Performance of HAFS-based Ensemble Prediction System (HAFSv0.1E) in 2020 Atlantic Hurricane Season

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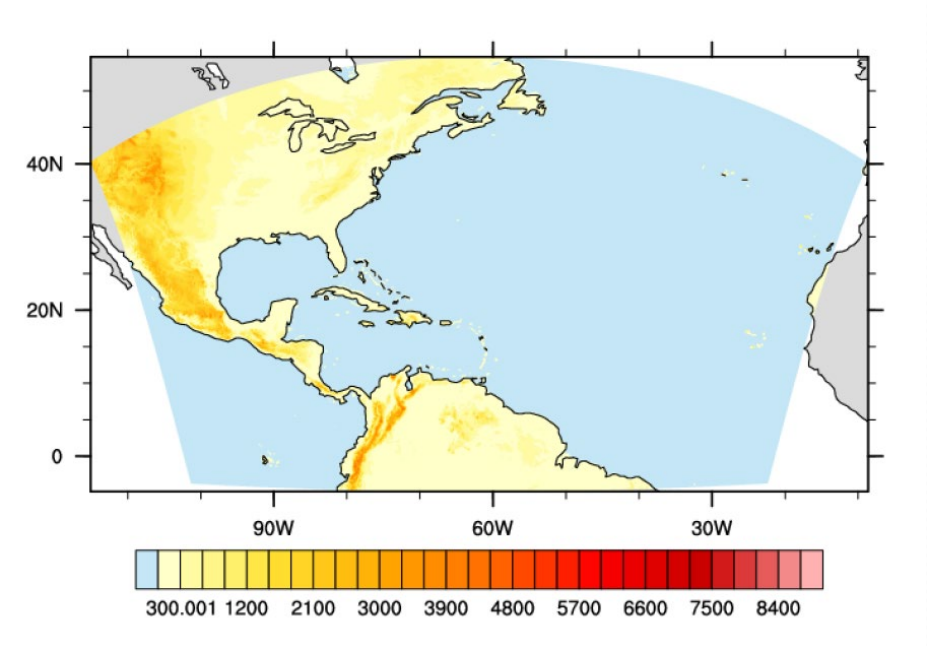
Experiment Objectives

- Provide ensemble averaged deterministic, and probabilistic guidance of TC track and intensity for 2020 NATL basin
- Demonstrate the benefit of HAFS based ensemble track/intensity prediction system
- Understand the statistical characteristics of HAFS based ensemble prediction system

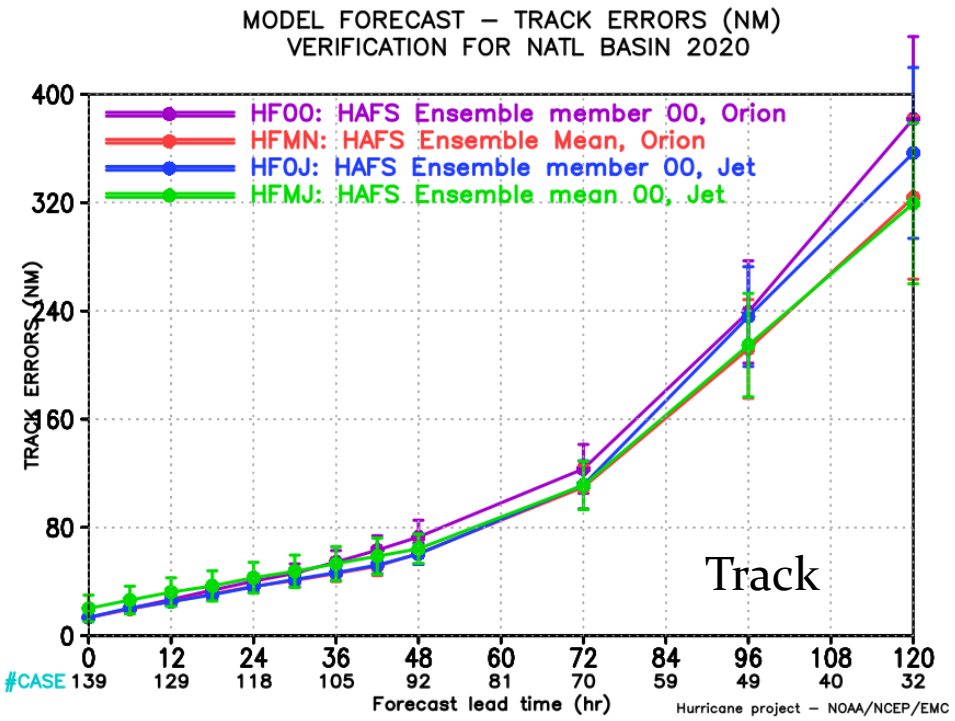
HAFS based Ensemble(HAFSv0.1E) Configuration for 2020 HFIP Real-time Demo

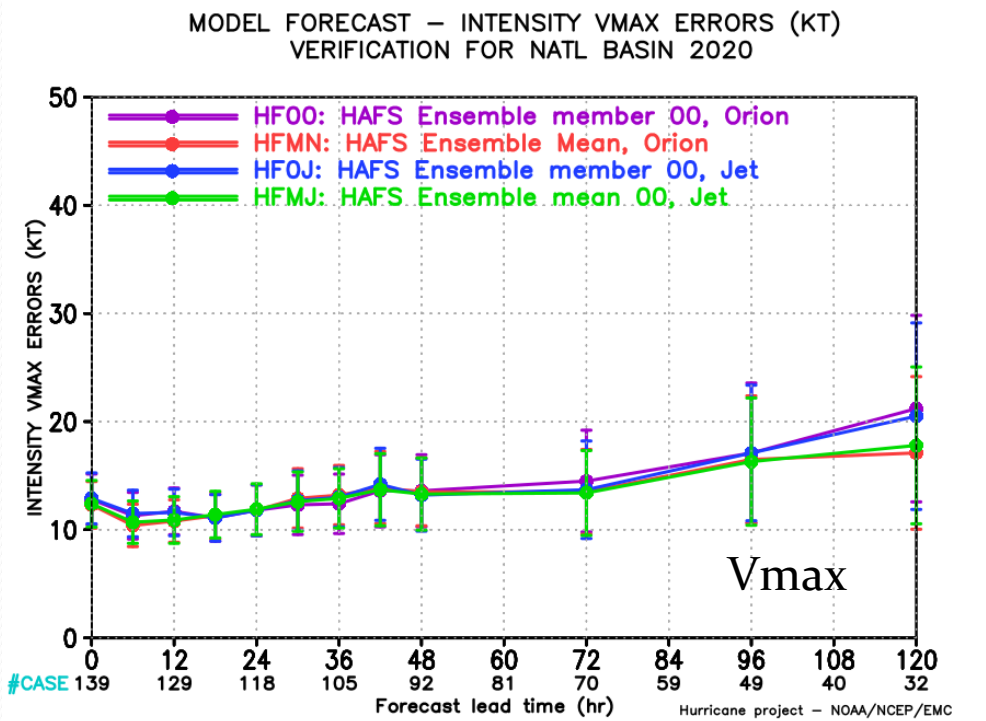
- Basic configuration, based on HAFSv0.1A
  - Lower horizontal resolution: refine ratio=2, ~6km vs. 3km, Lower vertical resolution: L64 vs. L91, with smaller domain
  - Scale-aware cumulus parameterization on
  - NSST, No Ocean coupling
  - One control member plus 17 perturbed ensemble members
  - Runs twice a day (00Z and 12Z), Atlantic basin only
  - Computer resources: 14 nodes or 336 cores per forecast jobs.



