



NCEP Operational Hurricane Modeling System



1

HWRF Performance Verification in 2016

The HWRF Team

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*& Several collaborators (extended team members) at NHC, JTWC, HRD/AOML, GFDL,
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NOAA
HURRICANE FORECAST IMPROVEMENT PROJECT



Highlights 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
- More products: MAG and AWIPS₂

➤ Initialization/DA Improvements

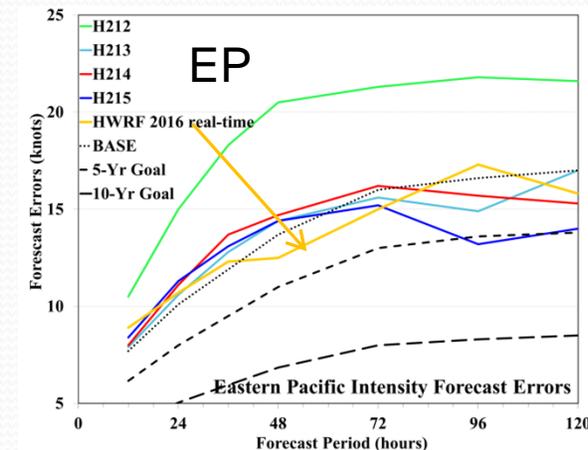
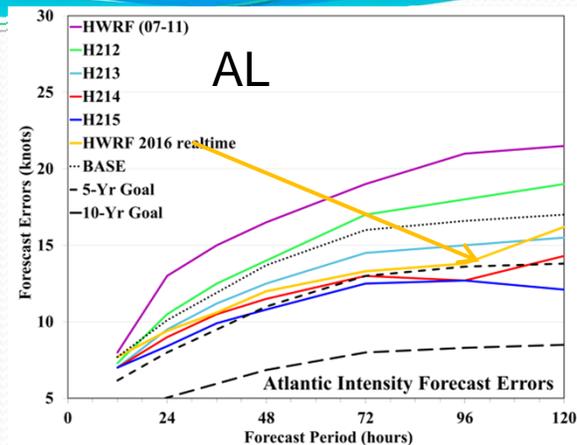
- GSI upgrades; new data sets for GSI (CrIS, SSMI/S, METOP-B changes)
- Turn on Data Assimilation for all storms in East Pacific

➤ 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 RTOFS 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](#)



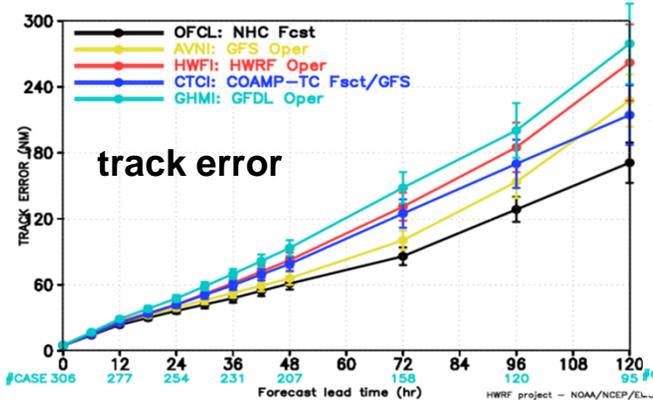


HWRF in the 2016 North Atlantic Basin (Alex to Otto)

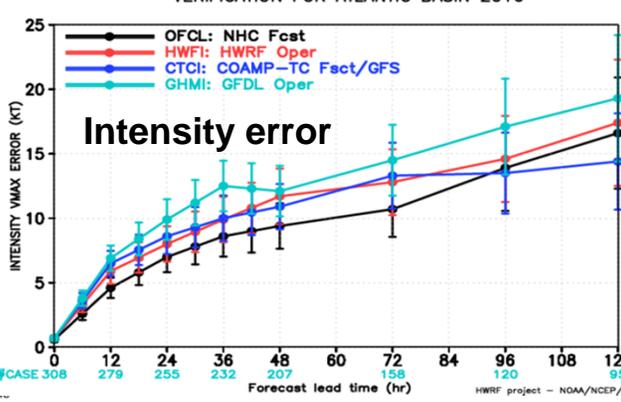


Real-Time Performance

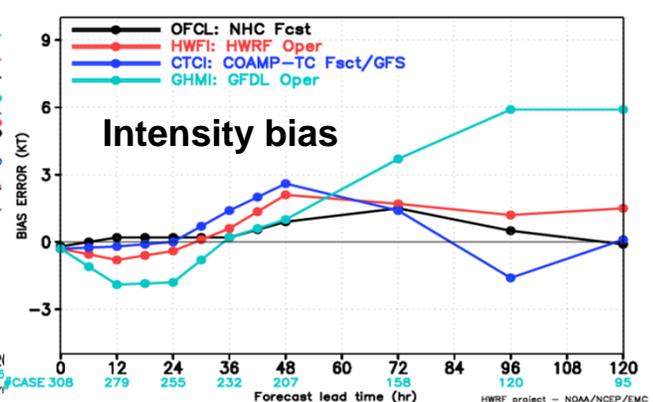
HWRf FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR ATLANTIC BASIN 2016



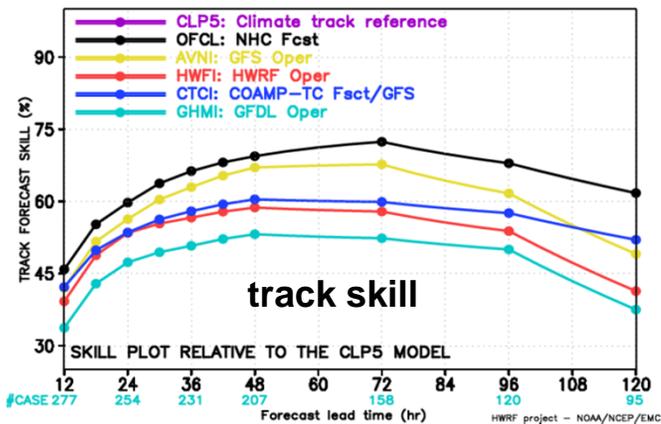
HWRf FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION FOR ATLANTIC BASIN 2016



