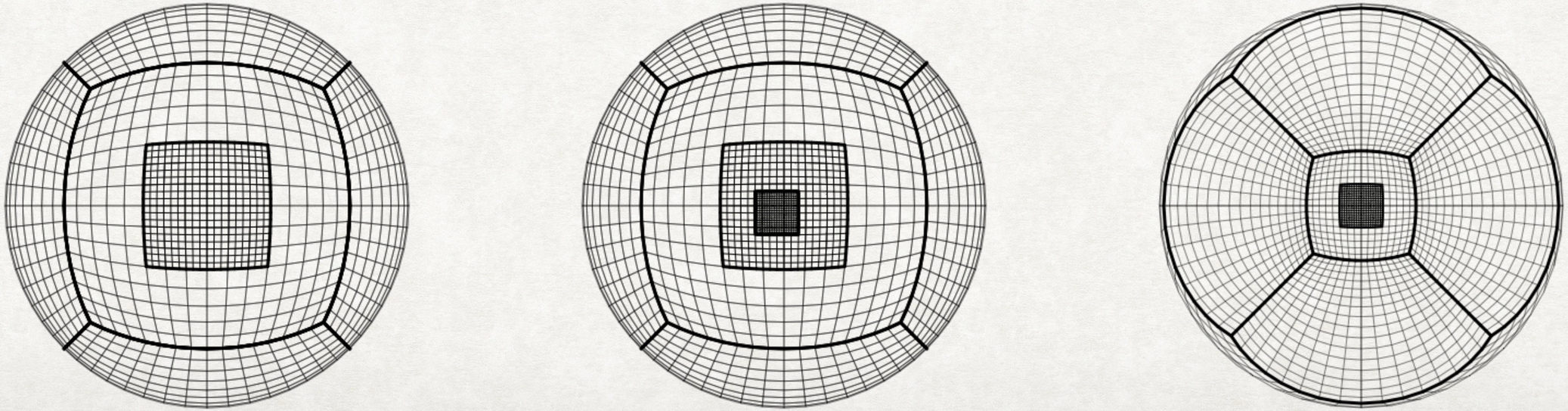
NESTED fvGFS DEVELOPMENT AT GFDL

LUCAS HARRIS
AND THE GFDL FV^3 TEAM

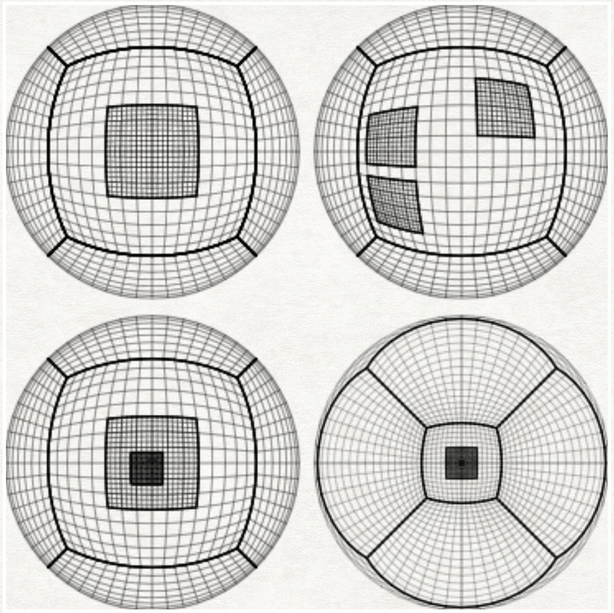
GRID REFINEMENT IN FV^3

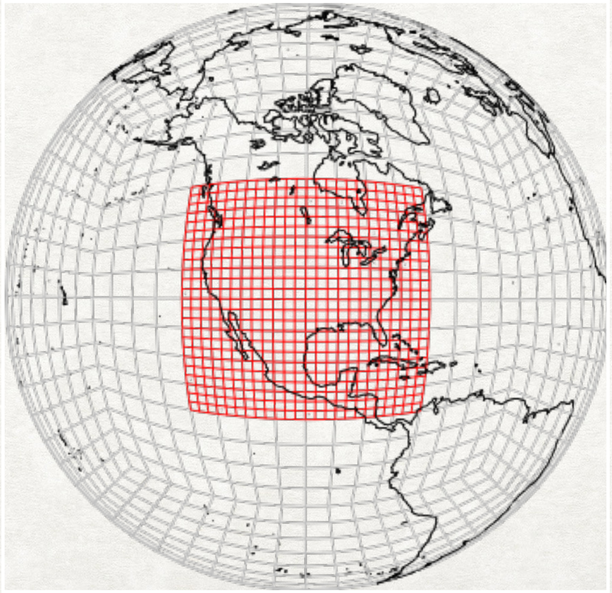
- FV^3 supports both grid stretching and two-way grid nesting
- Grids can be constructed on-the-fly within seconds.
- Both techniques have strengths and weaknesses:
  Combining the two leads to the best results



TWO-WAY NESTING IN FV^3

- Simultaneous coupled, consistent global and regional solution. No waiting for a regional prediction!
- Different grids permit different parameterizations and timesteps; doesn't need a "compromise" for high-resolution region
- Flexible! Great possibilities for combining nesting and stretching.