- IC/BC Perturbation:
  - IC/BC: GEFS grib2 (0.5x0.5)
- Model Physics:
  - Stochastically perturbed physics tendencies (SPPT)
    - ✓ Represents uncertainties in physical parameterizations
    - ✓ Multiplicative noise modifies total parameterized tendency
  - Stochastic kinetic energy backscatter (SKEB)
    - ✓ Counteract excessive energy dissipation from numerical diffusion and interpolation, mountain and gravity wave drag, and deep convection
    - ✓ Stream function is randomly perturbed to represent upscale kinetic energy transfer
  - Stochastically perturbed PBL humidity (SHUM)
    - ✓ Represents variability in the sub-grid humidity field
    - ✓ Similar to SPPT, but directly modifies low-level humidity field instead of tendency
- HAFS-E on Orion: Same configuration as Jet, but 1+20members, runs at 00Z, 06Z,12Z,and 18Z.

HAFSv0.1E Track/Intensity Verification (Jet vs Orion)
15L-28L, 2020

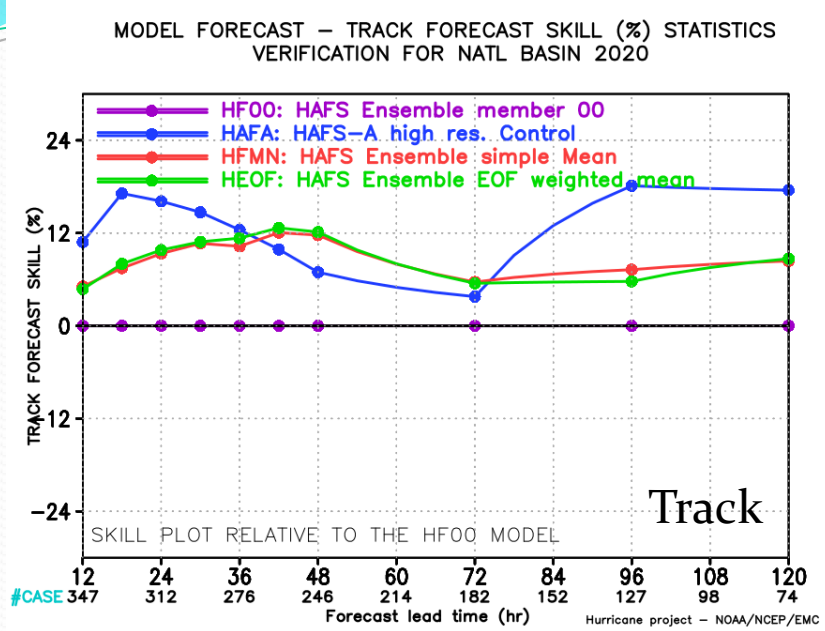


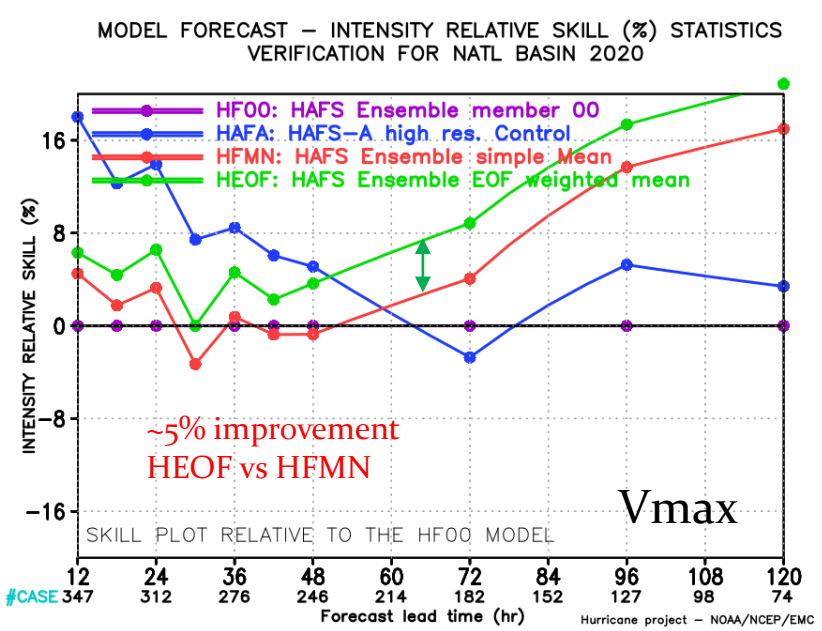


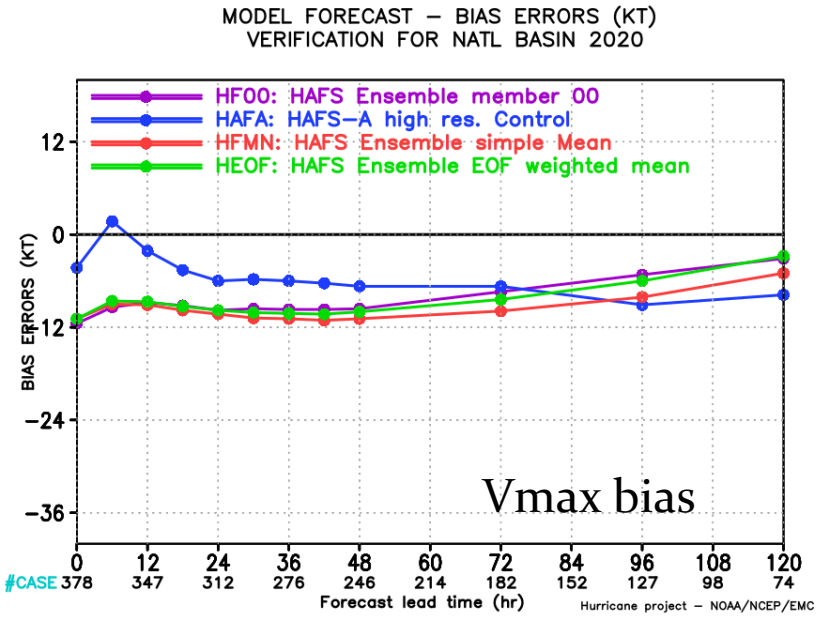
HF00: Jet version of un-perturbed ensemble member
HFMN: jet version of simple ensemble mean
HF0J: Orion version of un-perturbed ensemble member
HFMJ: Jet version of ensemble mean
Verification period: after Sept. 01, 2020, jet version had issues before 09/01

The two versions of ensemble mean produced similar forecast skills, even though the un-perturbed 00 member forecast skills differ.

