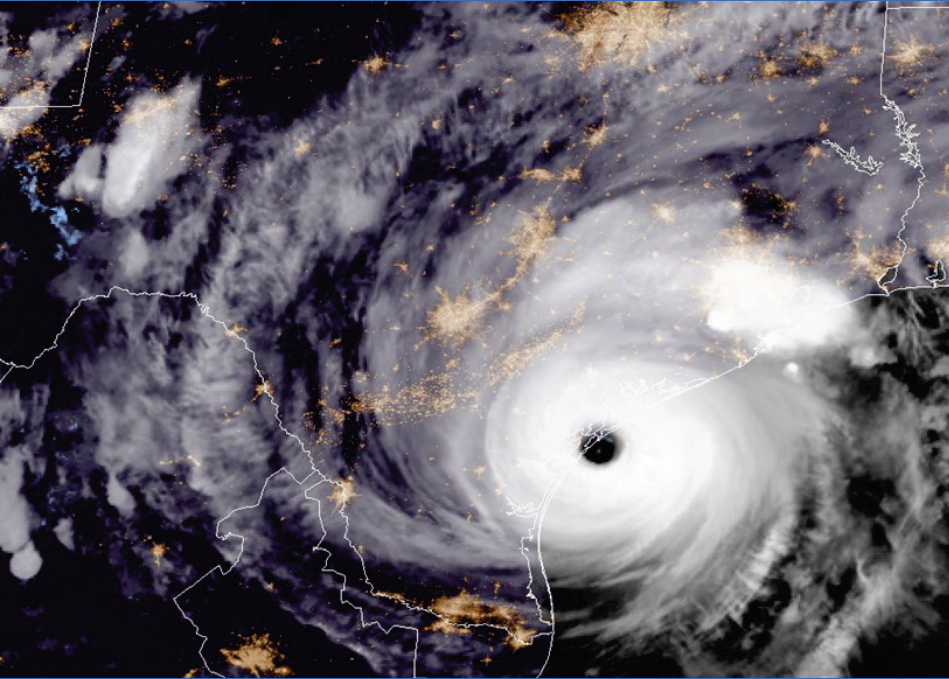
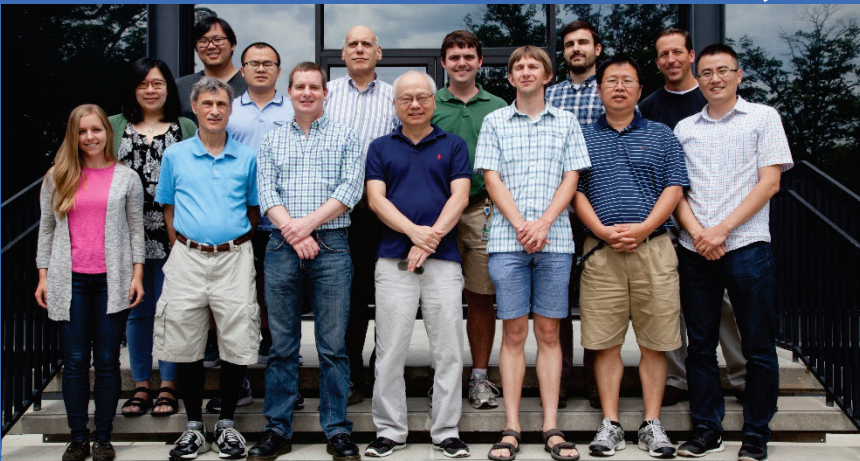


Evaluation of fvGFS on Hurricane Prediction



**Morris Bender, Andrew Hazelton, Matthew Morin,
Shian-Jiann Lin, and the GFDL FV³ Team**



*HFIP Annual Review
November 8th, 2017
Miami, Florida*

Focus of Talk

- Evaluation of 2 versions of fvGFS run on the Jet Computer facility by GFDL group
- Global version : 13 km Horizontal Resolution
- Second version: 3 km nest over Atlantic, two-way interaction with Global model
- 63 Vertical Levels
- *Global model*: Older version of SAS & PBL (*run 0 & 12z*)
- *Nested model* : Scale-Aware SAS (*run 4 times daily*)
- GFDL 6-class Micro-Physics replacing Zhao-Carr
- Both versions start from GFS initial fields (*cold start*)
- Evaluate Performance of Global version for 2015-2017 seasons for Atlantic, East and West Pacific Basins
- Evaluate Performance of Nested version for 2017 season for Atlantic (compare to HWRF, HMON, Basin-Scale HWRF)

Performance of fvGFS for 2015-2016 & 2017 hurricane seasons (Late Model Guidance)

Track Errors

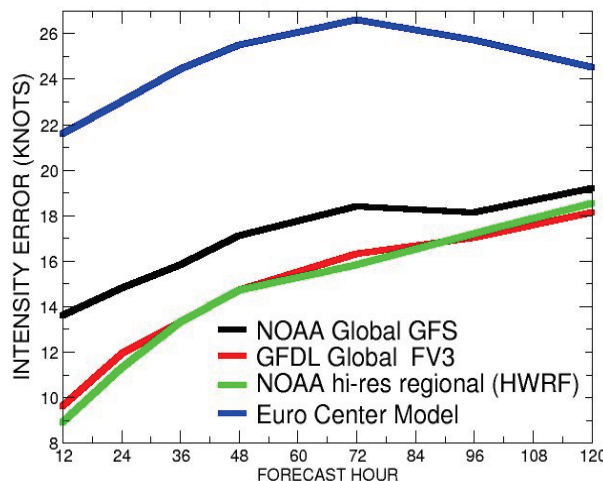
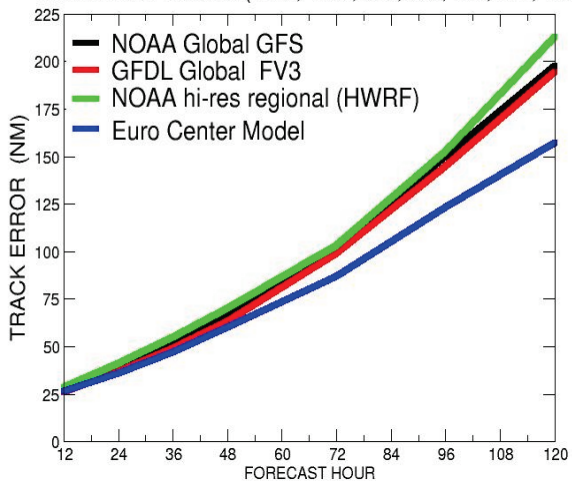
Intensity Errors

2015 & 2016 ATLANTIC, EPAC and WPAC SEASONS
NUMBER OF CASES: (1217, 1102, 995, 890, 697, 547, 420)

2015 & 2016 ATLANTIC, EPAC and WPAC SEASONS
NUMBER OF CASES: (1217, 1102, 995, 890, 697, 547, 420)

2015 and 2016

- fvGFS Track errors are slightly improved over operational GFS;
- Euro is the best for track prediction
- fvGFS Intensity skill is as good as HWRf
- EURO is worst in intensity

