2016 HWRF V10.0.0 Implementation Briefing to EMC:

Much improved operational forecast guidance for global tropical cyclones

Avichal Mehra

(on behalf of Dr. Vijay Tallapragada & the HWRF Team)

**Environmental Modeling Center,
NCEP/NOAA/NWS, NCWCP, College Park, MD 20740.**

**in collaboration with
NHC, DTC, GFDL, URI and HRD**

EMC CCB Meeting, May 18, 2016

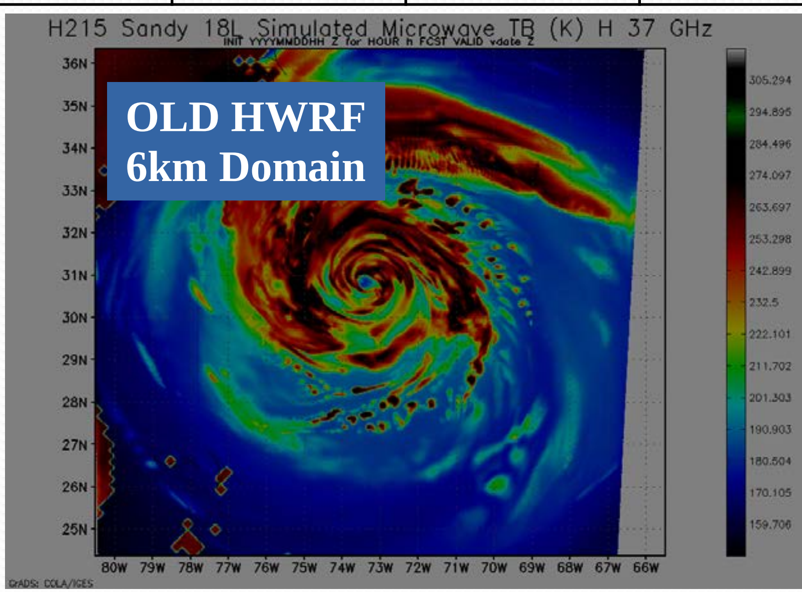
Scope of FY16 HWRF Upgrades

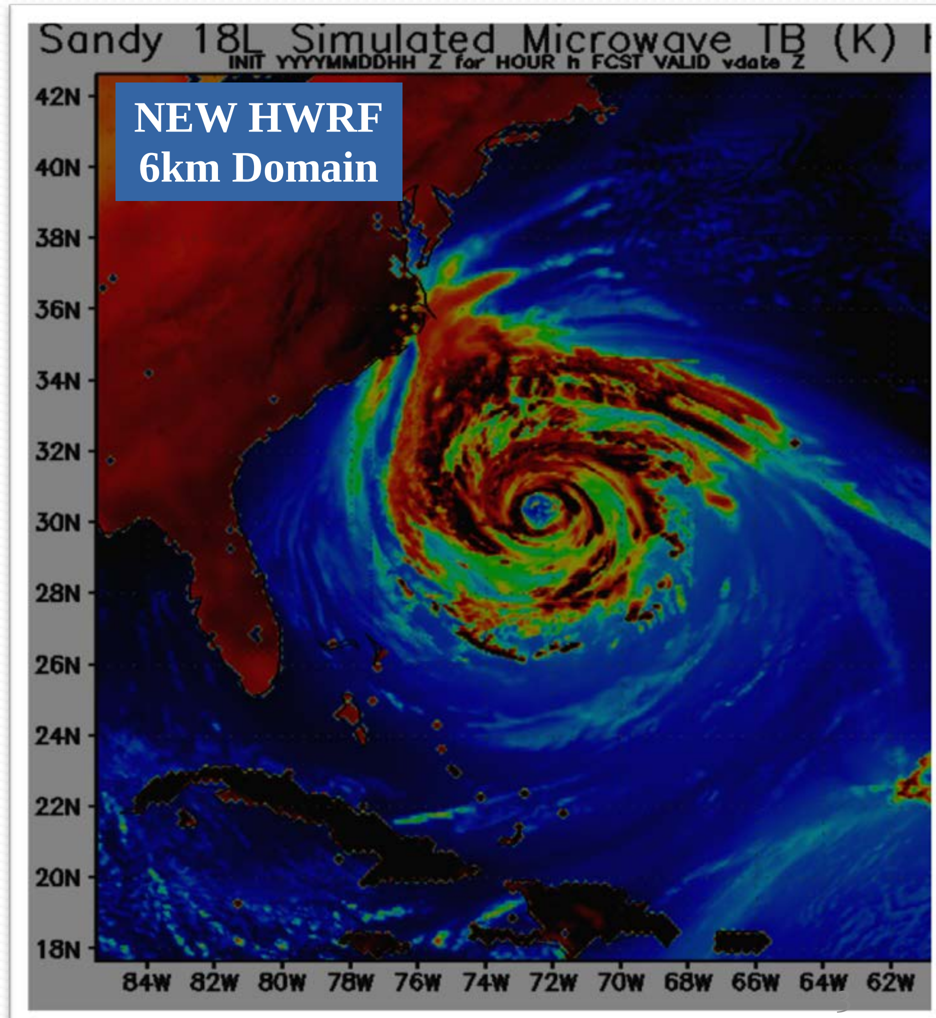
- **System & Resolution Enhancements**
  - T&E with new 2016 4D-Hybrid GDAS/GFS IC/BC
  - Upgrade dynamic core from WRF3.6a to WRF3.7.1a (with bug fixes)
  - Smaller time step (dt=30 s vs. 38 4/7 s)
  - *Increase the size of nested domains (details on next slide)*
  - More products: MAG and AWIPS2
- **Initialization/Data Assimilation Improvements**
  - GSI upgrades; new data sets for GSI (CrIS, SSMI/S, METOP-B changes)
  - Turn on Data Assimilation for all storms in East Pacific
- **Physics Advancements**
  - Implement new GFS PBL (2015 version)
  - Upgrade to new scale-aware SAS convection scheme for all domains
  - Update momentum and enthalpy exchange coefficients(Cd/Ch)
  - Improved vertical wind profile in the surface and boundary layer
- **First time in 2016….**
  - Implementation on WCOSS Cray
  - Use ROTFS initialization for EPAC storms to have more realistic ICs and improved RI forecasts; ocean coupling for CPAC
  - One-way coupling to wave model (Hurricane Wave Model)
  - *Use of dev-ecflow for accelerated T2O*

2016: Larger size nested domains and smaller timesteps

Domain Sizes/Time Steps

(Degrees/ Sec)	18 km	6 km	2 km
2015 HWRF	75 x 75 38 4/7	12 x 12 12 6/7	6.5 x 7 4 2/7
2016 HWRF	75 x 75 **30**	**25 x 25** **10**	**8.3 x8.3** **3 1/3**





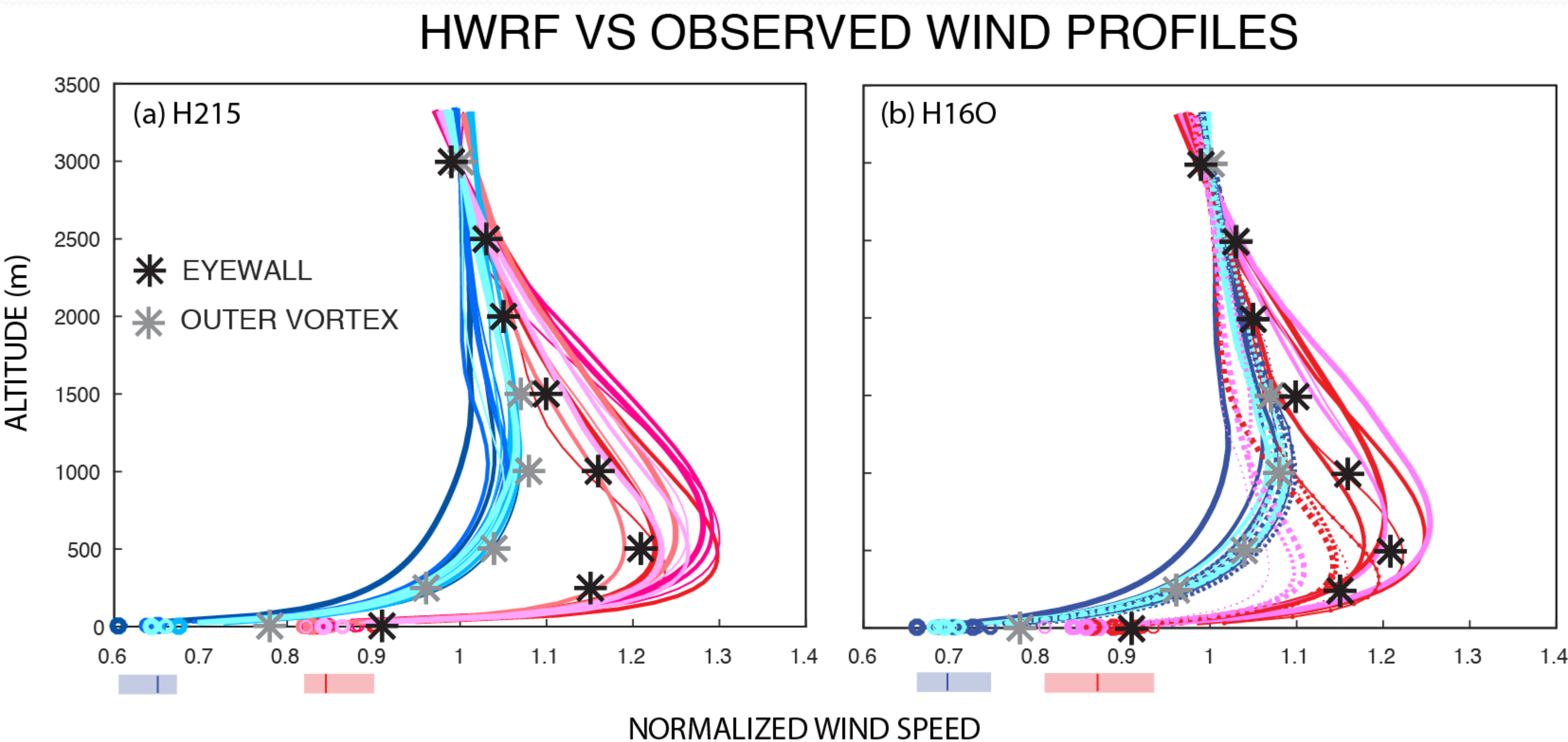
2016 Data Assimilation Upgrades (ATL and EPAC)

- Turn off blending of vortex initialization and GSI analysis for weak storms (Vmax < 50 kts)
- Turn on satellite DA on ghost d03
- Satellite data usage changes:
  - Adding assimilation of CrIS (JPSS), SSMIS, Metop-B AMSU-A, Metop-B MHS and IASI
  - Change from assimilation to monitor: NOAA 19 AMSU-A Channel 7; NOAA 18 AMSU-B Channel 5, 8; NOAA 19 HIRS4; NOAA 19 MHS channel 3; GOES sounder; SEVIRI Meteosat-10
  - Modified channels used for cloud detection: NOAA 15 AMSU-A; Metop-A AMSU-A; NOAA 18 AMSU-B; HIRS/3; HIRS/4; AQUA AMSU-A; ATMS; GOES sounder; IASI
- Turn on VarQC in the second minimization loop

2016 Physics Upgrades

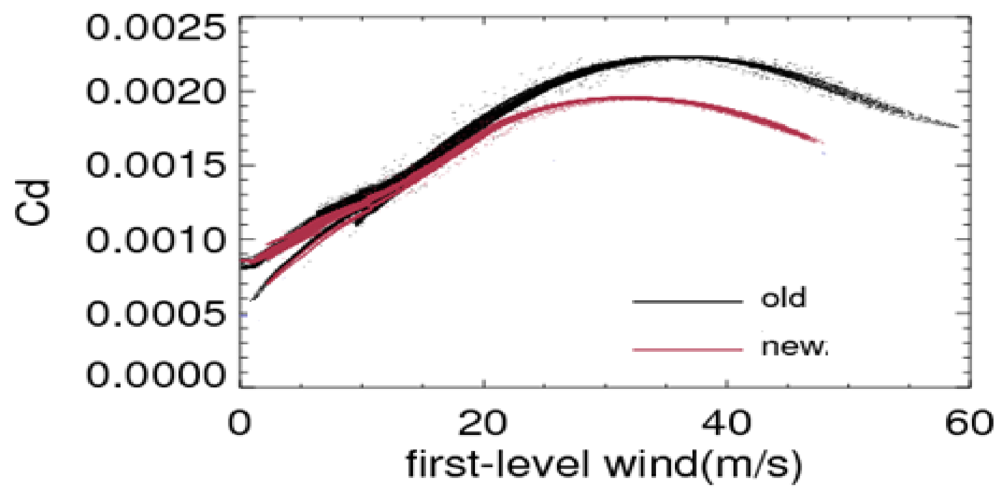
Module	Highlights	Improvements
Surface Layer	• Use 10m wind to calculate cd/ch • Update Cd, Ch for V >20m/s	o Independent of z grid o Better low level wind o Closer to observations
PBL	▪ Replace old GFS PBL with latest GFS-EDMF PBL ▪ Add observations based K adjustment ▪ Improve & remove discontinuity of K profile	o Better representation of CBL/SBL o Better low level winds o Better simulation of storm intensification
Convection	Scale-aware deep/shallow convection scheme in all domains	Represent multi-scale convection
Horizontal diffusion	Reduce horizontal length scale ~ 2/3 of that in 3-km HWRF, (COAC values of 0.75, 1, 1.2 from 0.75, 3, 4 in H215)	Consistent with higher resolution
Microphysics 1 adv Ferrier_hires 2 Thompson MP	Advect individual hydrometers good Ice physics	Tech issue, next year tests not yet done

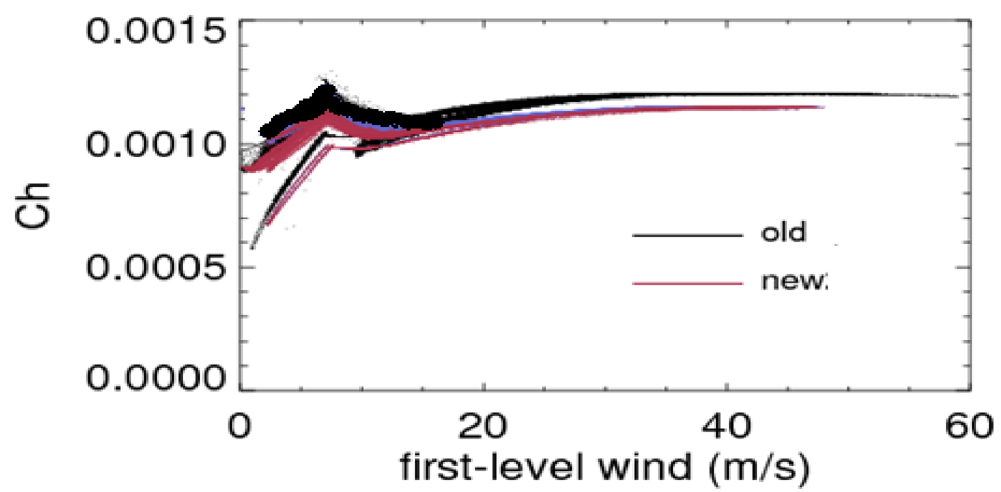
2016 Physics Upgrades



Upgraded HWRF generates more physically sensible structure.

