The Hurricane Analysis and Forecast System (HAFS) – Limited Area Model (LAM) on the Extended Schmidt Gnomonic (ESG) grids real-time experiments for the 2020 tropical cyclone (TC) season

2020 HFIP annual meeting

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Outline

Pre-season experiments

- Dynamics and physics experiments
- Increase horizontal resolution to improve intensity forecast
- A more uniform grid for HAFS-LAM: Extended Schmidt Gnomonic (ESG) grids
- Vertical levels

2020 HAFS-J (HAFS-LAM on ESG) HFIP real-time demonstration

- Model configuration and real-time set up
- seasonal statistics for N. Atlantic, E. and W. Pacific

Summary

Pre-season tests: plan from last year

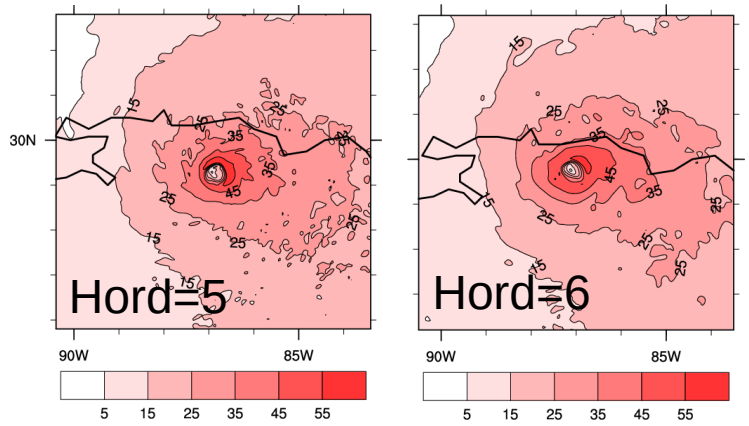
Dong, J.; Liu, B.; Zhang, Z.; Wang, W.; Mehra, A.; Hazelton, A.T.; Winterbottom, H.R.; Zhu, L.; Wu, K.; Zhang, C.; Tallapragada, V.; Zhang, X.; Gopalakrishnan, S.; Marks, F. The Evaluation of Real-Time Hurricane Analysis and Forecast System (HAFS) Stand-Alone Regional (SAR) Model Performance for the 2019 Atlantic Hurricane Season. Atmosphere 2020, 11, 617.

Future plan

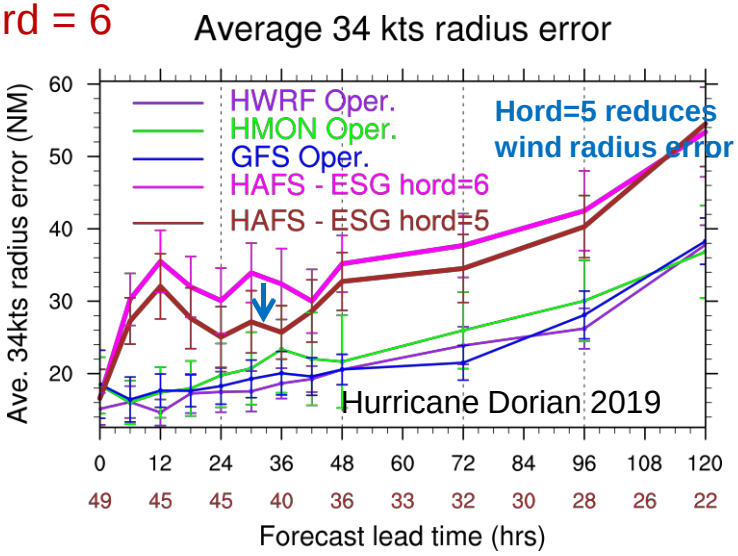
- Data assimilation with inner core/satellite observations to improve initialization
- Increase vertical levels to better resolve PBL dynamics and upper level outflow for TCs
- Physics and dynamics experiments to find optimized combination of physical parameterization and numerical schemes
- Improve lateral boundary condition processing (blending zones for relaxation to control numerical instability)
- Jim Purser grid for more uniform horizontal resolution
- Extend to 7 days forecasts for HAFS v0.A with FV3 restart capability

Pre-season tests: Dynamics and physics experiments

Horizontal advection schemes Hord = 5 vs. hord = 6

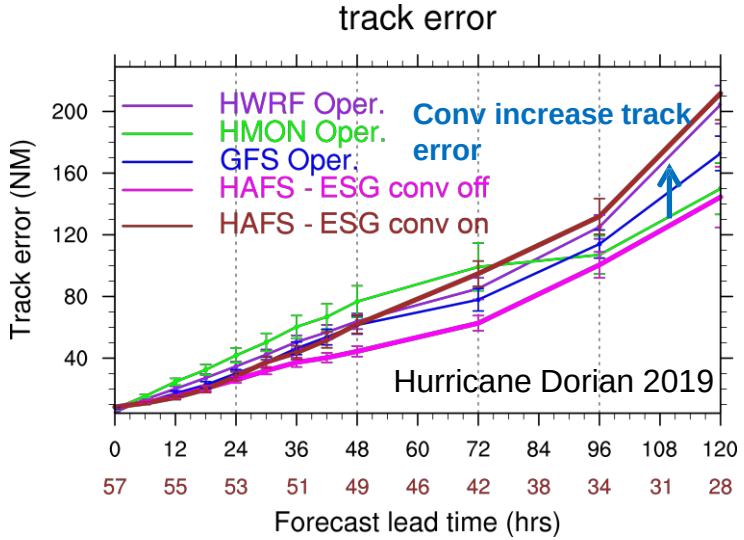


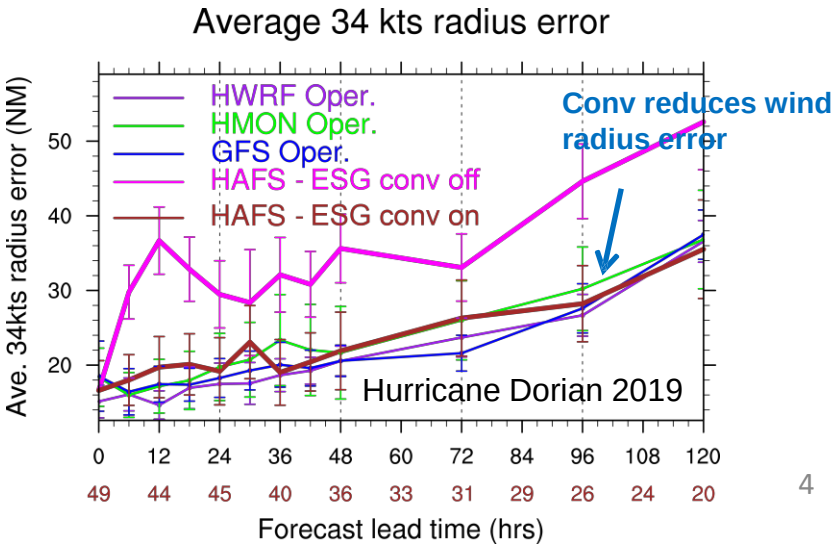
Hurricane Michael 2018: wind spd at 900 hPa (72 hrs fcst)



- Hord=5 degrades track forecast after D3
- Hord=5 improve intensity fcst between D1-D4