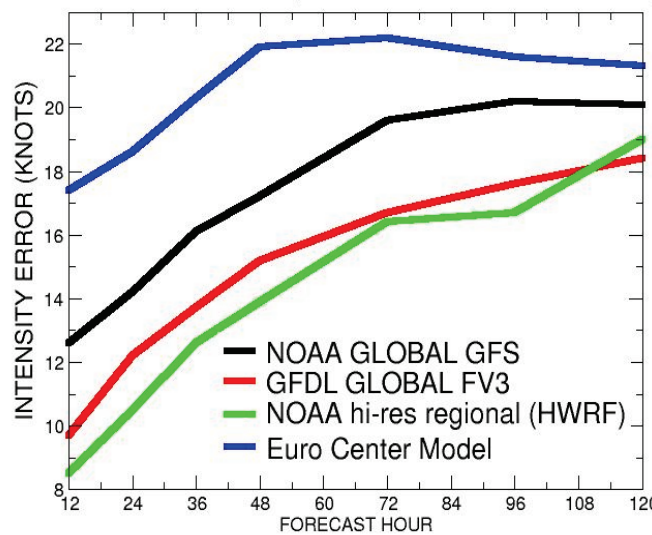
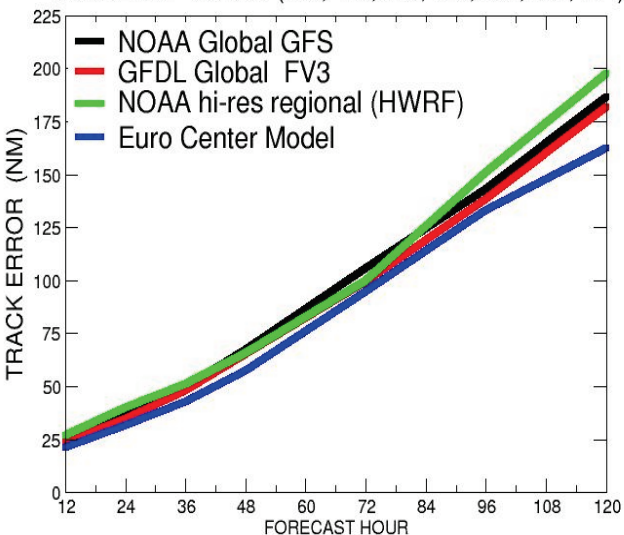


2017 ATLANTIC, EPAC and WPAC SEASONS
NUMBER OF CASES: (486, 440, 389, 346, 268, 205, 164)

2017 ATLANTIC, EPAC, and WPAC SEASONS
NUMBER OF CASES: (486, 440, 389, 346, 268, 205, 164)

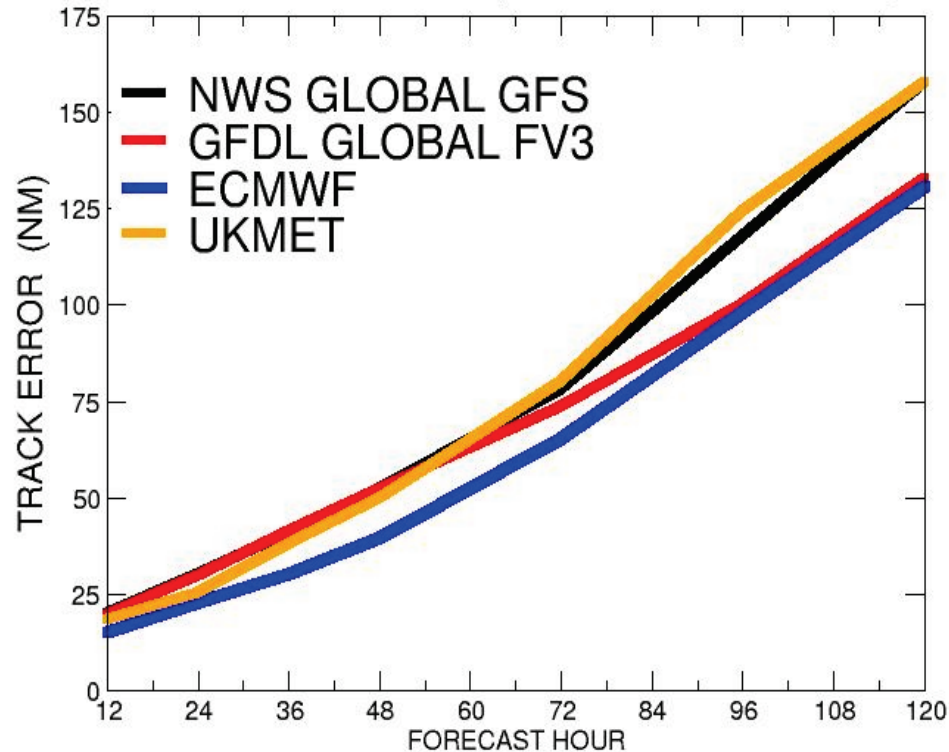
2017

- For 2017 season, fvGV3 is comparable in "track errors" to the Euro through 4 days
- fvGV3 intensity skill is almost comparable in to HWRf

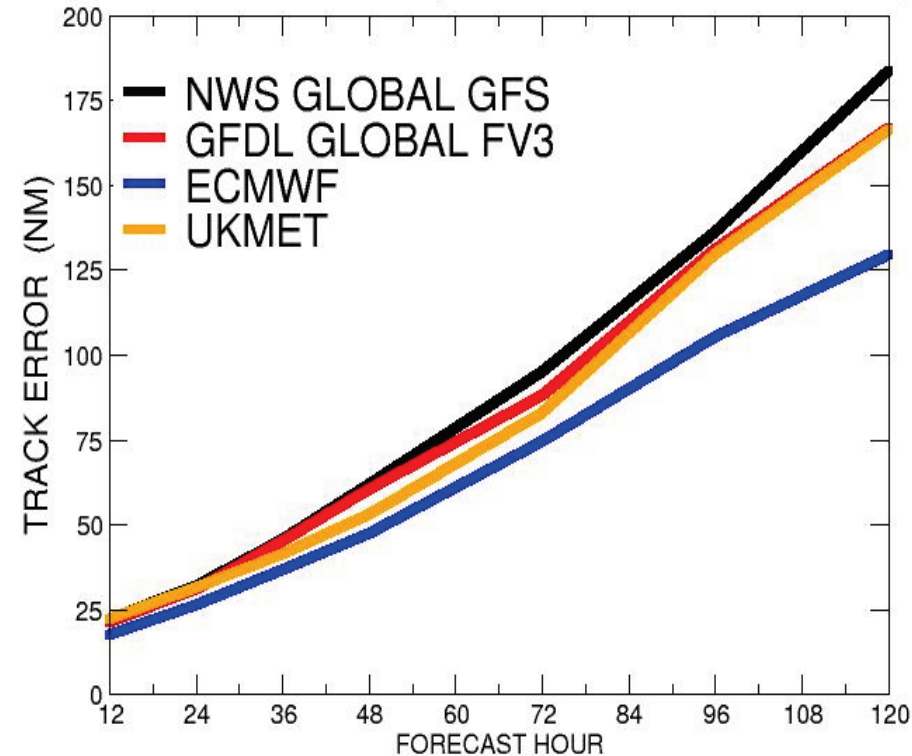


Performance of fvGFS in 2017 Atlantic Season (Late Model Guidance) Comparison with Global Models

HURRICANES HARVEY, IRMA and MARIA
NUMBER OF CASES: (70, 66, 62, 58, 52, 47, 41)



2017 ATLANTIC SEASON
NUMBER OF CASES: (164, 148, 134, 123, 100, 84, 70)



- fvGFS Track errors as good as EURO at days 4-5 for the 3 high impact events
- 12% reduced track errors at 3-5 days compared to GFS

- Euro was the best performers for entire season
- UKMET and fvGFS comparable (7% reduced errors at 3-5 days compared to GFS)

