#5: Demonstration of Variable Resolution and Nesting Capabilities

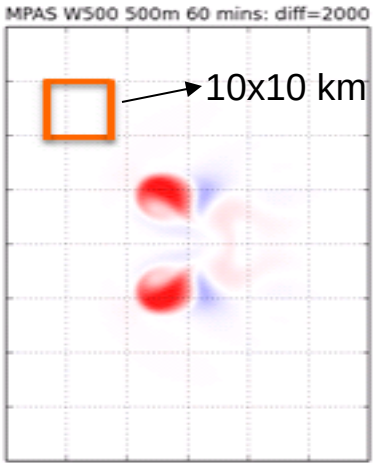
Includes simulations of convection in the high-resolution region, and includes supercell and tropical cyclone (TC) idealized tests

- Real-data forecasts:
  - Mesh varies from 13 km to 3 km over CONUS
  - GFS physics with deep convection disabled
  - Initial conditions for 2013051800 (Moore tornado) and 2012102418 (Hurricane Sandy), forecasts run to 10 days
  - MPAS used a non-uniform mesh, FV3 used a combination of a global stretched grid and a nest
- Idealized tests:
  - Since cases chosen involve severe convection and tropical cyclones, companion idealized tests used to isolate impact of dynamical core on simulations of these phenomena (with highly idealized physics and no mesh refinement)
  - Supercell test (DCMIP-2016, reduced sphere 0.51/2/4 km) also run in Phase I, but not with identical diffusion settings
  - TC test from DCMIP-2012 (full sphere, 13 km)

