3B.20. ROADMAPS OF CONVECTIVE STORM ATTRIBUTES AS A FUNCTION OF ENVIRONMENT: PART 1: UPDRAFT OVERTURNING AND ROTATION EFFICIENCY AND STEADINESS

Eugene W. McCaul Jr.[1], J. Cody Kirkpatrick[2], and Charles Cohen[3]

[1]USRA Science Technology Institute, Huntsville, AL
[2]EUniversity of Indiana, Bloomington, IN
[3]University of Alabama in Huntsville, Huntsville, AL

USRA

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

Background

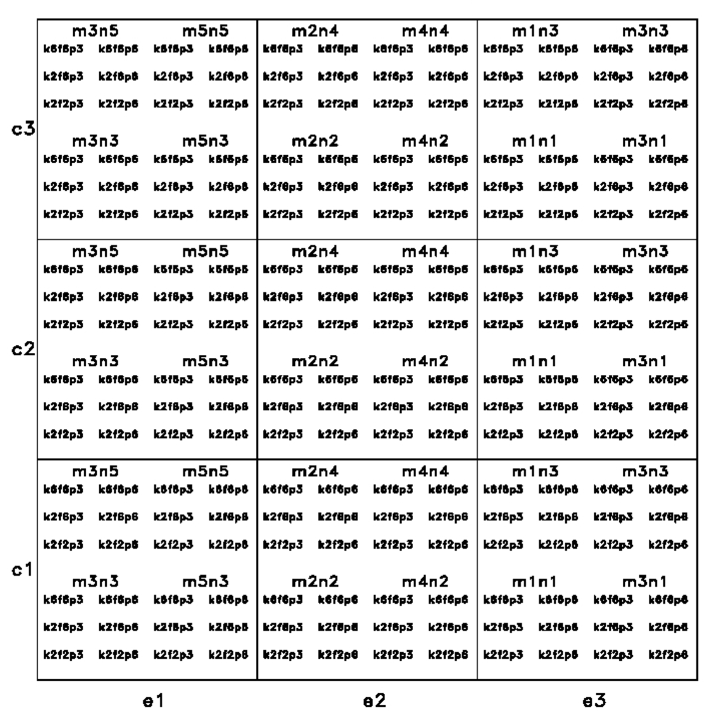
- The Convection Morphology Parameter Space Study (COMPASS) was designed to reveal patterns and trends in storm morphology (size, strength, rotation, persistence, etc.) as a function of position within a comprehensive 8D parameter space, using cloud simulations initialized with idealized profiles of T, q and u, v. It is assumed that the local vertical structure of the atmosphere dominates storm behavior.
- Profile parameters are: CAPE, Hodo. Radius, buoyancy profile shape, shear profile shape, LCL, LFC, PW (dictated by LCL T), and free tropospheric RH (FTRH) above the LFC.
- Choose 2 or 3 reasonable high and low values of each parameter, form all permutations, run simulations on each.
- Basic simulation set, using only high FTRH for completeness, s 216 expts. Nomenclature example:
- e2c2m4n2k2f6p3h9, where e denotes CAPE (1=800,2=2000, 3=3200 J/kg), c denotes hodo radius (1=8, 2=12, 3=16 m/s), m denotes buoyancy profile shape, n denotes shear shape, k and f denotes LCL and LFC altitudes (2=0.5, 6=1.6 km, with k2f6 featuring an 0.5 km LCL and 1.6 km LFC, with a moist adiabatic profile between), p denoting LCL T (3=3 cm PW, 6=6 cm PW), and h denoting FTRH.

