Impact of Aircraft High-Density Observations on GFSv16 Tropical Cyclone Forecasts

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1. Introduction

High-density observation (HDOB) data are assimilated in the operational Hurricane Weather Research and Forecast (HWRF) model. HDOBs include flight-level wind, temperature, and moisture measurements, and SFMR-derived surface wind speeds from the NOAA P-3, NOAA G-IV and Air Force Reserve Command C-130 aircraft. The assimilation of HDOB data in HWRF showed a considerable benefit (Tong *et al*. 2018) for tropical cyclone forecasts. HWRF has also implemented many enhancements to the aircraft data assimilation, including utilization of inner core dropsondes and drift corrections for dropsondes. Changes to the NCEP Global Forecast System (GFS) have been driven by the successes in HWRF data assimilation. There is also a need for the improved use of aircraft reconnaissance data (such as HDOBs and dropsondes), with specific requests from the Air Force, Air Operations Center, and National Hurricane Center to add HDOB data into GFS.

2. Model and Experiments

In this study the NCEP pre-operational GFS version 16 (GFSv16) was used to examine the impact of HDOB data on the GFS forecast for hurricanes. GFSv16 is based on GFS version 15 (GFSV15), which was developed with the finite volume cubed-sphere dynamical core and microphysics from GFDL. Changes in GFSv16 include increasing the vertical resolution from 64 to 127 levels and moving the model top to 80 km height, improved physics, using a Local Ensemble Kalman Filter with model space localization and linearized observation operator, and employing the 4-Dimensional Incremental Analysis Update technique (4D-IAU) for data assimilation (DA). The experiments to assimilate HDOB data were set up and run using the same GFSv16 pre-operational version for reforecast with a 6-hourly DA cycle, over the following selected periods with available HDOB data: (1) 20180902-20180919, (2) 20190822-20191002, (3) 20200601-20200612, and (4) 20200721-20200806.

3. Track and Intensity Analysis

Track and intensity are analyzed from the HDOB experiment (V16H), and compared to the GFSv16 reforecast (V16R) and GFSv15 operational forecast (GFSO) or reforecast (prior to GFSv15's implementation into operations). Figure 1 shows the model forecast track error and skill over the Atlantic for strong storms (with the maximum wind greater than 50 kts). Improvements are clearly observed in V16H, with less track error and an increase in track forecast skill (8-16% for day 1 to day 6). The improvements in the intensity forecast were also clear for forecast lead times greater than 48 hours (Figure 2). When all the hurricanes cases were considered, the improvements in track skill are 3-8% and the intensity forecast is neutral (not shown). For the West Pacific, similar improvements were also observed. However, for the Eastern Pacific basin, the impact is neutral on the track forecast and there is slight degradation in the intensity (not shown). Based on these positive impacts, the HDOB was added to GFSv16 for operations.

