10 fix, smaller coupling time step. 4. GSI upgrades.	1. HDOBS 2. Blending threshold 3. Fully self-cycled EnKF	Assess impact of physics changes	Baseline + DA changes + all physics changes + others
Cases	Three-season 2014-2016 simulations in ATL/EPAC cases (~2000)	Only Aircraft DA cases for 2014-2016	Priority cases (~400 cases in each basin)	**Three-season 2014-2016 retrospectives ~5000 simulations in all TC basins**
Platform	WCOSS/Jet/Theia	WCOSS/Jet/Theia	WCOSS/Jet/Theia	**WCOSS Cray**

FY17 HMON v1.0.0
Implementation plans

HMON: A New Operational Hurricane Model at NCEP replacing GFDL Hurricane Model





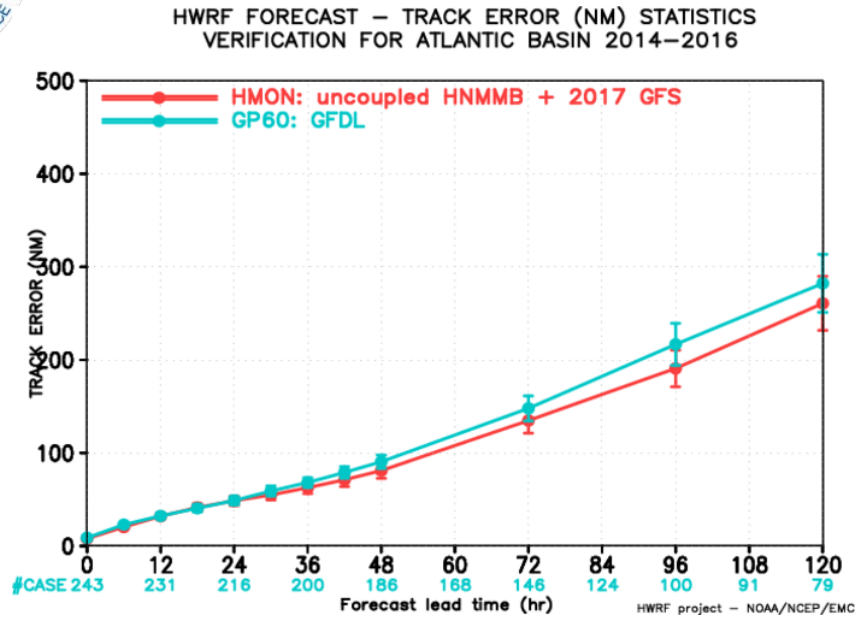
HMON: **H**urricanes in a **M**ulti-scale **O**cean coupled **N**on-hydrostatic model

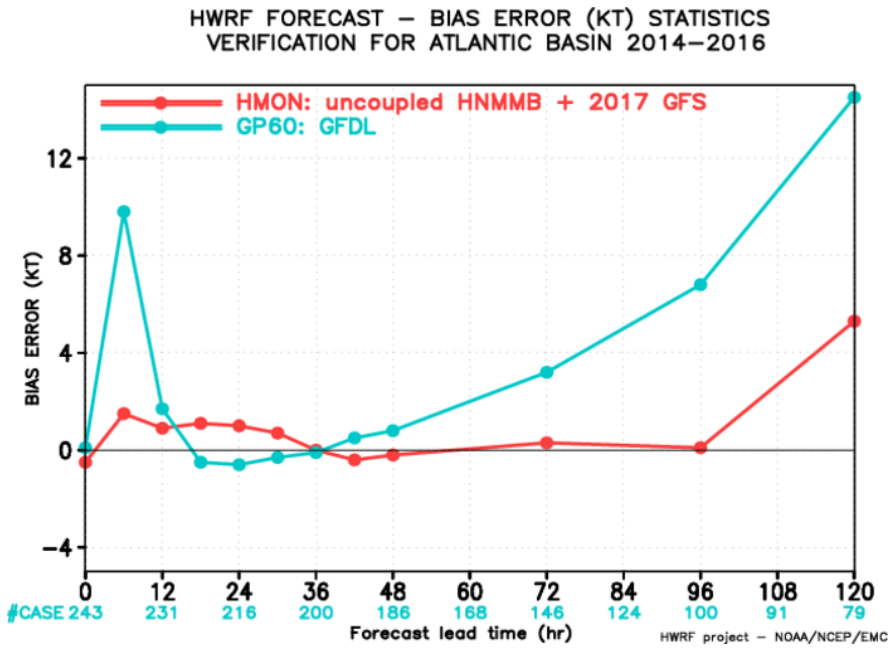
HMON: Implements a long-term strategy at NCEP/EMC for multiple static and moving nests globally, with one- and two-way interaction and coupled to other (ocean, wave, sea ice, surge, inundation, etc.) models using NEMS-NUOPC infrastructure.

