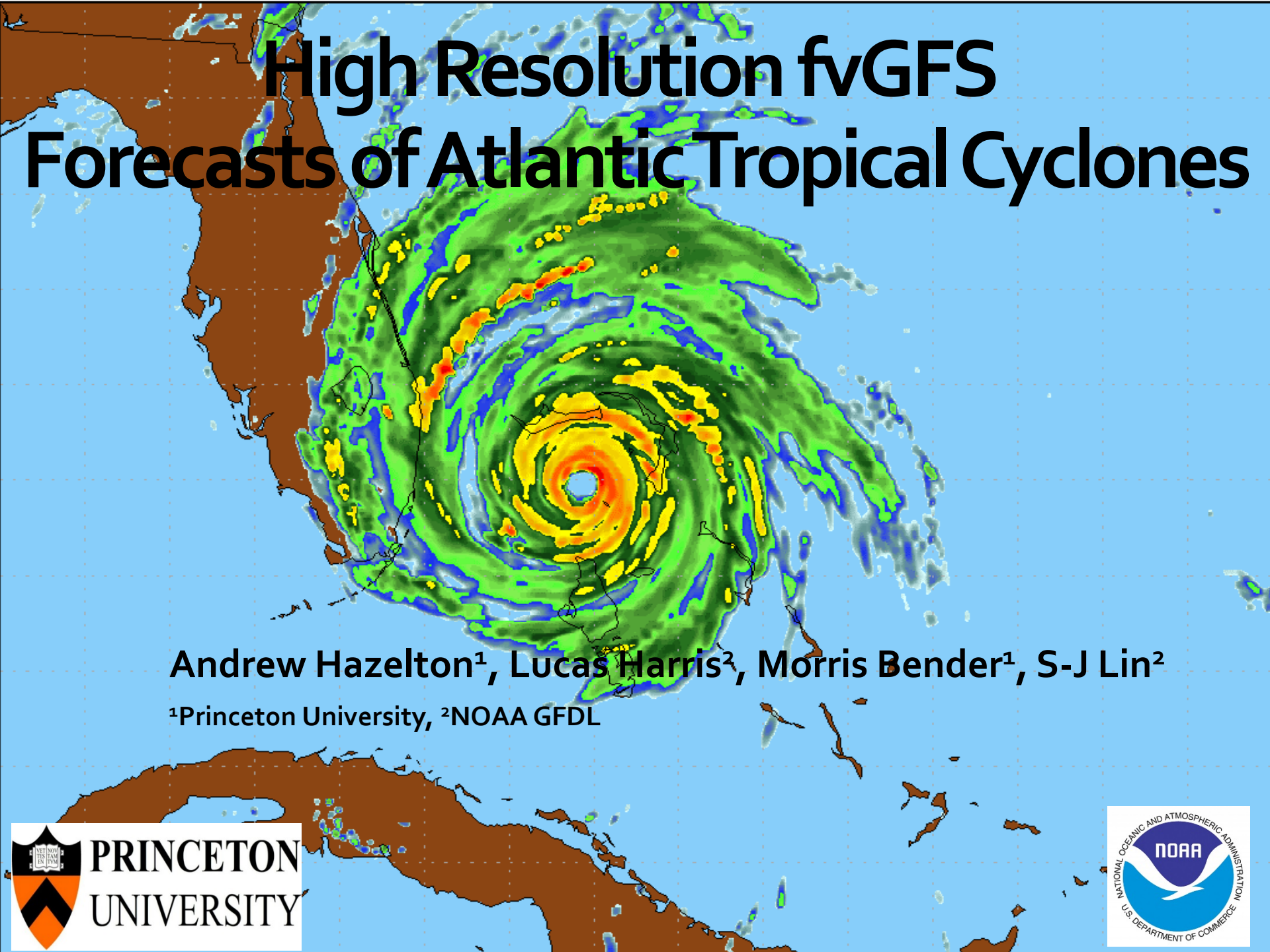
High Resolution fvGFS Forecasts of Atlantic Tropical Cyclones



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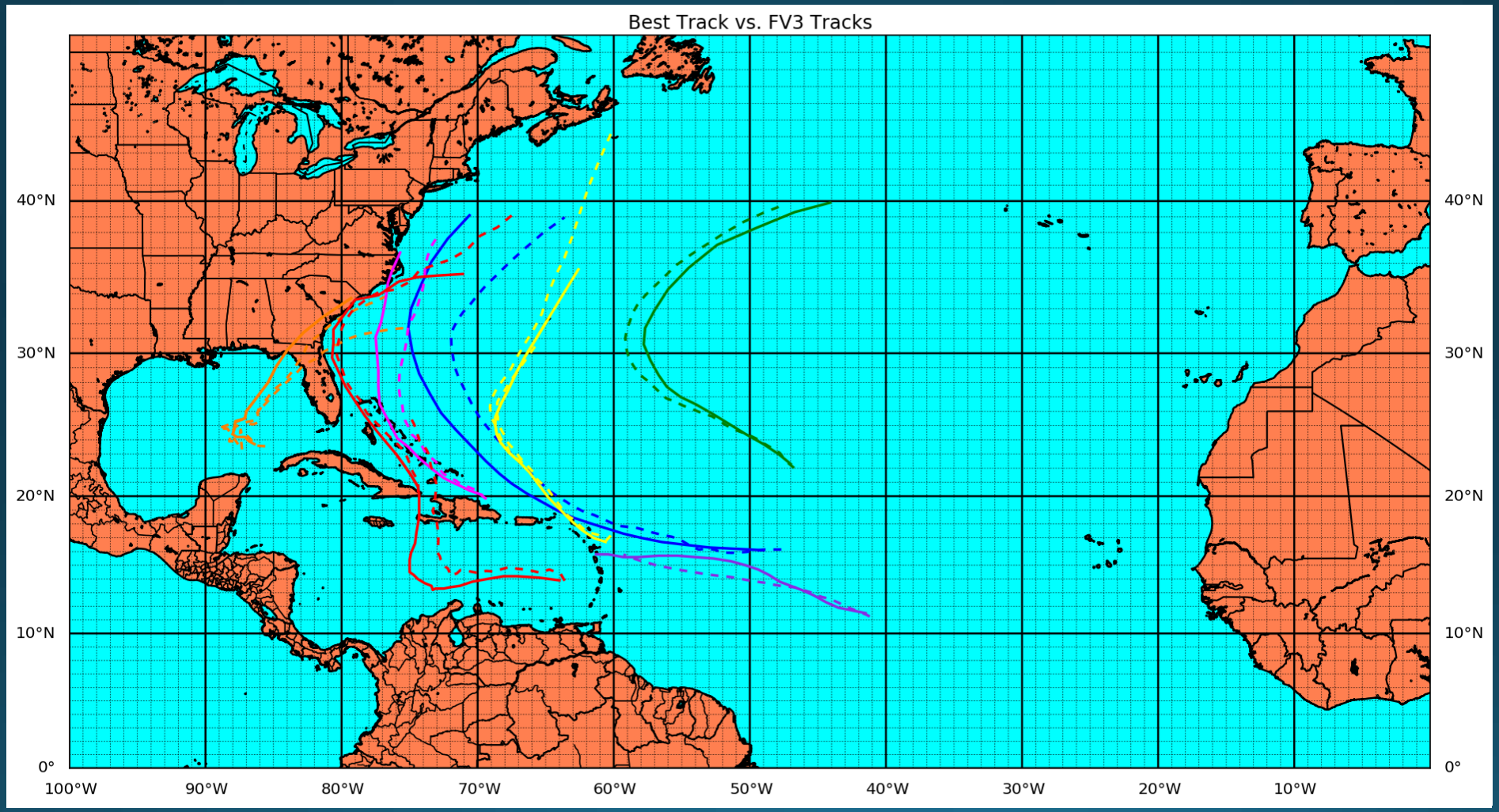
Motivation/Background

