



Track verification analysis for Hurricane Florence

September 27, 2018

SUMMARY

A comprehensive verification analysis of tropical cyclone track forecasts has been undertaken for Hurricane Florence. We compare CFAN's forecasted tracks with those from the NOAA NCEP global forecast models, the National Hurricane Center (NHC) forecasts, and ECMWF (the 'European model'). CFAN's track forecasts performed the best at all lead times beyond xx hours

INTRODUCTION

CFAN uses a proprietary tracking algorithm to produce tracks based on the ECMWF HRES and VarEPS and NOAA/NCEP GFS/GEFS global models. Using track error statistics derived from analysis between historical reforecasts (hindcasts) and NHC BestTracks data, CFAN calibrates the tracks of ensemble members to correct for historical along-track and across-track errors. CFAN then uses these error statistics to develop synthetic tracks track forecast probabilities based on a Monte Carlo resampling technique.

CFAN's track verification examines the distance between the track forecasts and the observed tracks obtained from NHC BestTracks dataset. The following track forecasts are compared in the evaluation:

- NOAA GFS – operational tracks provided by NOAA'
- CFAN GFS Raw – CFAN's tracker applied to the GFS forecasts
- CFAN GFS Calibrated – CFAN's calibrated tracks based on the GFS forecasts
- CFAN GEFS Raw (ensemble mean) – CFAN's tracker applied to the GEFS ensemble
- CFAN GEFS calibrated – CFAN's calibrated tracks based on the GFS forecasts
- ECMWF HRES – operational tracks provided by ECMWF for high-resolution simulation
- CFAN HRES Raw – CFAN's tracker applied to the HRES forecasts
- CFAN HRES Calibrated – CFAN's calibrated tracks based on the HRES forecasts
- CFAN ECMWF Synthetic – CFAN's calibrated synthetic tracks
- ECMWF VarEPS (ensemble mean) – operational tracks provided by ECMWF
- CFAN VarEPS Raw – CFAN's tracker applied to the VarEPS forecasts
- CFAN VarEPS Calibrated – CFAN's calibrated tracks based on the VarEPS forecasts
- NHC Official – official forecast from the National Hurricane Center
- NHC HWRF – NHC's high-resolution regional model
- NHC GMON – NHC's high-resolution regional model

For reference, several plots from 2017 track verification are provide in Appendix A for:

- All forecasts out to 10 day lead times for the entire season
- All forecasts out to 5 day lead times for Hurricane Irma
- ECMWF and CFAN forecasts out to 14 days for Hurricane Irma



HURRICANE FLORENCE

Florence originated from a strong African easterly wave that emerged off the coast on August 30. Heading on a west-northwest trajectory, the system became a tropical storm on September 1. An unexpected bout of rapid intensification ensued on September 4–5, Florence emerging as a Cat 4. Wind shear then tore the storm apart and Florence degraded to a tropical storm by September 7. The system regained hurricane strength on Sept 9 and major hurricane status by the following day, becoming a Cat 4 on Sept 10. Afterwards, Florence weakened slightly as it underwent an eyewall replacement cycle. After some restrengthening, wind shear reduced the intensity although Florence continued to increase in horizontal size. On Sept 14, Florence made landfall on the southern coast of North Carolina as a Cat 1.

