Track verification analysis for the 2017 Atlantic hurricane season

Climate Forecast Applications Network (CFAN)

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Contact information:
Judith Curry, President
Climate Forecast Applications Network
20 Woodchuck Ct
Reno, NV 89519
404 803 2012
curryja@cfanclimate.com

SUMMARY

A comprehensive verification analysis of tropical cyclone track forecasts has been undertaken for the 2017 Atlantic hurricane season. We compare CFAN's forecasted tracks with those from the NOAA NCEP global forecast model, the National Hurricane Center (NHC) forecasts, and the ECMWF (the 'European model'). CFAN's track forecasts performed the best at all lead times beyond two days for the season average and for Hurricanes Harvey, Irma and Nate.

The track error for CFAN's forecasts was smaller than the official NHC forecast at the valid times by an average of 12 nm (16%) at 3 days and 34 nm (26%) at 5 days. The relative skill of CFAN's track forecasts out to 5 days is attributed to the superior skill of the ECMWF forecast system and to CFAN's proprietary track calibration. CFAN's track calibration provides increasingly improved skill to the ECMWF-based tracks beyond 7 days, with an average reduction in track error at 10 days of 60 nm or 22%. CFAN's tracking algorithm provides the majority of the skill advantage at these longer forecast lead times.

INTRODUCTION

Over time, tropical cyclone track forecasts from the global forecast models have improved owing to model improvements, notably in horizontal resolution. CFAN has produced tropical cyclone forecasts for the North Atlantic since 2007. Over this period, our forecasts have improved not only from improvements to the global models, but also from improvements to CFAN's track and intensity algorithms.

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 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. We evaluate forecast track errors for the period starting with up to 12 hours prior to the naming of the storm, and until the storm is declassified as a tropical cyclone or makes a major landfall that leads to its demise. We do not include any tropical storm that lasted less than 48 hours.

The following track forecasts are compared in the evaluation:

- NOAA GFS – operational tracks provided by NOAA's global weather model
- ECMWF HRES – tracks provided by European model high-resolution simulation
- CFAN HRES – CFAN's calibrated tracks based on the ECMWF HRES forecasts
- ECMWF VarEPS (ensemble mean) – tracks provided by the ECMWF ensemble forecasts
- CFAN VarEPS – CFAN's calibrated tracks based on the ECMWF VarEPS forecasts
- NHC Official – official forecast from the National Hurricane Center
- NHC HWRF – NHC's high-resolution regional model