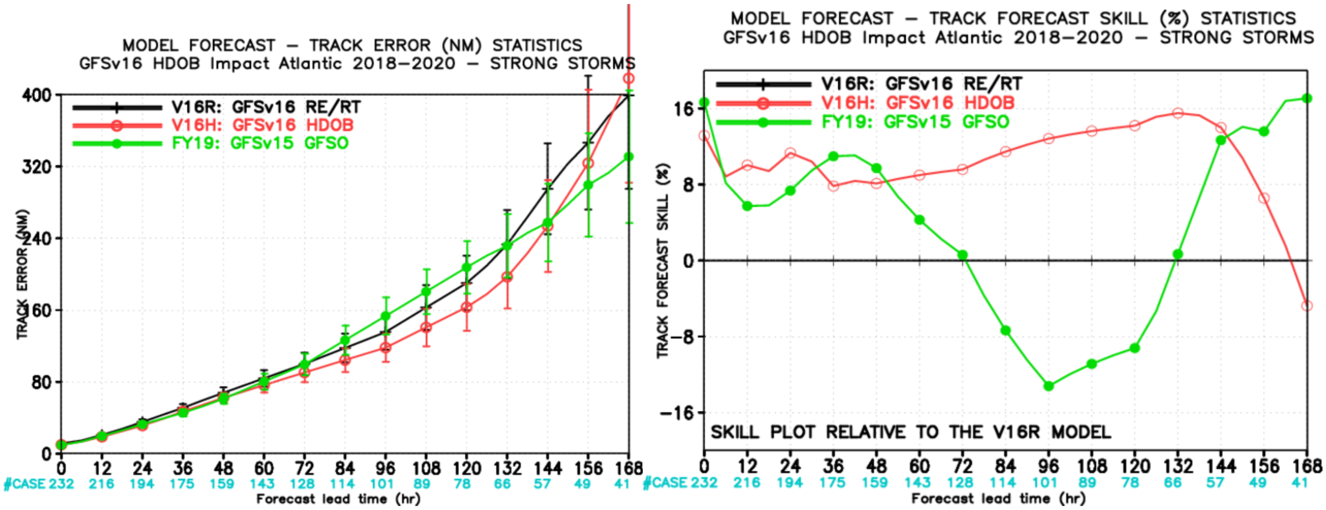

Figure 1. Model forecast track error (left) and skill (right) from GFSv16 reforecast (V16R, black), HDOB experiment (V16H, red) and GFSv15 (GFSO, green) from 2018-2020 for Atlantic strong storms (maximum wind greater than 50 kts).

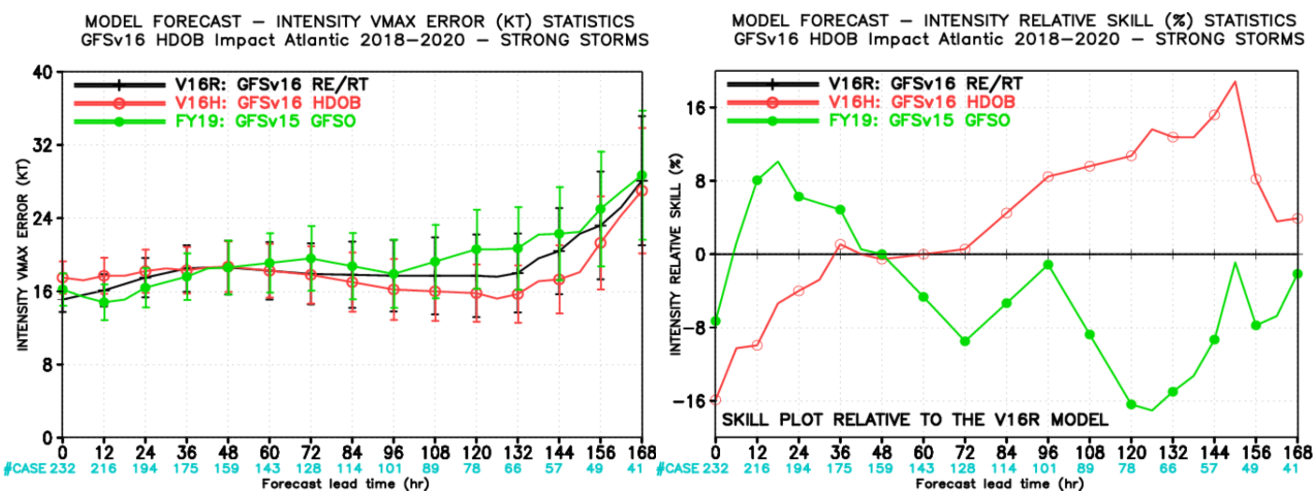

Figure 2. Model forecast intensity error (left) and relative skill (right) from GFSv16 reforecast (V16R, black), HDOB experiment (V16H, red) and GFSv15 (GFSO, green) from 2018-2020 for Atlantic strong storms (maximum wind greater than 50 kts).

References

Tong, M., and co-authors, 2018: Impact of Assimilating Aircraft Reconnaissance Observations on Tropical Cyclone Initialization and Prediction Using Operational HWRF and GSI Ensemble–Variational Hybrid Data Assimilation. *Mon. Wea. Rev., 146,* 4155-4177, https://doi.org/10.1175/MWR-D-17-0380.1.