Compare HAFSv0.1E with its Deterministic Controls



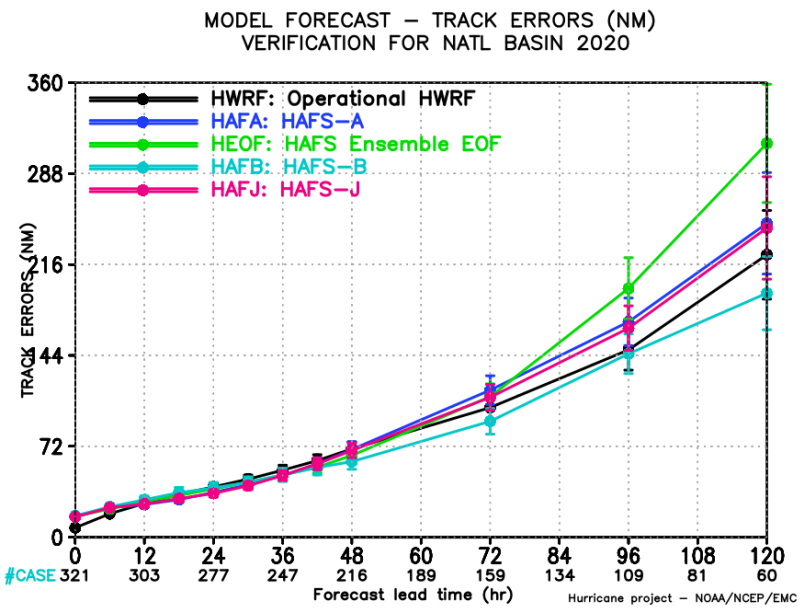


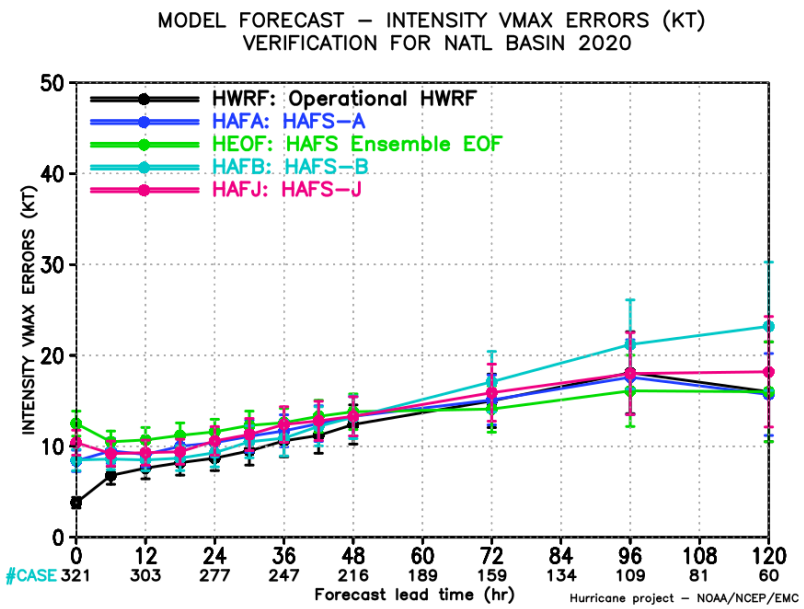


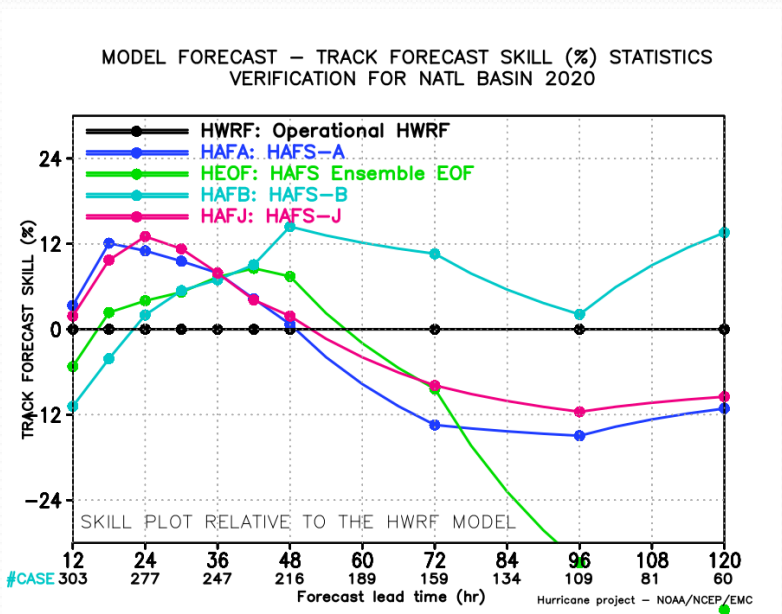
HF00: un-perturbed member, control 1
HAFA: high resolution version of deterministic model, control 2
HFMN: equal-weighted ensemble mean
HEOF: weighted ensemble mean based on EOF analysis

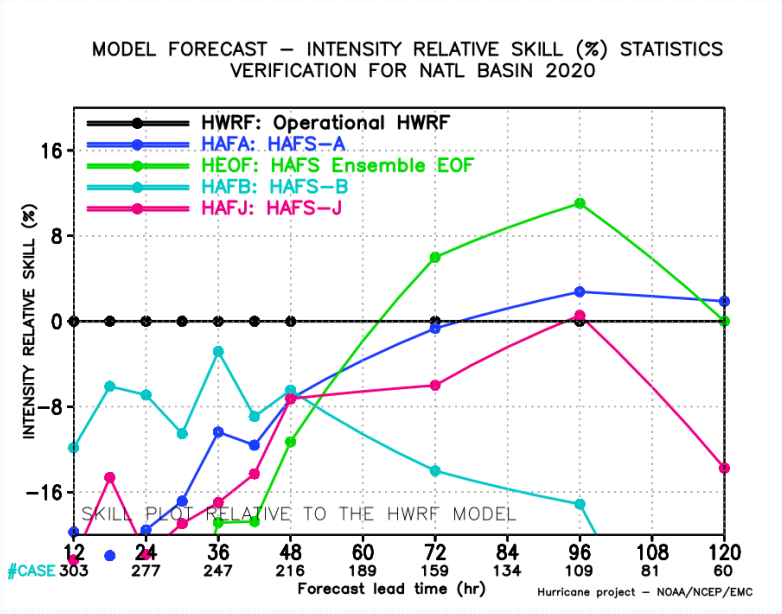
- As expected, HAFA is more skillful than HF00 in terms of both track and intensity
- EOF-weighted method improved simple mean (HFMN) by ~5% in intensity forecasts
- Both ensemble means (HEOF/HFMN) of intensity forecasts outperformed high res. deterministic forecasts (HAFA) after 60h, ~15% intensity forecasts improvement at day 4-5, comparing HEOF with HAFA.
- HEOF improved intensity bias over HFMN