2016 Physics Upgrades





Surface-layer Cd and Ch

- ✓ Reduce Cd for wind > 20 m/s
- ✓ Ch is reduced by 5%
- ✓ More consistent with Observations-derived Cd, Ch.
- ✓ Modify current Zo ~ wind function; Use the standard 10m wind to compute Cd, Ch through Zo.

2016 Physics Upgrades

Latest version GFS PBL EDMF

$$\overline{w'\phi'} = local\ flux + non\ local\ flux$$

HWRF2015

$$\overline{w'\phi'} = -K\left(\frac{\partial\overline{\phi}}{\partial z} - \gamma\right)$$

Counter-gradient method to represent nonlocal flux

HWRF2016

$$\overline{w'\phi'} = -K\frac{\partial\overline{\phi}}{\partial z} + M(\phi_u - \overline{\phi})$$

Local Eddy **Mass Flux**

Also, TKE-based dissipation heating

Scale-aware SAS convection scheme

For cumulus convection, a scale-aware parameterization will be necessary for the grid sizes of 500m ~ 10 km where the strong updrafts are partially resolved.

Scale function

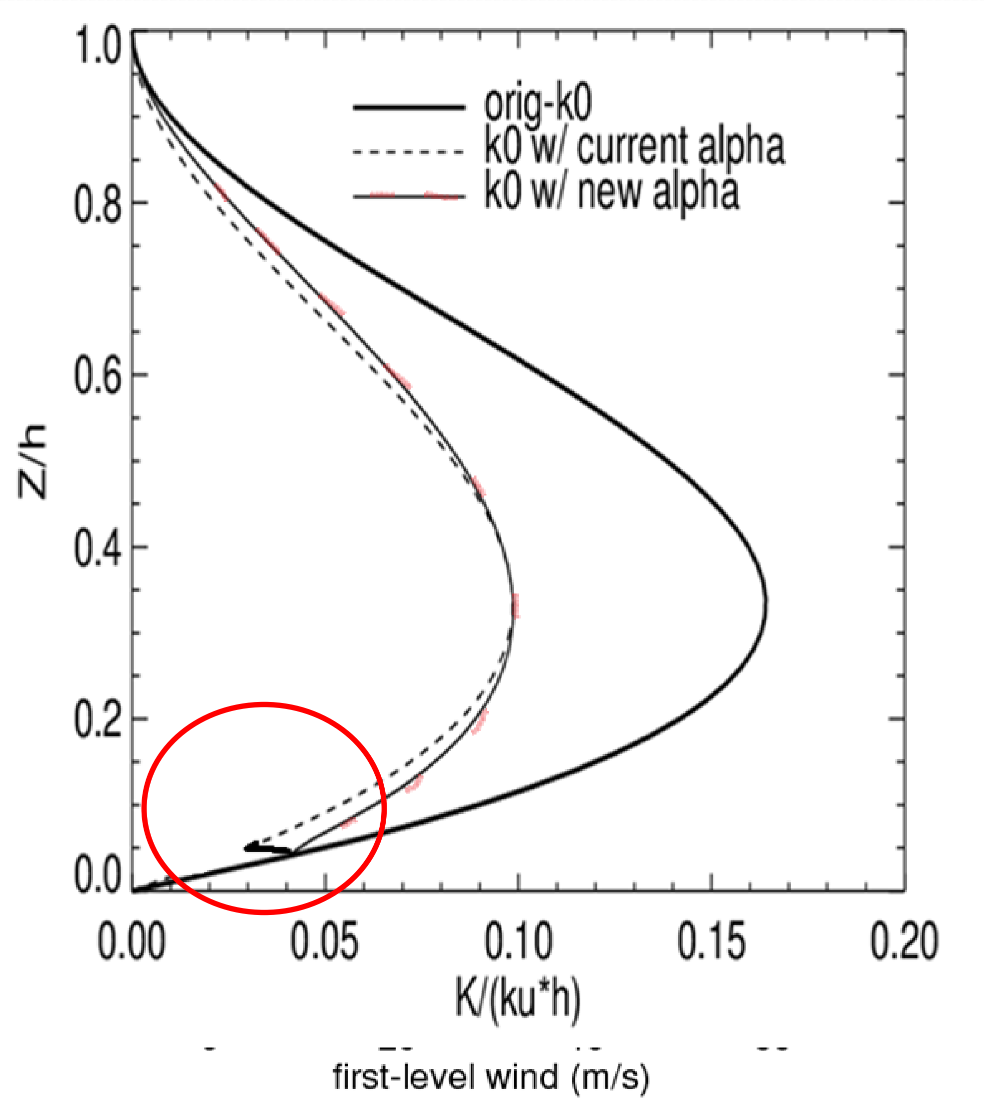
$$m_b' = (1-\sigma_u)^2 m_b$$

Based on Arakawa & Wu (2013): $\overline{w'\psi'} = (1-\sigma_u)^2 \left(\overline{w'\psi'}\right)_E$

σ_u: updraft area fraction (0~1.0)

m_b : original cloud base mass flux from AS quasi-equilibrium closure

m_b' : updated cloud base mass flux with a finite σ_u



K adjustment

- Observations based
- Constant (with z) adjustment, simply multiply *K* by a coefficient, discontinuous K, big impact on low-level wind.
- Fix: height-dependent adjustment so that K is continuous.

Q4FY16 Hurricane WRF V10.0.0

Project Status as of 05/18/2016

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Project Information and Highlights

Lead: Vijay Tallapragada, EMC and Steven Earle, NCO

Scope:

1.Smaller timestep needed to support extreme storms in AL/EP/CP.
2.Hybrid ENKF-3DVAR data assimilation for both ATL and EPAC storms
3.Further improvements to model physics: EDMF based GFS PBL, scale-aware convection, improved surface physics.
4. One-way coupling to Waves.
5.Daily updated **RTOFS** ocean conditions for EPAC instead of GDEM climatology.
6.Ocean coupling in CPAC.

Expected Benefits:

1. Improved track & intensity forecast skill
2. Improved products (including downstream applications and MAG).
3. Add AWIPS output.

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Issues/Risks

Issues: Complex T&E due to dependency on GFS and new RTOFS upstream requirement; porting and T&E on Cray

Expected Resource Requirements:

1. 3x increase in forecast window due to larger inner domains, smaller timestep, wave coupling
2. ENSDA will require additional resources for P3 TDR storms in the Atlantic

Risks: Implementation dates are dependent on completion of T&E

Mitigation: Conduct T&E as soon as (or along with) GFS and RTOFS retrospective data are available. Use ecflow for accelerated T2O.

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Scheduling

Milestone (NCEP)	Date	Status
Initial coordination with SPA team	1/29/2016	
EMC testing complete/ EMC CCB approval	5/18/2016	
Final Code Delivered to NCO	5/20/2016	
Technical Information Notice Issued	6/1/2016	
Initial Test Complete		
Test with specific cases		
Testing Ends		
IT testing ends		
Management Briefing		
Operational Implementation	July 2016	

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Finances

Associated Costs:

Funding Sources: EMC Base: T2O 18 Man-months (3 FTE full time for 6 months). NCO Base: 2 man-months for implementation, 1 man-month annually for maintenance

R Management Attention Required	Y Potential Management Attention Needed	G On Target

HWRF Upgrade Plan for 2016 Implementation

Multi-season Pre-Implementation

	Model upgrades	Physics and DA upgrades		Combined
	Baseline (H16C)	**Data Assimilation changes (H16S)**	**Physics changes (H16O)**	**H16O/H216**
Description	1. WRF-NMM V3.7.1a dynamic core with 1.a. retention of non-hydrostatic status during the nest movement; 1.b icloud=3 bugfix; 2. New GFS upgrade 3. Smaller time step	Hybrid GSI/HWRF EPS based DA	Assess impact of physics changes (Eddy Diffusivity Mass-Flux Scheme, scale aware SAS convection, update exchange coefficients, improved wind profile)	Baseline + DA changes + all physics changes + RTOFS initialization for EPAC + CPAC coupling + One-way coupling to Wave Model
Cases	Three-season 2013-2015 (and Hurricane Sandy) simulations in ATL/EPAC cases (~2000)	Only Aircraft DA cases for 2013-2015	Priority cases (~500 cases in each basin)	Three-season 2013-2015 (and Hurricane Sandy) retrospectives ~2000 simulations in ATL/EPAC/CPAC
Platform	WCOSS/Jet/Theia	WCOSS/Jet/Theia	WCOSS/Jet/Theia	WCOSS

2016 ATL Experiments

- **H215**: 2015 version of operational HWRF, 18/6/2km resolution, L61, input: T1534 L64 GFS (spectral files for both IC and BC);
- **H16B**: H215 driven by new GFS
- **H16C:** Baseline (new GFS, new WRF-NMM V3.7.1a dynamic core, smaller time step, grib2 BCs)
- **H16S:** H16C plus data assimilation upgrades
- **H16P:** Impact of CD
- **H16O**: H16S plus all physics upgrades – proposed **H216**
- **H16X: Additional levels (63) with damping at the top, new tracker, DA and RTOFS init for EP storms (rolled back to H16O; see next slide)**

Differences between H16X and H16O

Atlantic:

- Upgraded tracker; (rolled back)
- Two more vertical levels (L61 vs L63); (rolled back)

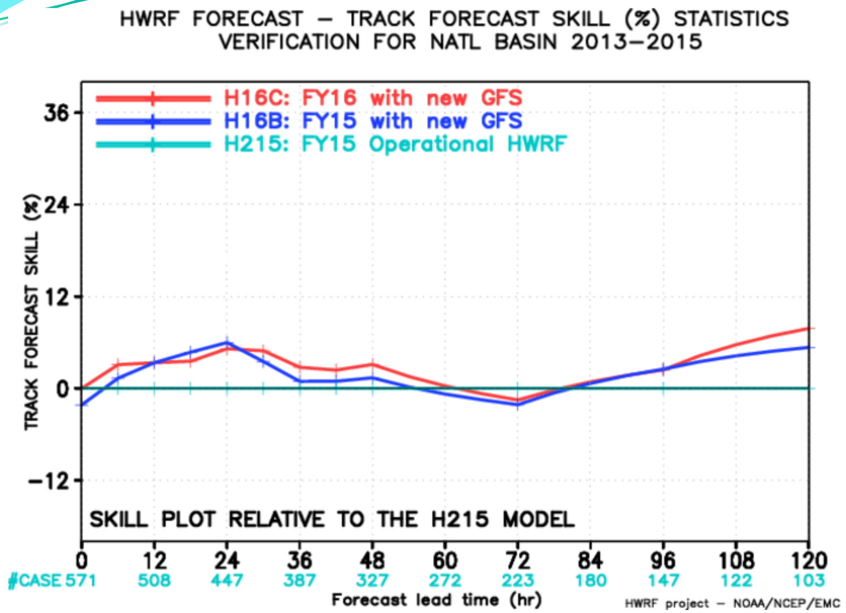
East Pacific:

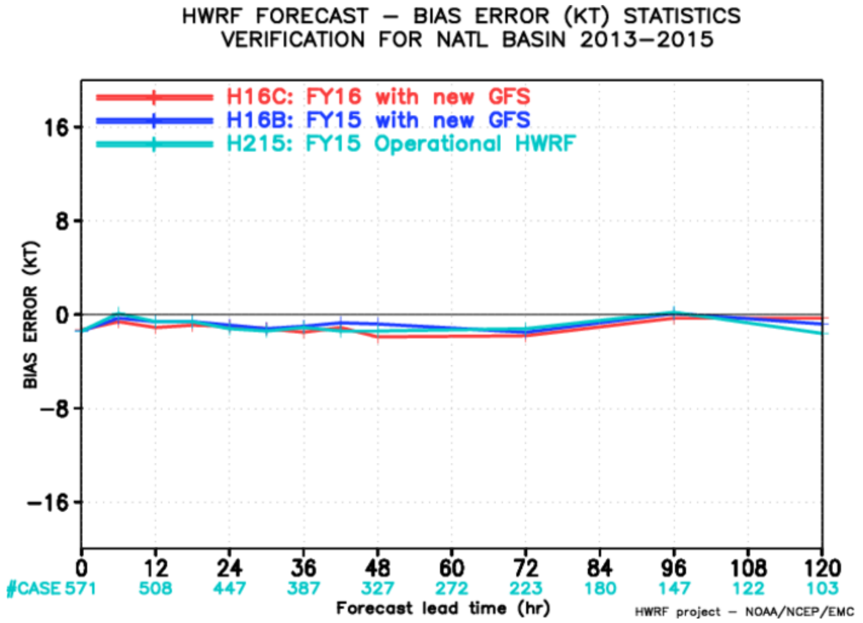
- RTOFS ocean initialization for EP storms;
- DA for all EP storms;
- Upgraded tracker; (rolled back)
- Two more vertical levels (L61 vs L63); (rolled back)

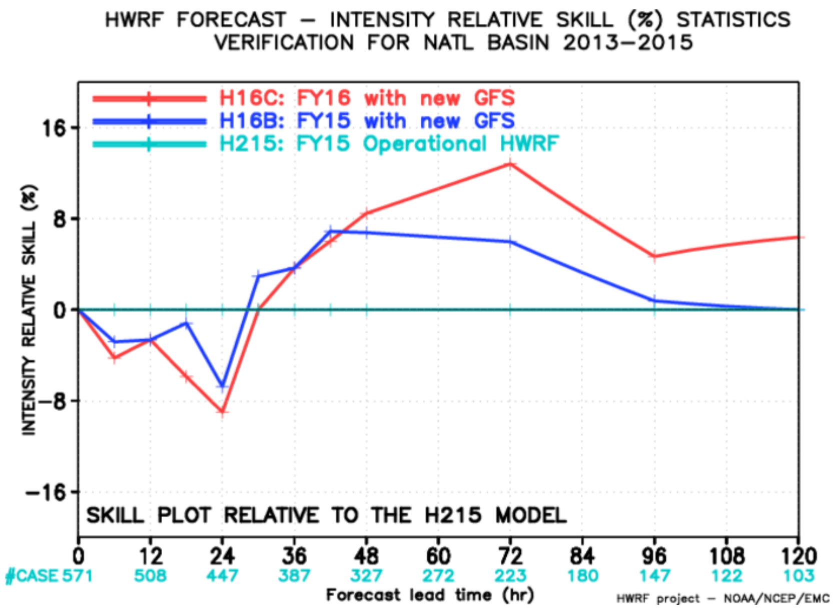
H16X with above changes is renamed as H216

Verification for Atlantic Storms (2012 Sandy, 2013-2015)

FY16 Baseline Performance in AL

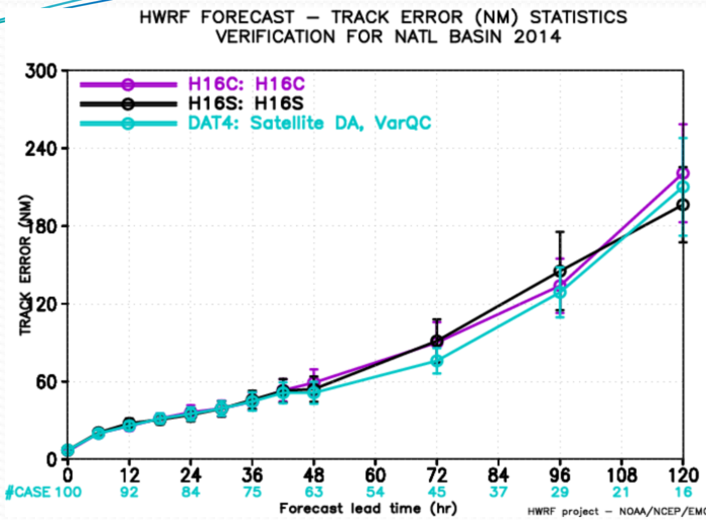


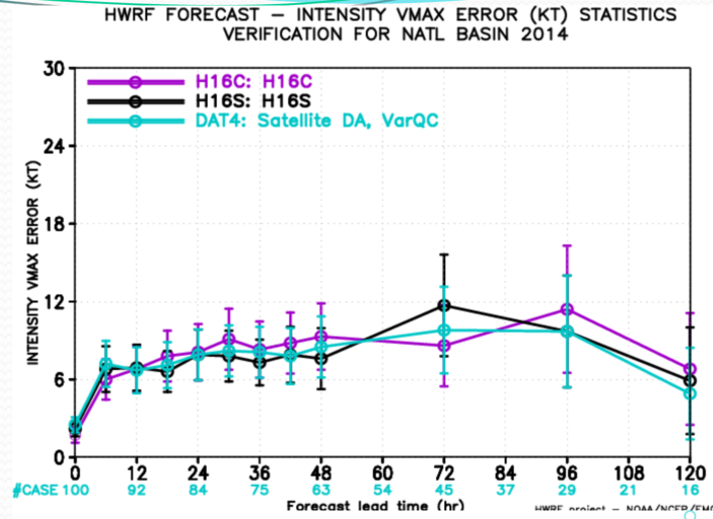


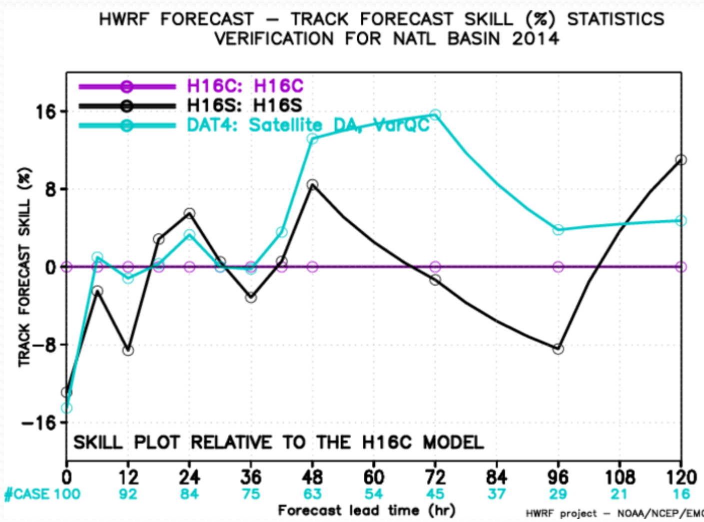


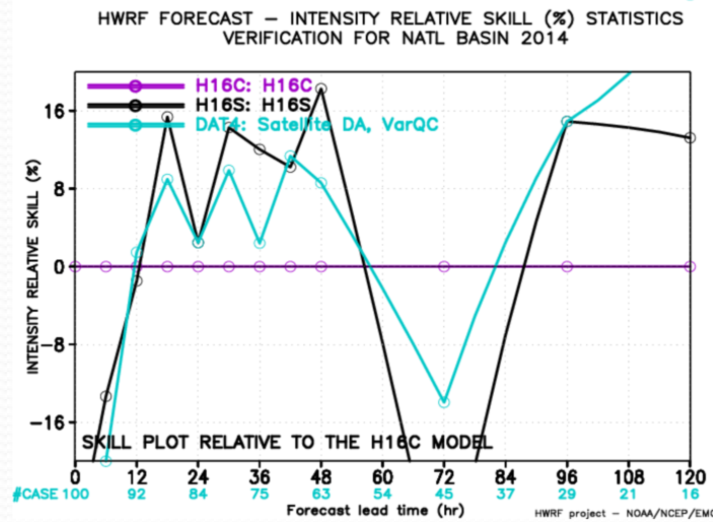
- Compared to H215, H16C track forecasts showed improvements for the first 36 hrs, and again beyond 84 hrs.
- Compared to H215, H16C intensity forecast indicated a degradation at 24h but significant improvements beyond hr 30.
- Compared to H16B, H16C intensity forecasts indicated positive impacts beyond day 2. Track skill is neutral.

FY16 Baseline plus Data Assimilation Impacts





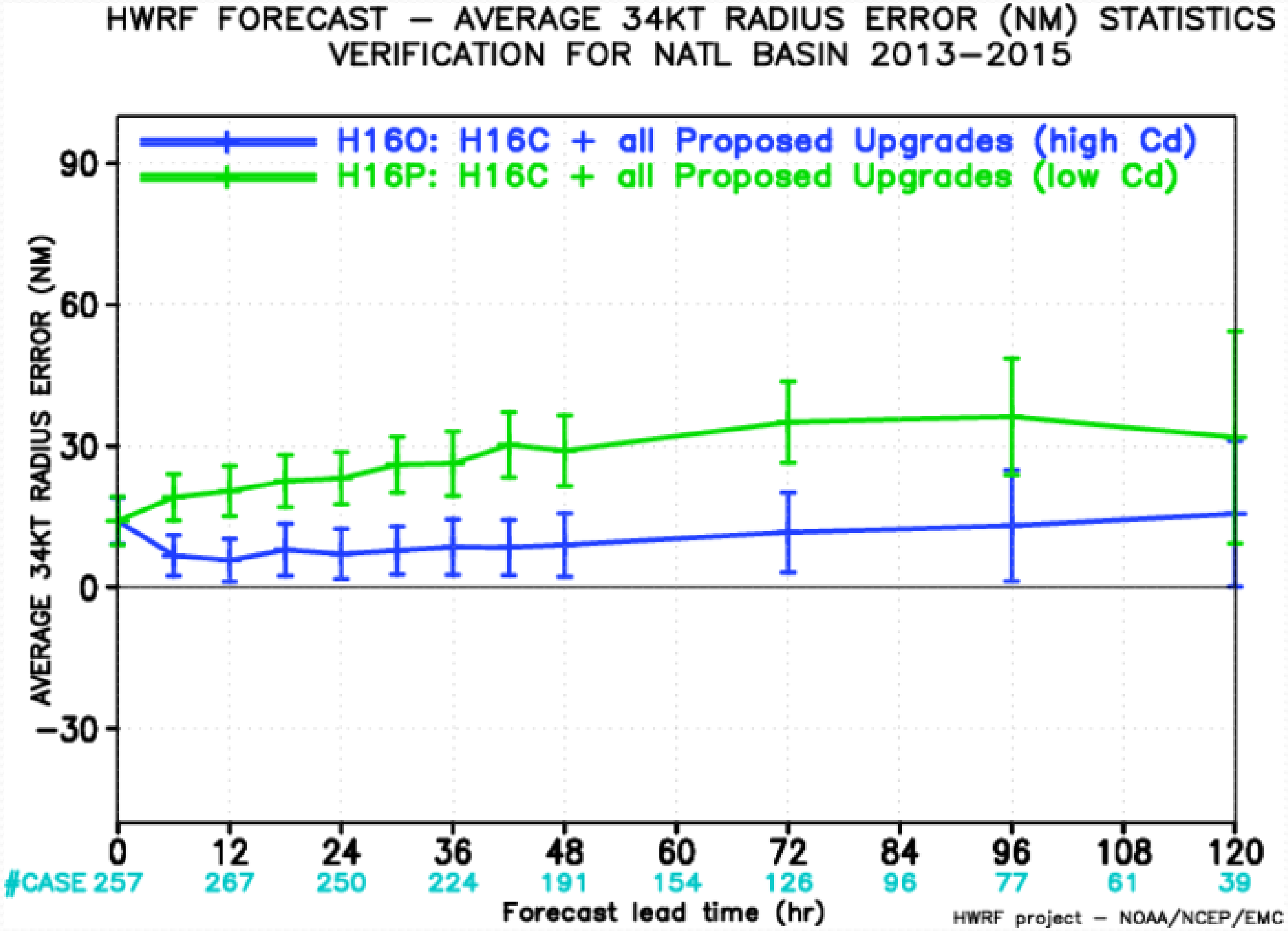




H16S: GSI data upgrades, Blending turned off for weaker storms
DAT4: Satellite DA for ghost d03 domain, VarQC turned on **(final)**

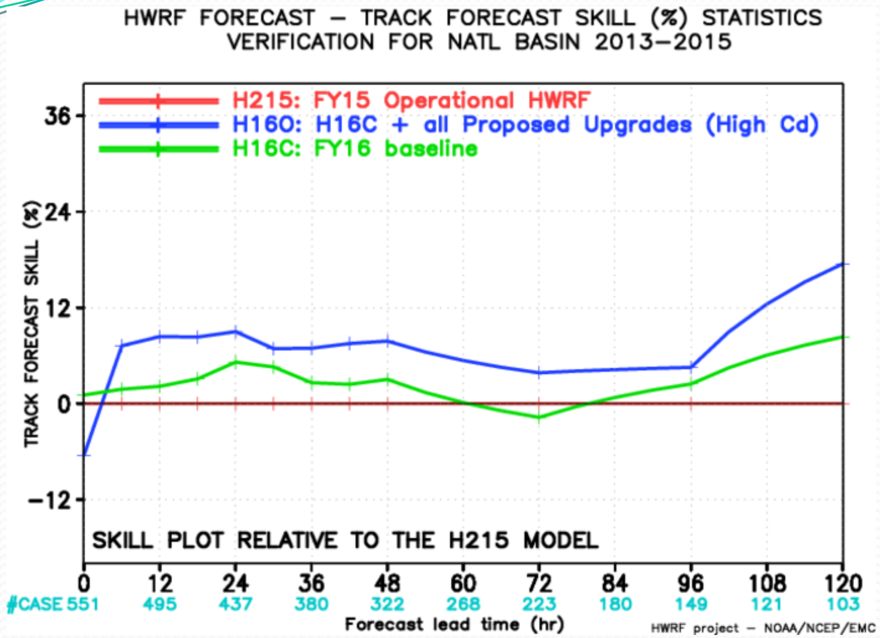
Impact: Much improved tracks with all DA upgrades, intensity is neutral