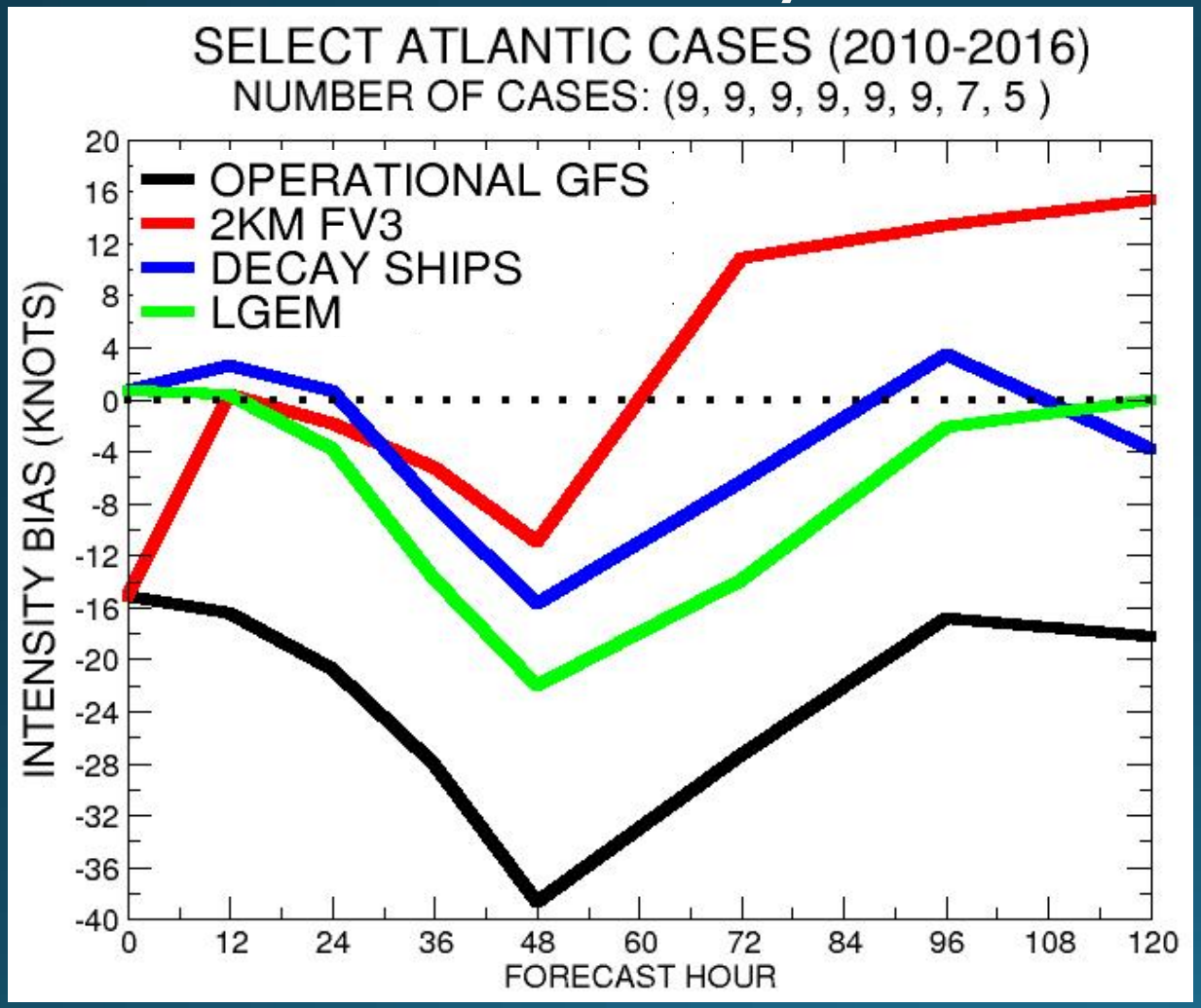
- FV3 dynamical core in the process of being implemented into GFS
- Nested version being developed for convective-scale applications
- Physics changes and new packages being developed
- Need to test high-resolution TC simulations

Model Description and Cases Chosen



- Cases: Earl 2010, Irene 2011, Edouard 2014, Gonzalo 2014 (2), Danny 2015, Hermine 2016 (2), Matthew 2016 (2): 10 total

Intensity Verification



-Weak bias in short term due to spinup issues from GFS ICs (mainly from 1 Matthew and 1 Gonzalo case)