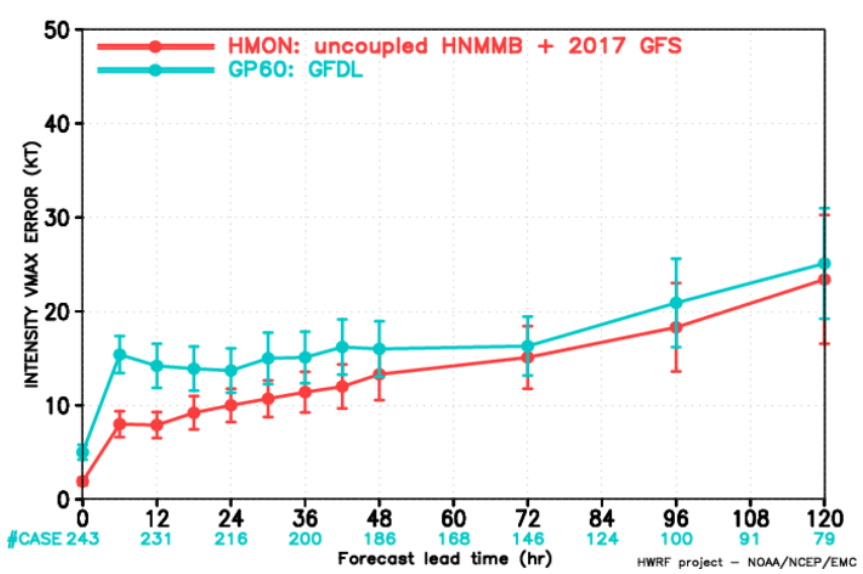
HMON: A New Operational Hurricane Model at NCEP

- **HMON:** Advanced Hurricane Model using NMMB dynamic core which is currently being used in NCEP's operational NAM and SREF systems.
- Shared infrastructure with unified model development in NEMS. A step closer towards NEMS/FV3 Unified Modeling System for hurricanes
- Much faster, scalable and uses CCPP style physics package
- Development supported by NGGPS, HFIP and HIWPP programs
- Provides high-resolution intensity forecast guidance to NHC along with HWRF (replacing the legacy GFDL hurricane model)