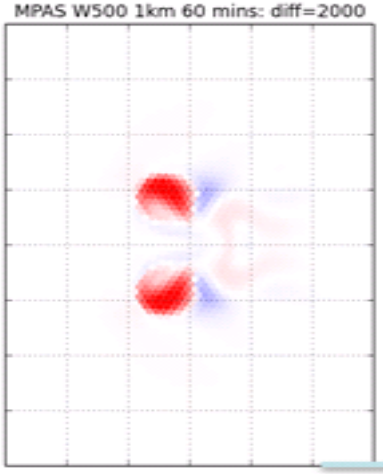
#5: Idealized Supercell Test

500 hPa Vertical Velocity (m/s), All Resolutions

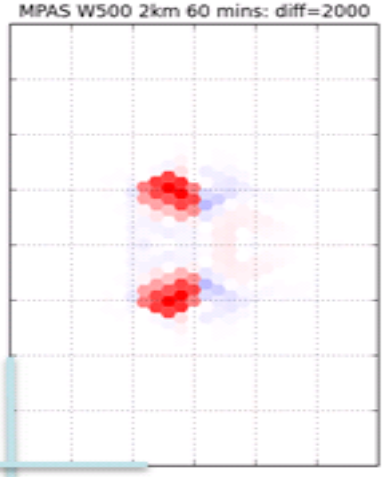
MPAS 500 m



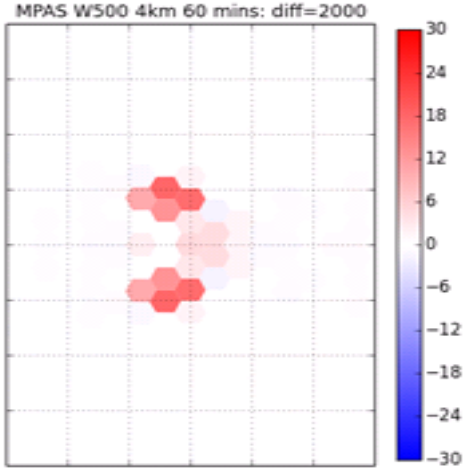
MPAS 1 km



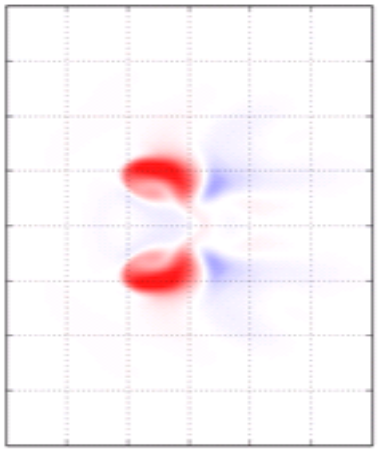
MPAS 2 km



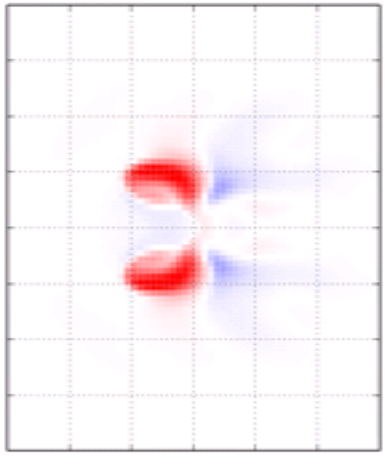