-After 12-24 hours, the bias decreases significantly

-High bias at longer lead times likely due to no ocean coupling

-Thanks to Morris Bender for Verification Plots

Structure Parameters

- Model data compared with 3-dimensional Doppler radar analyses from NOAA P-3 flights

- Several structural metrics analyzed:

-RMW at z = 2 km

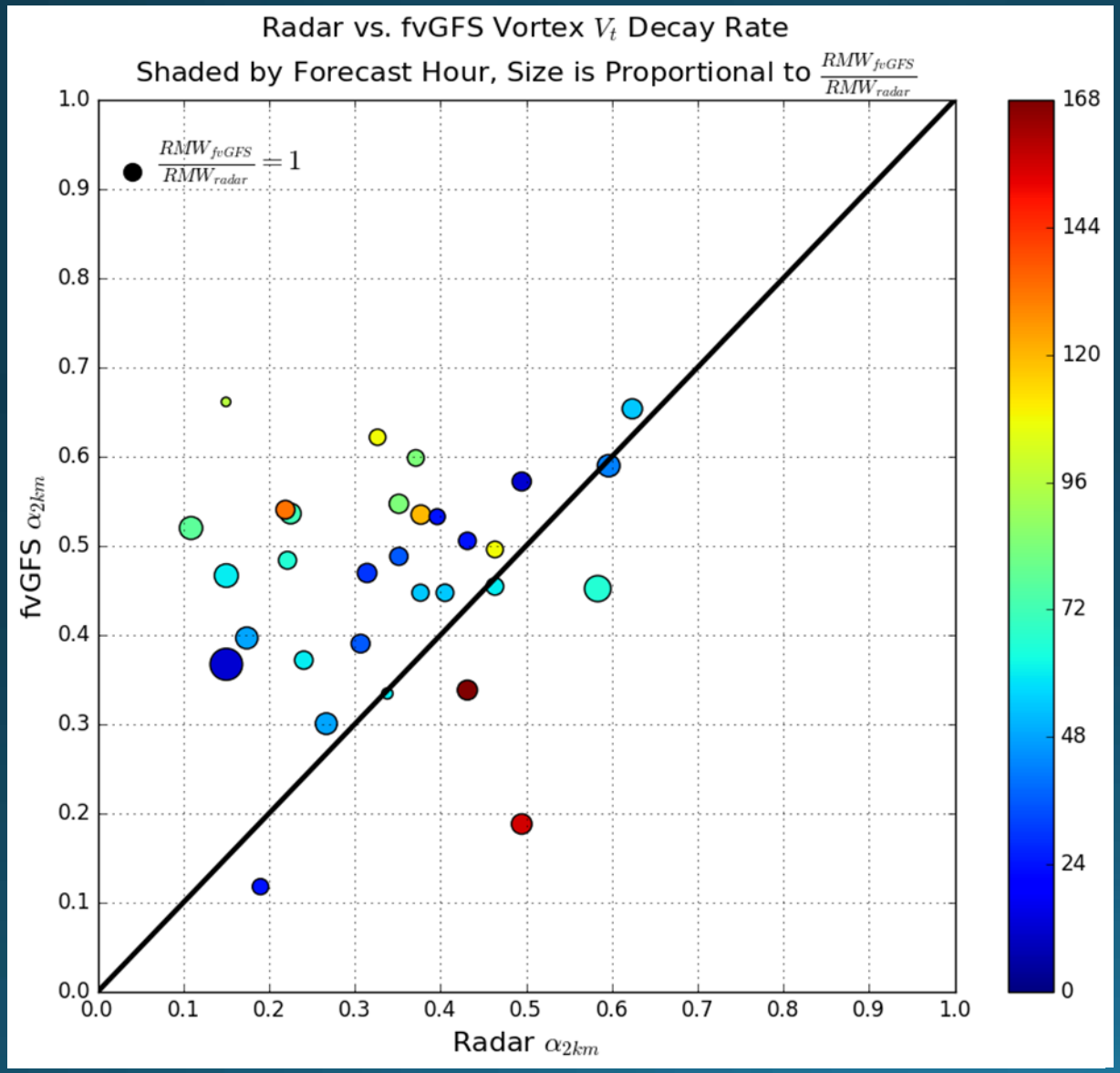
-Vortex Depth, defined as height at which tangential wind decays to 75% of its value at z = 2 km (50% for major hurricanes)

-α, the Rankine Vortex Decay Parameter (e.g. Mallen et al. 2005):