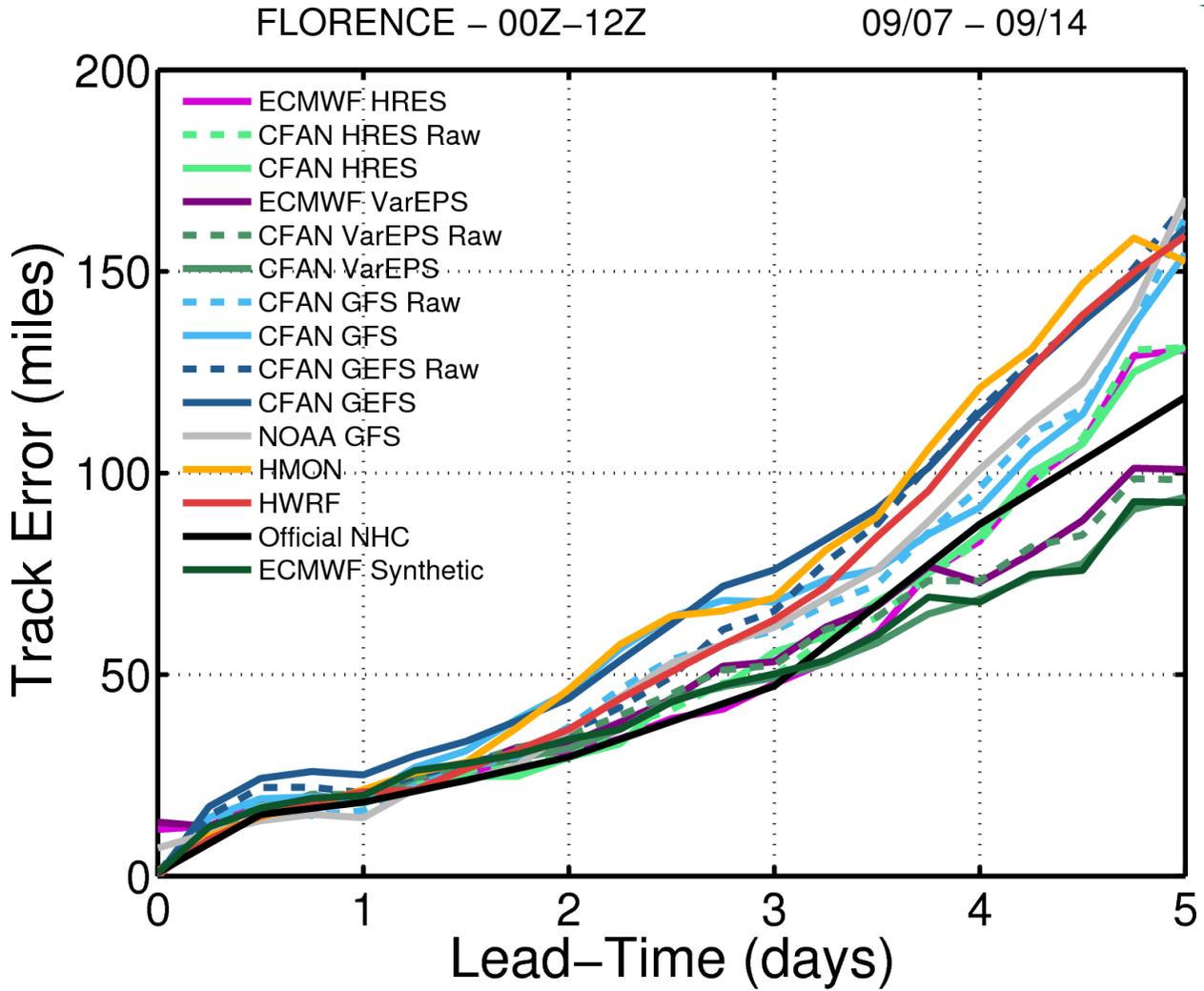
CFAN's track verification analyzed forecasts for the following periods:

- 9/5 to 9/14 - forecasts from 12 hours to 10 days before landfall
- 9/7 to 9/14 - forecasts from 12 hours to 8 days before landfall

Verification plots are provided for all forecasts in these periods for forecasts out to:

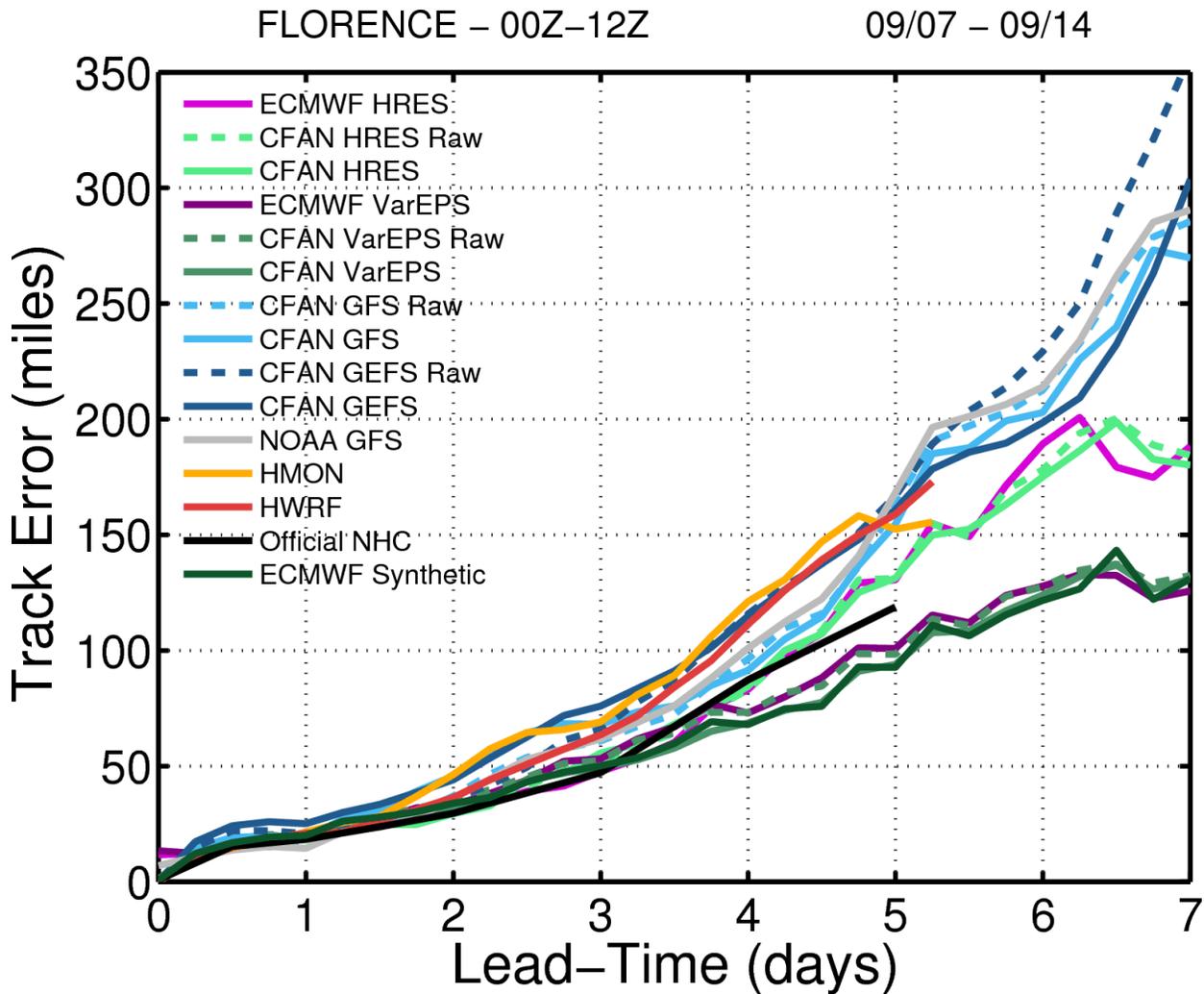
- 10 day lead time
- 7 day lead time
- 5 day lead time

For the forecasts closest to landfall, consider the analysis for forecasts for the period 9/7 to 9/14, for forecasts up to 5 day lead time:

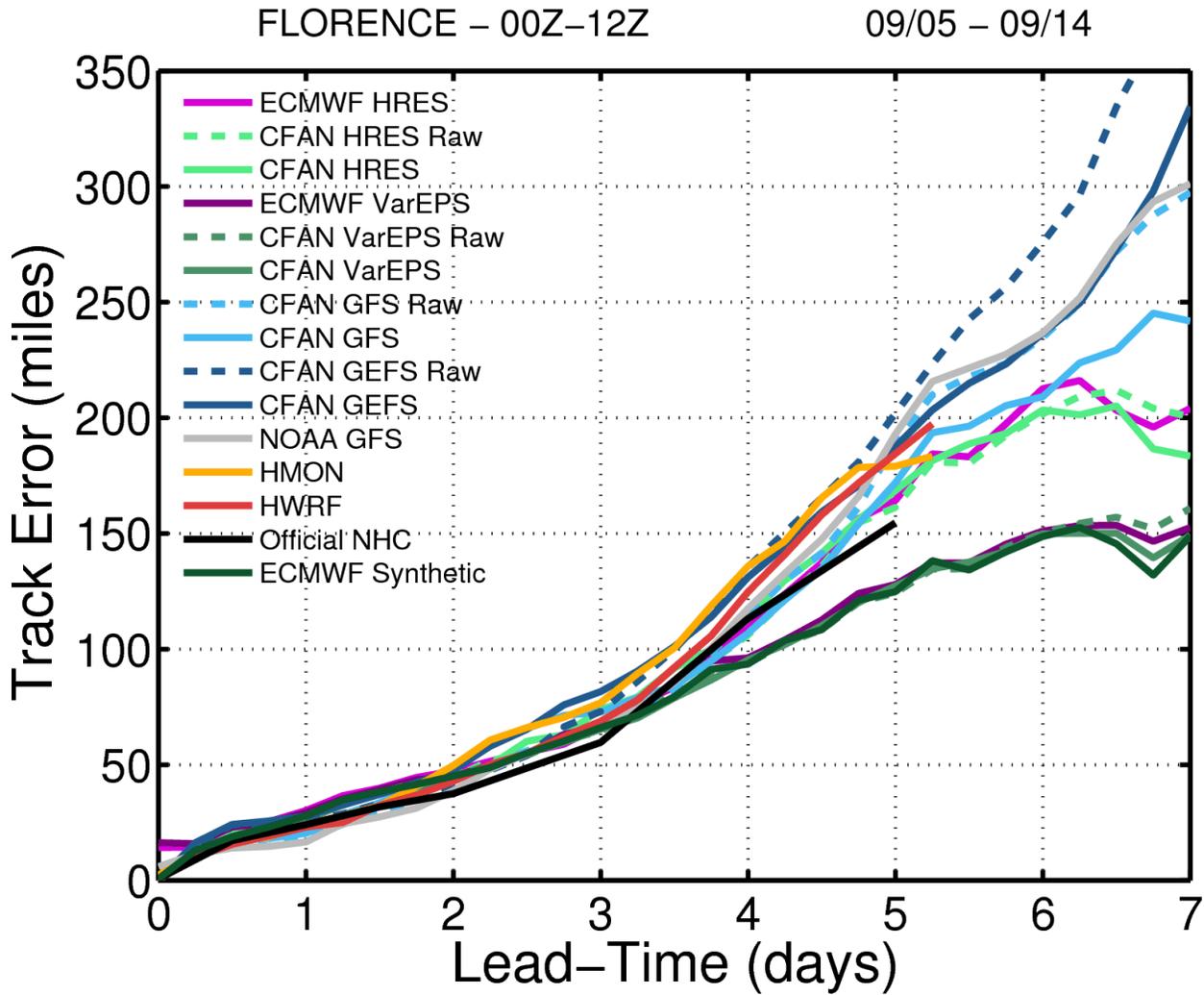


The track forecast skill out to 3 days for the most skillful models (NHC Official - black, ECMWF – light and dark purple, calibrated/synthetic CFAN – greens) is 50 miles or less. At 5 days, the raw ECMWF ensemble mean (dark purple) has a track error of 100 miles; CFAN’s calibrated ECMWF ensemble mean (medium green) and synthetic tracks (dark green) has an error at 5 days of about 90 miles. The Official NHC forecast (black) has a 5 day forecast error of 120 miles. The other NOAA/NHC forecasts – GFS (gray), HMON (yellow), HWRF (red) have 5 day track errors exceeding 150 miles.

Consideration of the forecasts for the period 9/7 to 9/14, for forecasts up to 7 days lead time shows that the raw ECMWF (purple), CFAN calibrated ECMWF ensemble mean (solid medium green) and CFAN's synthetic tracks (dark green) -- have 7 day track errors of about 130 miles. The NOAA GFS/GFS based forecasts (blue and gray) have 7 day forecast errors exceeding 270 miles.