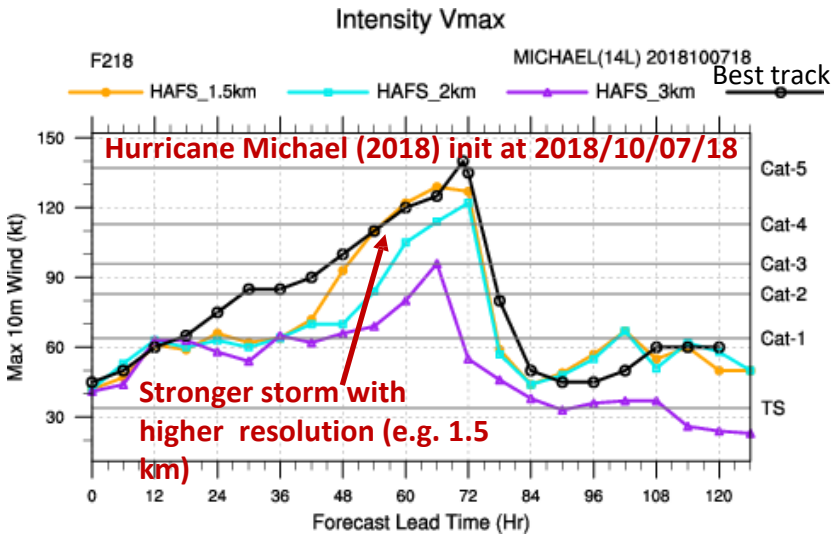
Scale-aware cumulus convection

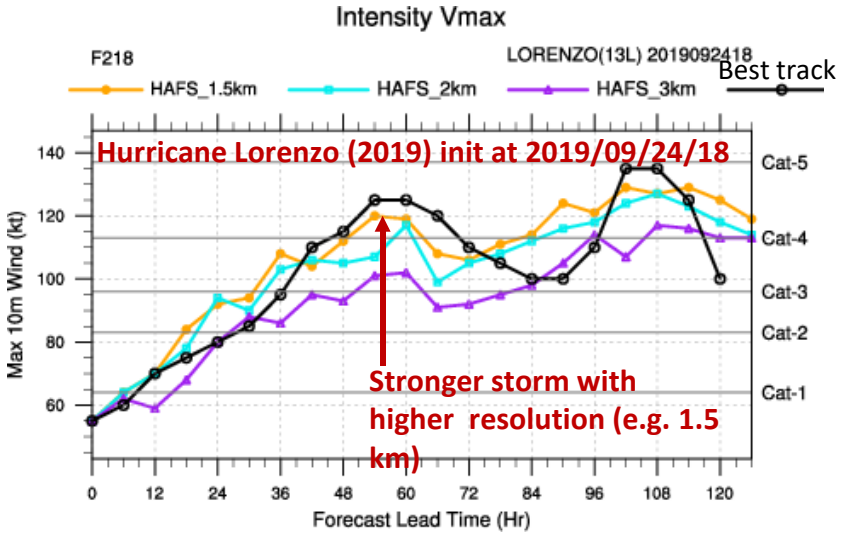




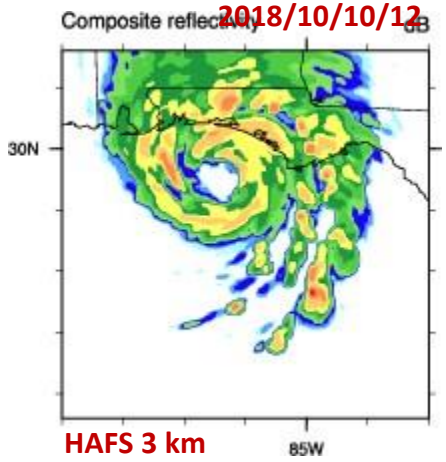
Pre-season tests: Increasing horizontal resolution for HAFS-LAM

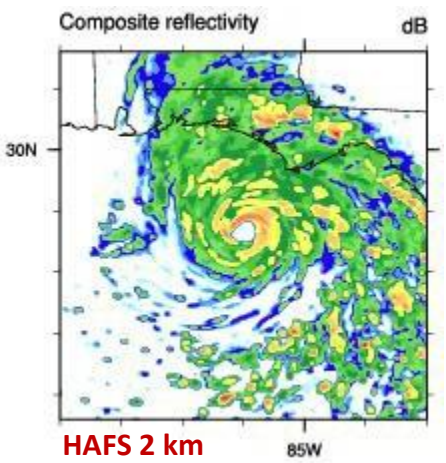
- Explore the sensitivity of HAFS intensity forecasts to horizontal resolution
- Increasing horizontal resolution from ~ 3km (2019 HAFS) to 2 km and 1.5 km with static HAFS-LAM domains: stronger storm predicted with higher resolution