Compare HAFSv0.1E with other HAFSs systems



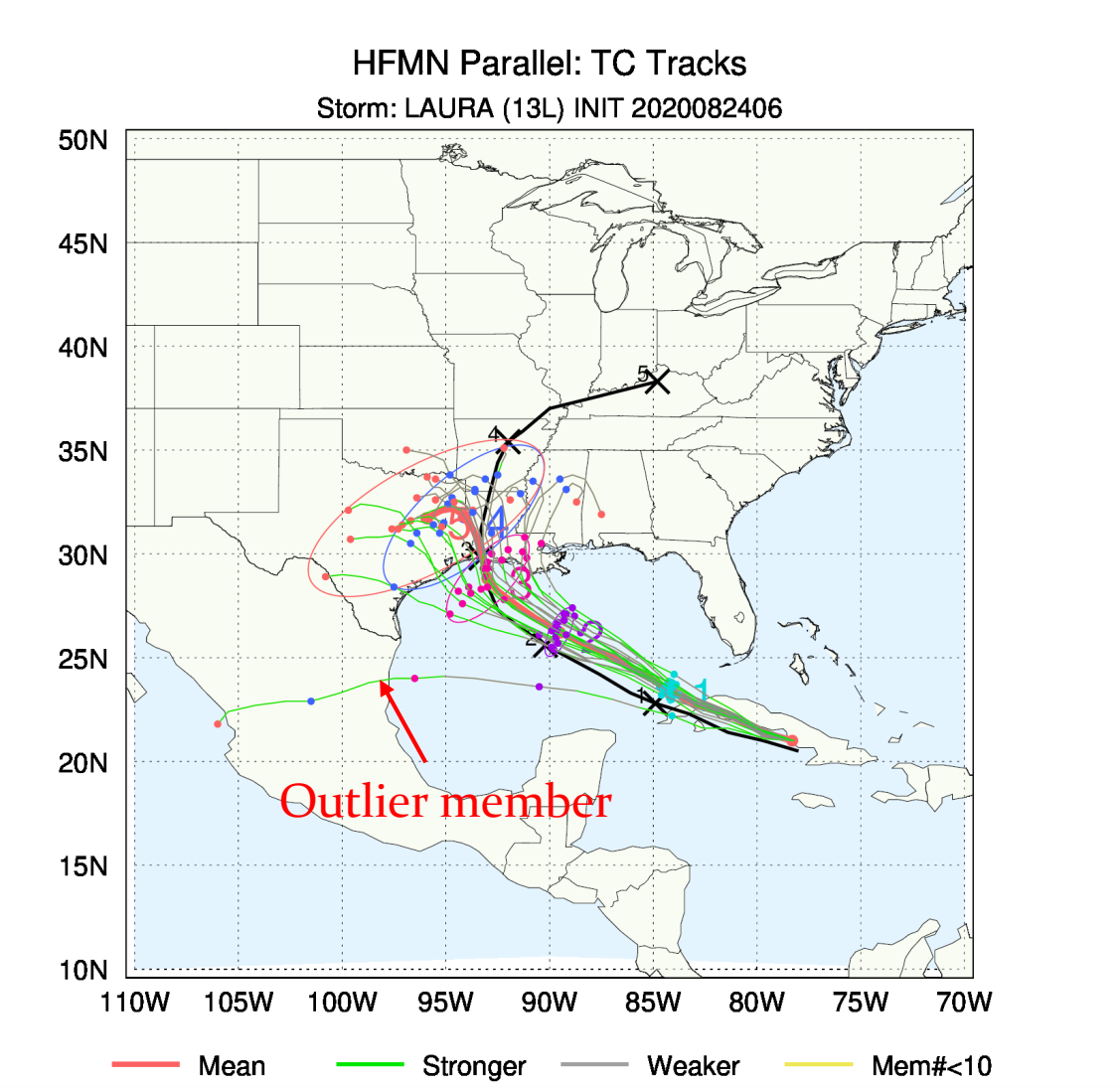


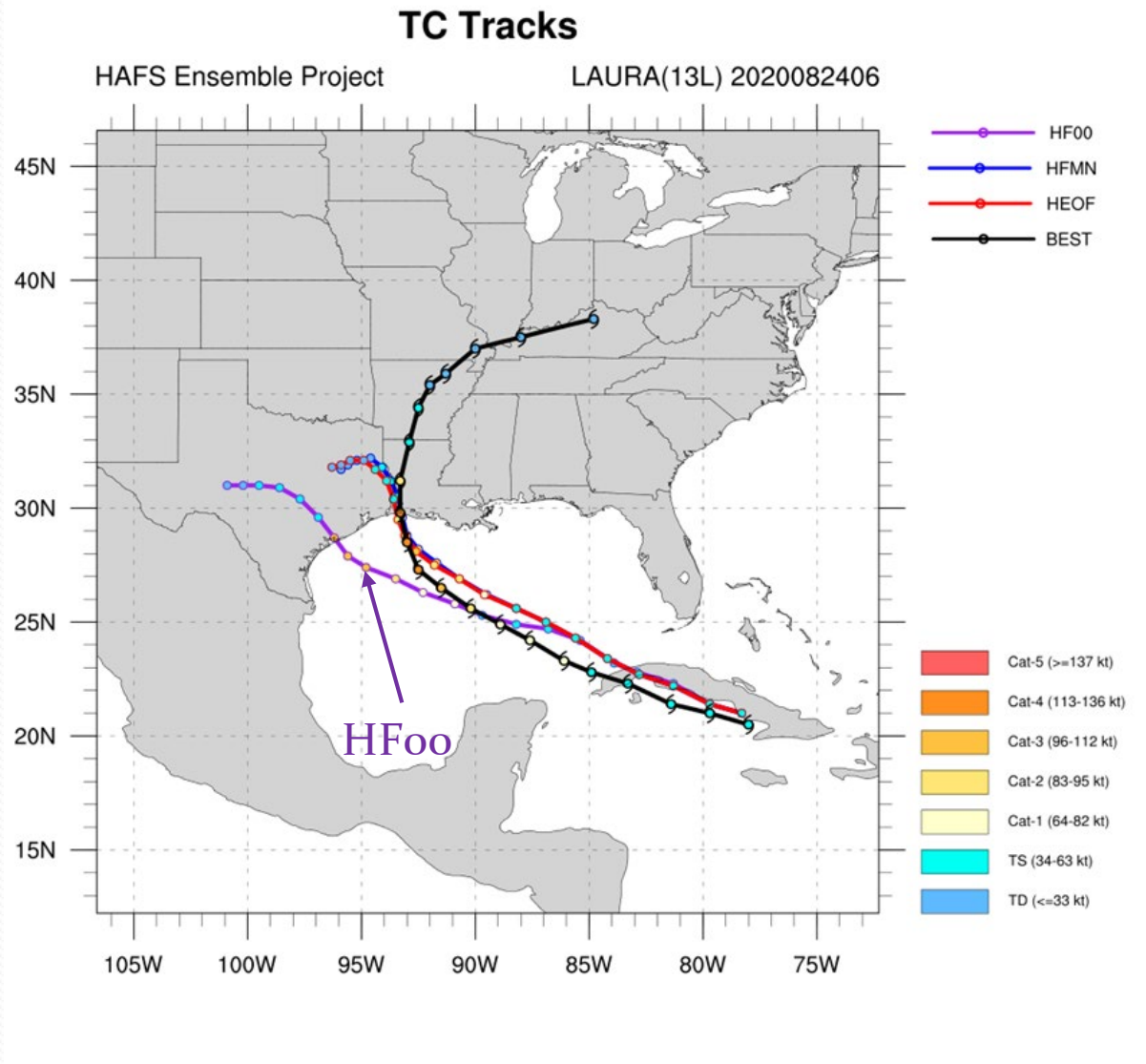




HAFS-E has comparable track forecast skills with HAFS-A and HAFS-J; HAFS-E has lowest intensity errors