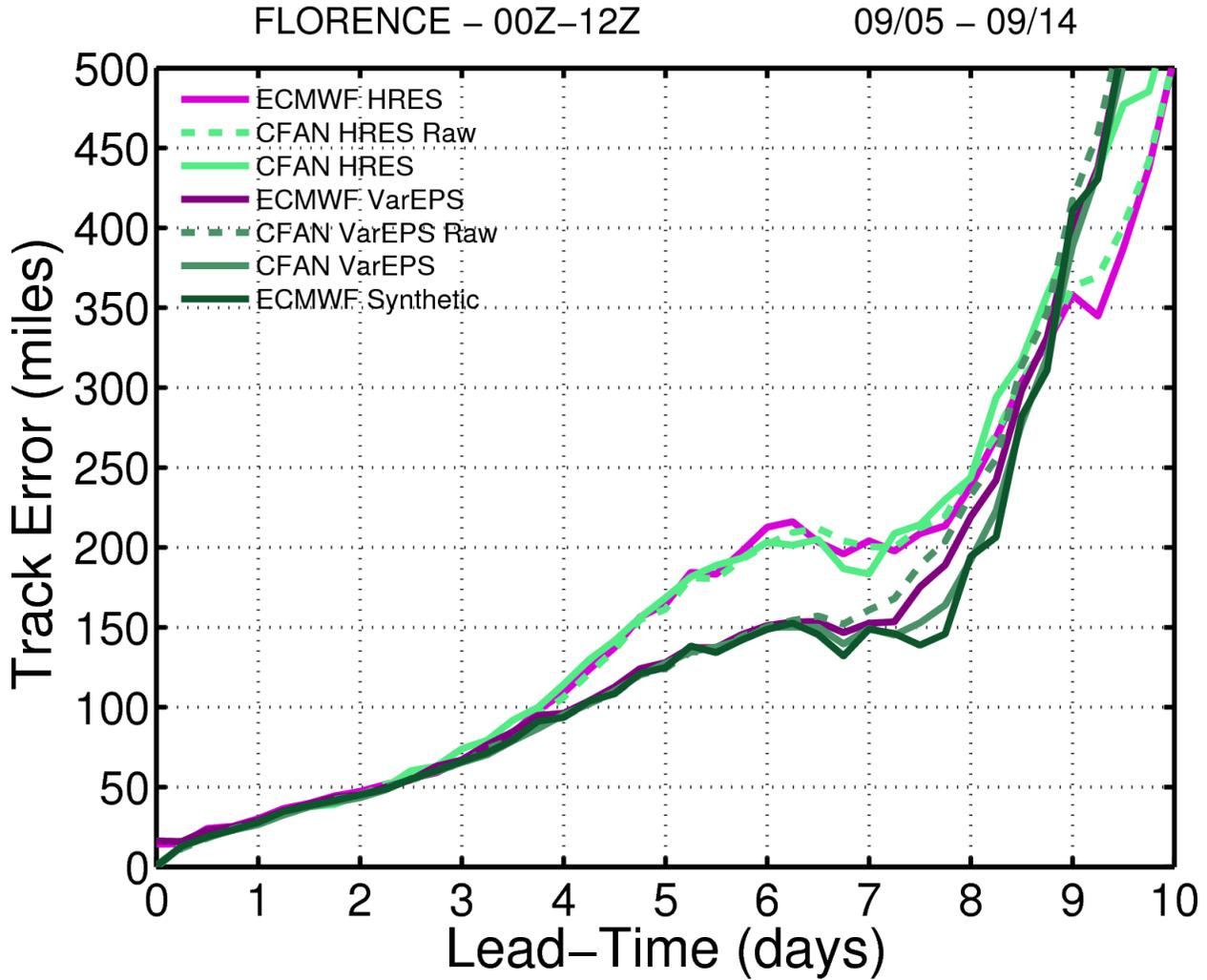
The figure below shows the same plot as on the preceding page, but for forecasts initialized over the period 9/5 to 9/14, providing a larger sample size for the longer forecast horizons. Forecast errors for days 3 and beyond are somewhat larger than shown on the preceding page, but generally the same patterns are seen. What is particularly interesting in this plot is the performance of CFAN’s calibration beyond 5 days.