Methodology

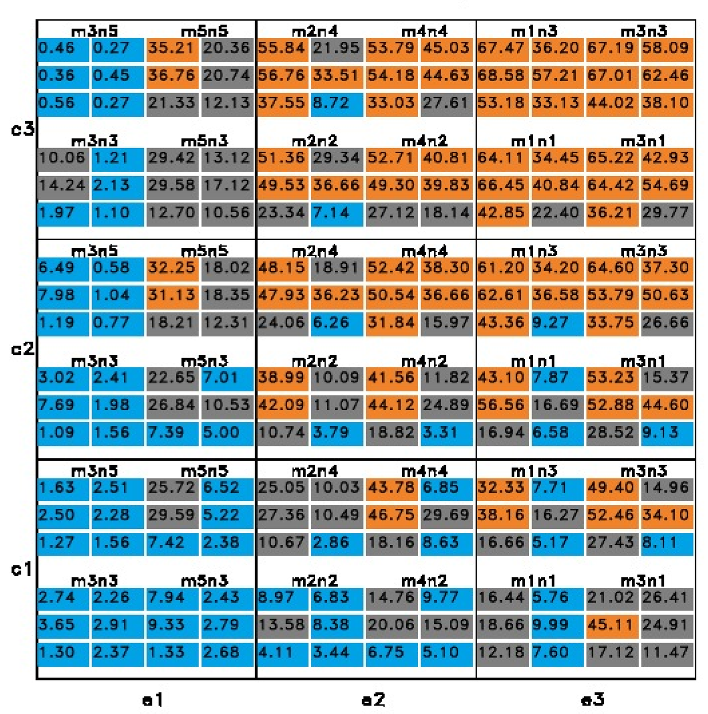
- Run 2-h RAMS simulations on each experiment, examine attributes of all the simulated storms. Used RAMS 3b with 1-moment microphysics, Smagorinsky-Lilly turbulence schemes, with no Coriolis.
- Used 500 m x,y mesh, z mesh stretched thru 20 km, sponge layer up to 24.5 km; dt=3.0 s, all data saved every 5 min.
- Spheroidal warm bubbles with 3K warmth used to initialize.
- All subcloud layers have theta-e independent of z; p3 cases have 321 K, p6 cases have 354 K.
- All subcloud layers have small positive lapse rates of theta, to ensure Ri stays large enough to prevent spontaneous mixout; we have verified that starting profiles are maintained on storm inflow sides of domains for all simulations, so that integrity of all experiments is not compromised by mixout of CAPE, shear, etc.
- Assess and tabulate means and extremes of many storm attributes, with special emphasis on 60 < t < 120 min data.

Results

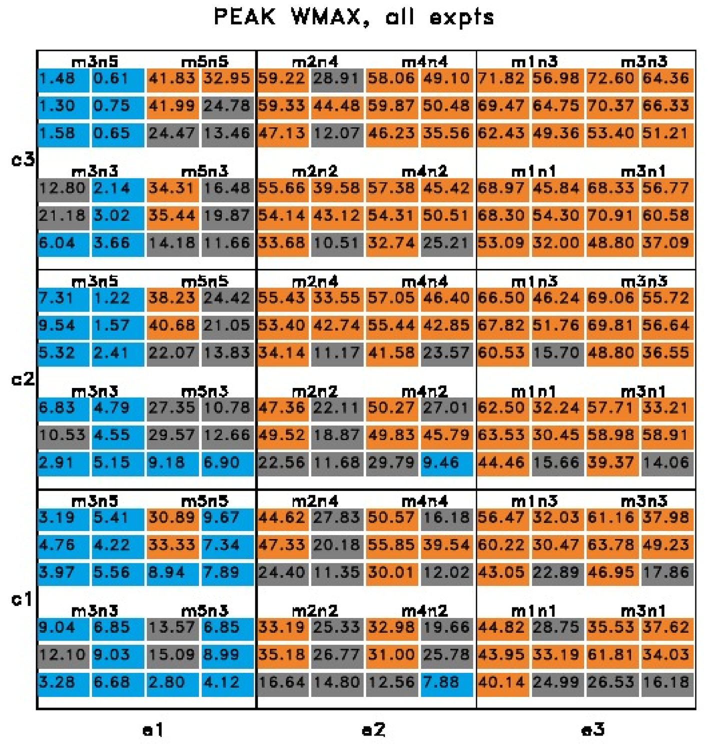
- Peak WMAX updraft efficiency (UE) can exceed 1.0 in CAPE=800 environments, when compressed b profiles cause latent heat of fusion to boost W at low altitudes, thus boosting WMAX aloft. UE is larger when PW is small.
- At small CAPE, steep lapse rates just above LFC can make the difference between a strong supercell and a non-survivor.
- WMAX steadiness is large when shear is large and PW small.
- ZETA aloft is larger when shear and CAPE are both large. Rotation efficiency vs. SRH is surprisingly large at weak shear and large CAPE, but there SRH is small so ZETA is only moderate. ZETA is also steadiest at large shear, CAPE.
- ZETA at z=0 is largest when shear Is large. Again, surface rotation efficiency is largest at weak shear, large CAPE, but ZETA(0) is smaller and less steady than ZETA aloft, with only a few exceptions.