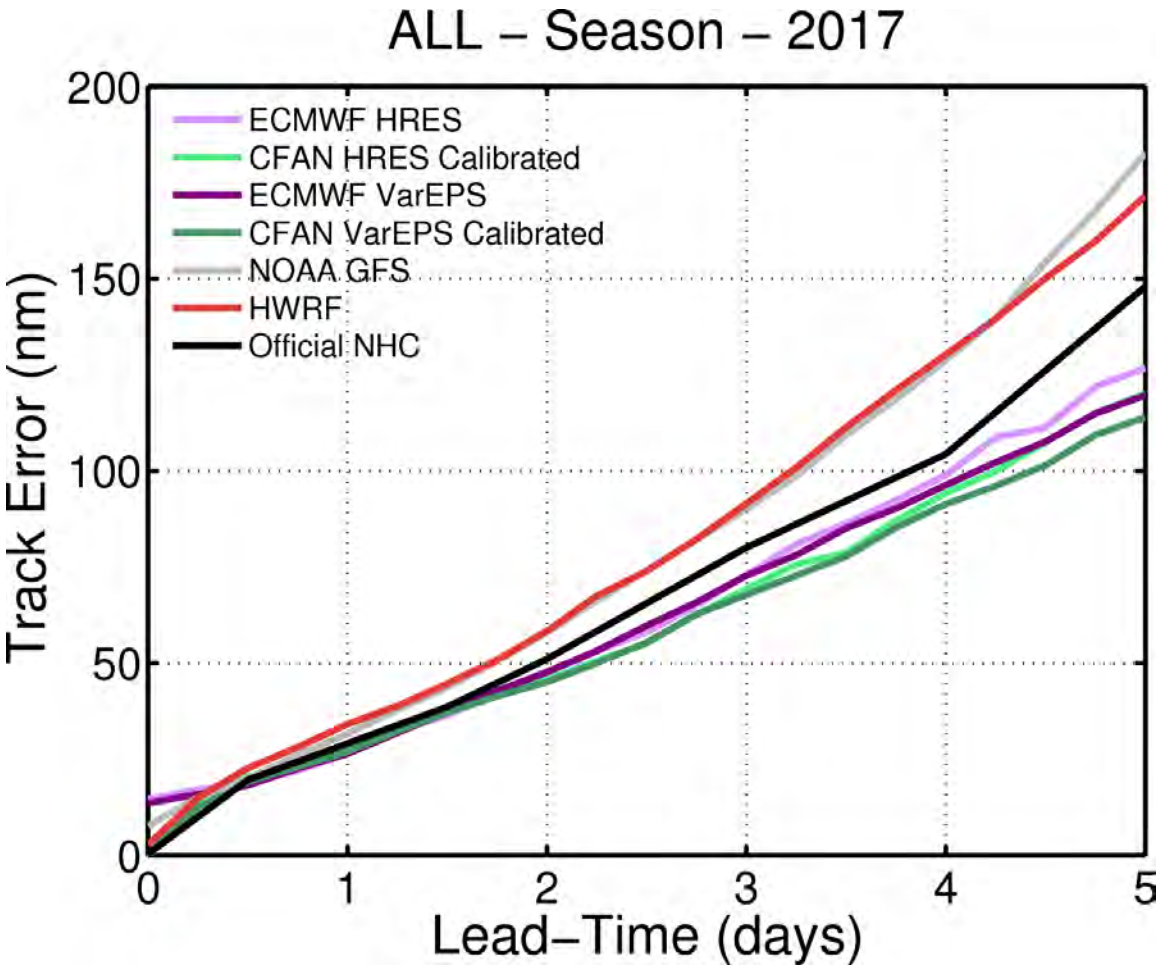
Evaluation of the models (both global and regional) and CFAN's forecast are compared based on the model initialization time (00 UTC, 06 UTC, 12 UTC, 18 UTC). Comparing the model forecasts with the official NHC forecast is not straightforward. We have identified two strategies for comparing the model forecasts with the NHC forecasts:

1. Compare the model and NHC forecasts based upon the input knowledge at the initialization/valid time. This method evaluates the different methods based on input at the same time in the state of the storm evolution.
2. Users of the track forecasts are most likely comparing later valid times for the NHC with earlier initializations of the dynamic models. The NHC compares their forecast with models available to the forecaster at the time of the forecast, by introducing an approximately 6 hour time lag that compares say the 12 UTC model forecasts with the 18Z NHC forecast (Eric Blake, NHC, personal communication).

The graphical analyses shown in this report are based on method #1. The table of track errors at 3 and 5 days includes both #1 and #2.