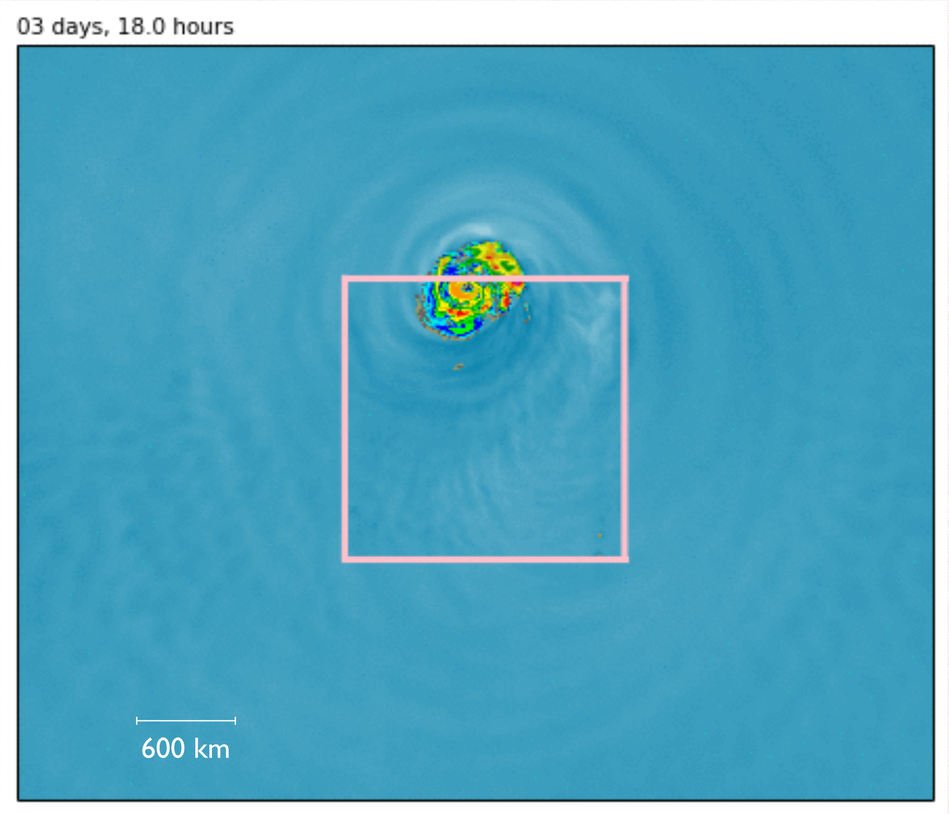
NESTED-GRID BCs

- Fill halo (ghost) cells with boundary conditions
  Correct upwind BCs “baked in” by FV’s upstream-biased fluxes
- Nonhydrostatic solver requires nonhydrostatic pressure, computed using the semi-implicit solver—consistent with interior algorithm
- **Concurrent nesting**: BCs extrapolated in time so nest and coarse grids can run simultaneously.
  Extrapolation is formally unstable but in practice not a problem
- New BC data updated at the nest interaction frequency, usually vertical remap frequency

TWO-WAY UPDATE

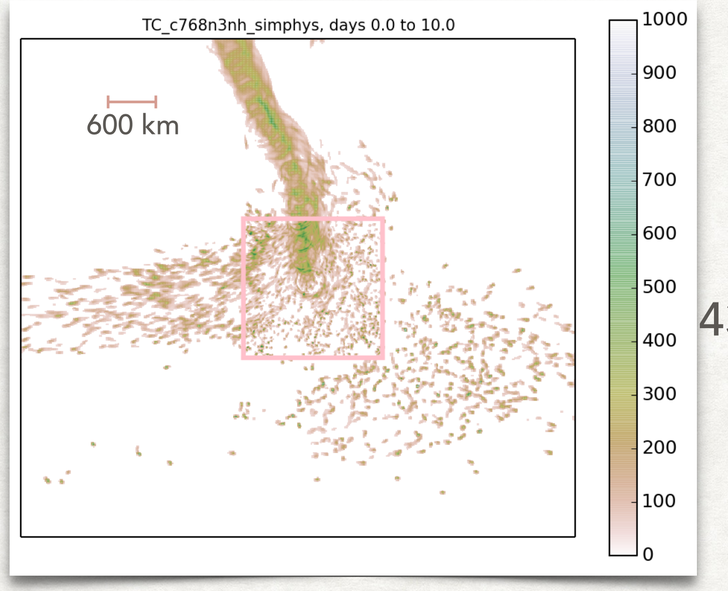
- Averaging update consistent with FV discretization
  - Cell average on scalars, including **ρ** and w
  - In-line average for winds, to conserve vorticity
- Our approach to mass conservation: Update everything except **δ**p (and tracers?)
  - Very simple! Works regardless of BC and grid alignment
  - **δ**p is the vertical coordinate: need to remap the nested-grid data to the coarse grid's vertical coordinate

