Performance and Evaluation of HWRF-based Ensemble Prediction System for 2018 Hurricane Season

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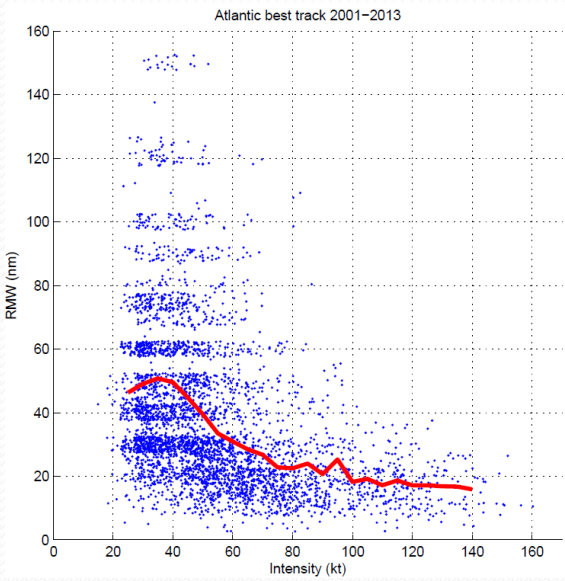
Outline

- Configuration of 2018 HWRF-base Ensemble Prediction System (HWRF-EPS)
- Comparison of verification of HWRF-EPS with its own deterministic control member (HWoo)
- Comparison of verification of HWRF-EPS with the 2018 operational HWRF
- Posterior analysis and HWRF-EPS Statistical Characteristics
- Conclusion and Future Work

2018 HWRF ensemble Configuration

- Use 2018 operational deterministic HWRF model except for
  - Less horizontal resolution: 14.5/4.5/1.5km vs. 18/6/2km (27/9/3km, in 2017)
  - Less vertical resolution: L75 vs. L61 (L43)
  - No GSI due to lack of GDAS data;
- IC/BC Perturbations (large scale): 20 member GEFS, 0.5x0.5 degree GRIB2 (1x1deg.)

- 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;
- Situation-appropriate perturbations to the initial time position and intensity in TCVital.
- Initial ocean SST perturbations (Xiao Hui & Ryan Torn)
  - Climatological (2012-2016), GFS surface analysis
  - Remove climatological mean, scale to 0.5K standard deviation.
  - Mix the initial SST perturbation downward into upper ocean (150 m).
- Use values of coac and codamp for 2km resolution



Storm List conducted in 2018 Hurricane Season

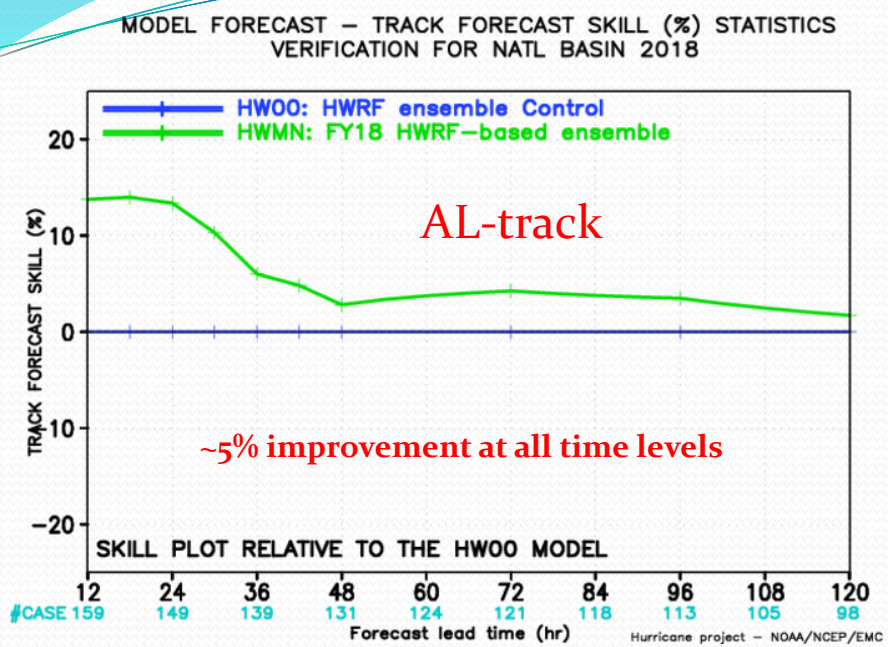
North Atlantic Basin (total sample: 187)

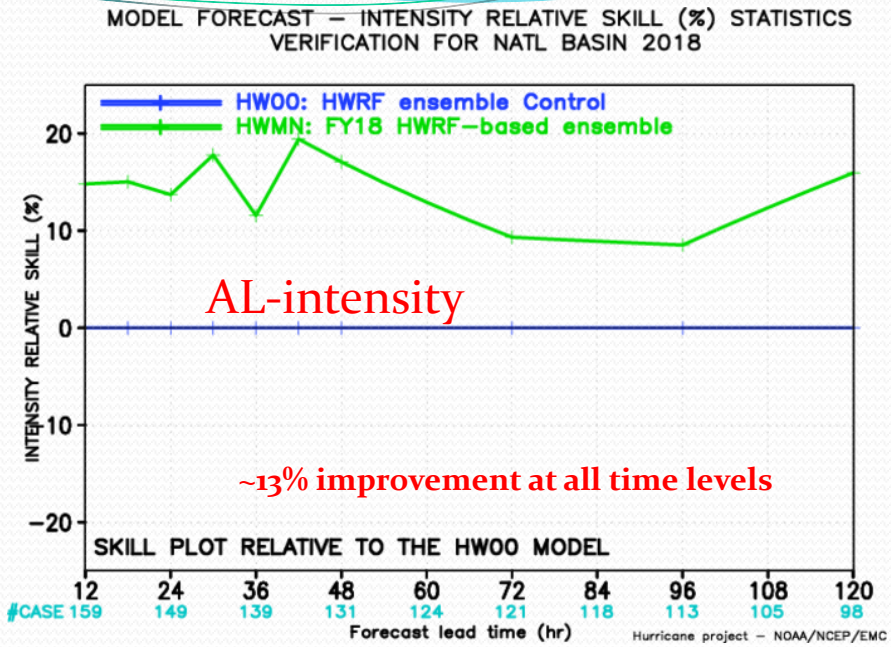
Storm Name	Start Cycle	End Cycle	No. of Cycles
Florence 06L	2018083018	2018091500	61
Gordon 07L	2018090212	2018090500	11
Isaac 09L	2018090712	2018091706	35
Kirk 12L	2018092106	2018092812	30
Leslie 13L	2018092318	2018101000	30
Michael 14L	2018100718	2018101112	20

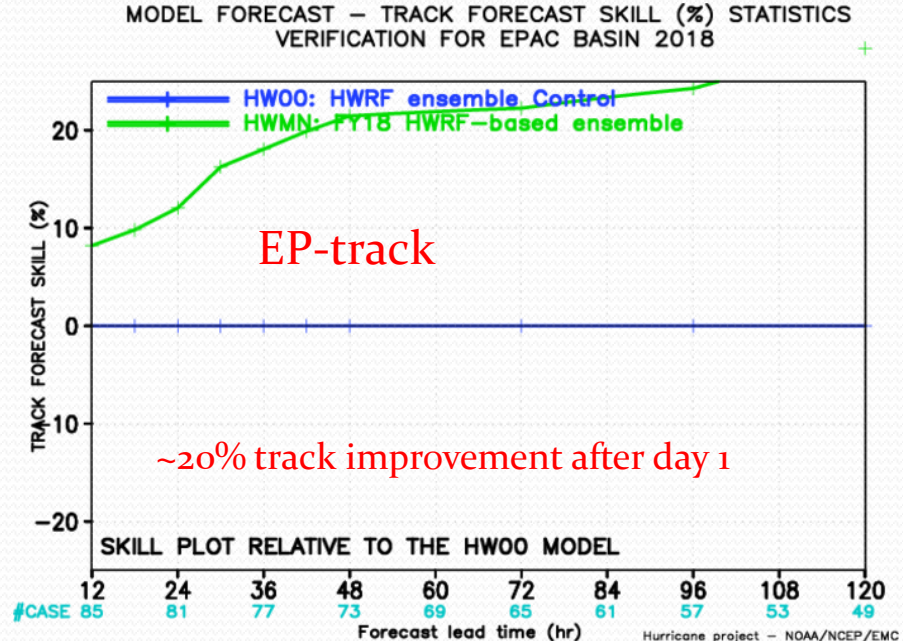
East Pacific Basin (total sample: 88)

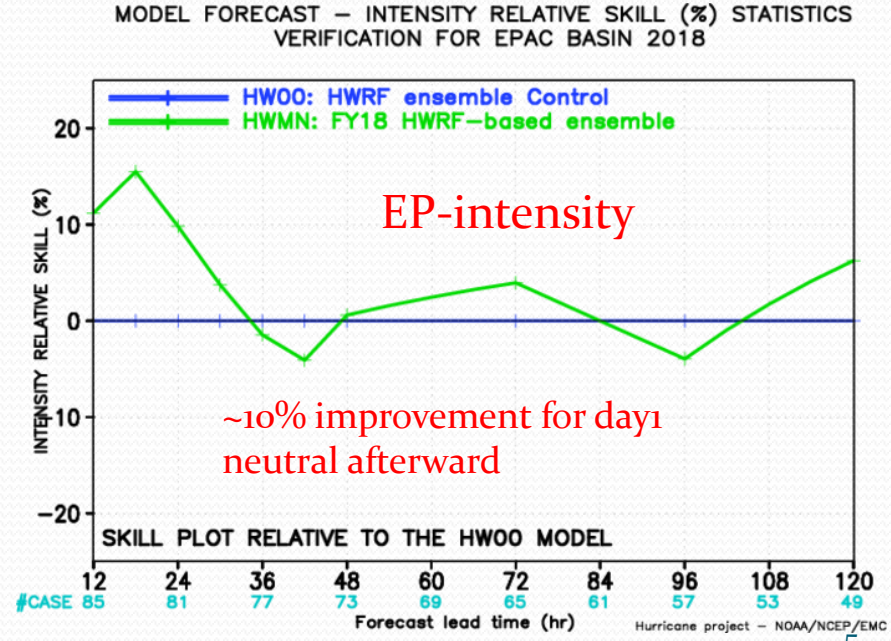
Storm Name	Start Cycle	End Cycle	No. of Cycles
Hector 10E	2018080400	2018081318	40
Lane 14E	2018081612	2018082806	48