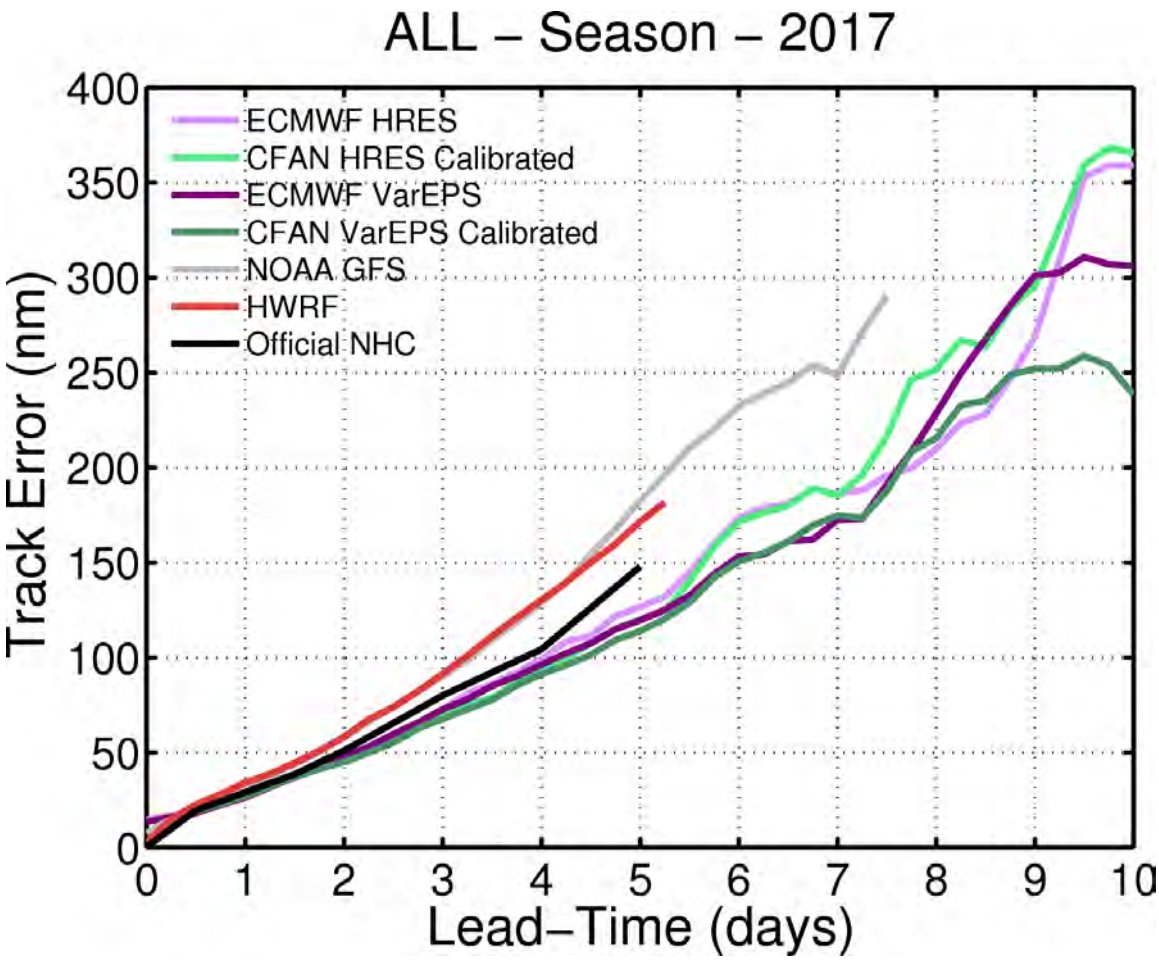
SEASON

For the overall season out to 5 days, it is seen that CFAN (green) and ECMWF (lavender, purple) perform better than the NHC Official forecast (black), GFS (gray) and HWRF (red) at all lead times beyond 12 hours. CFAN's calibrated ECMWF forecasts (green colors) perform noticeably better than the official ECMWF forecasts (lavender and purple) at all lead times.