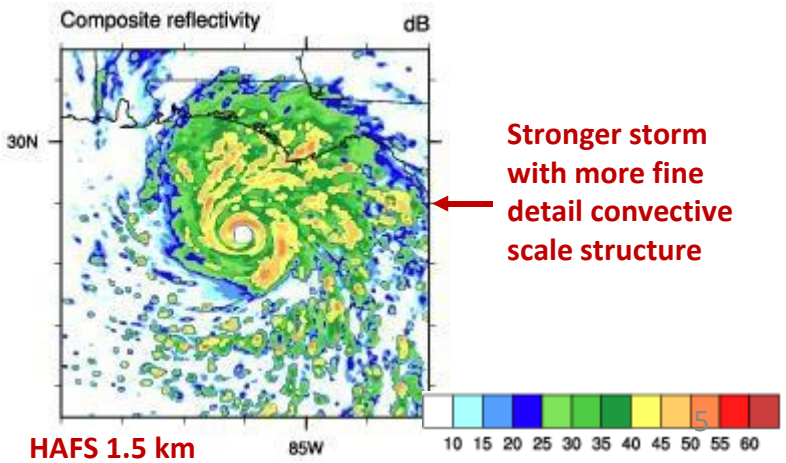




Composite reflectivity for Hurricane Michael valid at 2018/10/10/12

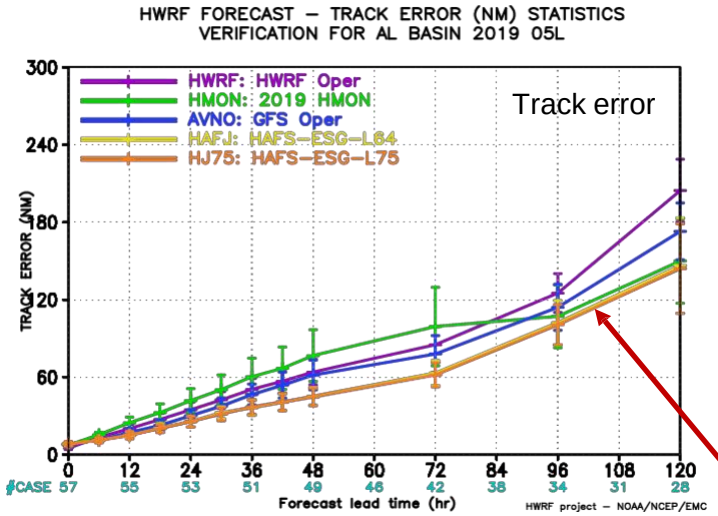


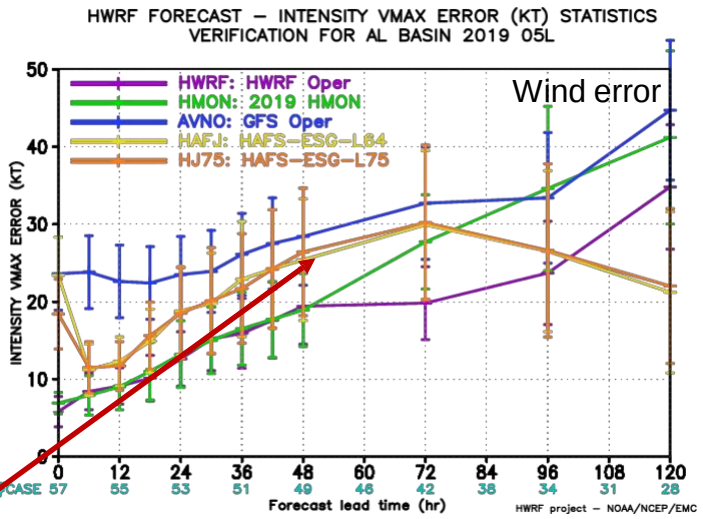


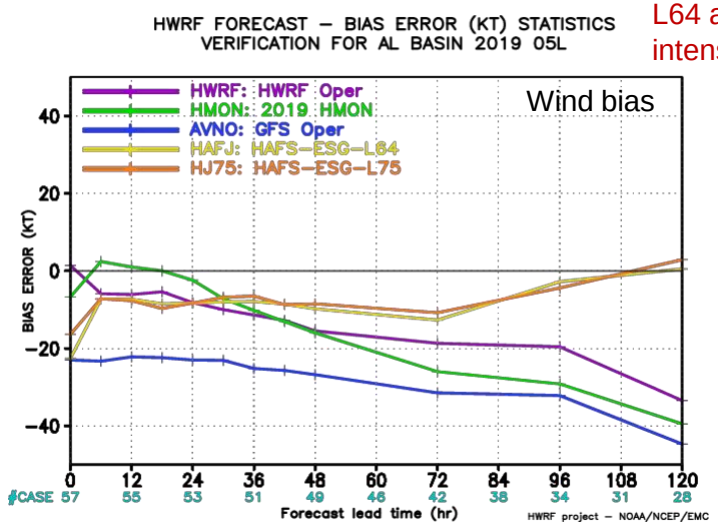


Stronger storm with more fine detail convective scale structure

Pre-season tests: vertical level test (L64 vs. L75)---Hurricane Dorian

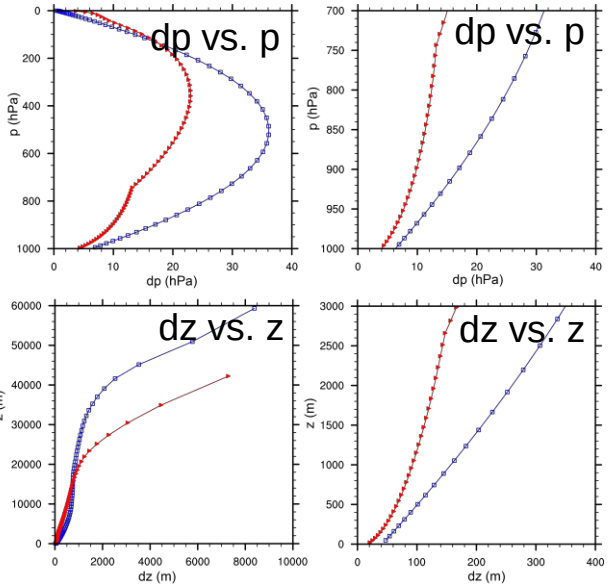






L64 and L75: close track and intensity forecasts

Low level zoom in



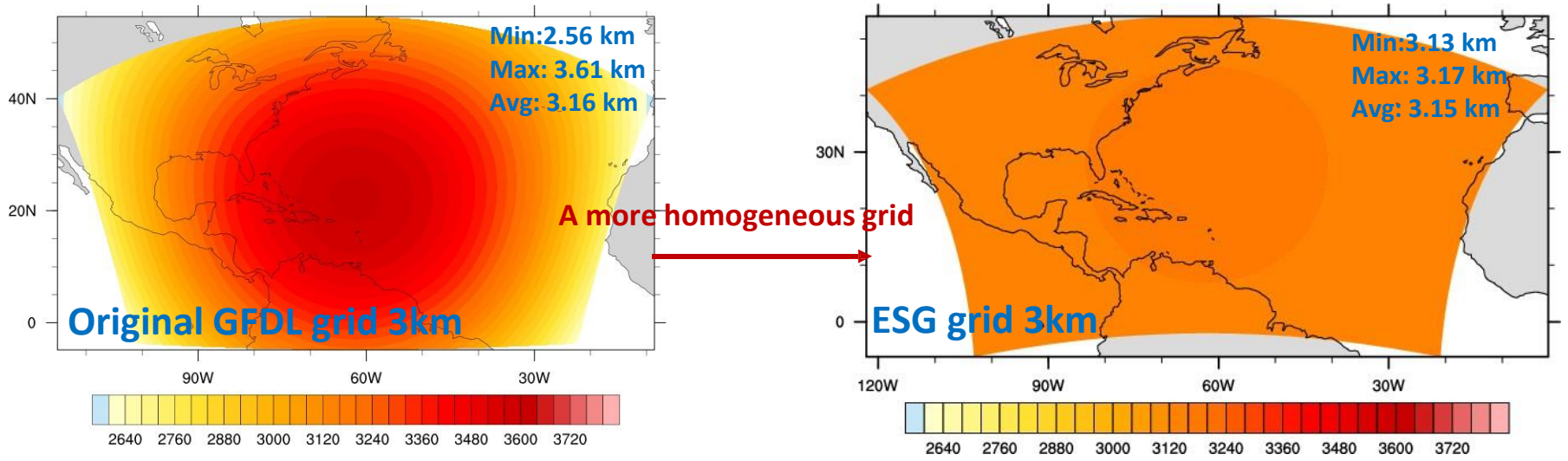
L75 vs. L64

Top: 2 vs. 0.2 hpa

Lowest: 10 vs. 23 m

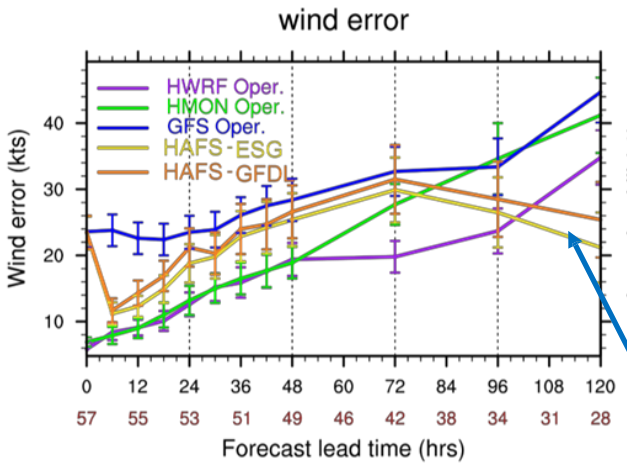
Pre-season tests: ESG (Extended Schmidt Gnomonic) grid for HAFS-LAM

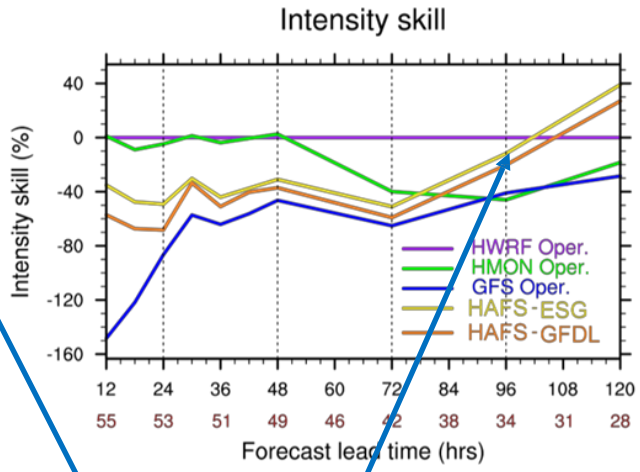
Horizontal resolution (m)

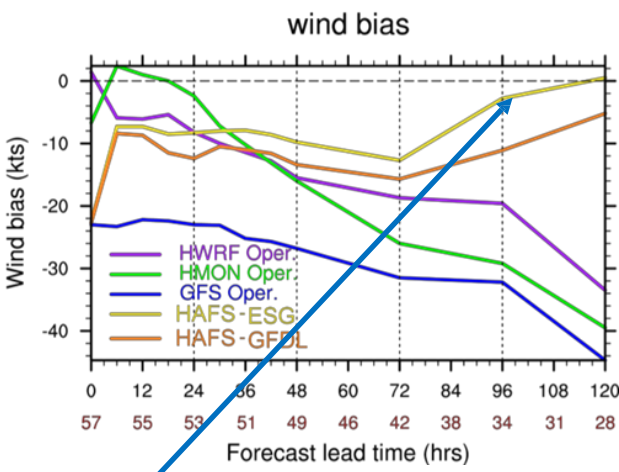


Also with the potential to reduce computing expenses and for the basin-scale HAFS

Pre-season tests : ESG (Extended Schmidt Gnomonic) grid for HAFS-LAM

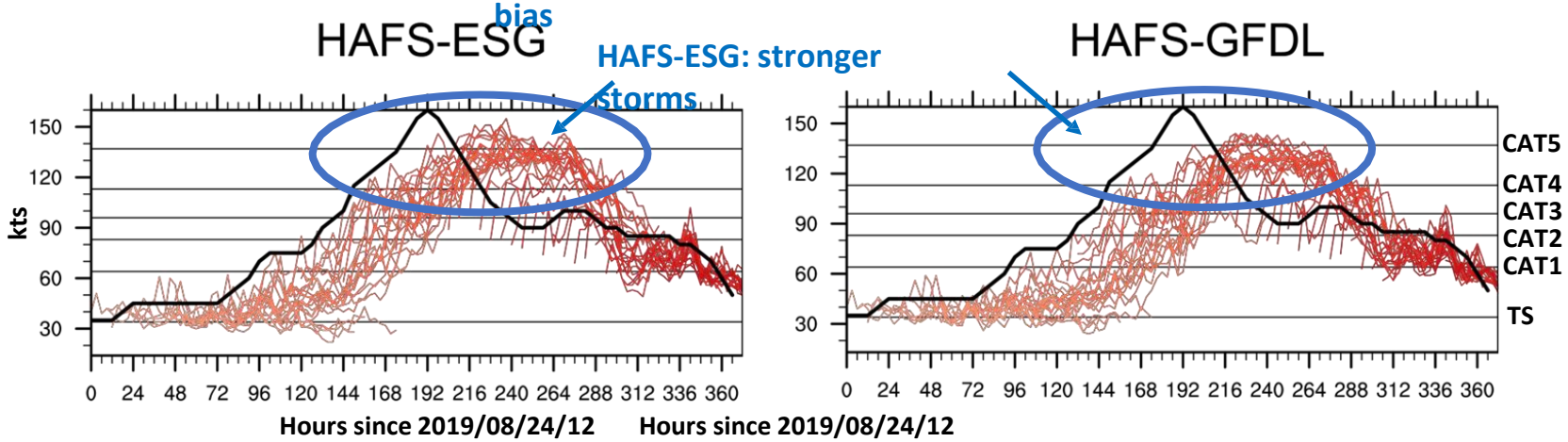






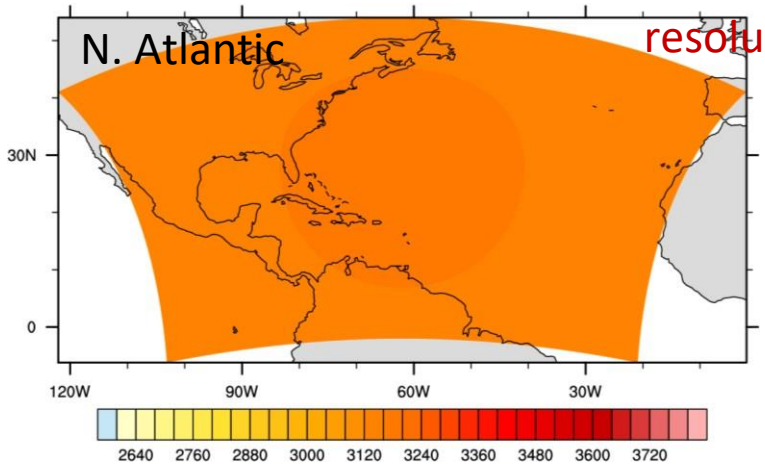
HAFS-ESG: smaller intensity error, better intensity skill and reduced negative wind bias