Track and Intensity Verification for NATL/EPAC
(HWMN vs HWoo)

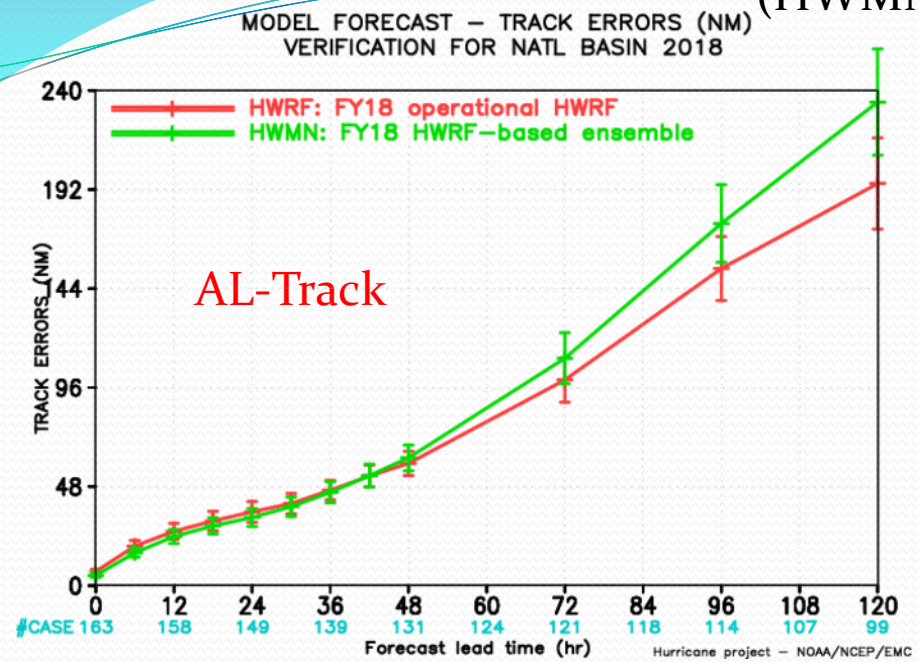


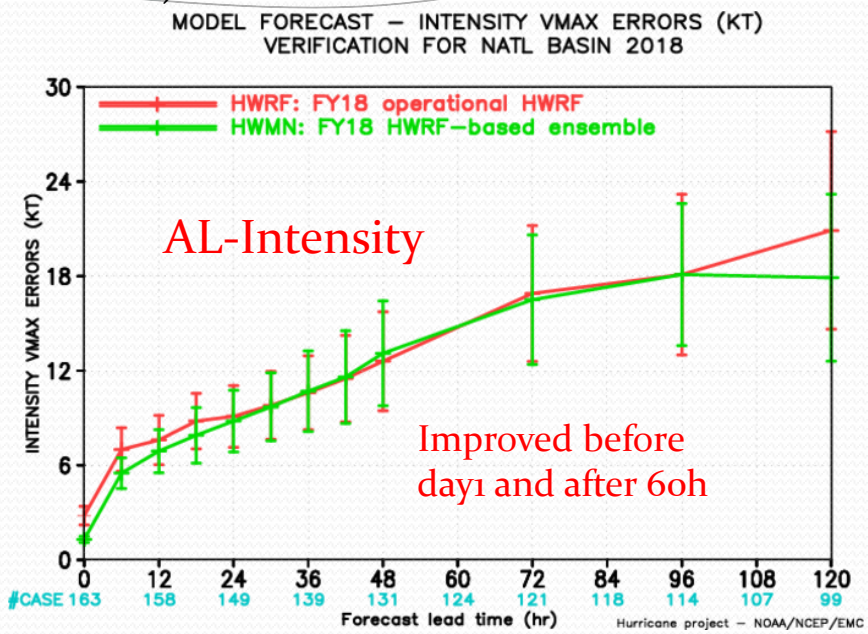


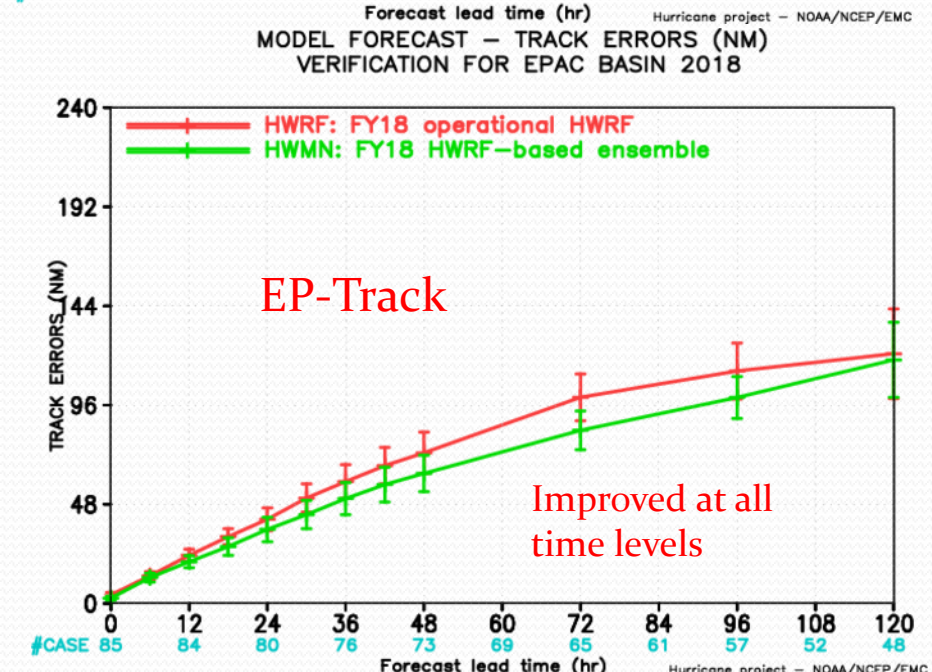


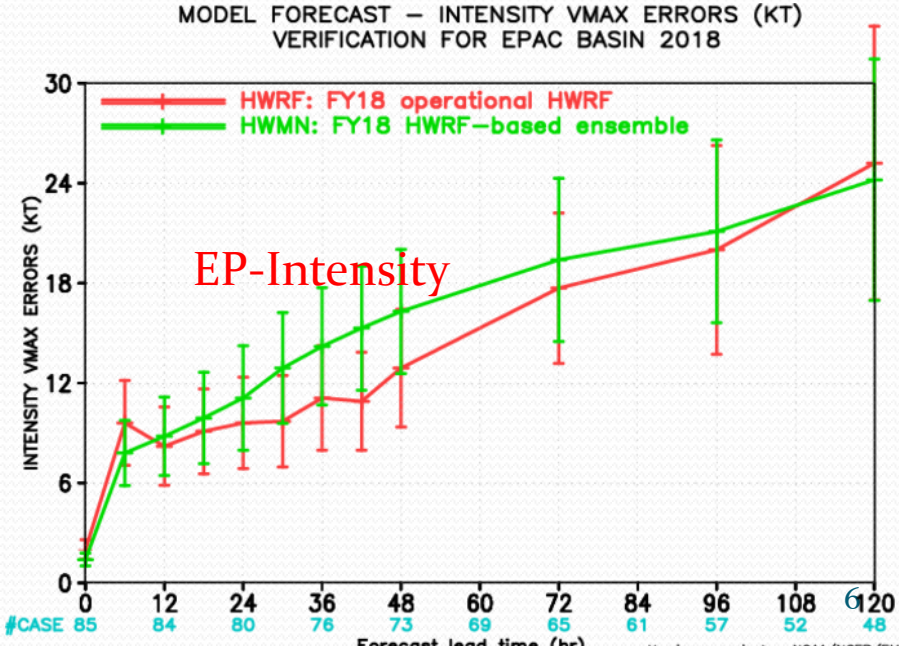


Track and Intensity Verification
(HWMN vs HWRF)