MPAS 4 km



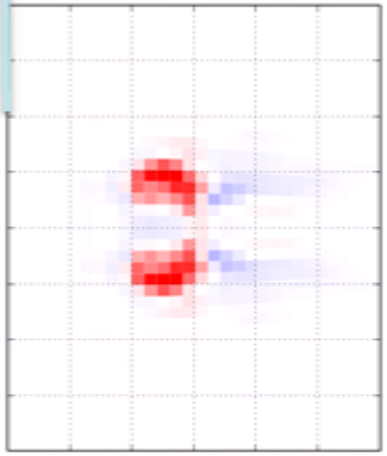
FV3 500 m



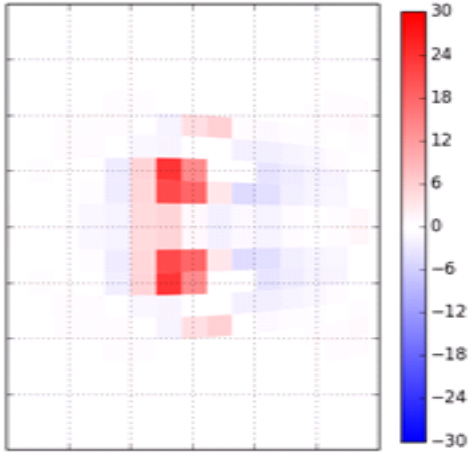
FV3 1 km



FV3 2 km

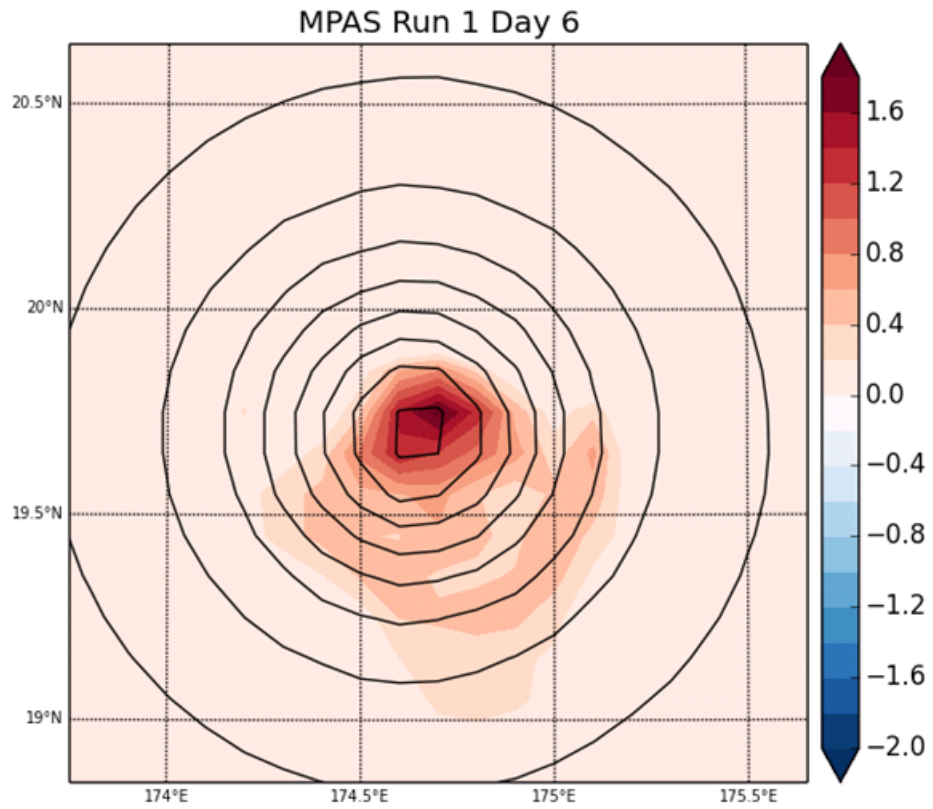


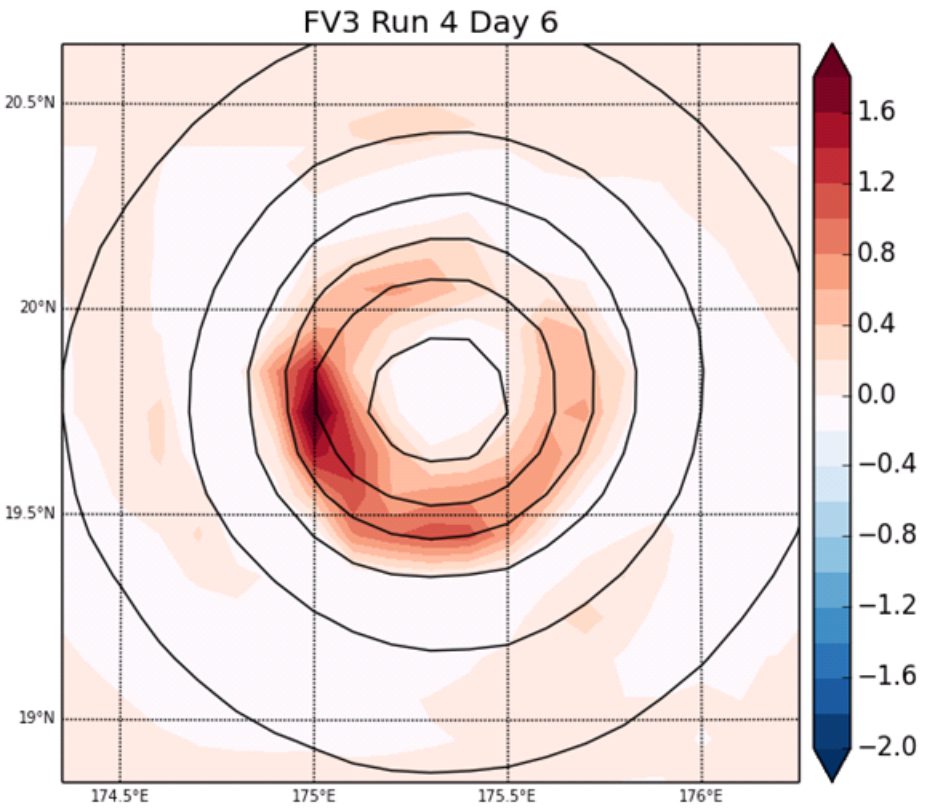
FV3 4 km



#5: Idealized TC Test

MSLP (black lines), 500hPa Vertical Velocity (color, m/s)