2017 HMON Performance: North Atlantic Basin

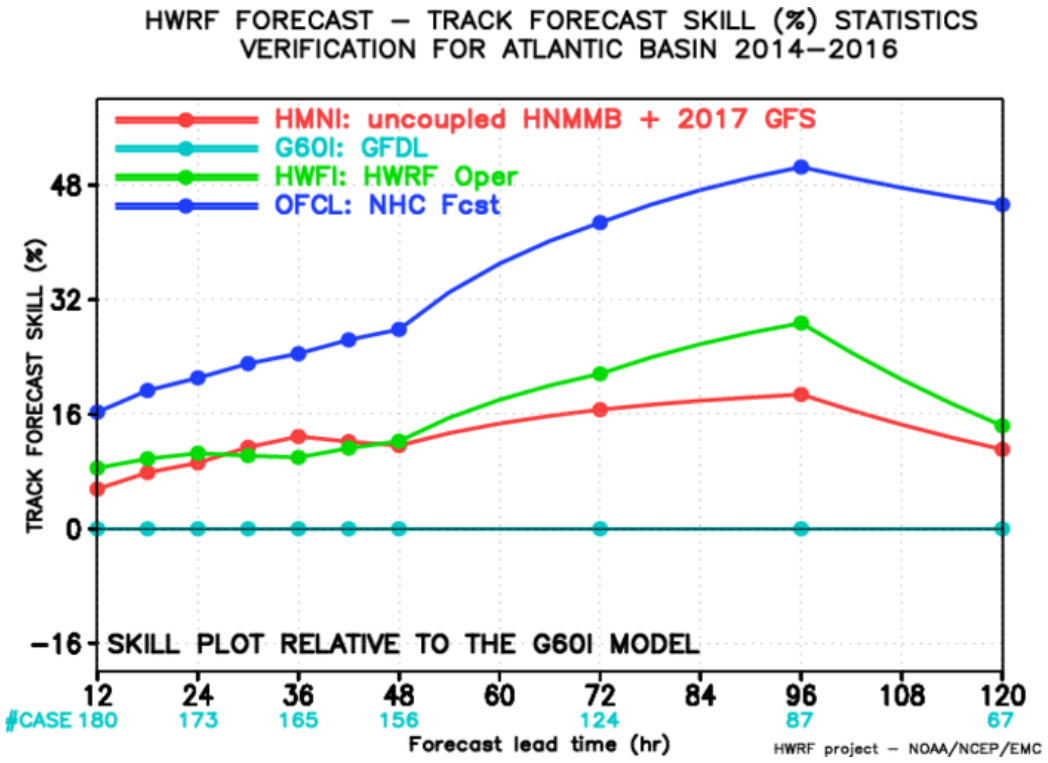


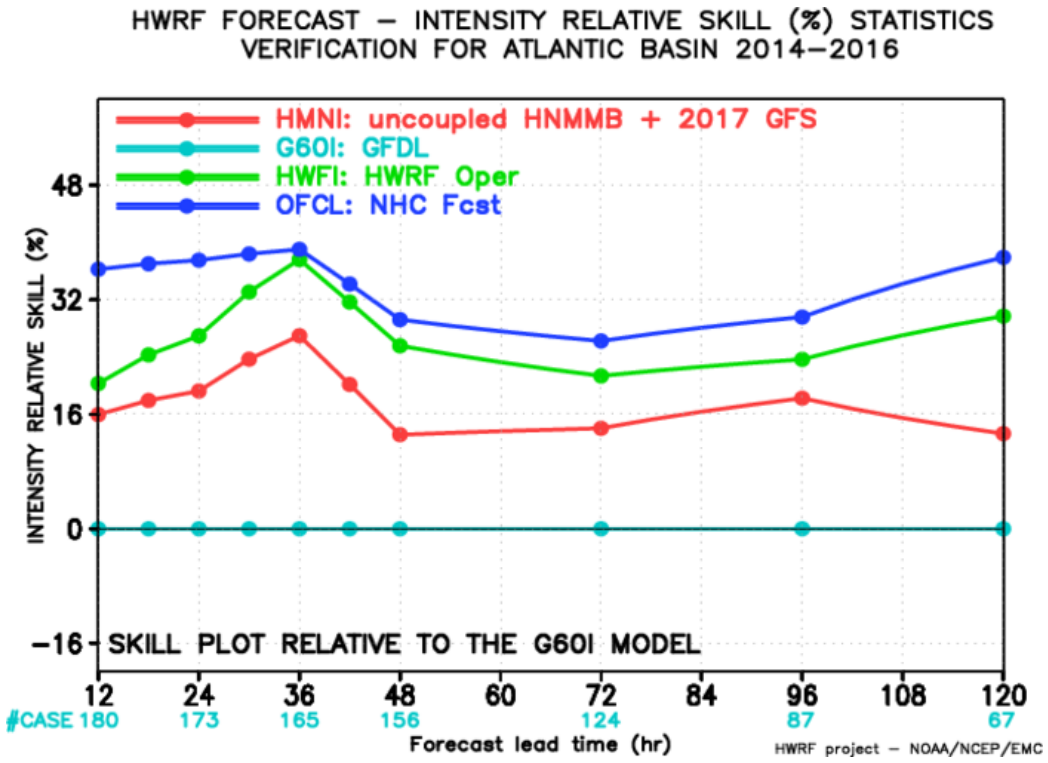




- 2017 HMON track errors shows significant improvement as compared to GFDL errors especially at long-lead times.