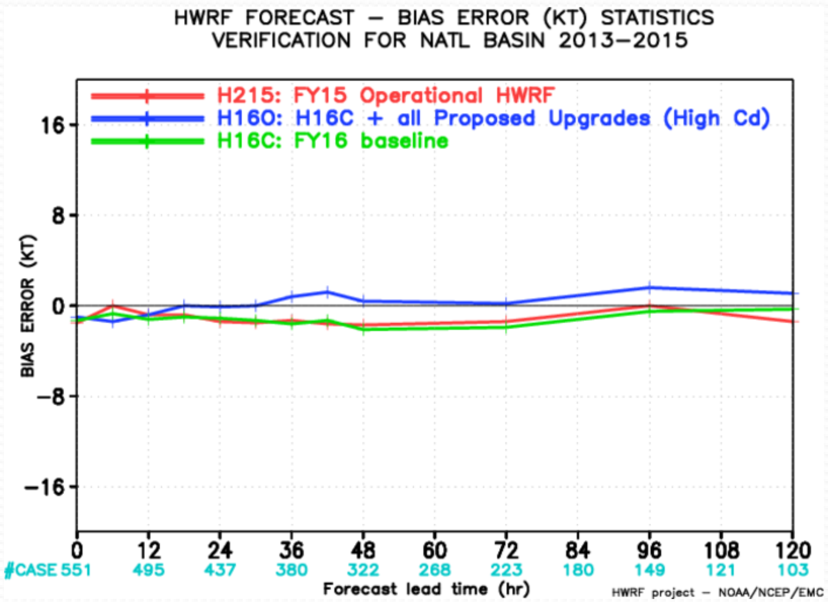
FY16: Impact of Physics Upgrades for AL

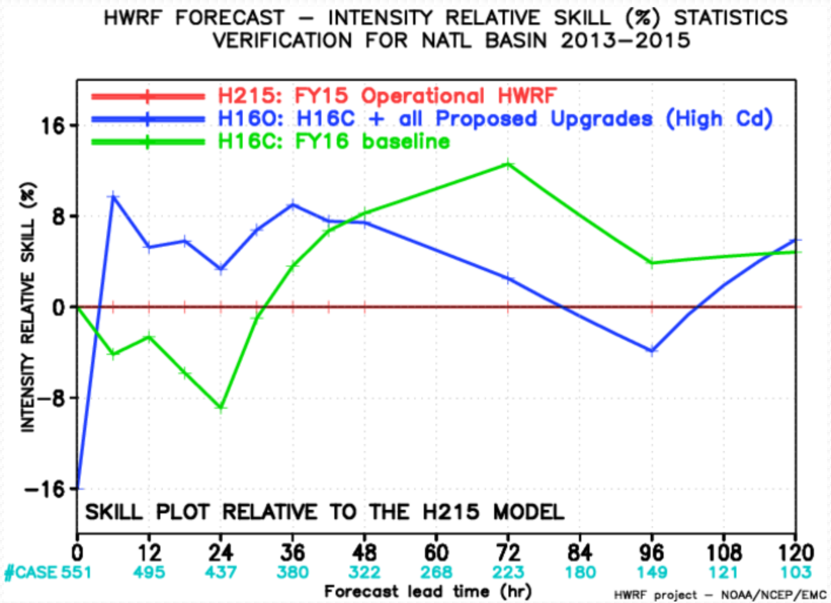


Two different settings for Cd were tested, the higher value of Cd resulted in improved storm size verifications, tracks and intensity are neutral

FY16: Impact of Physics Upgrades for AL

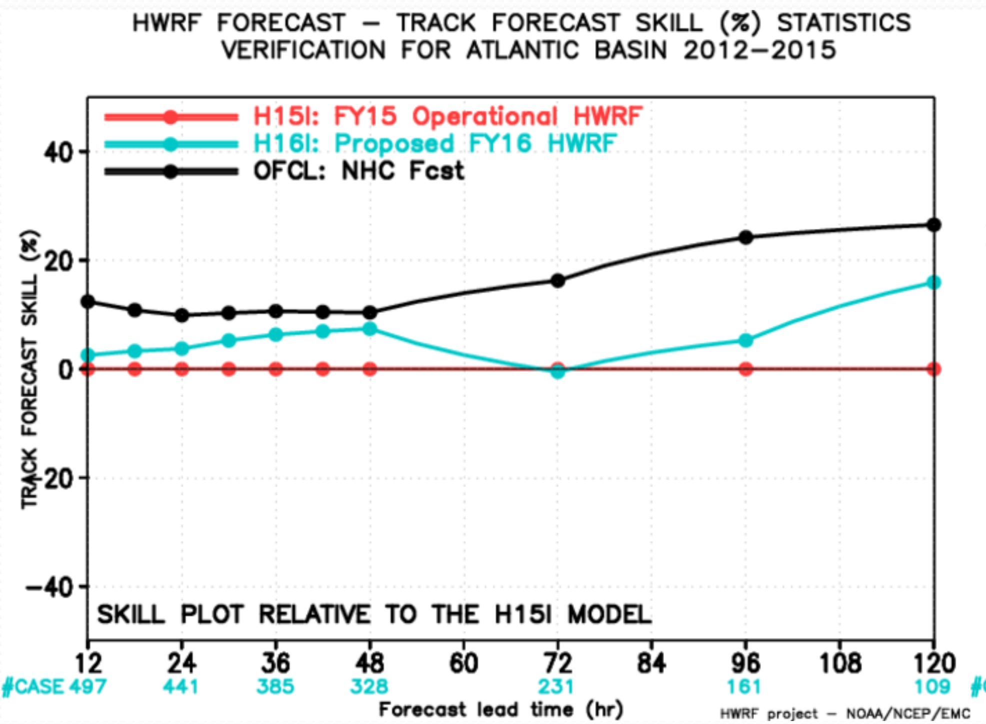


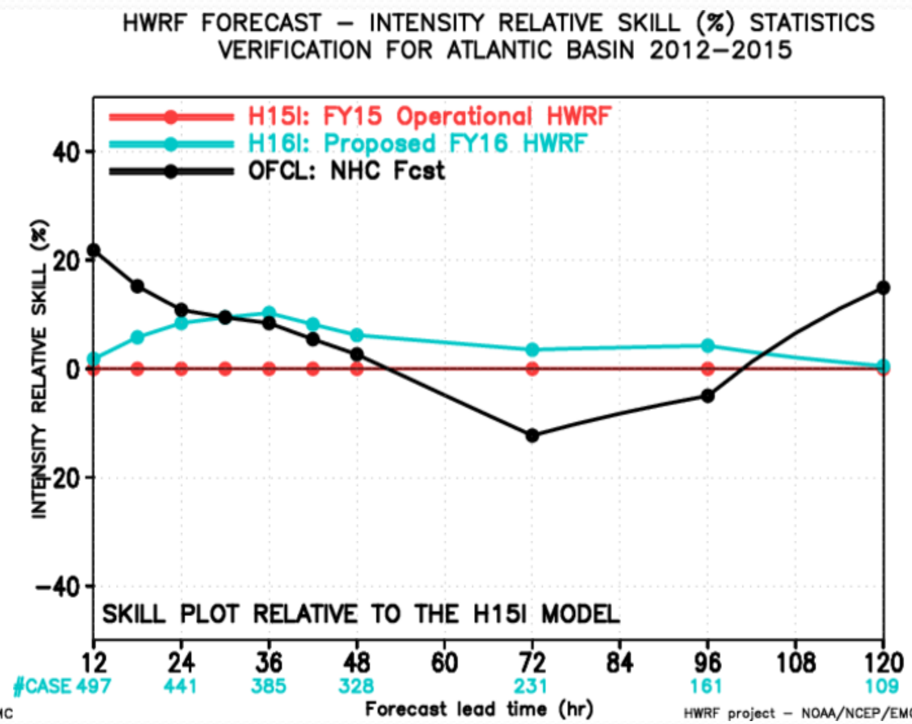




- Compared to H215 and H16C, H16O has improved track performance and also improved intensity skill for the first 2 days
- H16O also has a neutral to positive bias for intensity as compared to neutral to negative values for H215 and H16C
- **H16O provides the most improved configuration for NATL and is adopted as the H216 configuration for AL.**

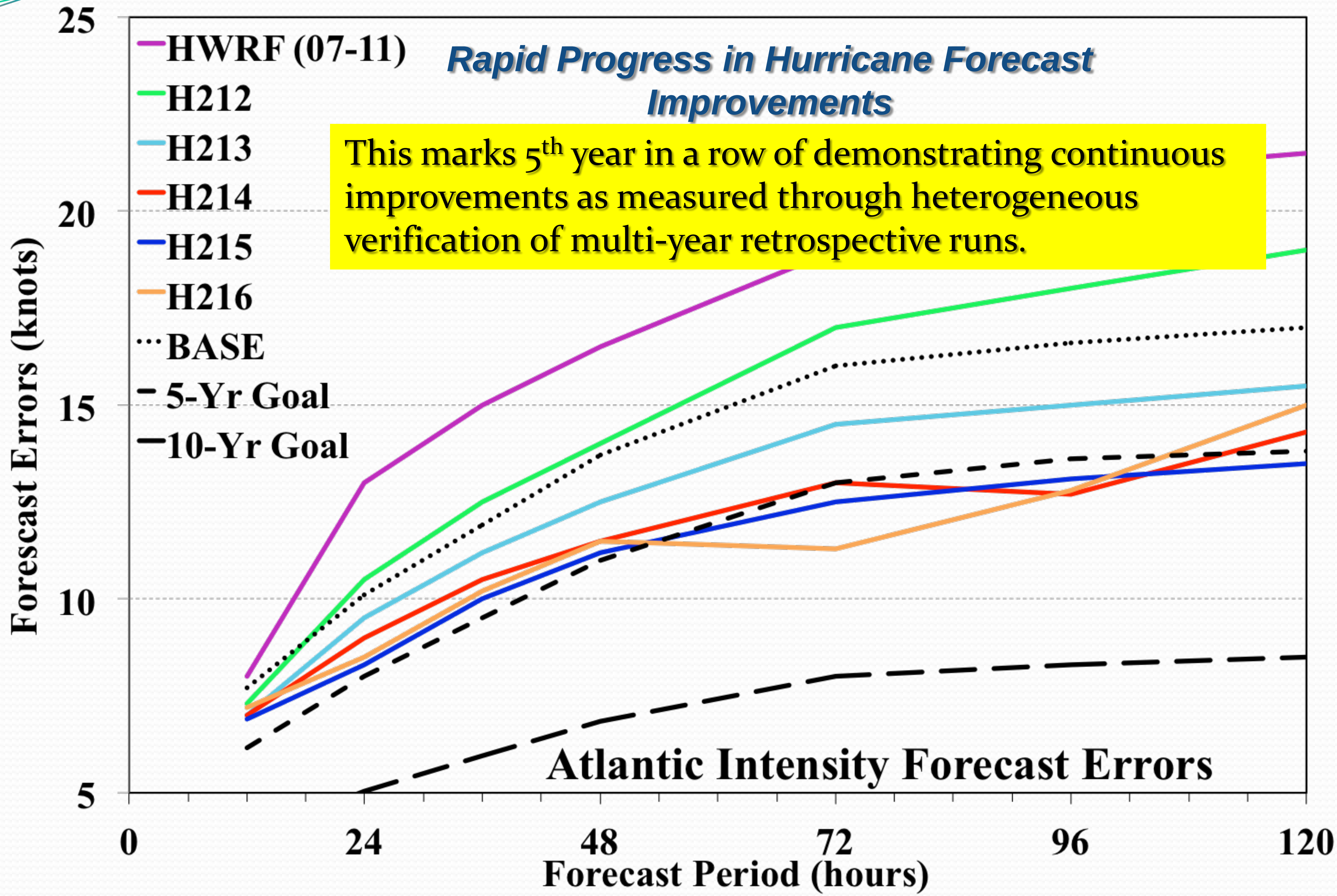
H216 performance compared to H15I in NATL