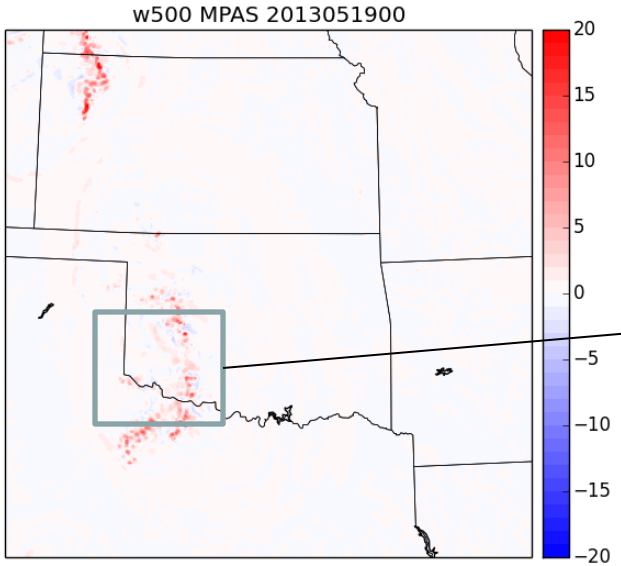
MPAS updraft is maximum in center of storm – no local minimum in eye.
FV3 updraft is still concentric, with subsidence in eye.

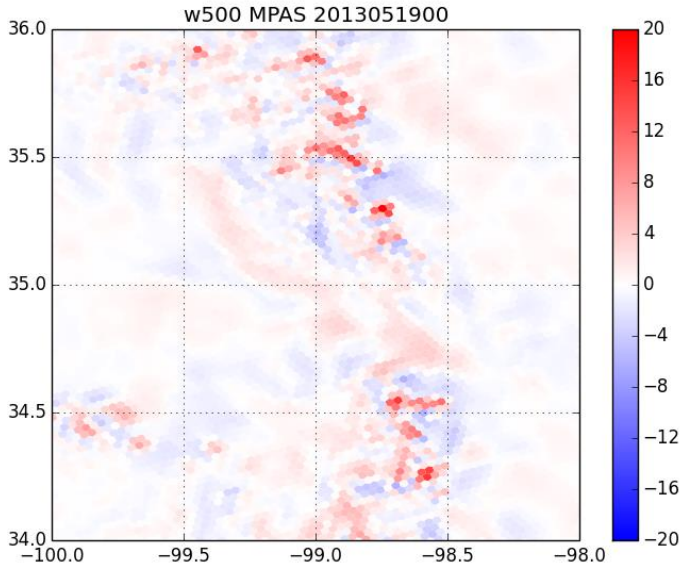
***MPAS real-data TC simulations did not have this structure.**

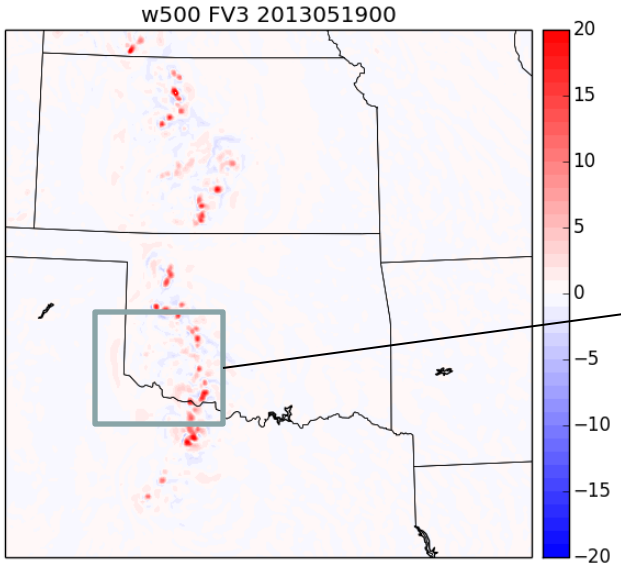
#5: Variable Resolution Tests

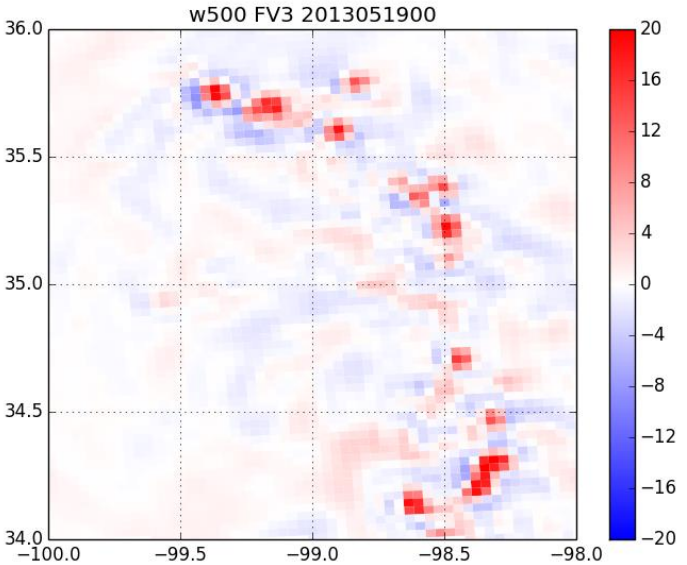
Moore Tornado Case – 24h Fcst Valid 00UTC May 19

