

Pre-implementation T&E of proposed upgrades for 2013 HWRF

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and HWRF team

HFIP telecon 04/10/2013

Features of Planned 2013 HWRF upgrades

Infrastructure upgrades:

- Upgrade the **nest tracking algorithm** based on NCEP tracker
- Re-design of **nest-parent interpolations** for improved treatment of nest boundaries
- **Increased frequency of physics calls** (from 180 sec. to 30 sec.) and **increased size of the third domain** (from 5°x5.5° to 6°x6.5°)

Data Assimilation and Vortex Initialization upgrades:

- Implement HWRF GSI V3.2 **one-way hybrid EnKF-3DVAR data assimilation** with GDAS forecasts as first guess and 80-member GFS EnKF forecasts for ensemble covariances, assimilation of all conventional data and provision **to assimilate real-time inner-core TDR/ FL/SFMR/Dropsonde recon datasets**
- **Improved storm size correction** in the vortex initialization, **modified filter domain** and **use of GFS vortex** when the storm is weaker than 16 m/s

Physics upgrades:

- **Modifications to GFS PBL** to allow the critical Richardson number vary with stability and wind speeds and **bug fix for GFDL radiation**
- **Implementation of Meso-SAS convection scheme and RRTM-G radiation scheme** (*withdrawn from 2013 implementation plans*)

Ocean upgrades:

- **Removal of flux truncation** from HWRF to POM
- **Trans-Atlantic/East Pacific 3D MPI-POM** (*withdrawn from 2013 implementation plans*)

2013 HWRF pre-implementation test plan

	Baseline (H130)	Physics upgrades				Combined (H213=H131)
		PBL(H131)	Meso-SAS (H132)	RRTMG (H133)	Ocean (H135)	Final configuration
Description	Revised init/GSI, New nest parent interpolations, Radiation bug fix, Revised nest movement, Increased frequency of Physics calls	Baseline + Variable Ric	Meso SAS	Radiation	MPI-POM	Baseline+ physics
Person	Qingu, In-Hyuk Sam Trahan Mingjing, Young	Young/ Weiguo	Qingfu	Chanh	Biju Thomas (URI)	All
Cases	Whole 2011 and 2012 storms and some 2010 storms	Whole 2011 and 2012 storms and some 2010 storms	Whole 2011 and 2012 storms and some 2010 storms	Priority cases	Whole 2011 and 2012 storms and some 2010 storms	Whole 2011 and 2012 storms and some 2010 storms

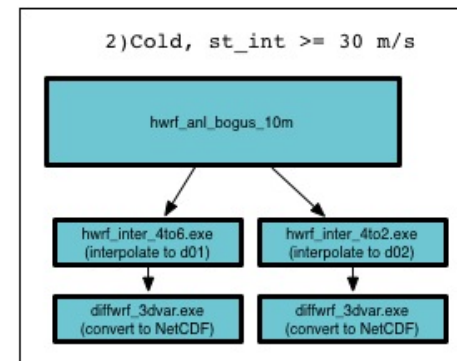
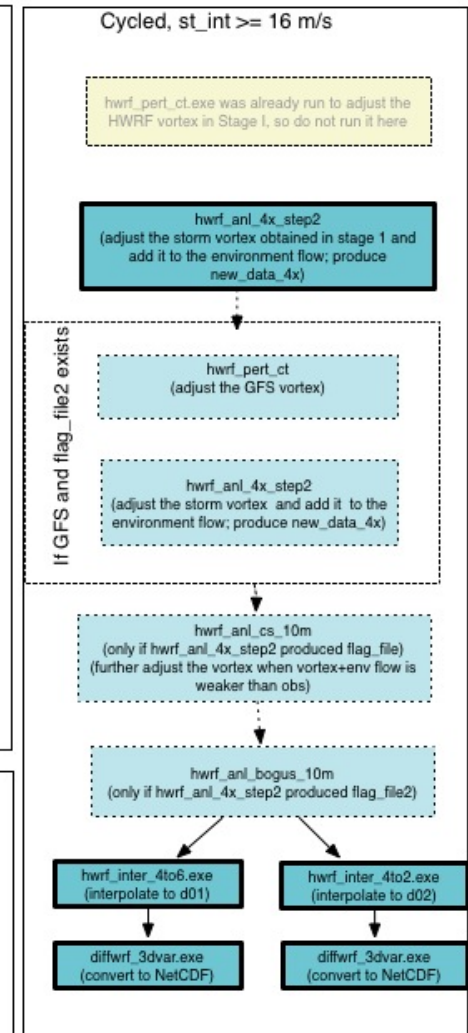
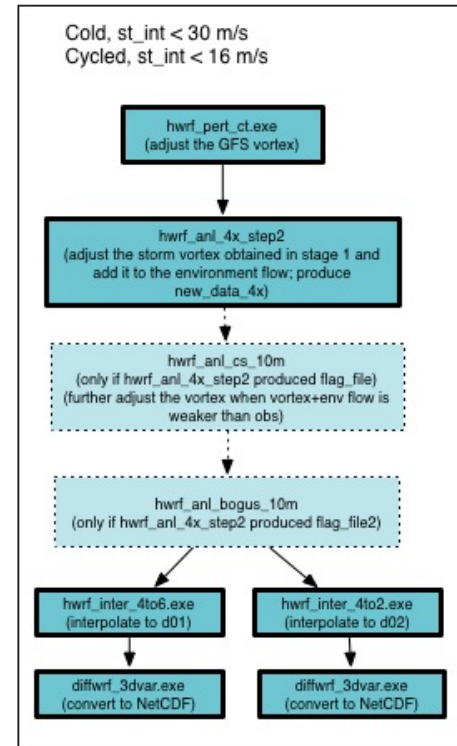
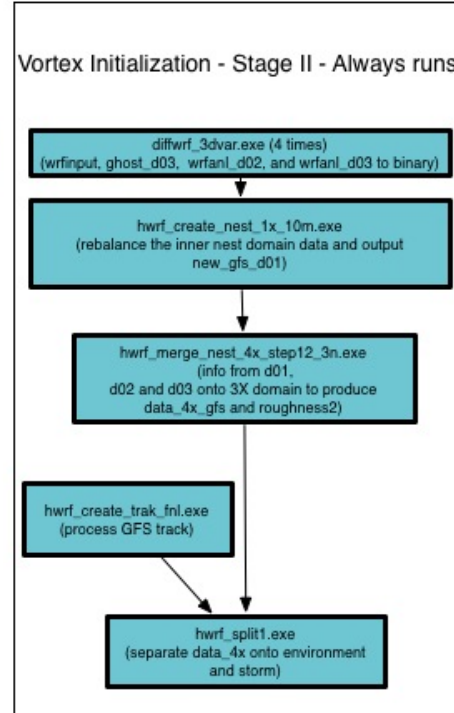
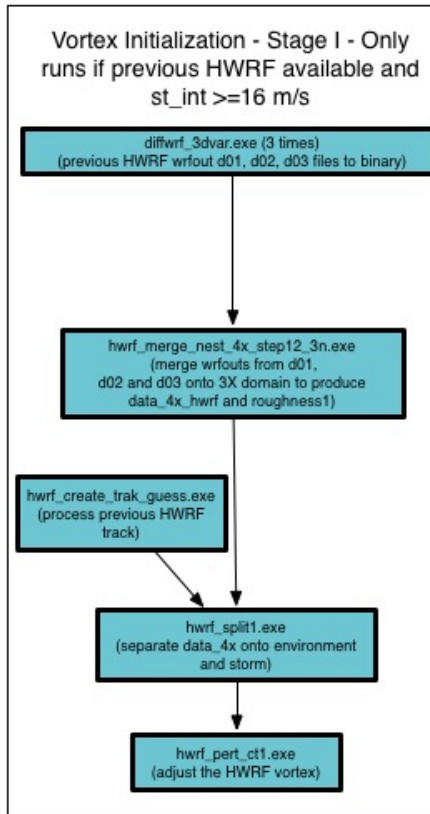
2013 HWRF pre-implementation Test Plan

EXP	Description	Comments	Platform/# of cases
Pre-Baseline Experiments			
TDRP	FY12 HWRF + One-Way Hybrid GSI	Run in real-time during 2012 hurricane season (Stream 2.0 Demo). Also included real-time TDR data for 19 cases.	CCS, All 2012 ATL and EP 821 cases
HDFL	FY12 HWRF + Flux truncation into POM	DTC performed these tests to evaluate the impact of 25% reduction of heat, momentum and radiative fluxes in the operational coupled HWRF-POM	Jet, All 2012 ATL and EP 821 cases
P160	F Y 1 2 H W R F + Initialization Changes	Improved size correction, modifications to filter domain and use GFS vortex when initial storm intensity less than 16 m/s	Jet, All 2012 ATL and EP 821 cases
HNPI	FY12 HWRF + New nest-parent interpolations	Revised nest-parent interpolations and improved treatment of variables at nest boundaries	Jet, All 2012 ATL and EP and 6 others from 2010 -11; 988 cases
HNTT	H N P I + New nest movement algorithm	Improved nest tracking based on membrane MSLP and Tim's tracker. Choice of 8 storms that had difficulty tracking the nest properly	Jet, 8 Selected storms 168 cases
HHPC	FY12 HWRF + High Frequency Physics Calls	Increased Physics calling frequency from 180 sec. to 30 sec. Third nest size increased by about 20% from 5.5x5 to 7x6.5	Jet, A few selected storms from 2012; 100 cases
Baseline Experiment			
H130	All modifications from pre-baseline experiments	2013 HWRF baseline is based on positive outcome from the pre-baseline experiments described above. Run on three different platforms.	Jet/Zeus/WCOSS, All 2010-2011-2012 ATL and EP 1870 cases each
Physics Upgrades			
H 1 3 1 (Final)	H130 + PBL changes	HWRF PBL (GFS based scheme) is upgraded to include variable critical Richardson number for improved treatment of PBL height in all weather conditions.	Jet, All 2011-2012 and August - October 2010 ATL and EP 1870 cases

Revised Vortex Initialization Procedure: GDAS Forecast as first guess for environment, GFS Vortex (int. <16m/s) or HWRF Vortex (int. >16 m/s)

