Two Configurations for HAFS IOC

Impacts of different physics suites on Hurricane Analysis and Forecast System (HAFS) performances

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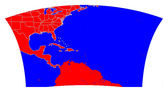
Motivation

To investigate the

- Impact of different physics suites on model performance
- Influences of changing the land surface model, planetary boundary layer (PBL) schemes, and microphysics on hurricane intensity and track

Methods

- The study is focused on the Hurricane Atlantic domain and uses the UFS Short-Range Weather (SRWeather) Application and Hurricane Analysis and Forecast (HAFS) system.
- The physics suites used in this study include GFS v15.2, GFS v16, GFS v17α, GFS_P8, RRFS v1α and RRFS v1β.
- The results are tested with different configurations.
- The model forecasts are verified against station observations and analysis data.



Physics schemes and model settings in the experiments

"sa" - scale-aware	Previously Operational	Operational	Experimental	Experimental	Experimental	Experimental
	GFSv15p2	**GFSv16**	**GFSv17α**	**GFSv17_p8**	**RRFSv1α**	**RRFSv1β**
Microphysics	GFDL(sa)	GFDL(sa)	GFDL(sa)	AA-Thompson	AA-Thompson	AA-Thompson
PBL	K-EDMF	Moist TKE-EDMF (sa)	Moist TKE-EDMF (sa)	Moist TKE-EDMF (sa)	MYNN-EDMF (sa)	MYNN-EDMF (sa)
Surface layer	GFS	GFS	GFS	GFS	GFS	MYNN
Deep Convection	SAS(sa)	SAS(sa)	SAS(sa)	SAS(sa, cas)		
Shallow Convection	SAS(sa)	SAS(sa)	SAS(sa)	SAS(sa)	MYNN-EDMF(sa)	MYNN-EDMF(sa)
Radiation	RRTMG	RRTMG	RRTMG	RRTMG	RRTMG	RRTMG
GWD	uGWP	uGWP	uGWPv1	uGWPv1	uGWP	uGWP
LSM	Noah	Noah	Noah MP	Noah MP	Noah MP	Noah MP
Ocean	NSST/SOS	NSST/SOS	NSST/SOS	NSST/SOS	NSST/SOS	NSST/SOS

HAFSv1.0	Domain*	Resolution*	DA/VI	Ocean/Wave Coupling	Physics	Basins
HFSA	Storm-centric with one moving nest, parent: ~75x75 degree, nest: ~12x12 degree	Regional (ESG)), ~6/2 km, ~L81, ~2 hPa model top	Vmax > 50 kt warm-cycling VI and 4DEnVar DA	Two-way HYCOM, one-way WW3 coupling for NHC AOR	Physics suite-1	All global Basins NHC/CPHC/JTWC Max 7 Storms Replace HWRF
HFSB	Storm-centric with one moving nest, parent: ~75x75 degree, nest: ~12x12 degree	Regional (ESG), ~6/2 km, ~L81, ~2 hPa model top	Vmax > 40 kt warm-cycling VI and 4DEnVar DA	Two-way HYCOM No Wave	Physics suite-2	NHC/CPHC Max 5 Storms Replace HMON

Case studies

- Hurricane Barry (2019), initialized at 00z, 20190712, 90h forecast. It has a right-of-track bias, GFSv17_p8 is slightly better(Fig. 1).
- Hurricane Lorenzo (2019), Initialized at 12z, 20190925, 90h forecast. It also has a right-of-track bias.
- Hurricane IAN (2022), initialized at 12z, 20220926, 120h forecast. It has a left-of-track bias.

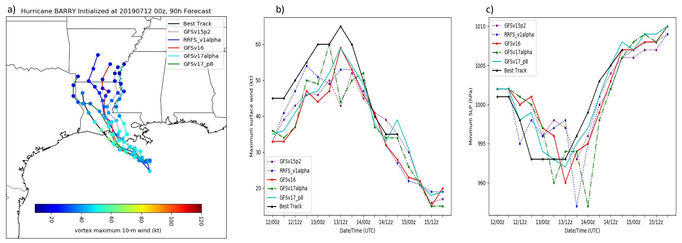


Fig. 1 Hurricane Barry initialized at 00z, July 12, 2019 for a) track, b) maximum surface wind, c) minimum sea level pressure (SLP).

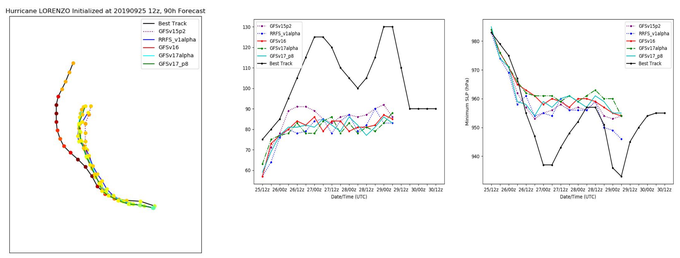


Fig. 2 Hurricane Lorenzo initialized at 12z, Sept. 25, 2019 for a) track, b) maximum surface wind, c) minimum sea level pressure (SLP).