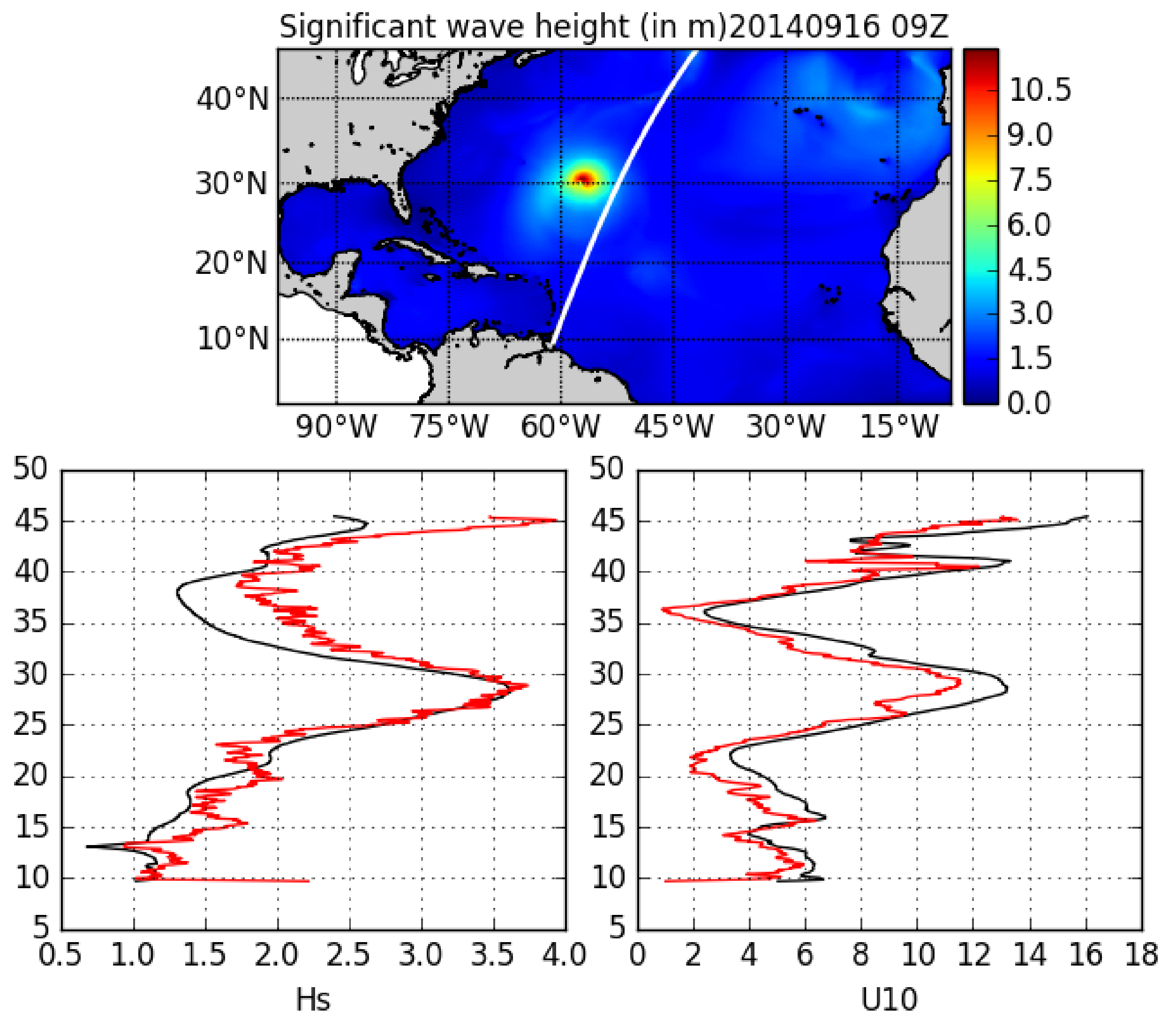


H216 shows improvements in both track and intensity as compared to H15I but still needs to catch-up to official tracks and intensity.

2016 HWRF: Continuing the trend of incremental but substantial improvements in NATL intensity forecasts



WAVEWATCH III results for Hurricane Eduardo (One way coupled)



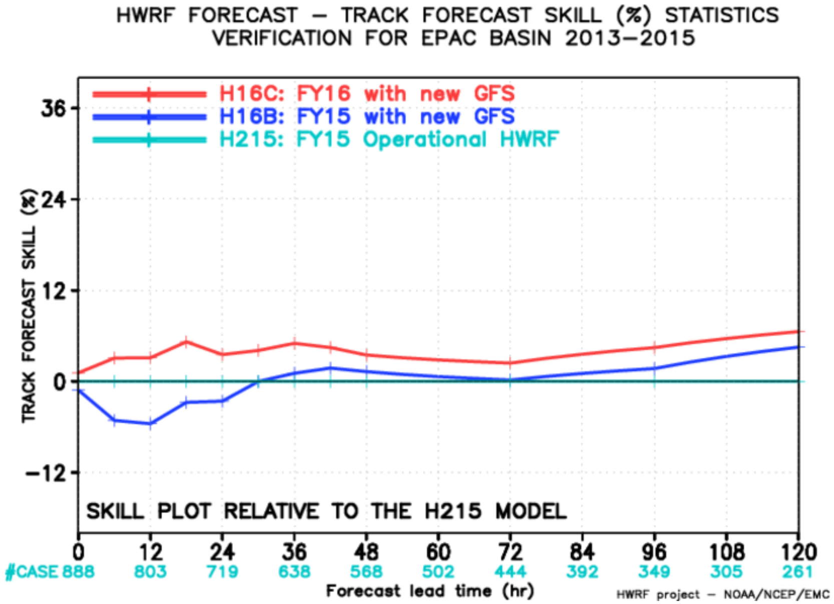
Red – Jason2; Black -- WAVEWATCH

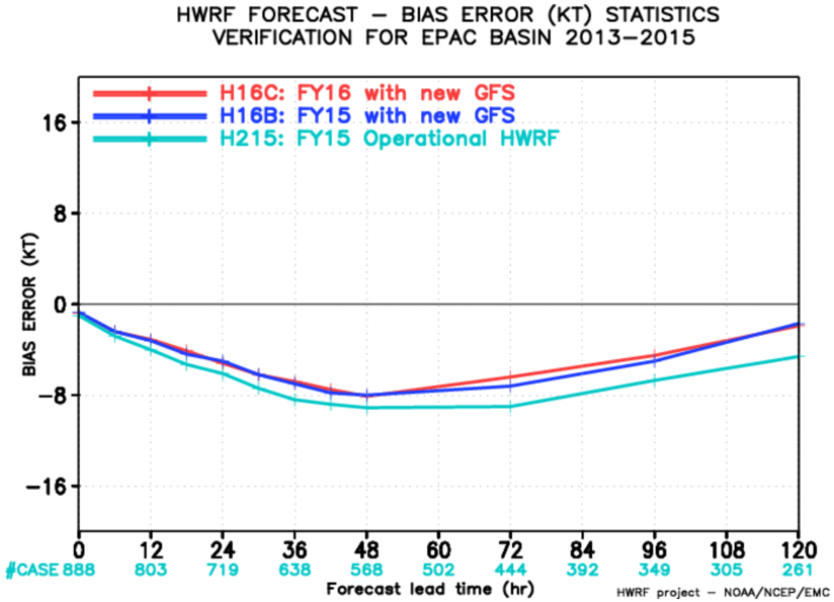
Verification for East-Pacific Storms (2013-2015)

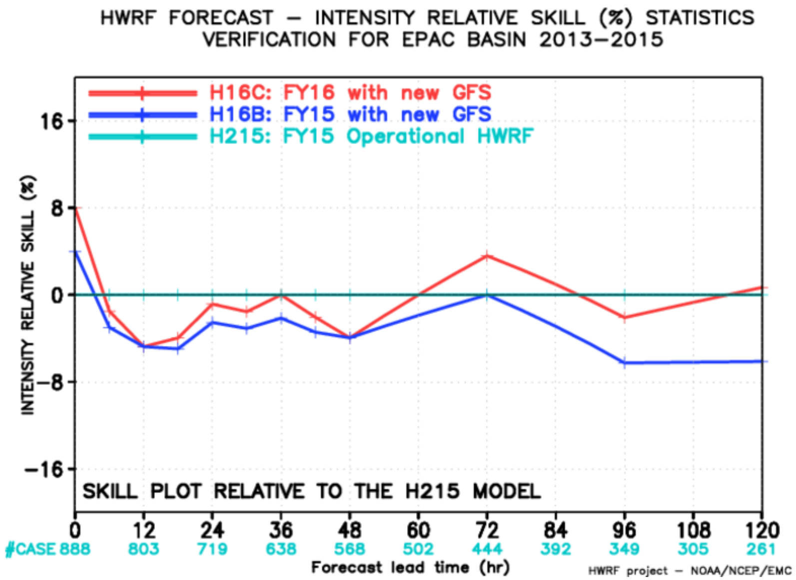
2016 EPAC Experiments

- **H215**: 2015 version of operational HWRF, 18/6/2km resolution, L61, input: T1534 L64 GFS (Spectral files for both IC and BC);
- **H16B**: H215 driven by new GFS
- **H16C:** Baseline (new GFS, new WRF-NMM V3.7.1a dynamic core, smaller time step)
- **H16P: H16C** plus physics changes
- **H16O**: H16C+H16P
- **H16X**: H16O+GSI+RTOFS init~~**+63levs+New Tracker**~~
- **H216: H16O+GSI+RTOFS Init**

FY16 Baseline Performance in EP

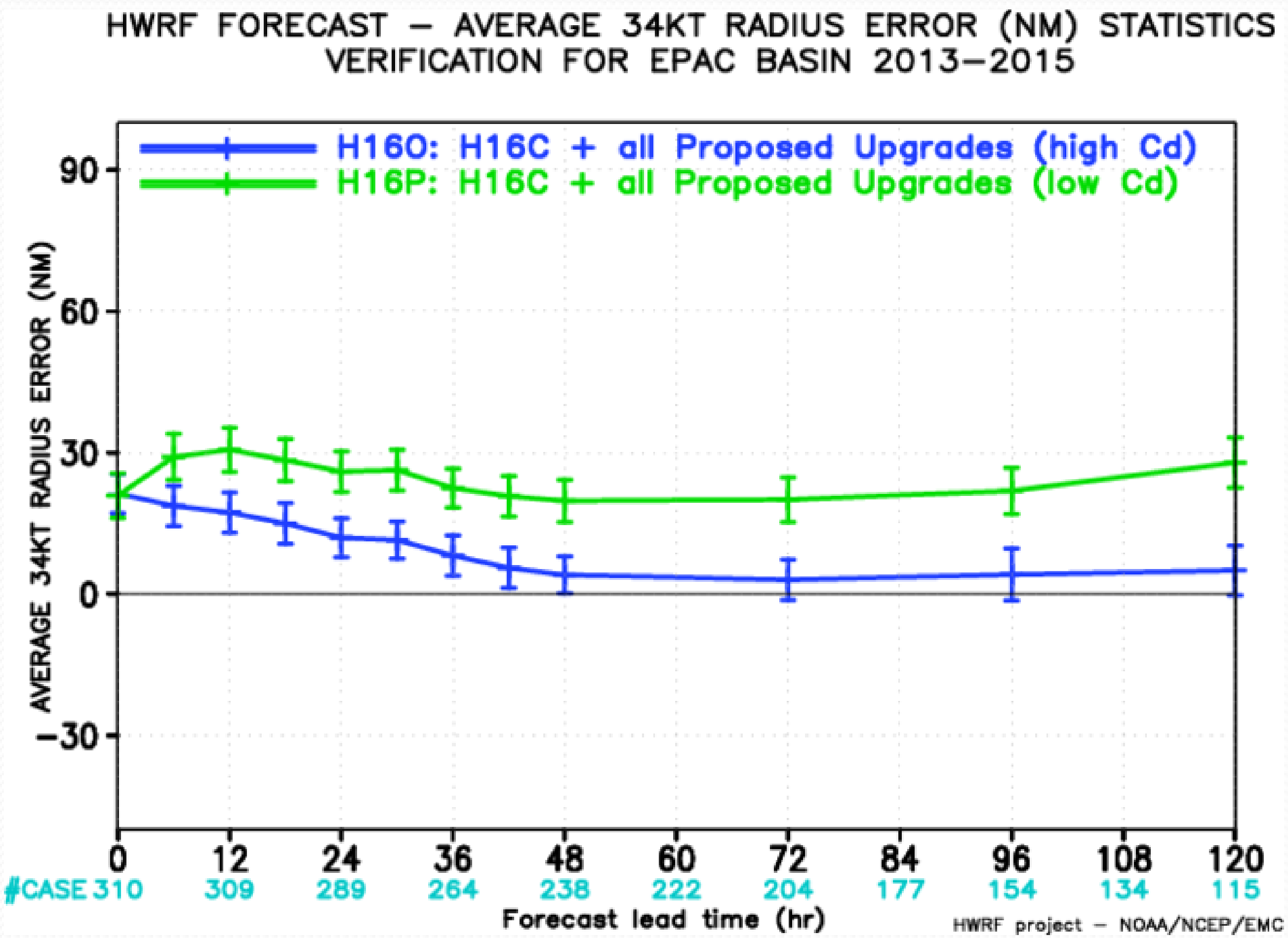






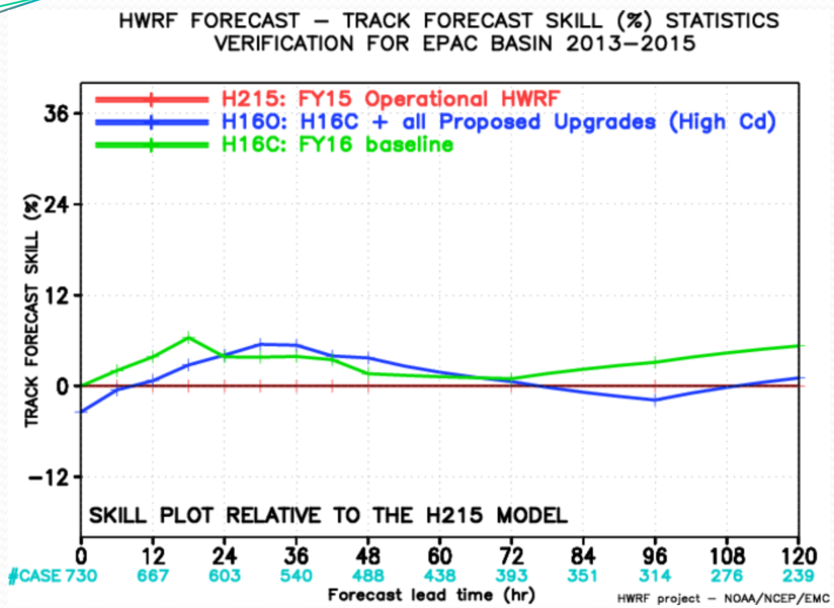
- H16C tracks are much improved over H215, but intensity impact is neutral
- Intensity bias shows some improvements compared to H215 across all forecast lead times.