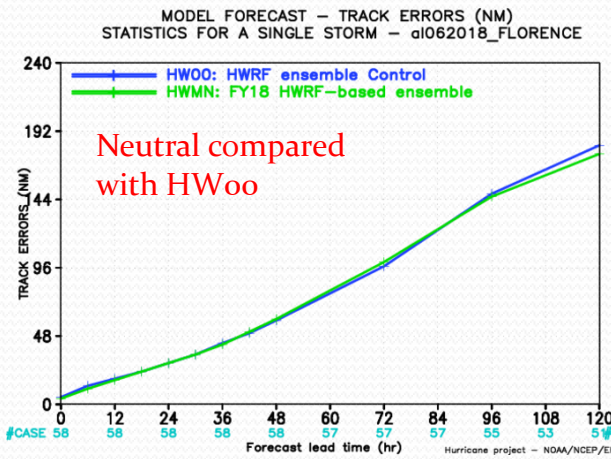


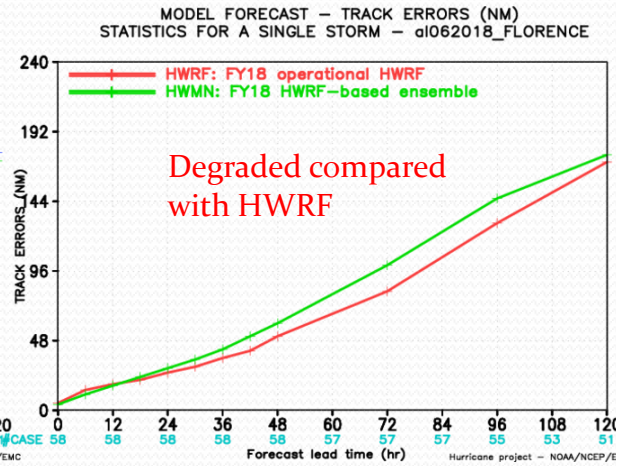


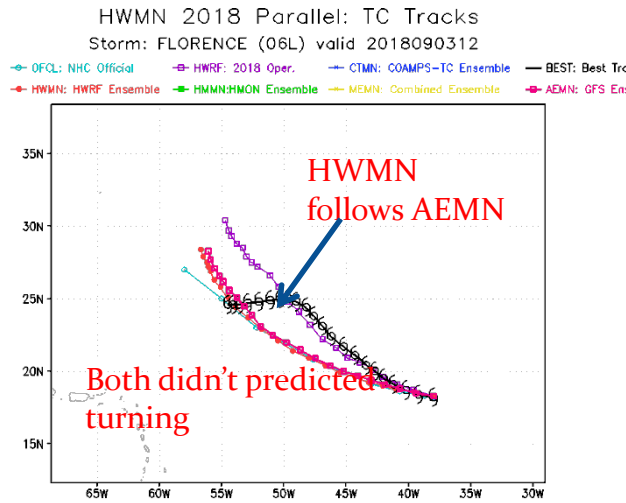


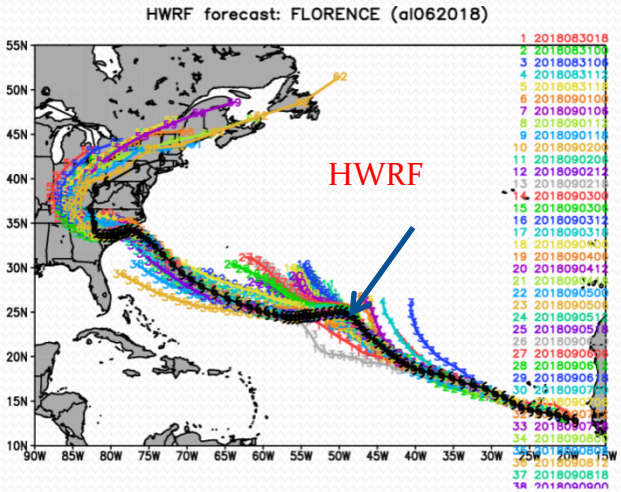


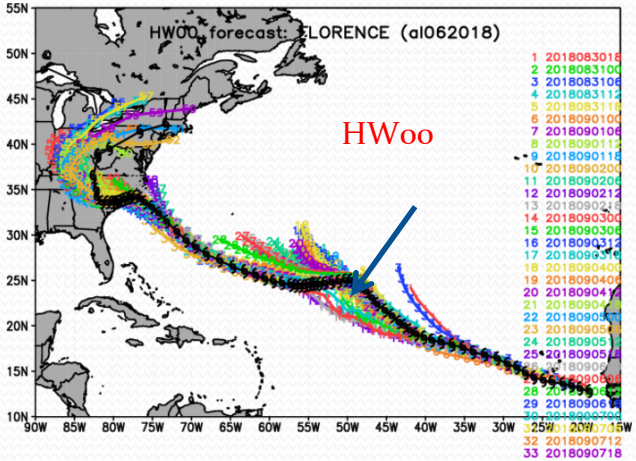
Composite Tracks for Florence, o6L

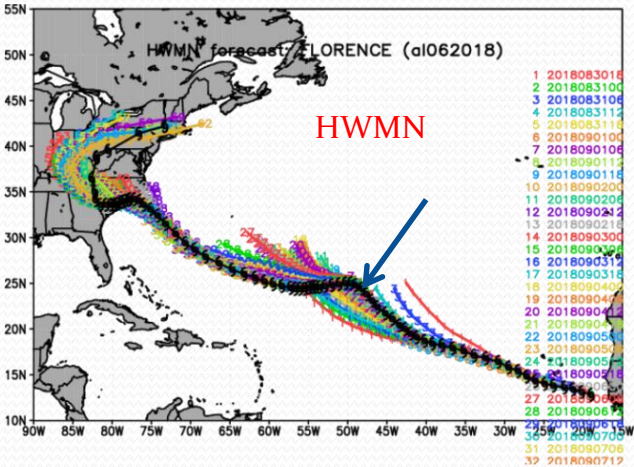






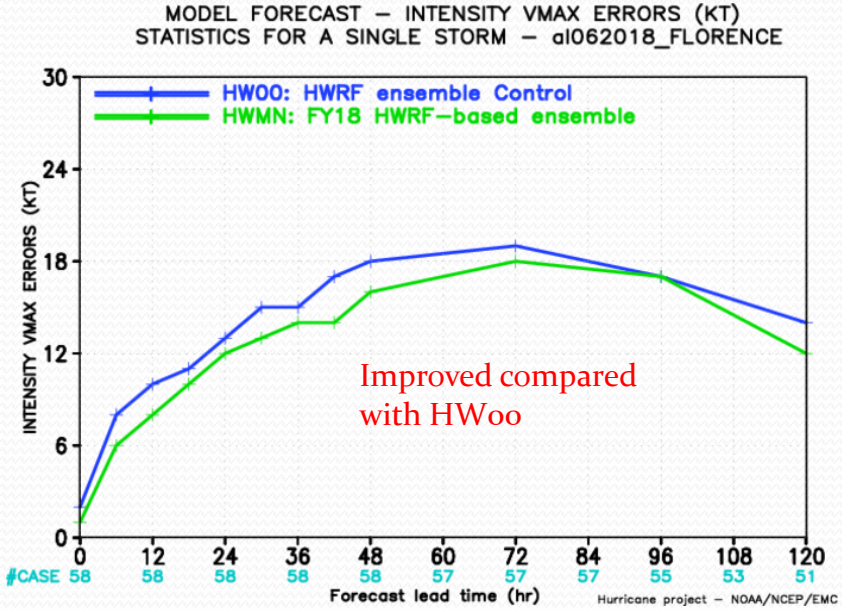


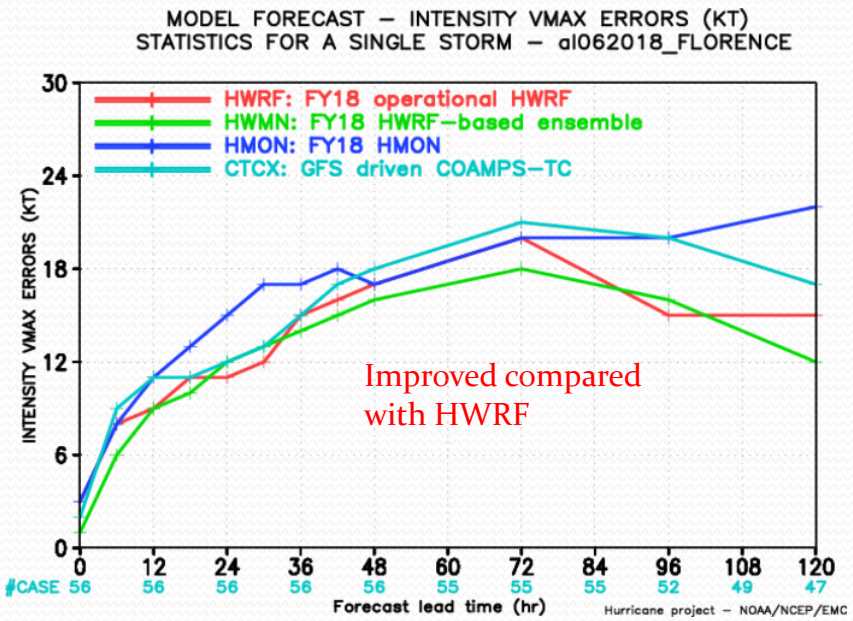


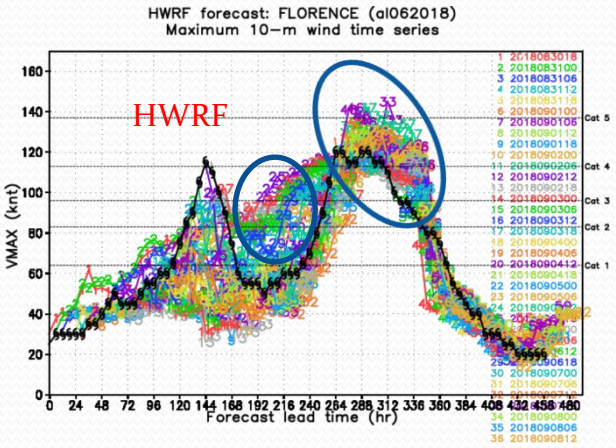


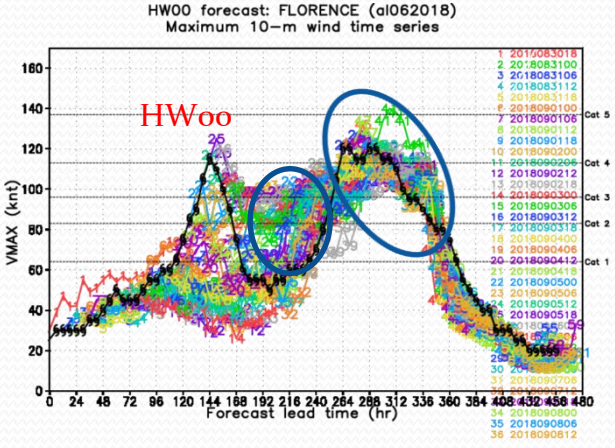
1. All three systems missed westward turning point;
2. HWoo/HWMN have southward track bias following GEFS.