GFS or GDAS Vortex Initialization - Stages I and II

Vortex Initialization - Stage III - Always runs

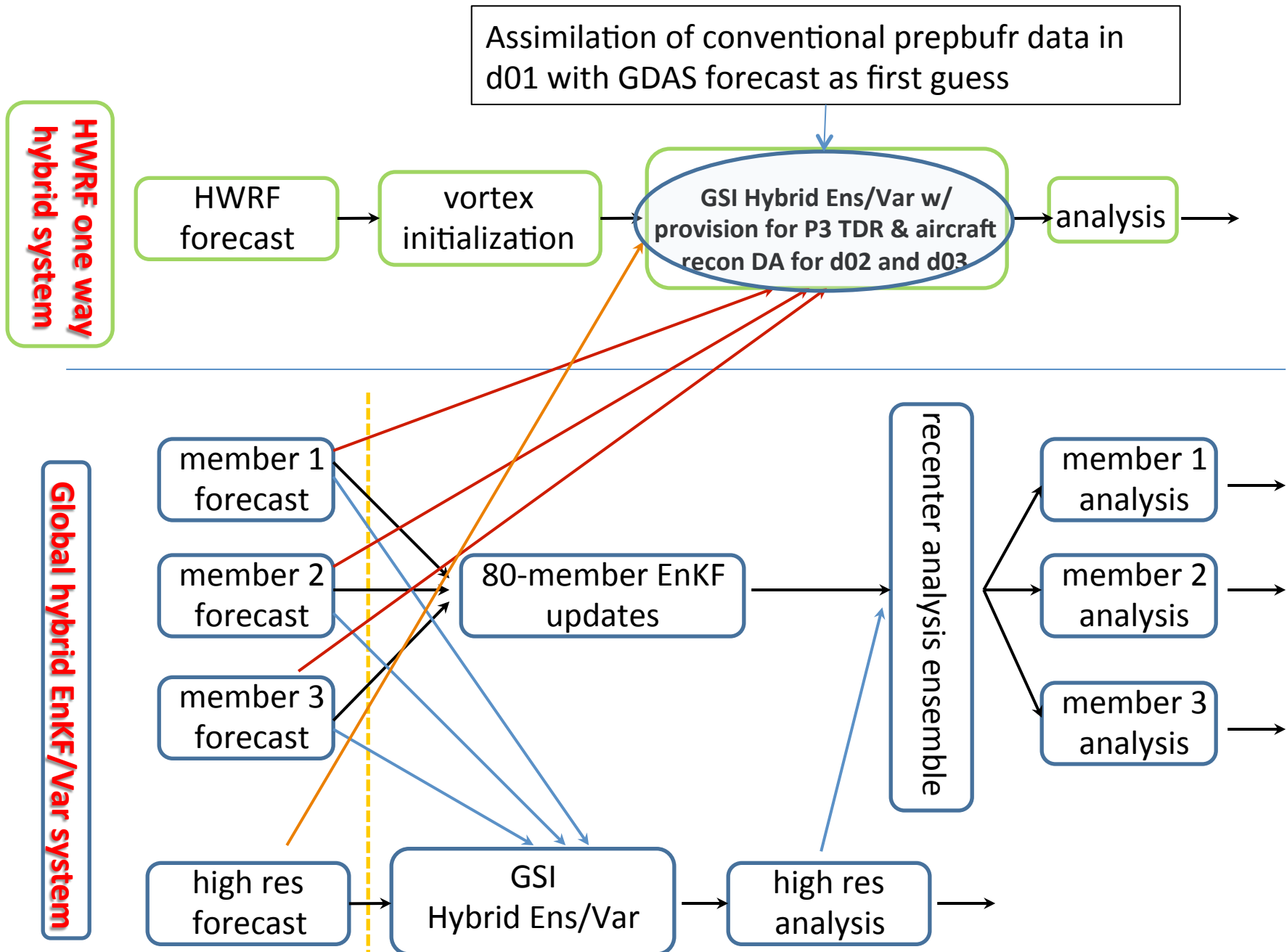


Stage III

- For cold starts, we bogus strong storms but use the GFS vortex for weak ones.
- For cycled starts, we cycle the HWRF vortex for strong storms but cycle the GFS vortex for weak ones.
- Special case I: if flag_file2 (RMW_obs/RMW_model > 16), we abort model vortex insertion and resort to bogus.
- Special case II: If HWRF vortex is being cycled and (flag_file2 and GFS-not GDAS), abort use of HWRF vortex and use GFS vortex.

Stage I is used to split the previous HWRF forecast onto storm and environment so that the vortex can be adjusted and relocated. This is not done when the storm is very weak as it is best to use the GFS vortex in that case

Stage II is used to split the GDAS or GFS forecast to get the environment

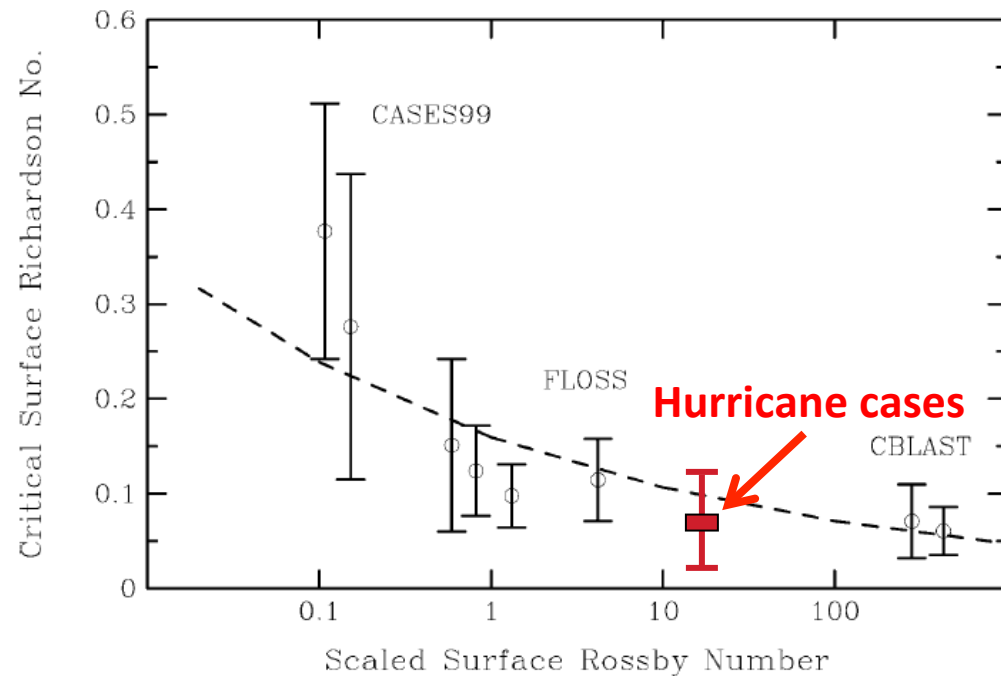


One-Way Hybrid Ensemble-Var GSI DA System for HWRF

Critical Richardson number function of Ro (Vickers and Mahrt, 2003)

Vickers and Mahrt(2003)
Critical Richardson number is not a constant but varies with case by case.

$$R_{ic} = 0.16(10^{-7} U_{10}/fZ_0)^{-0.18}$$



The magnitude of Ric modifies the depth of PBL and diffusivity, so the Ric varying with conditions would fit both hurricane condition and environments.

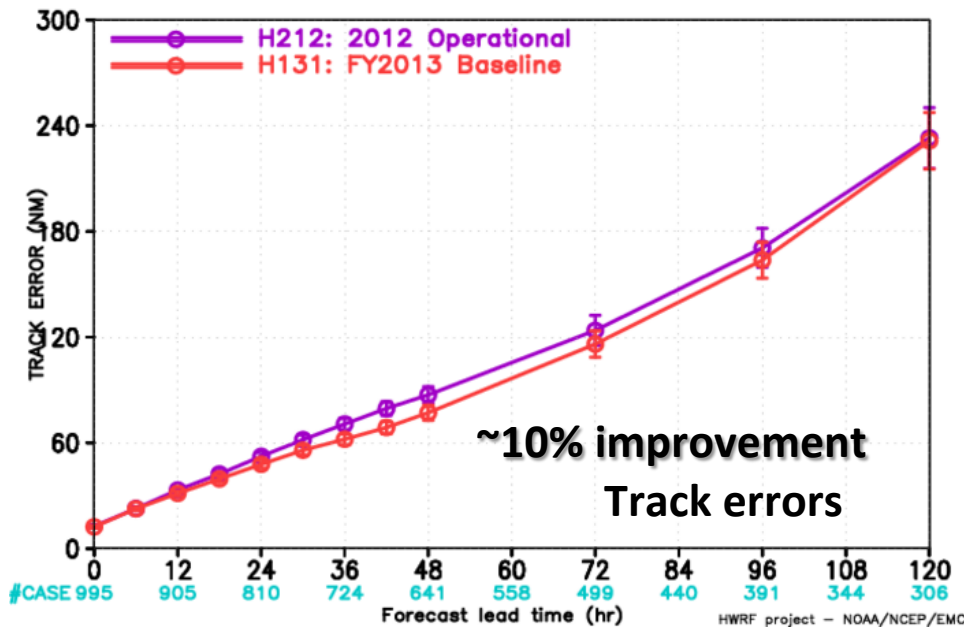
**Performance of H131 (proposed FY2013
HWRF configuration) compared to 2012
operational HWRF (H212)**

2010-2012 seasons, ATL and EPAC

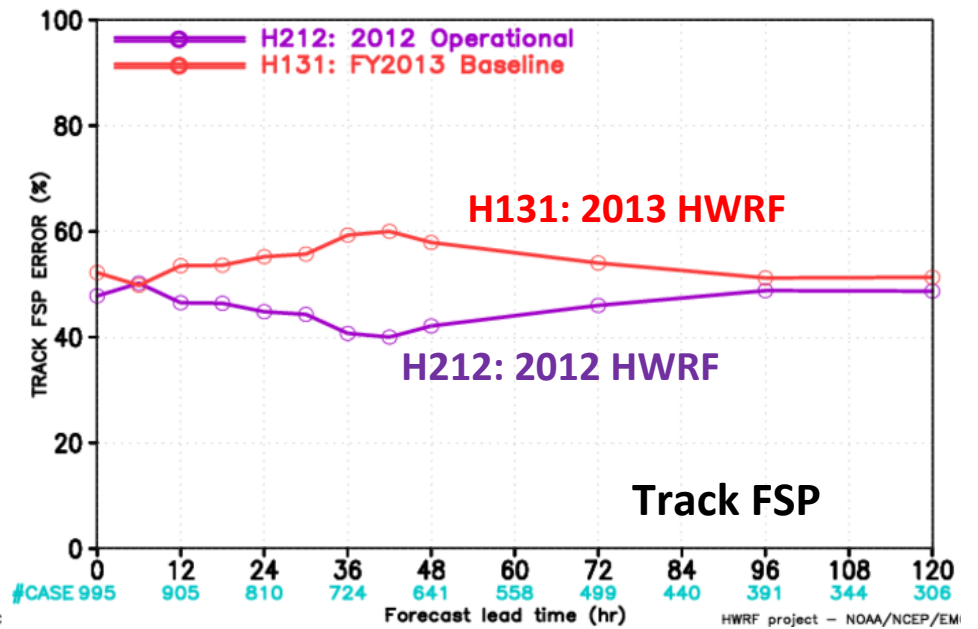
Atlantic Basin

2010-2012 Track Verification

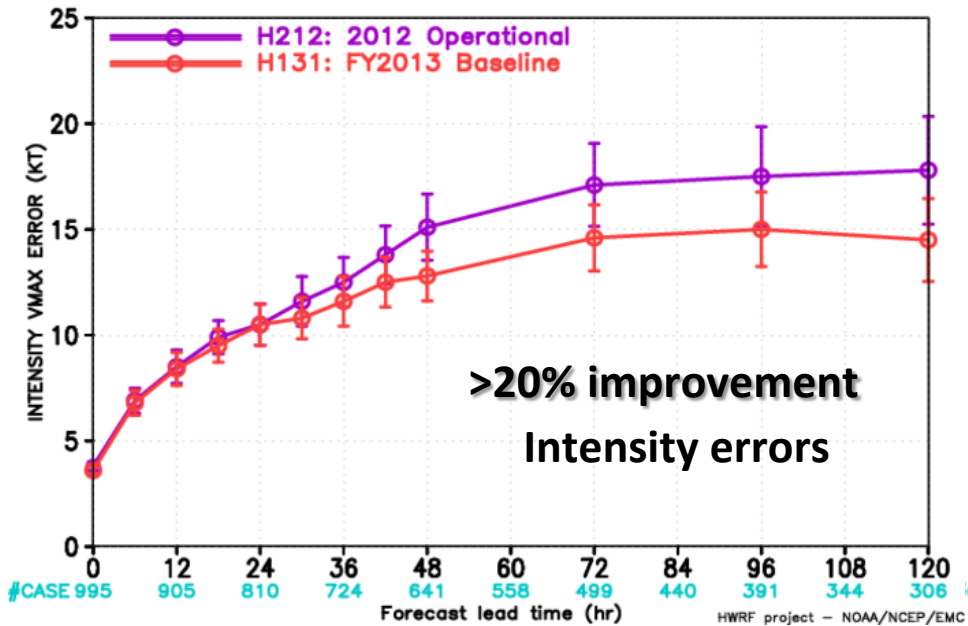
HWRP FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR NATL BASIN 2010–2012