Hurricane Dorian 2019

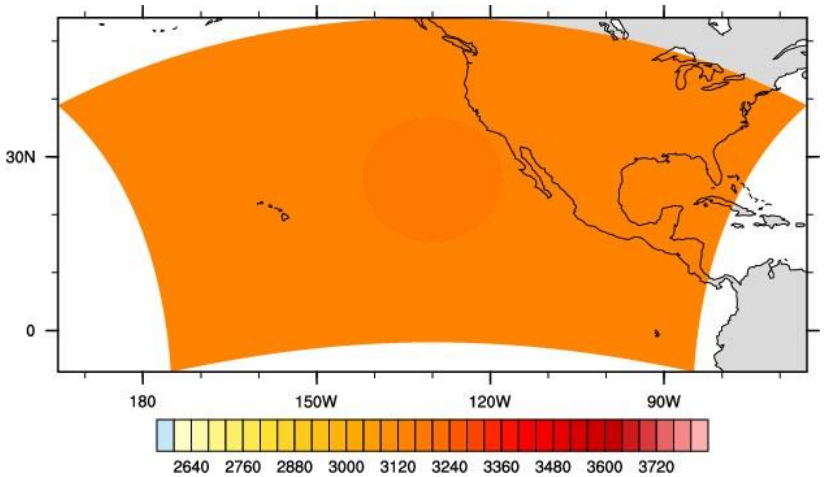


- Track forecasts close to each other
- ESG improve on intensity forecast and reduce negative wind bias
- Size similar; ESG tend to reduce size error in longer lead times

2020 real-time results: HAFS-LAM on Extended Schmidt Gnomonic (ESG) grids (v0.1J)



Horizontal resolution



- North Atlantic on Jet; eastern and western Pacific on Orion; real-time started on 07/22

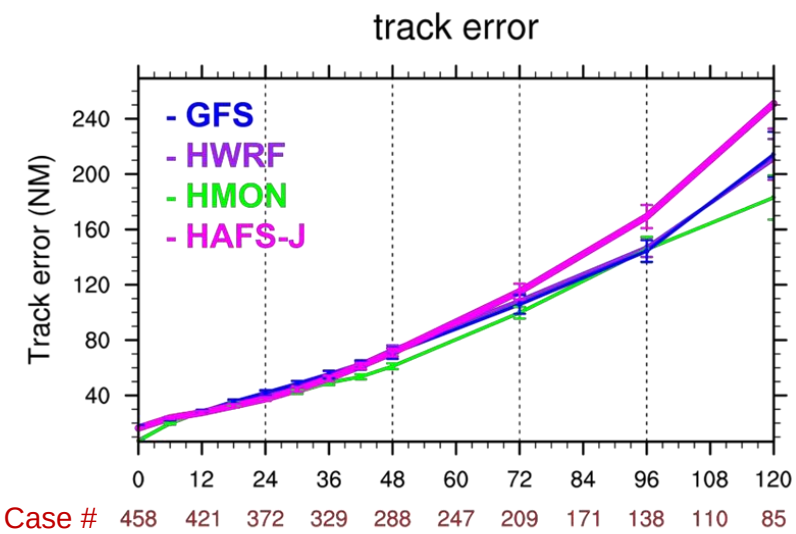
- GFDL microphysics
- Hybrid EDMF PBL
- GFS surface
- RRTMG radiation
- Hord=6
- Convection off
- GWD off

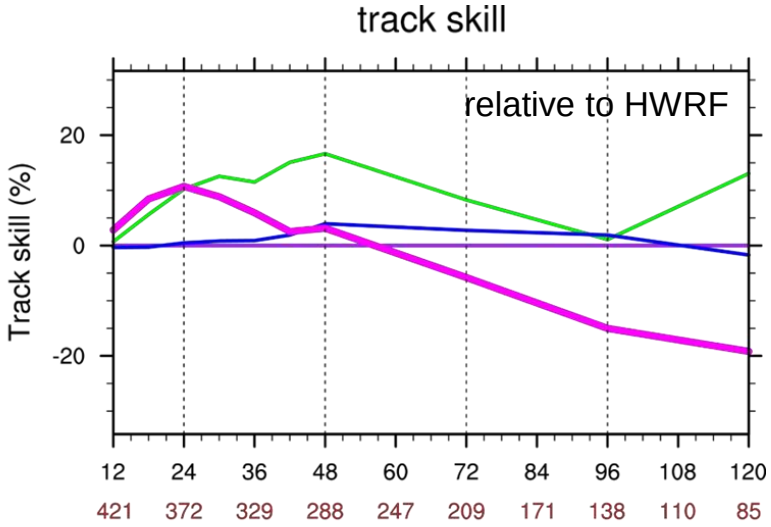
Thanks to Lin Zhu and Biju Thomas for data transfer; Keqin Wu for real-time plots and website; Chunxi Zhang and Weiguo Wang for physics; Vijay Tallapragada, Wei Yu and Shawn Needham for real-time reservations

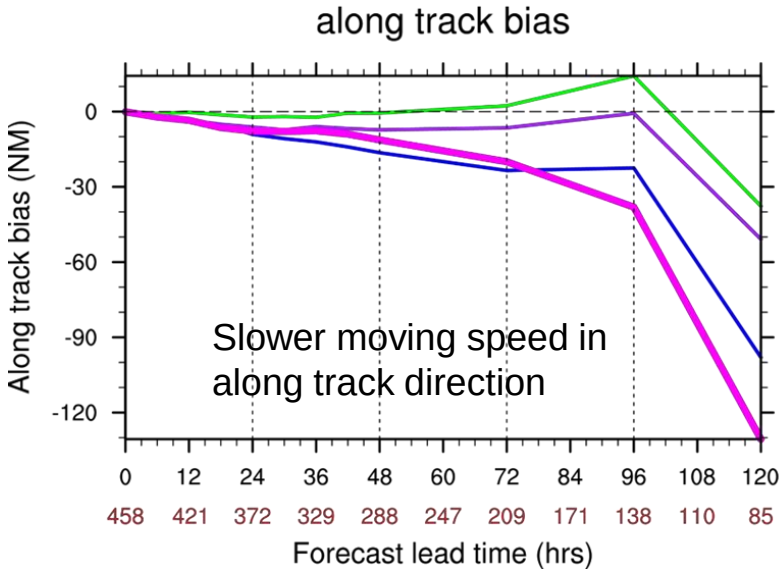
	HAFA	HAFB	HAFJ
Grid	GFDL (3km)	GFDL (3km)	ESG (3km)
LAM/global-nest	LAM	Global-nest	LAM
Vertical levels	L91	L75	L64
Ocean coupling	Yes	No	No
Physics (e.g. PBL)	H-EDMF	TKE-EDMF	H-EDMF
Fcst length	126 hrs	168 hrs	168 hrs
Computing resrc (wall time = ~ 5hrs)	169 nodes	174 nodes	88 nodes

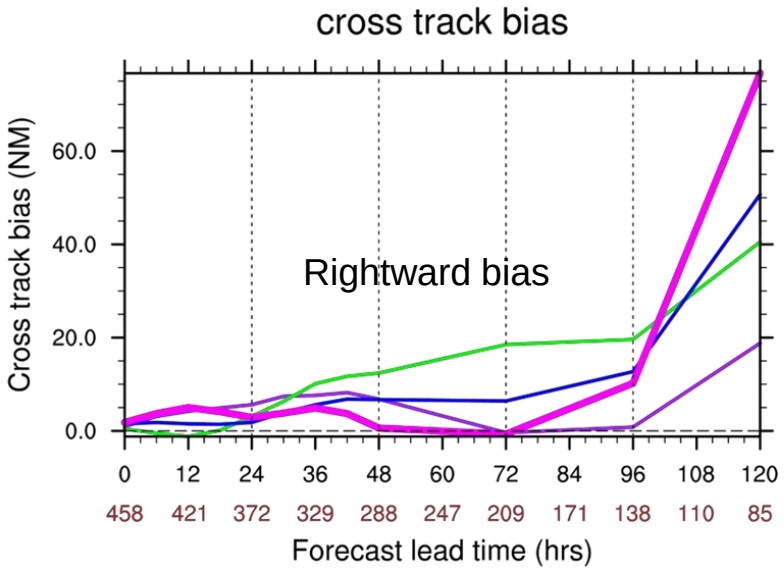
https://www.emc.ncep.noaa.gov/HAFS/HAFJ/