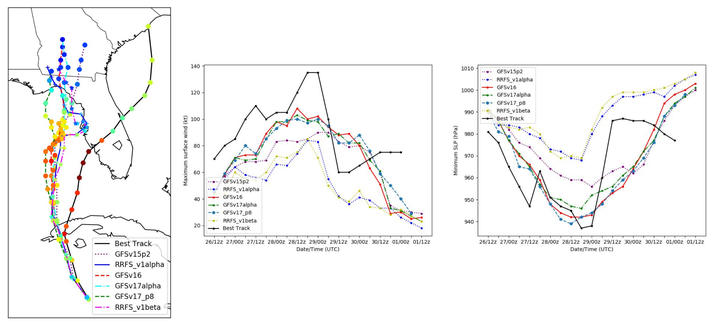


Fig. 3 Hurricane IAN (2022), initialized at 12z, Sept. 26, 2022 for a) track, b) maximum surface wind, c) minimum sea level pressure (SLP).

SRW vs HAFS

- Hurricane IAN (2022), Initialized at 12z, 20220926
- More layers make track shift to right
- HAFS has better results

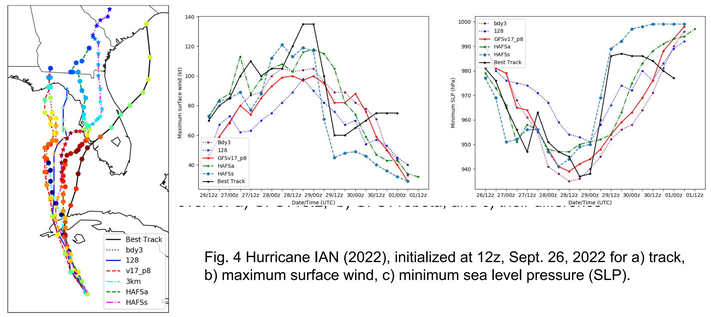


Fig. 4 Hurricane IAN (2022), initialized at 12z, Sept. 26, 2022 for a) track, b) maximum surface wind, c) minimum sea level pressure (SLP).

Verification

- ST4 slightly larger than MRMS at heavy precipitation
- CCPA slightly smaller than MRMS at heavy precipitation
- IMERG underestimate precipitation overland
- HAFSB seems have better pattern and intensity than HAFSA

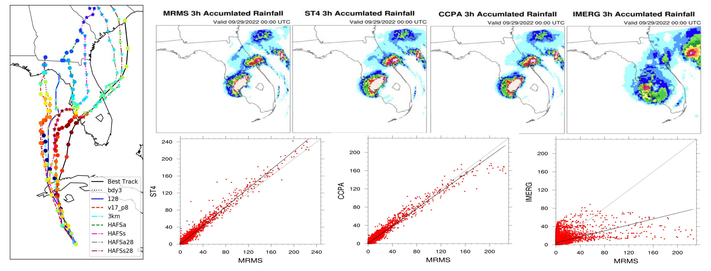


Fig. 5 Hurricane IAN track (a) and observed three hour accumulation of rainfall valid at 00z, Sept. 29, 2022 for b) MRMS, c) ST4, d) CCPA, e) IMERG, f) MRMS vs ST4, g) MRMS vs CCPA, and h) MRMS vs IMERG

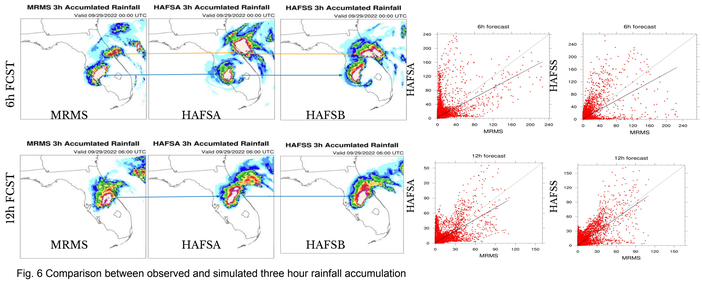


Fig. 6 Comparison between observed and simulated three hour rainfall accumulation

Summary

- Three hurricanes (Barry, Lorenzo, and IAN) are investigated. Different physics scheme can have impact on hurricane track and intensity.
- Sensitivity tests show that the boundary condition and model layer number can also influence the track.
- HFSB seems have better QPF than that for HFSA

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