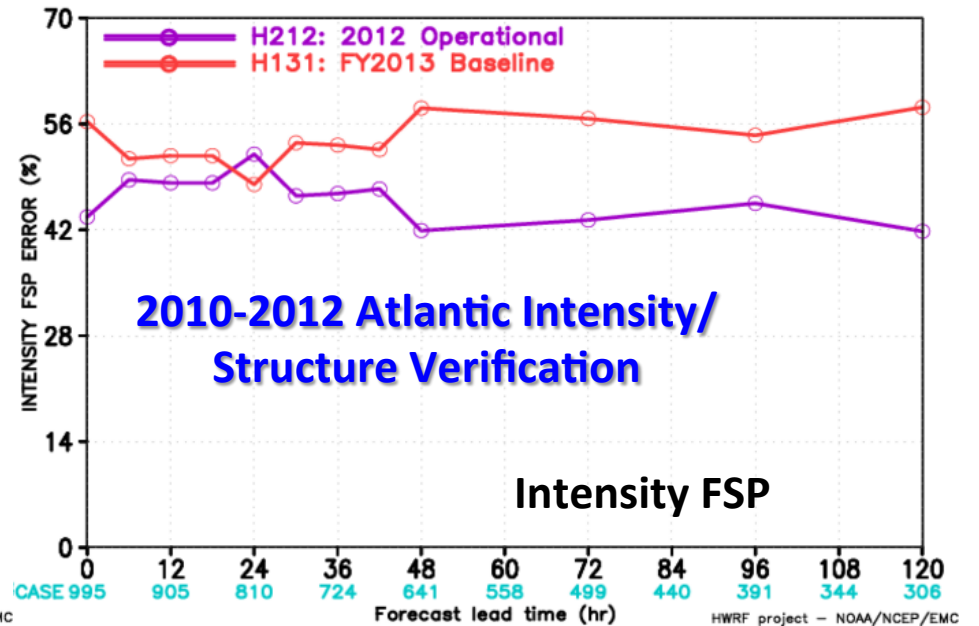
HWRP FORECAST – TRACK FSP ERROR (%) STATISTICS
VERIFICATION FOR NATL BASIN 2010–2012



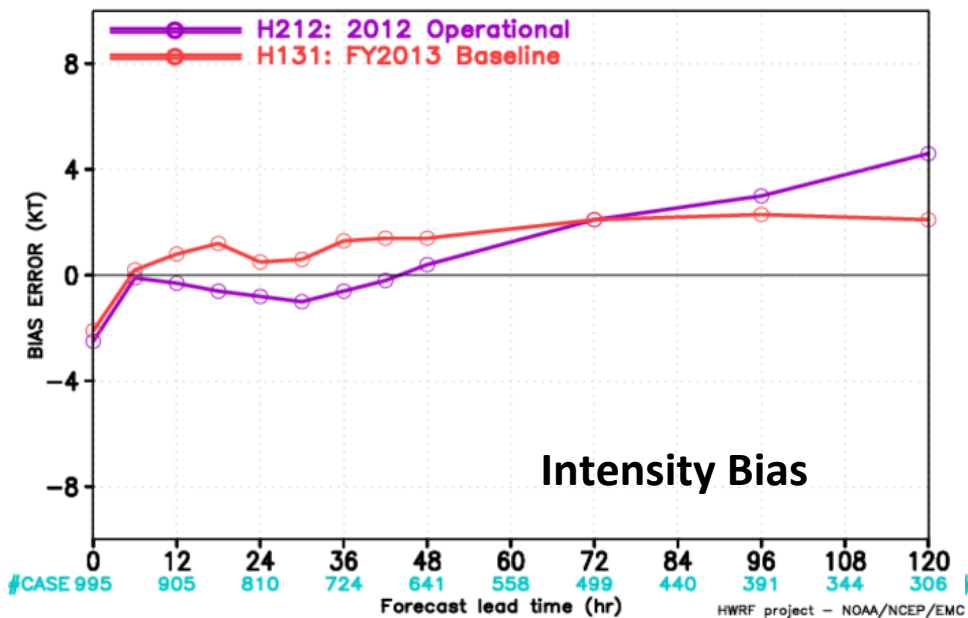
HWRF FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION FOR NATL BASIN 2010–2012



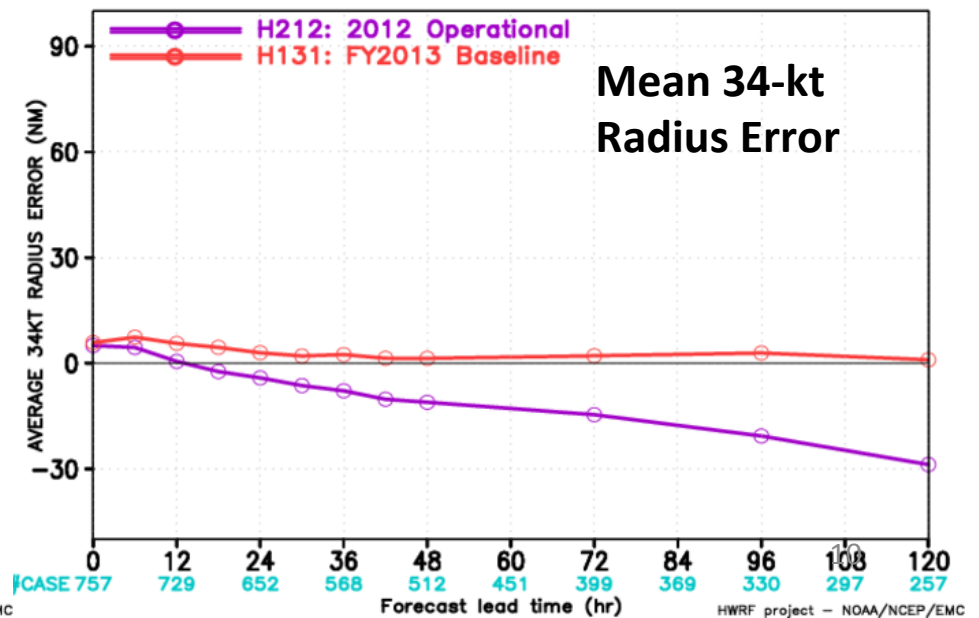
HWRF FORECAST – INTENSITY FSP ERROR (%) STATISTICS
VERIFICATION FOR NATL BASIN 2010–2012



HWRF FORECAST – BIAS ERROR (KT) STATISTICS
VERIFICATION FOR NATL BASIN 2010–2012



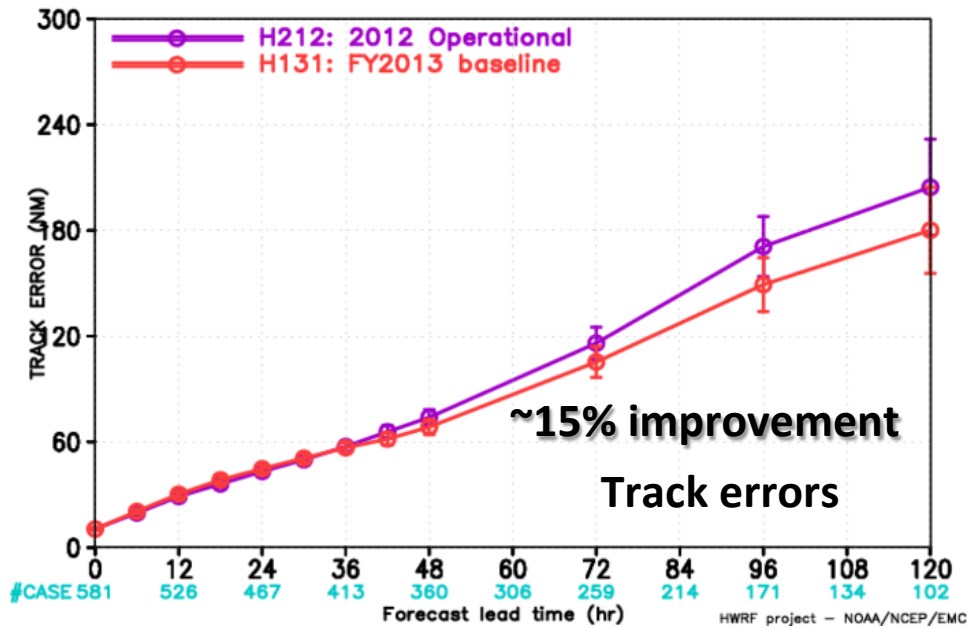
HWRF FORECAST – AVERAGE 34KT RADIUS ERROR (NM) STATISTICS
VERIFICATION FOR NATL BASIN 2010–2012



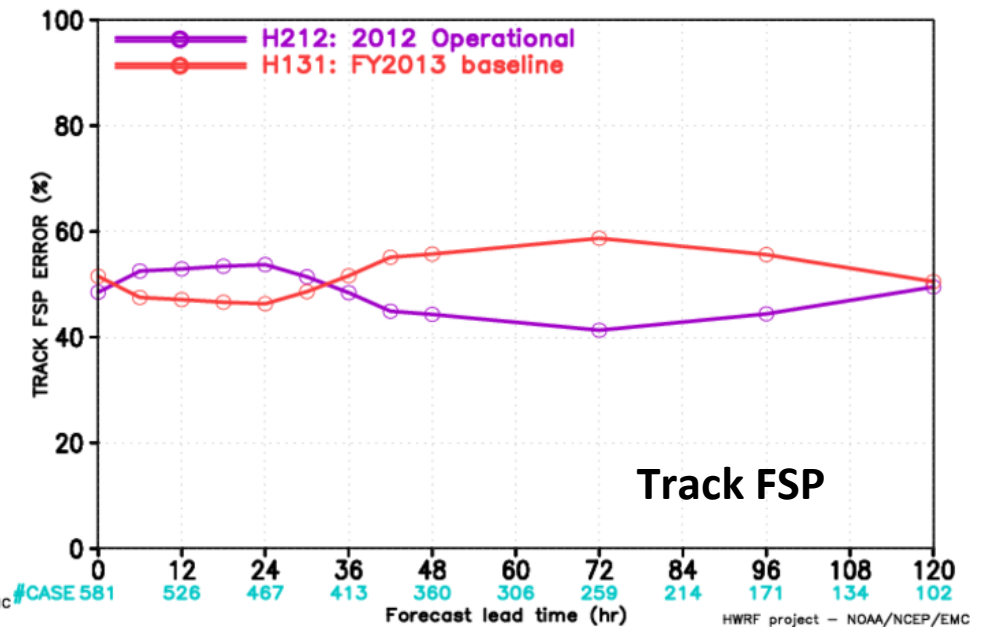
Eastern-Pac Basin

2010-2012 Track Verification

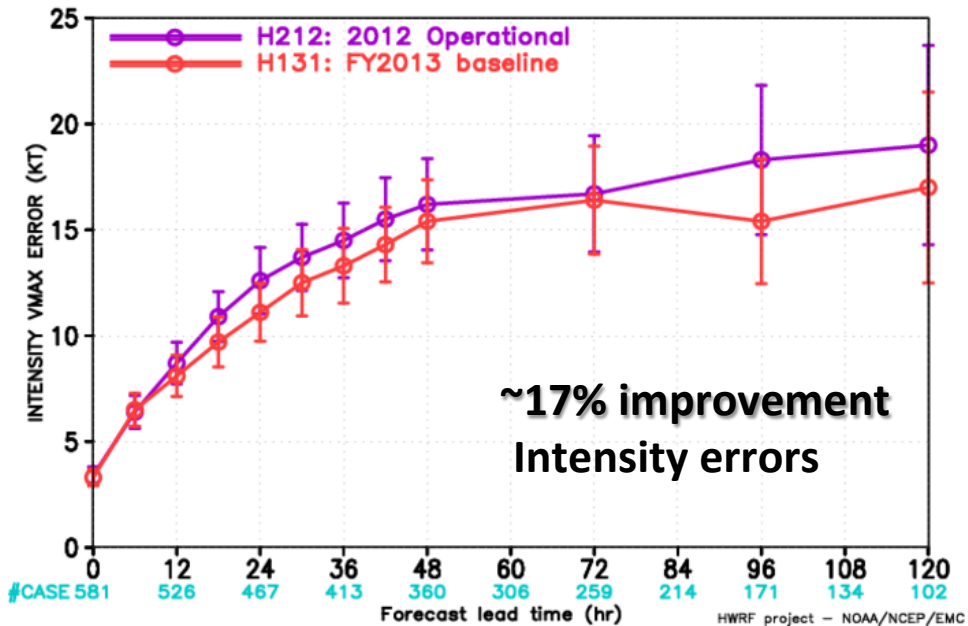
HWRf FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR EPAC BASIN 2010–2012