$$\frac{V_1}{V_2} = \left(\frac{R_2}{R_1}\right)^{\alpha}$$

$R_1 = RMW_{2km}$, $R_2 = 3*RMW_{2km}$

Horizontal Structure: RMW and α



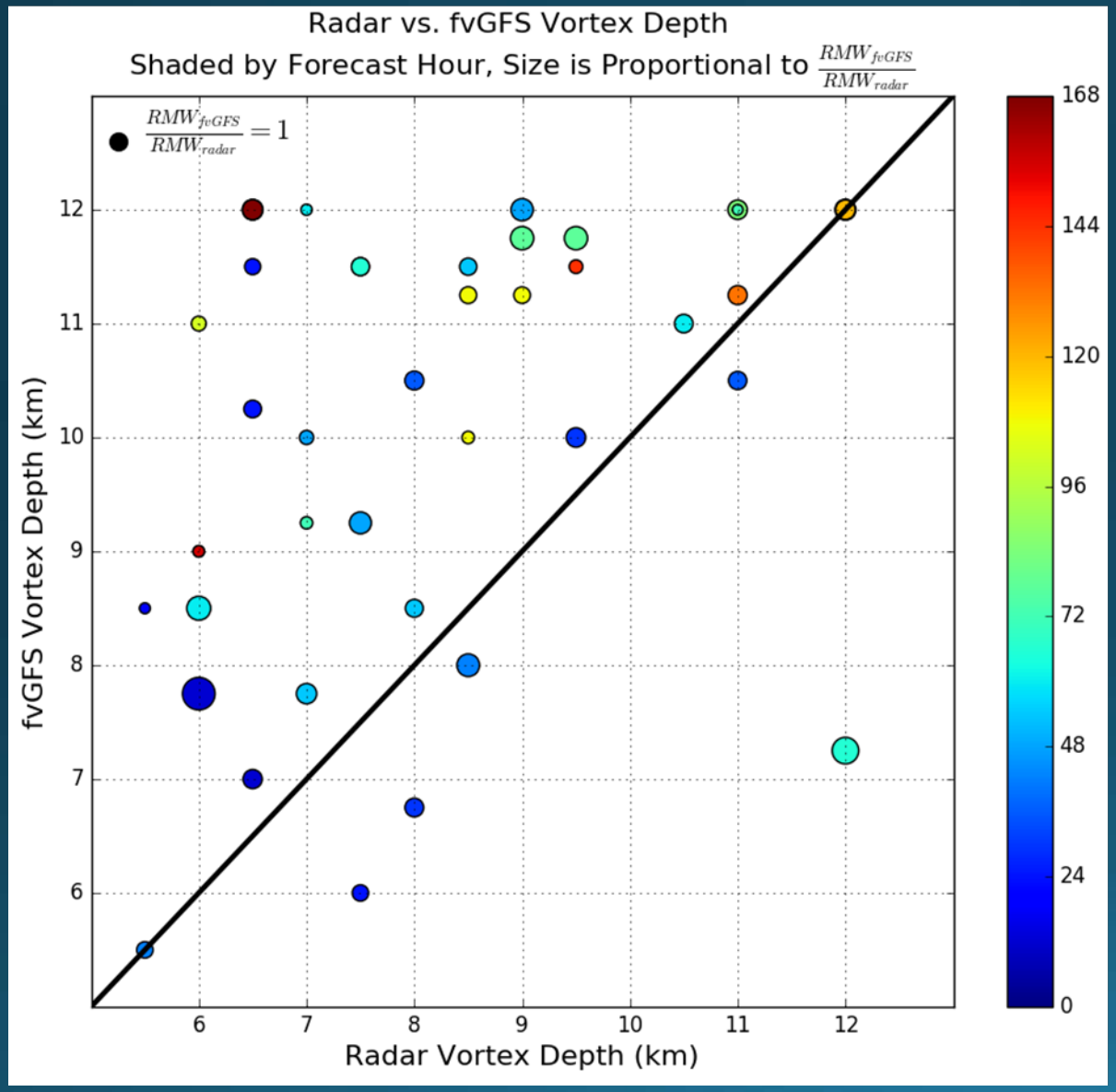
-Wind peak generally too sharp

-RMW best in the 25-50 km range

-Several cases with large eyes not included (3*RMW > 200 km)