500hPa Vertical Velocity (m/s)



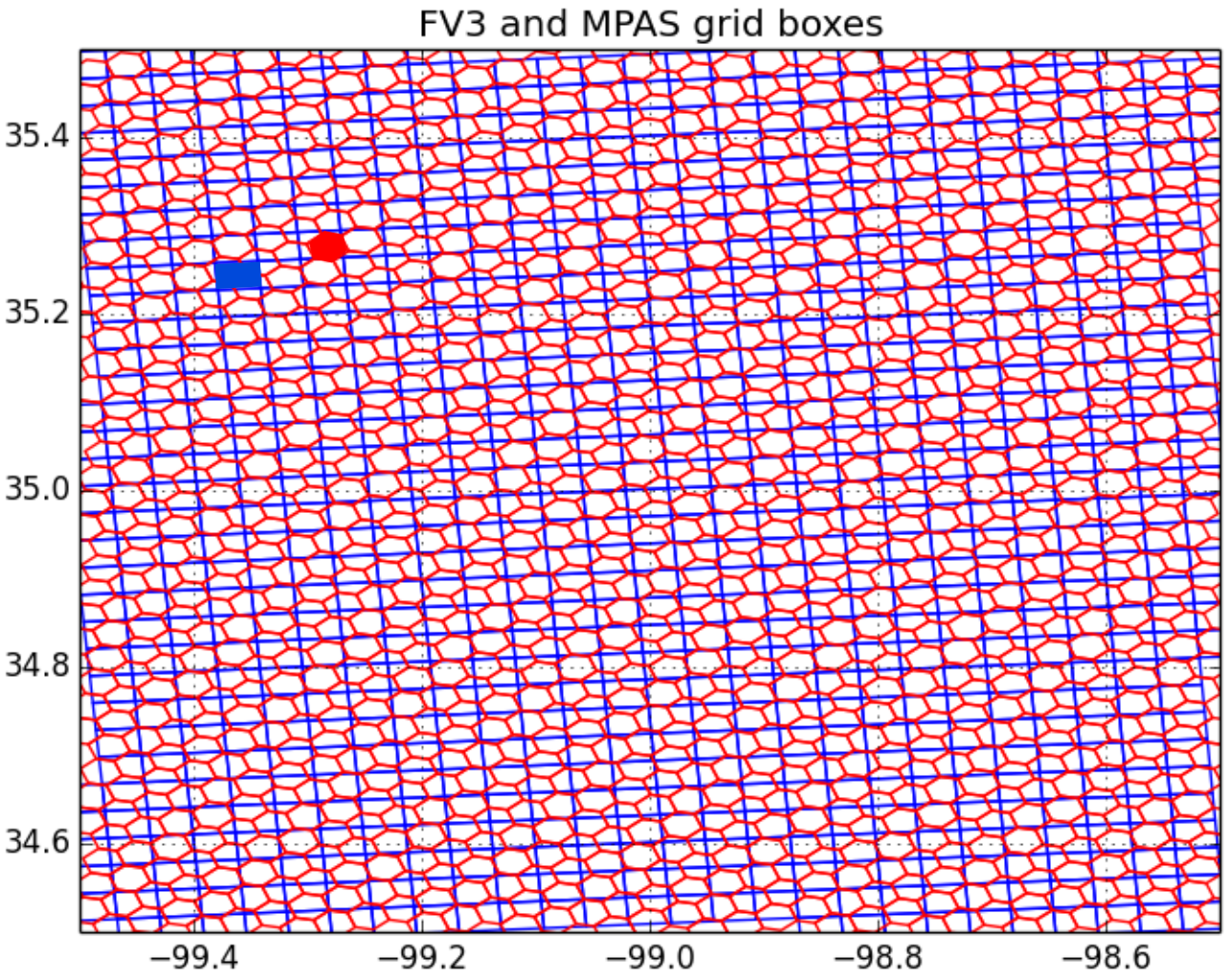






#5: Variable Resolution Tests: Grid Structure in Region of Interest

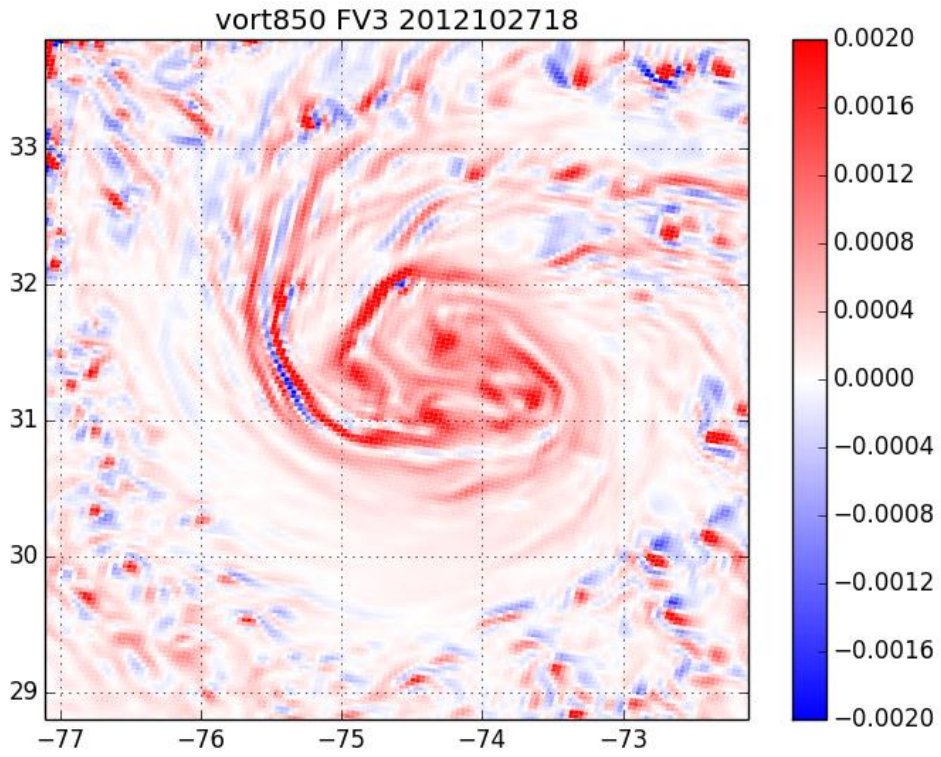
MPAS grid cells (red) are smaller in the region of interest

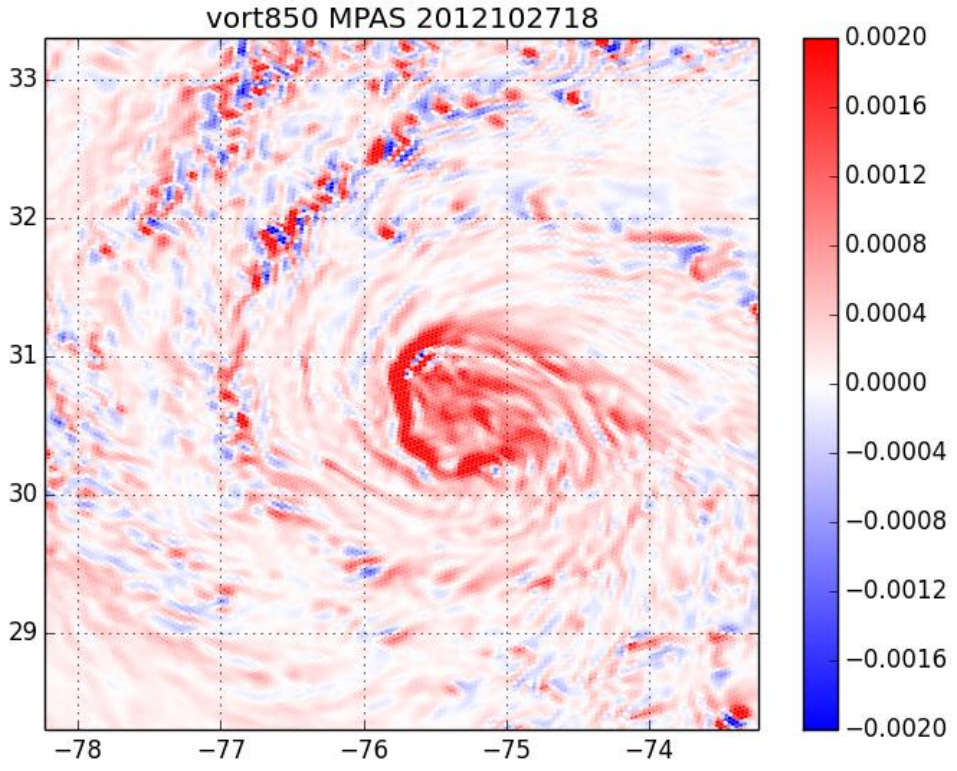


#5: Variable Resolution Tests:

Hurricane Sandy Case: 72h Fcst Valid 18 UTC Oct 27

850 hPa Vertical Vorticity (s^{-1})