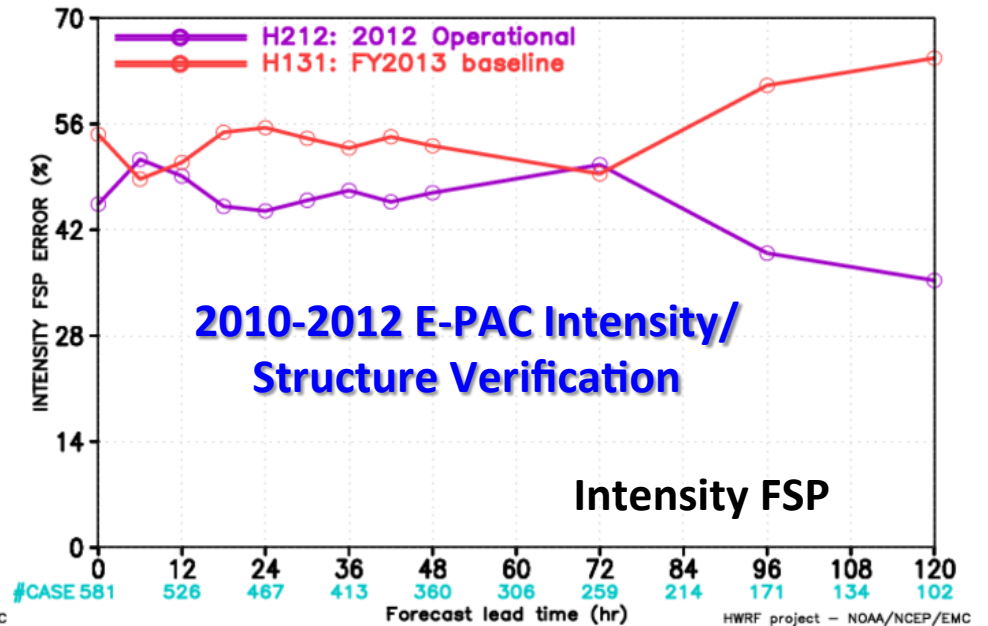
HWRf FORECAST – TRACK FSP ERROR (%) STATISTICS
VERIFICATION FOR EPAC BASIN 2010–2012



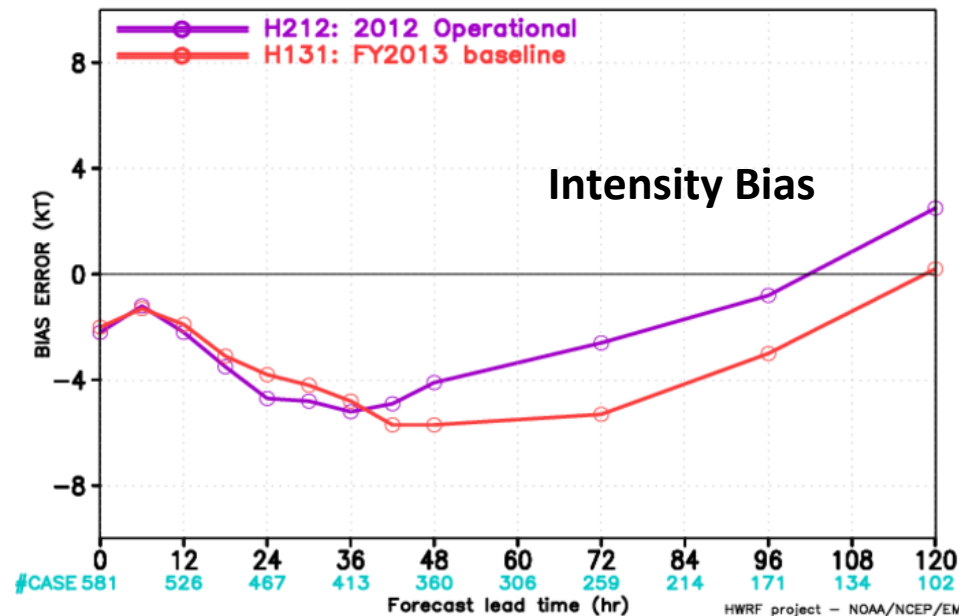
HWRP FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
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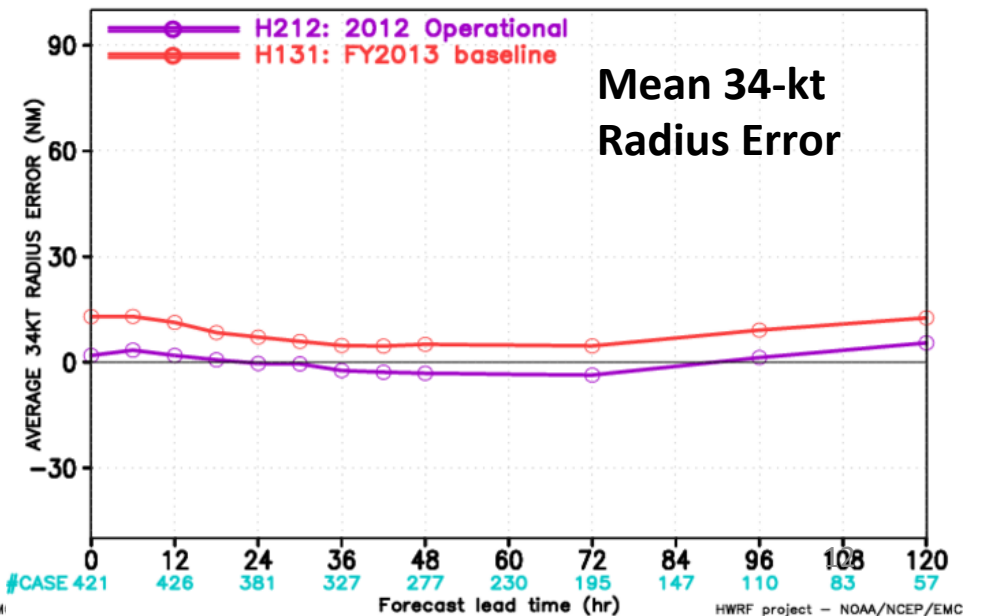
HWRP FORECAST – INTENSITY FSP ERROR (%) STATISTICS
VERIFICATION FOR EPAC BASIN 2010–2012



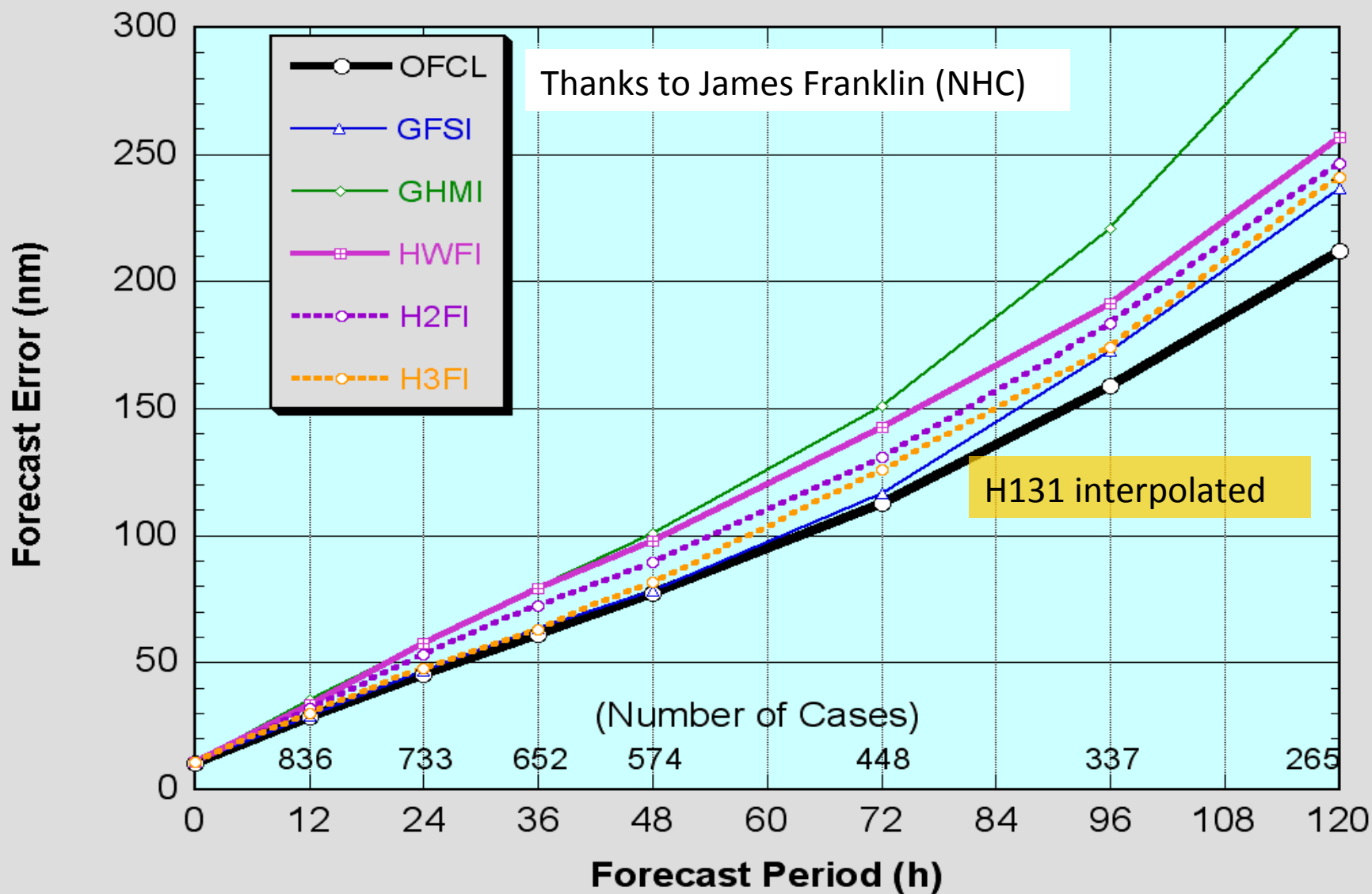
HWRP FORECAST – BIAS ERROR (KT) STATISTICS
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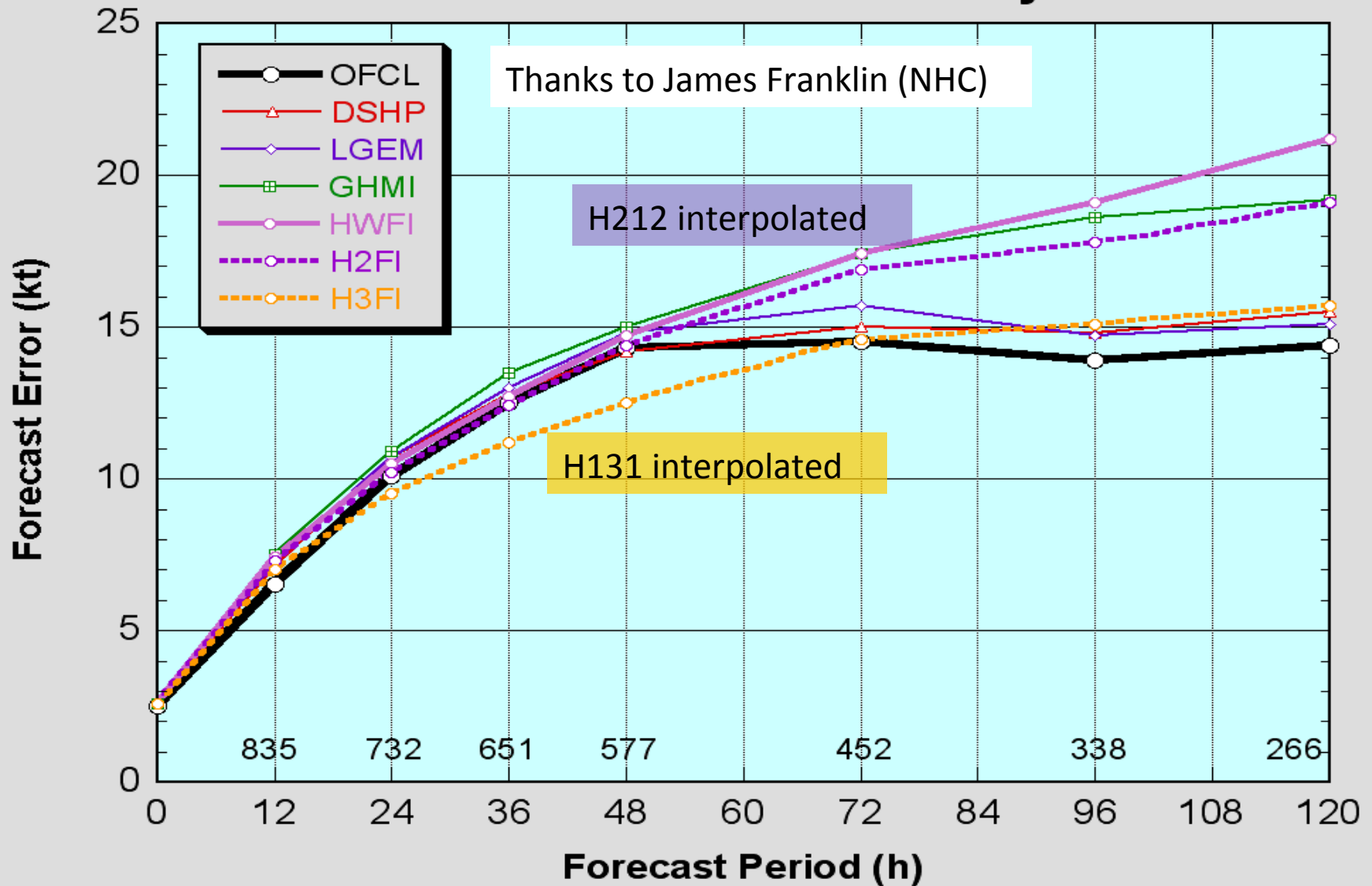
HWRP FORECAST – AVERAGE 34KT RADIUS ERROR (NM) STATISTICS
VERIFICATION FOR EPAC BASIN 2010–2012