2020 real-time results: track forecasts of HAFS-J for north Atlantic



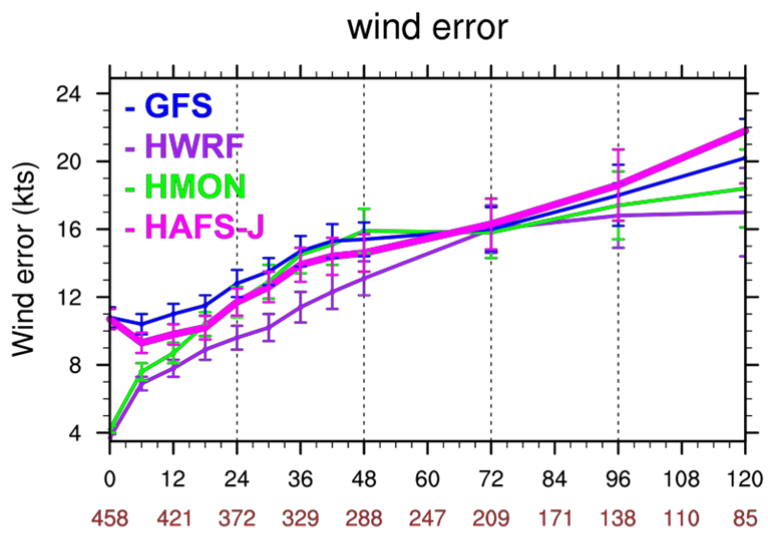


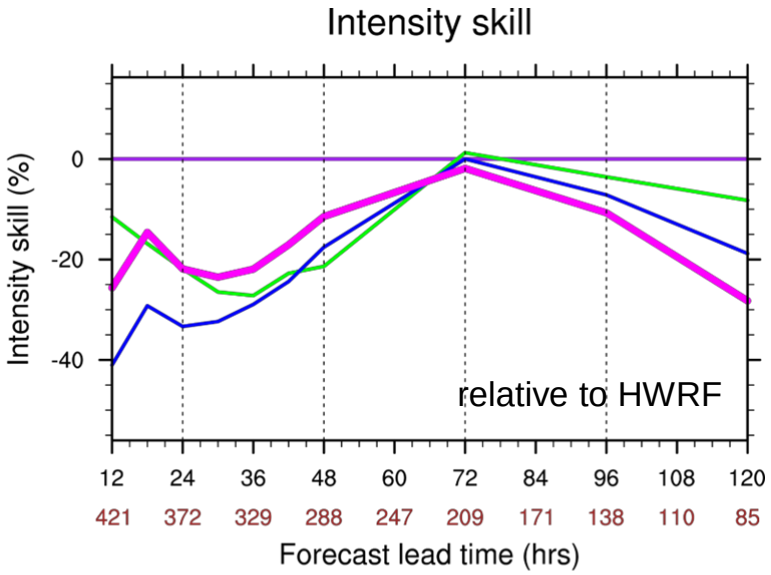


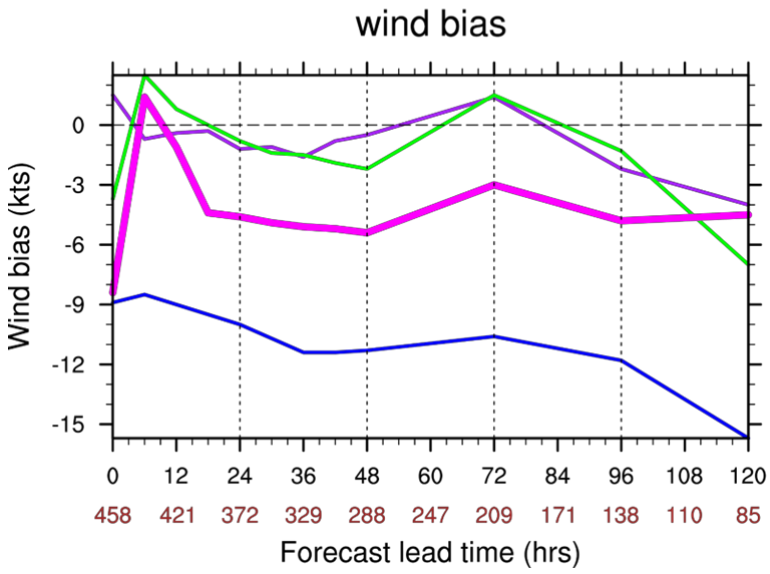


4 cycles daily with or without active storms; from 05L Edouard to 29L Eta (part I)