- Intensity errors are also considerably less than GFDL with improved results for early lead-times (up to 48 hrs).
- Preliminary results.

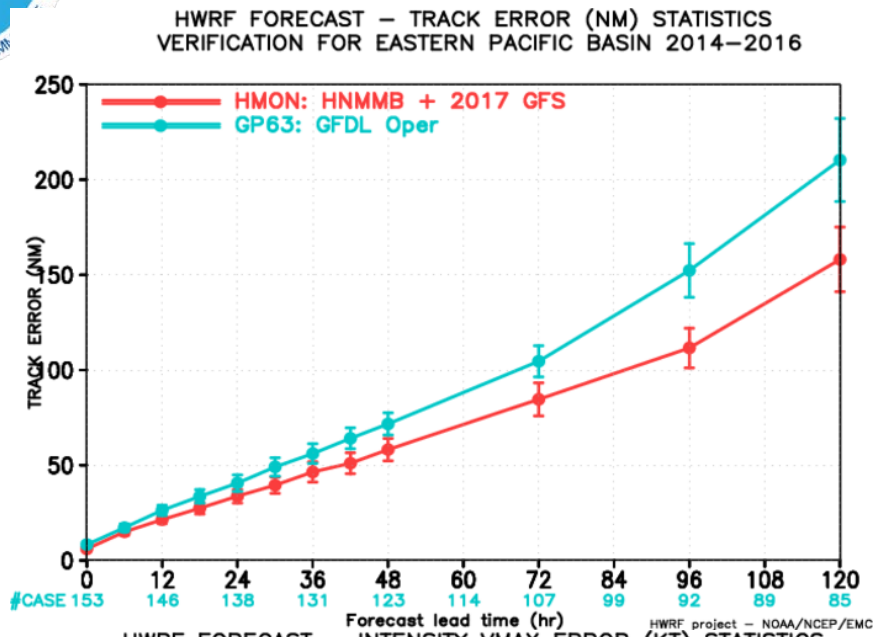
2014-16 Atlantic Basin: Relative to GFDL (interpolated)