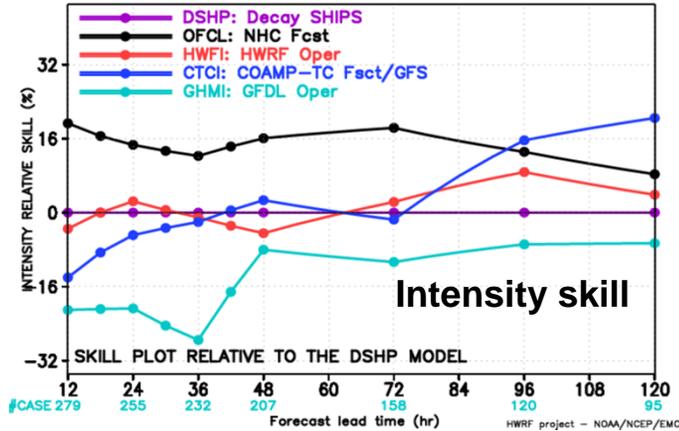
HWRf FORECAST – BIAS ERROR (KT) STATISTICS
VERIFICATION FOR ATLANTIC BASIN 2016



HWRf FORECAST – TRACK FORECAST SKILL (%) STATISTICS
VERIFICATION FOR ATLANTIC BASIN 2016



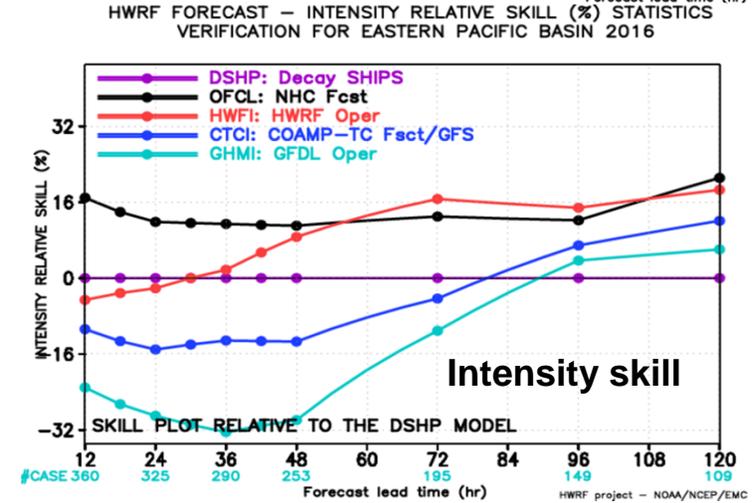
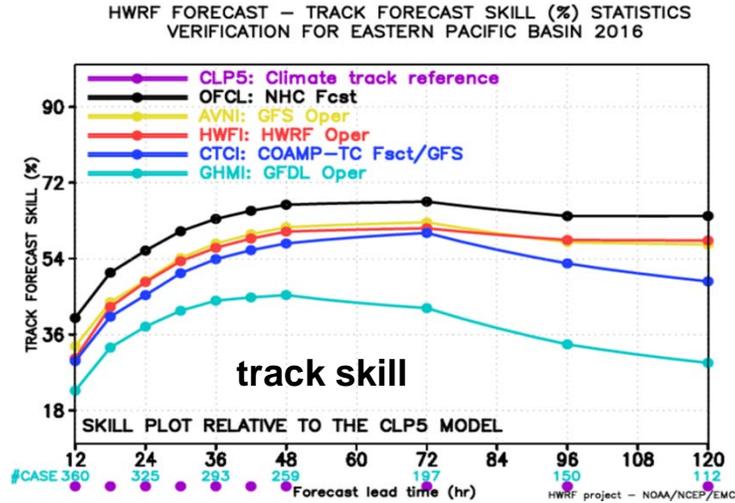
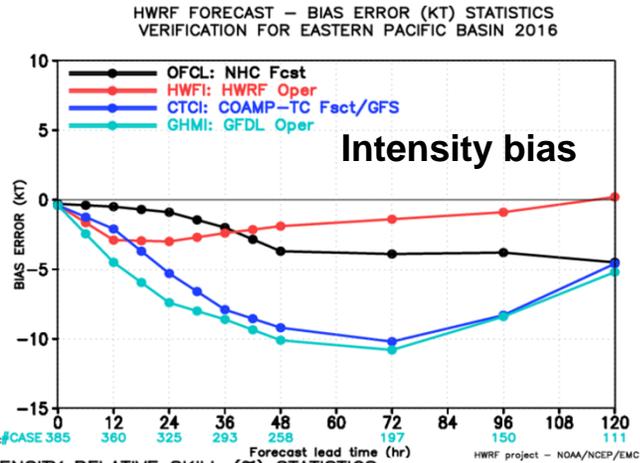
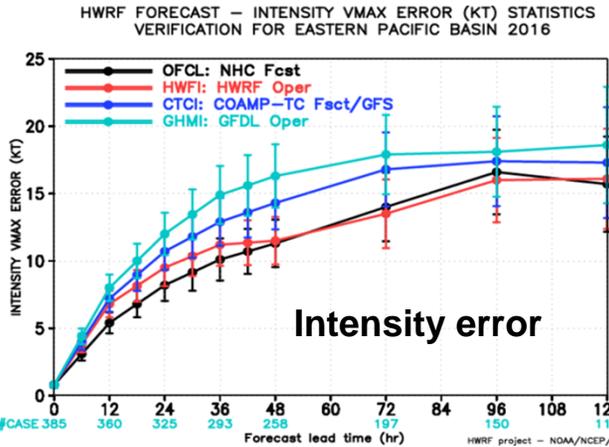
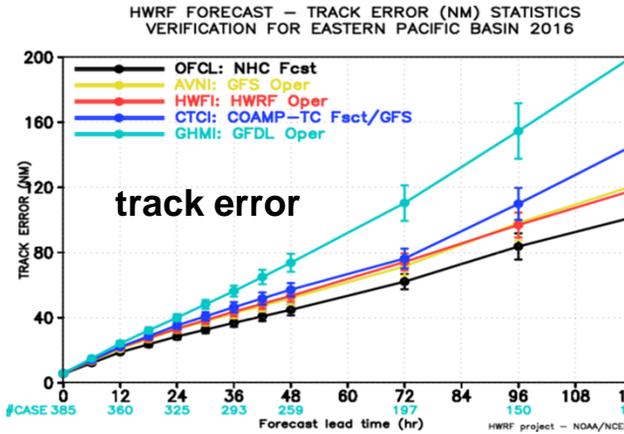
HWRf FORECAST – INTENSITY RELATIVE SKILL (%) STATISTICS
VERIFICATION FOR ATLANTIC BASIN 2016





HWRF in the 2016 Eastern Pacific Basin (Agatha-Otto)

Real-Time Performance

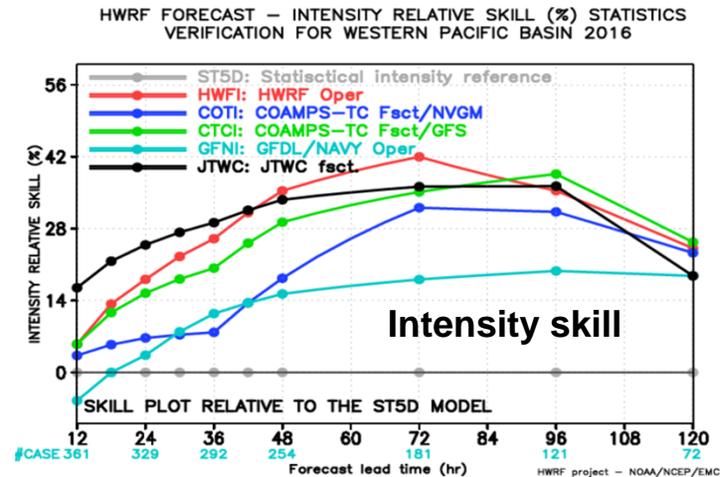
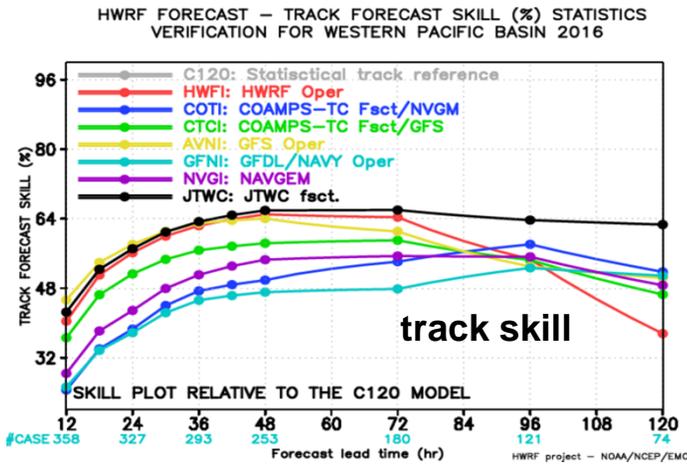
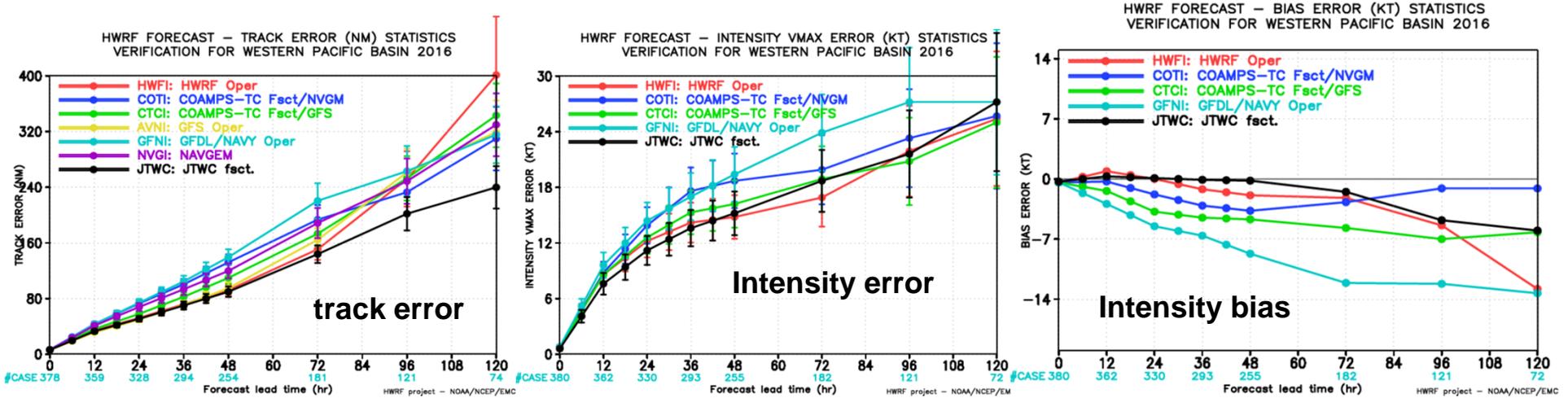




HWRF in the 2016 Western Pacific Basin (Nepartak to Nock-Ten)