Individual case of Hurricane Laura, 0600 UTC, 24 August, 2020





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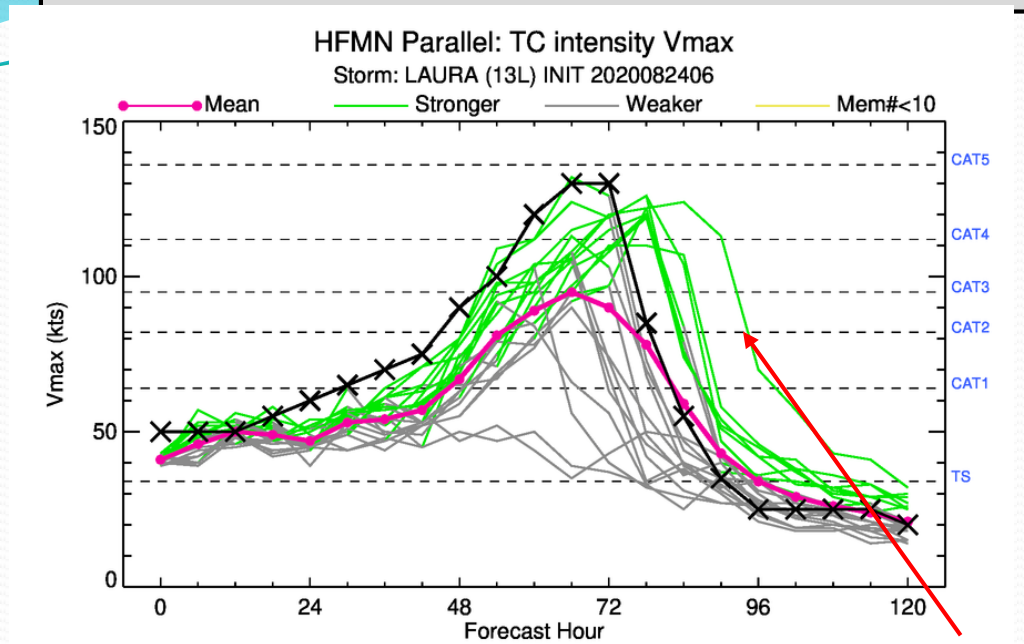
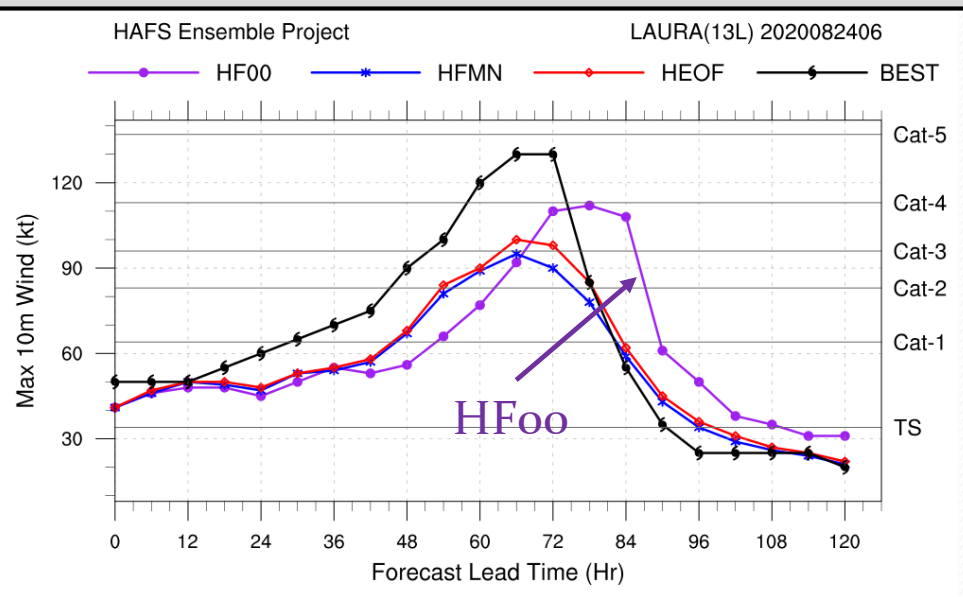
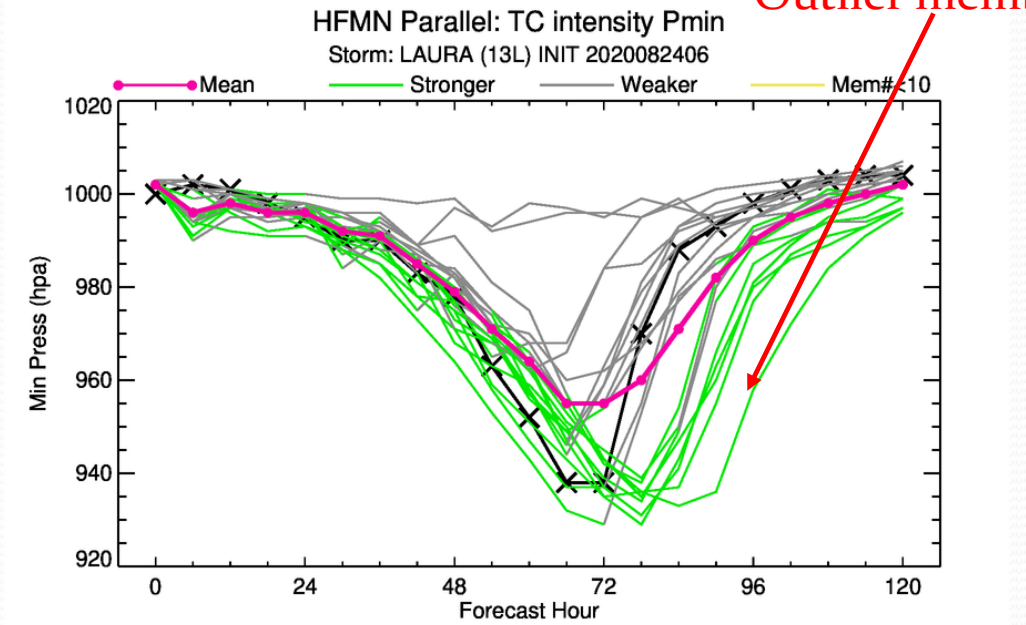
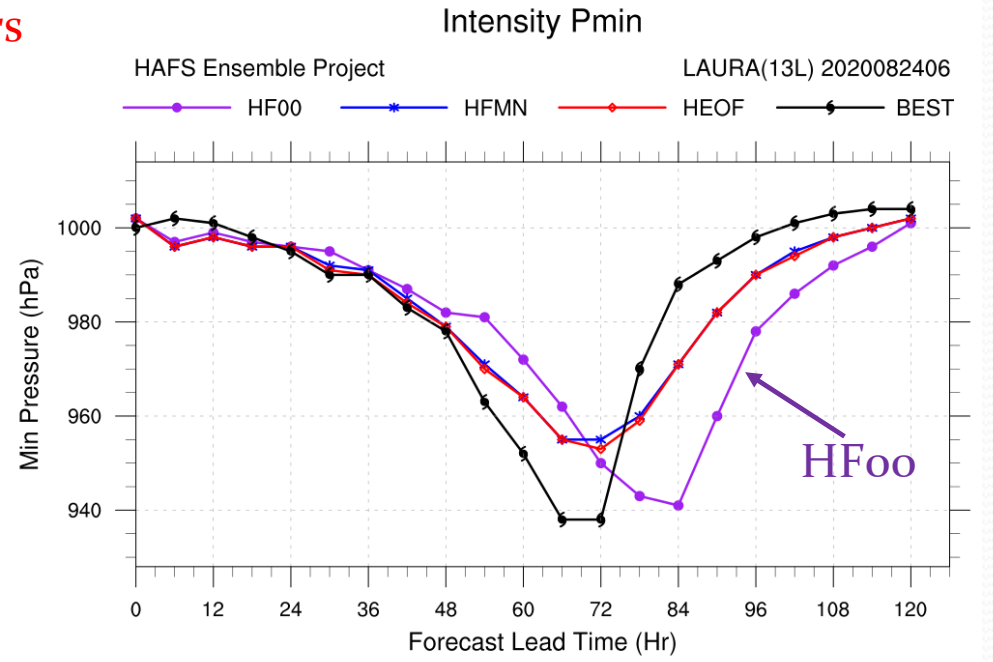