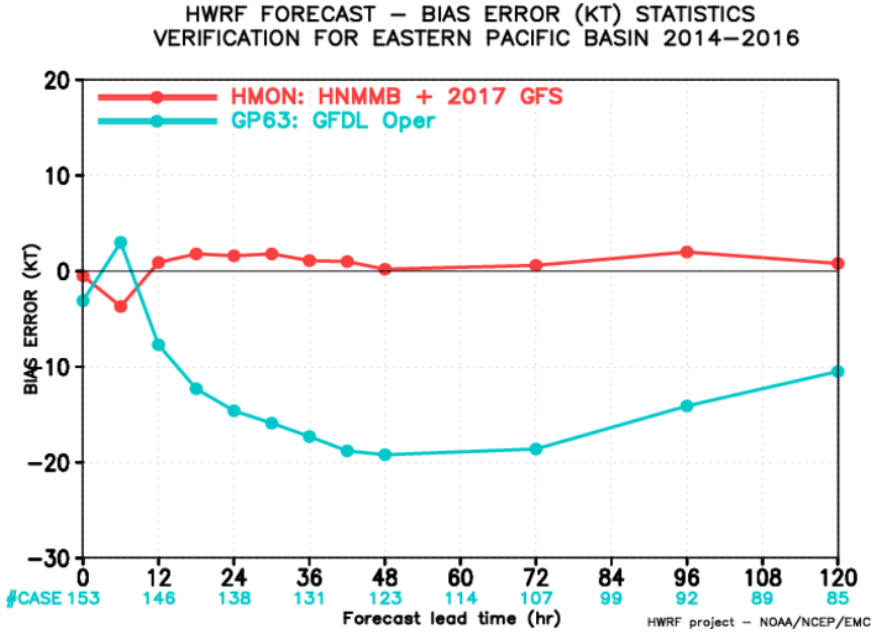


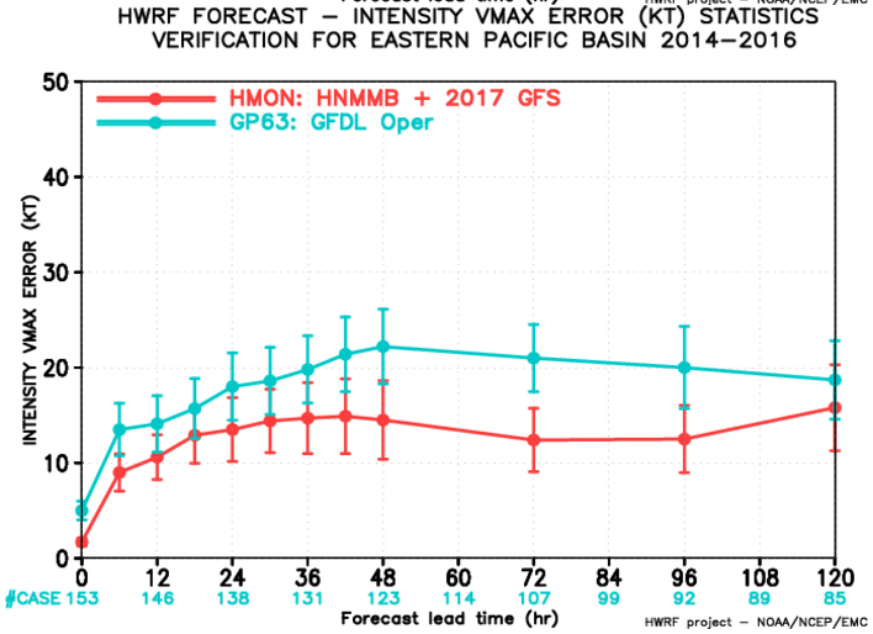


HMON has improved track skills as compared to GFDL with an average improvement of more than 8%. It also has improved intensity skills with a mean improvement of >15%.