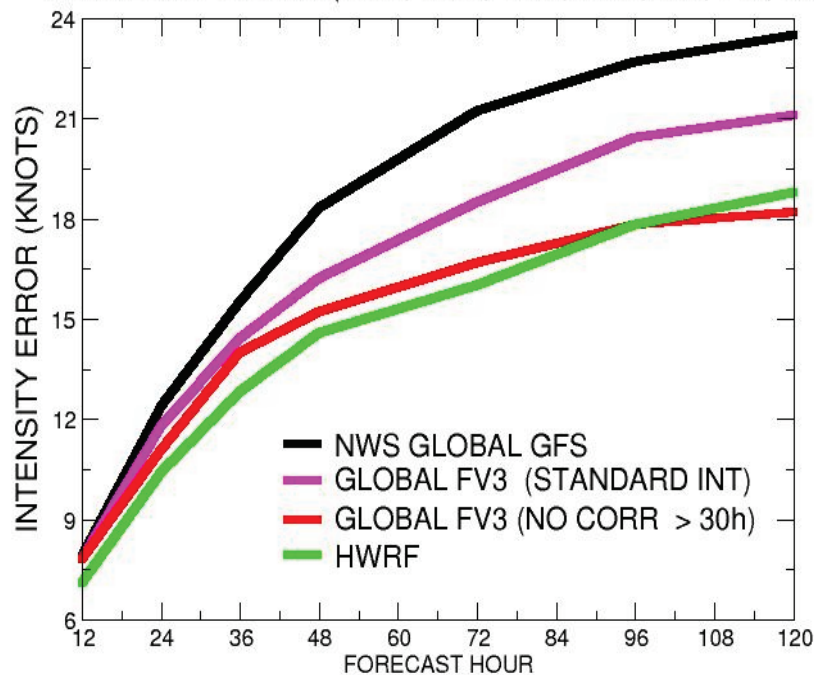
Evaluation of Early Model Intensity Guidance

Operational GFS and HWRF &

Global fvGFS using both standard interpolator and GHMI based version

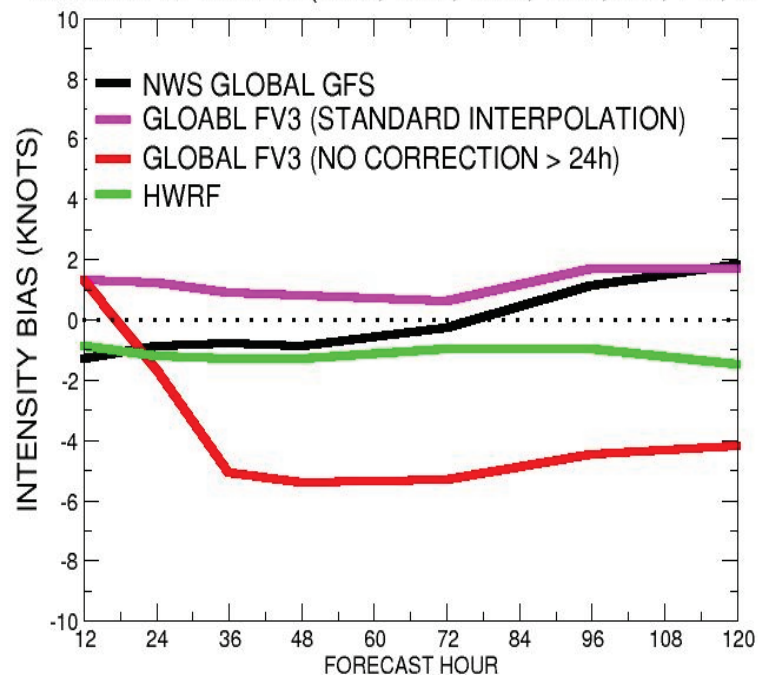
Intensity Errors

2015, 2016 & 2017 ATLANTIC, EPAC & WPAC SEASONS (INTERP)
NUMBER OF CASES: (1698, 1532, 1381, 1229, 958, 742, 570)



Intensity Bias

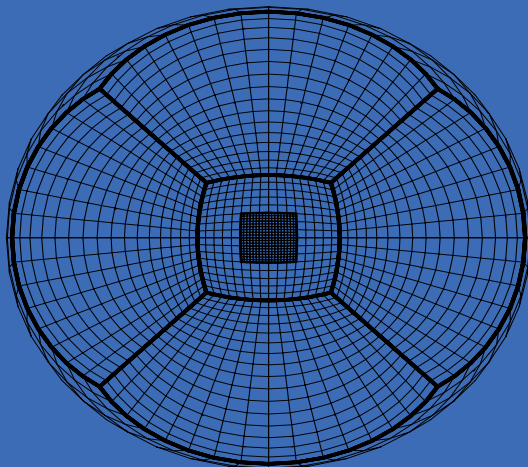
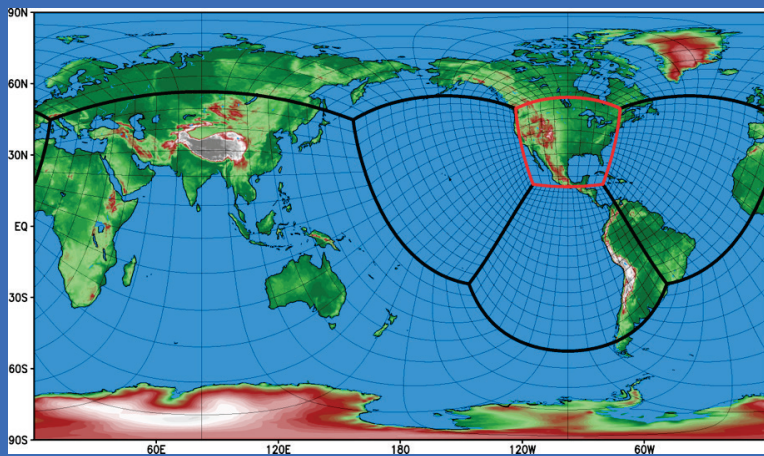
2015, 2016 & 2017 ATLANTIC, EPAC & WPAC SEASONS (INTERP)
NUMBER OF CASES: (1698, 1532, 1381, 1229, 958, 742, 570)



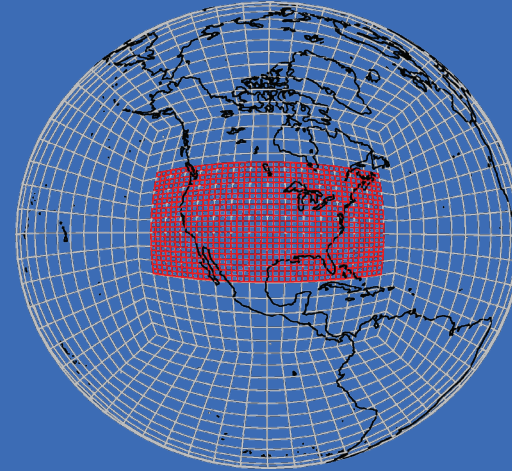
- Method of interpolation had large impact on intensity errors for fvGFS
- With GHMI interpolator, fvGFS remained nearly as good as HWRF for intensity prediction