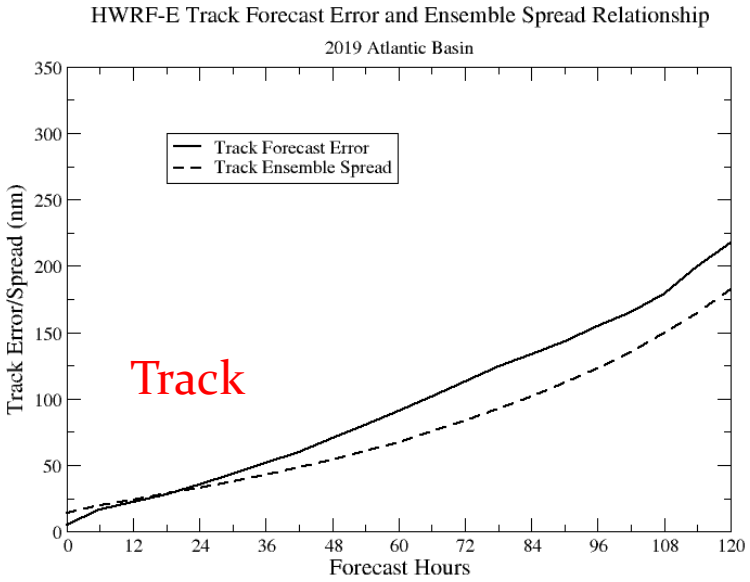


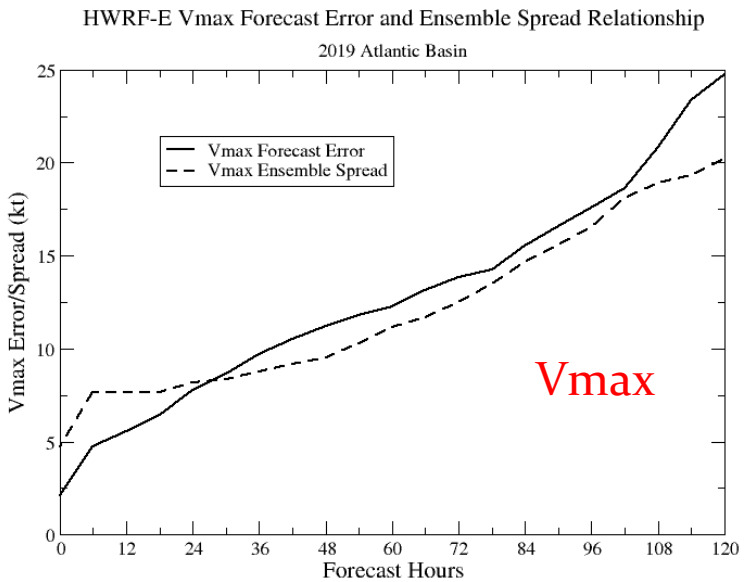
Outlier members



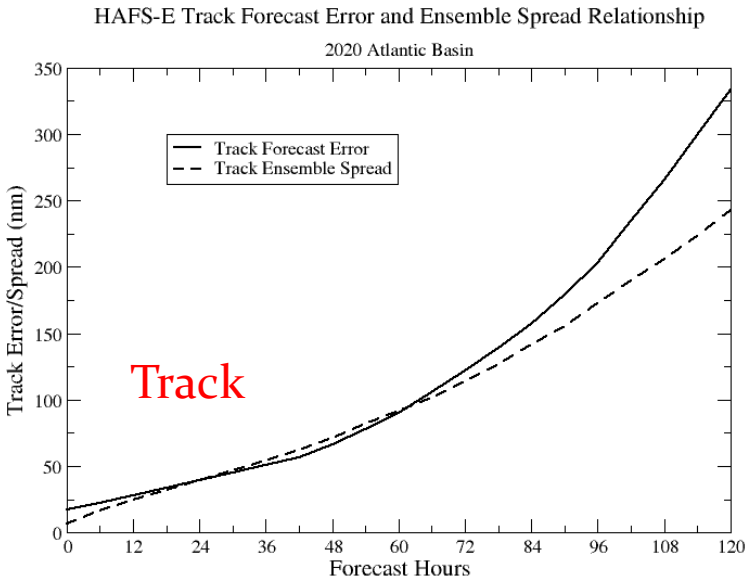


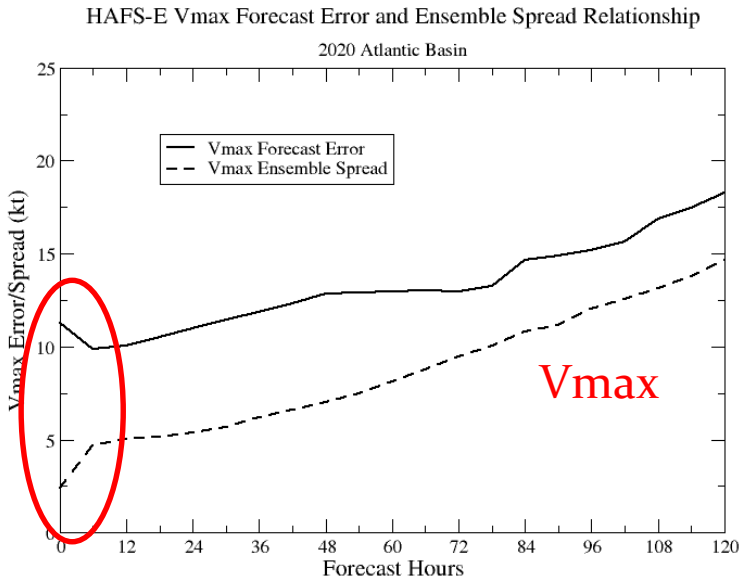
Forecast Error vs Ensemble Spread





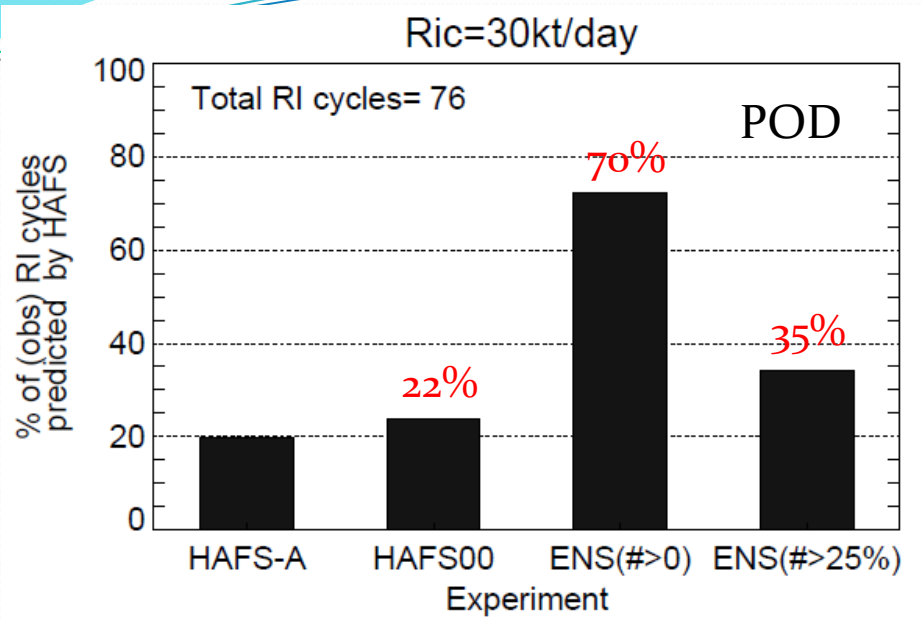
HWRF based ensemble, 2019

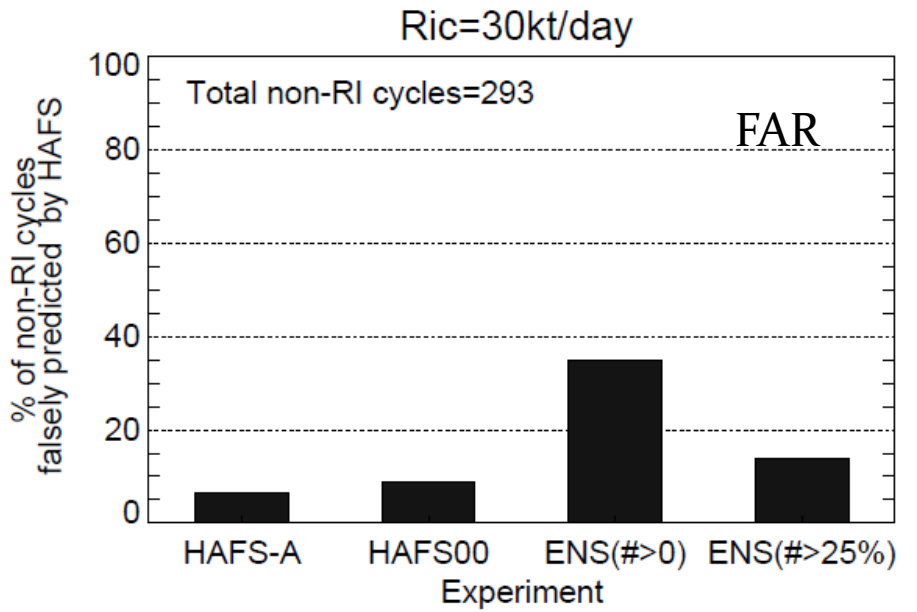




HAFS based ensemble, 2020

Statistics of Rapid Intensification Forecasts from HAFSv0.1E





HAFS –ENS runs

Total cycles = 369 (excluding cycles during which best-track data < 24hr)