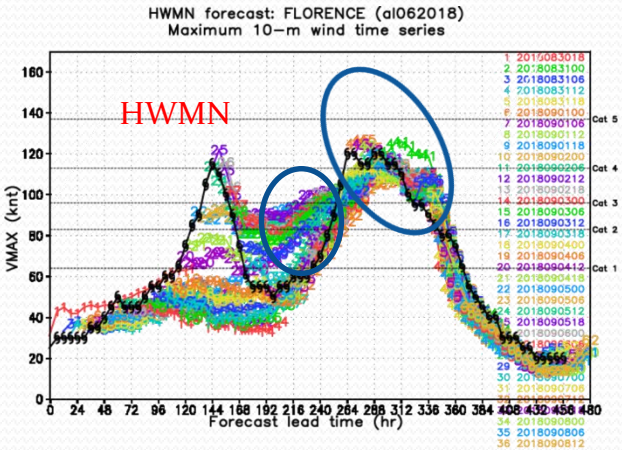
Composite Intensities for Florence 06L











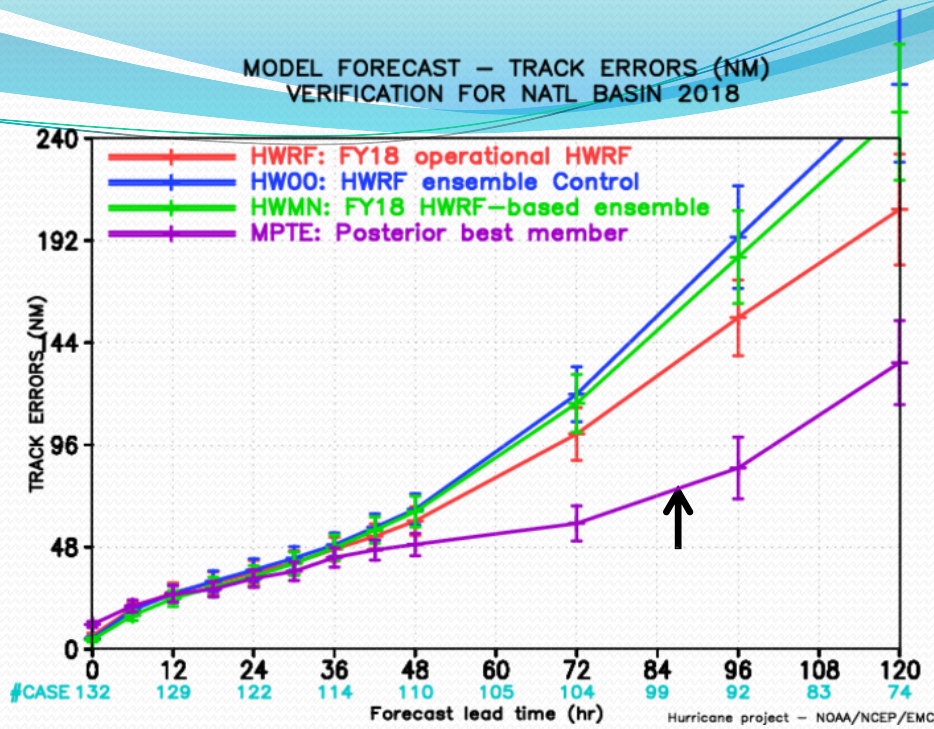
Posterior Analysis on Track/Intensity forecasts

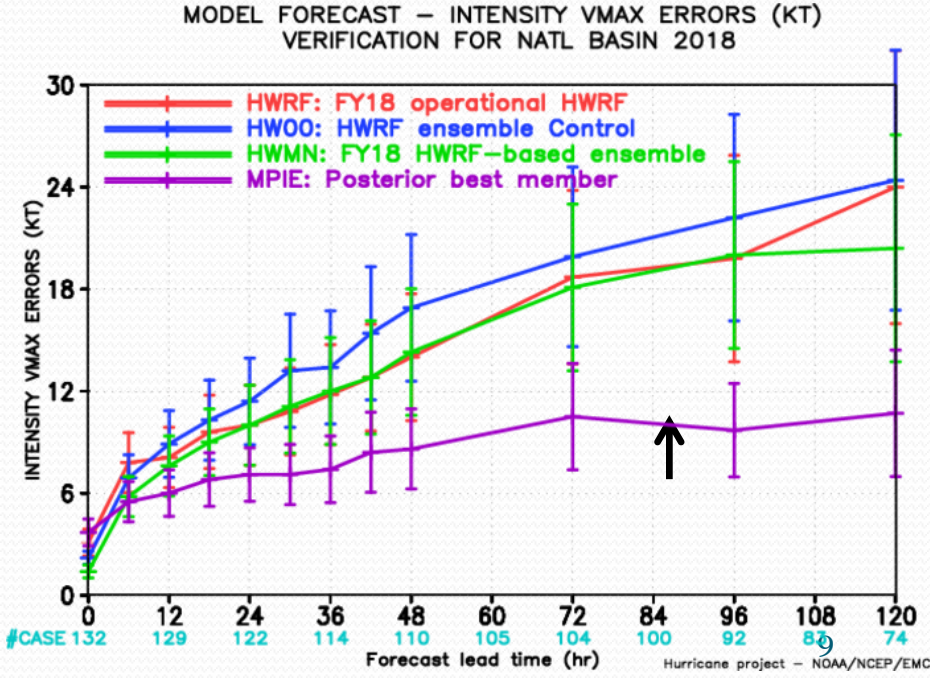
MPTE: Minimum Potential Track Error
MPIE: Minimum Potential Intensity Error

The track/intensity forecasts in MPTE/MPIE consist of the ensemble member that is closest to the observed track/intensity in the best track at each cycle.

Potential applications of MPTE/MPIE:

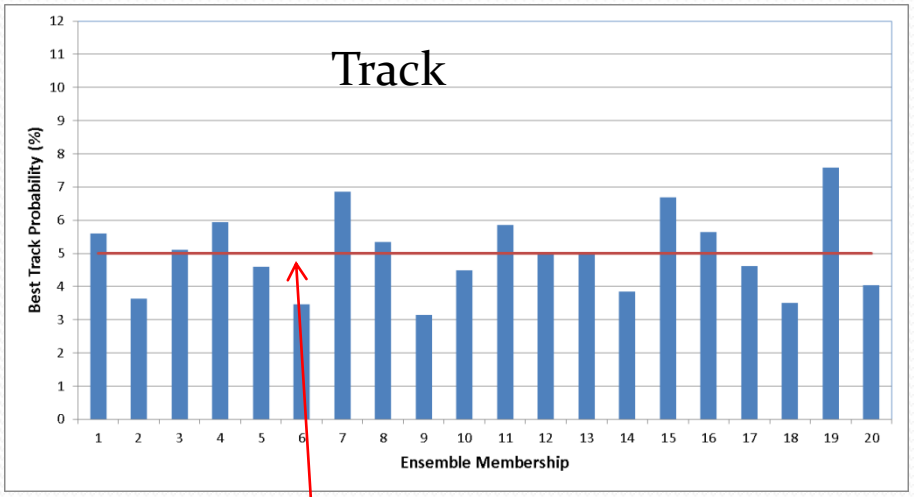
1. Verify/validate ensemble system by checking equal chance of being best forecast for each individual ensemble member (next slide);
2. Select best ensemble member by using available model/obs. Information;
3. Investigate best forecast member to understand model physics;
4. Study the predictability of current dynamic model, intrinsic forecast limit.