Global-to-Regional Modeling

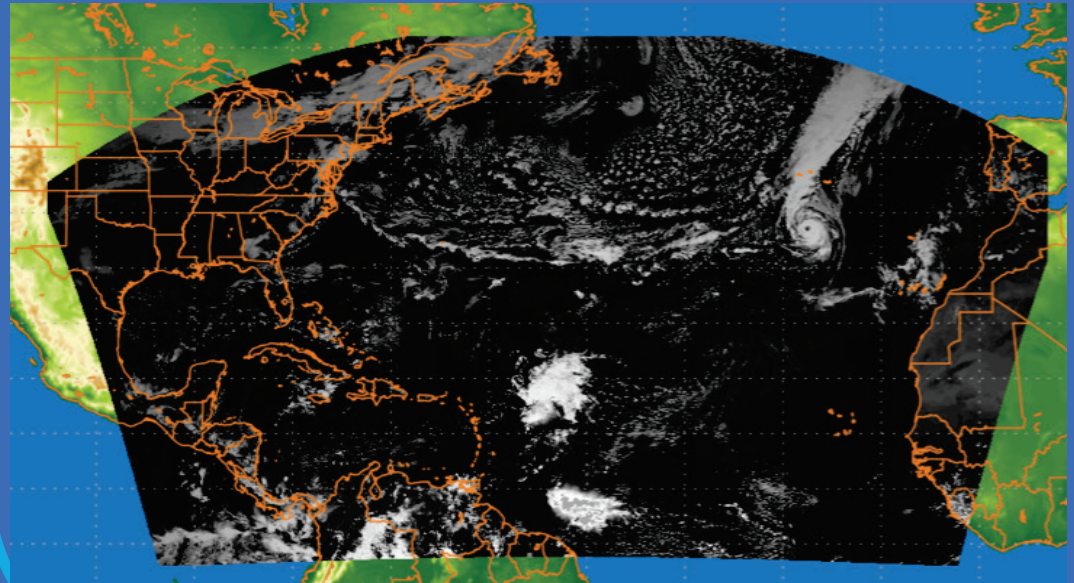
Grid Stretching



Grid Nesting

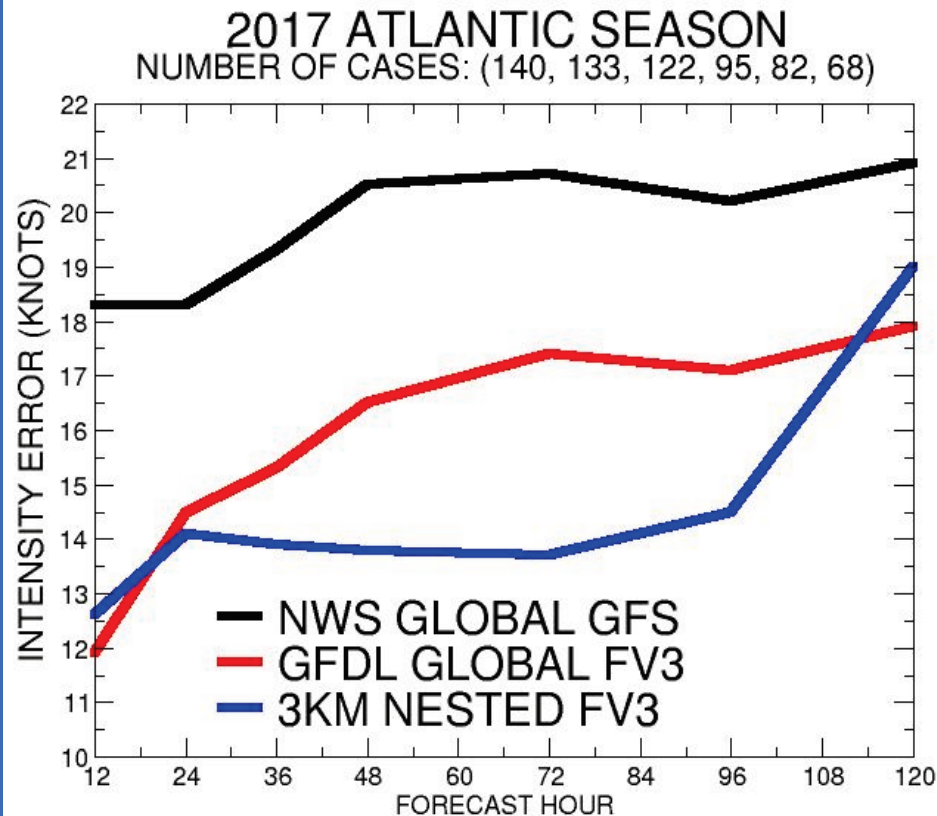
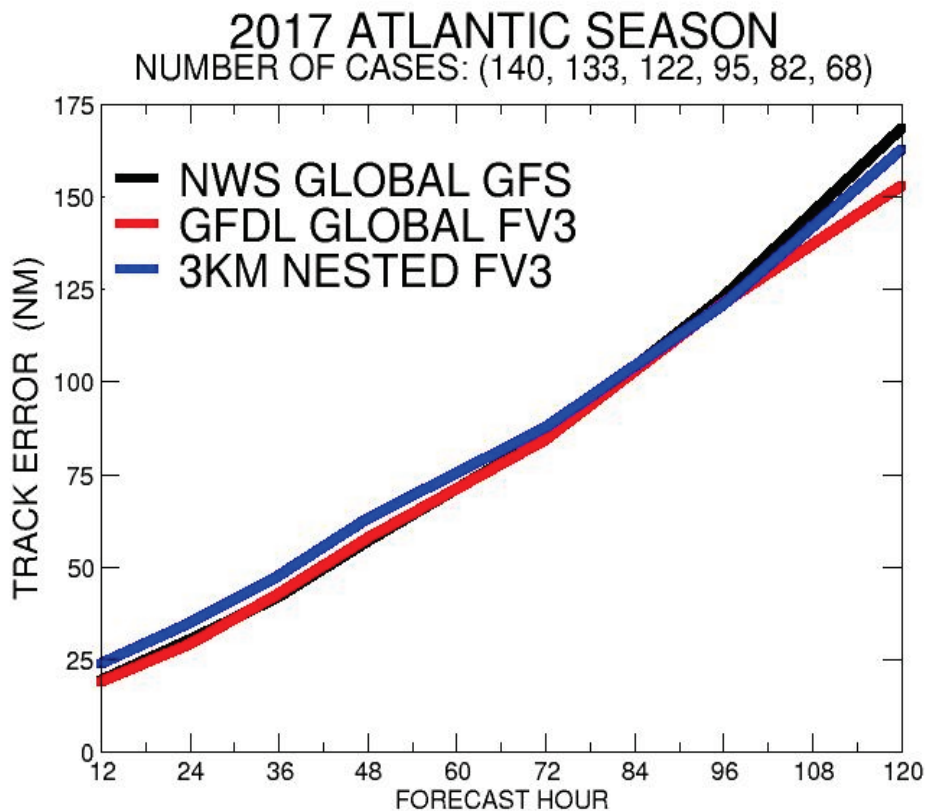


CONUS
Nest



Hurricane Nested Domain

Comparison of 2017 Atlantic Error (*Late*) (13 km fvGFS, 3km fvGFS, GFS)



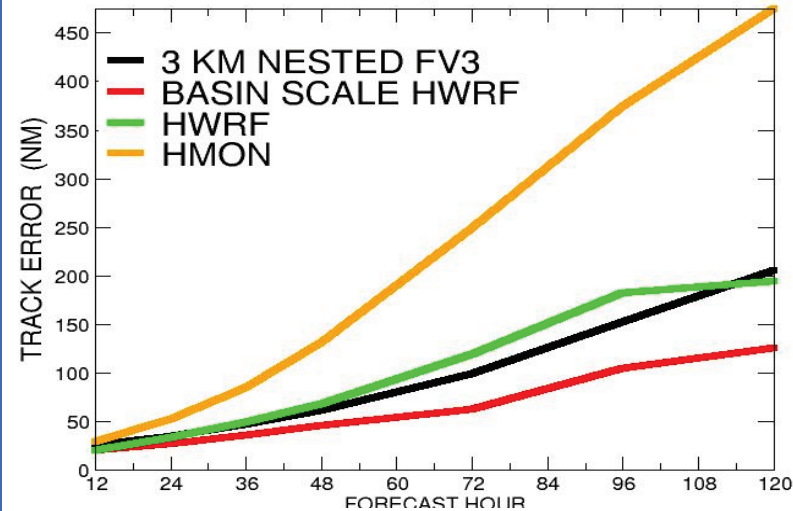
- 9% track degradation with introduction of 3km nest

- 15% reduced intensity errors 1-4 days
- Degraded performance day 5 (lack of ocean coupling ???)

