



Performance of HAFS-based Ensemble Prediction System (HAFSv0.2E) in 2021 Atlantic Hurricane Season

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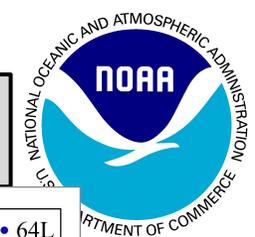




Experiment Objectives



- Provide ensemble averaged deterministic and probabilistic guidance of TC track and intensity for 2021 NATL basin
- Demonstrate the benefits of HAFS based ensemble track/intensity prediction system
- Understand the statistical characteristics of HAFS based ensemble prediction system



HAFS vo.2E Ensemble Configuration for 2021 HFIP Real-time

● Basic configuration, based on HAFSv0.2A

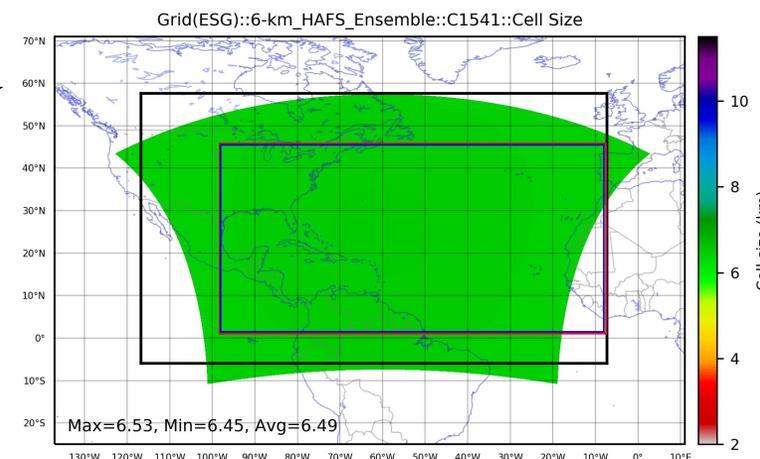
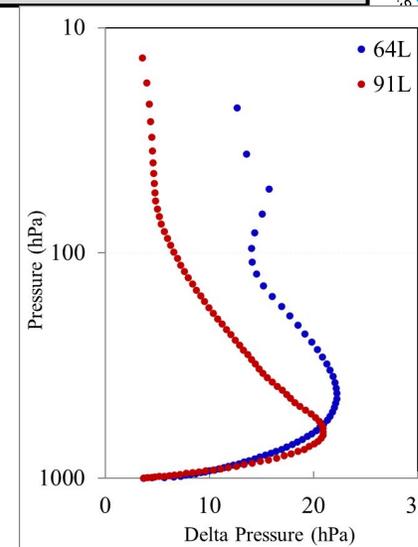
- Lower horizontal resolution: refine ratio=2, ~6km vs. 3km, Lower vertical resolution: L64 vs. L91, with smaller domain
- Ocean: NSST, No Ocean coupling
- dt_atmos: 120s vs. 90s, k_/n_split= 3/4
- Radiation time step: 3600s vs. 900s
- One control member plus 20 perturbed ensemble members (11 on jet and 10 on orion)
- Runs four cycles a day (00Z,06Z, 12Z and 18Z), Atlantic basin only
- Computer resources: 14 nodes or 336 cores per forecast jobs.

● IC/BC Perturbation:

- IC/BC: GEFS grib2 (0.5x0.5) vs. GFS

● Model Physics:

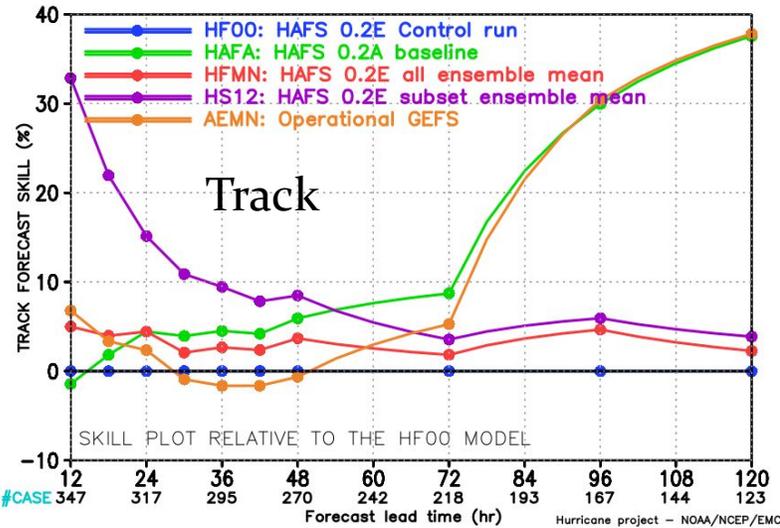
- Stochastically perturbed physics tendencies (SPPT)
- Stochastic kinetic energy backscatter (SKEB)
- Stochastically perturbed PBL humidity (SHUM)



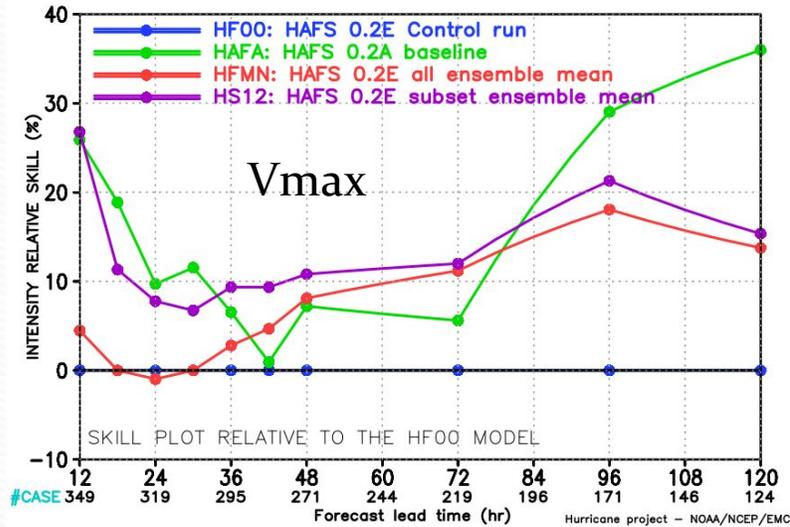
Domain size: 1441x1081

HAFS-E track/intensity verification

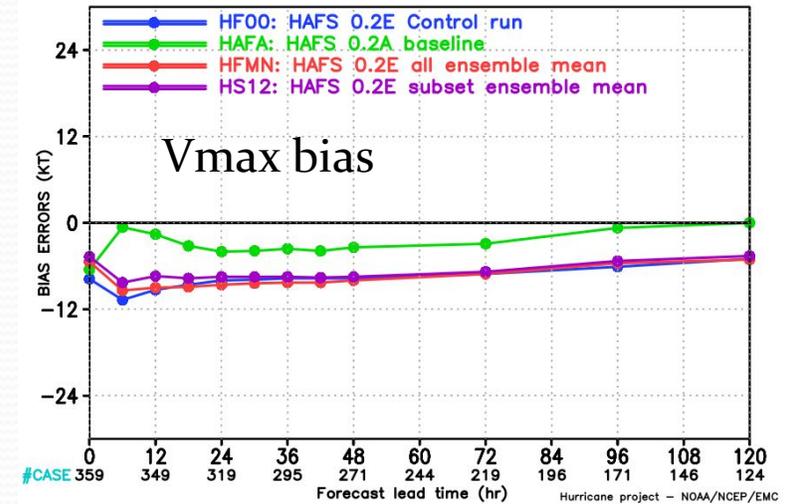
MODEL FORECAST – TRACK FORECAST SKILL (%) STATISTICS
VERIFICATION FOR NATL BASIN 2021