2017 HMON Performance: North East Pacific Basin

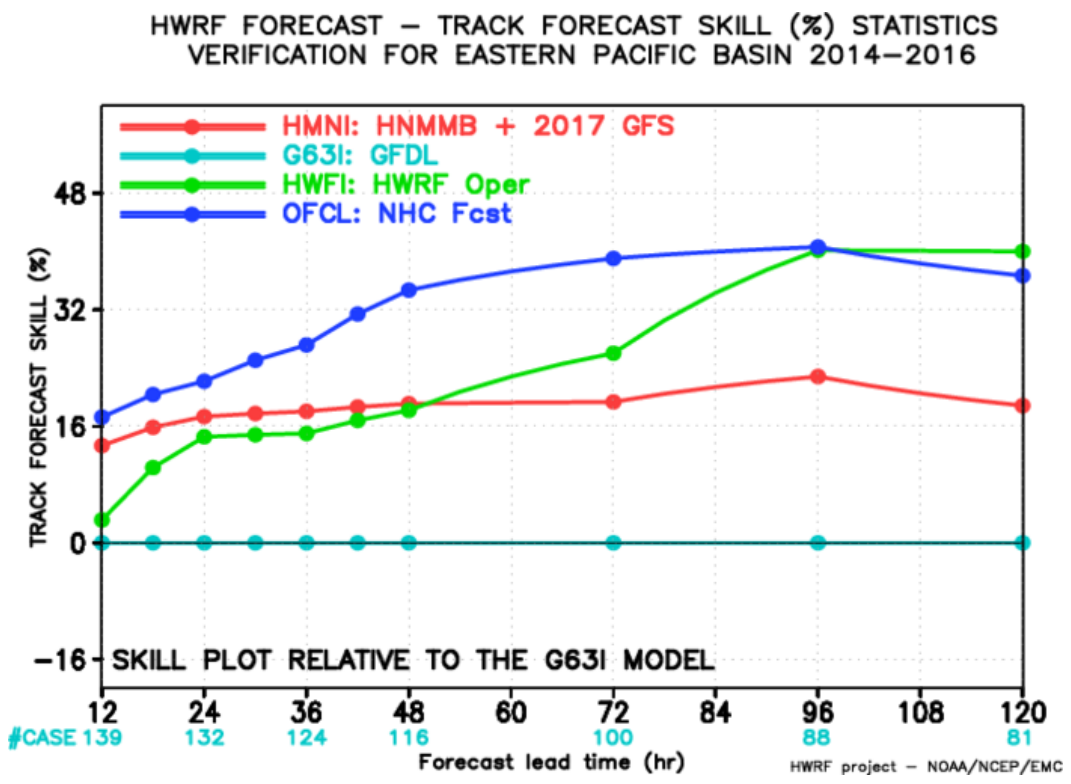


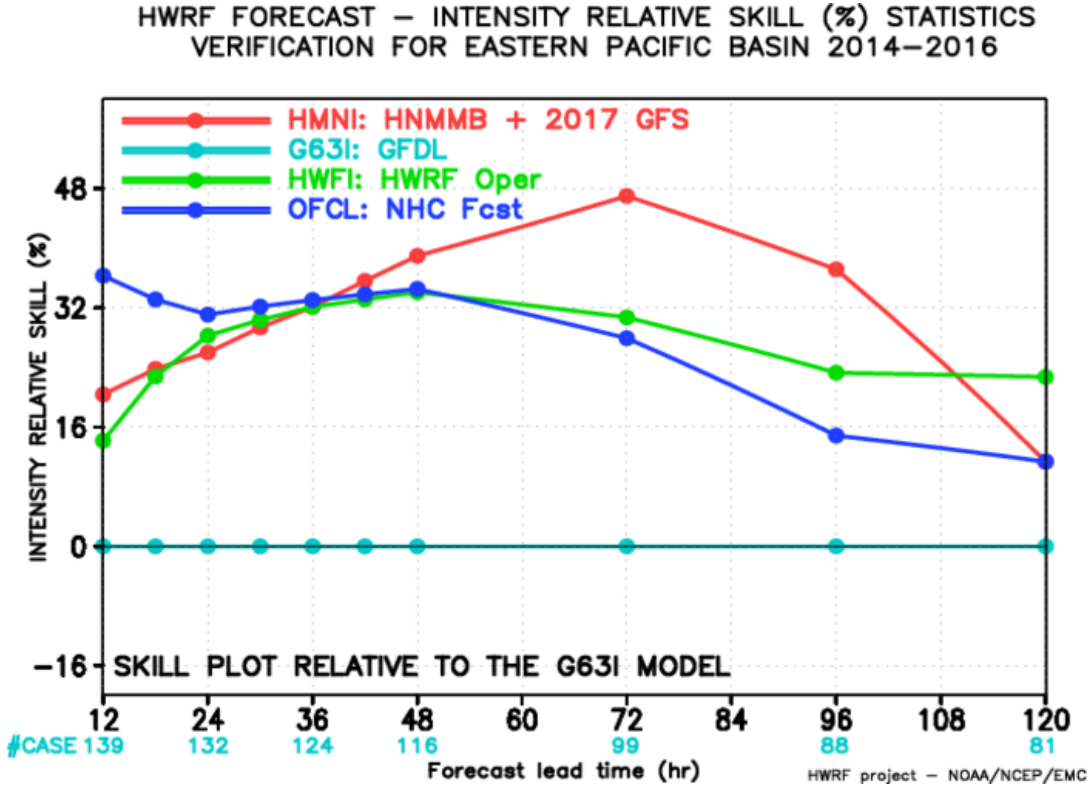




- 2017 HMON has much better results than GFDL for track error in the East Pacific basin.
- 2017 HMON has much superior results than GFDL for intensity errors at all lead times in the East Pacific basin.
- Intensity bias is also much improved as compared to GFDL.
- Preliminary results.

