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
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+20 members, runs at 00Z, 06Z, 12Z, and 18Z.
HFO0: Jet version of un-perturbed ensemble member
HFMN: jet version of simple ensemble mean
HFOJ: 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 oo 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
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
Individual case of Hurricane Laura, 0600 UTC, 24 August, 2020

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

% members predict RIs

% members falsely predict RIs

RIs predicted but many cannot match time

Total 21 Observed RI cycles

Control (HF00)

Failed to capture any RIs

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
HAFSe0.1E Track and Intensity Clustering

Dendrogram

Clustered tracks

Clustered Vmax

Track-distance based clustering

Track-similarity based clustering

Vmax based clustering
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