REED-JABLONOWSKI TC TEST

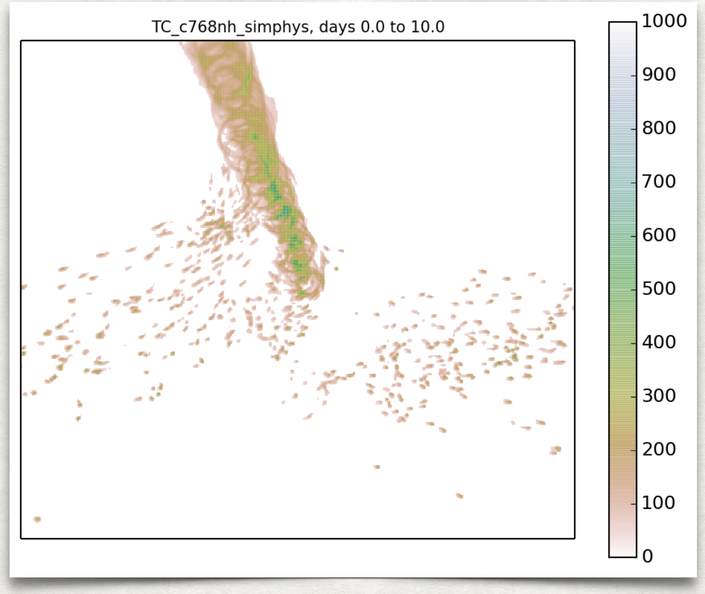


12 & 4 km, GFDL MP
total water vapor and radar reflectivity

10 day Accumulated rainfall



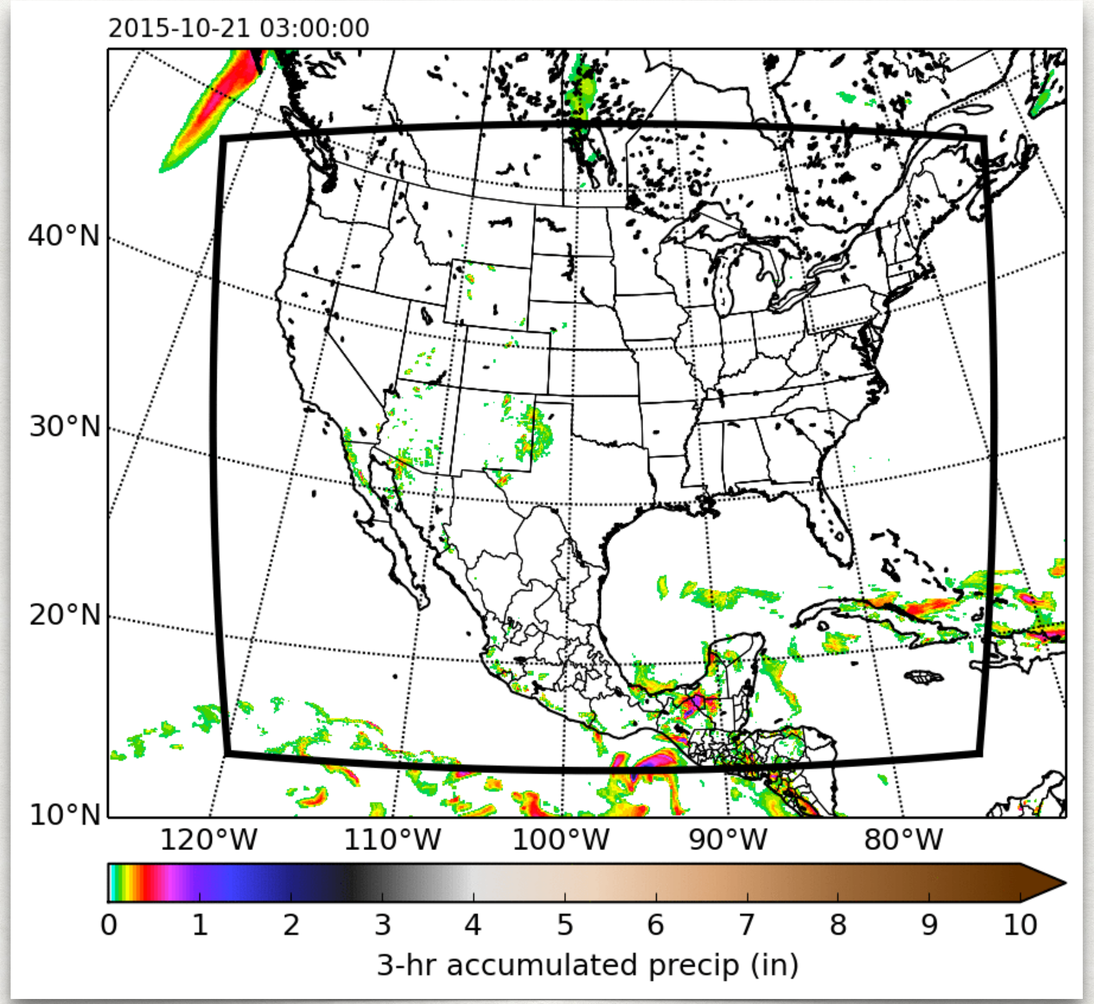
12 & 4 km
432 x 432 nest



12 km

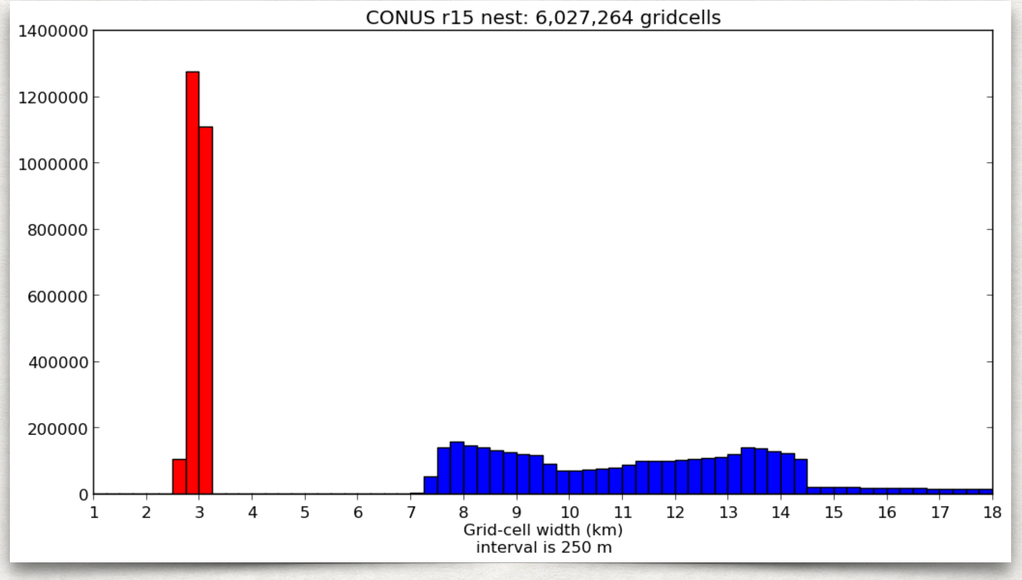
mm

3-KM NESTED fvGFS

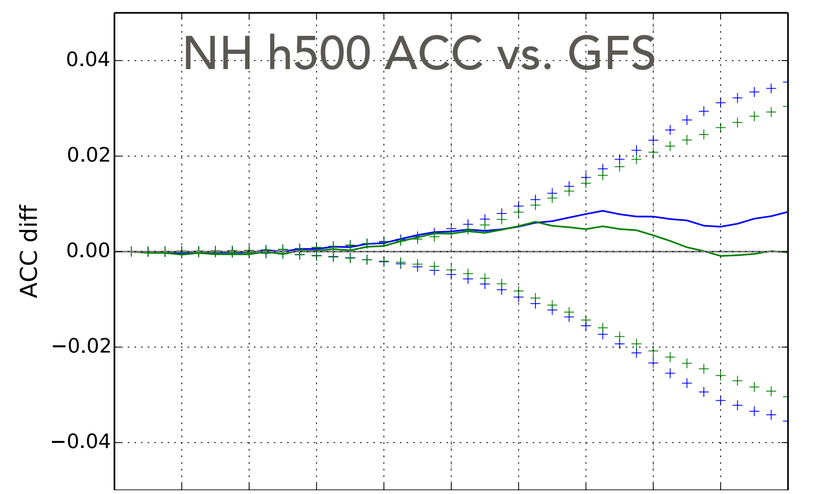


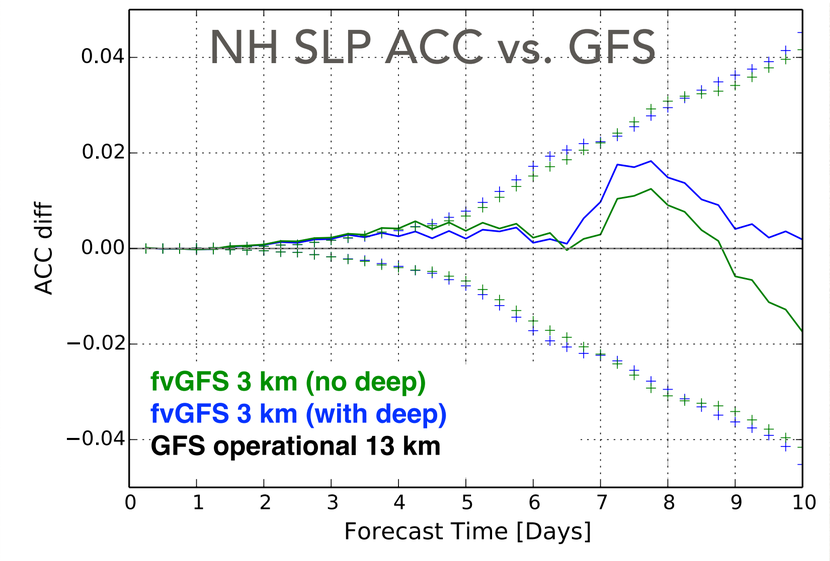
c768 (13 km) global grid