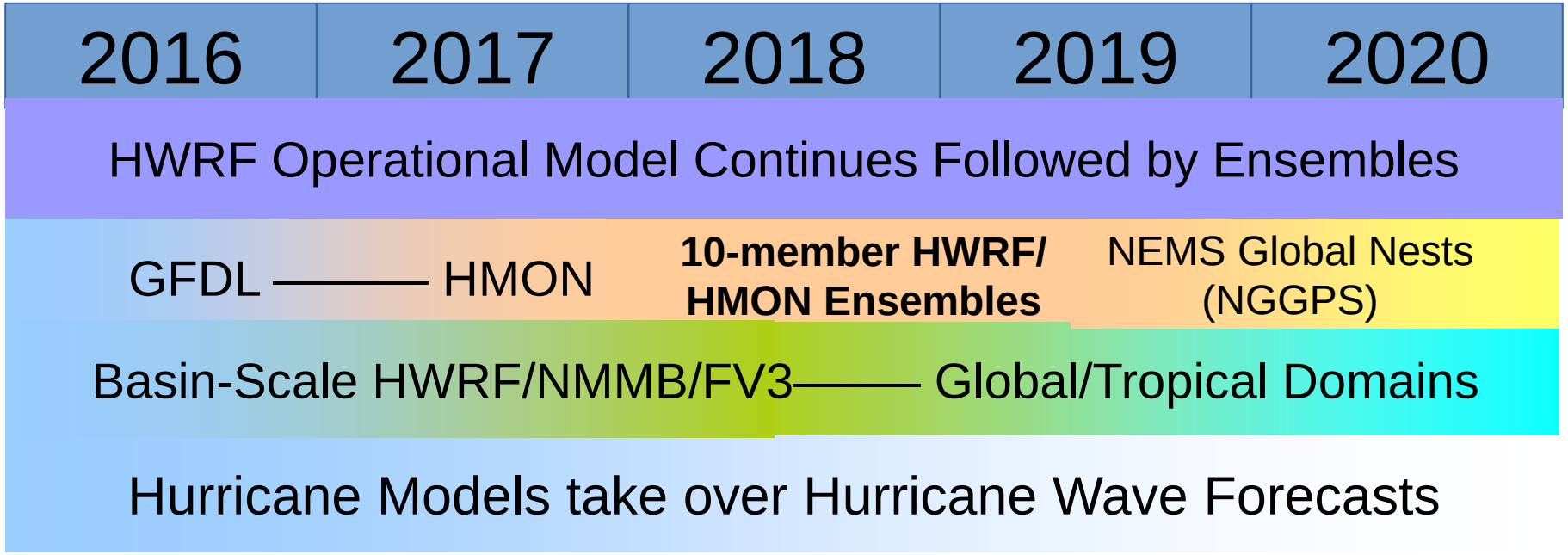
2014-16 East Pacific Basin: Relative to GFDL (interpolated)





HMON has improved track skills as compared to GFDL with an average improvement of more than 15%. It also has significantly improved intensity skills with a mean improvement of >20%.