2017 Atlantic Track Errors (*Interpolated*)

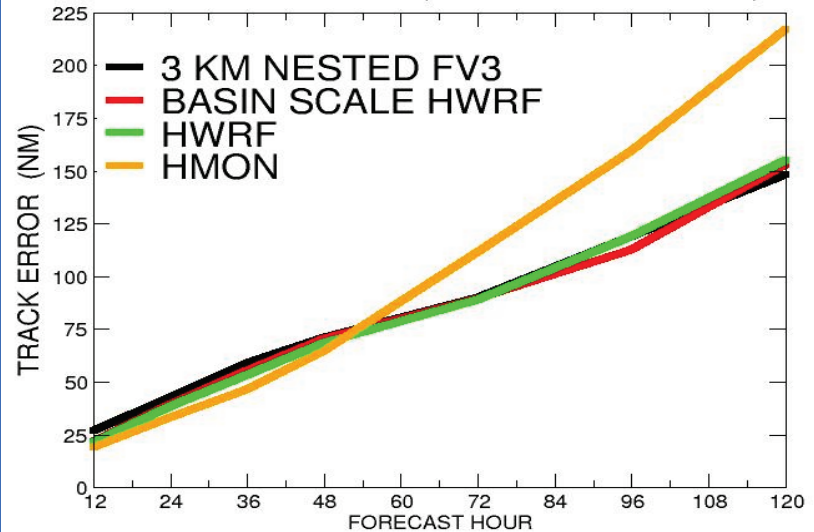
HURRICANE HARVEY

NUMBER OF CASES: (31, 29, 25, 22, 18, 14, 3)



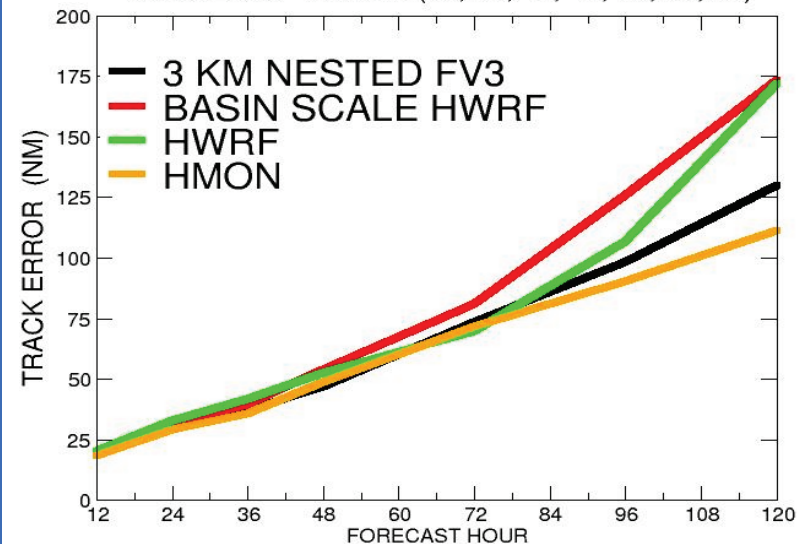
HURRICANE IRMA

NUMBER OF CASES: (42, 40, 38, 36, 32, 28, 24)



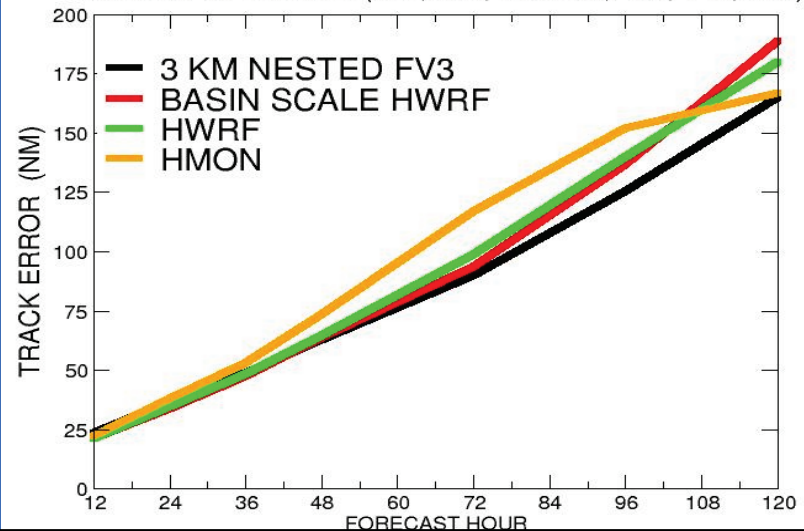
HURRICANE MARIA

NUMBER OF CASES: (53, 51, 48, 47, 43, 39, 35)



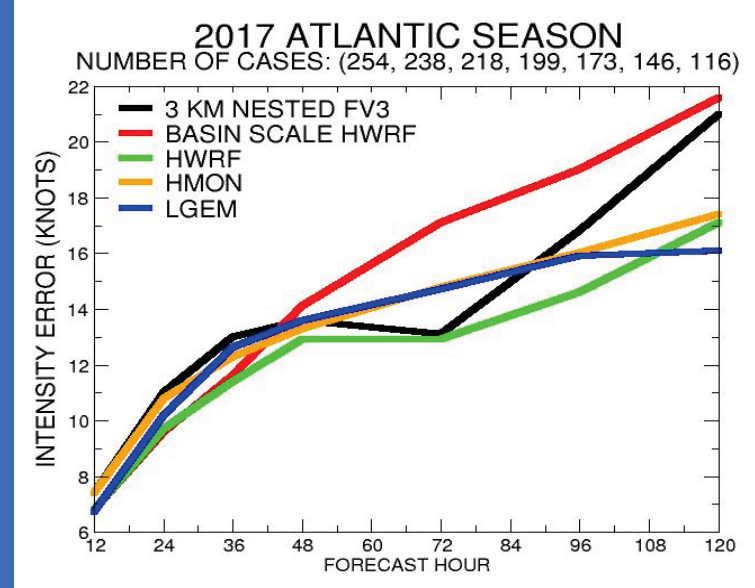
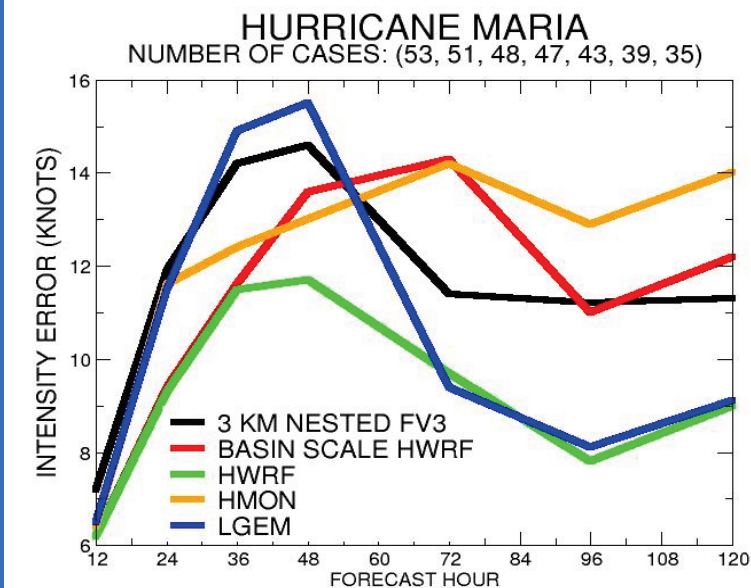
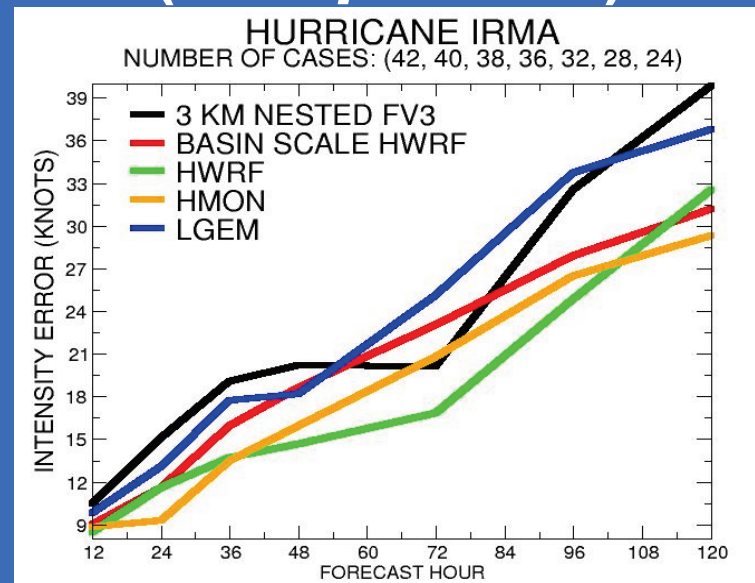
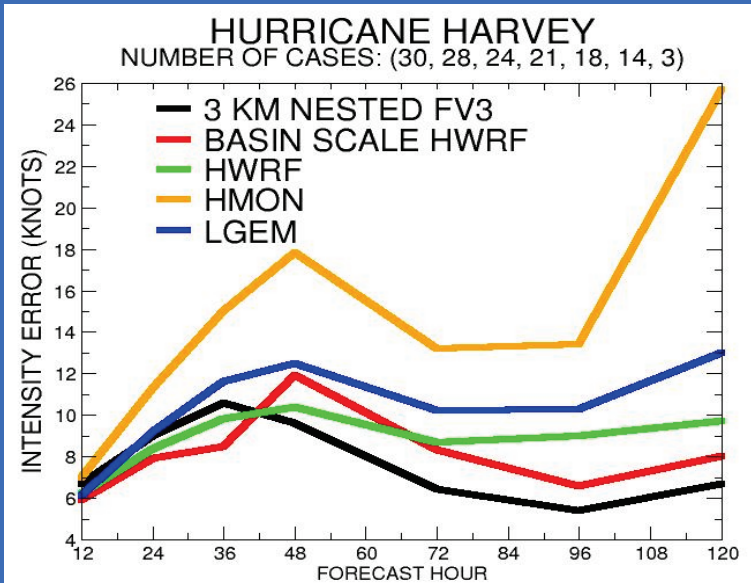
2017 ATLANTIC SEASON