CFAN’s tracker and track calibration are evaluated for GFS/by comparing the raw GFS (from NOAA; gray) with CFAN’s tracker (light blue dash) and CFAN’s calibrated GFS (solid light blue). It is seen that CFAN’s tracker (light blue dash) closely matches the GFS track (gray), with CFAN’s calibrated GFS (solid light blue) provides substantial improvement beyond 4.5 days. CFAN’s ensemble mean tracker for GEFS is dark blue dash; CFAN’s calibrated GEFS ensemble mean is dark blue. At 6 days, CFAN’s calibration for GEFS provides 50 mile improvement over the uncalibrated GEFS.

Little improvement is seen in CFAN’s calibration for ECMWF prior to 6 days.

The figure below shows the forecasts out to 10 days for ECWMF and CFAN. Beyond 6.5 days, CFAN’s calibrated track for the ensemble mean (medium green) is essentially the same as the raw ECMWF tracks (dark purple). Improved skill is seen in CFAN’s synthetic track (dark green) beyond 7 days. However, beyond 8.5 days, the forecast error increases rapidly.



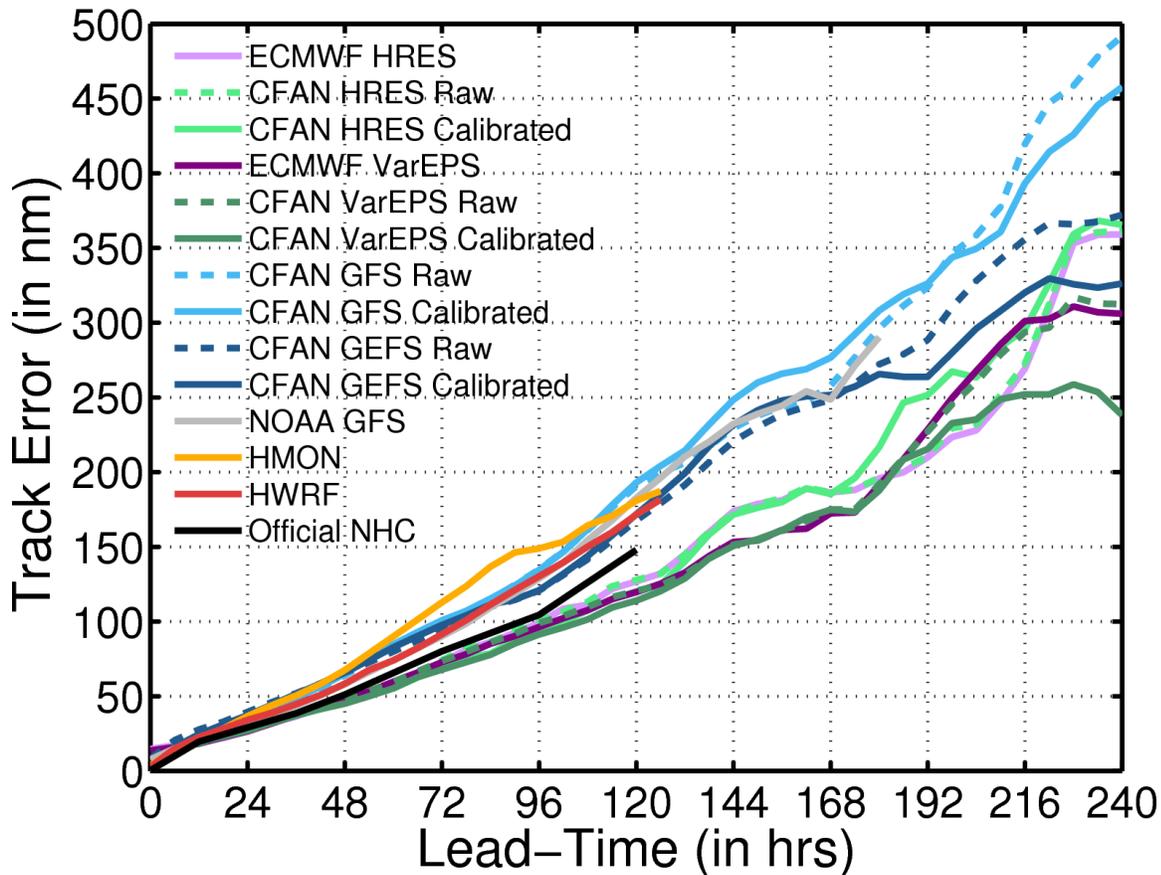
SUMMARY

Year-to-year and storm-to-storm variations in track error are to be expected. The track errors for Florence out to 5 days are similar to the average track error for the 2017 season (Appendix A). CFAN/ECMWF tracks out to 8 days show lower track error on average than for 2017. Beyond 8.5 days, track errors for Florence are greater than the average for 2017 and those for Irma.