HWRF/HMON Long-Term Plans



Development, T&E and Implementation Plans for HWRF & HMON

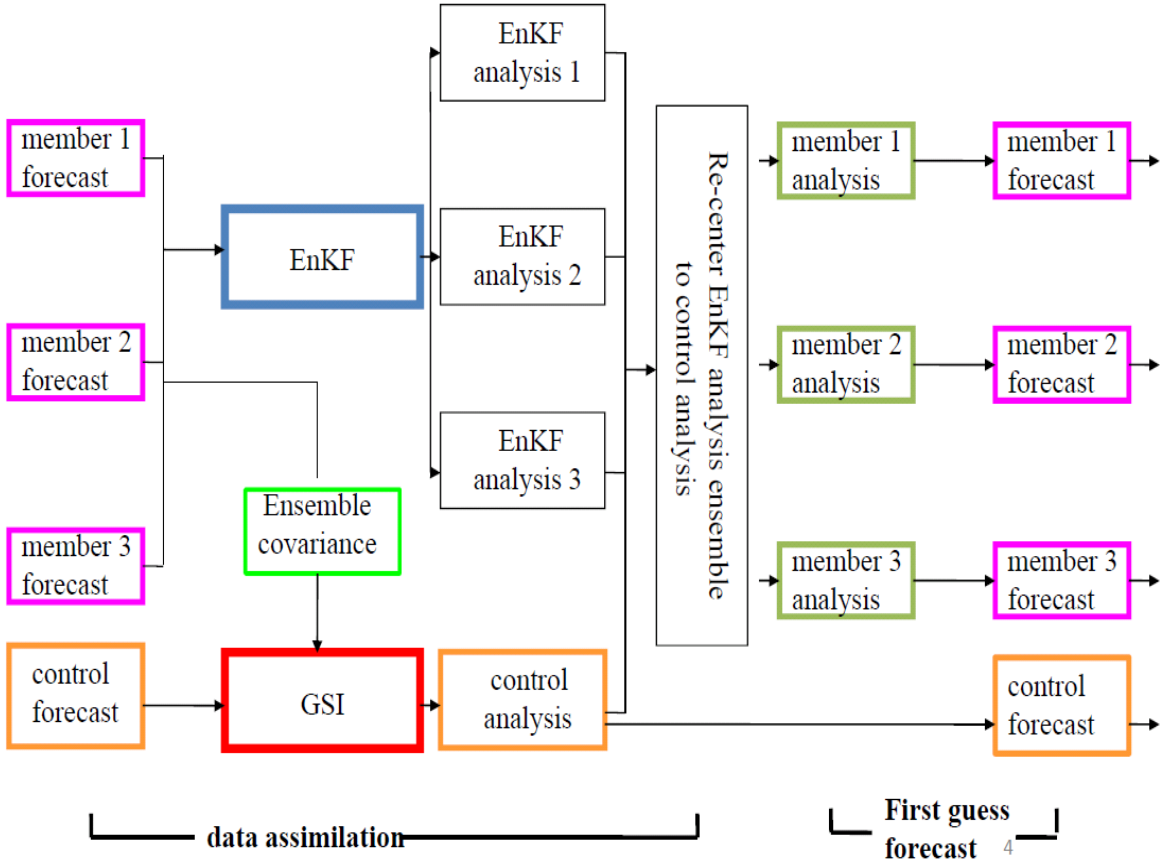
2016 Nov: Configuration ready
2016 Dec- 2017 March: Pre-implementation retrospective testing
2017 April: EMC CCB and code hand-off
2017 June: Operational Implementation

Thank You!

Supplementary Slides

2017 Data Assimilation Upgrades (ATL and EPAC)

Hybrid EnKF-GSI DA system: 2 way coupling



Advanced self-cycled HWRF EnKF-GSI Hybrid Data Assimilation System (HDAS)

HWRF: Current and Future Tasks

- Further improvements to hurricane physics
- Further improvements to vortex initialization and data assimilation
- Increase/change vertical resolution, nested domain sizes
- Replace operational Hurricane Wave model with HWRF system
- Three-way Atmosphere-Ocean-Wave coupling
- Basin-scale configurations

Targeted Resources for Hurricane Modeling (maximum per storm)

Operational System	2016 (nodes)	2017 (nodes)	Comments
HWRF	63	63	No change from 2016
WW3-multi2	9	0	WW3 coupled to HWRF
GFDL	3	0	Discontinued
HNMMB	0	26*	Uses much less resources than HWRF
TOTAL	**75**	**89**	18.7% resource increase*

- Initial implementation is targeted for only 5 storms serving NHC areas of responsibility (NATL & EPAC)