2010-12 Average Forecast Errors Atlantic Basin - Track



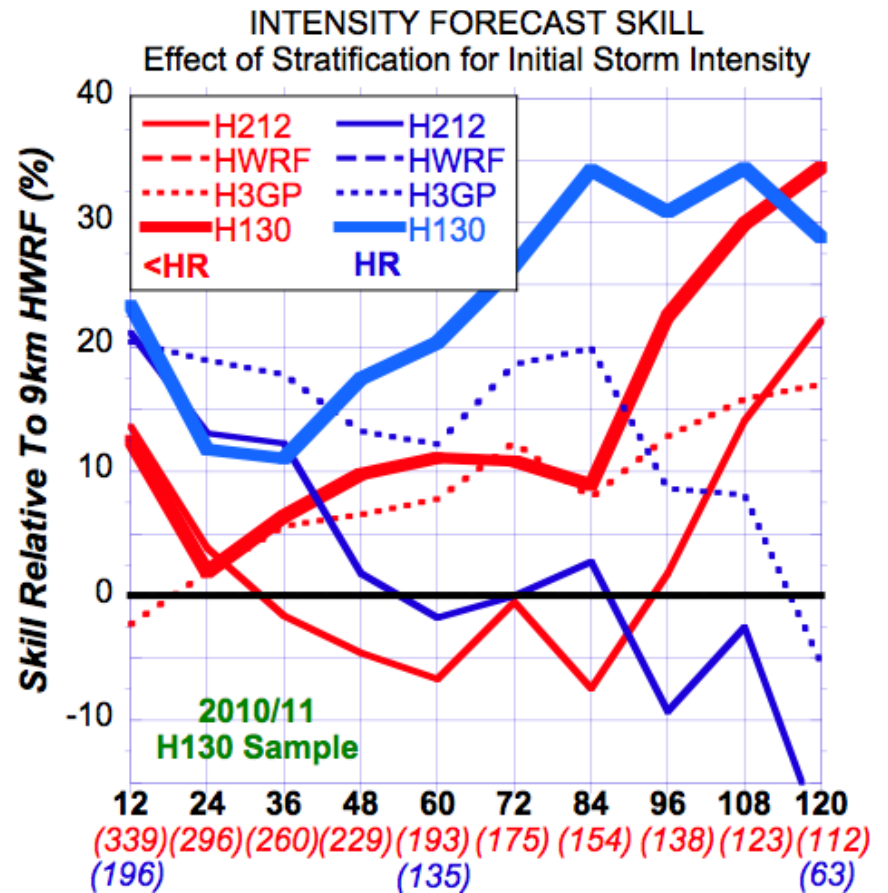
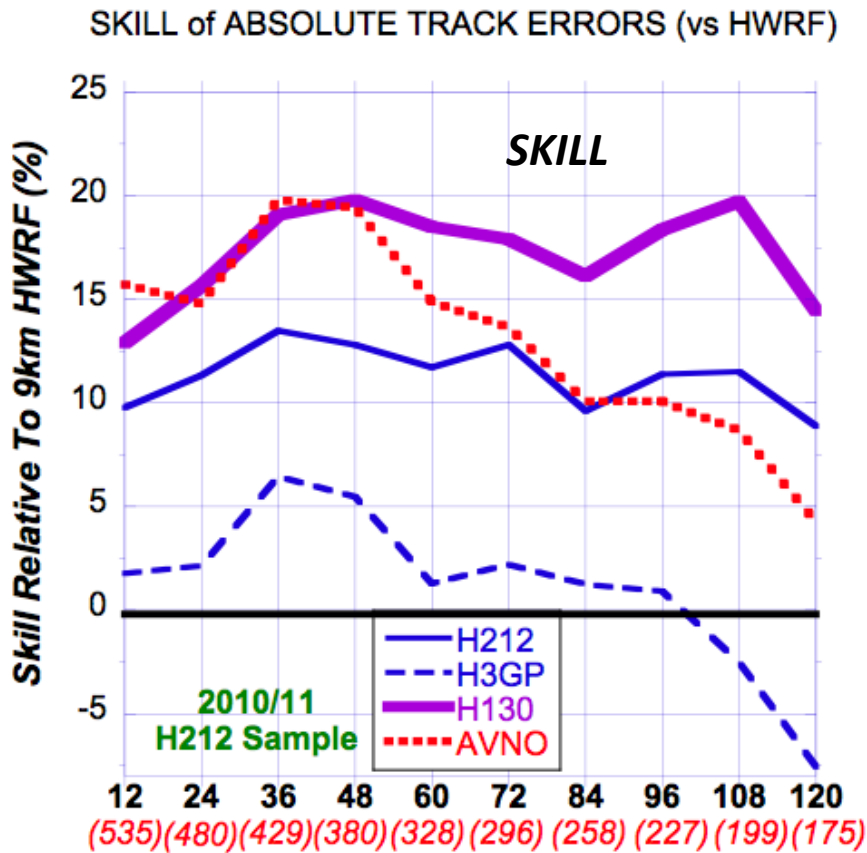
2010-12 Average Forecast Errors Atlantic Basin - Intensity



TRACK/Intensity Forecasts

2010-2011 Seasons Retrospective Runs

H212/H3GP/H130 (27:9:3 km) -- Skill relative to HWRF (27:9 km)