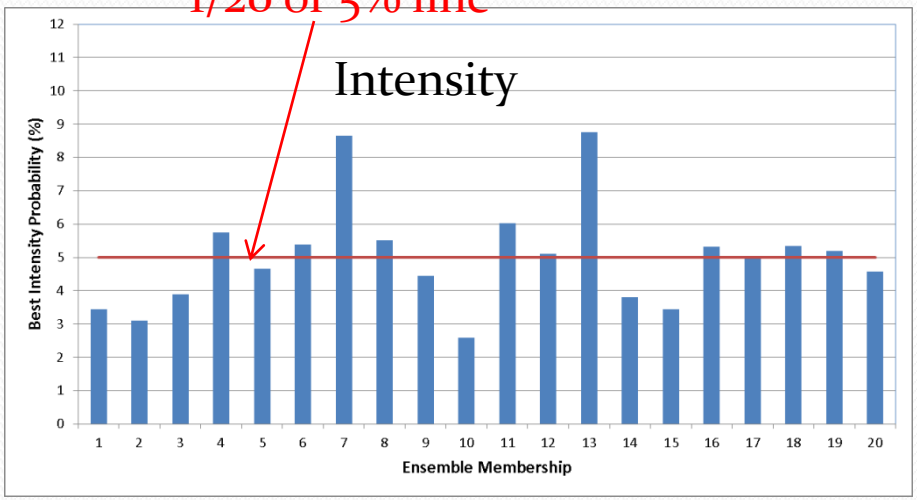




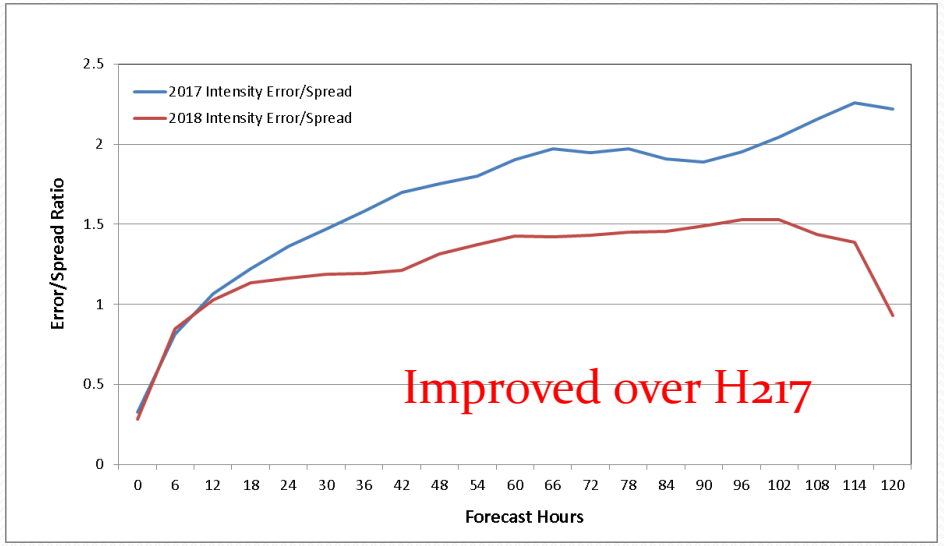
Statistical Features of HWRF-EPS

Probability of individual ensemble member being best track/intensity





Ratio of Forecast Error to Ensemble Spread



Conclusion

- HWRF EPS produced lower track/intensity forecast errors, compared to its deterministic control run at both AL and EP basins in 2018;
- Although HWRF-EPS uses lower resolution and no DA, it outperformed the operational HWRF in terms of intensity forecasts at NATL basin, track forecast is still behind (partially followed its parent model, GEFS);
- HWRF-EPS has its desired feature that each member has equal chance to be closest to best track obs., and the ensemble spread and forecast error ratio of HWRF-EPS is improved compared to 2017 version;

Future Work

- Further improve the ratio of ensemble spread and forecast error
- Develop better track/intensity post-process based on MPTE/MPIE

Thank You!

HWRF-EPS:
http://www.emc.ncep.noaa.gov/HWRF/HWRFEPS/index.php

Additional Slides

Highlights for HWRF's FY2018 implementation --related to HWRF-based ensemble

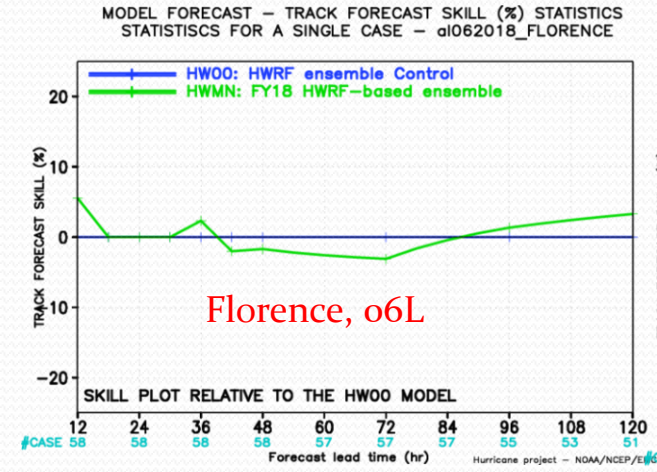
HWRF Infrastructure Enhancements:

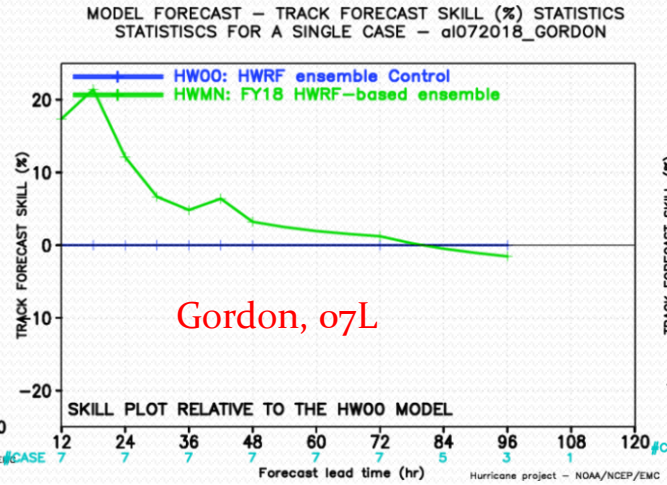
Upgrade dynamic core from WRF3.8.1a to WRF3.9.1
Test and evaluation with 2017 4D-Hybrid GDAS/GFS initial and boundary conditions
Increase horizontal resolution from (18/6/2-km) to (13.5/4.5/1.5-km), with slightly reduced domain sizes for the two nested domains

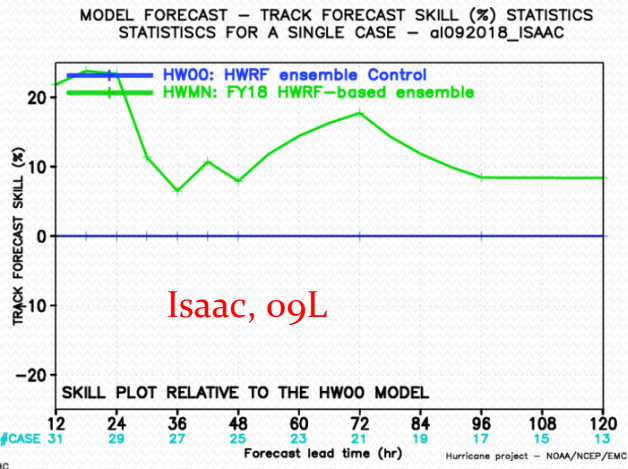
HWRF Physics Advancements:

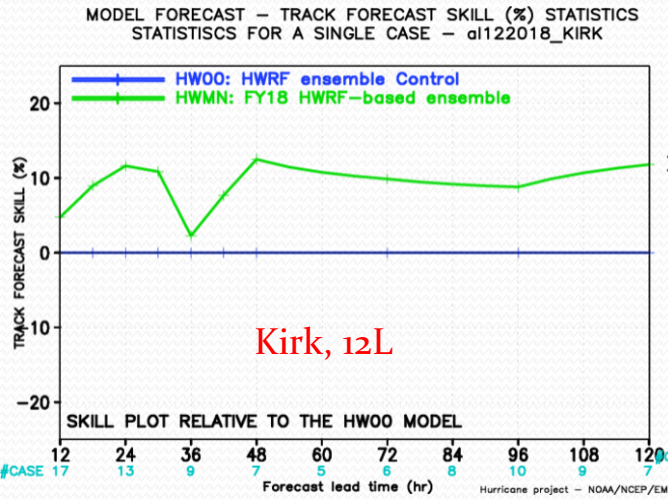
Upgrade the RRTMG scheme with a modified cloud overlap method
Adjust the horizontal diffusion and convergence damping coefficients

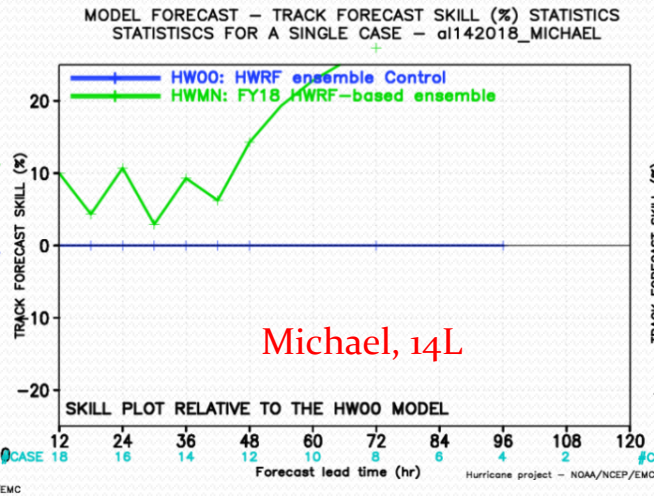
Individual Storm Track Improvement for NATL (HWMN vs HWoo)