-Model has a general bias toward being too small at larger observed radii

Vertical Structure: Vortex Depth

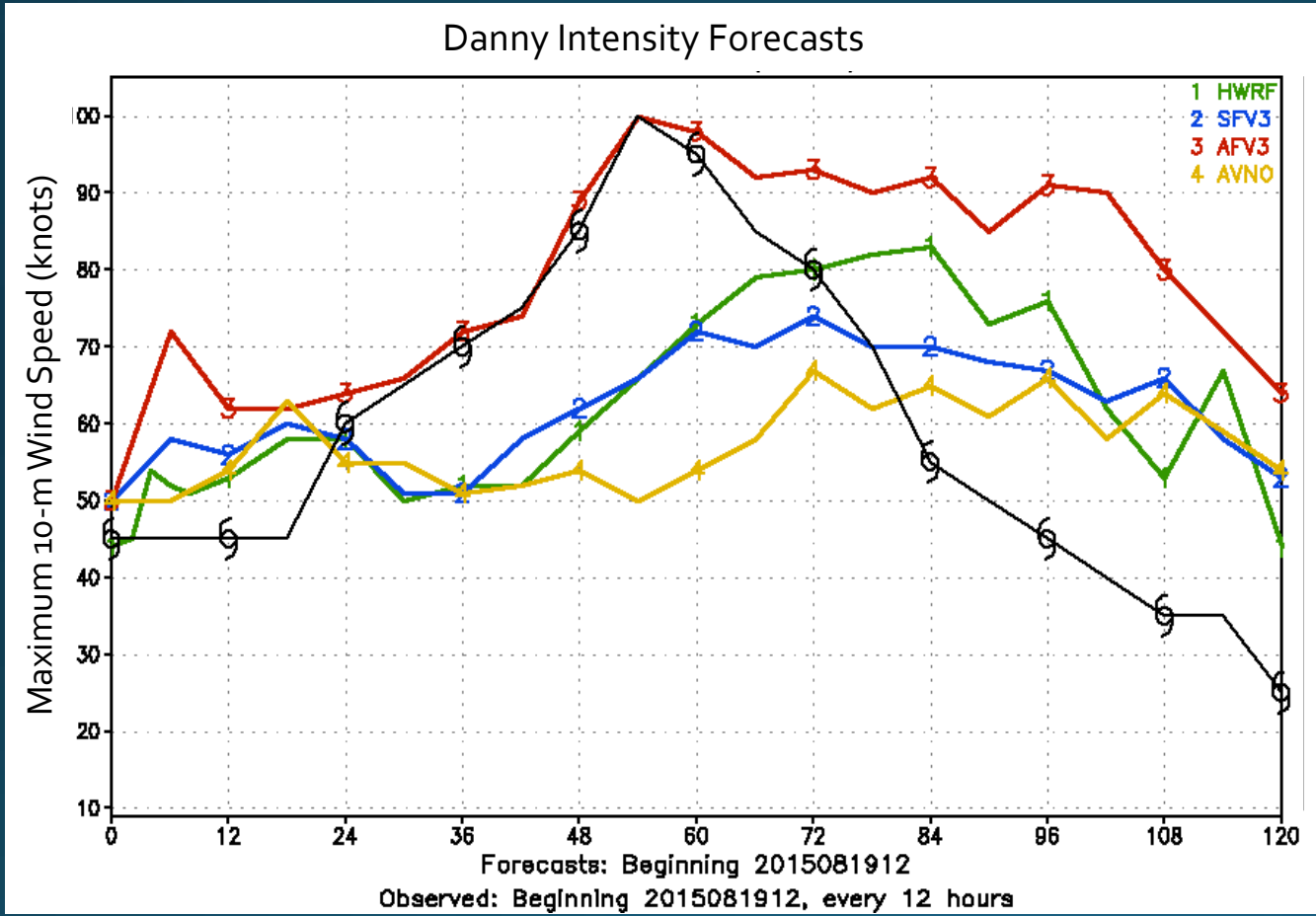


-Model tends to be too deep for observed shallow TCs

-Lower bias for observed deep TCs

Case Studies

Danny 2015



-SFV3 is global fvGFS

-AFV3 is the 2-km nested version used here

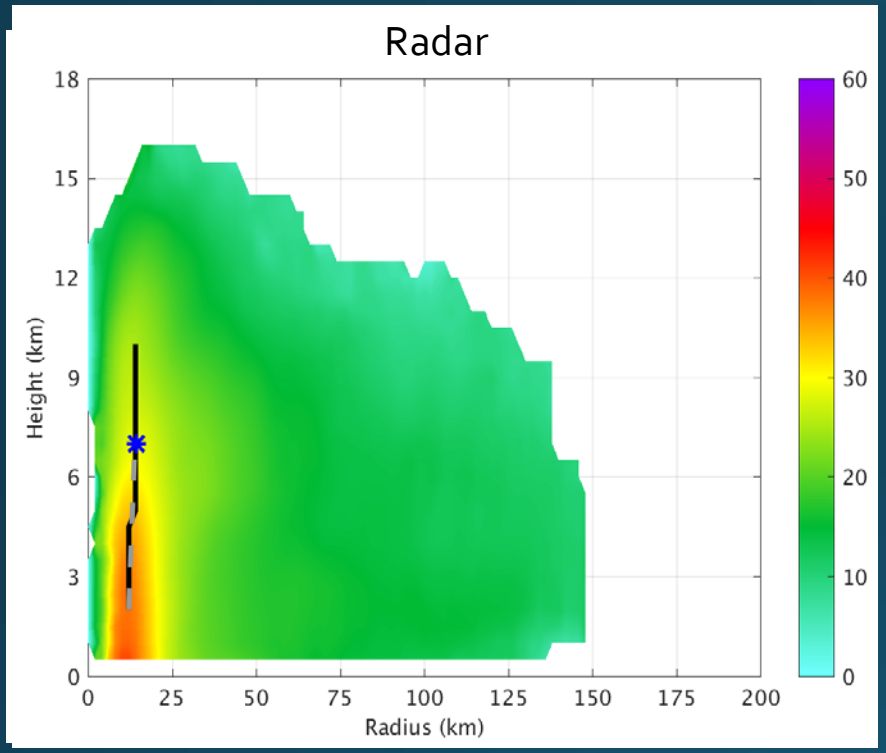
-Track similar to HWRF, avoids GFS northerly bias