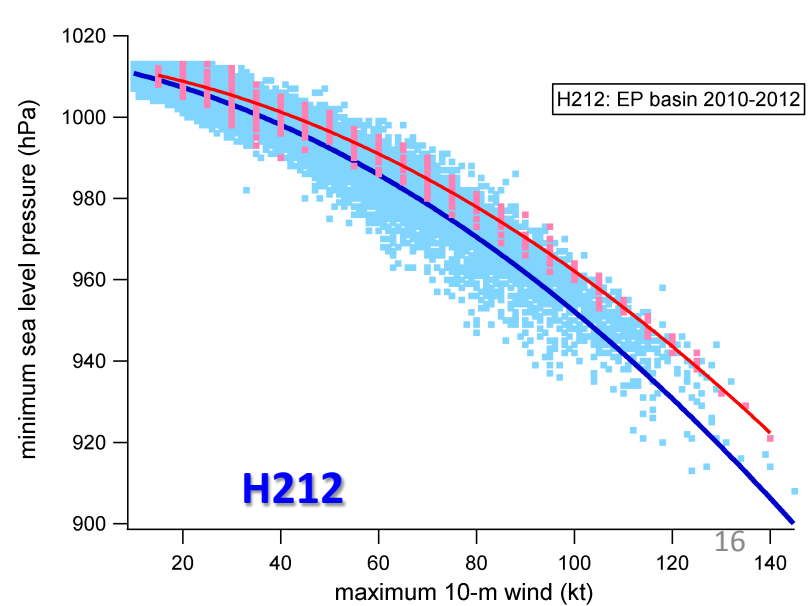
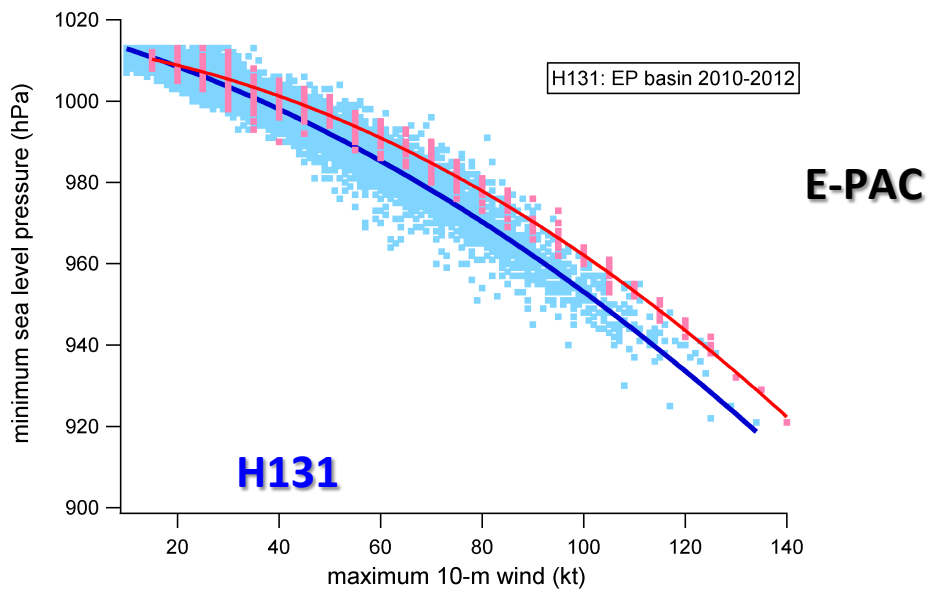
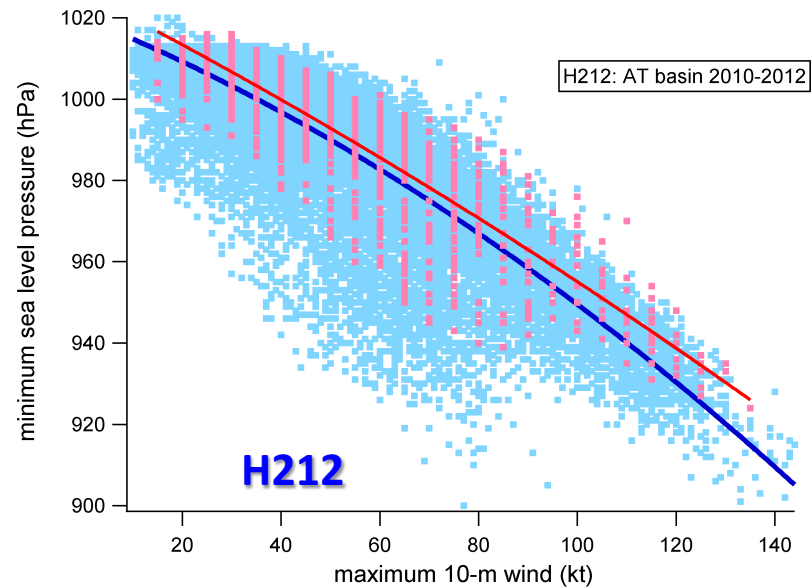
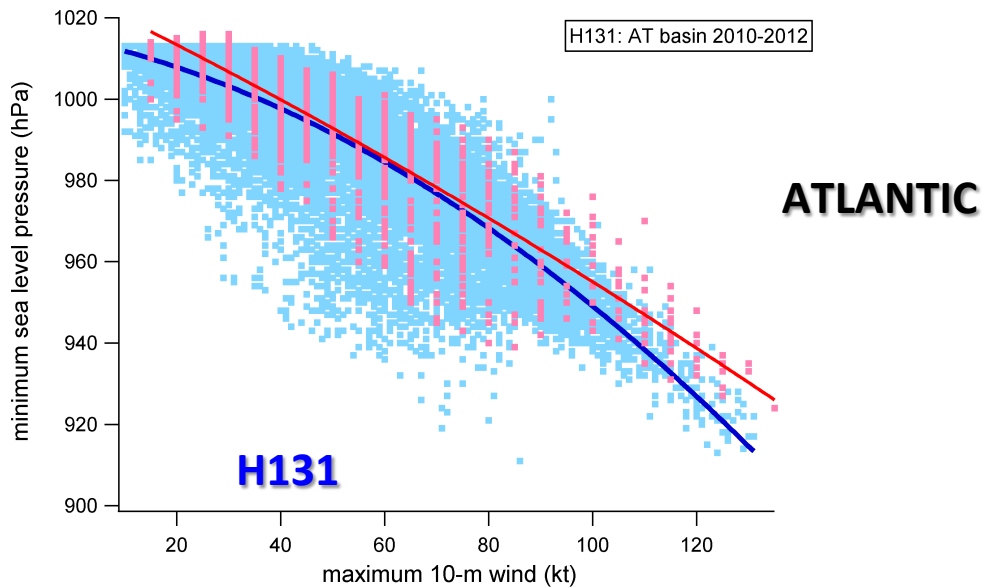


**H130: Major improvements over HWRF & H3GP +
Improved over H212
& better than AVNO (GFS) For 2010-11**

From Stan Goldenberg (HRD/AOML)

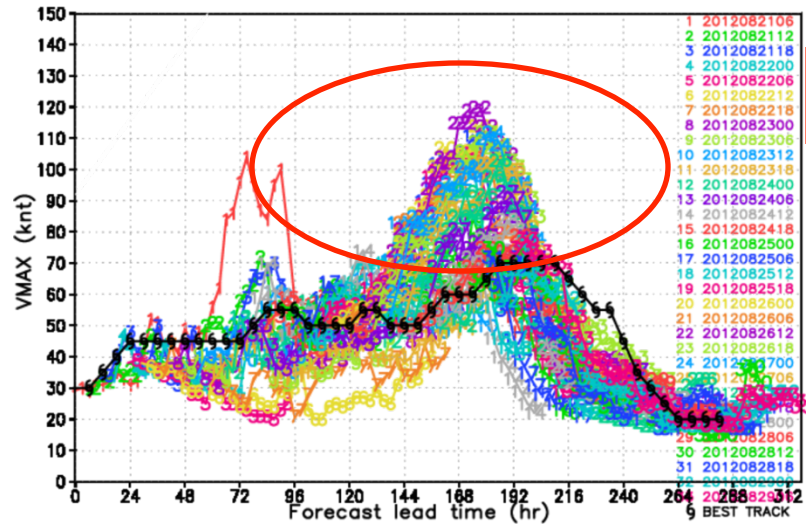
H131 vs. H212 P-W relationship

Red: Best Track



H212

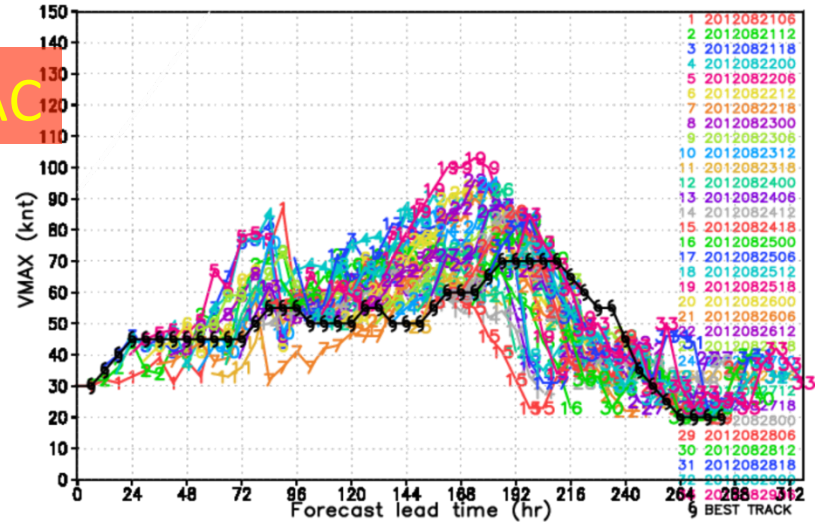
H212 forecast: ISAAC (a1092012)
Maximum 10-m wind time series



ISAAC

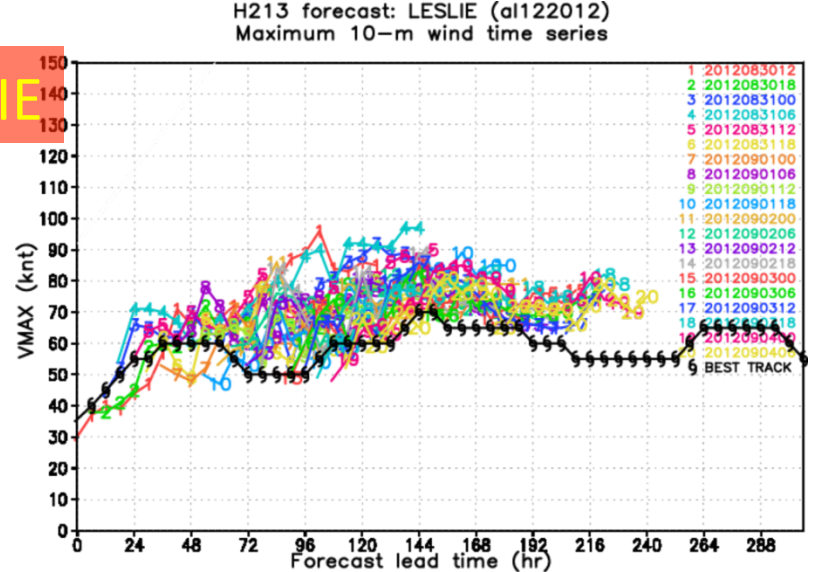
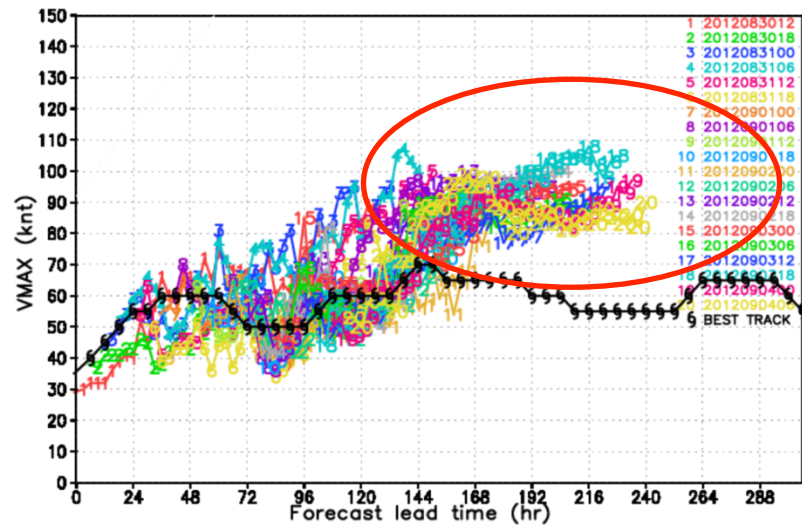
H131

H213 forecast: ISAAC (a1092012)
Maximum 10-m wind time series



LESLIE

H212 forecast: LESLIE (a122012)
Maximum 10-m wind time series



Summary

- Major upgrades for 2013 operational HWRF are implementation of one-way hybrid GSI; improved nest tracking and nest-parent interpolations; increased 3rd domain size; increased frequency of physics calls; improved vortex initialization; and improved PBL.
- Retrospective testing for 2010, 2011 and 2012 hurricane seasons with H131 indicated significant enhancements in model forecast skill for track, intensity and structure compared to the 2012 operational HWRF. For the Atlantic basin, there was about 10-15% improvement in track forecasts and about 20-25% improvement in intensity forecasts over the current operational HWRF configuration.
- Similar improvements were noted for the Eastern Pacific basin as well.
- Results also indicated improved storm size from H131 as measured in terms of radius error for various intensity thresholds.

Recommendation from NHC for implementing the 2013 HWRF system

NHC has reviewed the performance of the proposed HWRF implementation for 2013. The model has been extensively tested on a three-year sample of cases with very impressive results. **For Atlantic basin track, the HWRF is improved by ~5-15% and now appears competitive with the GFS. For intensity, the model reduces errors by ~15%, has demonstrated skill greater than that of the NHC official forecast and greater than that of the statistical models.** These are remarkable results and Rick has asked me to relay NHC's strong endorsement for implementation of the upgraded HWRF for the 2013 season.

Congratulations on a tremendous effort. NHC is eager to see the new model in operations as soon as possible.