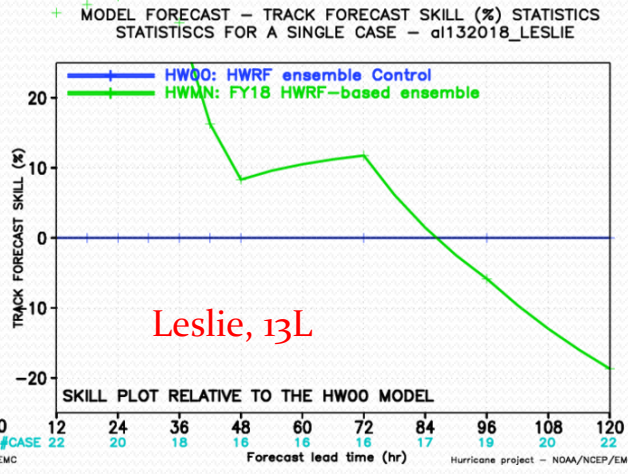




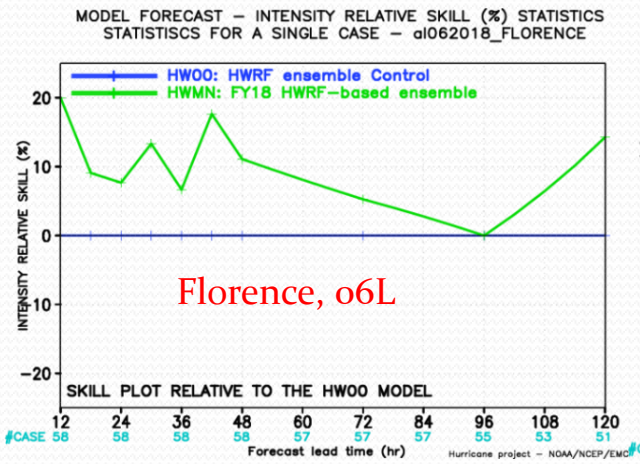


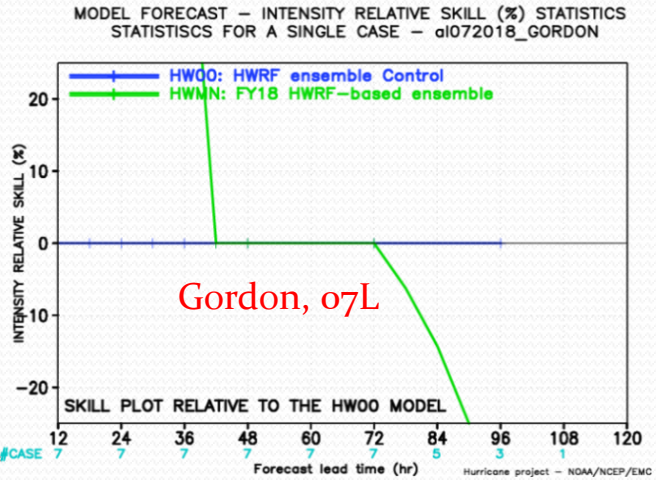


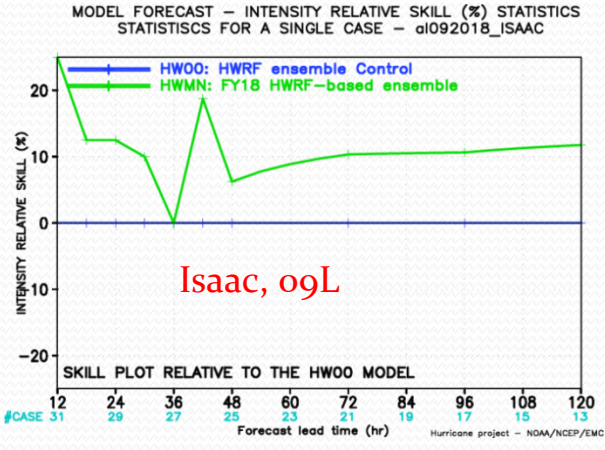


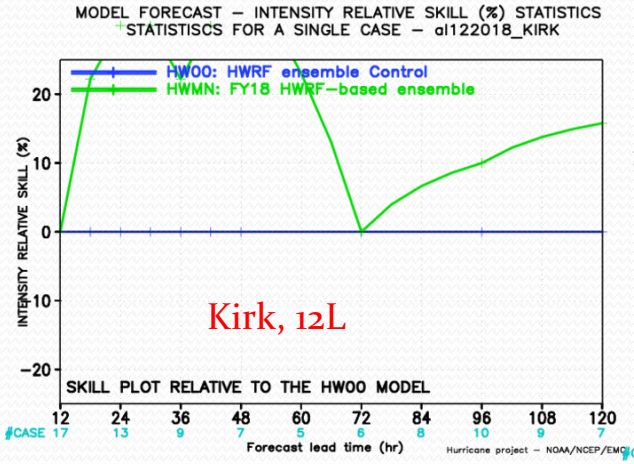


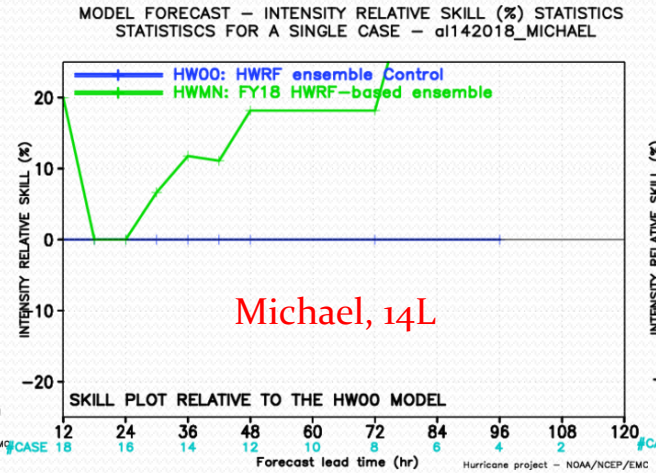
Individual Storm Intensity Improvement for NATL (HWMN vs HWoo)

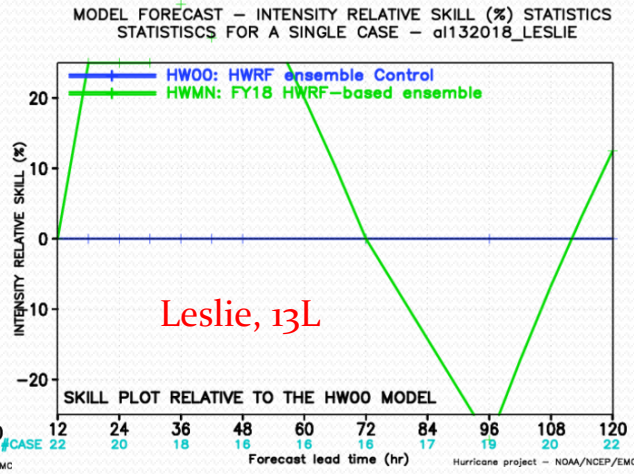




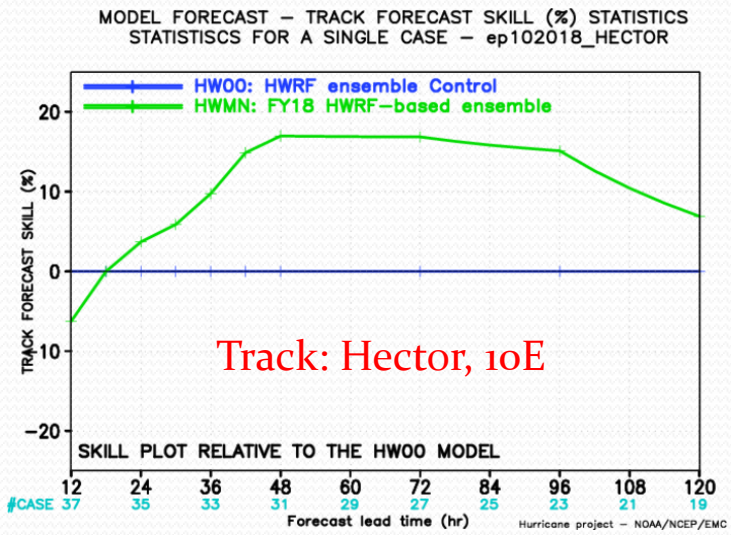




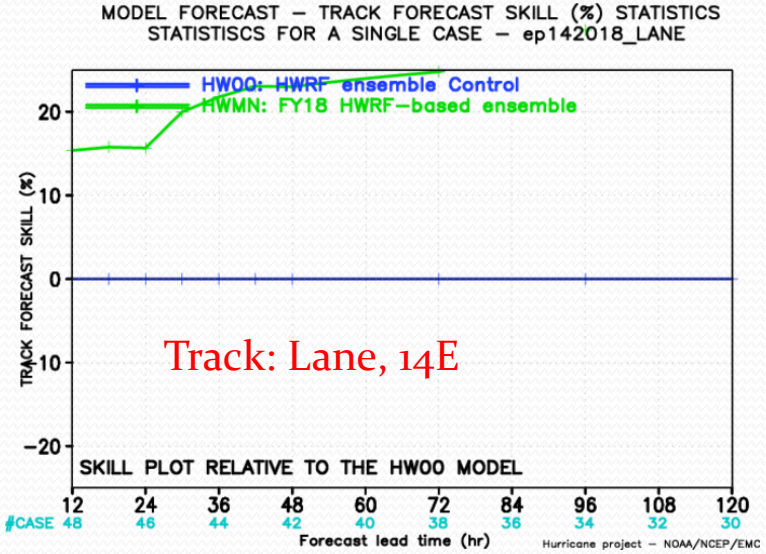




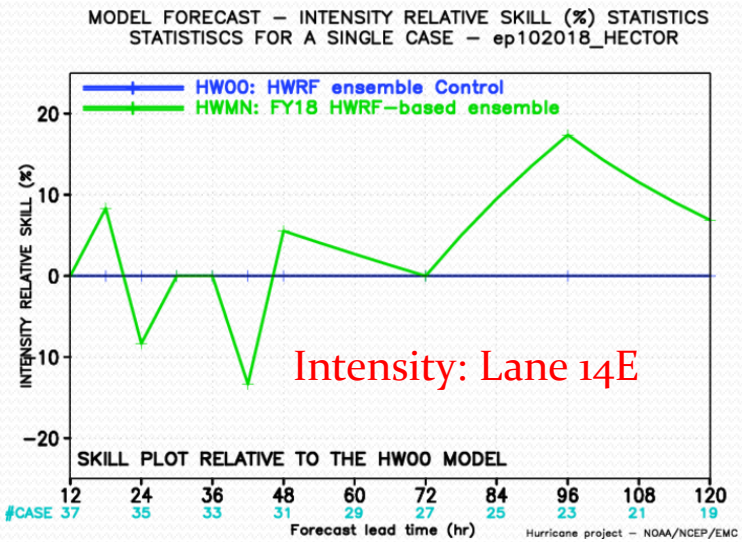
Individual Storm Track/Intensity Improvement, EPAC (HWMN vs HWoo)