Stretched by 1.5,
factor-of-3 two-way nest

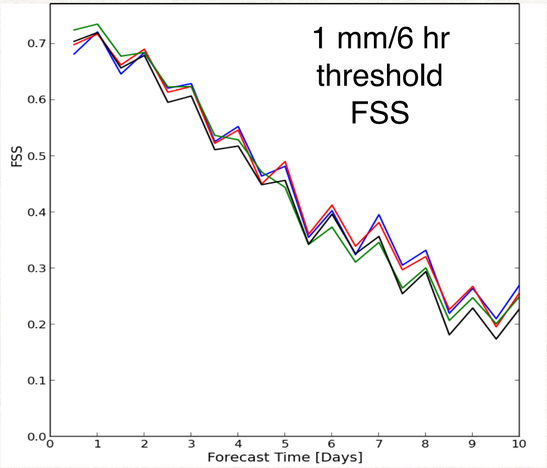
GFS Physics
with GFDL 6-category MP
GFS 63 levels



2015 HINDCAST SKILL IN NESTED fvGFS

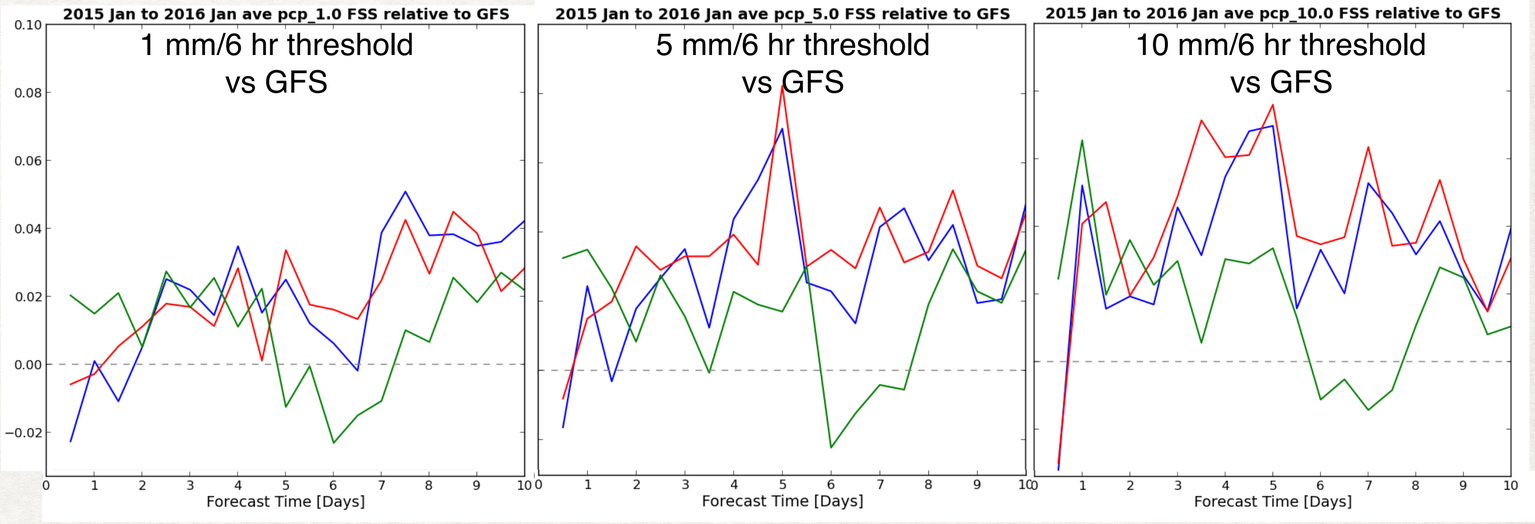






CONUS Precipitation Fractions Skill Score
12 km neighborhood for nested,
40 km for uniform

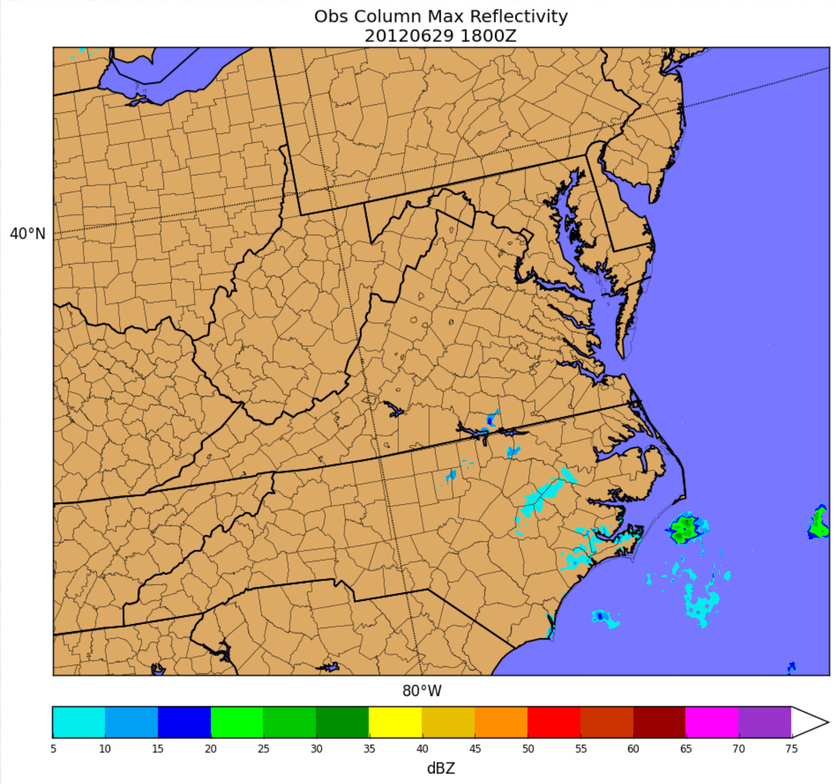
fvGFS 13 km
fvGFS 3 km (no deep)
fvGFS 3 km (w/ deep)
GFS 13 km



