A Statistical Analysis of High Frequency Track and Intensity Forecasts from NOAA's Operational Hurricane Weather Research and Forecast (HWRF) Modeling System

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1. Introduction

In addition to the tropical cycle (TC) track and intensity forecast guidance at 6-hourly synoptic times valid at 00Z, 06Z, 12Z, and 18Z provided in Automated Tropical Cyclone Forecasting (ATCF) format, the operational Hurricane Weather Research and Forecast **(**HWRF) model also provides high-frequency tropical cyclone forecast (HTCF) output at every model time step of the innermost domain (10/3 seconds). The variables in the HTCF output include magnitude and location (latitude/longitude) of 10-meter maximum wind speed (Vmax), minimum sea level pressure (Pmin), and radius of maximum wind (RMW). In this study, a statistical analysis is performed on the high-frequency output from the operational HWRF forecasts of track and intensity for all TCs in the North Atlantic basin for a 3-year period (2017-2019). The results show that there are large temporal fluctuations and uncertainties in the high-resolution TC track and intensity that is not captured by the conventional (six-hourly) forecast guidance provided to the TC forecast centers. Running means at various time windows are applied to the high frequency track and intensity forecast data from the model output to study their statistical characteristics. The analysis demonstrates for the first time that the operational HWRF model is capable of producing the high frequency trochoidal TC motion seen in observations. The TC track and intensity verification indicates that the +/- 3-hour and 4.5-hour running means of the high-frequency intensity outputs are ~5% more skillful than the standard 6-hourly HWRF intensity forecasts, while the skill for the track forecast is comparable between the two methods.

2. High-Frequency Track and Intensity Analysis

Track forecasts using the high-frequency internal tracker and the 6-hourly external tracker are compared with one and another and with observations for Hurricane Florence initialized at 0000 UTC 09 September 2018, Figure 1a. Observations include the observed best track and high-frequency (2-min) track observations. Fig. 1a represents typical characteristics of high-frequency HWRF track output and clearly shows the small-scale oscillation of trochoidal motion, which rotates counterclockwise around the 6-hourly TC tracks. Trochoidal TC motions have been previously observed in radar observations (Marks et al. 2008). Fig. 1b shows the temporal fluctuations of the TC intensity forecasts for Hurricane Florence. TC intensity is compared between the HWRF external tracker (every 6 h), the HWRF internal tracker at every model time step (10/3 s), plus 10-, 60-, and 360-minute running averages, and the best track.

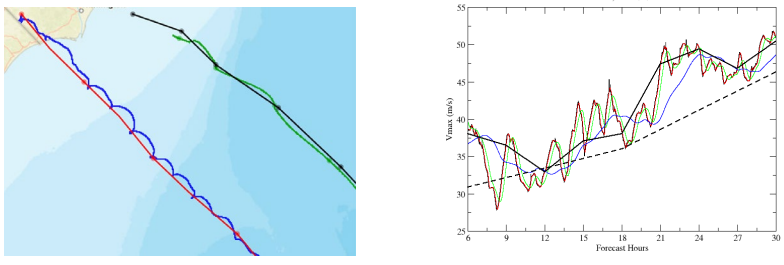

Fig. 1 a) HWRF track forecasts for Hurricane Florence 06L, 20180909 00UTC (left). Two forecast tracks and two observed tracks are displayed the operational HWRF track forecasts (red), HWRF high-frequency track (blue), observed. b). HWRF intensity forecasts for Hurricane Florence 06L, 20180909 00UTC (right) panel.

3. Verification

The track and intensity forecast skill are compared between the operational HWRF, and 6h- and 9h-running means of high frequency. It is found that track forecast skill was similar at all forecast lead times for the operational HWRF, 360M, and 540M (not shown). This result was expected because small temporal scale trochoidal motion uncertainties are removed by using sufficiently long running mean windows. At early forecast lead times, 540M shows a 3% track skill improvement over the operational HWRF. On the other hand, intensity verification shows quite different results. The intensity forecast skill for both 360M and 540M show at least a 3% improvement over the operational HWRF Vmax forecasts at all lead times.

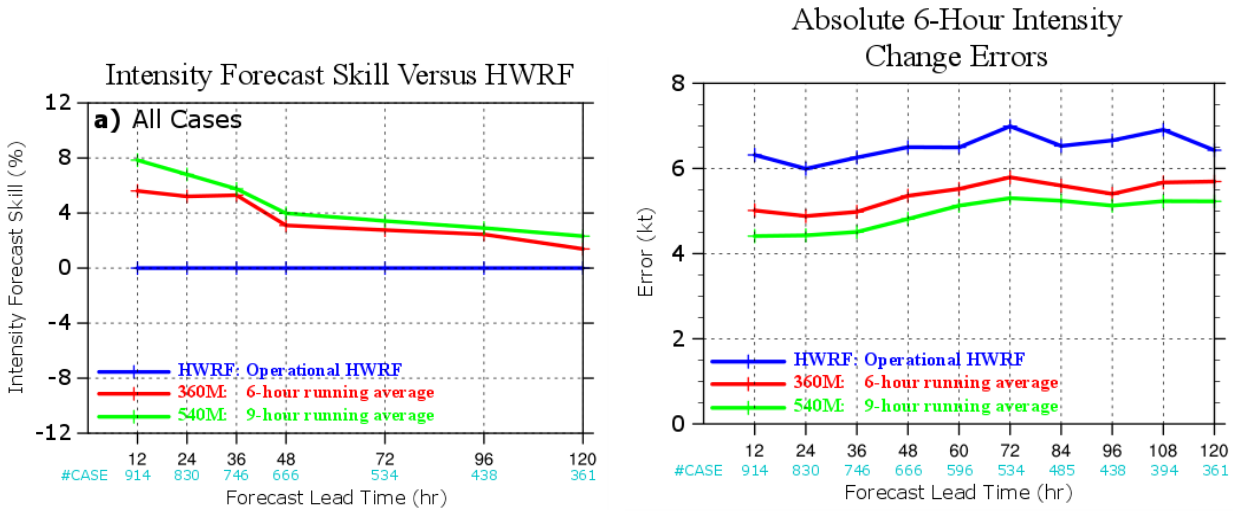

FIG. 2 Comparisons of intensity (left) and 6h intensity change (right) forecast skill for all cycles, the operational HWRF (HWRF, blue line), running mean of high frequency over +/-3-hour time window (360M, red line), and running mean of high frequency over +/-4.5 hour time window (540M, green line).

4. Conclusions

The analysis demonstrates for the first time that the operational HWRF is capable of producing the trochoidal TC motion in the high-frequency TC tracks seen in observations. The high frequency fluctuations of predicted TC tracks show trochoidal motion with a rotational period of ~1-hour in the temporal scale and ~20-100 kilometers in the spatial scale. The fluctuations that lead to large uncertainties in the 6-hourly model track and intensity forecast guidance are estimated. It is found that the uncertainties in model track forecasts are small enough to have no impact on the verification against the best track. On the other hand, the high frequency fluctuations of Vmax present some uncertainties in the 6-hourly intensity forecasts. Removing temporal intensity uncertainties results in a ~3-5% improvement in TC intensity forecasts, compared to the standard 6-hourly HWRF forecasts.

References:

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