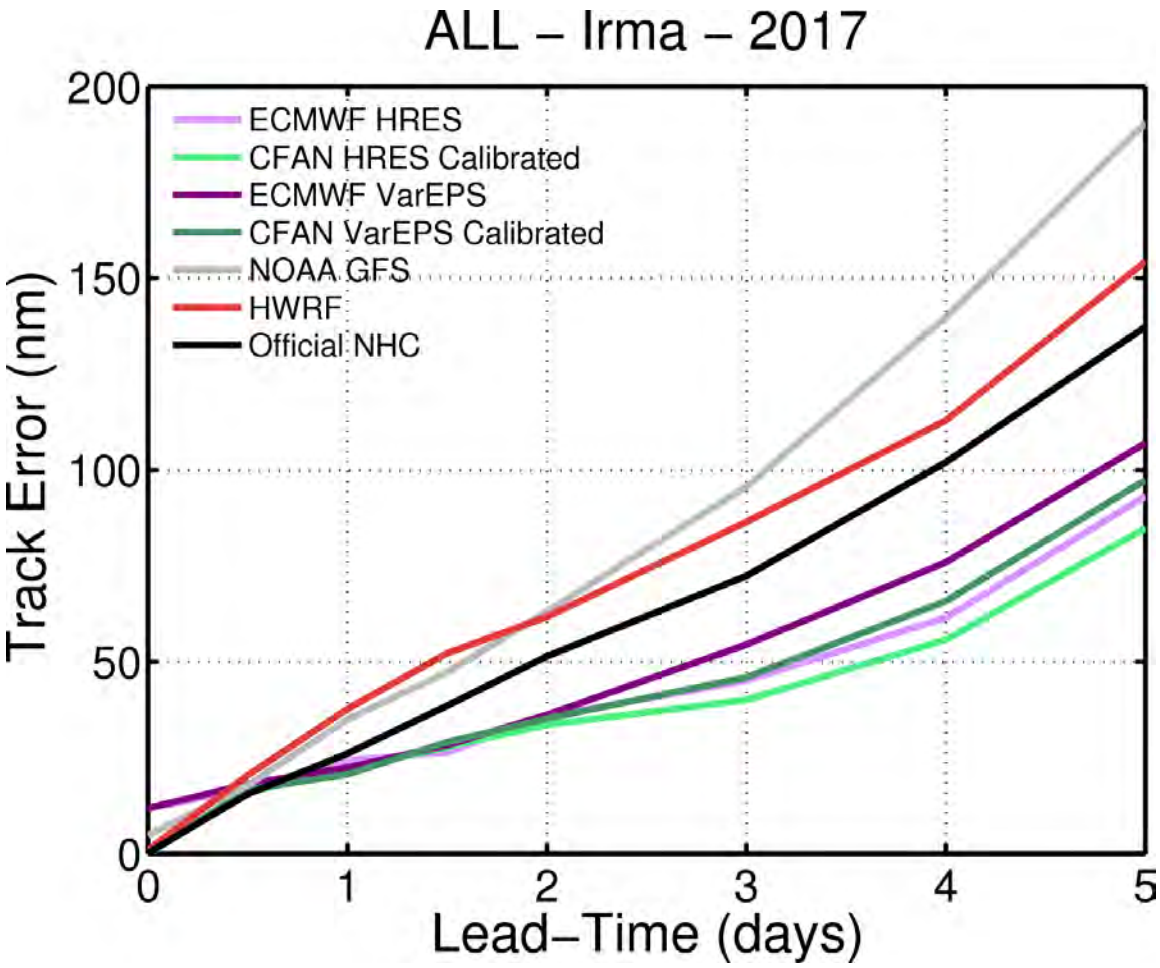
The track error for CFAN's calibrated VarEPS forecasts (dark green) was smaller than the official NHC forecast (black) by an average of 12 nm (16%) at 3 days and 34 nm (26%) at 5 days. The relative skill of CFAN's track forecasts out to 5 days is about equally attributed to the superior skill of the ECMWF forecast system and to CFAN's track calibration.

At longer lead times, the advantage of CFAN's calibrated tracks becomes increasingly evident (note: the NHC does not currently provide forecasts beyond 5 days). CFAN's calibrated tracks for the ECMWF VarEPS ensemble mean (dark green) show increasing skill over ECMWF's tracks (purple) particularly beyond 8 days, with an average reduction in track error at 10 days of 60 nm or 22%. CFAN's tracking algorithm provides the majority of the skill advantage at these longer forecast lead times.