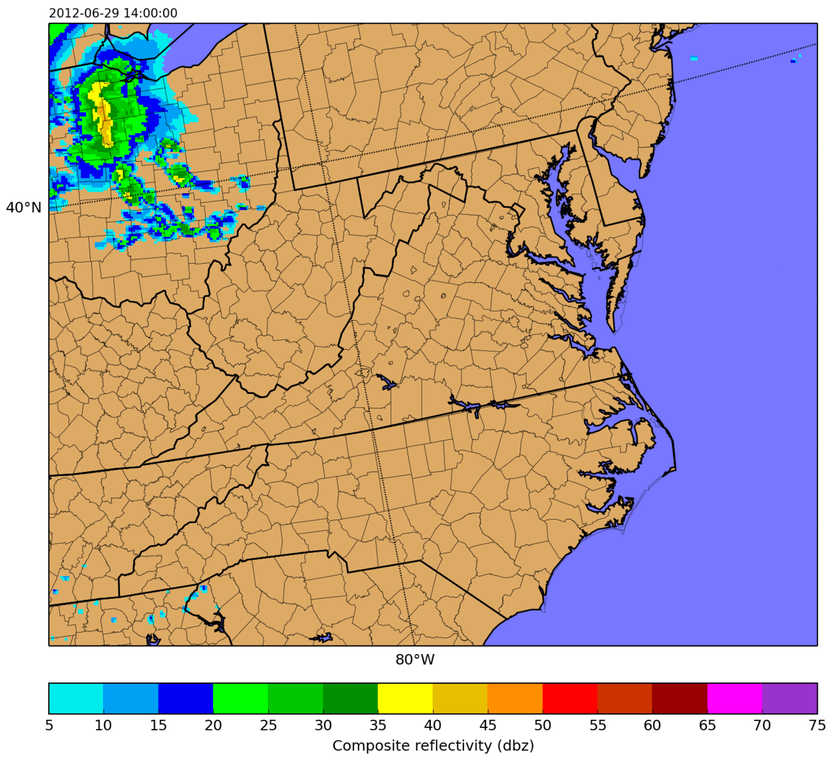
SEVERE CONVECTION IN fvGFS

2012 Derecho forecast initialized 00Z 27 June (72 hour lead)
No deep convection, tuned SAS-shallow and PBL

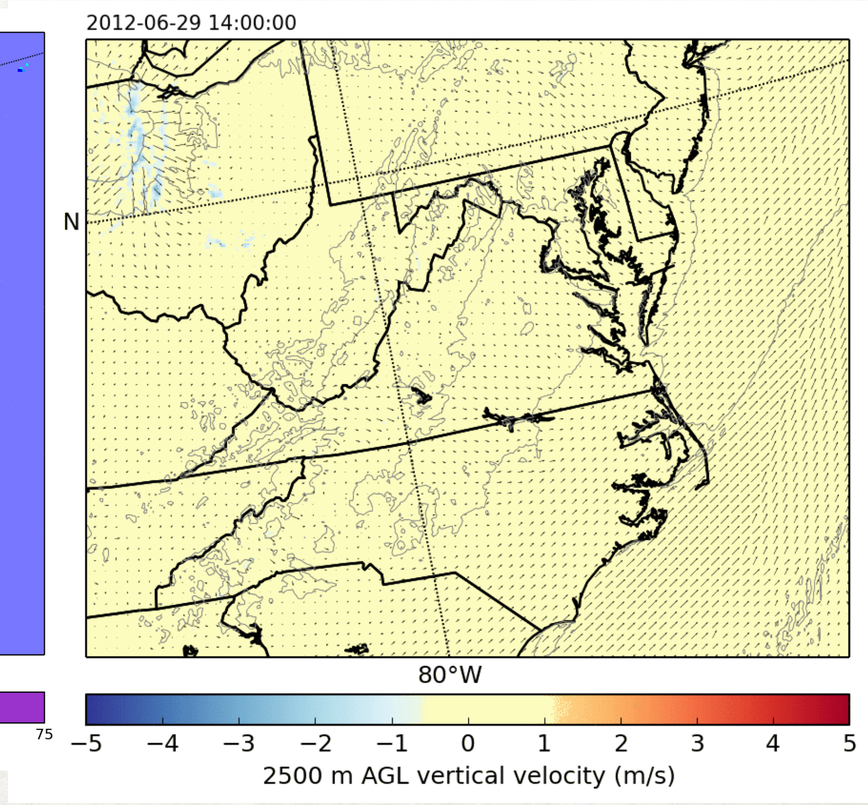
Observed
Composite Reflectivity



fvGFS
Composite Reflectivity (-4 hr)