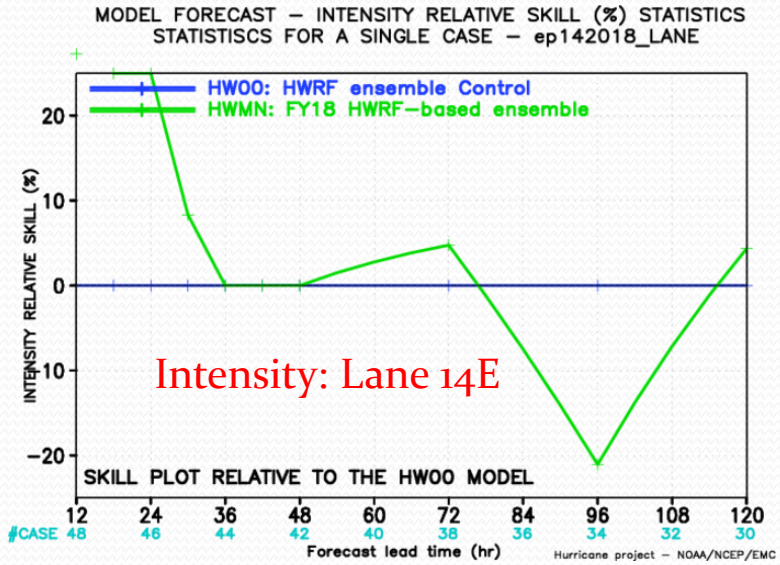
Track: Hector, 10E



Track: Lane, 14E

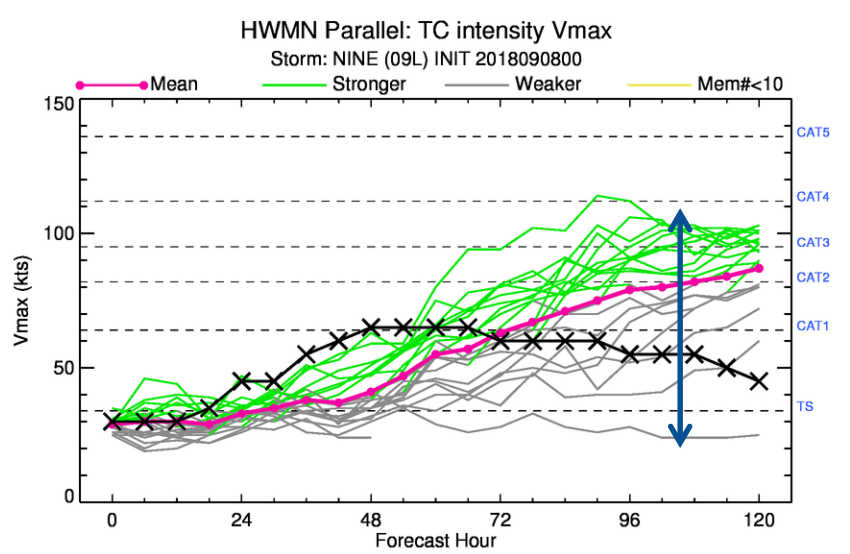


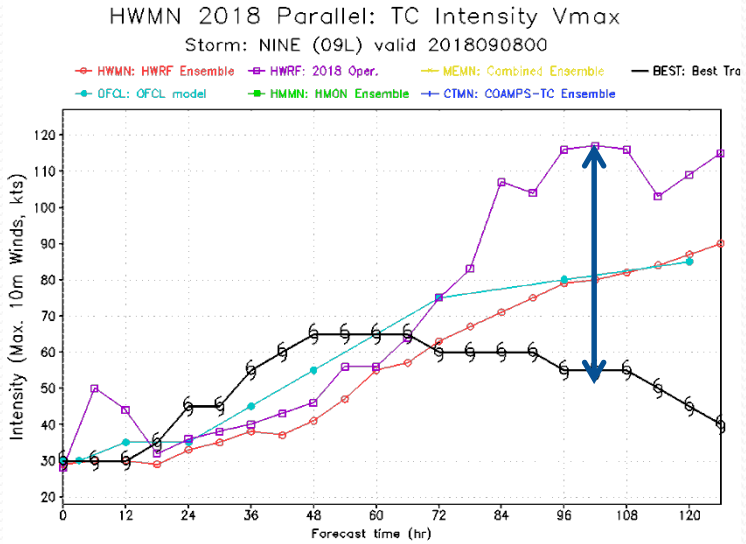
Intensity: Lane 14E

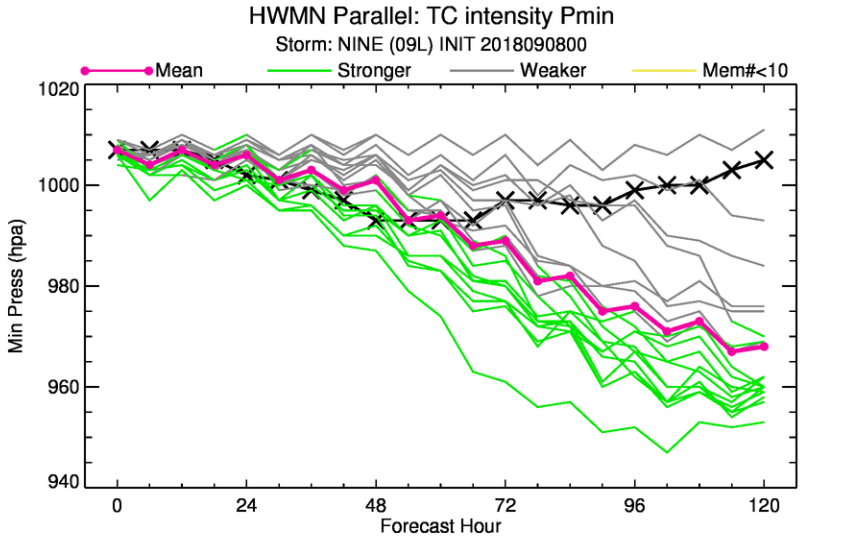


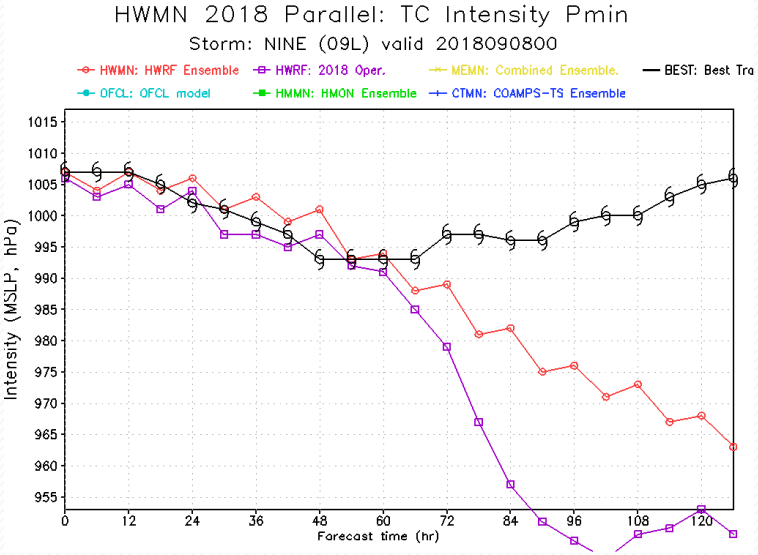
Intensity: Lane 14E

Larger Ensemble Spread indicates larger Forecast Errors

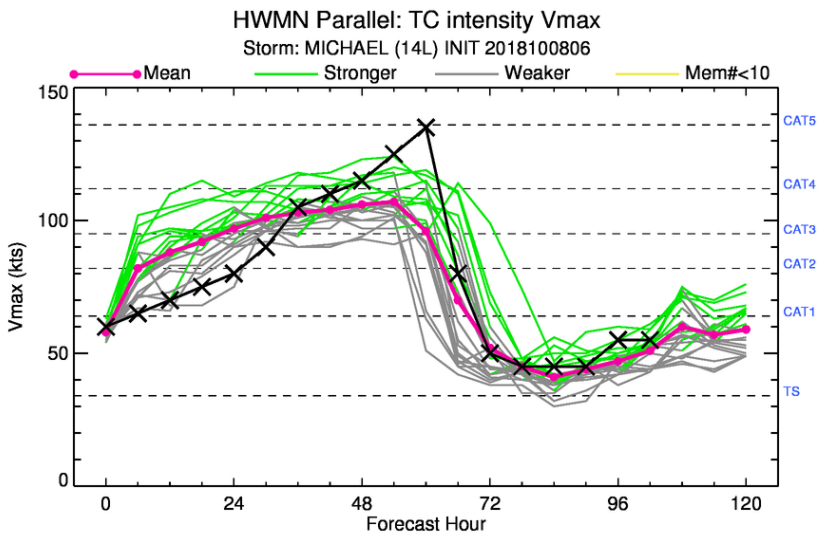


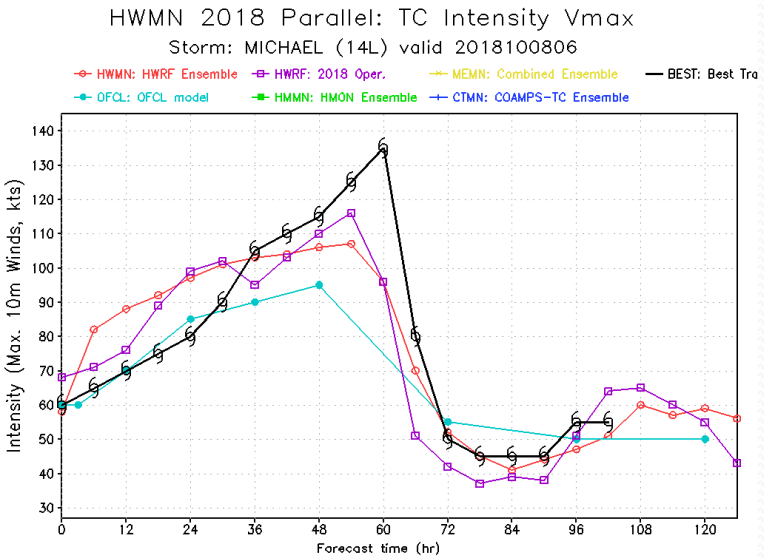