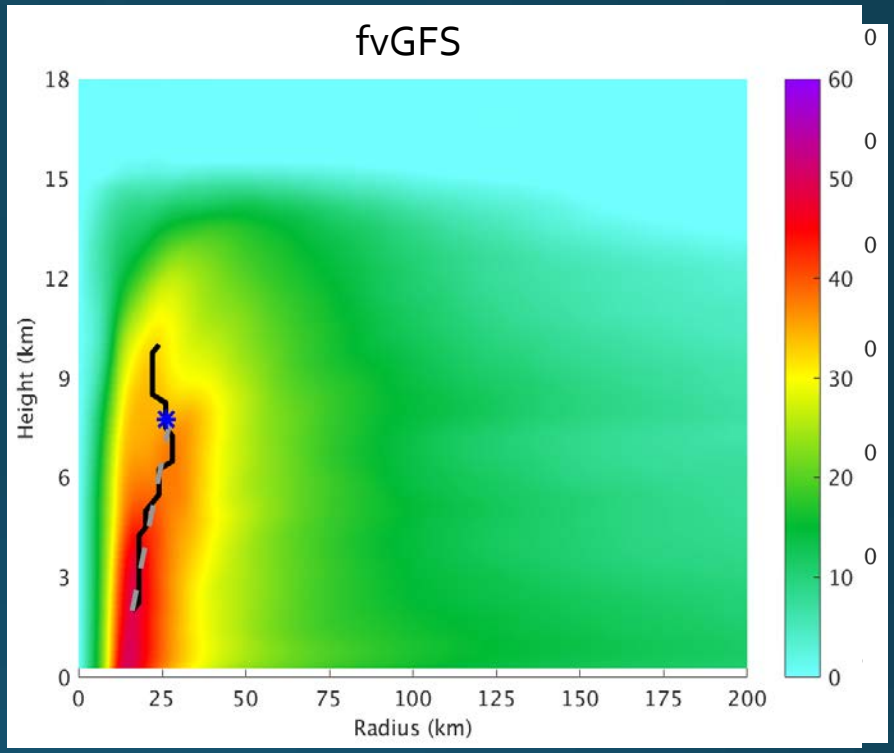
-RI well captured

-Weakens after but too slowly

-Thanks to Morris Bender for Verification Plots

Danny 2015: Hour 54 Tangential Wind





-Tangential wind is somewhat too strong and deep

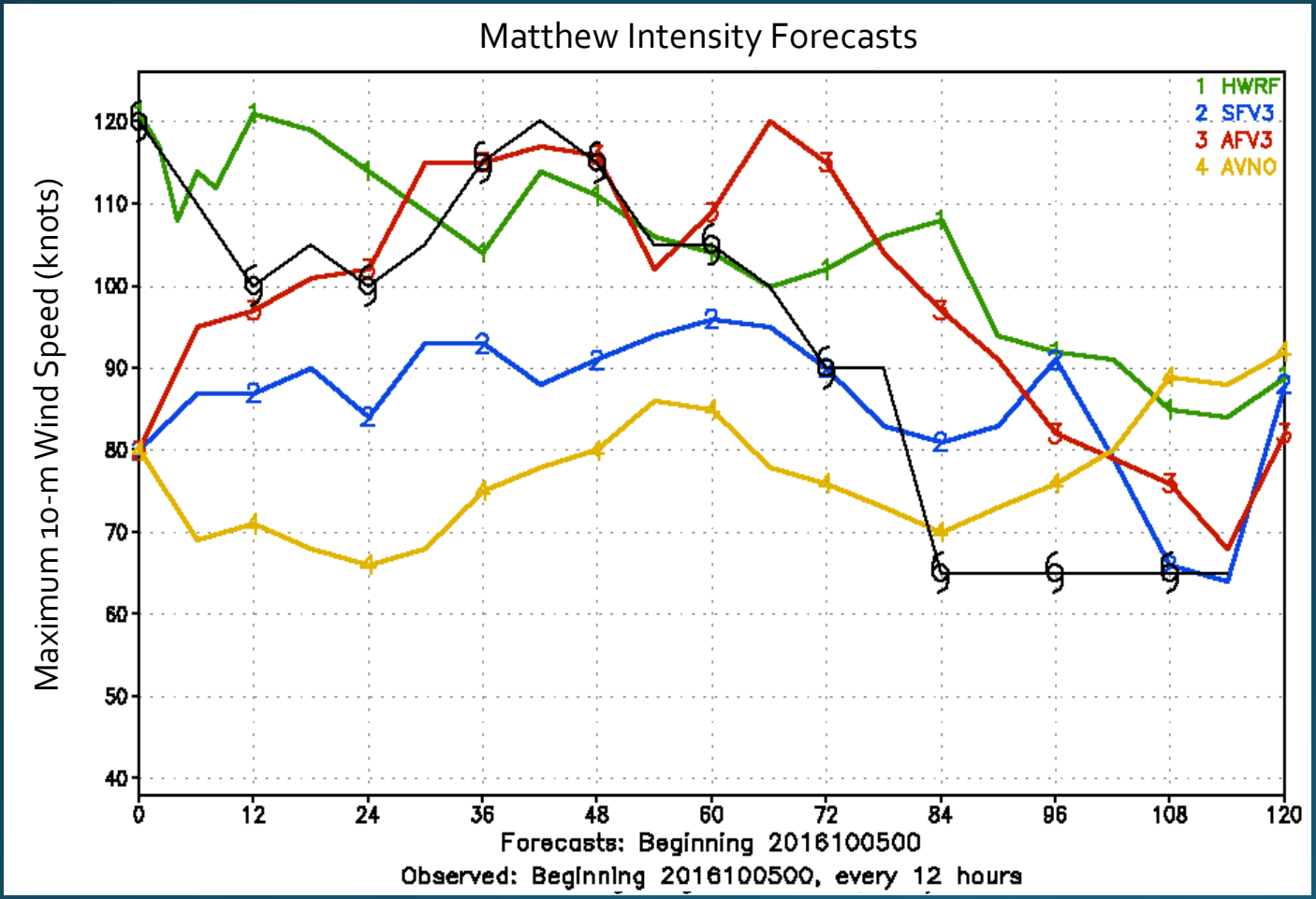
-Small RMW and relatively upright vortex captured

-Model/**radar** structure parameters:

RMW: 16 km/12 km, *Vortex Depth*: 7.75 km/7 km, α: 0.65/0.62

Matthew 2016:
Initialized North of Cuba

Matthew 2016



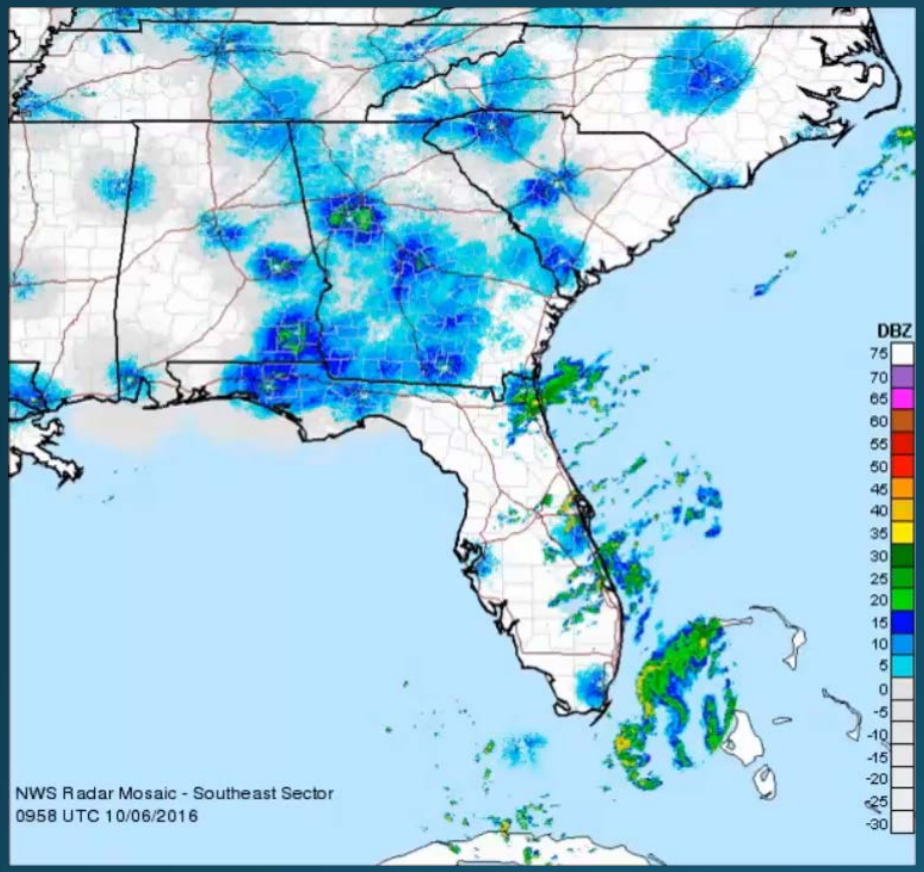
-Track is very good until ~Day 5 (closest model to the coast, but keeps it offshore)