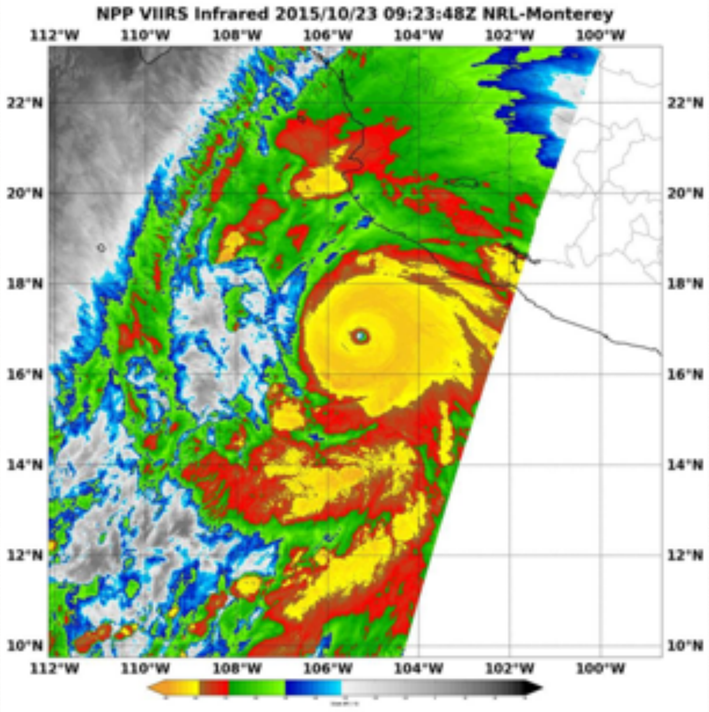


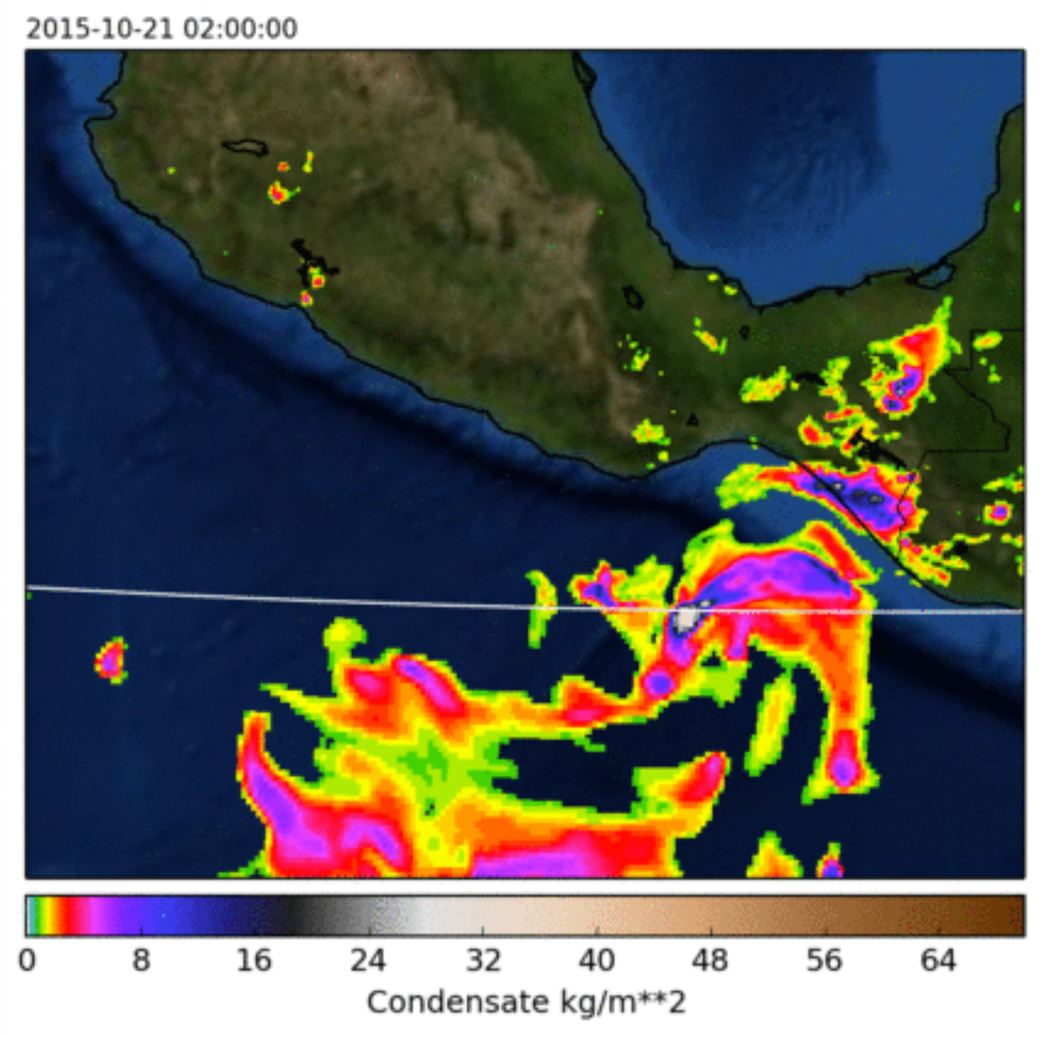
fvGFS
w2500 and lowest-level winds, T



HURRICANE PATRICIA

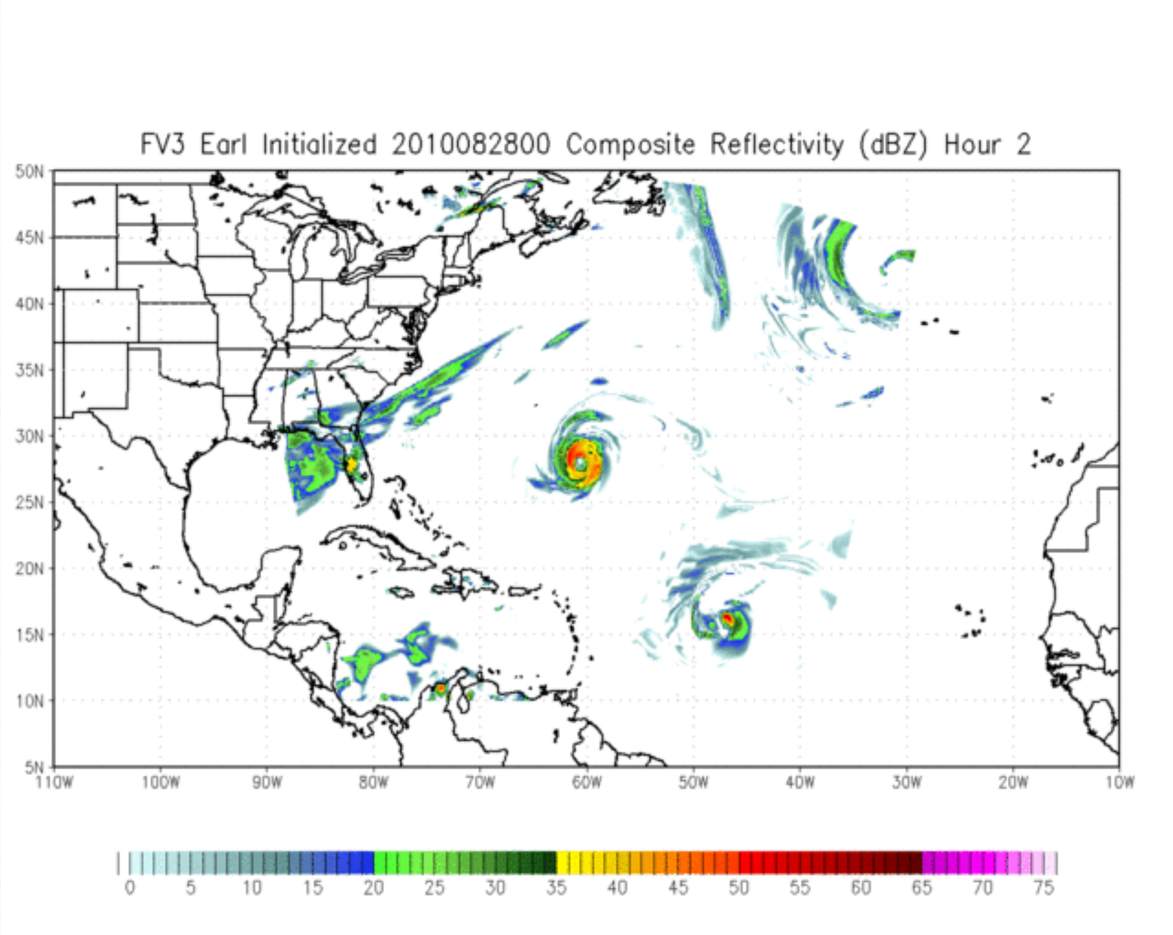
INITIALIZED 00Z 21 OCTOBER 2015
GFDL MP, SAS ON

