High-Shear Low-CAPE Supercell Simulations

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Why high-shear low-CAPE?

- MLCAPE < 1000 J kg^{-1}: 49 percent of U.S. tornadoes [1]
- MLCAPE < 500 J kg^{-1}: 16 percent of significant tornadoes [1]
- Tornado watches [2] and warnings [3] are less accurate
- Radar detection is limited [4]

Are processes leading to supercell tornadogenesis different with lower CAPE?

Method

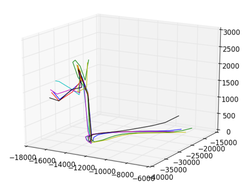
Idealized modeling with CM1 [5]

- Horizontally homogeneous base state taken from HRRR analysis of southeastern U.S. event
- Updraft nudging initiation
- 100-m horizontal grid
- Lowest scalar level 10 m AGL
- NSSL 2-moment microphysics [6]
- Free-slip bottom boundary

Comparisons across a CAPE spectrum

8 cases (7 shown) from 31 Mar 2016 with MLCAPE near or below 1000 J kg^{-1}

1 case (top row) from 27 Apr 2011



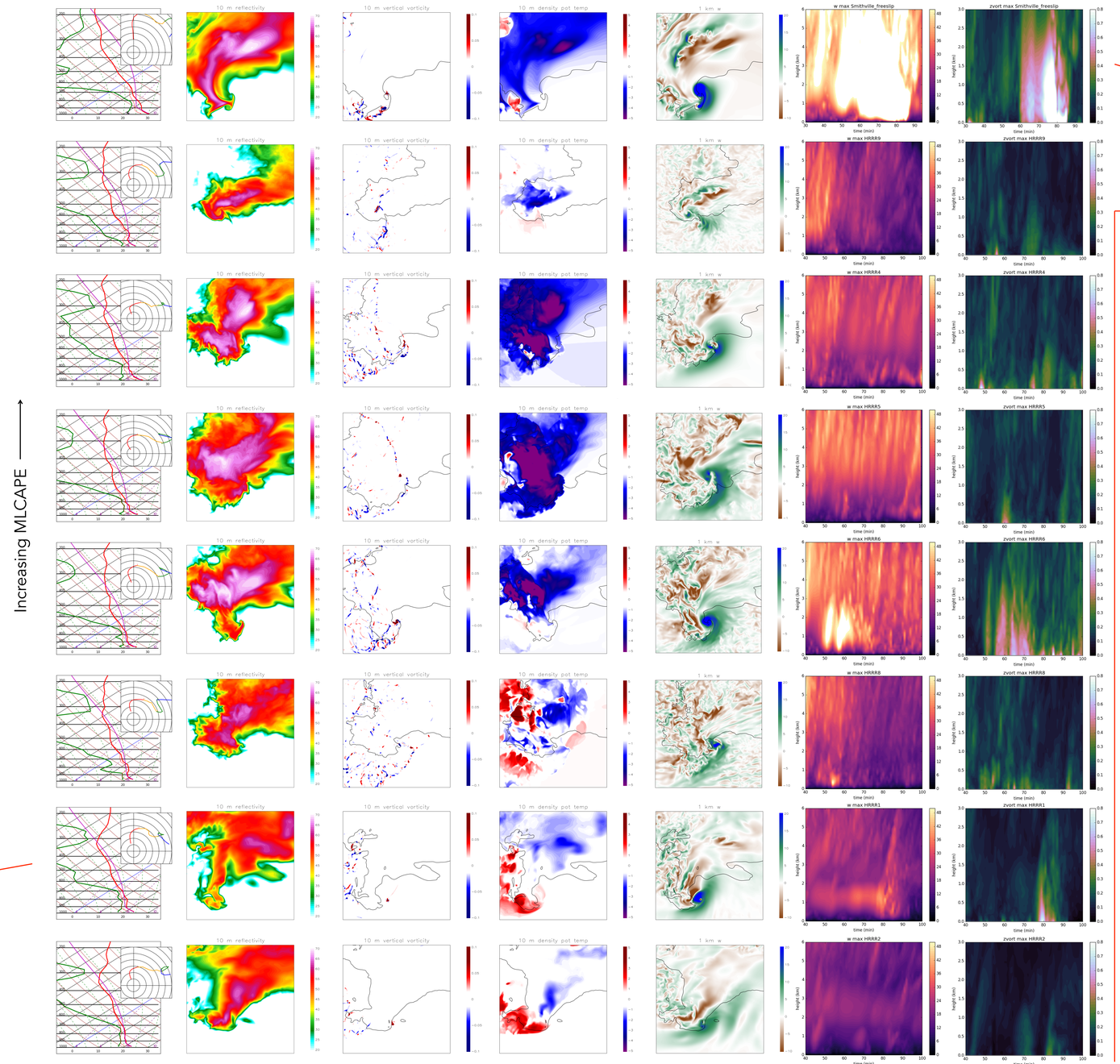
Parcels entering a low-CAPE vortex stop ascending, at least temporarily, at 1.5 – 2 km AGL

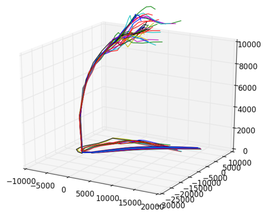
Skew-*T* log-*p* & hodograph

Peak time reflectivity, vertical vorticity, density potential temperature perturbations, 1 km *w*

Time-height updraft and vorticity maxima near mesocyclone

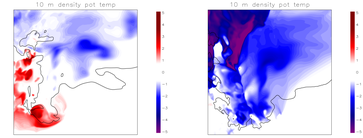
Increasing MLCAPE



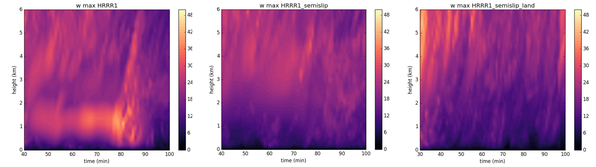


Parcels entering a high-CAPE vortex ascend monotonically to near the equilibrium level

Sensitivity to model physics



Density potential temperature perturbations in a low-CAPE case with NSSL [6] (left) and Morrison [7] (right) microphysics



Time-height maximum vertical velocities in the same case with (left to right) free-slip lower boundary, semi-slip water surface, and semi-slip land surface

Conclusions

- High-shear low-CAPE supercell vortices and their genesis are confined to relatively **low levels**, consistent with radar detection difficulties.
- Parcels in these vortices often **stagnate** near the shallow vortex top; high-CAPE vortex parcels continue upward to the equilibrium level.
- Some low-CAPE supercells produce **weak cold pools**, but use of density potential temperature still reveals baroclinity.
- Low-CAPE supercell simulations are sensitive to common differences in model physics. **Friction** has an unexpected effect—input appreciated!

Current and future work: reasons for sensitivity to bottom boundary condition, pressure gradient accelerations at top of low-CAPE vortices, inclusion of topography similar to southeastern U.S.

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