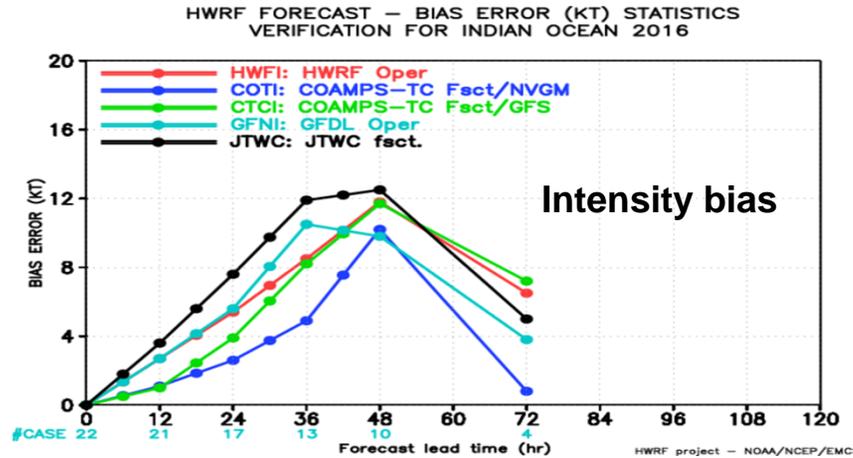
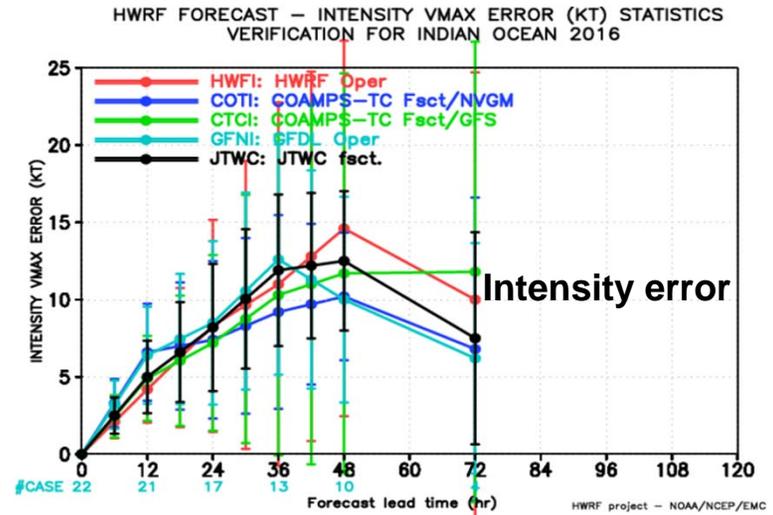
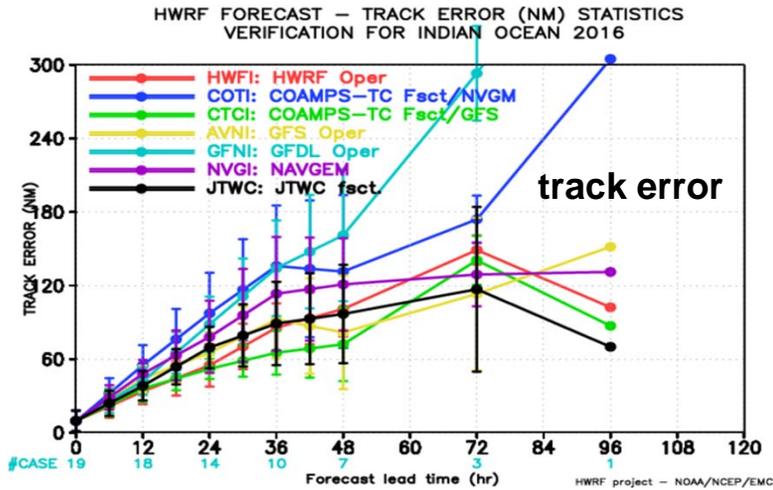
Real-Time Performance





HWRF in the 2016 North Indian Basin (Roanu-Vardah)

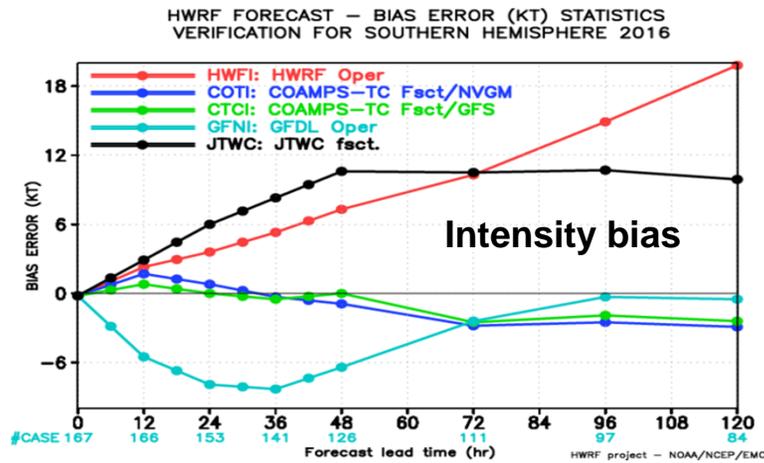
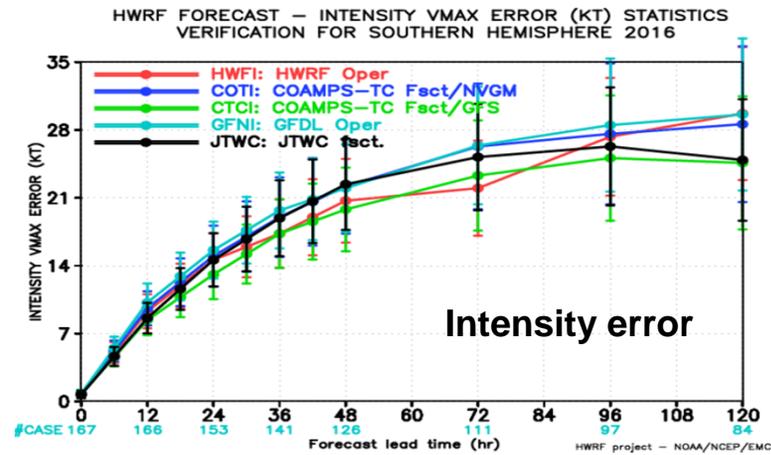
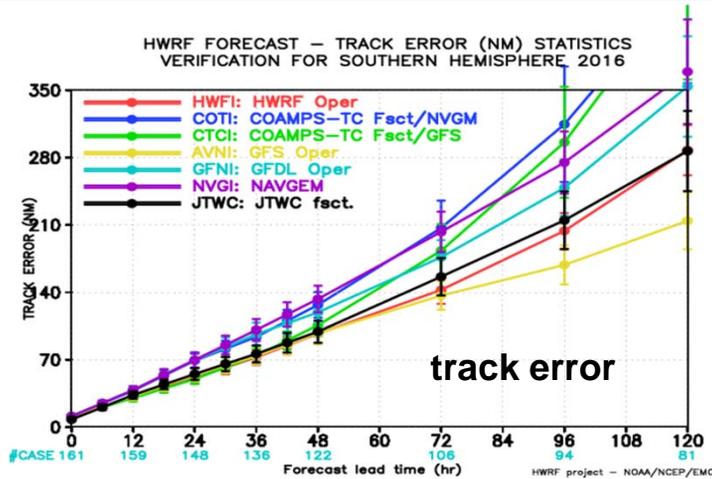
Real-Time Performance





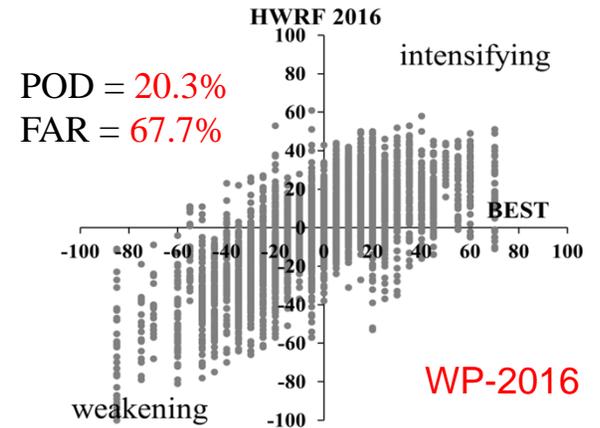
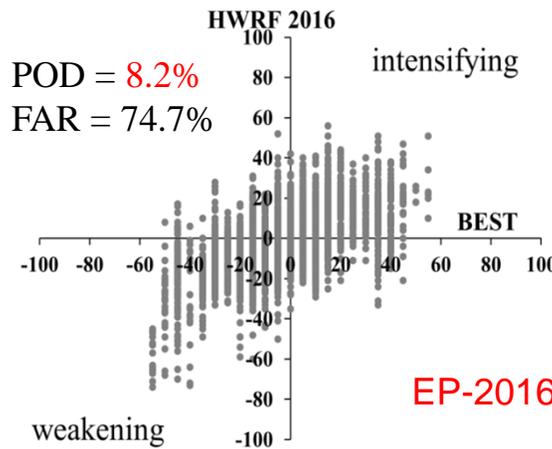
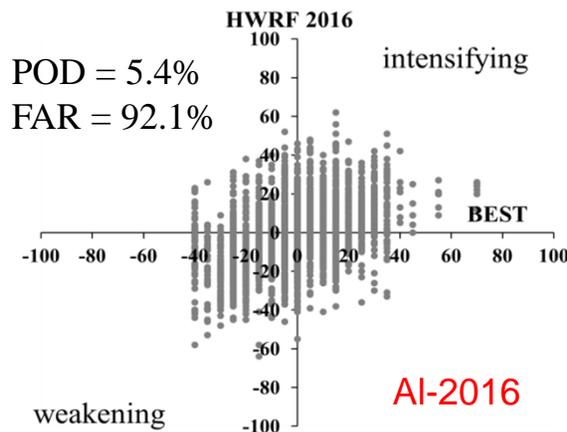
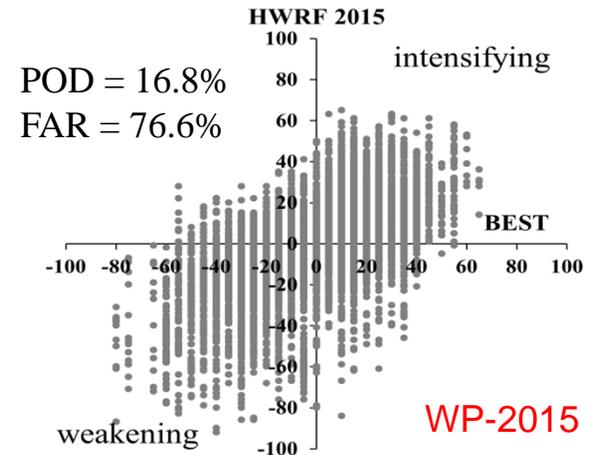
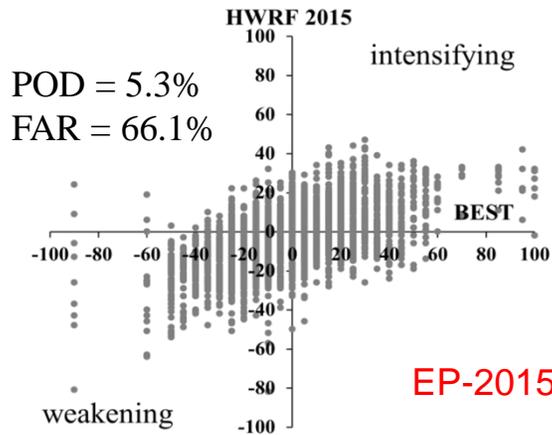
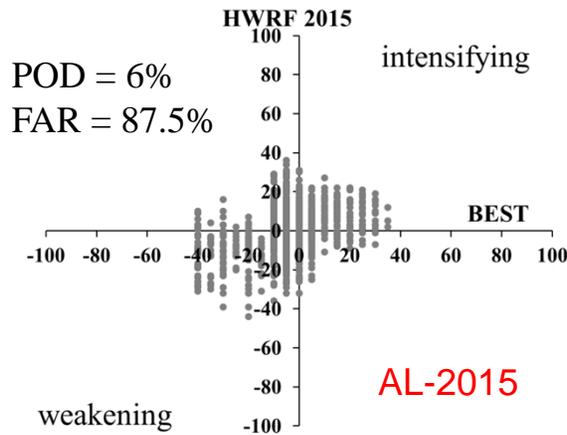
HWRf in the 2016 Southern Hemisphere