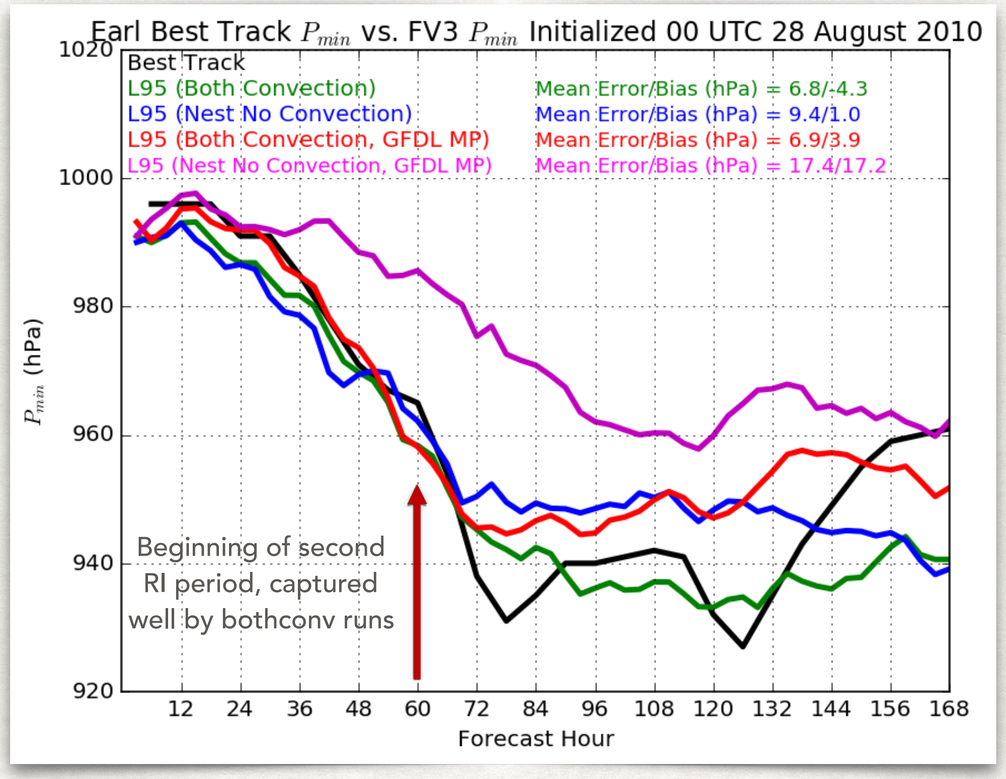




HURRICANE EARL

3 km nested grid
95 vertical levels
GFDL 6-category MP

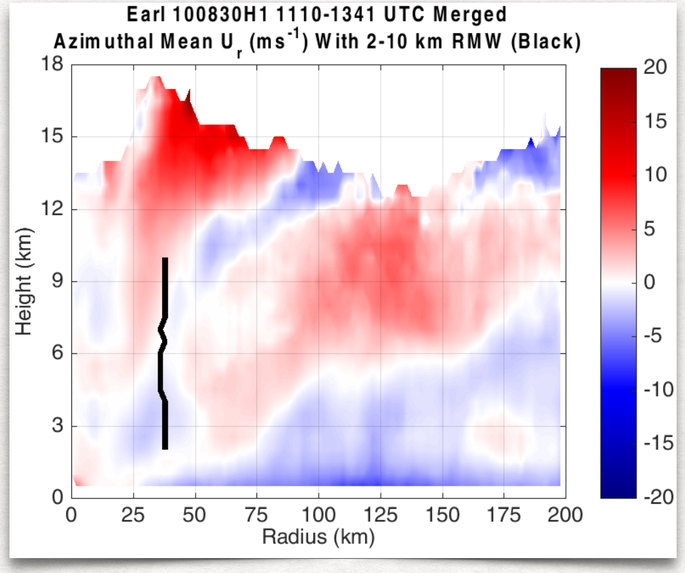


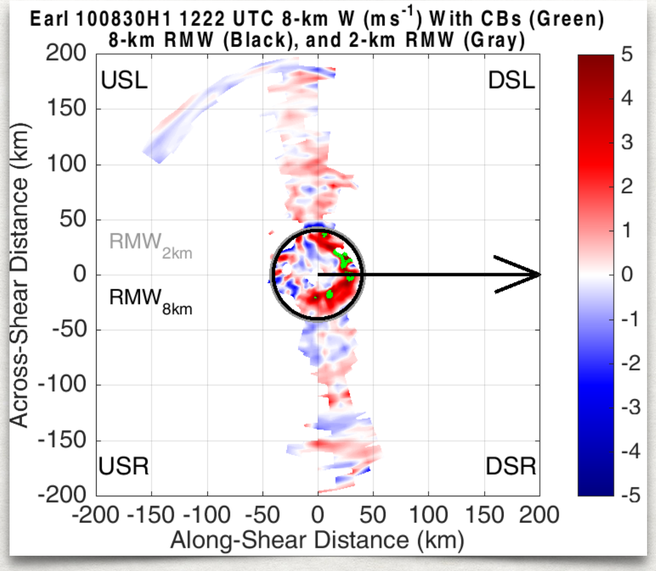


Courtesy
Andy Hazelton

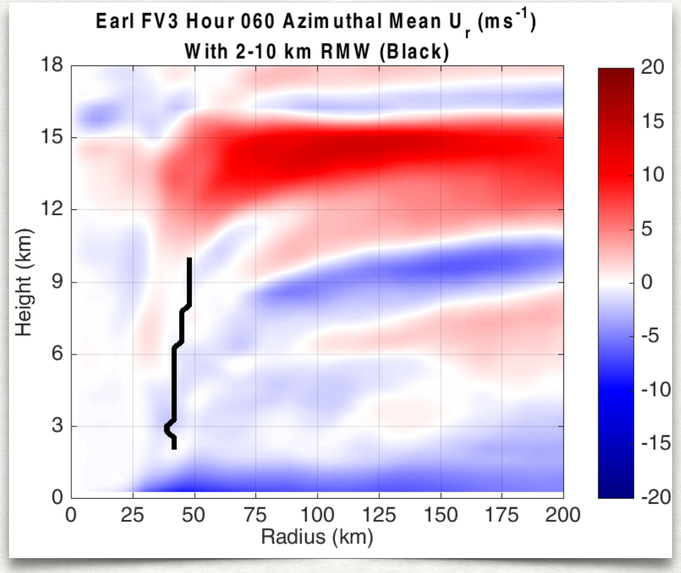
HURRICANE EARL

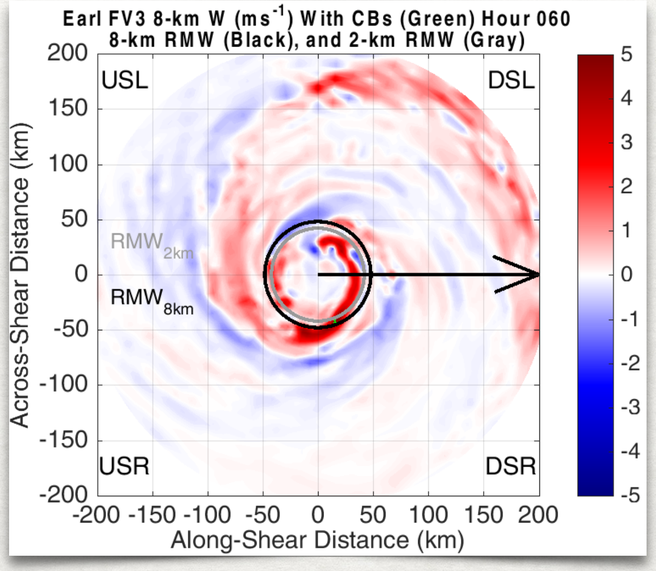
Radar Observations



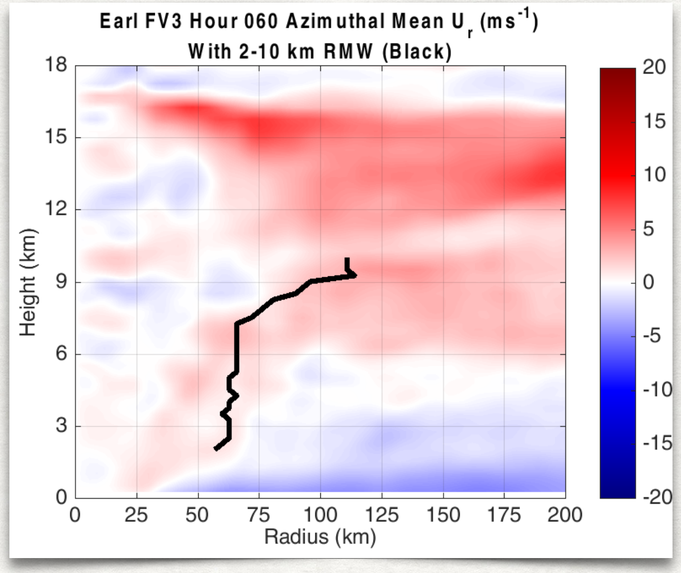