APPENDIX A 2017 TRACK VERIFICATION SUMMARY

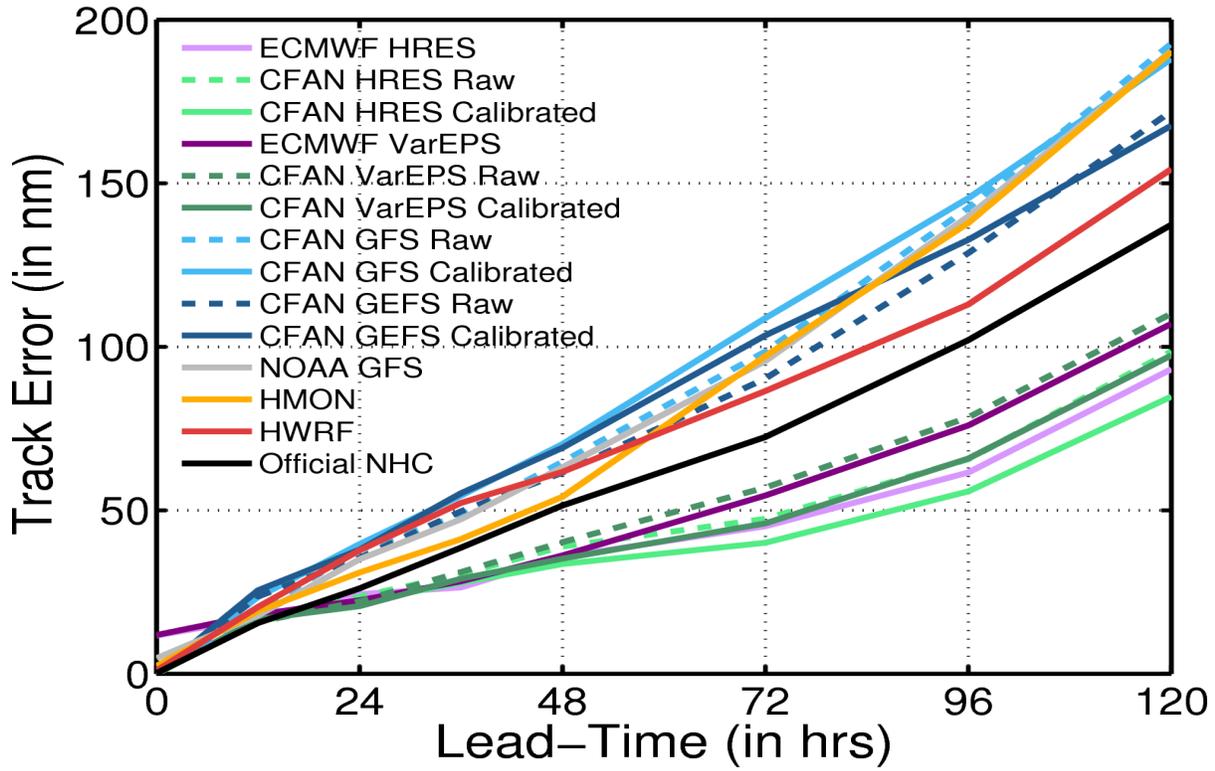
Note: 2017 track errors are given in nautical miles (nm). 1 nm = 1.15 mile

ALL – Season – 2017



Tracks	72hr	120hr
NOAA GFS	90	183
NHC Official	80	148
NHC HWRF	92	172
NHC HMON	113	181
ECMWF HRES	73	127
CFAN HRES Raw	74	128
CFAN HRES calibrated	69	120
ECMWF VarEPS (ens mean)	73	120
CFAN VarEPS Raw	74	121
CFAN VarEPS calibrated	68	114

ALL – Irma – 2017



ECMWF – Irma – 2017