Real-Time Performance



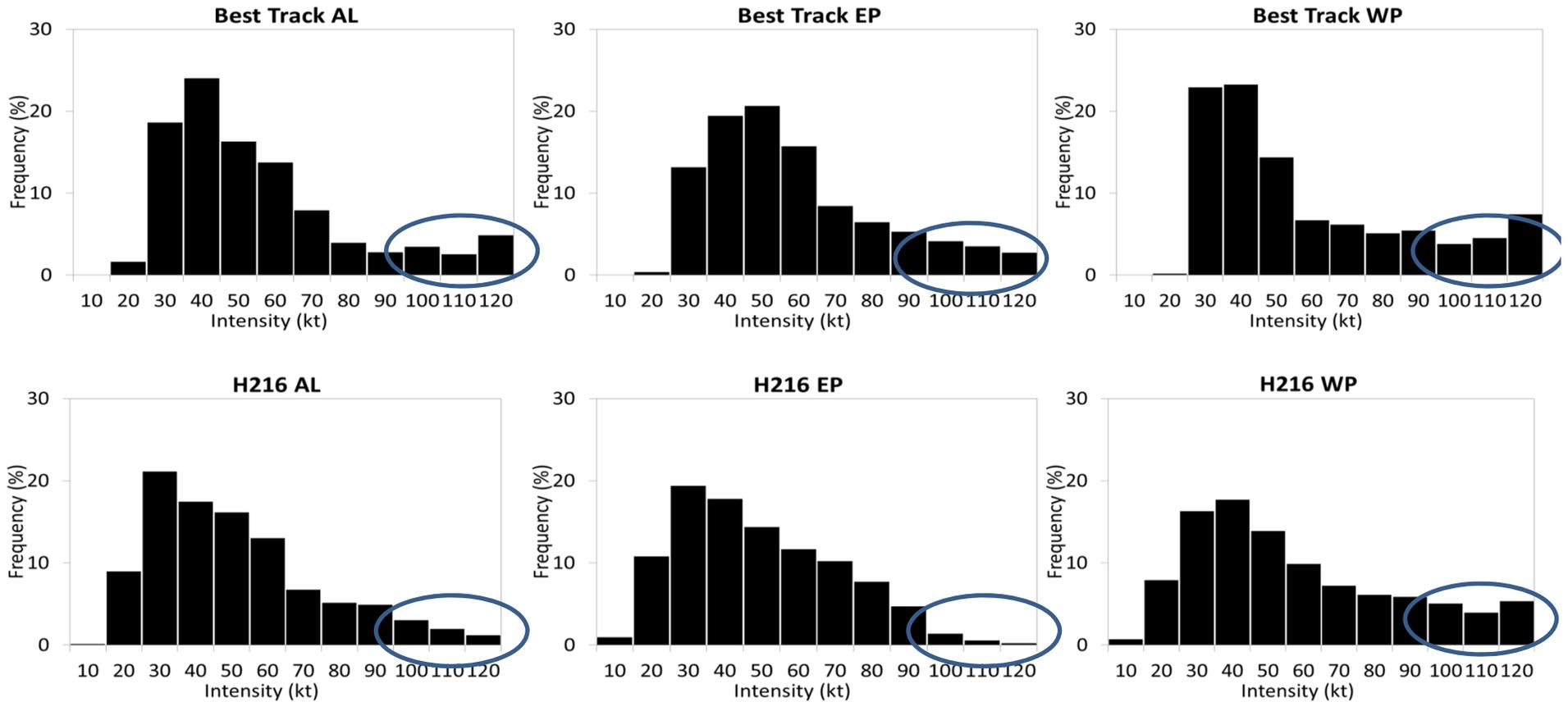


RI POD in AL/EP/WP Basins (From 2016 real time)



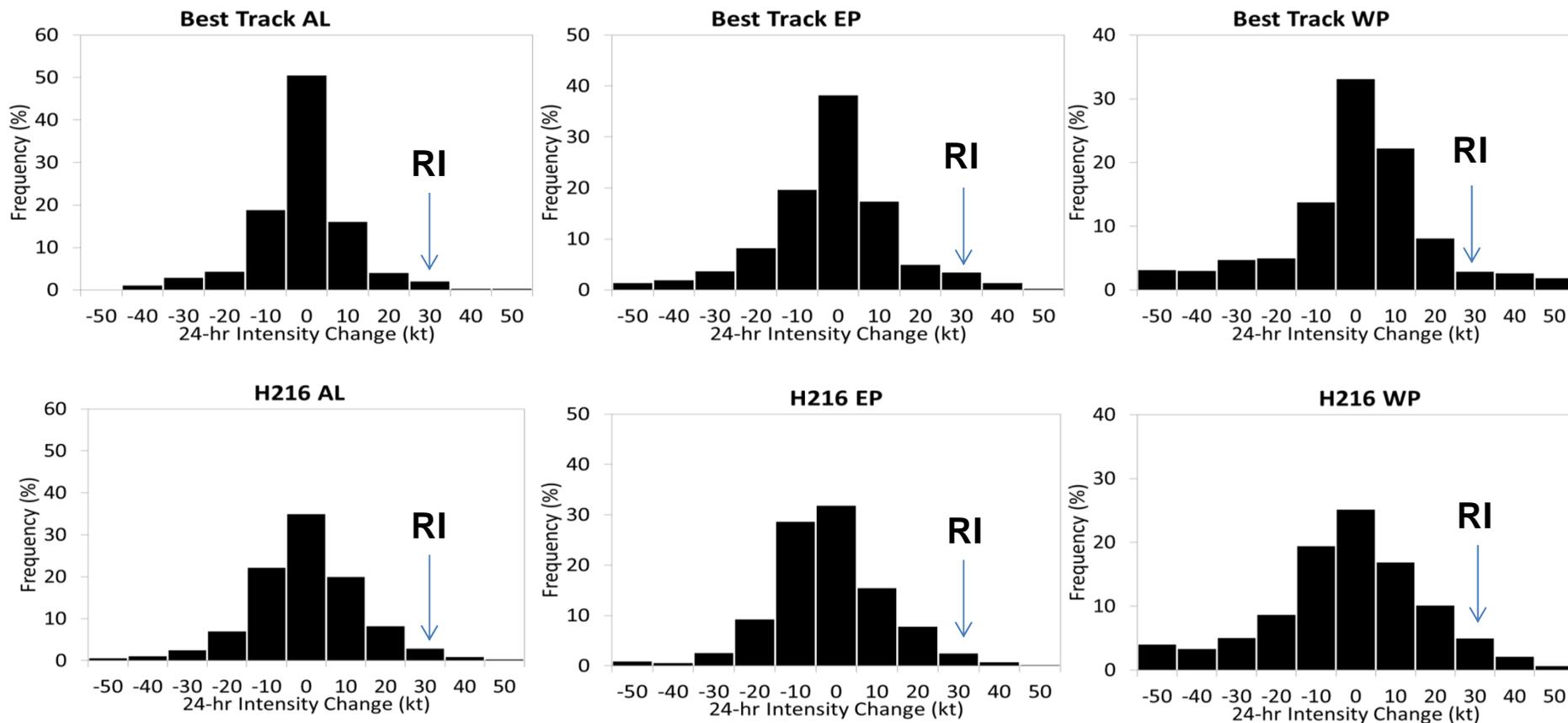
Intensity Distribution

(From 2016 real time)



24hr Intensity Change Distribution

(From 2016 real time)





Basin-scale HWRF Real time Parallel



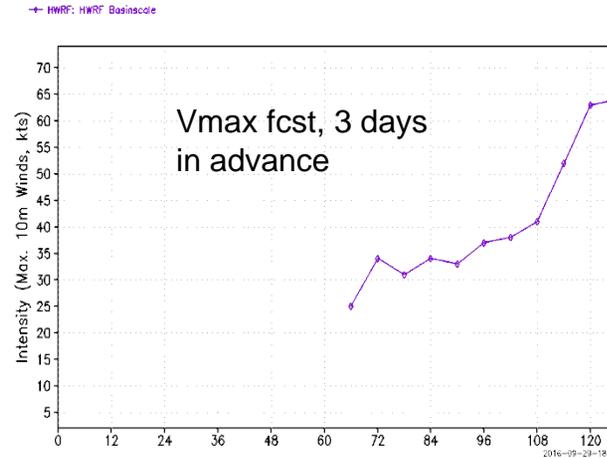
Basin-scale Configuration:
nx=864, ny=632 (160°x60°),
dx=0.09, dy=0.09, ~12km
domain center fixed at (80.0W, 25.0N)

The basin-scale model does have the ability to forecast the formations of almost all storms.