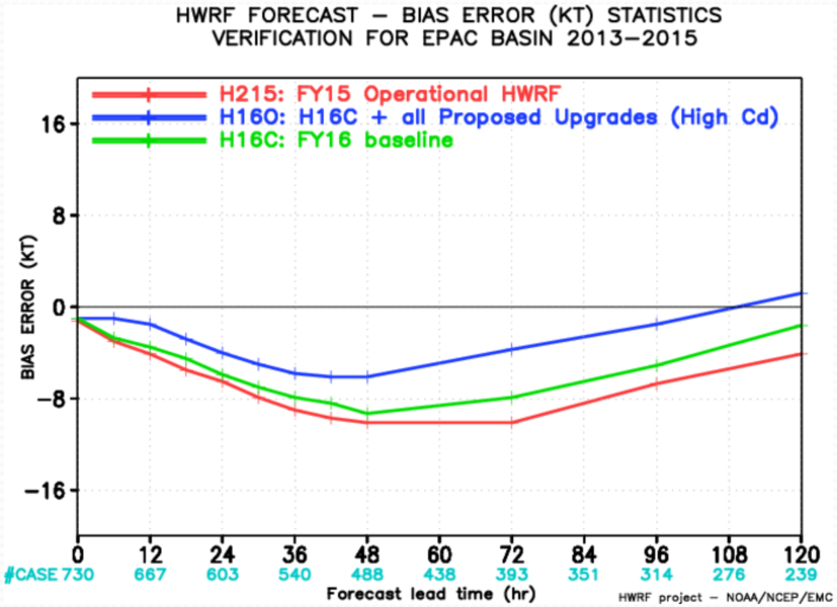
FY16: Impact of Physics Upgrades for EP

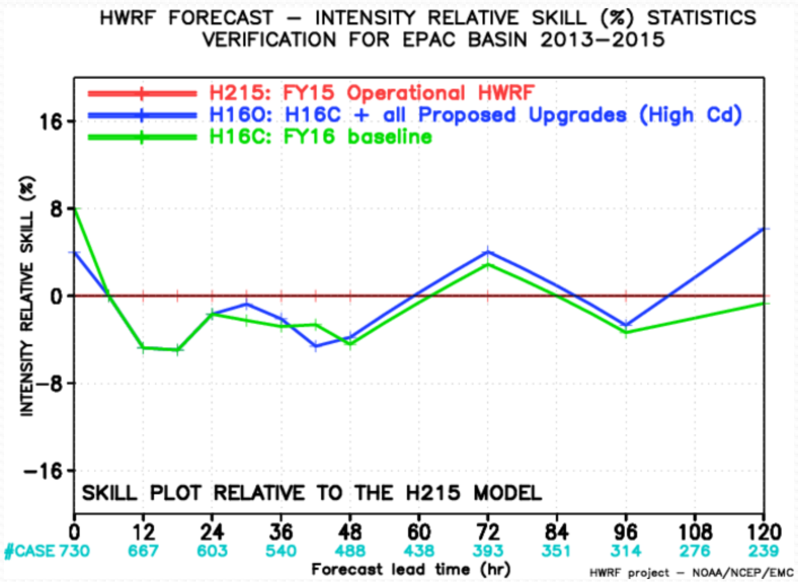


Two different settings for Cd were tested, the higher value of Cd resulted in improved storm size verifications, tracks and intensity are neutral (similar to AL results)

FY16: Impact of model upgrades for EPAC

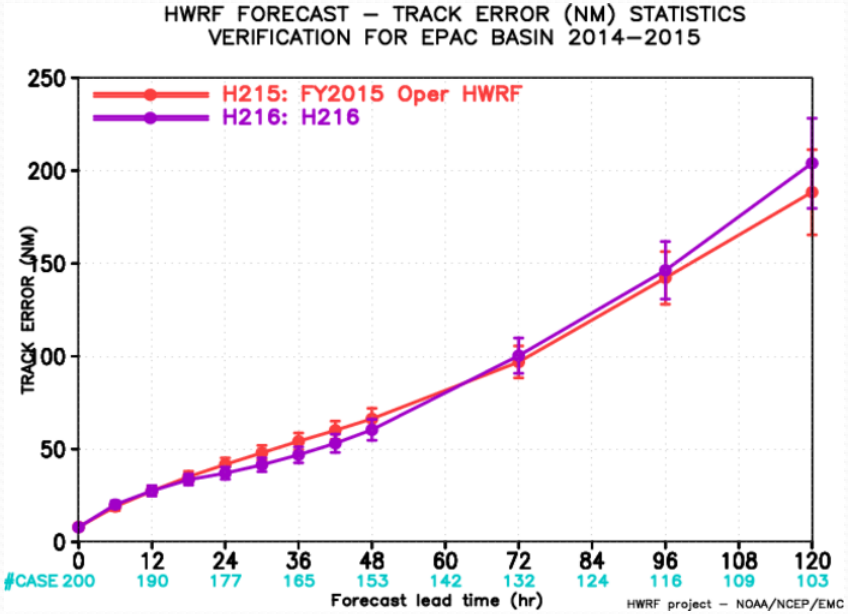


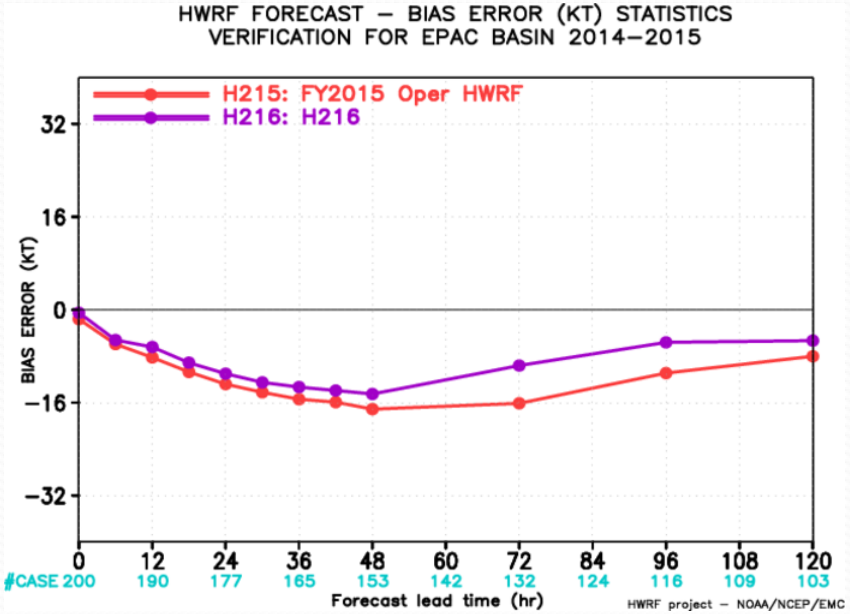


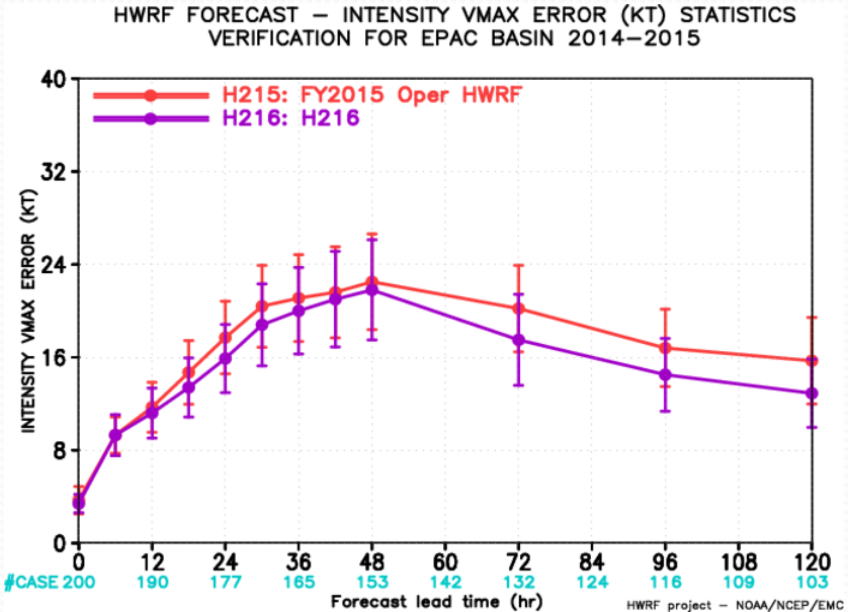


- Compared to H215, H16O has improved track skill in the first 3 days but the intensity is a little degraded.
- For days 4 and 5, both track and intensity skill is neutral.
- H16O has the best intensity bias measures compared to H215 and H16C
- **H16O provides an improved configuration for EP**

FY16: Impact of RTOFS Initialization and GSI on RI cases

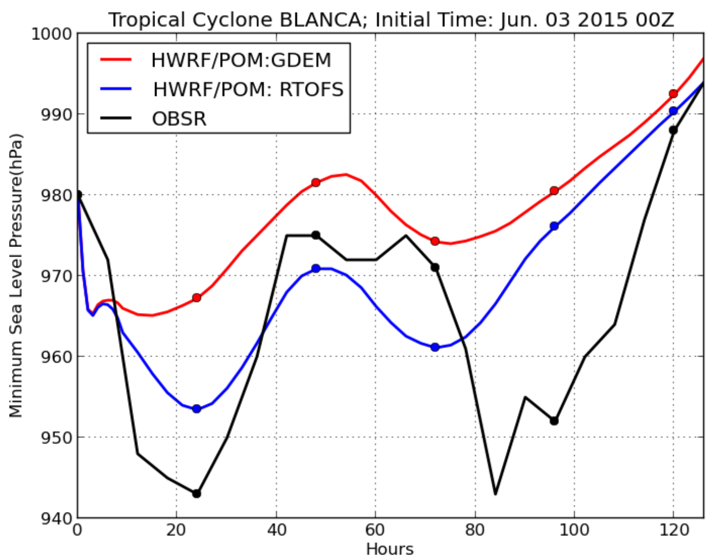


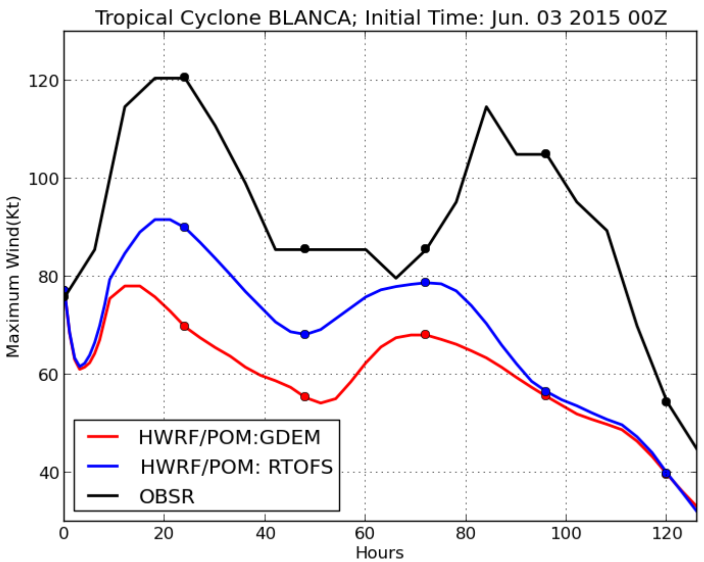


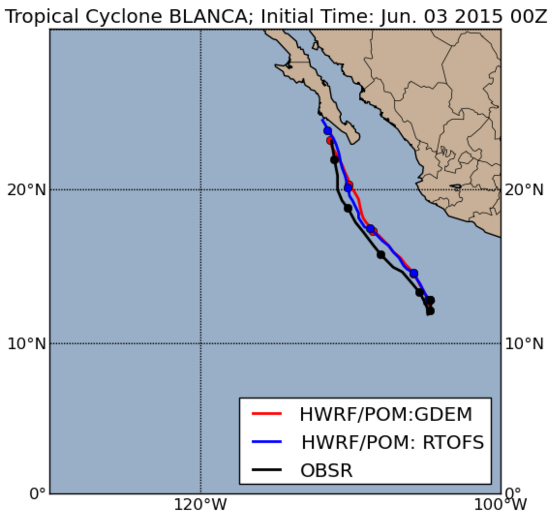


- For RI cases in EPAC, DA and RTOFS initialization of MPIPOM gave improved performance for intensity skill after the first few hours (both error and bias). Impact on track is neutral.
- Results very similar to GFDL