2020 real-time results: intensity forecasts of HAFS-J for north Atlantic



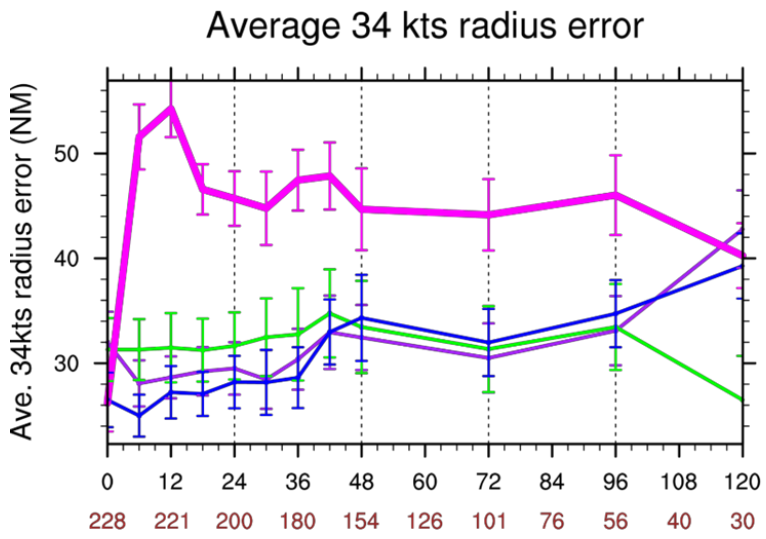


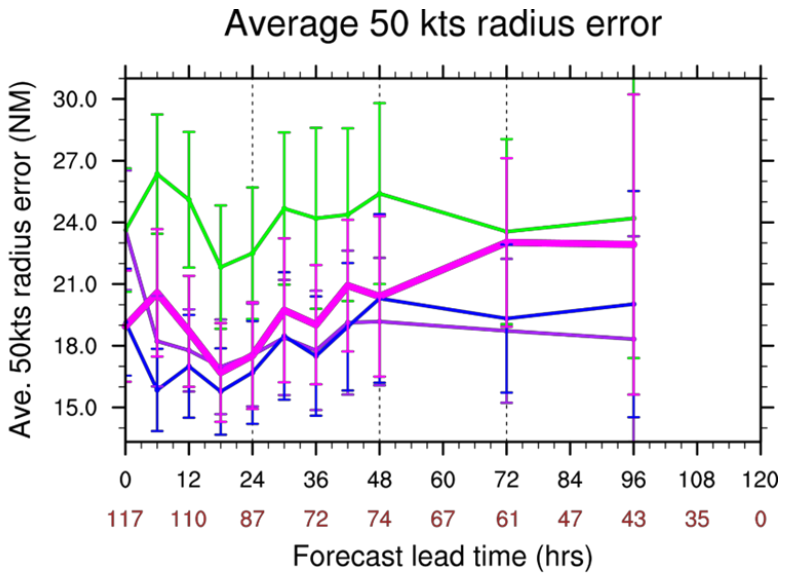


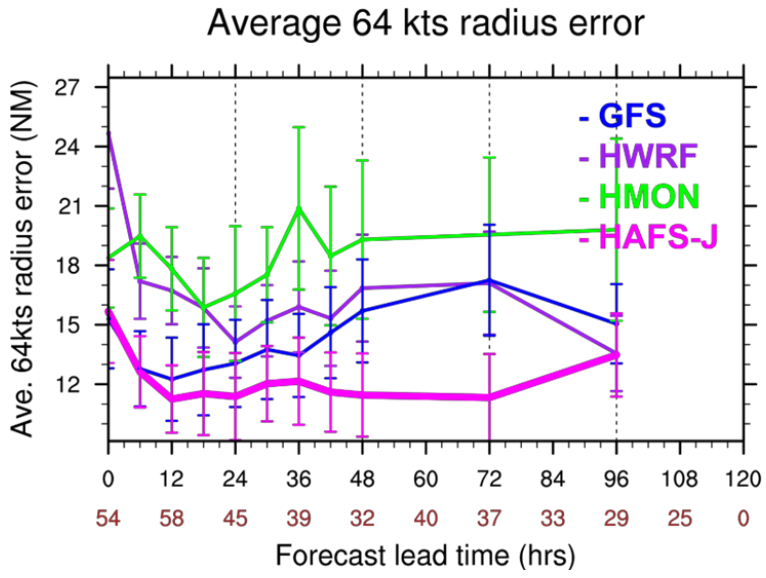
Underpredicted storm intensity

Larger wind error after D3

2020 real-time results: size forecasts of HAFS-J for north Atlantic



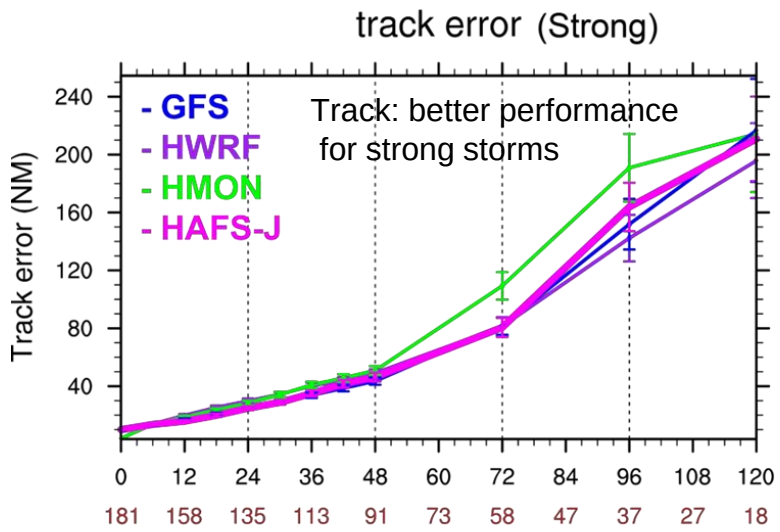


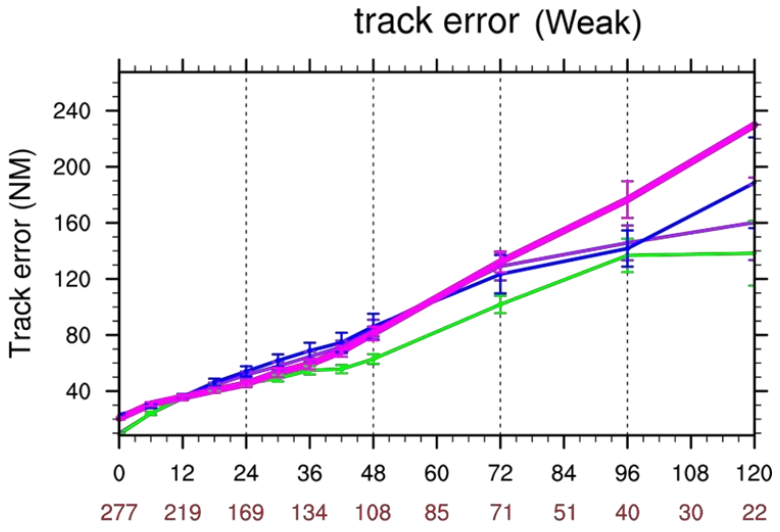


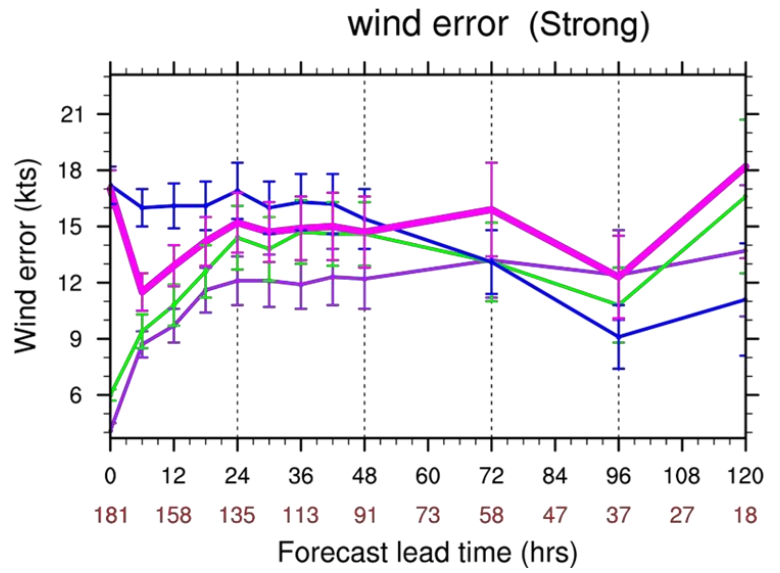
Overpredicted storm size at 34 kts wind radius

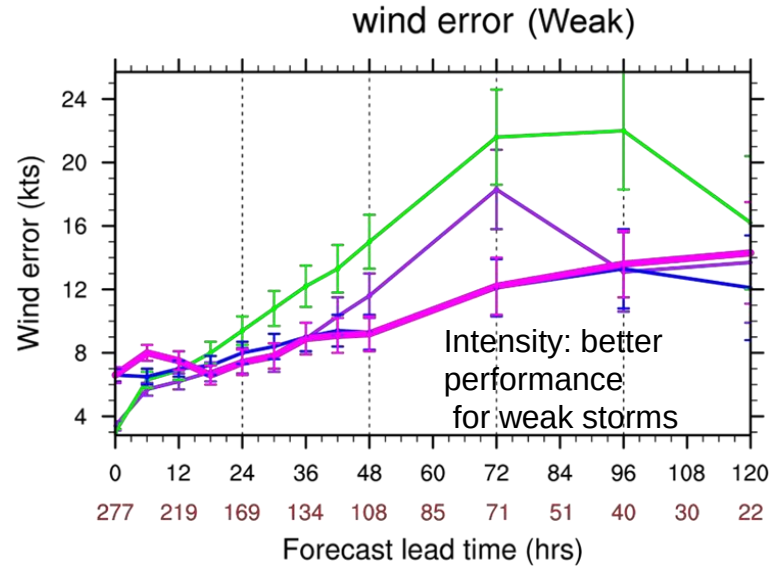
Cumulus convection can help to alleviate the size overprediction

2020 real-time results: strong vs. weak storms (50 kts threshold) for north Atlantic