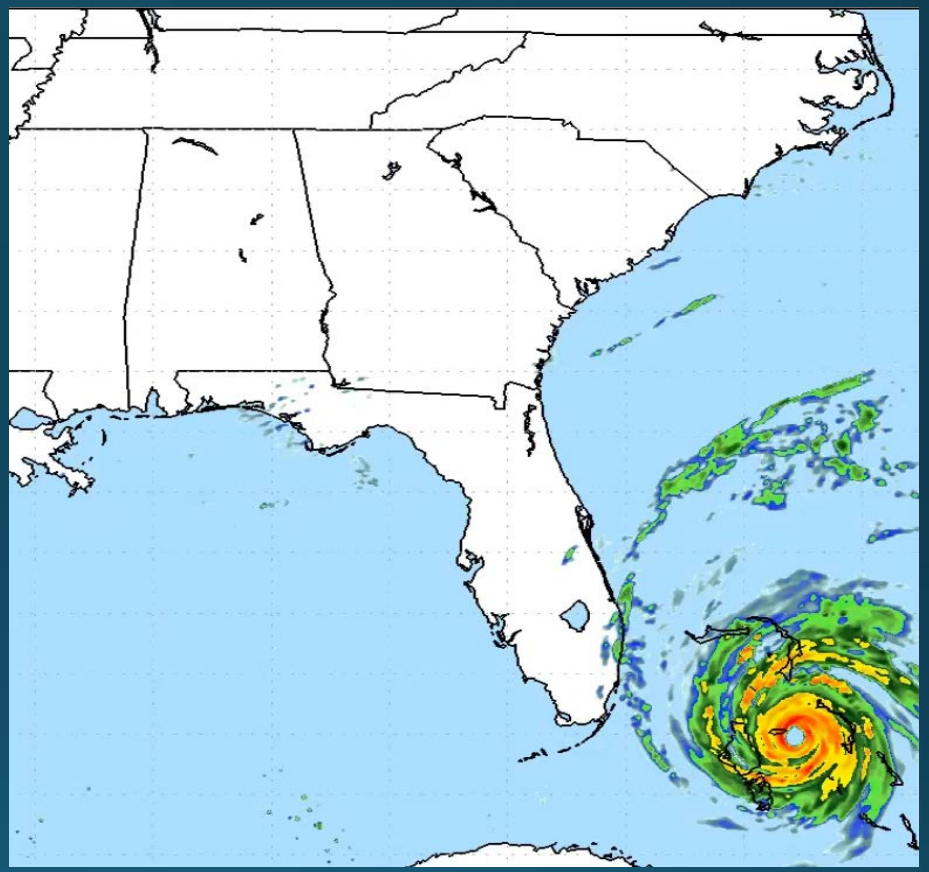
-After spinup, intensity evolution good for first ~48 hr

-Reintensification from hrs 54-66 not in observations (completion of ERC?)