MODEL FORECAST – INTENSITY RELATIVE SKILL (%) STATISTICS
VERIFICATION FOR NATL BASIN 2021



MODEL FORECAST – BIAS ERRORS (KT)
VERIFICATION FOR NATL BASIN 2021



HF00: un-perturbed member, control 1

HAFS: high resolution version of deterministic model, control 2

HFMN: equal-weighted all ensemble mean,

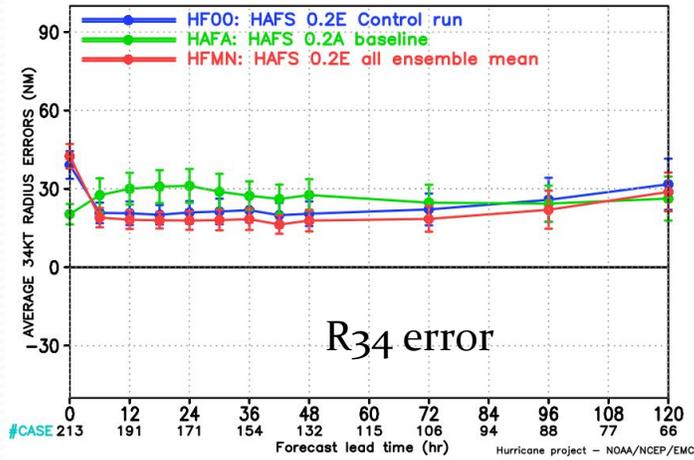
HS12: equal-weighted 12-member subset ensemble mean

AEMN: Ensemble mean track from GEFS, host model for HAFS-E

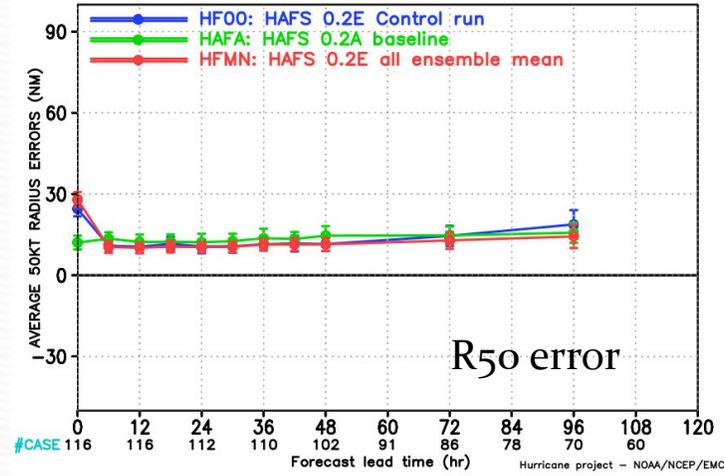
- HAFS-A is more skillful than HF00 in terms of both track and intensity at all lead times, and has better intensity bias.
- Equally-weighted HAFS-E ensemble mean improved the track forecast by ~5% at all lead times, the intensity forecasts by > 10% after day-2 over its deterministic model (HF00)
- The 12-member subset of ensemble mean further improved track/intensity forecasts, especially before day-2
- HAFS ensemble mean track forecasts outperformed its host model GEFS in the short lead hours (< 60h)

HAFS-E storm size verification

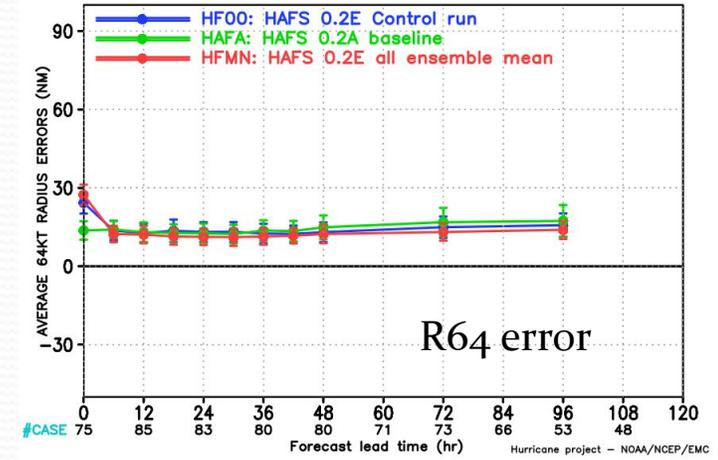
MODEL FORECAST – AVERAGE 34KT RADIUS ERRORS (NM)
VERIFICATION FOR NATL BASIN 2021



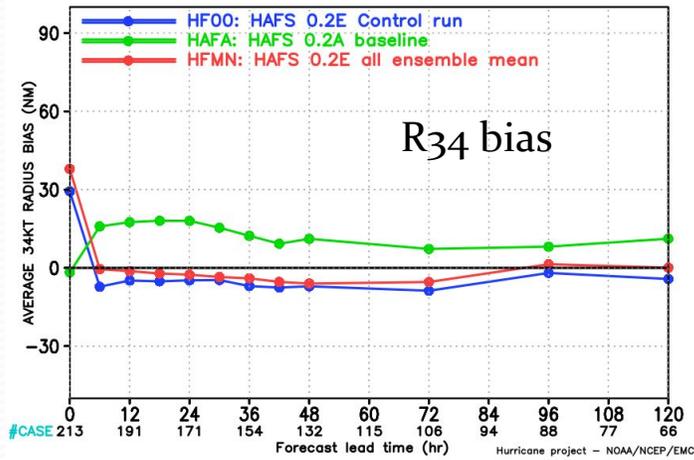
MODEL FORECAST – AVERAGE 50KT RADIUS ERRORS (NM)
VERIFICATION FOR NATL BASIN 2021



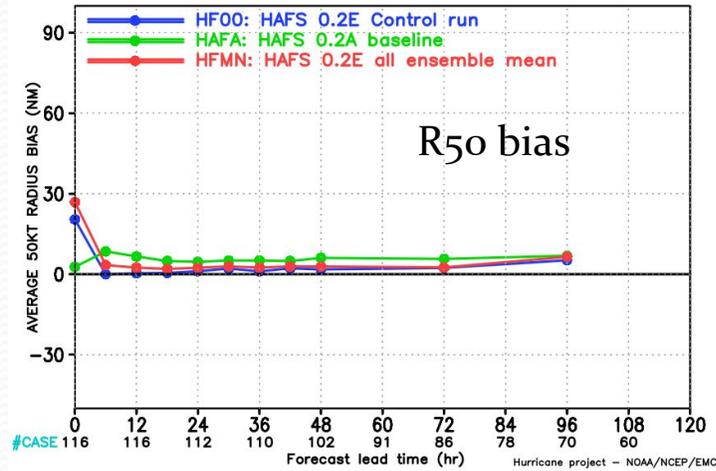
MODEL FORECAST – AVERAGE 64KT RADIUS ERRORS (NM)
VERIFICATION FOR NATL BASIN 2021