-- James Franklin

HWRF Team Plans for 2013 Hurricane Season

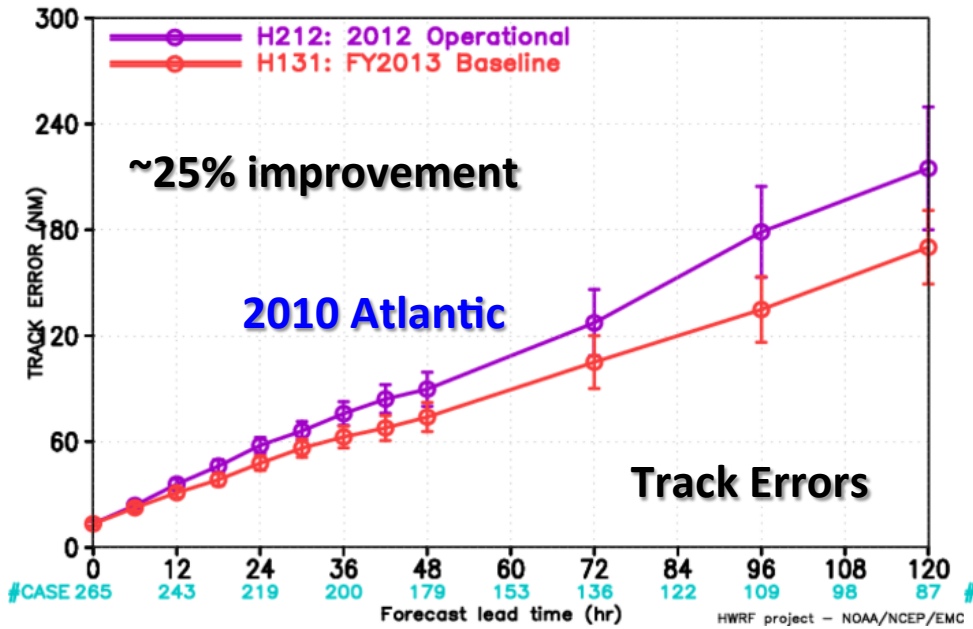
- **Stream 1.0:**
 - Operational implementation of FY13 HWRF (H131) on WCOSS (parallel feed from NCO until WCOSS goes live in August)
- **Stream 1.5:**
 - 20-member HWRF ensembles using GEFS initial conditions and stochastic convective physics perturbations (***Zhan Zhang, pending evaluation by NHC/TCMT***)
- **Stream 2.0:**
 - FY13 HWRF with MYJ PBL, RRTMG, Meso-SAS and MPI-POM (***High-Resolution Physics Tiger Team***)
 - FY13 HWRF with aircraft recon and TDR DA (***Recon Data Impact Tiger Team***)
 - FY13 HWRF with higher model top, increased vertical levels and global-regional blended vertical coordinate (***Satellite DA Tiger Team***)
 - FY13 HWRF with HYCOM
 - FY13 HWRF with High-Resolution ECMWF IC/BC
 - FY13 HWRF for Western Pacific and Indian Ocean basins

Satellite DA experiments for HFIP Stream 2.0 Demo

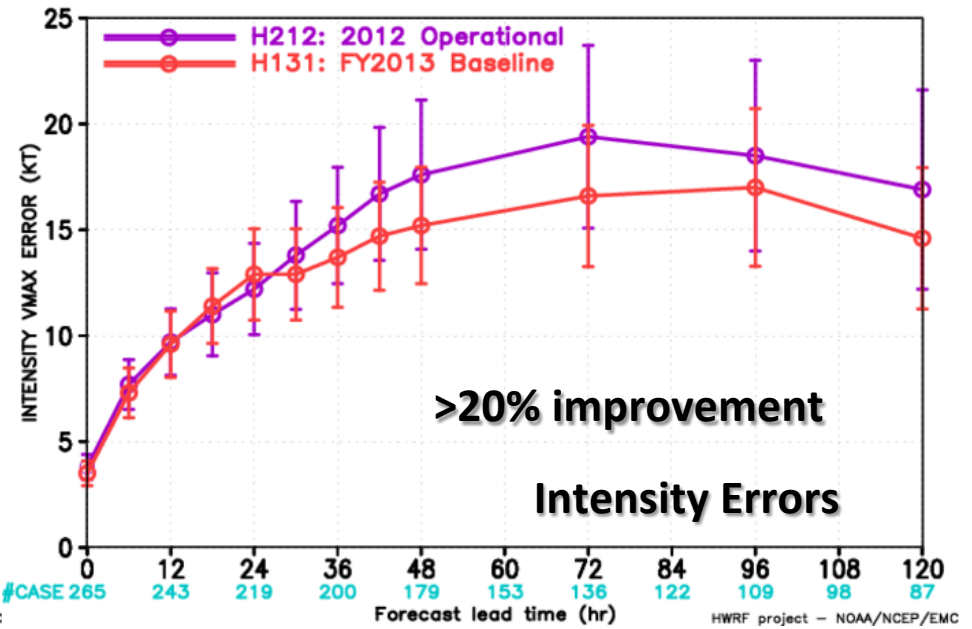
Stream 2.0	Satellite data assimilated	Notes
Control	None	FY13 HWRF Conventional data assimilated
A	AMSU-A and ATMS (O ₂ channels) radiances GPS bending angle	Provide temperature information Jun. 1 – Nov. 1 2013
B	A + MHS and ATMS (H ₂ O channels) radiances	Provide moisture information in the troposphere Jun. 1 – Nov. 1 2013
C	A + B + GOES Sounder, HIRS, AIRS & IASI radiances	Provide temperature & moisture constraint Jun. 1 – Nov. 1 2013
D	A + B + C + EUMETSAT IR/VIS cloud drift winds NESDIS IR/VIS cloud drift winds NESDIS imager water vapor winds	Provide wind (u & v) information on various vertical levels, and geographical regions Jun.1 – Nov. 1 2013
E	Best combination of satellite data determined from experiments A to D	Aug. 1 – Nov. 1 2013

Performance of H131 for Individual Hurricane Seasons

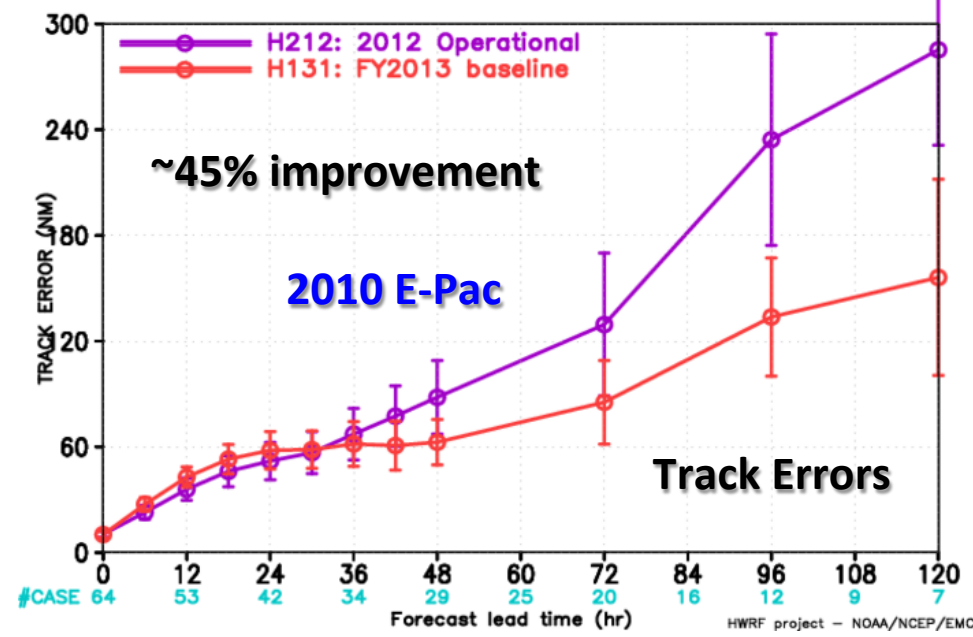
HWRP FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR NATL BASIN 2010



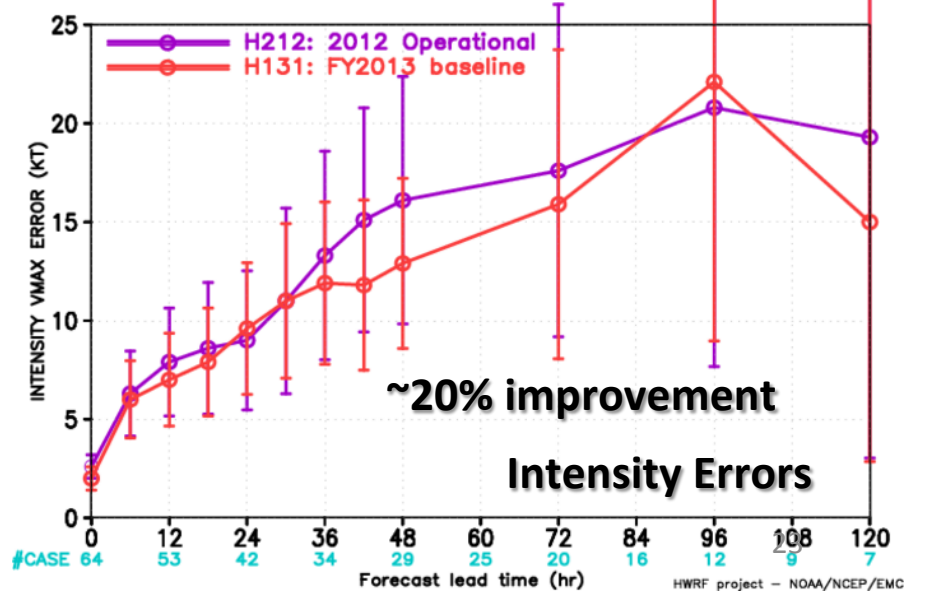
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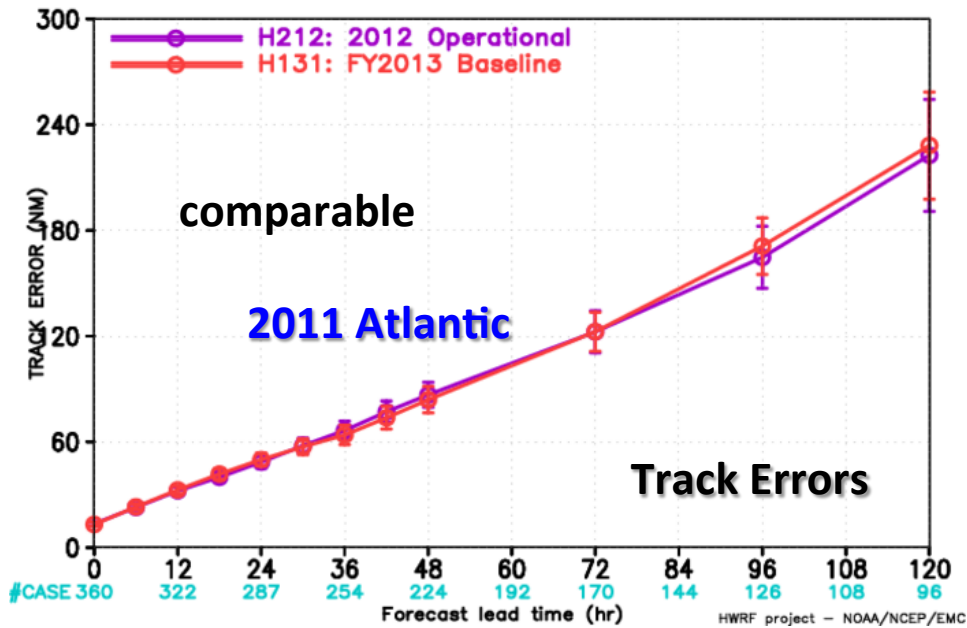
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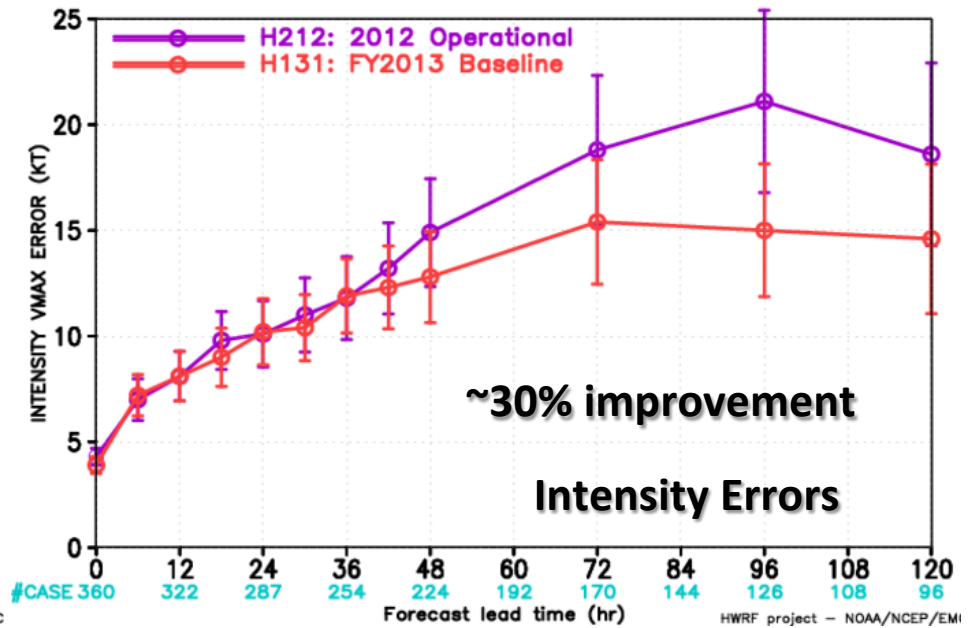
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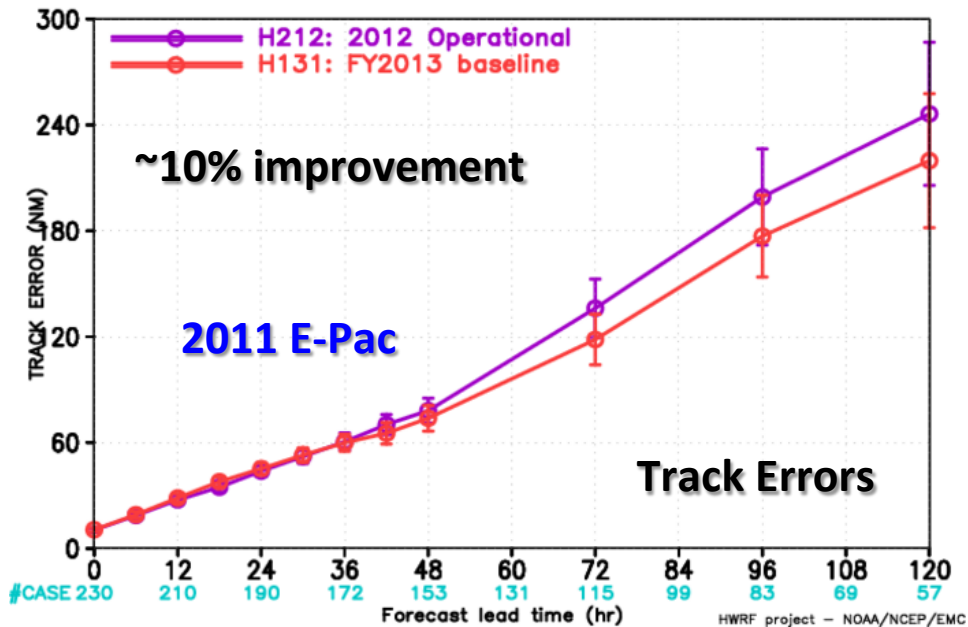
HWRf FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR NATL BASIN 2011