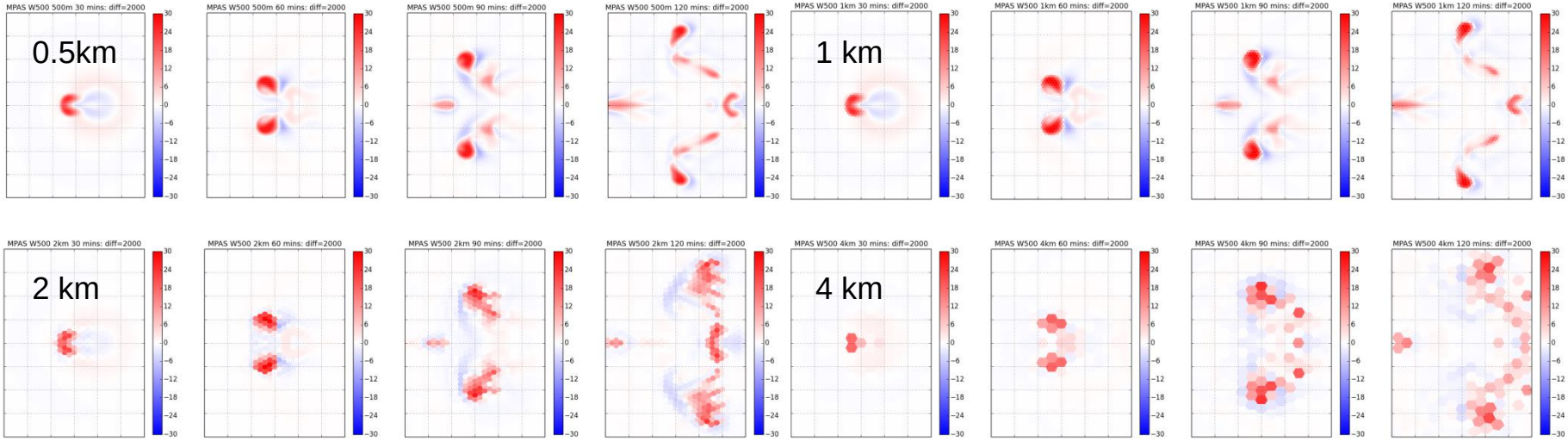


#5: Modifications to Phase 1 Supercell Test Case Configuration

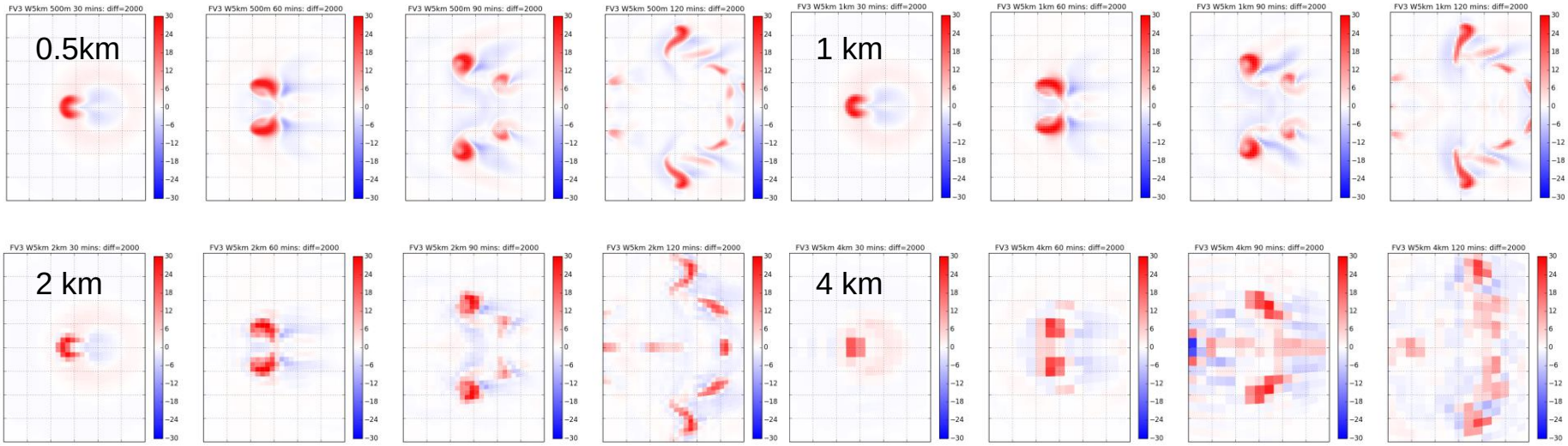
- MPAS
  - Disable vertical diffusion
  - Set Prandtl number to 1 (so that horizontal diffusion coefficient is same for all variables)
  - Physics timestep same as large RK step
  - Large RK step set to 3,6,12,24 seconds for 500m,1km,2km,4km resolutions
  - Number of acoustic timesteps per large RK step set to 6 in all cases
- FV3
  - Disable Smagorinsky diffusion by setting dddmp=0
  - Disable monotonic horizontal transport
  - Turn on 2nd order horizontal diffusion of tracers (using inline_q=.T. to ensure that tracers are integrated on the same time step as other prognostic variables)
  - Physics timestep set to 20,20,20,25 secs for 500m,1km,2km,4km resolutions
  - Number of vertical remaps per physics timestep (k_split) set to 8,5,2,1 for 500m,1km,2km,4km resolutions
  - Number of acoustic time steps per vertical remap (n_split) set to 5 in all cases

- With these mods, both models use constant 2nd order horizontal diffusion for all variables, no vertical diffusion. A horizontal diffusion coefficient of 2000 m^2/s is used, since it appears to produce a converged solution at 500 m for both models.