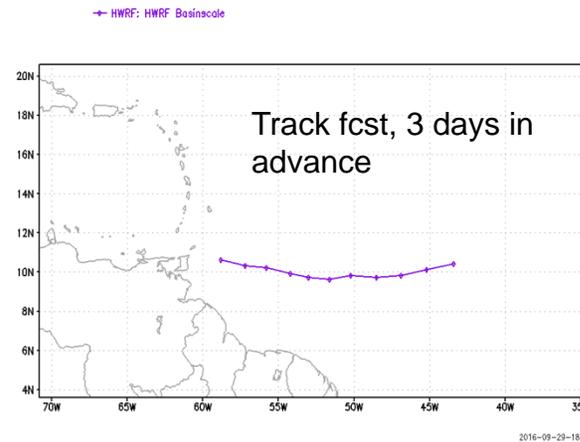
Hurricane Matthew (14L 2016) became a named storm at 15:00 UTC 28 September 2016.

Basin-scale HWRF forecast its formation at 12:00 UTC 23 September 2016.

HWRF Basinscale: TC Intensity Vmax
Storm: 2016092312



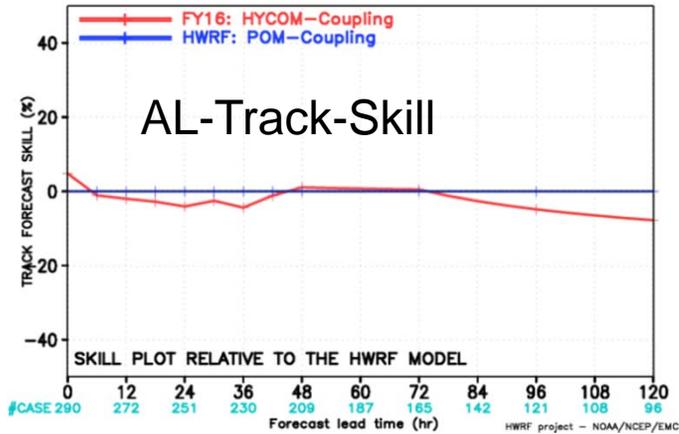
HWRF Basinscale: TC Tracks
Storm: 2016092312



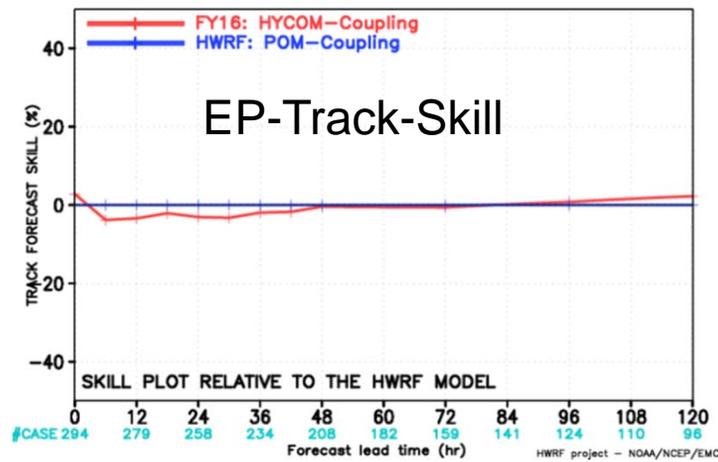


HYCOM-HWRF Coupling Real Time Parallel

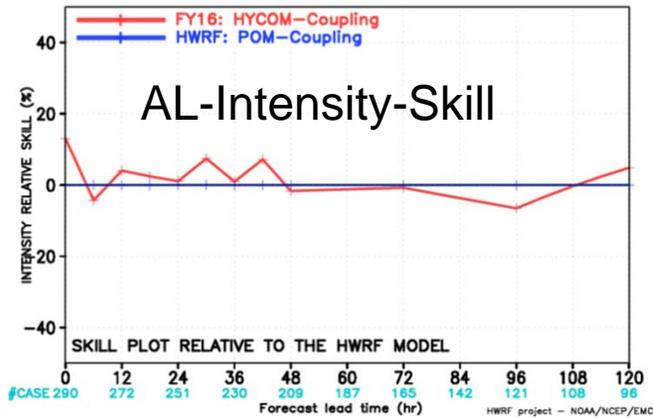
HWRF FORECAST – TRACK FORECAST SKILL (%) STATISTICS
VERIFICATION FOR NATL BASIN 2013–2015



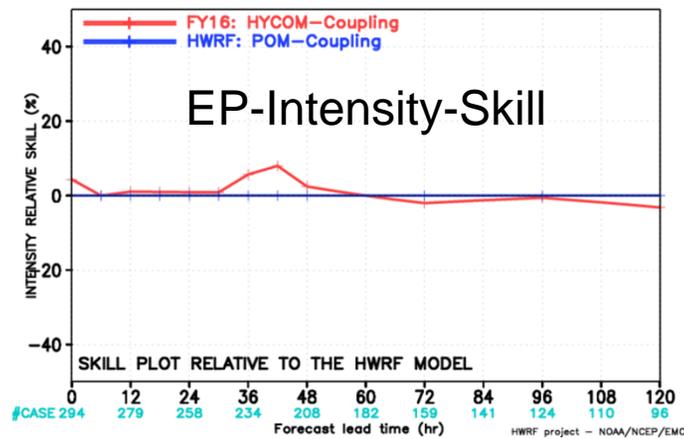
HWRF FORECAST – TRACK FORECAST SKILL (%) STATISTICS
VERIFICATION FOR EPAC BASIN 2013–2015



HWRF FORECAST – INTENSITY RELATIVE SKILL (%) STATISTICS
VERIFICATION FOR NATL BASIN 2013–2015



HWRF FORECAST – INTENSITY RELATIVE SKILL (%) STATISTICS
VERIFICATION FOR EPAC BASIN 2013–2015





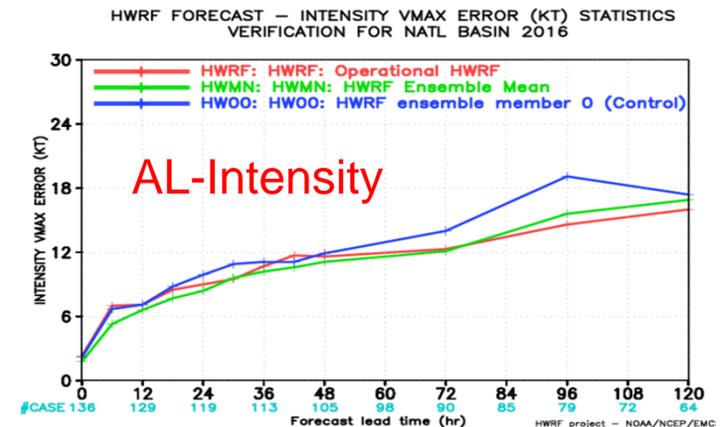
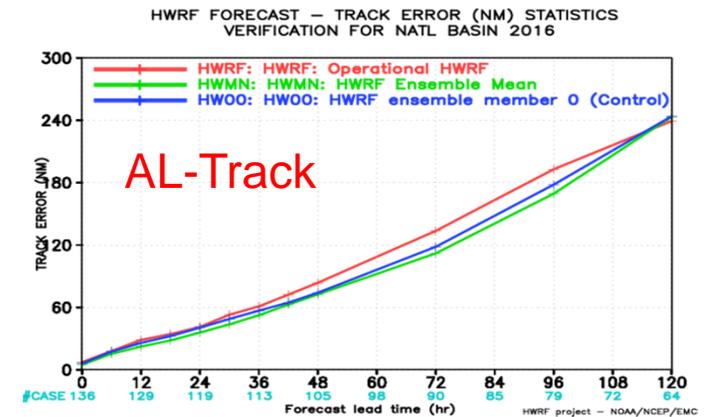
HWRF based ensemble Real time Parallel



- Use 2016 operational deterministic HWRF model except for
 - Less horizontal resolution: 27/9/3km vs. 18/6/2km
 - Less vertical resolution: L43 vs. L61;
 - No GSI due to lack of GDAS data;
- IC/BC Perturbations (large scale): 20 member GEFS.
- Model Physics Perturbations (vortex scale):
 - Stochastic Convective Trigger Perturbations in SAS: -50hPa to +50hPa white noise ;
 - Stochastic boundary layer height perturbations in PBL scheme, -20% to +20%;
 - Stochastic Cd perturbation;
 - Stochastic initial wind speed and position (TCVital) perturbations considering best track uncertainty.