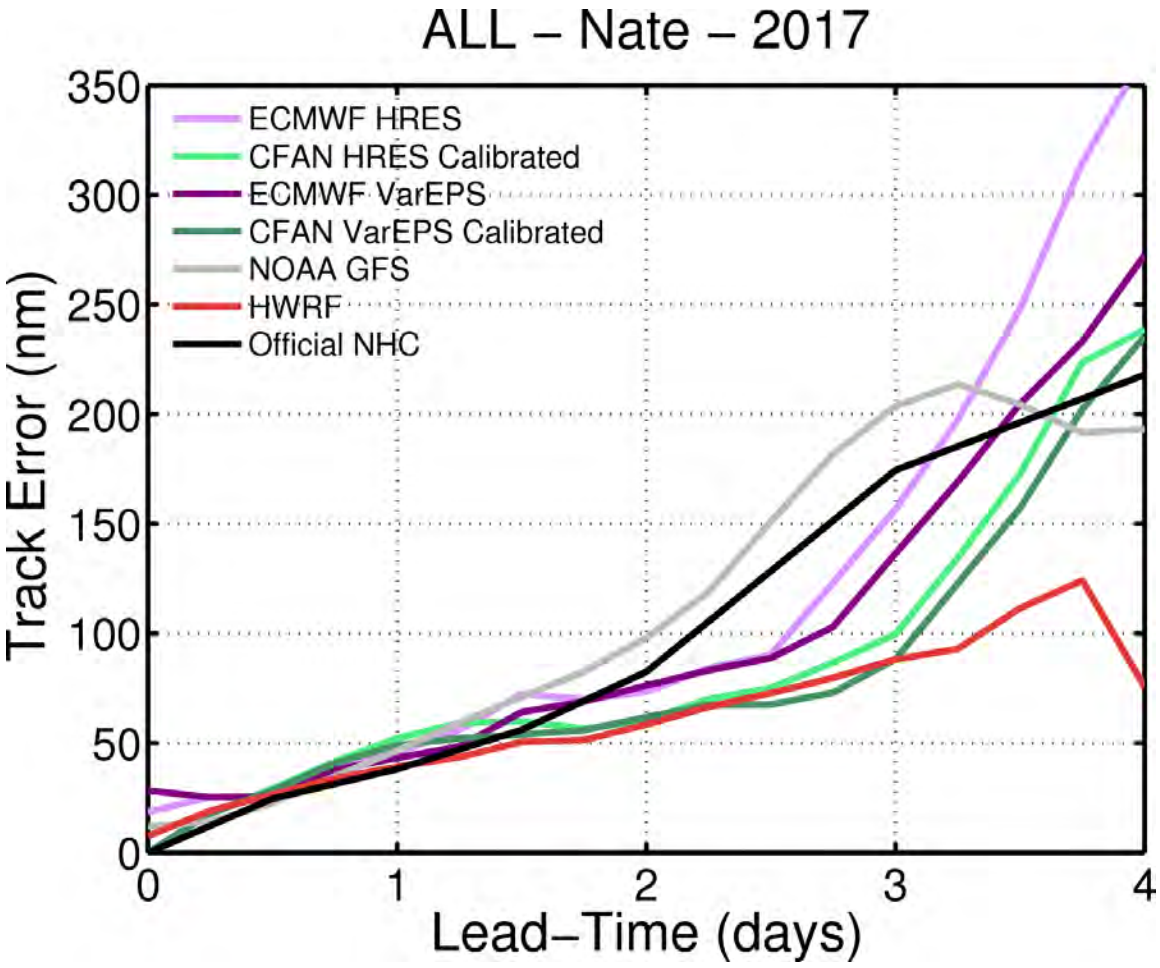
HURRICANE IRMA

CFAN's calibrated tracks (green) perform the best beyond 24 hours. CFAN's HRES forecast (light green) at 3 days has a track error that is about 30 nm smaller than the Official NHC track (black). At 5 days, CFAN's calibrated HRES track error (light green) is >50 nm smaller than the Official NHC (black).