#5 Supercell Test: MPAS 500 hPa w

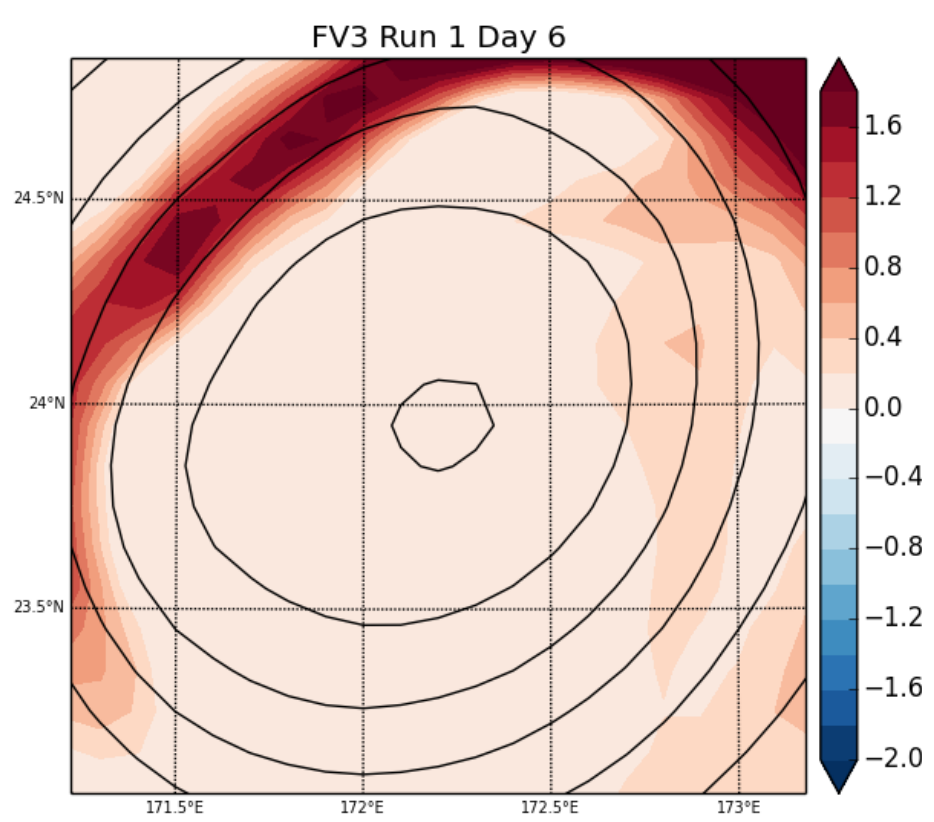


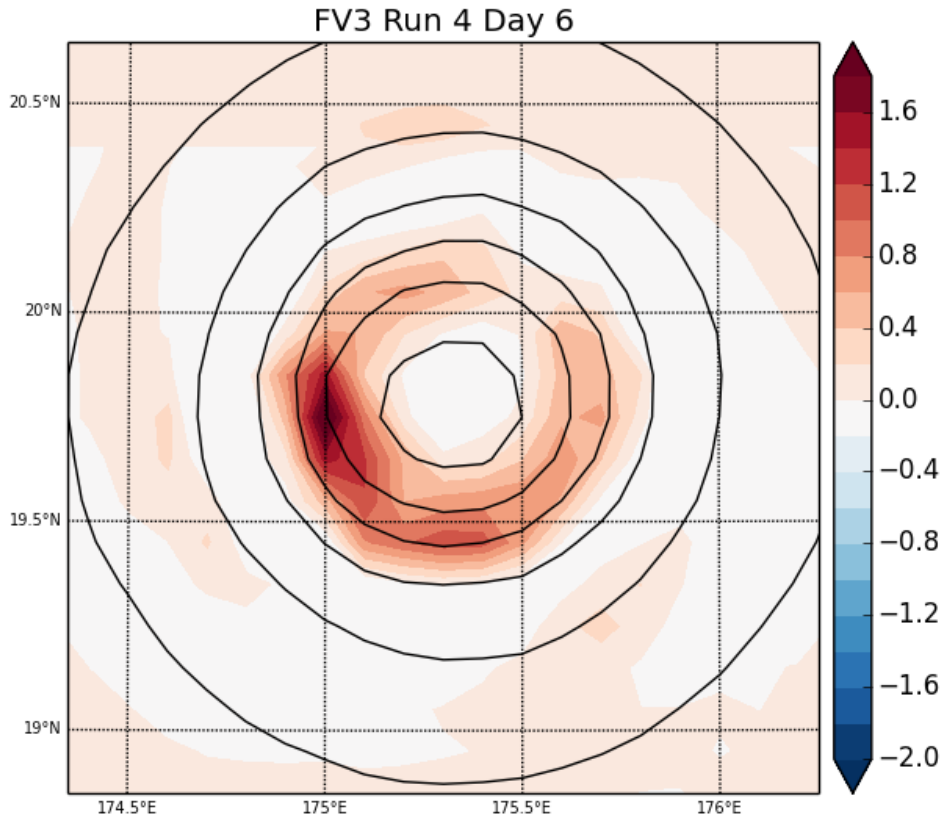
#5: Supercell Test: FV3 500 hPa w



#5: Idealized TC Test

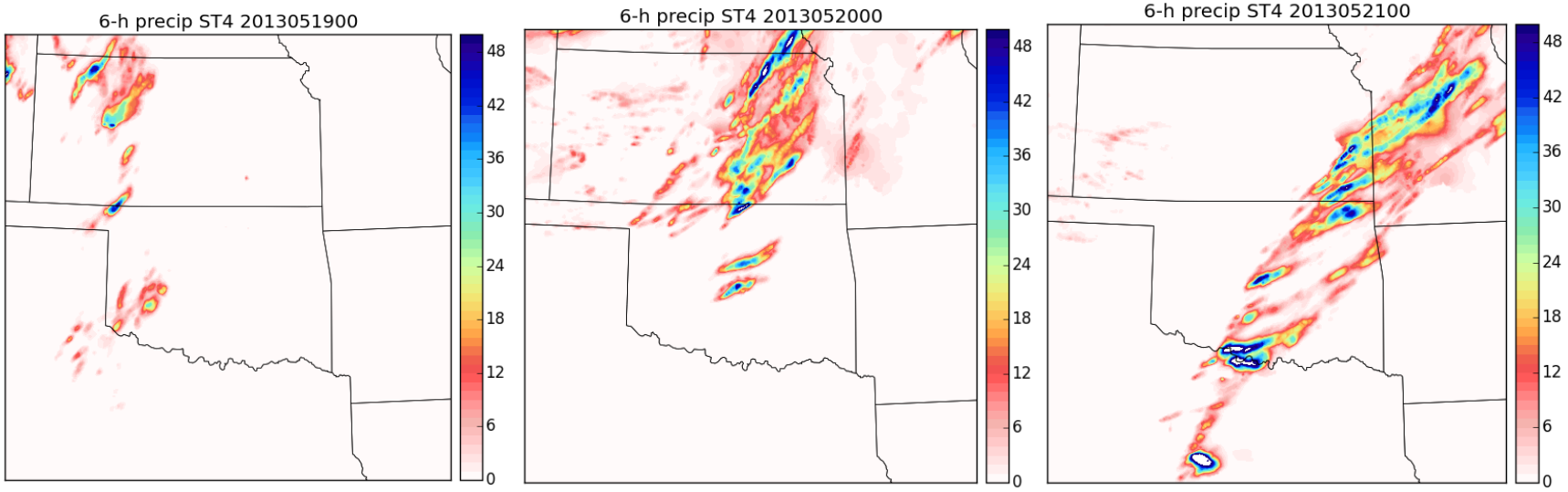
MSLP (Black Lines), 500hPa Vertical Velocity (color, m/s)