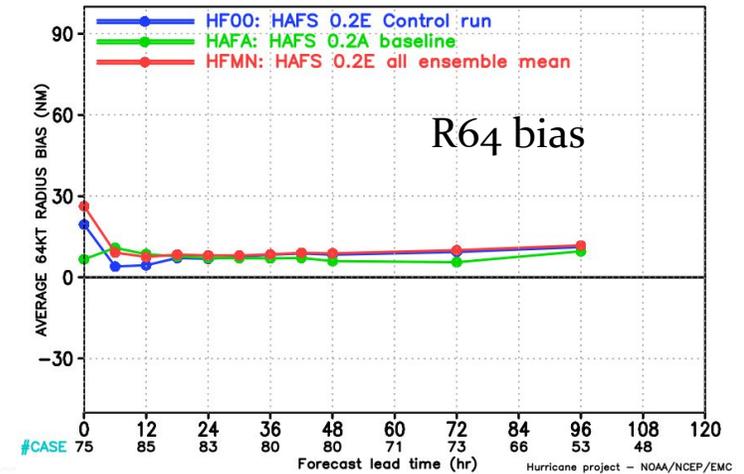
MODEL FORECAST – AVERAGE 34KT RADIUS BIAS (NM)
VERIFICATION FOR NATL BASIN 2021



MODEL FORECAST – AVERAGE 50KT RADIUS BIAS (NM)
VERIFICATION FOR NATL BASIN 2021



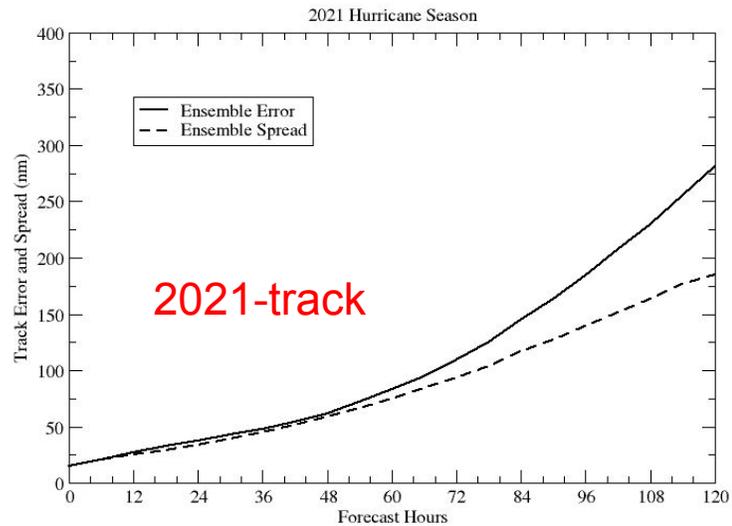
MODEL FORECAST – AVERAGE 64KT RADIUS BIAS (NM)
VERIFICATION FOR NATL BASIN 2021



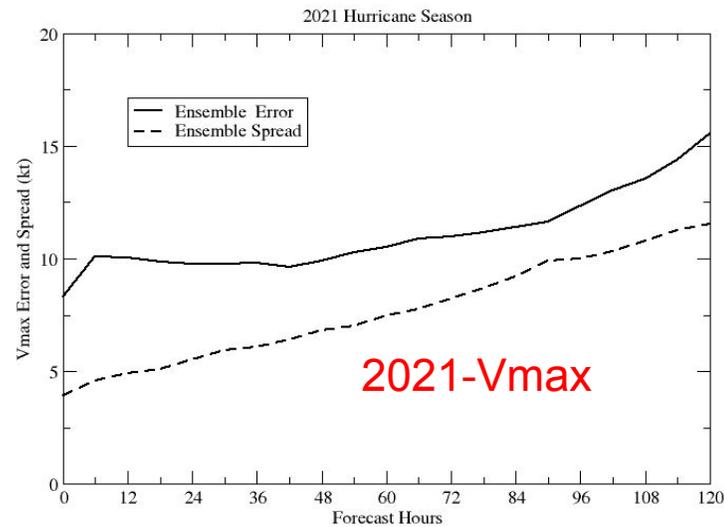
The storm size error is reduced in HFMN, compared to HAFA/HF00, especially for R34 wind radius

Forecast Error vs Ensemble Spread (HAFS vo.2E)

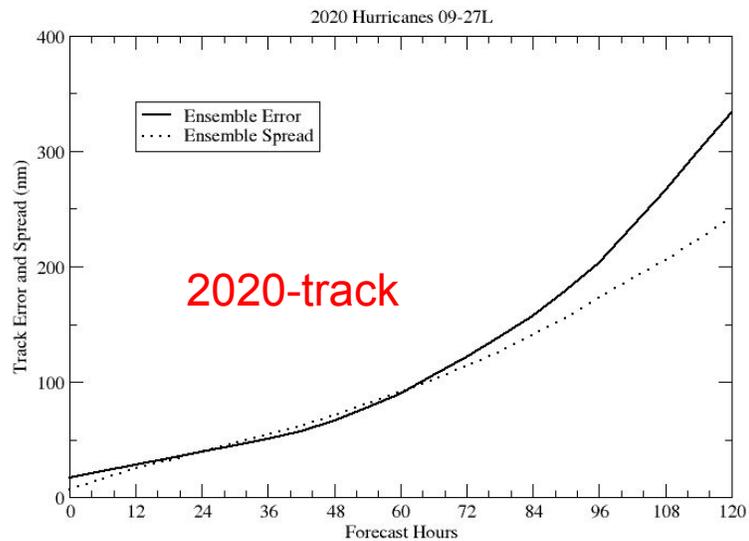
Forecast error vs Ensemble spraed



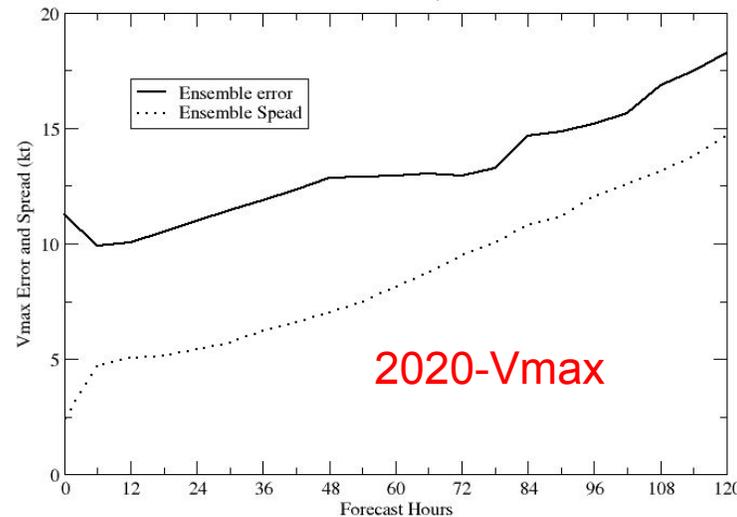
Forecast error vs. Ensemble spread



Forecast error vs Ensemble spraed



2020 Hurricanes 09L-27L



- The ensemble track spread has the similar magnitude as track forecast errors, and can be used to indicate the degree of confidence for the deterministic forecast
- The ensemble spread of Vmax is under-dispersed, but proportional to the forecast error
- The ensemble intensity spread is improved in 2021, compared to 2020.