FY16: Impact of RTOFS Initialization on Blanca: Initial time Jun 3, 2015 00Z

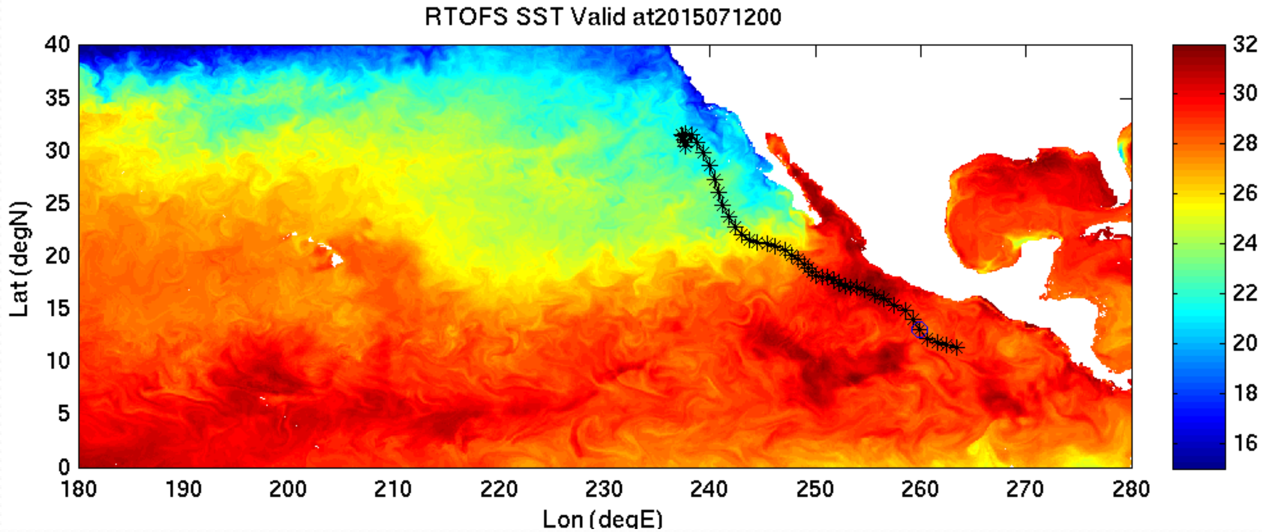




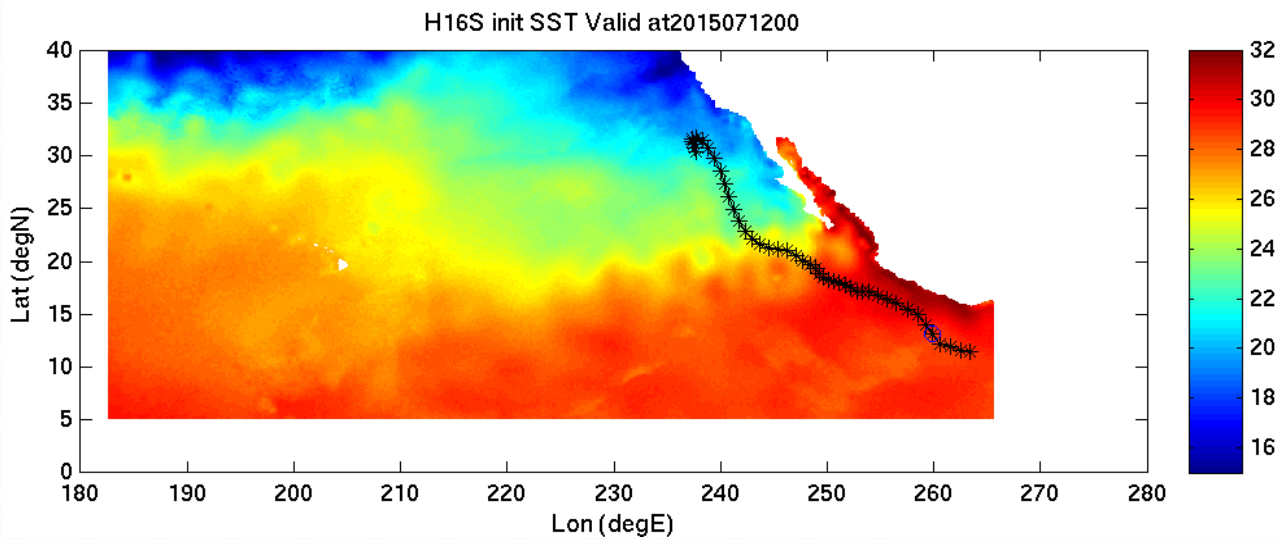


Difference between RTOFS and GFS SST for 2015071200Z (Dolores)

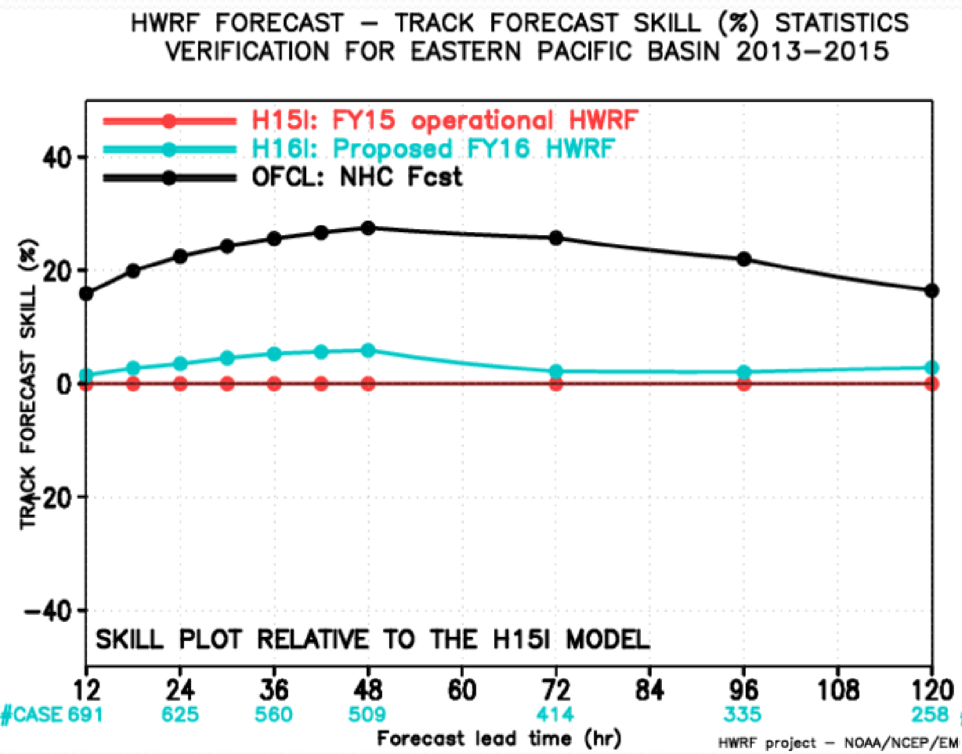
For RTOFS first model level, ~0.5m depth

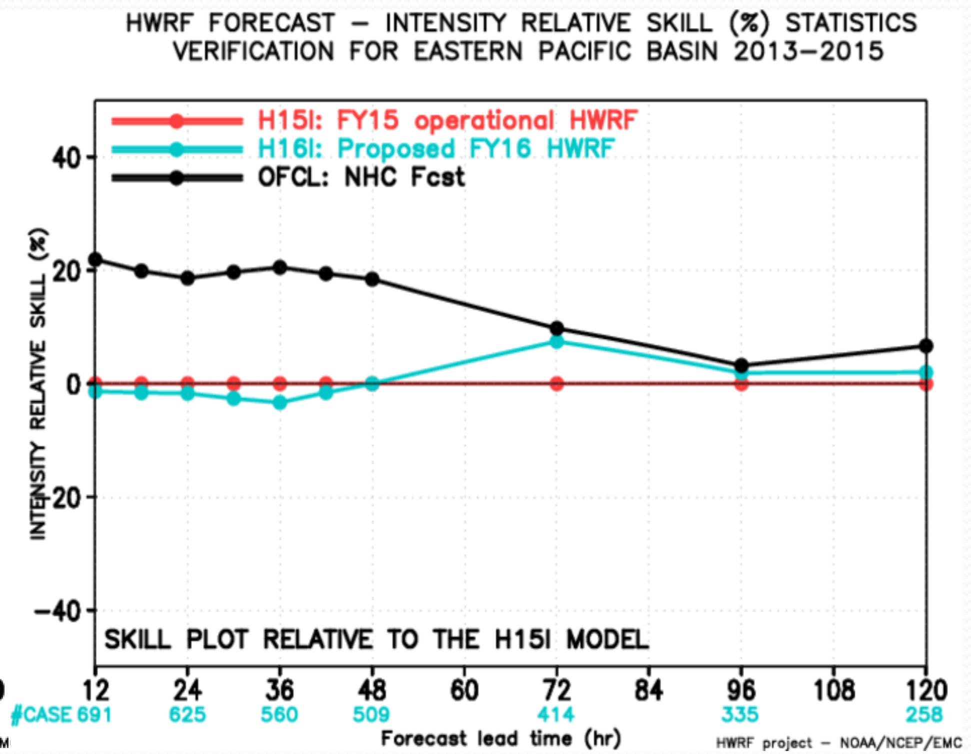


For MPIPOM first half-sigma model level, varying from ~0.1 to ~5 m depth



H16I performance compared to H15I in EPAC





H16I exhibits improvements over H15I in track but is poor compared to official tracks. Intensity is neutral to positive after 48 hrs.

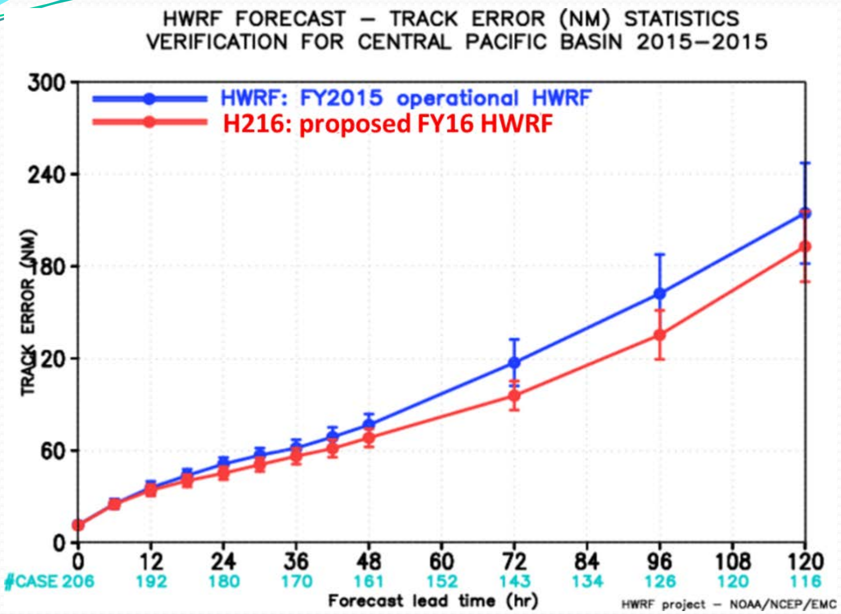
Verification for 2015 Central Pacific Storms

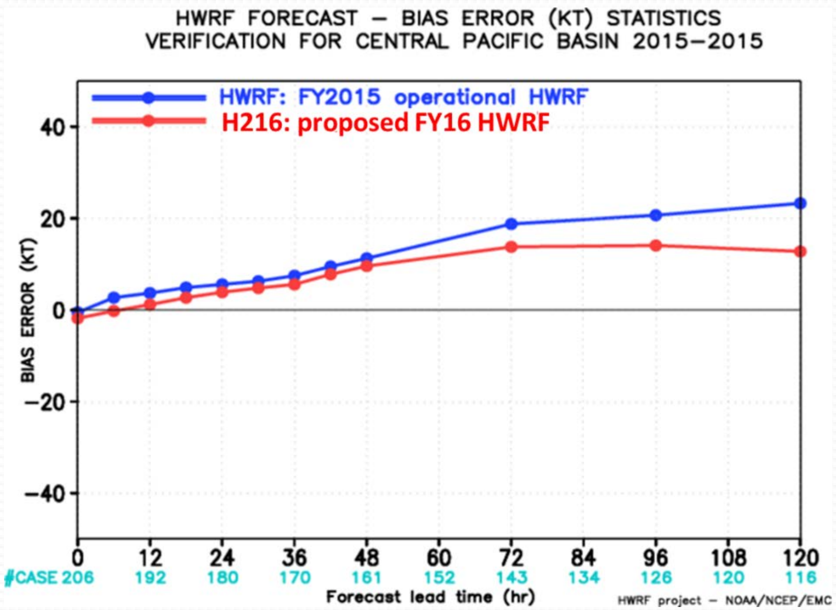
2016 CPAC Experiments

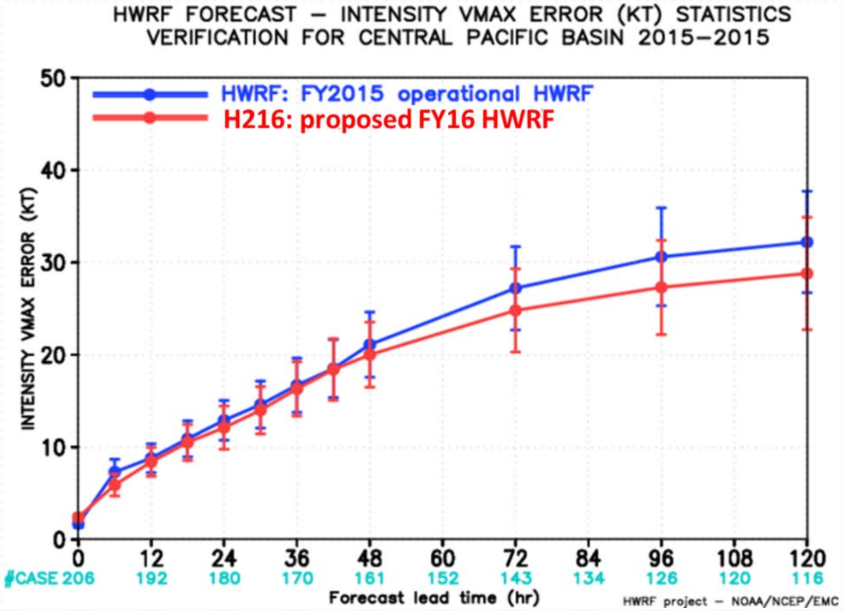
- **H215**: 2015 version of operational HWRF, 18/6/2km resolution, L61, input: T1534 L64 GFS (Spectral files for both IC and BC);

- **H216**: All upgrades + coupling to MPIPOM (GDEM climatology) for CPAC

H216 performance compared to H215 in CPAC







- H216 (final configuration) shows significant improvements in both track and intensity performance especially after 2 days.
- H216 also exhibits reduced positive intensity bias after 2 days.