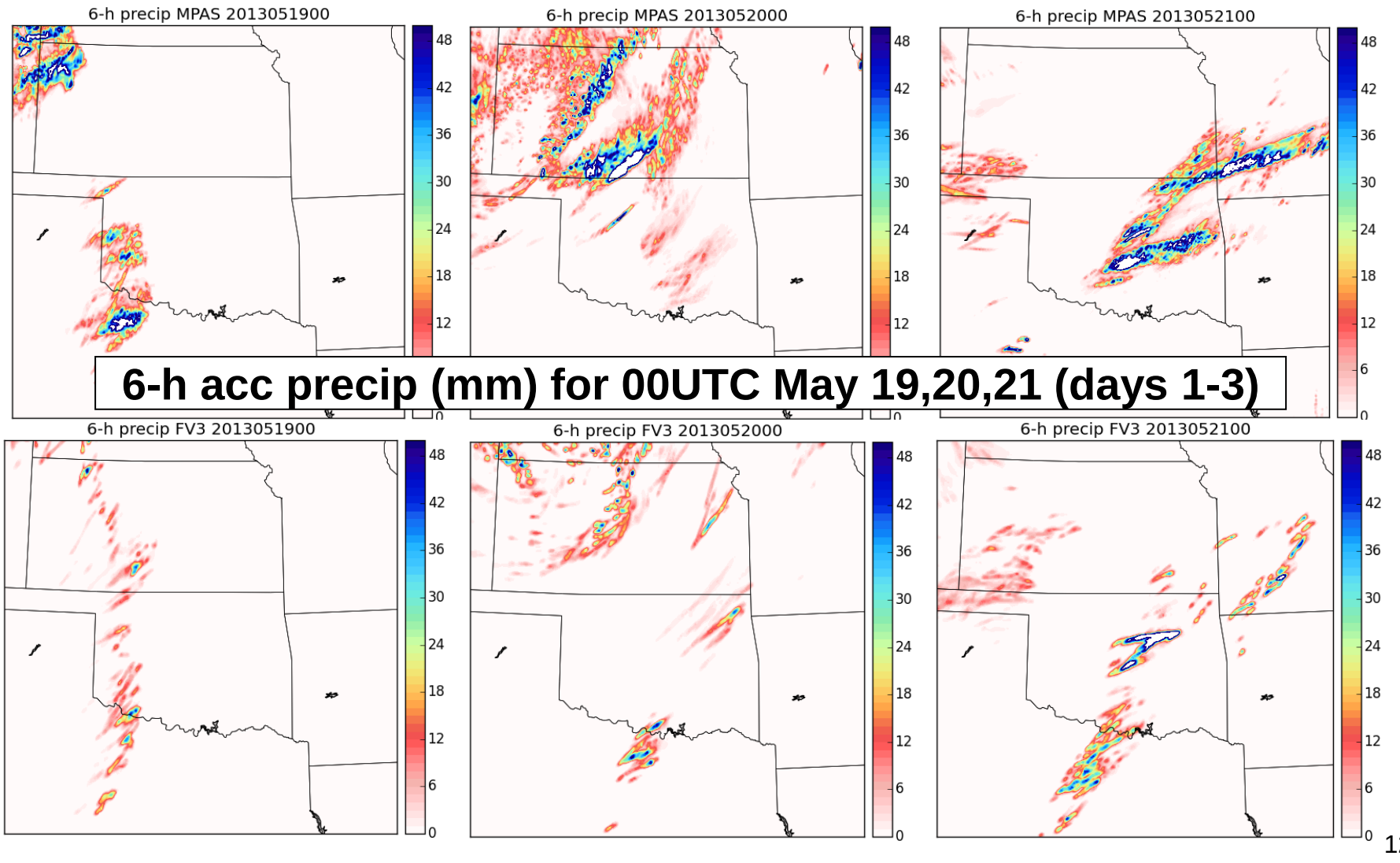


FV3 as originally configured has a huge eye (left); removing the vertical 2dz filter produced a much smaller, more realistic storm structure (right).

#5: Moore Tornado Case: Stage IV Precipitation Analyses



#5: Moore Tornado Case: Simulated Precipitation



#5: Moore Tornado Case: Simulated Total Cloud Condensate