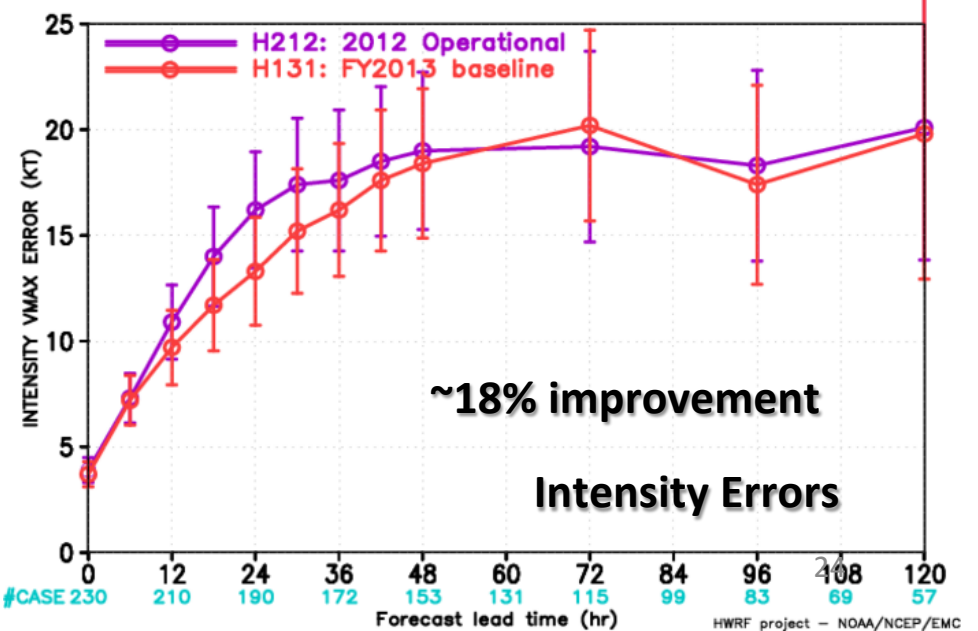
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VERIFICATION FOR NATL BASIN 2011



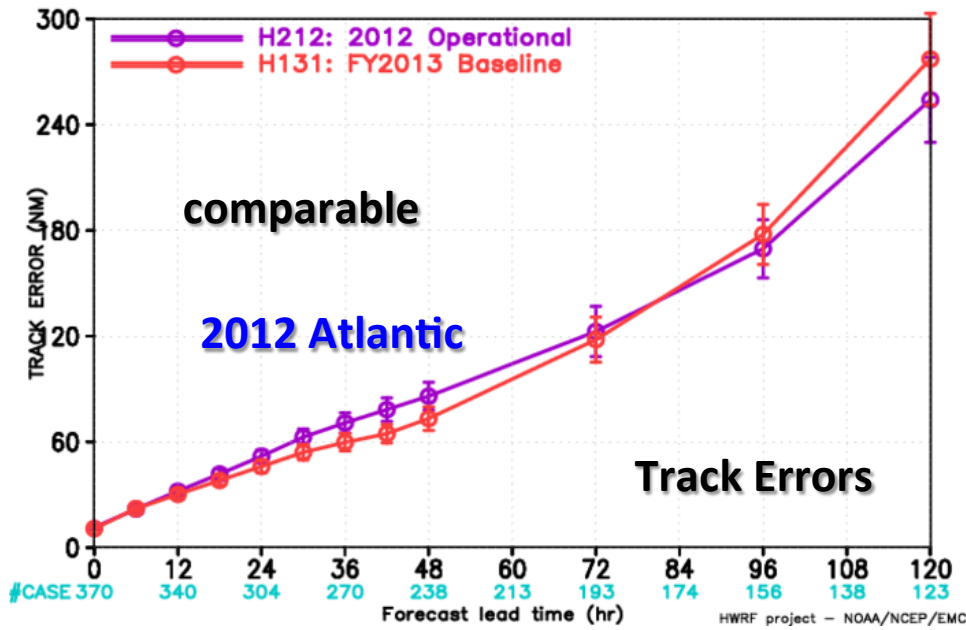
HWRf FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR EPAC BASIN 2011



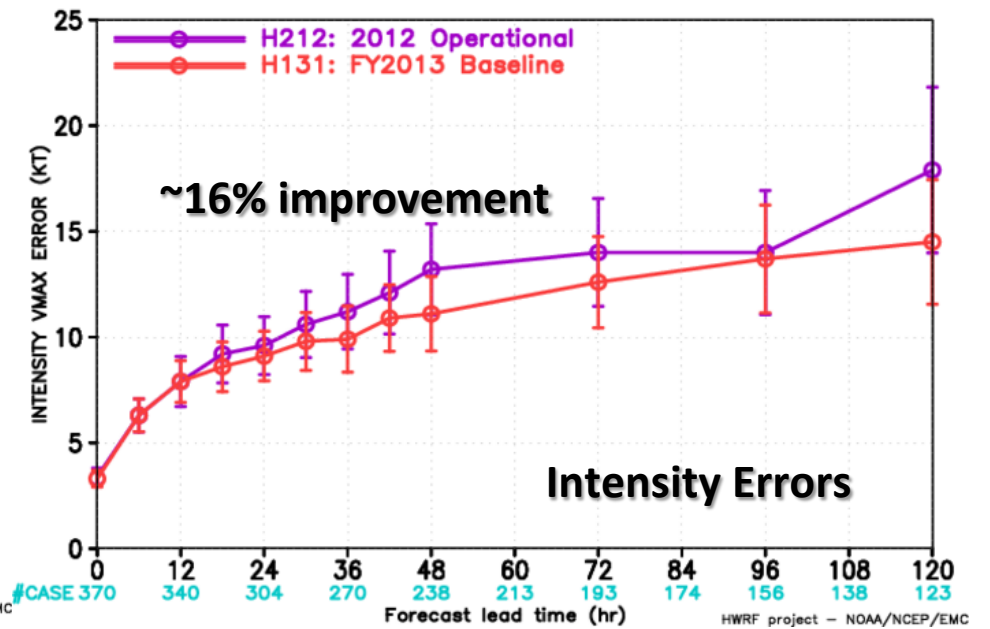
HWRf FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION FOR EPAC BASIN 2011



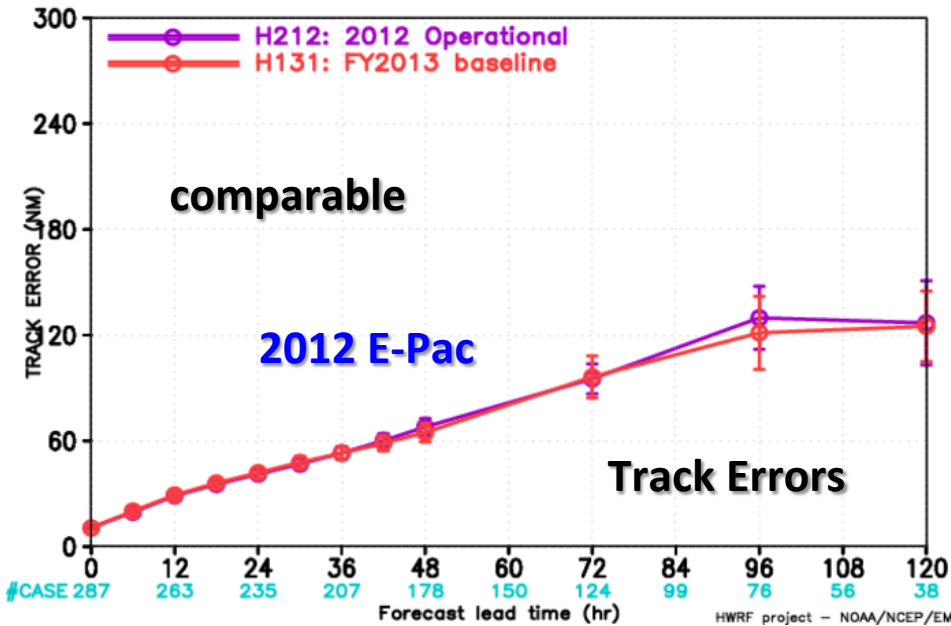
HWRP FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR NATL BASIN 2012



HWRP FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION FOR NATL BASIN 2012



HWRP FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR EPAC BASIN 2012



HWRP FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION FOR EPAC BASIN 2012