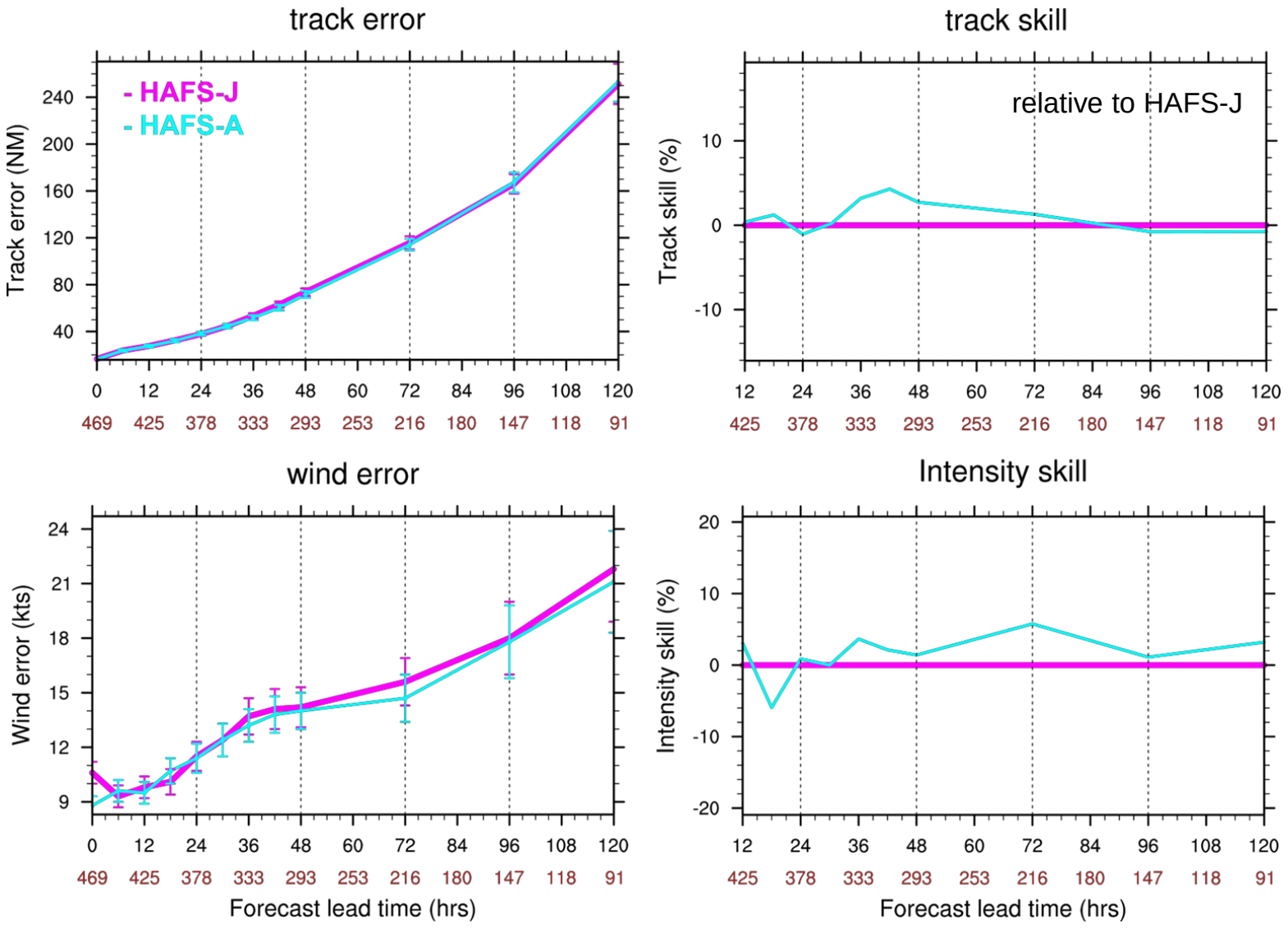






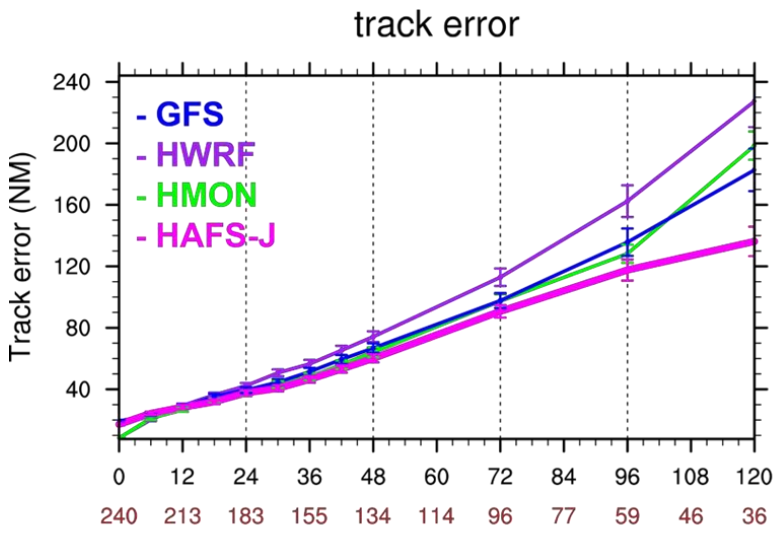


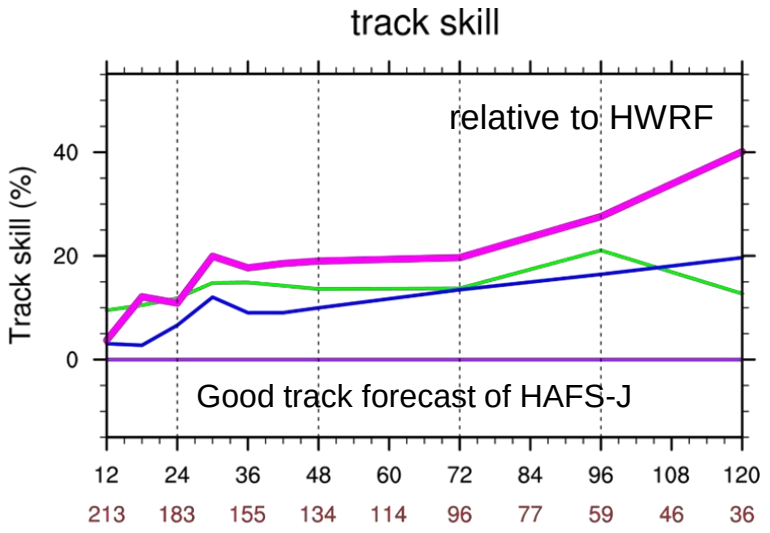
2020 real-time results: HAFS-J vs. HAFS-A for north Atlantic

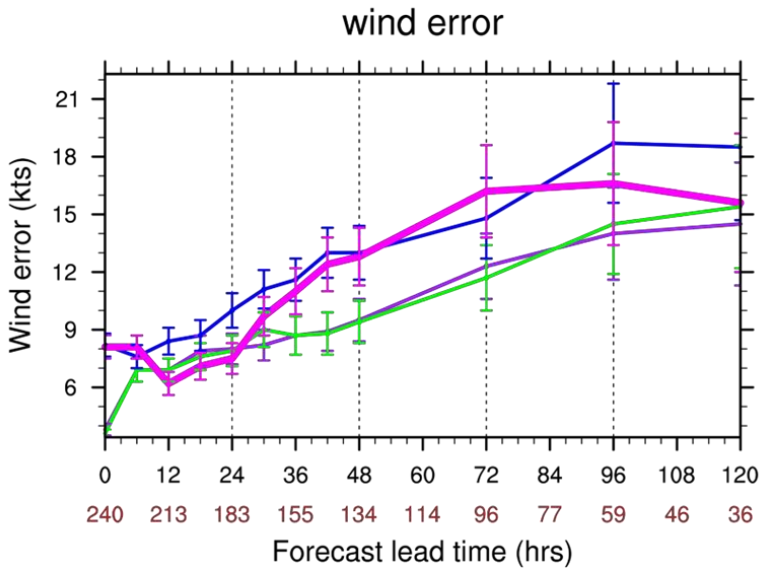


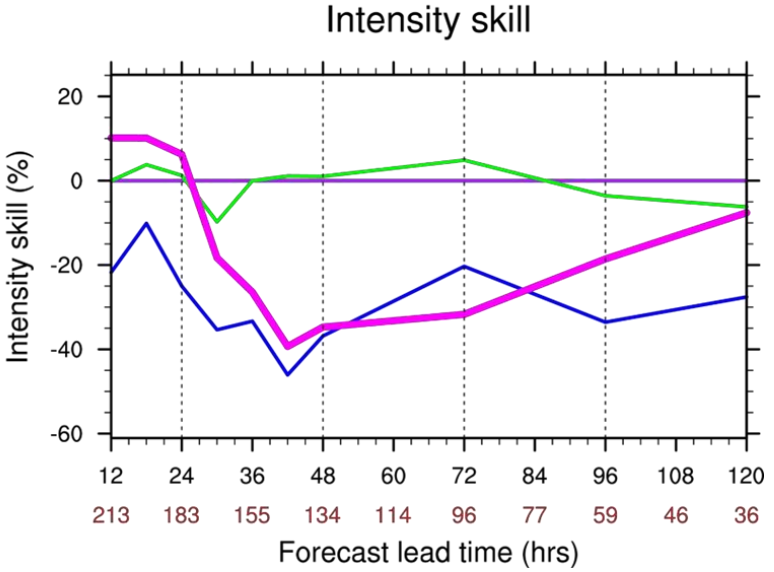
Similar stats in track/intensity forecasts