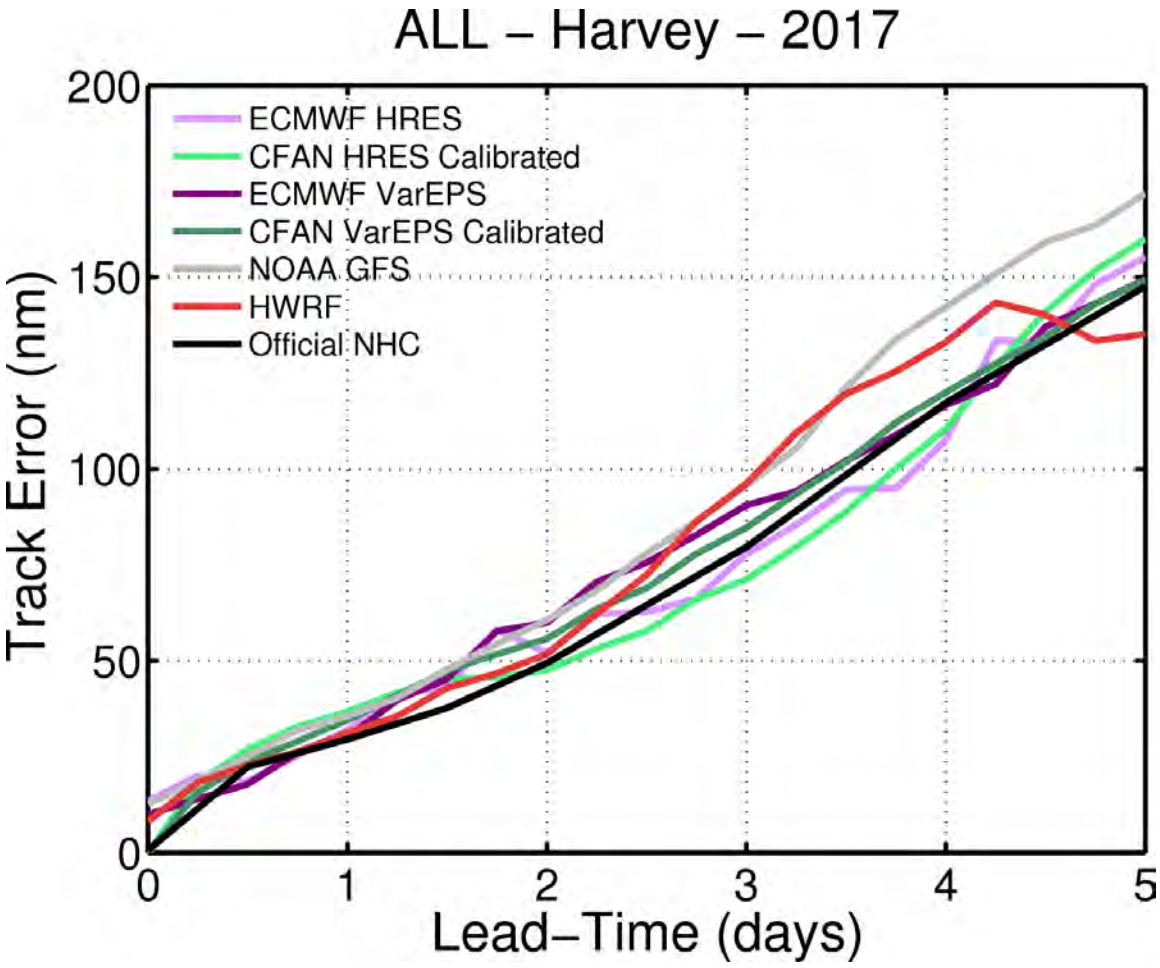
HURRICANE NATE

At 3 days, CFAN's calibrated VarEPS tracks (dark green) have a track error that is 75 nm smaller than the official NHC tracks (black), and 50 nm smaller than the ECMWF VarEPS tracks (purple). The official NHC forecast closely followed the GFS model (gray), unfortunately failing to recognize how well the HWRF (red) was forecasting.



HURRICANE HARVEY

ECMWF and CFAN's track forecasts perform significantly better than the GFS, although NHC's official forecast performed very well. At times between 2 and 4 days, CFAN's calibrated HRES tracks perform the best.



SUMMARY

At 3 day and and 5 day lead times, the following overall track error statistics for the 2017 season are obtained (nm) for the valid times of the forecast:

Tracks	3 day	5 day
NHC Official	80	148
NHC HWRF	92	172
ECMWF HRES	74	128
CFAN HRES	69	120
ECMWF (ensemble mean)	73	120
CFAN ECMWF calibrated	68	114

CFAN's calibrated ECMWF tracks perform best at both 3 and 5 days.

Relative to the official NHC track forecasts, the track error for CFAN's forecasts was smaller by an average of 12 nm (16%) at 3 days and 34 nm (26%) at 5 days. The relative skill of CFAN's track forecasts out to 5 days is about equally attributed to the superior skill of the ECMWF forecast system and to CFAN's track calibration.

NHC's forecasts are issued up to 6 hours earlier than model-based forecasts at the same valid (initialization) time. Hence, a forecast user may be comparing at the same time forecasts based on dynamical models with the NHC forecasts that have a valid time 6 hours later than the model initialization time. Accounting for this discrepancy in the forecast availability changes the error statistics slightly, to NHC's advantage. Relative to the official NHC track forecasts, the track error for CFAN's forecasts was smaller by an average of 7 nm (9%) at 3 days and 28 nm (21%) at 5 days.

CFAN's calibrated tracks provide increasingly improved skill to the ECMWF-based tracks beyond 7 days, with an average reduction in track error at 10 days of 60 nm or 22%. CFAN's tracking algorithm provides the majority of the skill advantage at the longer forecast time horizons.