NUMBER OF CASES: (256, 240, 219, 200, 173, 146, 116)



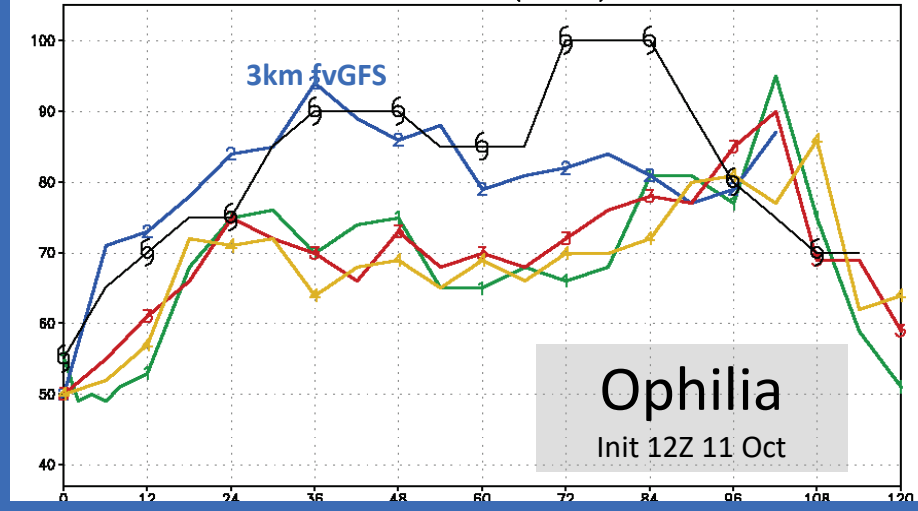
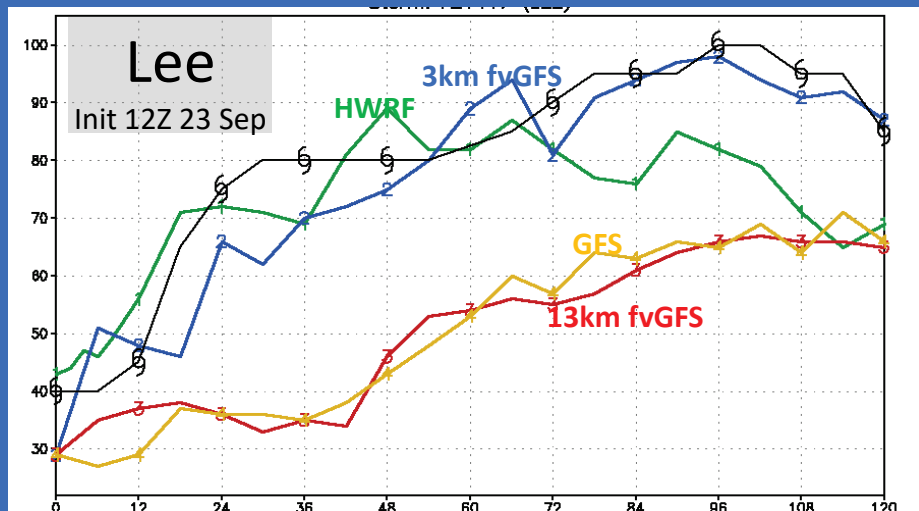
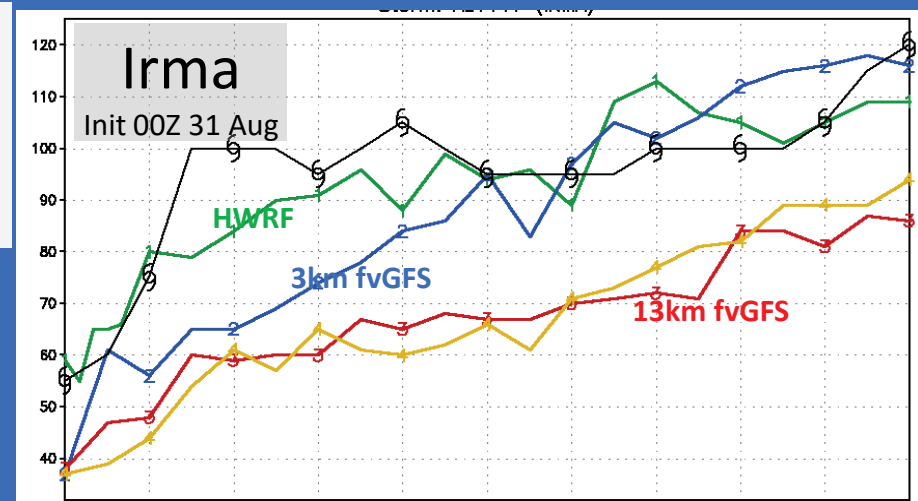
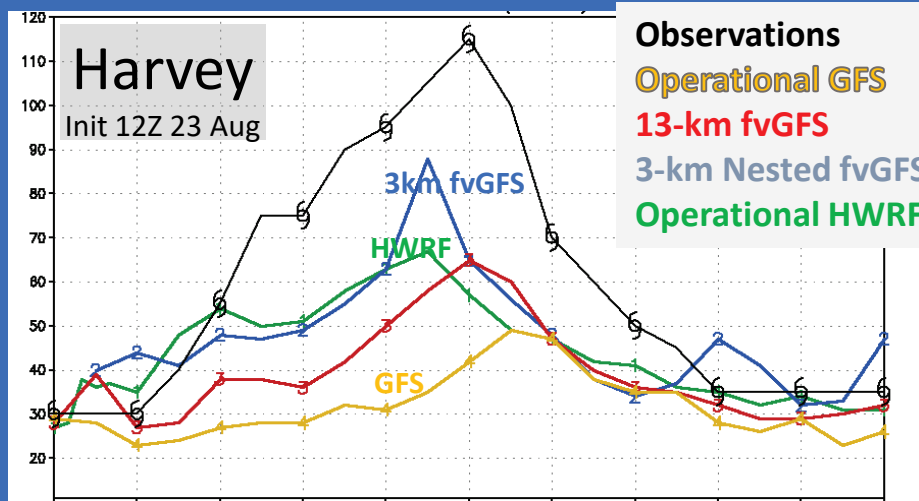
- Significant storm by storm variability between high resolution models, but nested fvGFS best track performer for entire season