Difference from 2015 HWRFEES:

1. Larger D02 and D03;
2. Scale-aware convection scheme turned on for all domains.

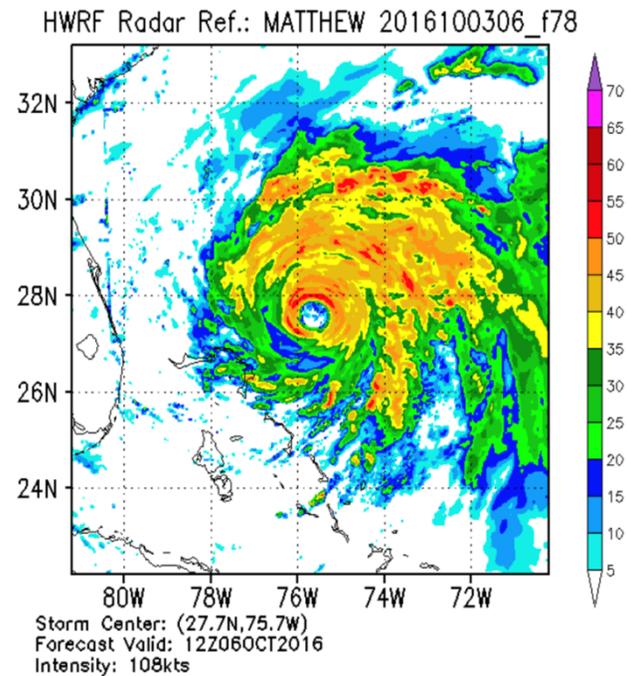
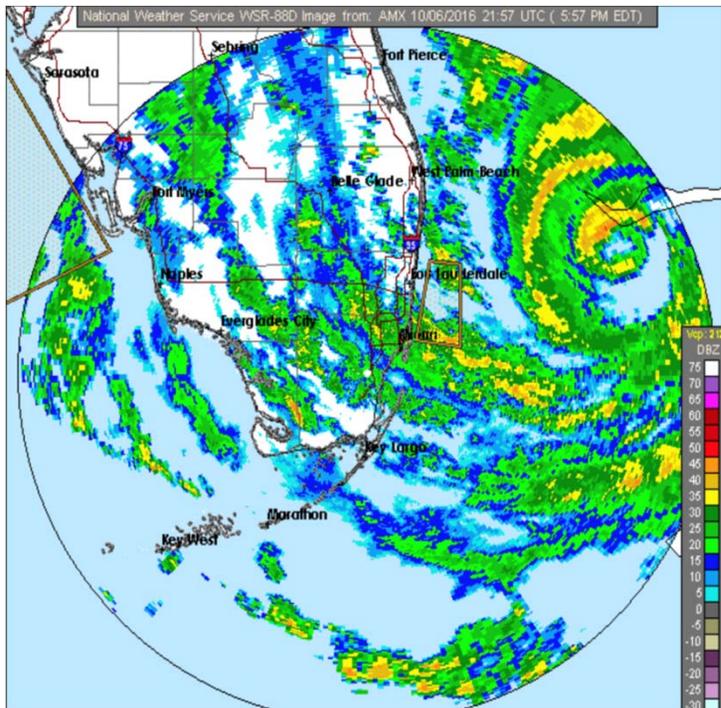


Secondary Eyewall in HWRf

Matthew, 14L, 2016

Operational cycles:

- September 28-31, ~30% of the cycles show a SE towards the end of the integration
- October 01-05, ~80% cycles show SE & ERC

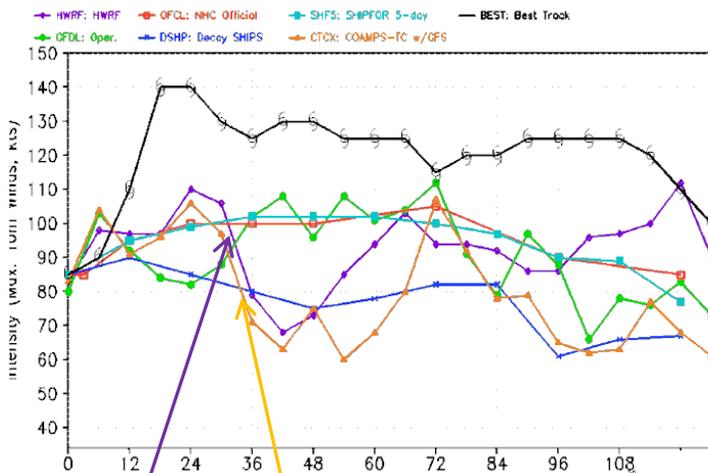




HWRF Simulated Intensity Oscillation and Hurricane Hook for Matthew 14L, 2016



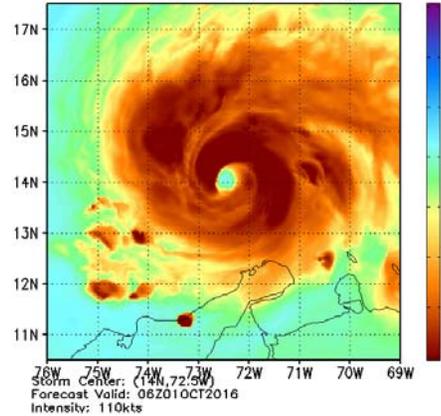
Operational HWRf: TC Intensity Vmax
Storm: MATTHEW (14L) valid 2016093006



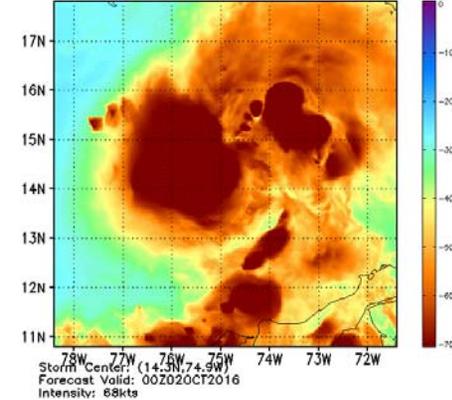
HWRF CTCX

- Large fluctuations in intensity in model forecasts
- Storm structure collapse
- Not happened in observation