Forecast Error vs Ensemble Spread (HAFS vo.2E)

Individual storms

Elsa 05L

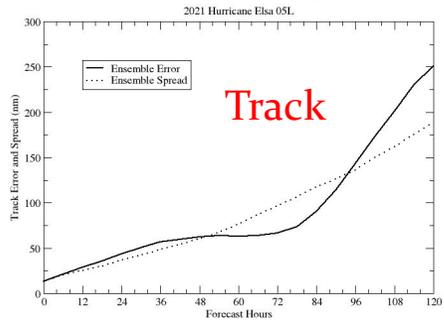
Fred 06L

Grace 07L

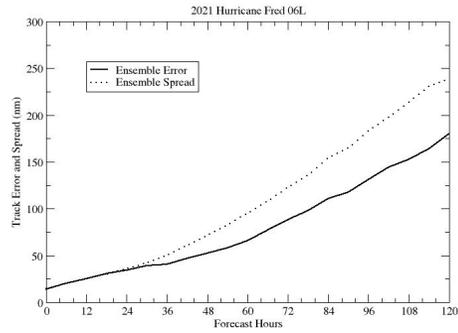
Henri 08L

Ida 09L

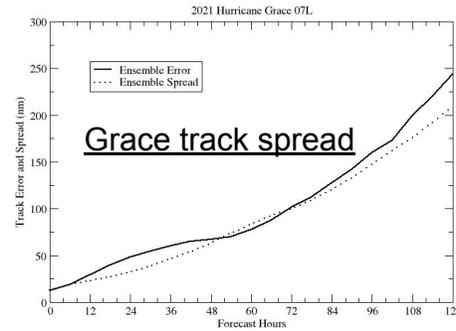
Forecast error vs Ensemble spraed



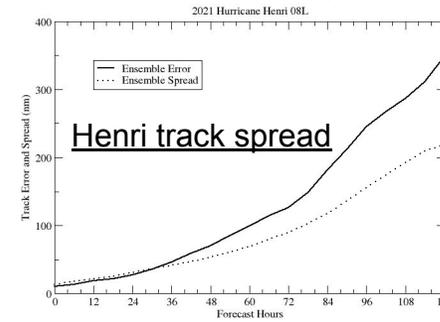
Forecast error vs Ensemble spraed



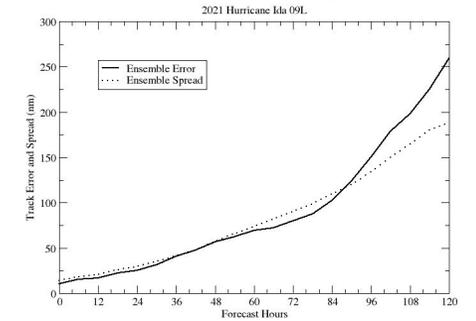
Forecast error vs Ensemble spraed



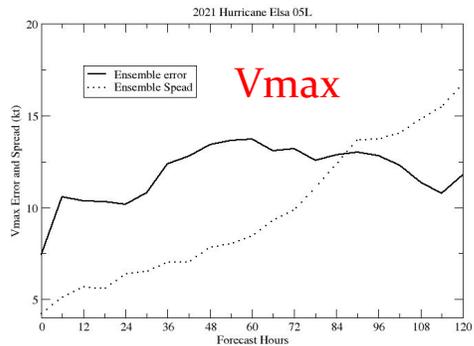
Forecast error vs Ensemble spraed



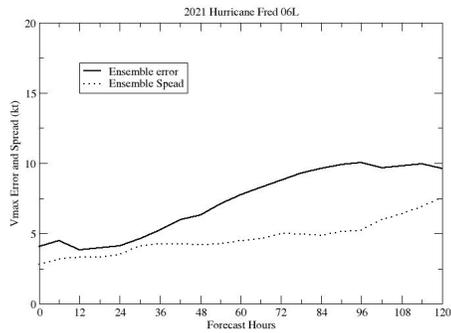
Forecast error vs Ensemble spraed



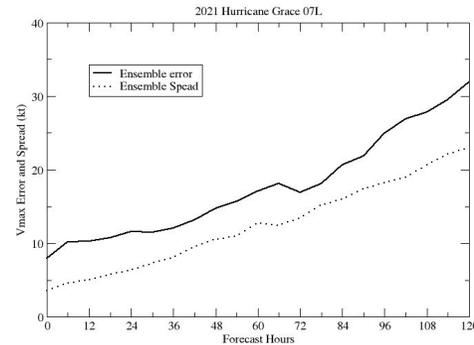
Forecast error vs. Ensemble spread



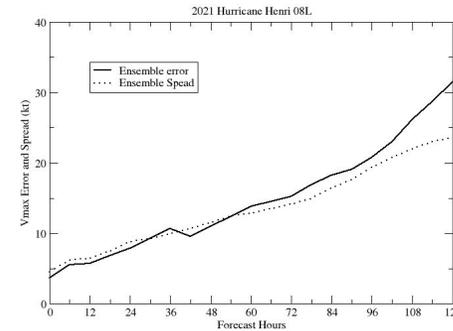
Forecast error vs. Ensemble spread