-Thanks to Morris Bender for Verification Plots

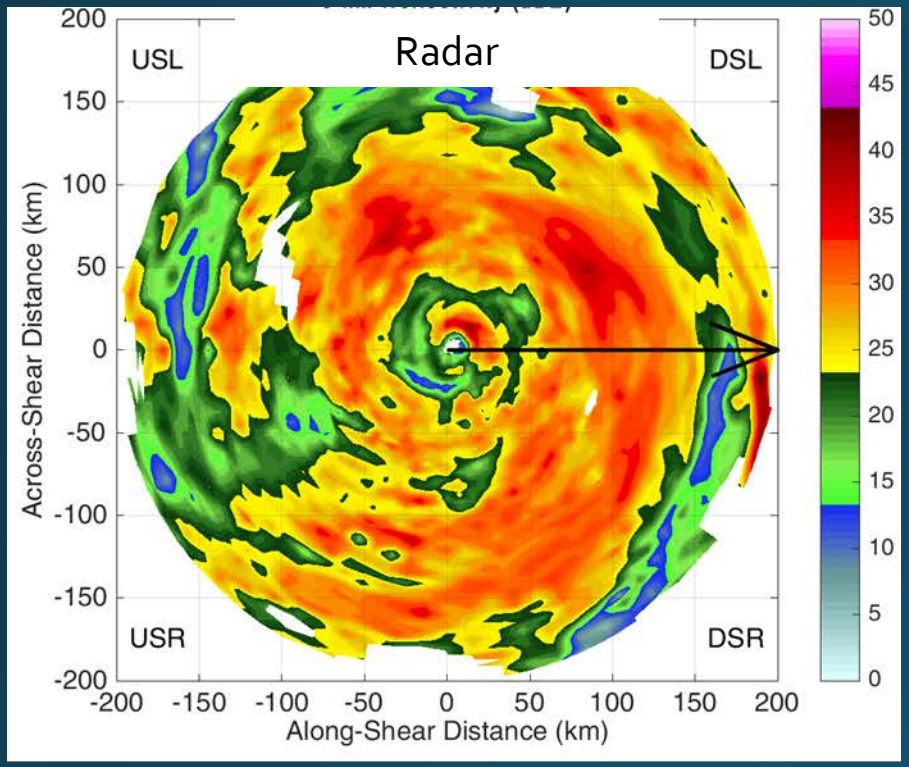
Matthew 2016

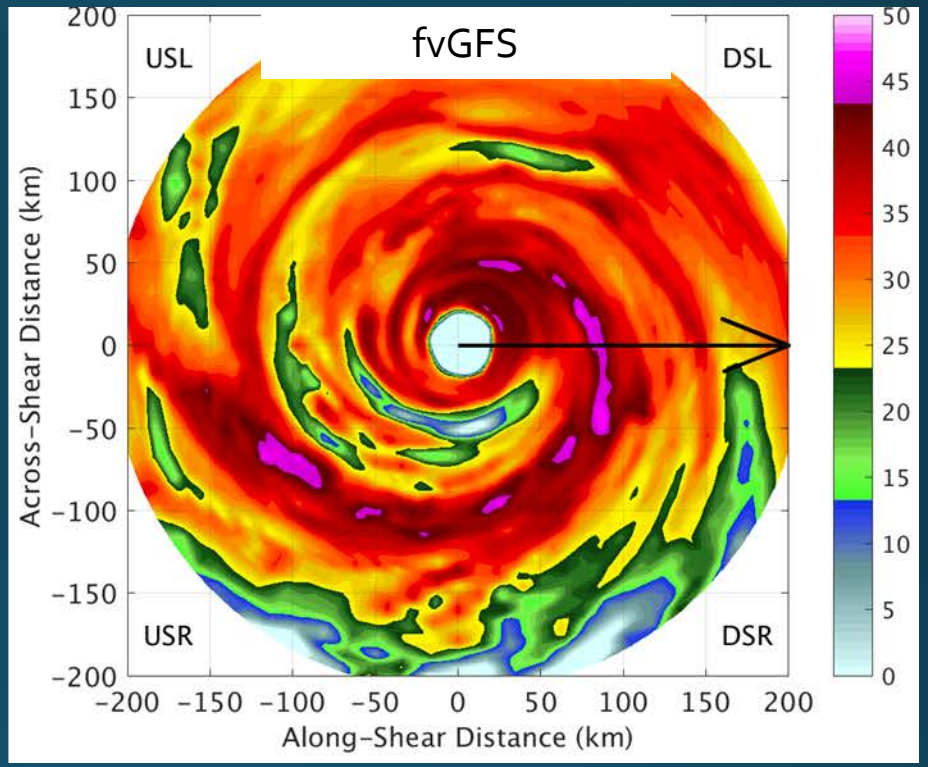




-Observed radar loop generated by Brian McNoldy

Matthew 2016: Hour 48 5-km dBZ

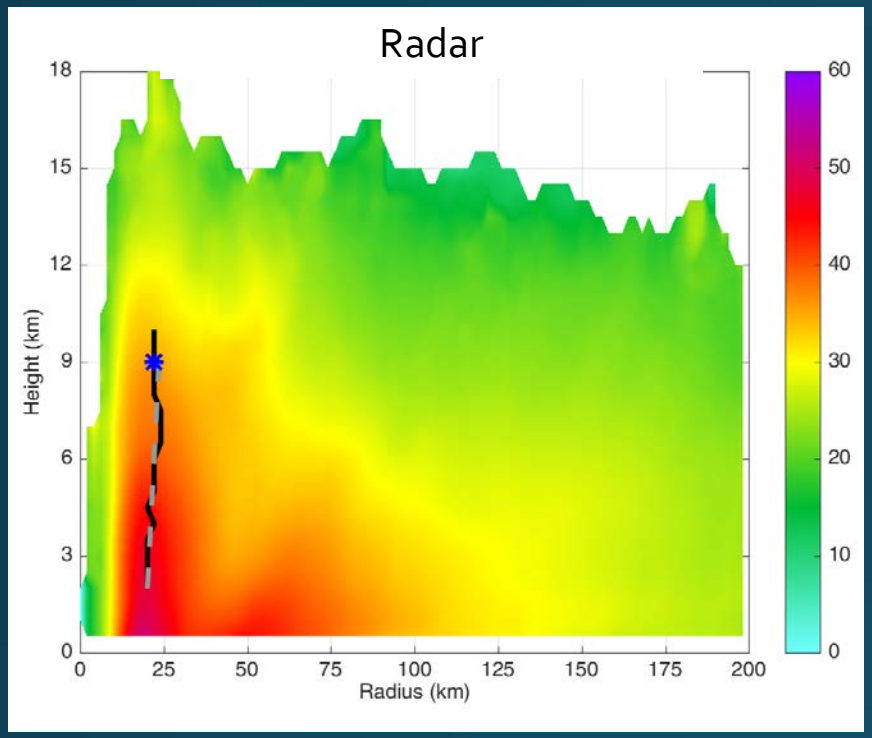


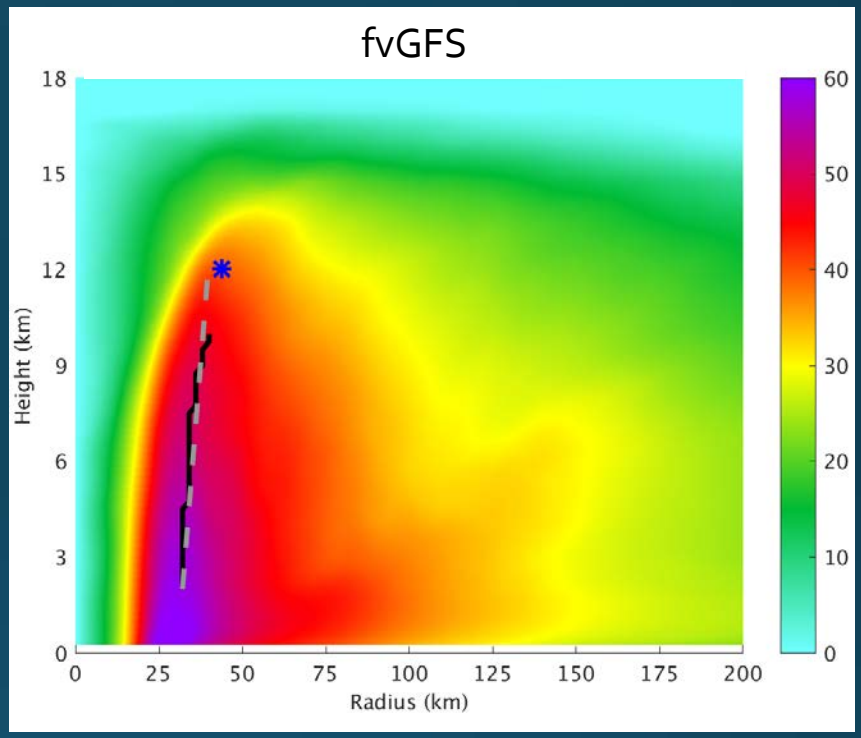


-Inner eye too large

-Spiral band structure similar to observations

Matthew 2016: Hour 48 Azimuthal Mean Vt





-Model TC is somewhat too strong/deep
-Double maximum similar to observations though
-Model/**radar** structure parameters:
RMW: 32 km/20 km, *Vortex Depth*: 12 km/9 km, α: 0.40/0.17

Conclusions

- High-resolution nested fvGFS shows promise in forecasts of TC track, intensity, and structure
- High bias after peak intensity potentially due to lack of ocean coupling (future upgrade)
- Model generally struggles with small RMW, but can produce them (Danny)
- Model able to simulate secondary-eyewall-like features, although the scale is imperfect
- Further upgrades should lead to further reduction of intensity and structure biases