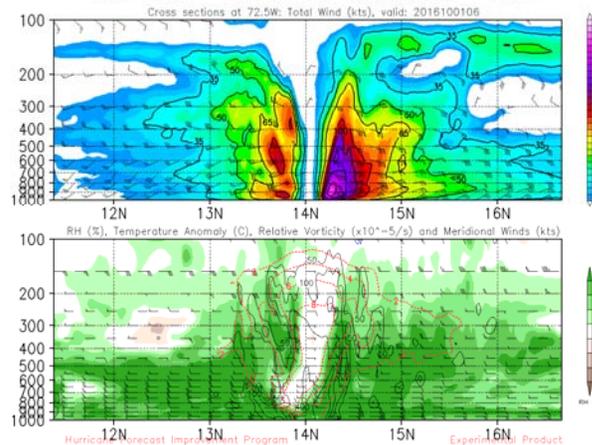
HWRf WV: MATTHEW 2016093006_f24



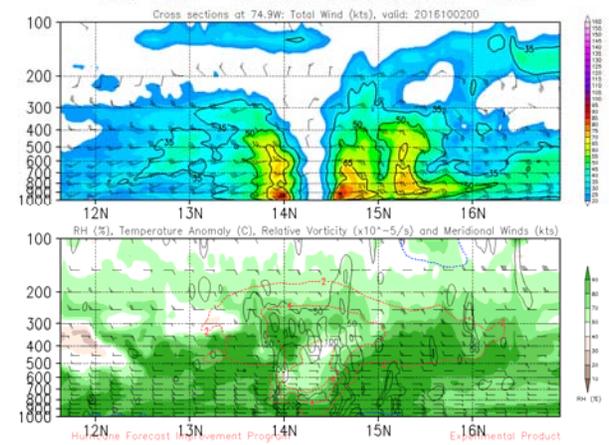
HWRf WV: MATTHEW 2016093006_f42



NCEP HWRf - MATTHEW14L 2016093006 - F024

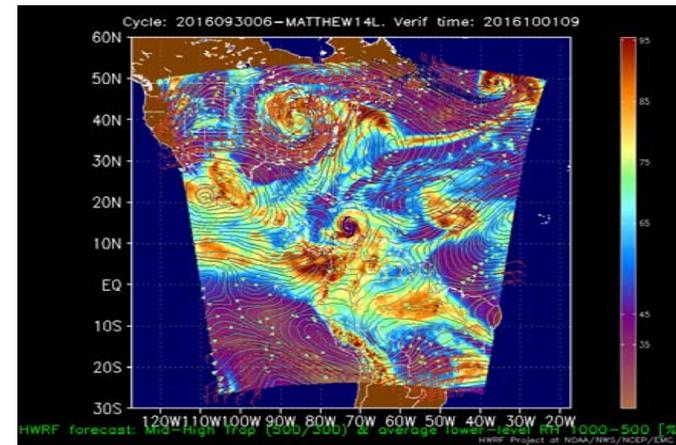
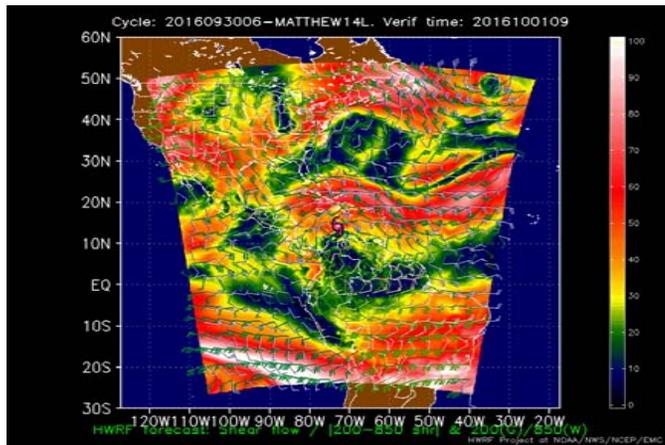
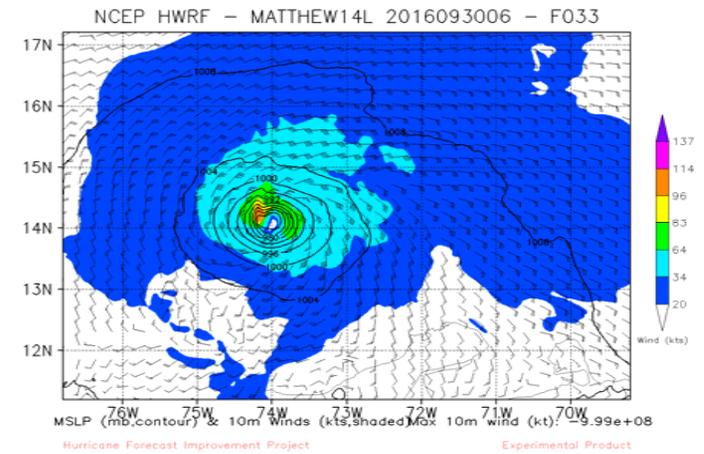
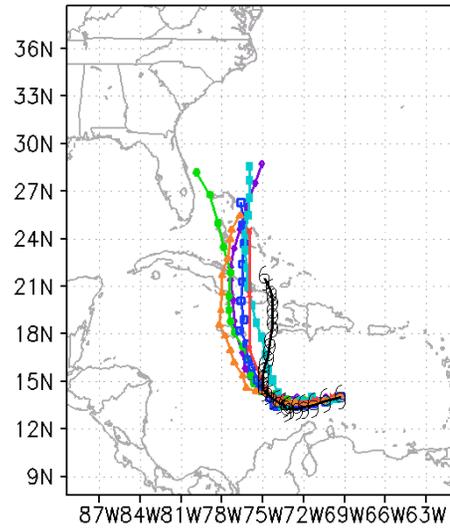
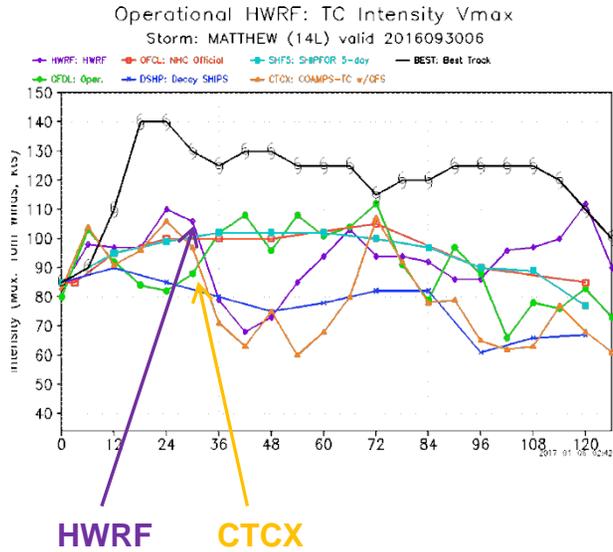


NCEP HWRf - MATTHEW14L 2016093006 - F042





HWRF Simulated Intensity Oscillation and Hurricane Hook for Matthew 14L2016

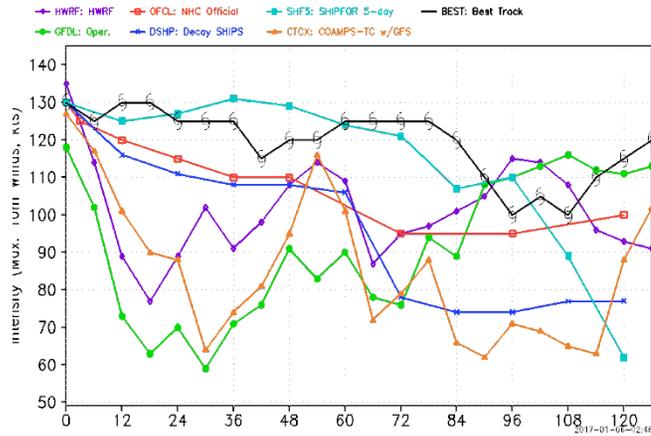




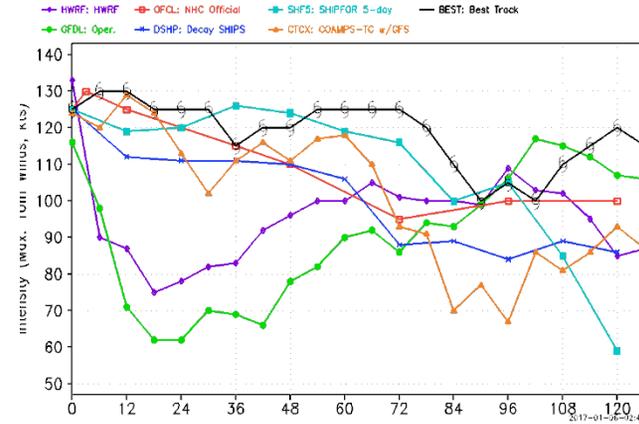
Intensity Oscillation and Spin-Down due to both VI/DA and Hurricane Hook



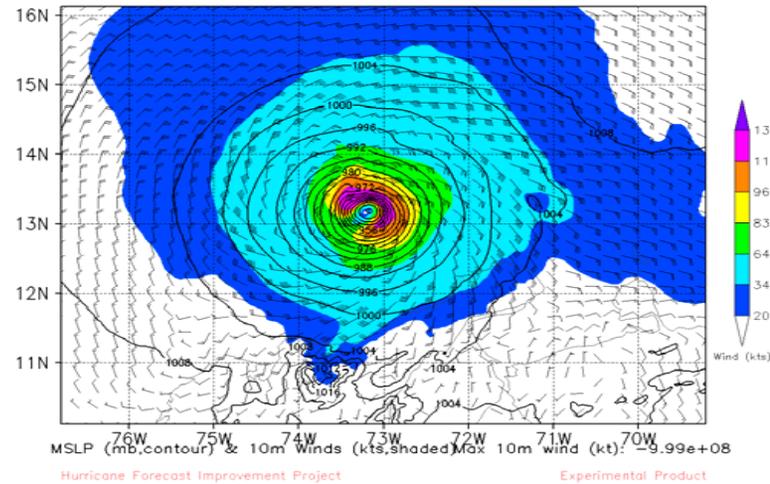
Operational HWRf: TC Intensity Vmax
Storm: MATTHEW (14L) valid 2016100112



Operational HWRf: TC Intensity Vmax
Storm: MATTHEW (14L) valid 2016100118



NCEP HWRf - MATTHEW14L 2016100118 - F000

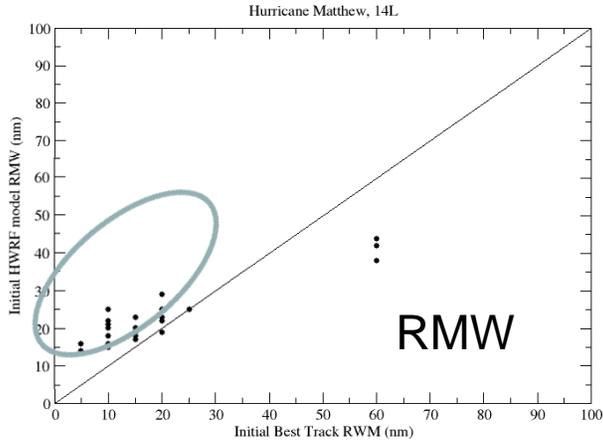




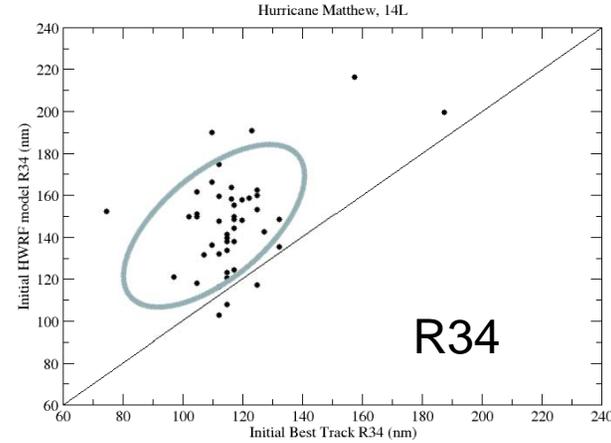
Comparison of Initial Storm Sizes (Model vs. Best) Hurricane Matthew, 14L, 2016



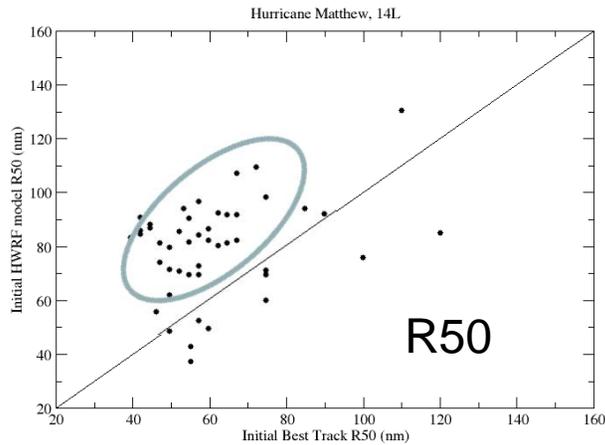
Initial Radius of Max Wind (Model vs. Obs.)