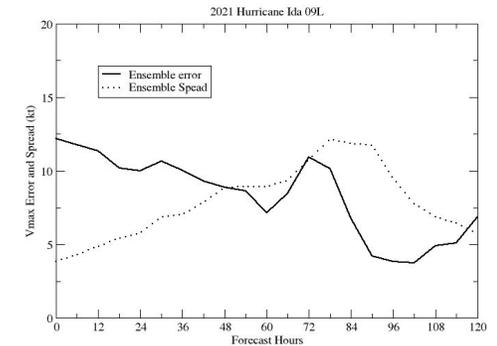
Forecast error vs. Ensemble spread



Forecast error vs. Ensemble spread



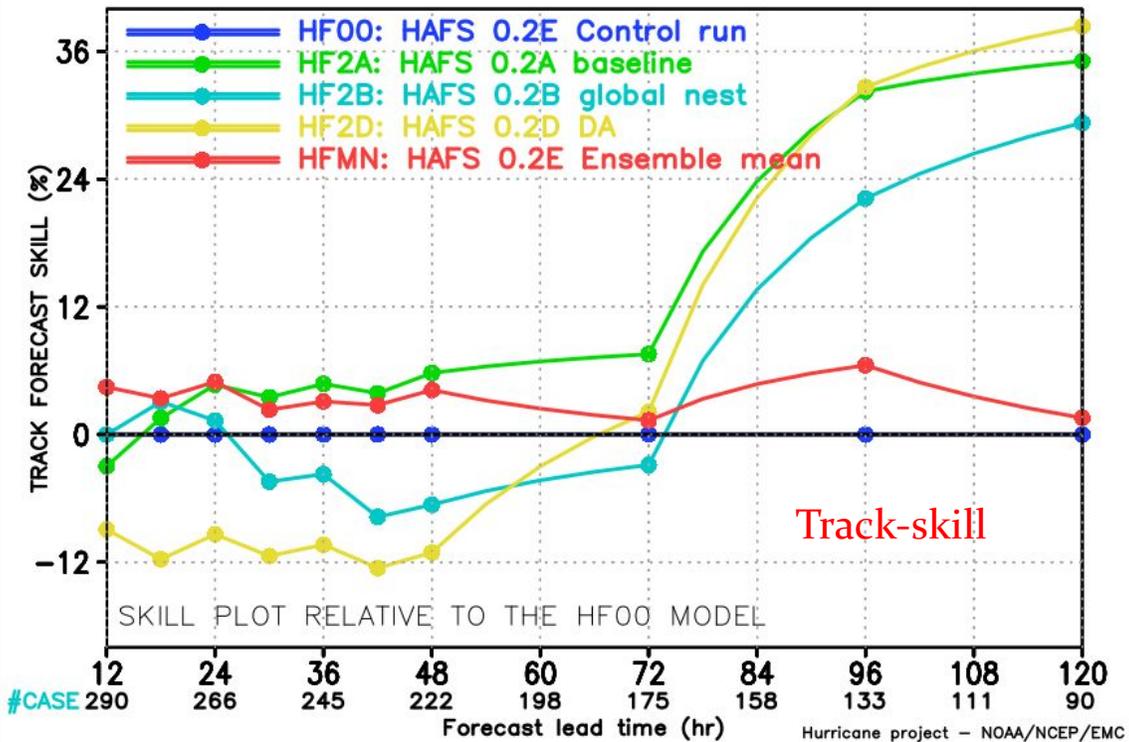
Forecast error vs. Ensemble spread



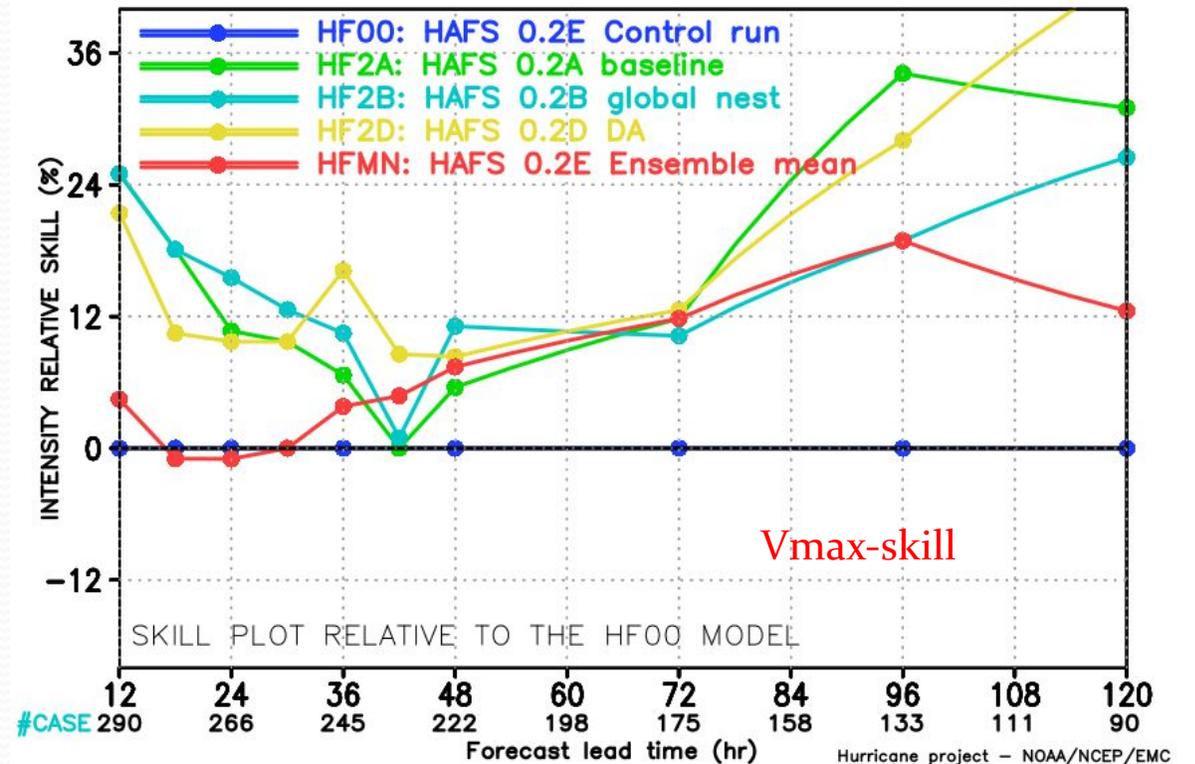
HAFS ensemble spread indicated forecast reliability and the degree of confidence to the forecast. Smaller track spread indicate better track forecast, vica versa

Comparison of HAFSv0.2E with other HAFS configurations

MODEL FORECAST – TRACK FORECAST SKILL (%) STATISTICS
VERIFICATION FOR NATL BASIN 2021



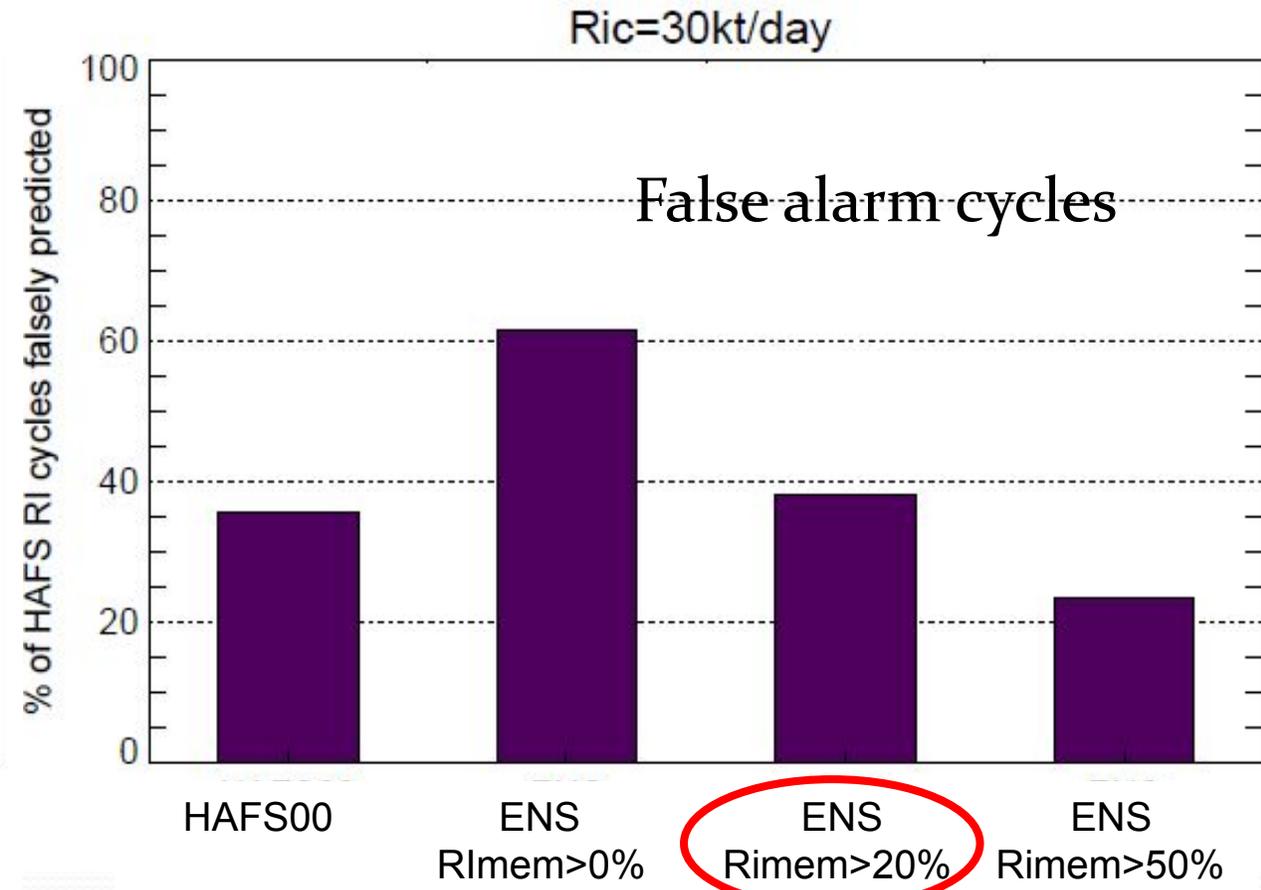
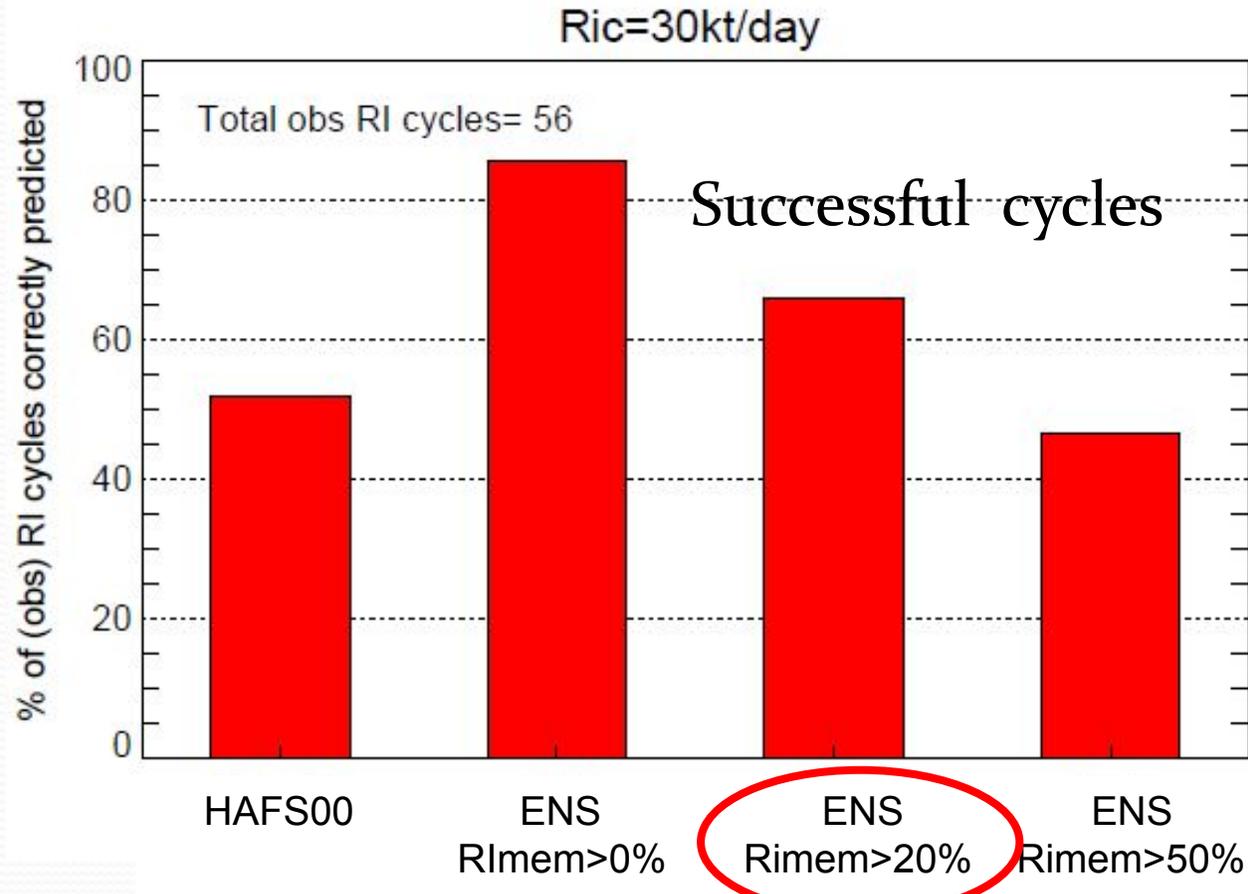
MODEL FORECAST – INTENSITY RELATIVE SKILL (%) STATISTICS
VERIFICATION FOR NATL BASIN 2021



