NCEP HMON-based hurricane ensemble forecast system

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1. Introduction

A non-hydrostatic hurricane model has been built at NCEP/EMC, known as the HMON (Hurricanes in a Multi-scale Ocean-coupled Non-hydrostatic) model. HMON replaced the GFDL hurricane model in operational forecasts in July 2017. Meanwhile, a HMON-based ensemble system (HMON-ENS) was also built and real-time experimental runs were made during the hurricane season for two years. The ensemble method is a useful approach for representing model errors and to potentially improve model performance, given that uncertainties in the forecasts and simulations of tropical cyclone track, intensity, and structure are still significant. In addition to improving HMON performance, HMON-ENS experiments can help quantify the uncertainties and sensitivities of the relatively new HMON model when investing resources for further improvement. HMON-ENS provides products for the multi-model ensemble exercise. Next, we will briefly describe the HMON-ENS system and its performance.

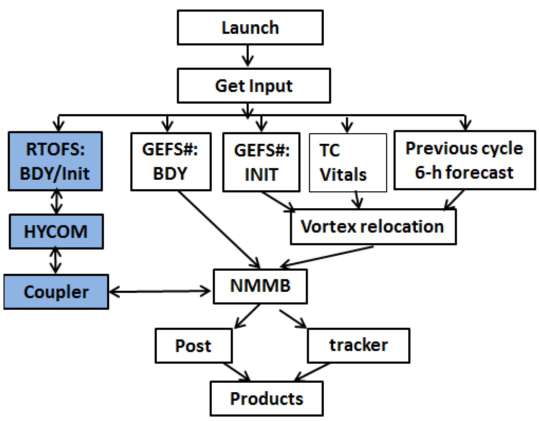

FIG. 1 Flow chart of NCEP HMON-ENS

Table1 Physics options in members of HMON-ENS

member	Domains	CU	PBL	Land	Cd,Ch	MP
Control (00)	D1: 451x451 D2: 231x201 D3: 381x345 NZ=51 18 Km 6 Km 2 Km	Scale_SAS	EDMF	NOAH	ICOEF=10	Fer_hires
01		SAS	EDMF	NOAH	ICOEF=10	Fer_hires
02		BMJ	EDMF	NOAH	ICOEF=10	Fer_hires
03		Scale_SAS	GFSPBL	NOAH	ICOEF=10	Fer_hires
04		Scale_SAS	EDMF	SLAB	ICOEF=10	Fer_hires
05		Scale_SAS	EDMF	NOAH	ICOEF=10	WSM6
06		Scale_SAS	EDMF	NOAH	ICOEF=6	Fer_hires
07		Scale_SASumix	EDMF-A	NOAH	ICOEF=10	Fer_hires
08		Scale_SASumix	EDMF-A	NOAH	ICOEF=6	Fer_hires
09		SAS	EDMF	NOAH	ICOEF=10	WSM6
10#	# uses FV3GFS data for IC/BC	Scale_SAS	EDMF	NOAH	ICOEF=10	Fer_hires

2. HMON-based ensemble system

The operational deterministic HMON system (Mehra et al., 2018) contains two major components (Fig 1). The atmospheric component uses the Non-hydrostatic Multi-scale model on a B grid (NMMB) as its dynamic core. It is configured as triple-nested regional domains, with one parent domain and two movable nests. The model has 51 vertical levels, with horizontal resolution of the three domains being 18, 6, and 2 km, respectively (Table 1). The ocean is simulated by HYCOM, coupled to NMMB through a coupler developed at NCEP. Large scale data are provided by the operational Global Forecast System (GFS) and the Real-Time Ocean Forecast System (RTOFS). The HMON-ENS configuration is the same as the operational HMON except (1) the NCEP operational Global Ensemble Forecast System (GEFS) (a control plus 9 members) and FV3GFS analysis and forecast are used to provide initial and boundary conditions for each member, (2) random perturbations are added to the TC intensity and location, and (3) different PBL, convection, microphysics, and land (sea)-atmosphere interaction schemes are used in the members (Table 1).

3. Results and discussions

HMON-ENS was run in real-time during the 2018 hurricane season. Due to limited resources, not all cycles of all storms were simulated. We had 148 verifiable cycles in total for six storms (Debby, Florence, Gordon, Isaac, Kirk, and Michael) in the North Atlantic basin and 76 cycles for two storms (Hector and Lane) in the East Pacific basin. For the Northern Atlantic basin, the statistics of track and intensity errors from the control member are close to those from the operational HMON. The ensemble mean track and intensity from HMON-ENS are better than the operational HMON (Fig. 2). This was our expectation when HMON-ENS was designed.