2017 Atlantic Intensity Errors (*Interpolated*)



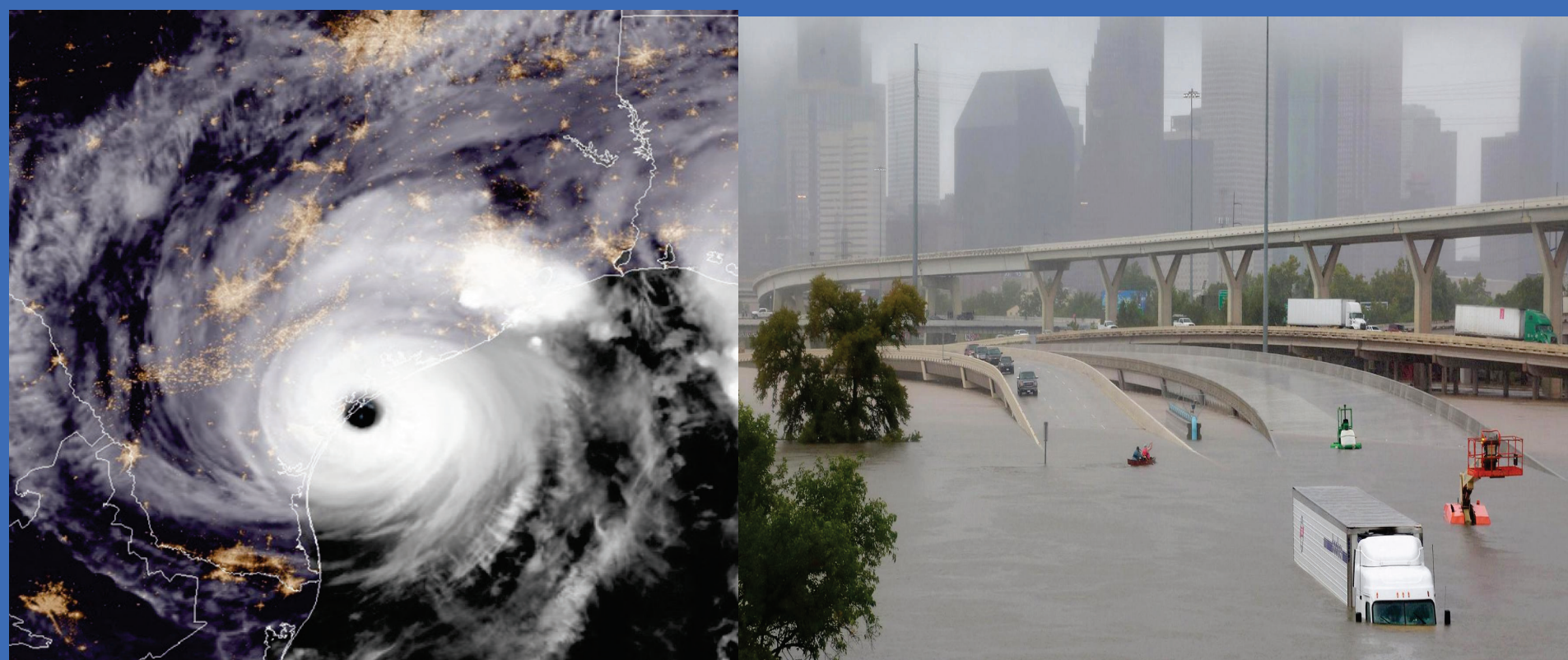
- HWRF lowest intensity errors in Atlantic, Basin Scale HWRF worse performer (*no ocean coupling ???*), nest fvGFS almost as good as HWRF 2-3 days.

Individual Forecasts: Max wind vs. Obs



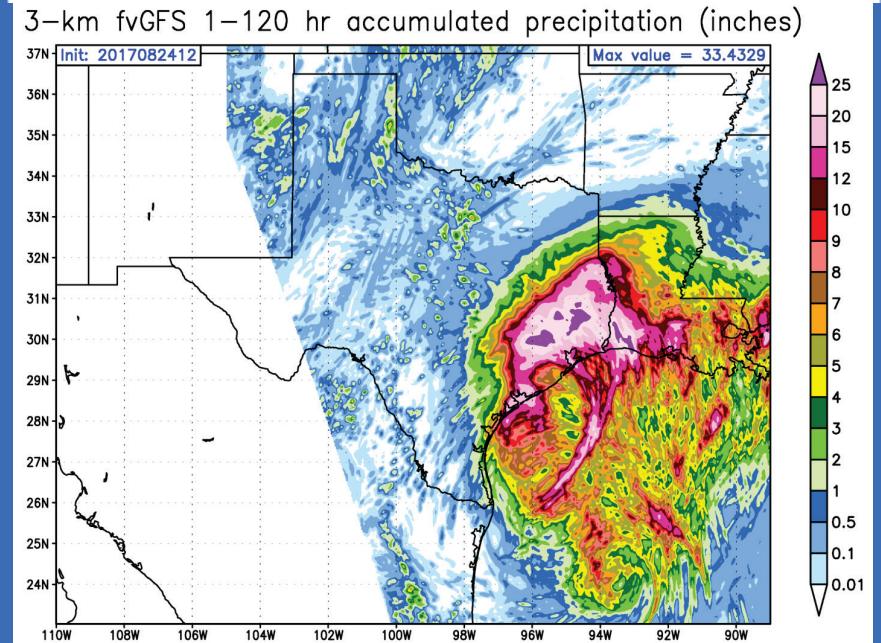
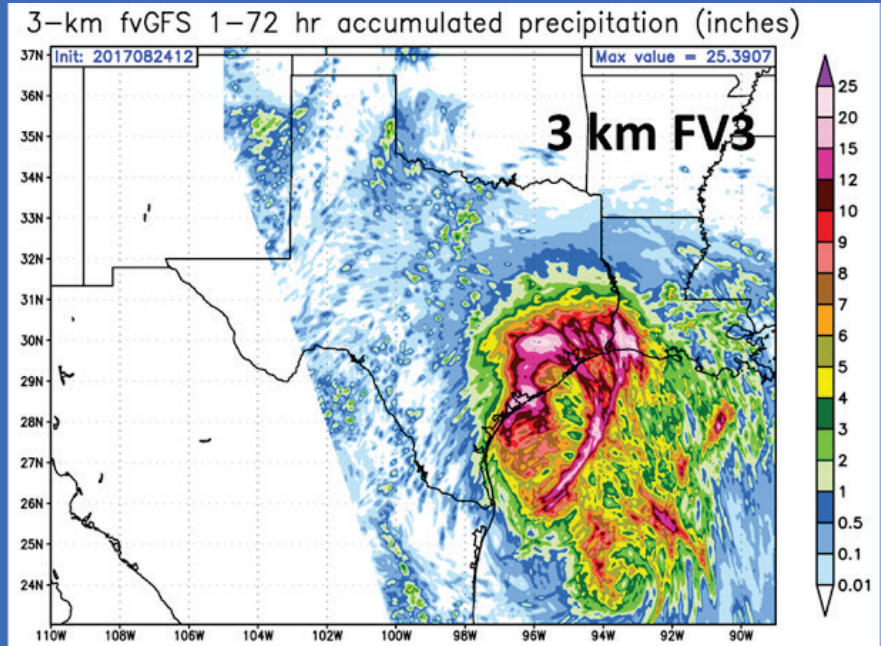
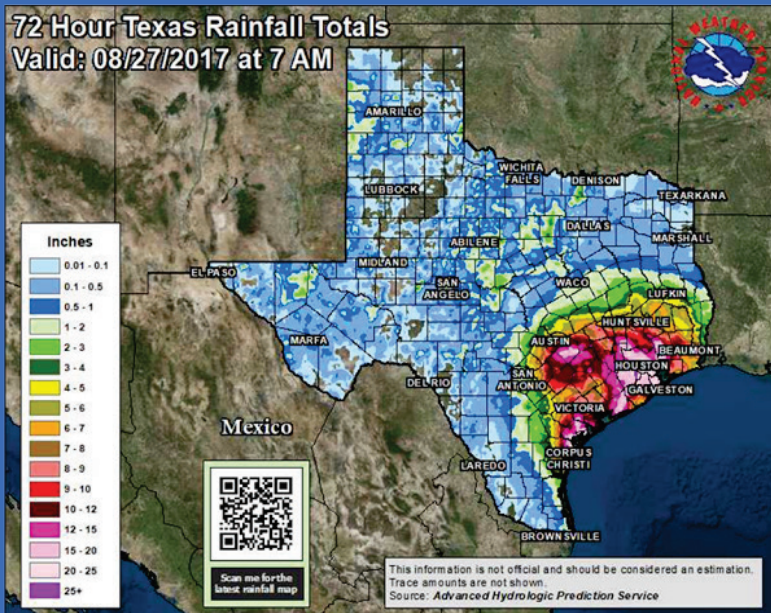
- 3km nested fvGFS shows promise in improved prediction of Rapid Intensification