Operational HWRF Configurations: 2015 (top) vs. 2016 (bottom)

Basin	Ocean	Data Assim	Ensemble	Vertical	Model Top
NATL	3D POM GDEM	Always	TDR Only	61 level	2 mbar
EPAC	3D POM GDEM	TDR Only	TDR Only	61 level	2 mbar
CPAC	None	None	None	61 level	2 mbar
WPAC	None	None	None	43 level	50 mbar
NIO	None	None	None	43 level	50 mbar
SIO	None	None	None	43 level	50 mbar
SPAC	None	None	None	43 level	50 mbar

Basin	Ocean	Data Assim	Ensemble	Vertical	Model Top
NATL	3D POM GDEM	Always*	TDR Only†	61 level	2 mbar
EPAC	3D POM **RTOFS**	**Always***	TDR Only†	61 level	2 mbar
CPAC	**3D POM GDEM**	None	None	61 level	2 mbar
WPAC	None	None	None	**61 level**	**2 mbar**
NIO	None	None	None	**61 level**	**2 mbar**
SIO	None	None	None	43 level	50 mbar
SPAC	None	None	None	43 level	50 mbar

Summary

- Further enhancements suggested for 2016 operational HWRF include:
  - Upgrade model physics consistent with observations, improve surface physics, convection and PBL, improved GSI and ocean init for EP
- H216 retrospective evaluation of 2012-2015 hurricane seasons (total 571 verifiable cycles in NATL, 888 in EPAC, 206 in CPAC) demonstrated improved forecasts compared to both FY15 operational HWRF (H215) and baseline FY16 driven by new GFS (H16C);
- Results from H216 for the Atlantic basin and the Central Pacific suggested additional 5-10% improvement compared to H215.
- Results from H216 for the Eastern Pacific basin suggested a modest (~5%) improvement in intensity forecasts is shown possible from 2015 operational HWRF. Use of DA and RTOFS for ocean initialization should help in RI cases.

Summary

- Evaluation metrics in the skill space confirmed the positive improvements from H215.
- High-resolution ensemble based TDR DA paves way for the next generation vortex scale DA efforts supported by HFIP, while bringing immediate benefits in the operations.
- Centralized HWRF Development Process for both research and operations with community involvement is critical for making further enhancements.
- Use of ecflow in development environment accelerates the transition of model upgrades to operations
- Seek more direct engagement of HFIP supported researchers for active participation in model evaluation, enhancements and future R2O.
- Full credit to the entire HWRF team for another successful execution of pre-implementation T&E for implementing improved HWRF model in operations.

NHC Evaluation and Recommendations

The National Hurricane Center strongly endorses the implementation of new versions of the GFDL Hurricane Model and the HWRF model for 2016. Retrospective runs of these models for the 2013, 2014, and 2015 hurricane seasons mostly show improvements to track and intensity forecasts. For the HWRF, the improvements were as large as 7 percent for 1-5 day track forecasts in the Atlantic basin. We look forward to receiving this improved guidance for our operations, and **would like to see these models implemented as early in this year's hurricane season as possible.**

Dr. Richard J. Pasch
Senior Hurricane Specialist ,
National Hurricane Center

What it takes in operations to run 2016 HWRF

- Resource requirements:
  - FY16 HWRF H216: ~3x increased resources are needed for large nest domains, smaller time step, DA changes (atmosphere & ocean), wave coupling, and ocean coupling for additional basins, ~1512 cores or 63 nodes on Cray;
  - Run maximum seven storms in all global basins simultaneously.
  - No changes in delivery time (before t+6);

FY16 HWRF Computer Resource Requirement

JOBS	Computer Resources	Run Time	Starting Time
JHWRF_PRE_MASTER	1 core/2GB (1 core/2GB)	<1min	T+3:20 (T+3:20, first GFS grib2 analysis available)
JHWRF_WAVE_INIT (new)	1 node (24cores/2GB)		
JHWRF_OCEAN_INIT	24 cores (9 core) POM RTOFS init	~12min (~22min)	
JHWRF_INIT (Step 1) (WPS+PREP+REAL+ 3DVAR_ANALYSIS)	96 cores (48 cores)	~13min (several jobs combined) (~10min)	T+3:20 (GFS GRIB2 available) Run continuously until gfs 126h grib2 file is available
JHWRF_INIT (Step 2) (PREP+REAL+ 3DVAR_ANALYSIS)	96 cores (48 cores)	~33min (several jobs combined) (~45min)	T+4:09 (one by one continuously until gfs 126h grib2 file is available)
JHWRF_INIT (GDAS) 3 GDAS jobs run simultaneously	3 copies of 96 cores (48cores)	~13min (~8min)	T+3:24 (gdas 3,6,9h fcst available)
JHWRF_RELOCATE 3 relocate run simultaneously	3 copies of 1 nodes (24 cores)	~34min (~25min)	

Red: Last year resource requirement; Green: Jobs submitted simultaneously.

FY16 HWRF Computer Resource Requirement

JOBS	Computer Resources	Run Time	Starting Time
JWHRF_NMM_GSI_D2	5 nodes (4 nodes)	~14min (~18min)	Run parallel with GSI_D03
JWHRF_NMM_GSI_D3	10 nodes (8 nodes)	~14min (~18min)	Run parallel with GSI_D02
JHWRF_MERGE	1 node (1 node)	~5min (~3min)	
JHWRF_FORECAST (Coupled or Un-coupled)	1512 cores (508 cores) 63 nodes (22 nodes)	~95min (~95min)	T+4:19min (T+4:16) Forecast to finish by T+5:54
JHWRF_POST Run parallel with forecast job	2 copies of 24 cores (24 cores)	~100min (~100min)	We need to run 2 copies due to I/O speed variation
JHWRF_PRODUCTS tracker, swath and others	2 nodes (1 node)	~101min (~101min)	Run in parallel with forecast job ATCF Forecast delivered by T+6:00
JHWRF_OUTPUT Archiving hwrf output	1 node (1 core) due wave coupling	~9min (~9min)	
JHWRF_GEMPAK	1 cores (1 core)	~2min (~2min)	T+6.09 (T+6:00)

Computer Resource Requirement for HWRF-ensemble Based Data Assimilation HWRF V10.0.0, Q4FY16

J-job name	Job Description	Current Resource requirement (w/ T1534 GFS)	New Resource requirement
JHWRF_ENSEMBLE	HWRF Ensemble 6h forecast from Global EnKF analysis. 40-member 2-nest domain(18/6)	Each possible storm (for AL/EPAC basins) requires: 3 nodes each for 40 independent jobs for 30 min. 10 simultaneous ensemble runs will take 2 hrs to complete all 40 members	Can start at T+7:02 to be completed by T+9:30

IT Testing

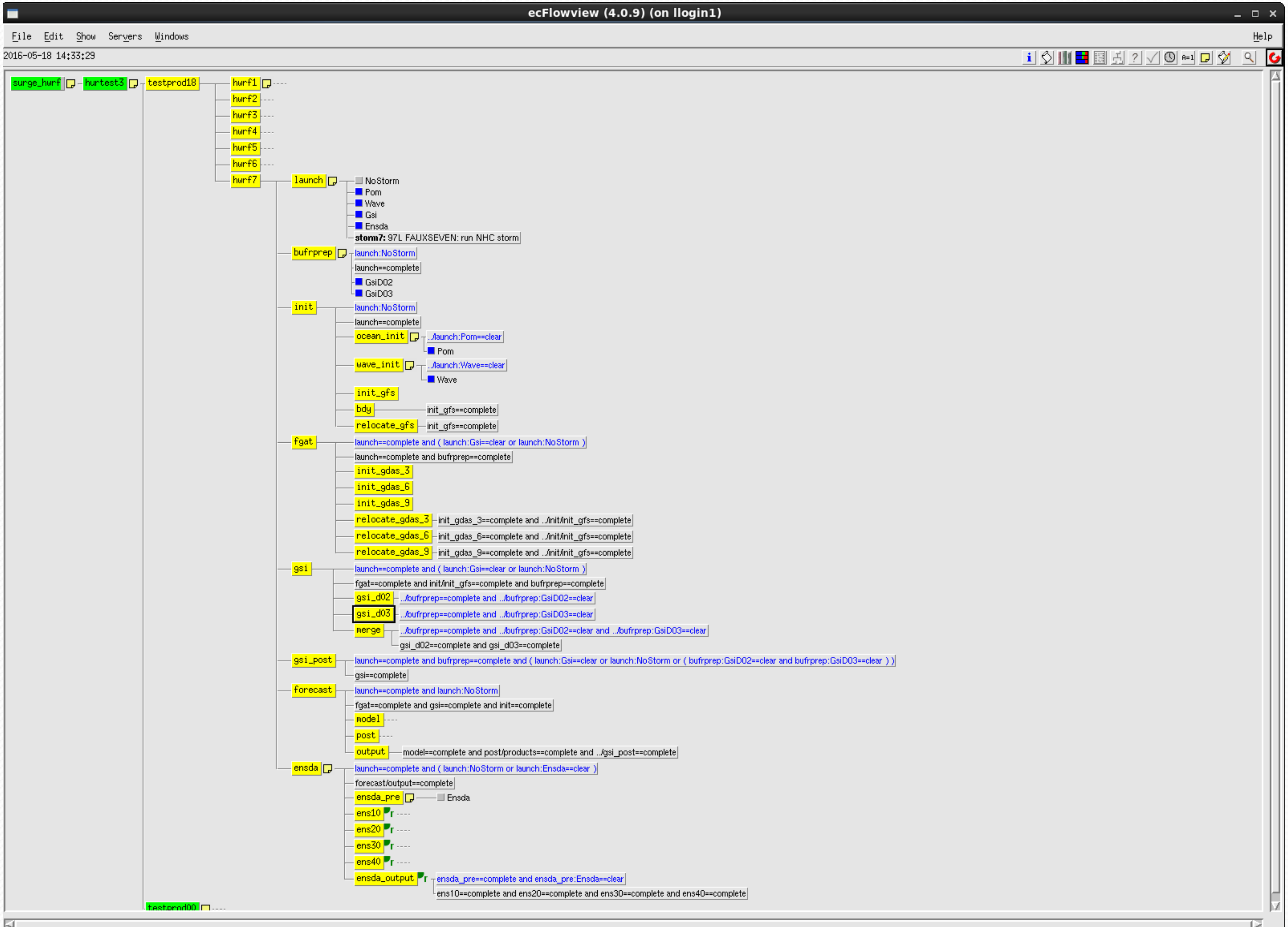
Test Objective	Comment
Missing GDAS EnKF members (total 80 mem)	if Nmissing >= 40, hybrid EnKF/GSI else conventional GSI
TDR (Tailed Doppler Radar) test	GSI will be done w/wo TDR for D03
Missing ICs from GDAS data	HWRF fails with proper error message
Missing BCs from GFS data	HWRF fails with proper error 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	Operational failure of 20160112 12/18Z

Use of ecFlow for accelerated transition to operations

To reduce SPA work, EMC has put HWRF in ecFlow:

- Most of SPA work in past years has been transitioning workflow due to the complexity of HWRF's dependencies and needed ecflow events.
- Entire system is in ecFlow now.
- Events and triggers in scripts are tested.
- Everything was tested in NCO directory structure and as close as possible to NCO environment

Use of ecFlow for accelerated transition to operations



Code Hand-Off and Release Notes

- Release Notes (includes dependencies for ocean coupling); HWRF setup; triggering for HWRF ensembles
- IT testing
- Implementation instructions
- Workflow diagram

SVN Tag for HWRFV10.0.0 (entire system):

https://svnemc.ncep.noaa.gov/projects/hwrf/branches/hwrf.v10.0.0

Next Steps

1. Retrospective T&E at EMC: **May 6, 2016 --- Completed**
2. Briefing to NHC: **May 11, 2016 ----- Completed**
3. NHC Evaluation and Recommendations: **May 16, 2016 -- Completed**
4. Briefing to EMC and CCB: **May 18, 2016 --- Now Completed**
5. Submission of Codes to NCO: ***May 20, 2016 --- Code Hand-Off, Submission of RFC form, release notes and flow diagram in progress***
6. TIN for HWRF : **June 1, 2016**
7. NCO IT Testing and Code Freeze: ~**June 27, 2016 (six weeks after code hand off)**
8. Briefing to NCEP Director's Office: ~**June 30, 2016 ???**
9. Implementation by NCO: **July 5-6, 2016**

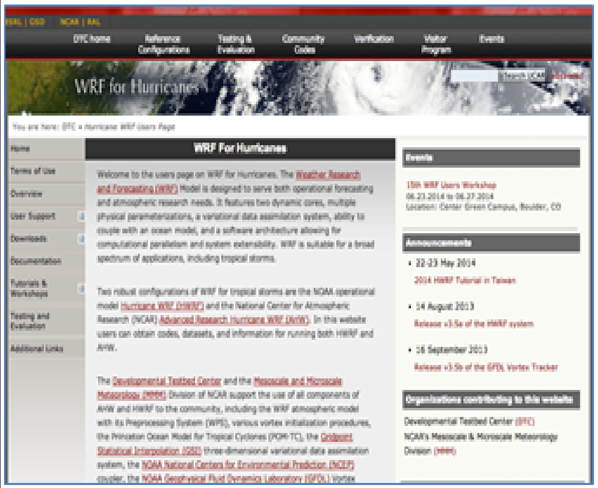
HWRF as a unique global tropical cyclone model

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