HAFS-E and HAFS-A have better track forecast than HAFS-D and HAFS-B before day-3. HAFS-E track forecast skills are not as good as other configurations after day-4
 HAFS-E has comparable intensity forecast skills between 36h and 96h with other HAFS configurations
 In general, HAFS-E did not do very well for longer forecast lead times for both track/intensity forecasts

Summary of forecast cycles with/without RI events

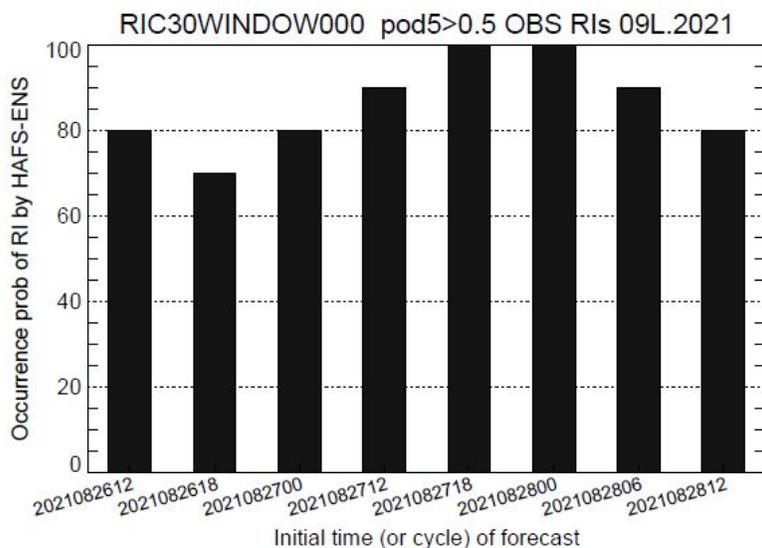
of total available cycles = 354
of cycles with observed RIs = 56
of cycles without observed RIs = 298



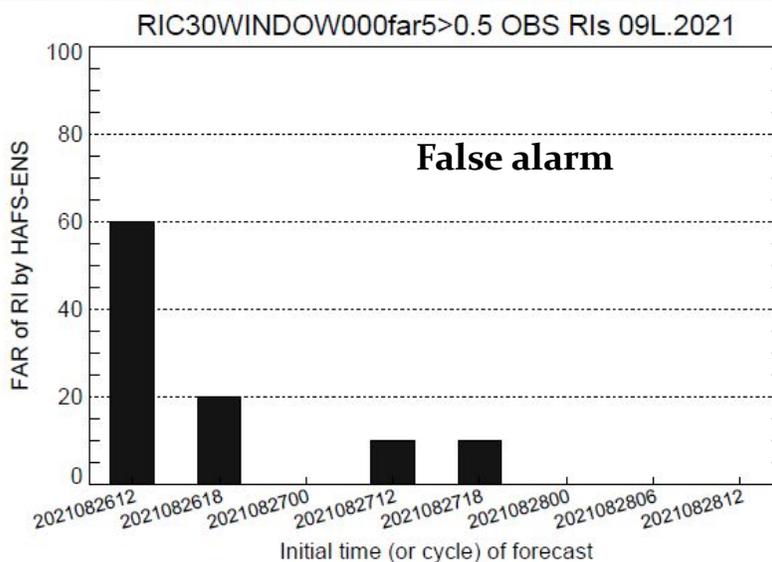
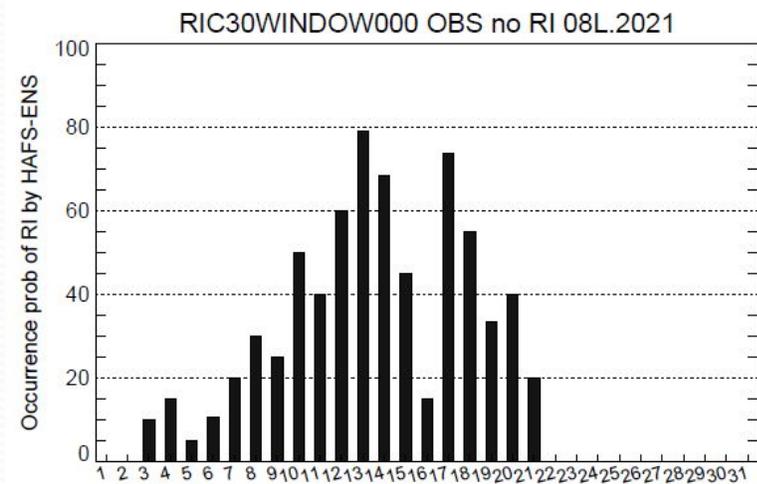
Compared to control run HF00, the threshold of >20% of ensemble members produced the better successful rate while remained relatively lower false alarm rate for RI events.