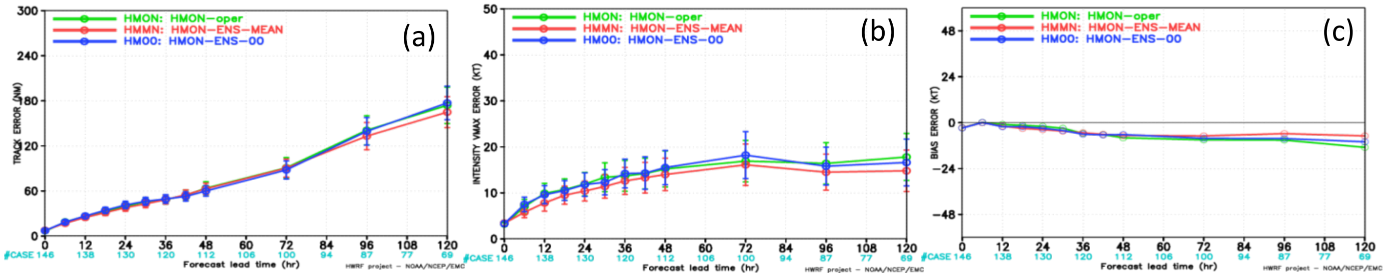

FIG. 2 Comparison of (a) track and (b) intensity errors and (c) bias from operational HMON (green), ensemble mean (red), and control member (blue).

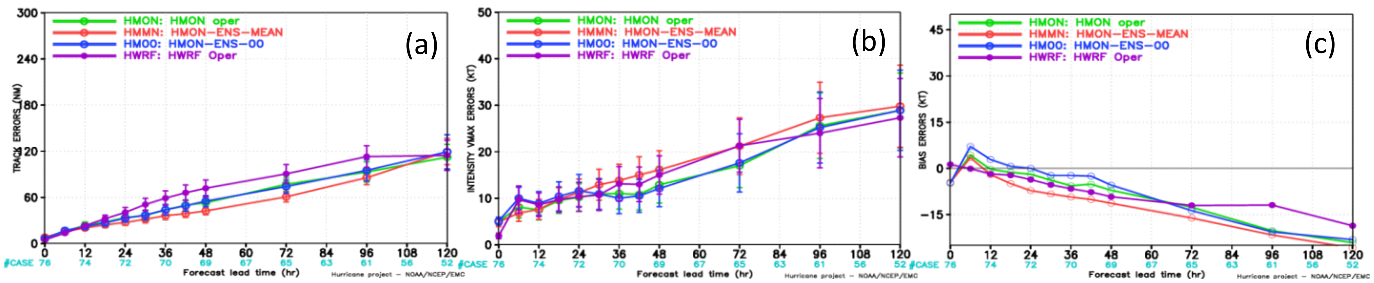

FIG. 3 As in Fig.2 except for East Pacific Basin.

For the Eastern Pacific basin, HMON-ENS generated the best track forecasts. It is even much better than those from the state-of-the-art HWRF. But for intensity forecasts, HMON-ENS did not yield better results than the operational HMON and control member (Fig. 3). This might suggest that we need to take a closer look at the performance of members and make further adjustments.

Compared with the deterministic HMON, HMON-ENS has an advantage in forecasting rapid intensification (RI) of TCs. Analyses suggested that HMON-ENS can capture RI better than the operational HMON (Fig. 4). In Fig 4, HMON-ENS forecast RI for a given cycle is very likely (or likely) when more than 50% (or 30%) of members exhibit RI.

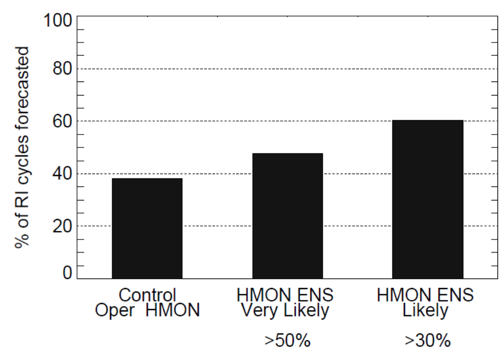

FIG. 4 Percentage of observed RI cycles captured by operational HMON and HMON-ENS.

4. Conclusions

In general, as expected, the performance of HMON-ENS is better than the operational HMON. Analyses of individual members suggest that most members performed worse than the well-tuned operational HMON, but results from the averages of all members are the best. The results give us confidence that HMON-ENS improves the multi-model ENS for probabilistic guidance. Further work will focus on adjustments of members to improve intensity forecast.

References:

Mehra, A., V. Tallapragada, Z Zhang, B Liu, L Zhu, W Wang and H Kim, 2018, Advancing the State of the Art in Operational Tropical Cyclone Forecasting at NCEP, ***Tropical Cyclone Research and Review*** , Vol 7(1), 51-56