RI Cycles = 76

(i.e., cycles during which best-track data indicate RIs)

Non-RI cycles= 293

(i.e., cycles during which best-track data do **NOT** indicate RIs)

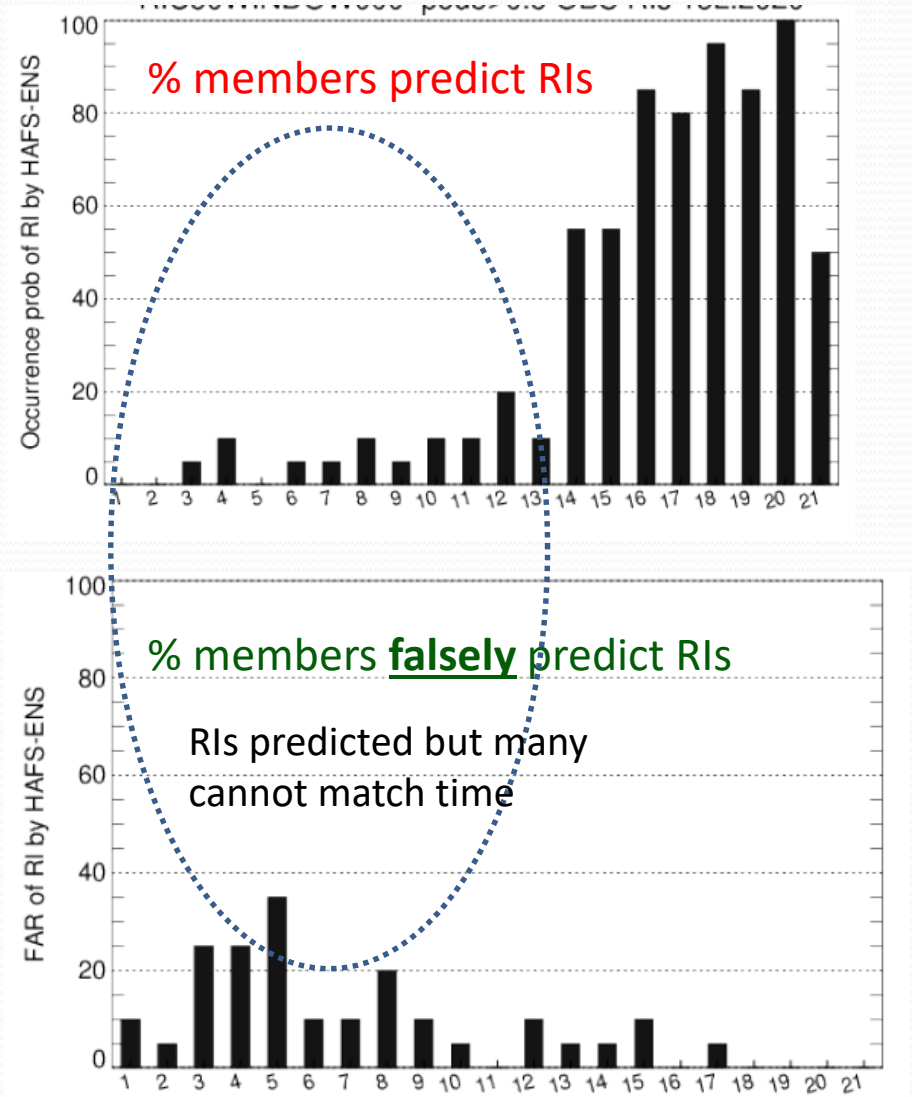
HF00 got **~22%** RI cycles

HAFS-ENS :

+ at least one member predicts RI in **70%** of cycles
+ 25% members predict RI in **35%** of cycles

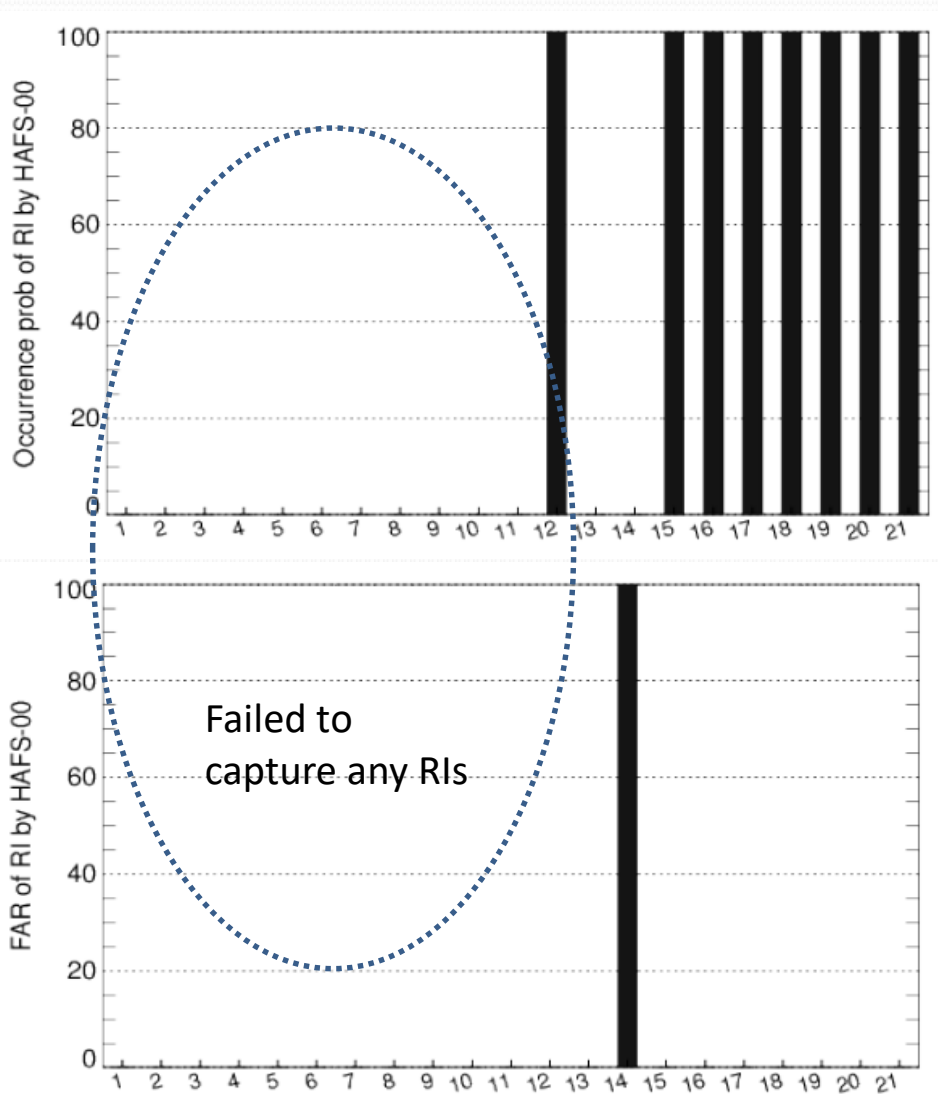
RI Performance for Individual Hurricane Laura, 13L