3km Nested fvGFS Precipitation and Structure



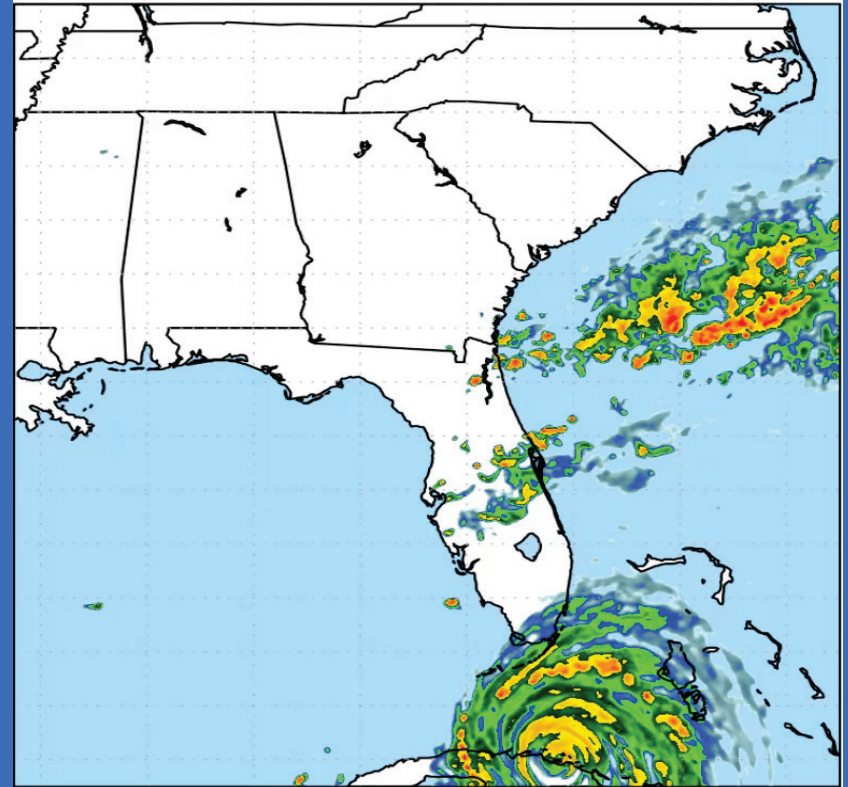
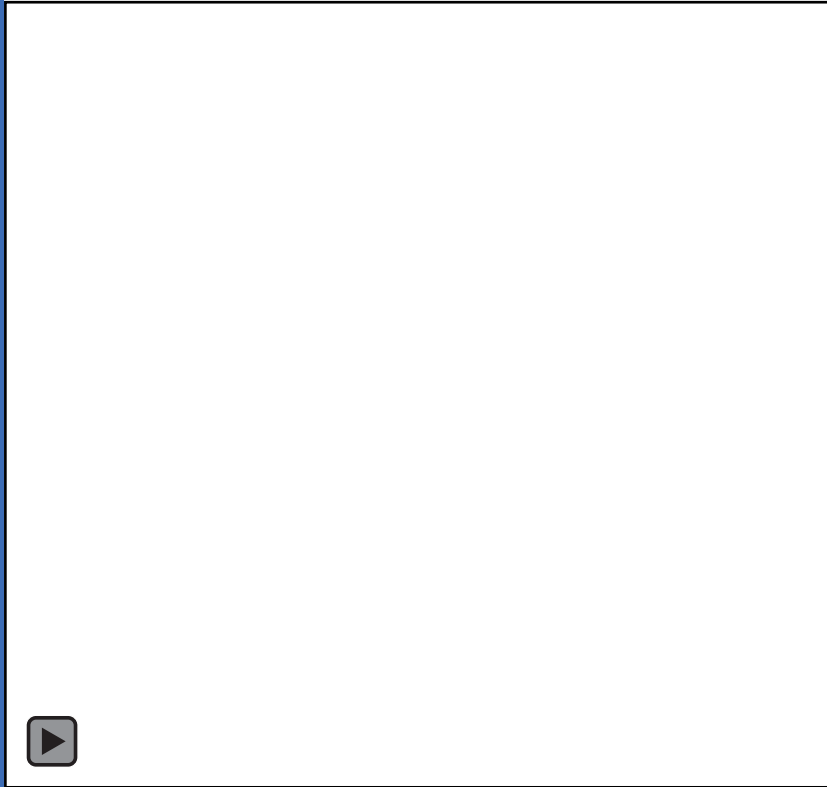
Harvey Precipitation

OBSERVED 72h PRECIPITATION TOTALS



- Nested fvGFS captured the double max structure with the core near Corpus Christi and the band training into Houston
- Slightly too far east due to motion bias
- 5-day precip shows continued accumulations near Houston and SW LA

fvGFS vs. Observed Radar for Irma US Landfall



-Observed radar image from Brian McNoldy

SUMMARY

- **Global fvGFS track error comparable to operational GFS in combined 3 year sample of NH storms. In Atlantic 7% reduced track error at 3-5 days.**
- **Although fvGFS track errors were comparable to ECMWF for Harvey, Irma and Maria 4-5 days, for entire Atlantic season ECMWF track performance again far superior to any other guidance in Atlantic.**
- **Global fvGFS intensity errors better than any other global model, and almost as good as HWRF for NH storms !**
- **The nested fvGFS not as good a track performer as the global fvGFS in Atlantic but demonstrated better overall intensity prediction.**
- **3km nested fvGFS shows promise in improved prediction of Rapid Intensification events !**