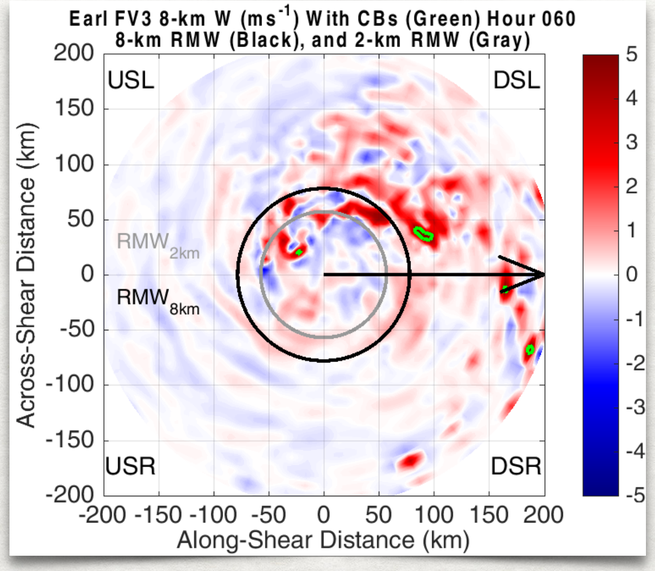
3 km fvGFS, SAS conv. ON





3 km fvGFS, SAS conv. OFF





PLANS FOR FVGFS

- Further alternative parameterizations:
  - Thompson, Ferrier, or M-G Microphysics (collaboration with OU-CAPS and EMC)
  - Scale-aware SAS or UW-GFDL convection
  - YSU, EDMF, or M-Y-type PBL
- Higher-resolution land model inputs