2020 real-time results: East Pacific

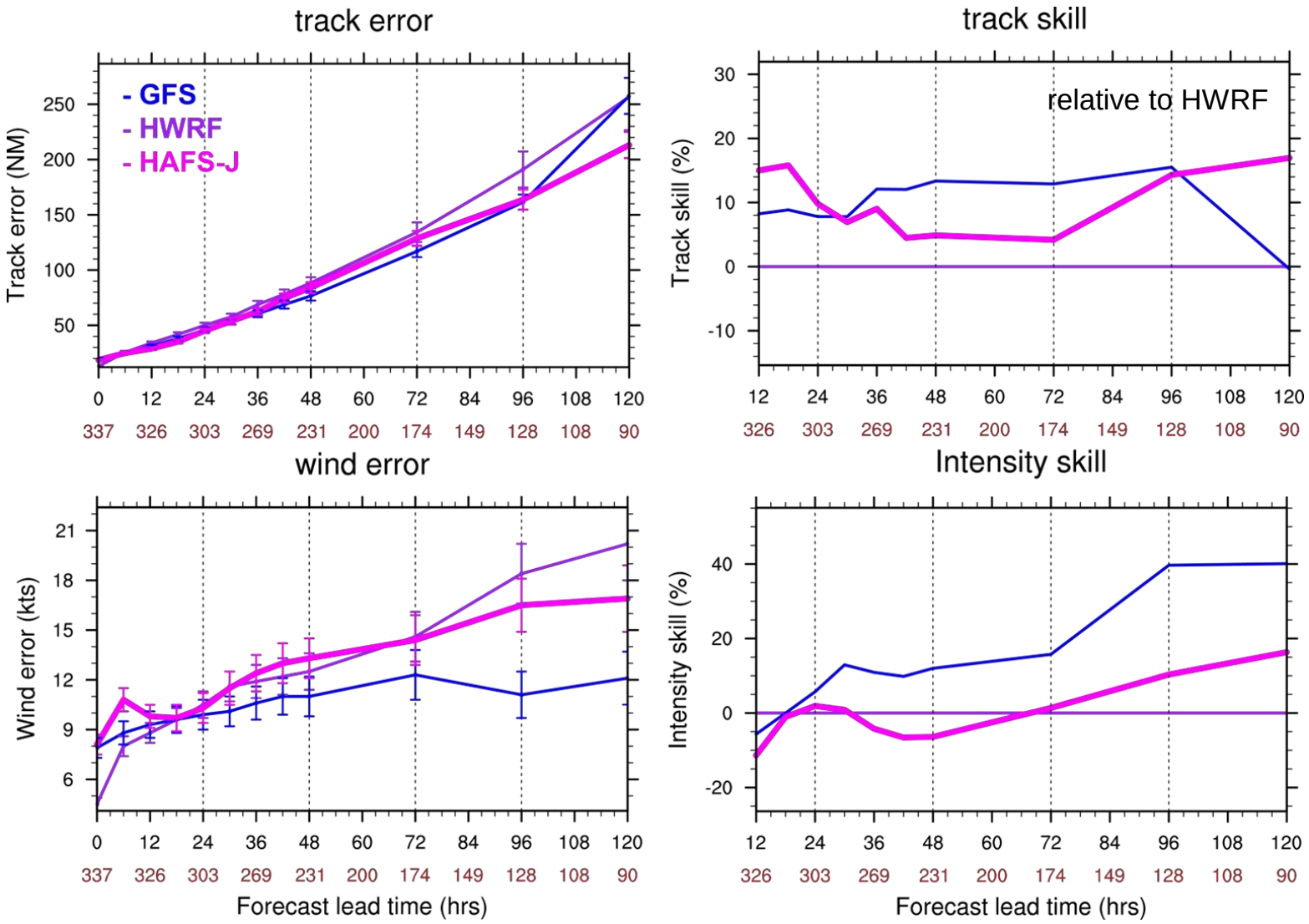






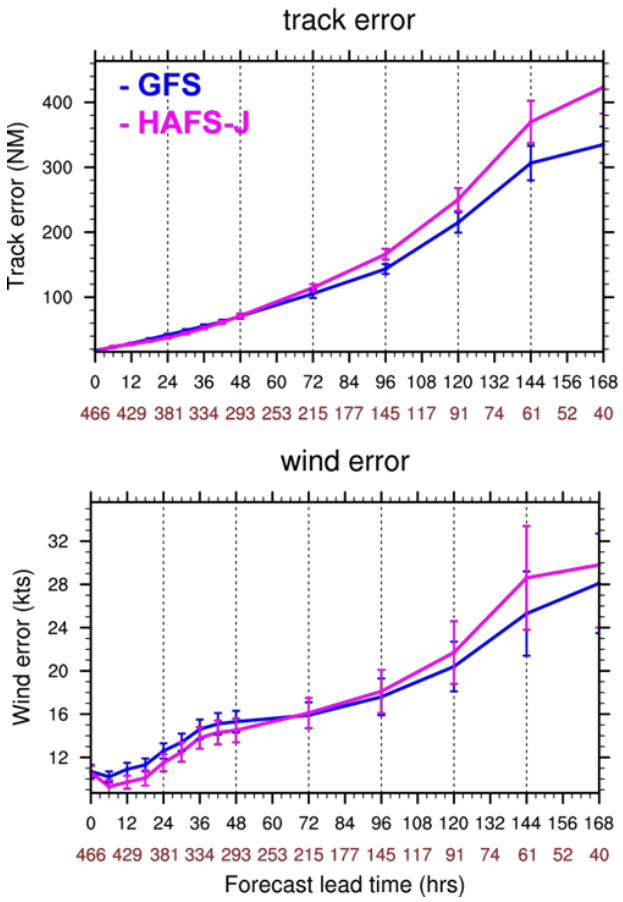


2020 real-time results: West Pacific

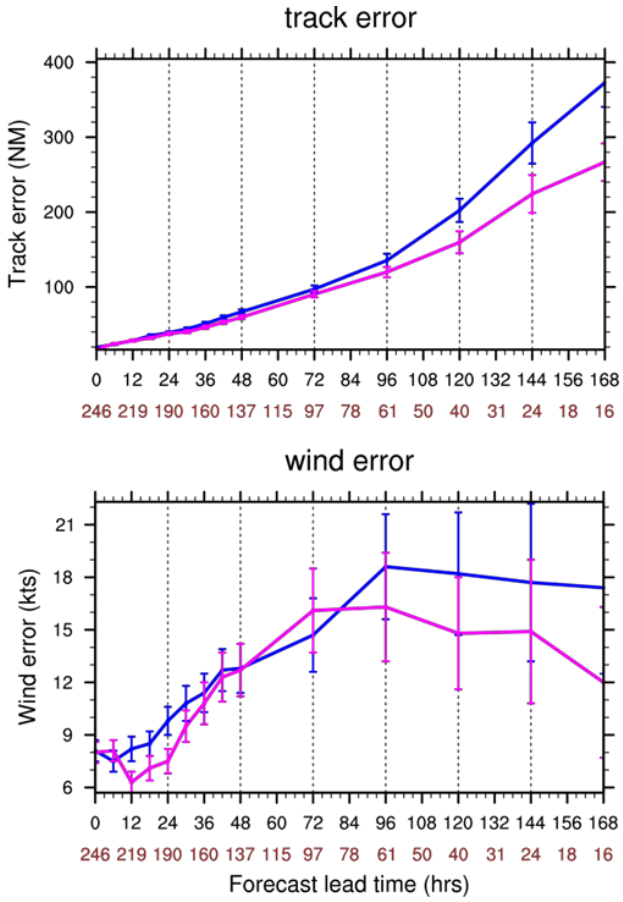


2020 real-time results: 7 days forecast

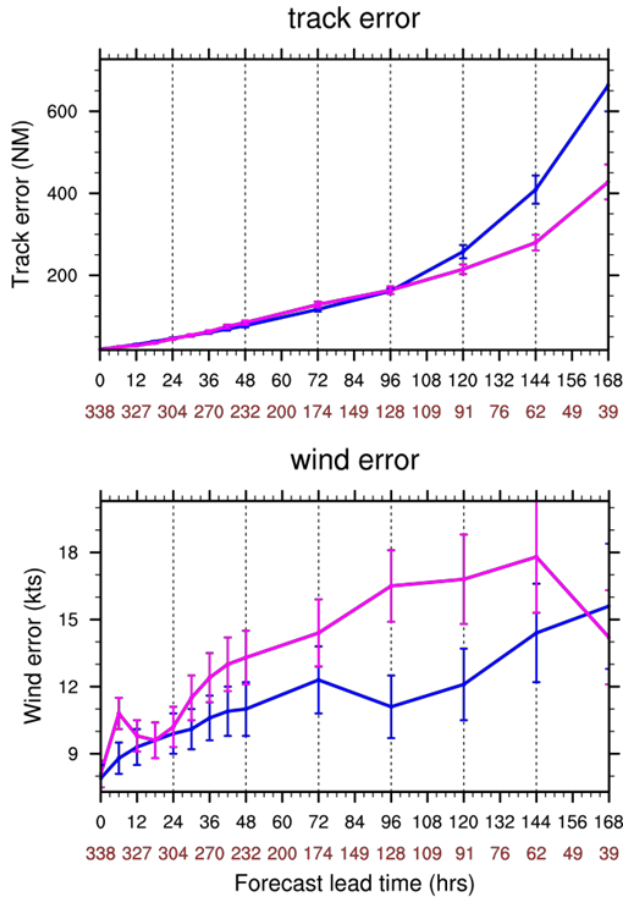
N. Atlantic



E. Pacific



W. Pacific



Summary

- HAFS-LAM is systematically tested and evaluated with ESG grids for the first time for N. Atlantic, E. and W. Pacific (HAFS v0.1J); the experiments generally run successfully without crashing in N. Atlantic and E. Pacific (only 4 cycles failed in W. Pacific among
~1000 cycles)

- For N. Atlantic: HAFS-J performs well in track forecast before D2 but degraded after D3; intensity skill is comparable to GFS and HMON before D3 but having larger error

- For E. Pacific: HAFS-J has better track forecast after D1 with 20-40 % improvement over HWRF; intensity comparable to GFS

- For W. Pacific: HAFS-J improves over HWRF on D4-5; intensity comparable to HWRF

- Overprediction of 34 kts wind radius

- HAFS-J and HAFS-A have similar performance in track, intensity and size forecast stats