Examples of RI Prediction

Successful example, Ida 09L

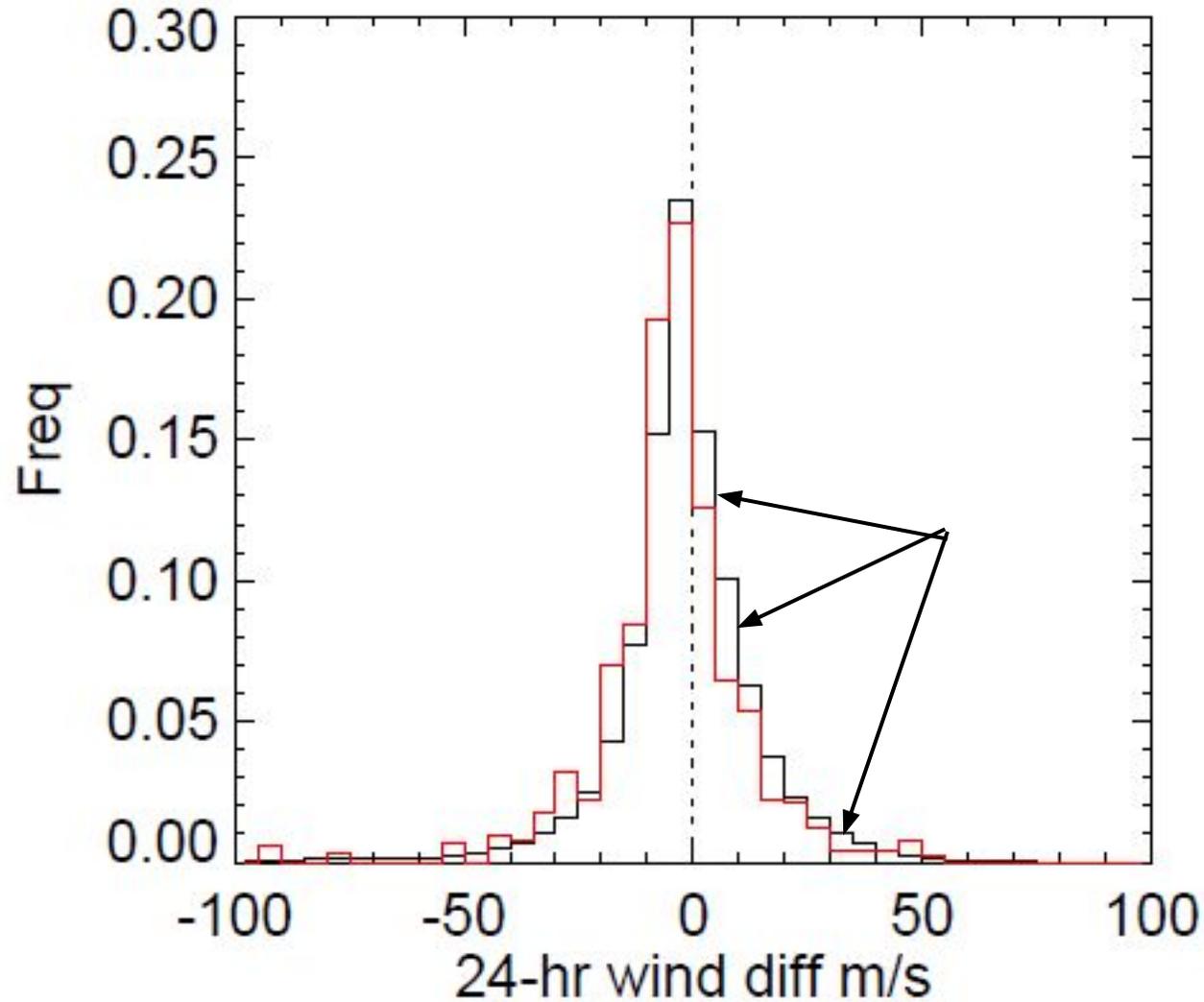


Failed example, Henri 08L



- HAFS-E successfully predicted RI events for Ida 09L, with low false alarm rates
- No RI events for Henri 08L, based on best-track data. HAFS-E had high false alarm

Distribution of 24-hr wind change of NATL Hurricanes

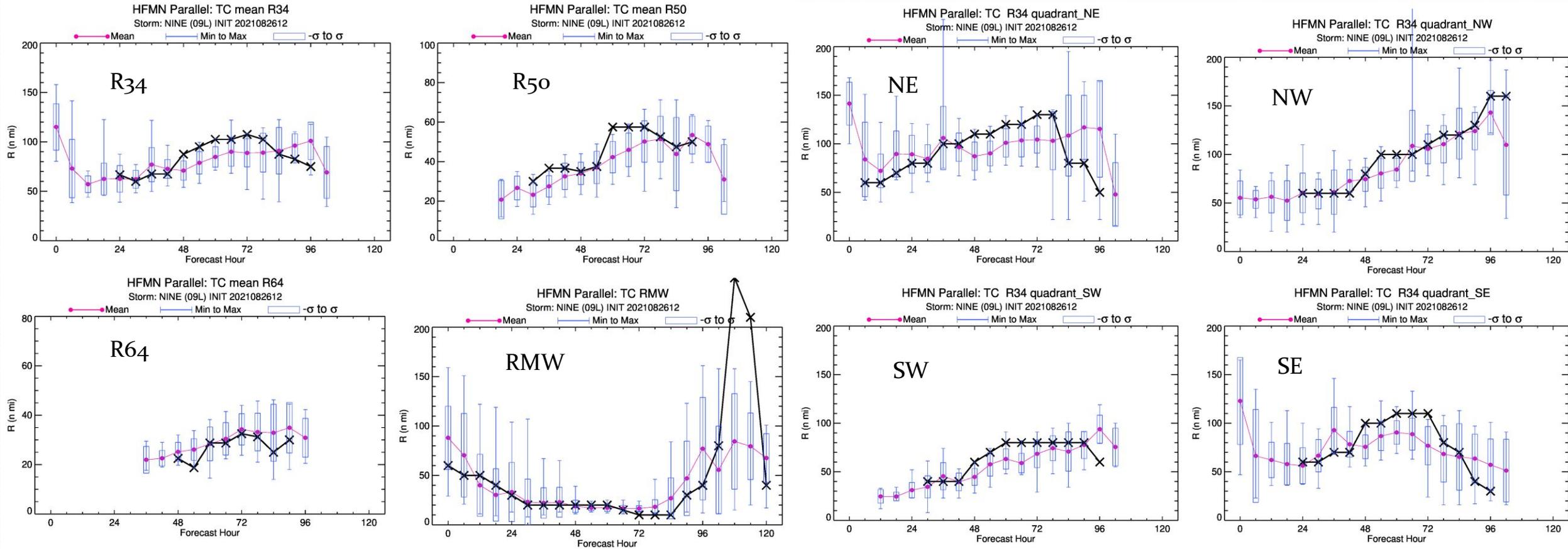


Red: Best-track data

Black: HAFS-ENS all members

- In general, HAFS ensemble mean produced similar distribution of 24-hr wind speed change as observed
- HAFS-E distribution skewed toward positive side, it indicated that HAFS-E might have high false alarm rate. e.g. Hurricane Henri o8L

