Hurricane Analysis and Forecast System (HAFS) Stand-alone Regional (SAR) Model: Real-time Experiments for 2019 North Atlantic Hurricane Season

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1. Introduction

The next generation hurricane forecast system Hurricane Analysis and Forecast System (HAFS) has been developed to accelerate improvements in tropical cyclone (TC) intensity and track forecasts within a unified global and regional modelling framework. HAFS utilizes the Finite Volume Cubed Sphere (FV3) based global-regional modelling system for TC prediction. The system can be applied in either a high resolution regional stand-alone regional model (HAFS v0.A or HAFS-SAR) or a uniform global model with a high resolution nest mode (HAFS v0.B or HAFS-global-nest). HAFS-SAR has been developed to cover the North Atlantic basin for hurricane forecasting (Fig. 1) and includes improved planetary boundary layer (PBL) and surface flux parameterization schemes designed specifically for TC predictions. The workflow for HAFS v0.A has also been developed to include preprocessing, post-processing, and a vortex tracker.

Both the HAFS-global-nest and HAFS-SAR were successfully implemented in real-time HFIP experiments for the 2019 North Atlantic hurricane season. The results are analyzed and compared with other regional and global models for further evaluation.

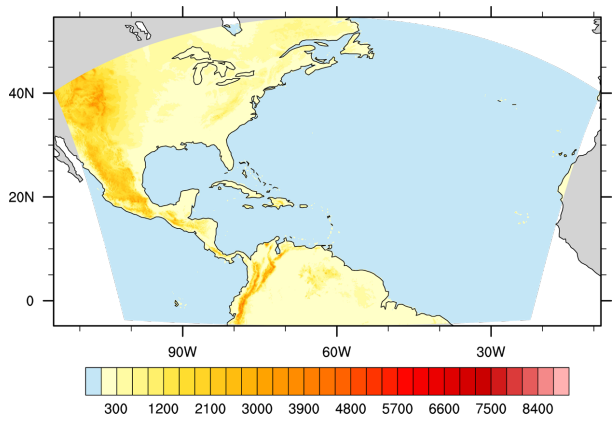
2. HAFS-SAR model

The FV3 based HAFS regional model has a single domain with the dimensions 2880 by 1920. The domain covers the North Atlantic basin with a horizontal resolution of 3 km. HAFS-SAR has 64 vertical levels on the sigma-pressure hybrid coordinate, with the lowest model level at about 25m above the surface and the top level at 0.2 hPa. Initial and boundary conditions are interpolated from the Global Forecast System (GFS) (~13 km) onto the HAFS SAR domain. Lateral boundary conditions (LBCs) are provided every 3 hours from the same GFS forecasts.

Physics parameterizations in HAFS SAR include the EDMF PBL scheme and GFS surface fluxes scheme, which are further modified with a formula from HWRF, and the GFDL microphysics scheme with 6 category hydrometeors. HAFS-SAR also uses the same GFS land surface scheme and RRTMG longwave and shortwave parameterizations. Cumulus convection is turned off at the convective scale resolution ~ 3 km. SST is from the GFS Near-Sea-Surface Temperature (NSST) scheme which predicts the vertical profile of ocean temperature between the surface and a reference level.

3. 2019 real-time experiments

2019 HAFS SAR real-time experiments for the North Atlantic hurricane season started on July 13, 2019 and ended on November 1, 2019. The experiments were performed on the NOAA RDHPCS Jet supercomputer and covered 18 storms with a total of 269 cycles. The track forecast error of HAFS-SAR is smaller than the GFS and the two regional hurricane models HWRF and HMON at almost all forecast lead times (Fig. 2a). Track forecast skill is improved about 20% by HAFS-SAR with respect to HWRF throughout the 5 days of forecasts (Fig. 2b). The cross-track component contributes more to the track forecast improvement than the along-track component. The initial intensity error of HAFS-SAR is comparable to that of GFS, due to the lack of inner core data assimilation. Intensity error is reduced within the first 6 hours of spin-up and then grows until 72 hours (Fig. 2c). The intensity error of HAFS-SAR at day 5 is lower than other models presented here.



The intensity bias is generally negative before day 5, suggesting an underprediction of TC intensity from HAFS-SAR, along with other models (Fig. 2d). The intensity forecasts of weak storms have better performance than strong storms when stratified with 50-kt thresholds.

Fig. 1: HAFS-SAR domain for 2019 north Atlantic hurricane season.

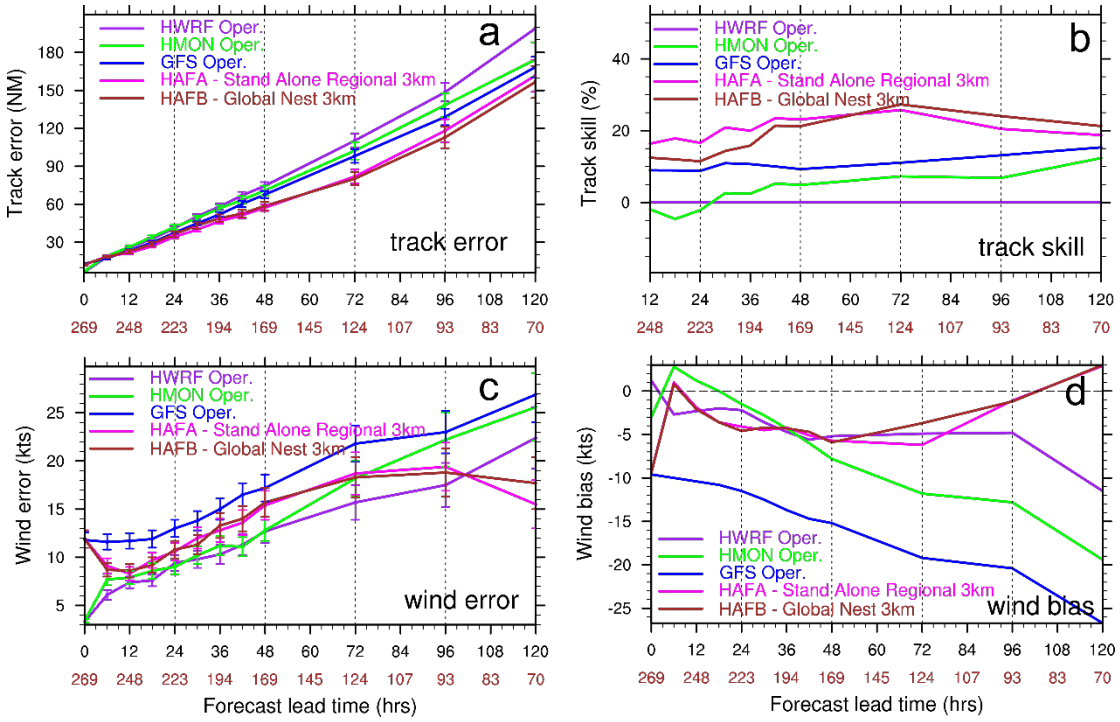


Fig. 2: (a) Track error statistics for HAFS-SAR, HAFS-global-nest, operational GFS, HWRF and HMON; (b) Track skill; (c) Intensity error statistics (wind); (d) Intensity bias statistics (wind).

4. Summary

For the 2019 North Atlantic hurricane season, the FV3-based HAFS-SAR showed great potential to improve TC forecasts, particularly the track forecasts. The improvement for high-impact storms (e.g., Barry and Dorian) is also very encouraging. Inner core data assimilation being developed for HAFS is expected to further improve the intensity forecasts.