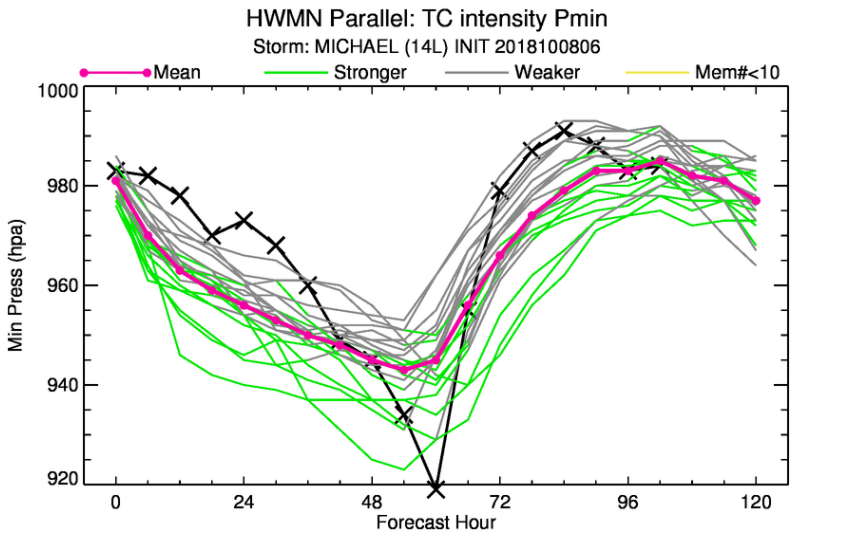


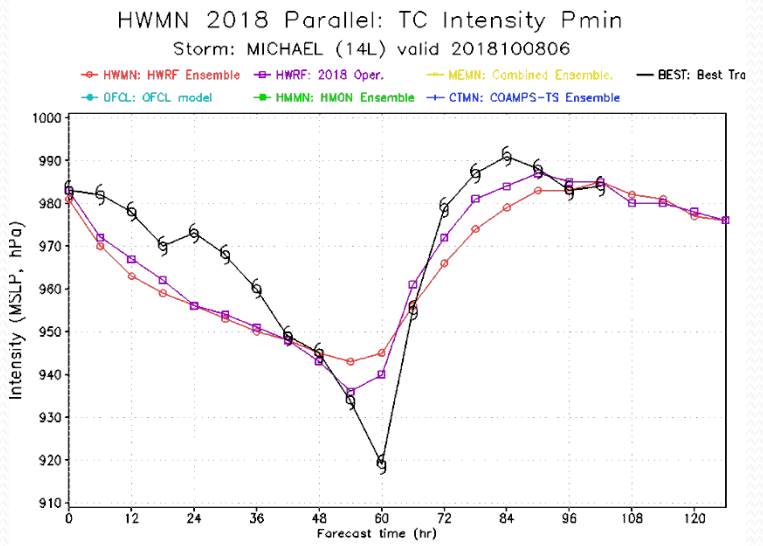


Smaller Ensemble Spread indicates Smaller Forecast Errors

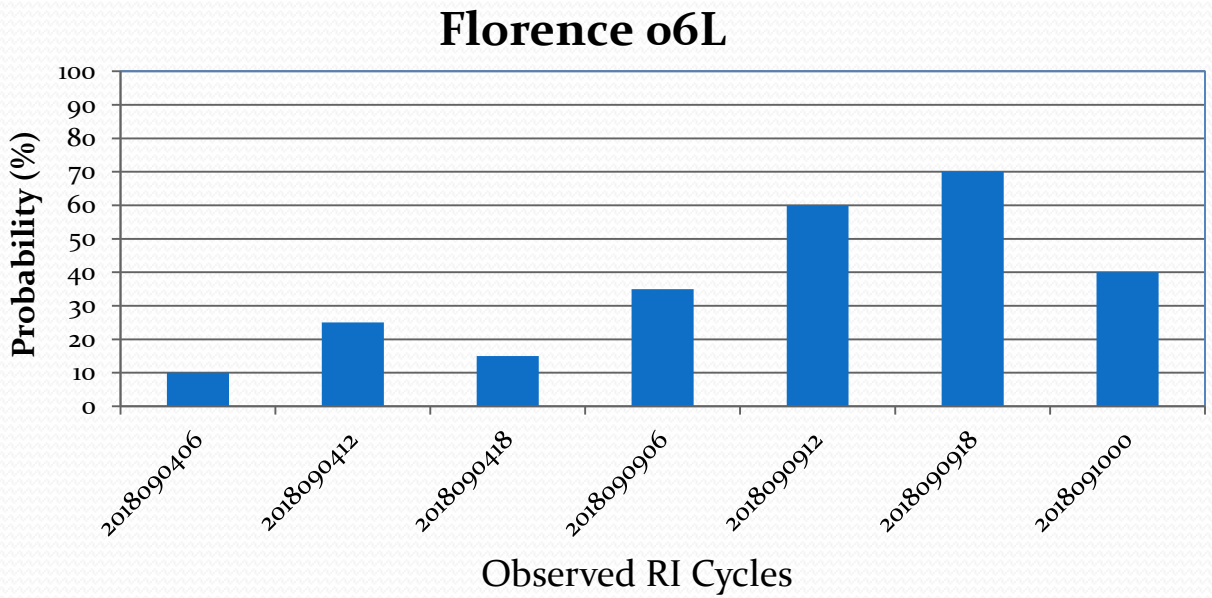


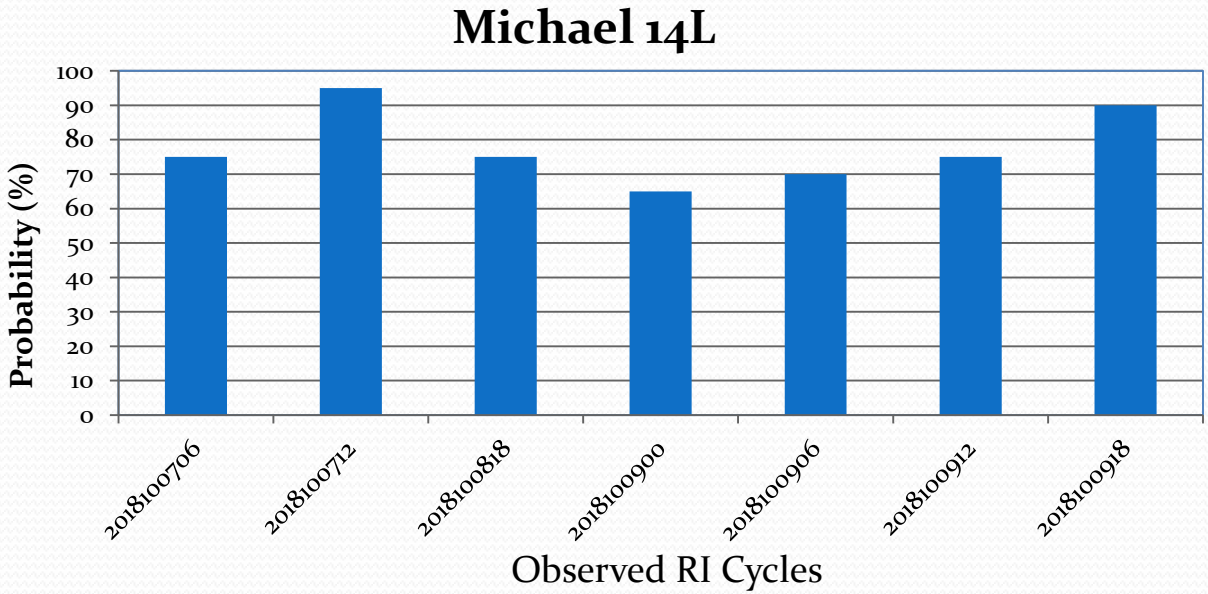






RI Probability Forecast from HWRF-EPS





$P_{RI} = N_{RI} / N_{total}$

N_{RI} is the max No of ensemble members that predicted RI event in 96h;

N_{total} equals 20, the total No. of ensemble numbers.