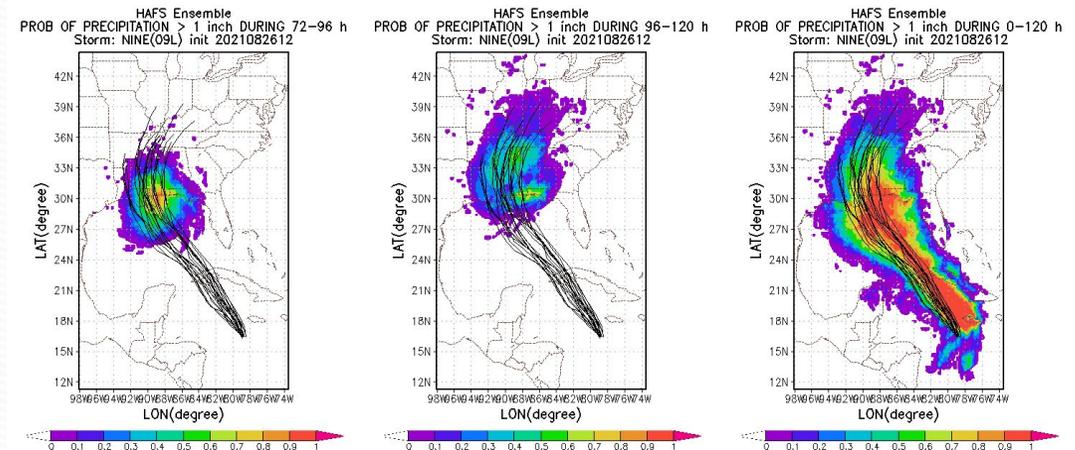
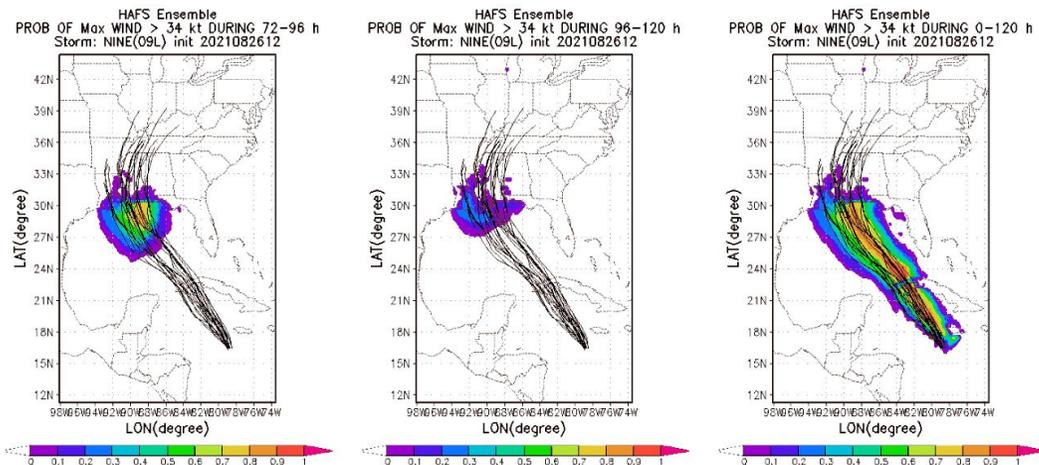
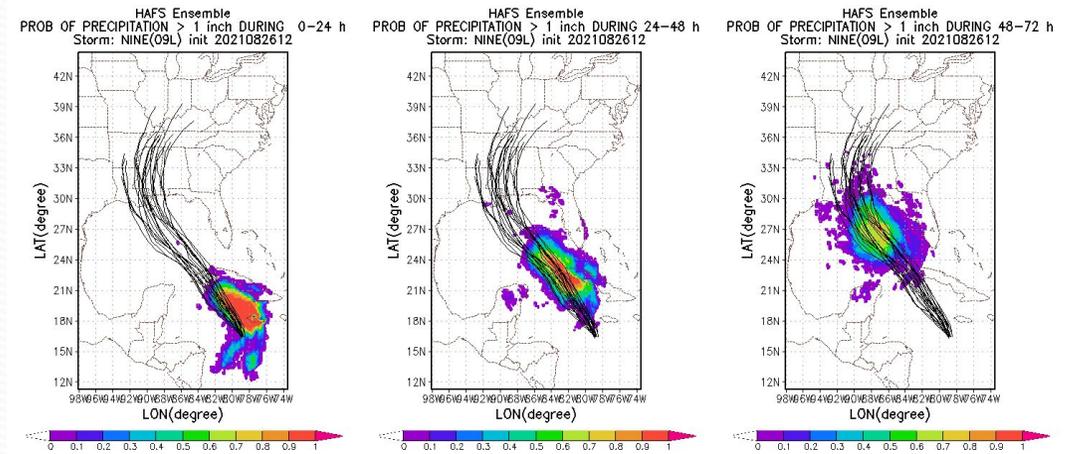
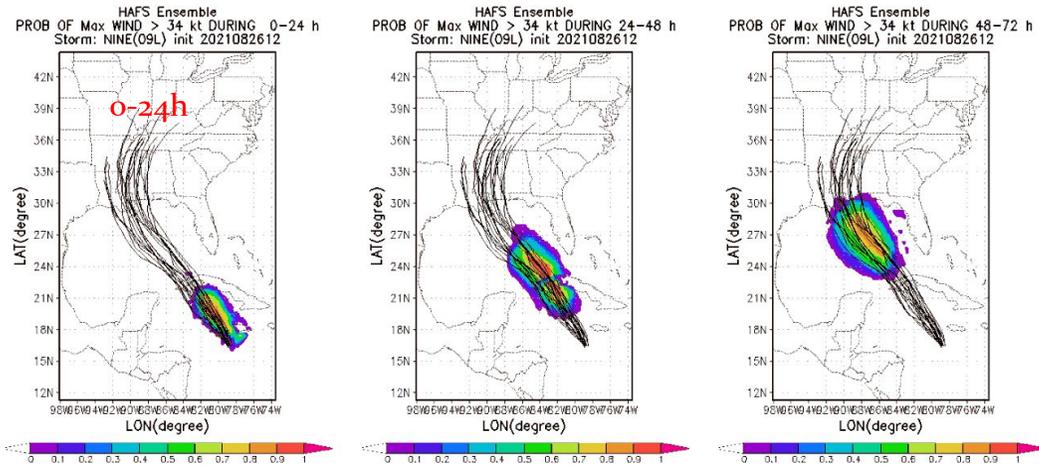
New probabilistic forecast products of HAFS-E



Wind radii predictions with uncertainties

Wind radius at R34 for each quadrant with uncertainties

New probabilistic forecast products of HAFS-E



Wind Probability

every 24 hours & 0 - 120 hours, Wind > 34 kts
(shown here), Wind > 50 kts
Wind > 64 kts

Precip Probability

every 24 hours & 0- 120 hours, Precip > 1
in (shown here), Precip > 4 in
Precip > 8 in

Conclusion Remarks

- All-members and subset-members ensemble mean produced more skillful forecasts than their deterministic control HF00 in terms of both track (~5%) and intensity (>10%) forecasts
- Both ensemble means (HFMN and HS12) of intensity forecasts outperformed high resolution deterministic forecasts (HAFA) between 36h-72h
- HAFS ensemble mean has comparable track/intensity forecast skills at early forecast hours, compared to other HAFS configurations, still behind in the longer lead times.
- Ensemble track spread is comparable with 2020 HAFS EPS, the intensity spread from HAFS-E is improved in HAFSv0.2E compared to 2020 system, but is still under dispersed.
- New probabilistic products are developed and introduced in 2021 HAFS EPS



Questions

<https://www.emc.ncep.noaa.gov/HAFS/HAFSEPS/tcall.php>