HAFS –ENS



Total 21 Observed RI cycles

Control (HF00)

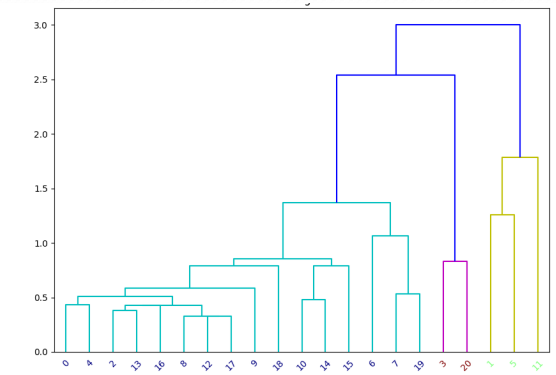
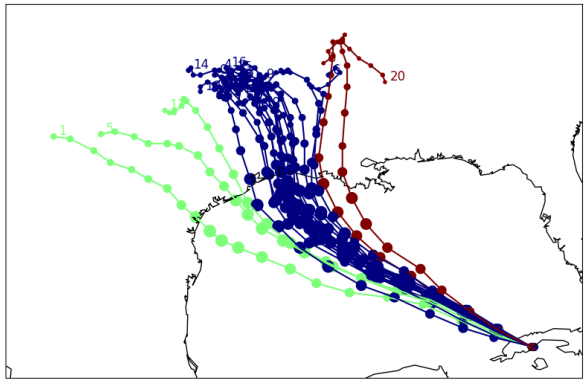
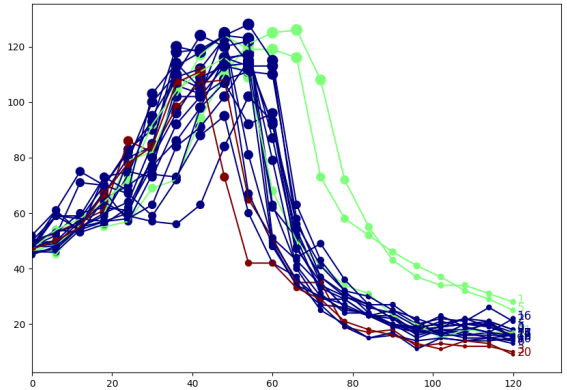
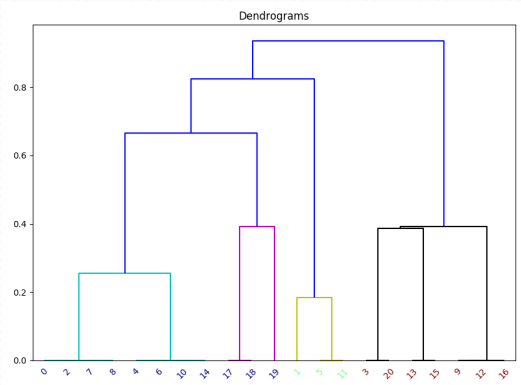
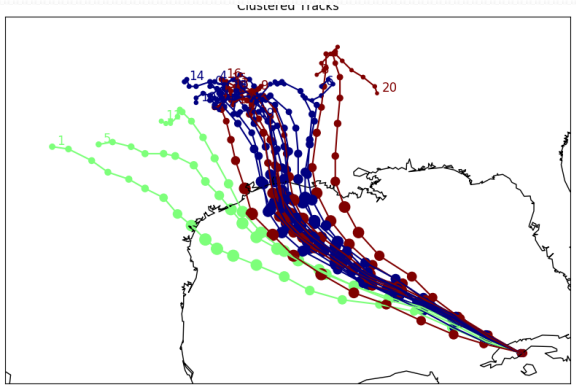
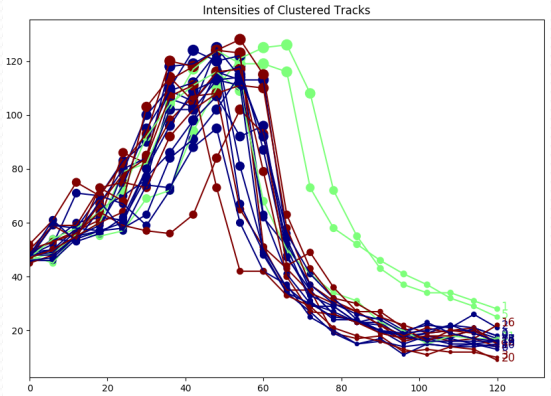
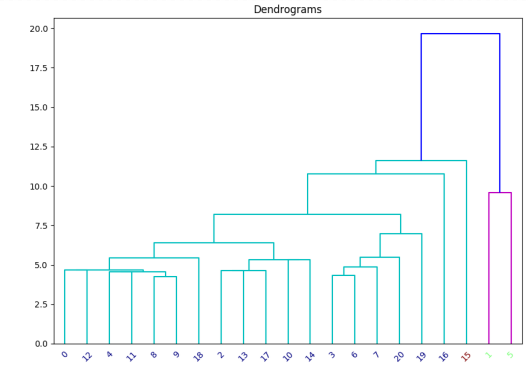
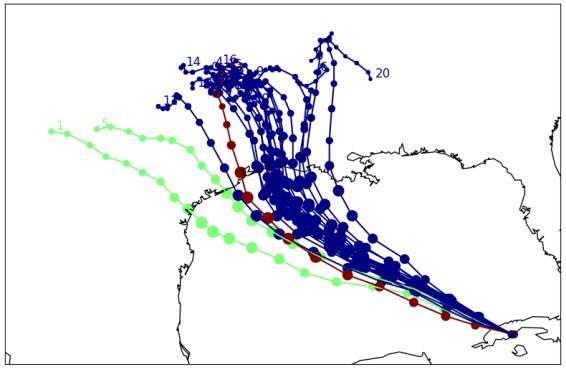
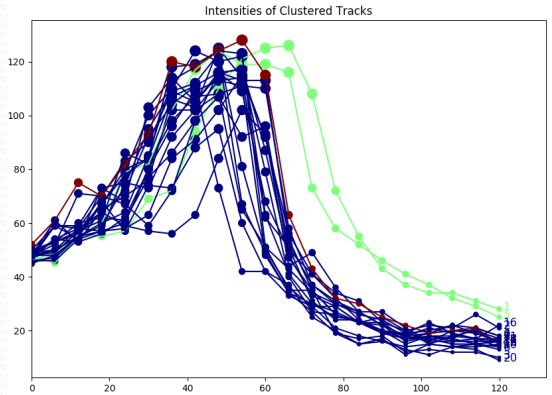


Total 21 Observed RI cycles

Hierarchical Clustering

- Agglomerative: bottom up approach
- Distance criteria for TC track:
  - Average distance between two neighboring members
  - Similarity between two neighboring members
- Distance measurement for TC Vmax:
  - Average distance between two neighboring members

HAFSv0.1E Track and Intensity Clustering

	Dendrogram	Clustered tracks	Clustered Vmax
Track-distance based clustering			
Track-similarity based clustering			
Vmax based clustering			

Conclusion Remarks

- It is demonstrated that HAFS-E is more skillful than HF00 in terms of both track and intensity
- A new method to represent ensemble forecasts, EOF-weighted ensemble average, is developed, which improved the intensity forecasts over simple mean (HFMN) by ~5%
- Both ensemble means (HEOF/HFMN) of intensity forecasts outperformed high resolution deterministic forecasts (HAFA) after 60h, ~15% intensity forecasts improvement at day 4-5.
- Ensemble track spread is comparable with 2019 HWRF EPS, ensemble intensity spread is still under dispersed.
- New product of ensemble clustering is being developed.

Questions

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