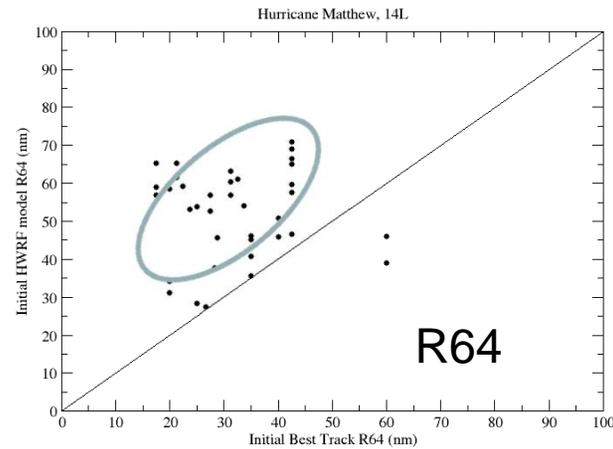
Radius of 34kts Wind (Model vs. Obs.)



Radius of 50kts Wind (Model vs. Obs.)



Radius of 64kts Wind (Model vs. Obs.)



In most of cycles, model initial storm sizes are bigger than Obs.

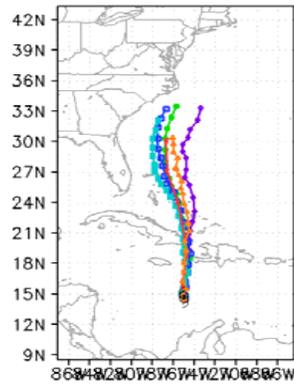


Consider Storm's Meridional Movement when Choosing Domain Center



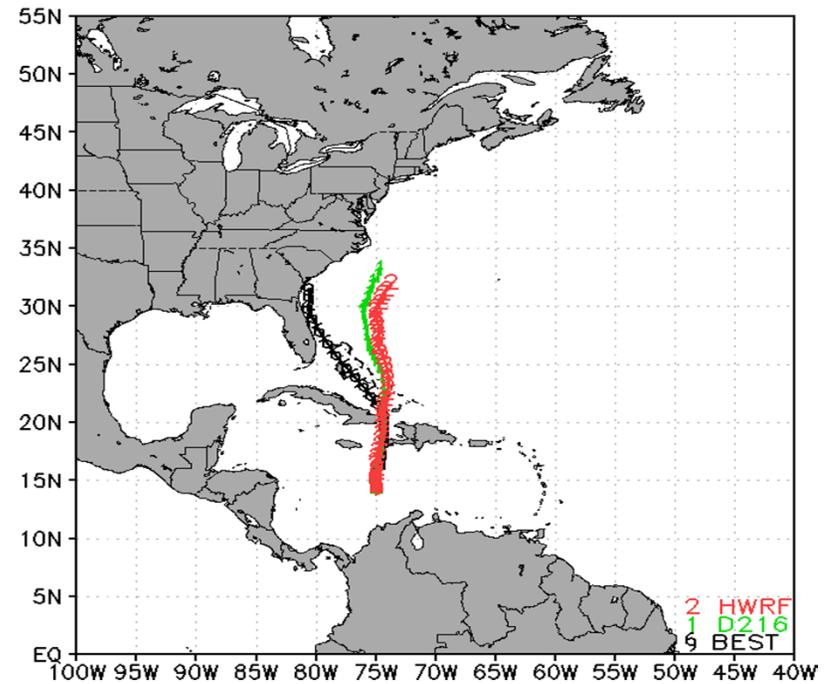
Operational HWRf: TC Tracks
Storm: MATTHEW (14L) valid 2016100300

— HWRf: HWRf — AVNO: Oper. GFS — OFCL: NHC Official — BEST: Best Track
— GFDL: Oper. — NVGM: NVGM model — CTCX: COAMPS-TC w/GFS



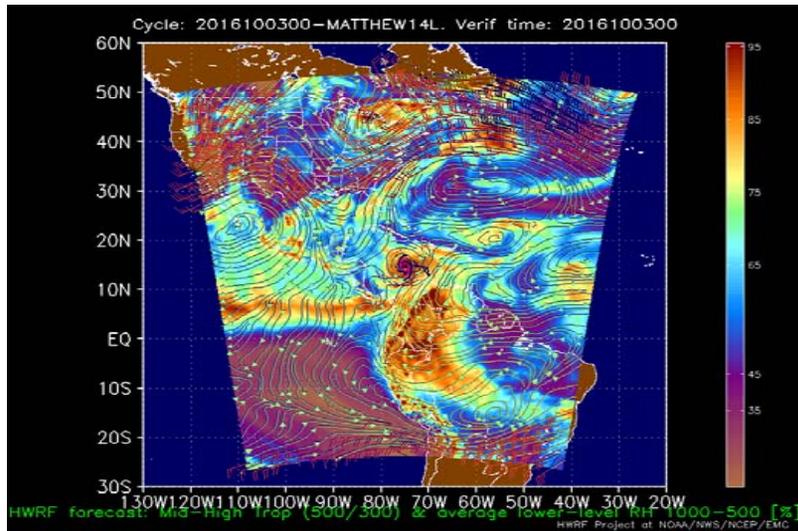
2016-10-03-10:05

HWRf Forecast of MATTHEW at 2016100300



2 HWRf
1 D216
9 BEST

Cycle: 2016100300-MATTHEW14L. Verif time: 2016100300

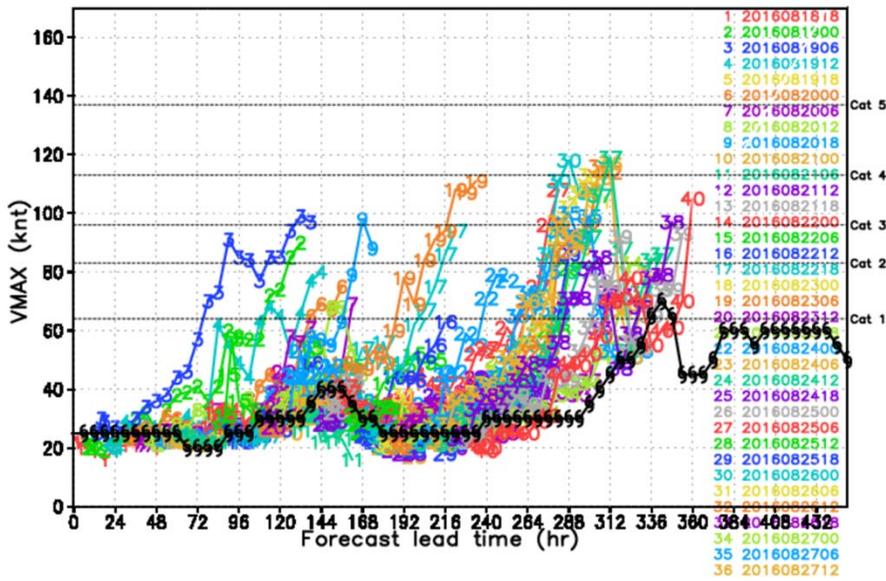


HWRf forecast: Mid-High Trop (500/300) & average lower-level RH (1000-500) [%]
HWRf Project at NOAA/NWS/NCEP/EMC

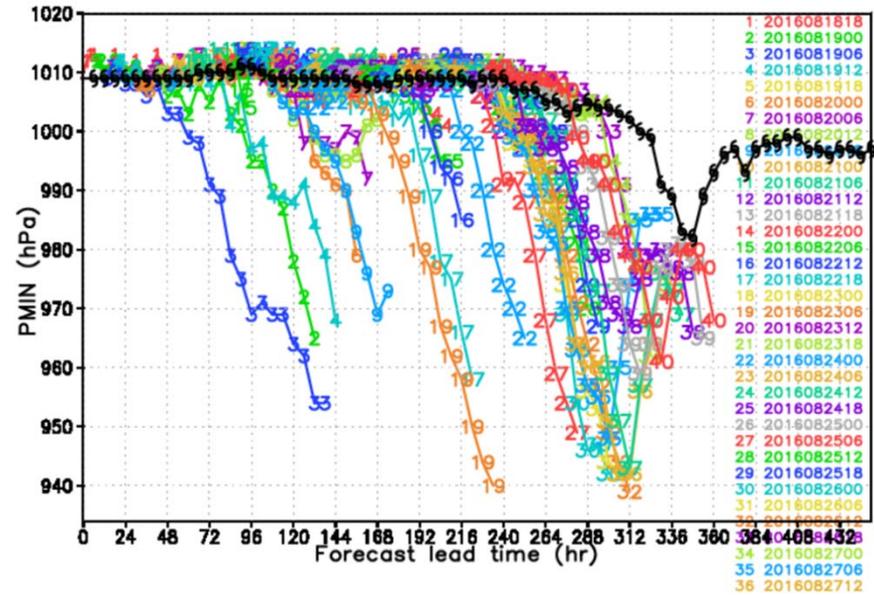


Strong Intensity Forecast Bias for INVEST INVEST 99L

HWRf forecast: INVEST99L (aI092016)
Maximum 10-m wind time series



HWRf forecast: INVEST99L (aI092016)
Minimum sea level pressure time series





Challenges and Issues

- Large fluctuations in intensity forecasts
- Initial intensity spin up/down
- Track forecasts impacted by LBC
- Over-prediction of intensity for INVEST storms