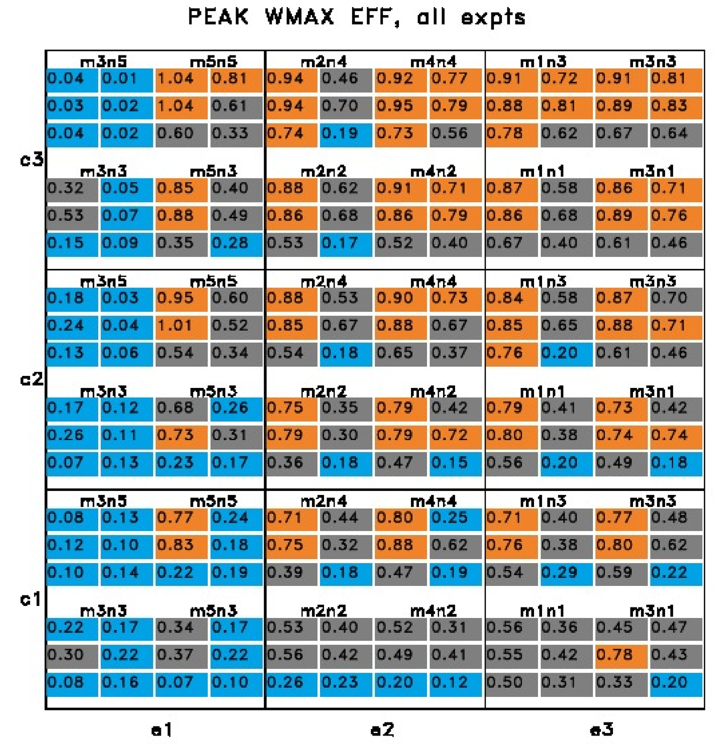
Mean peak WMAX, 60 min to 120 min



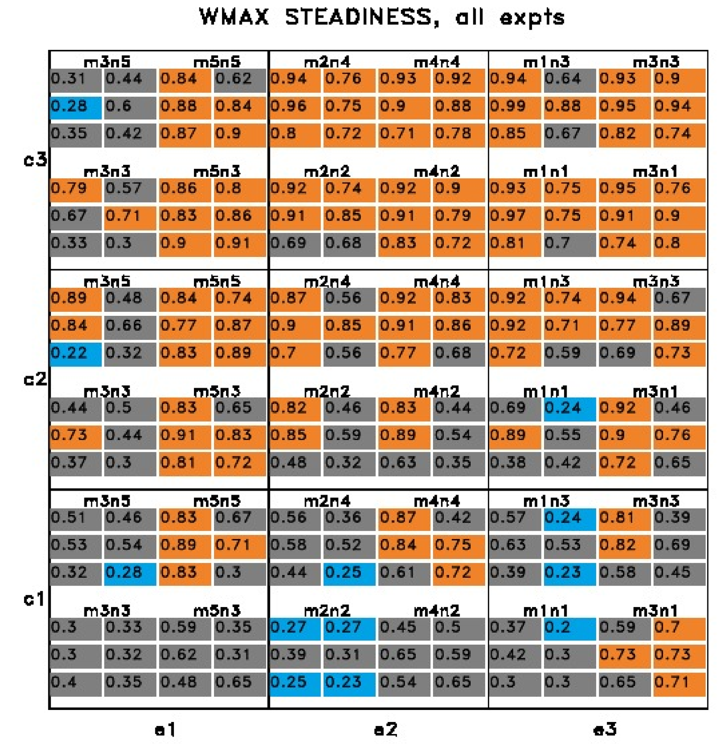
Extreme peak WMAX, 60 min to 120 min:

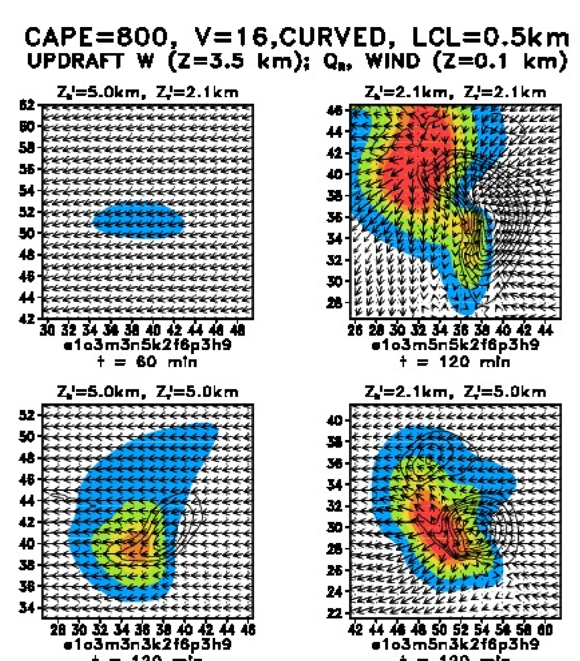


Peak updraft efficiency, 60 min to 120 min

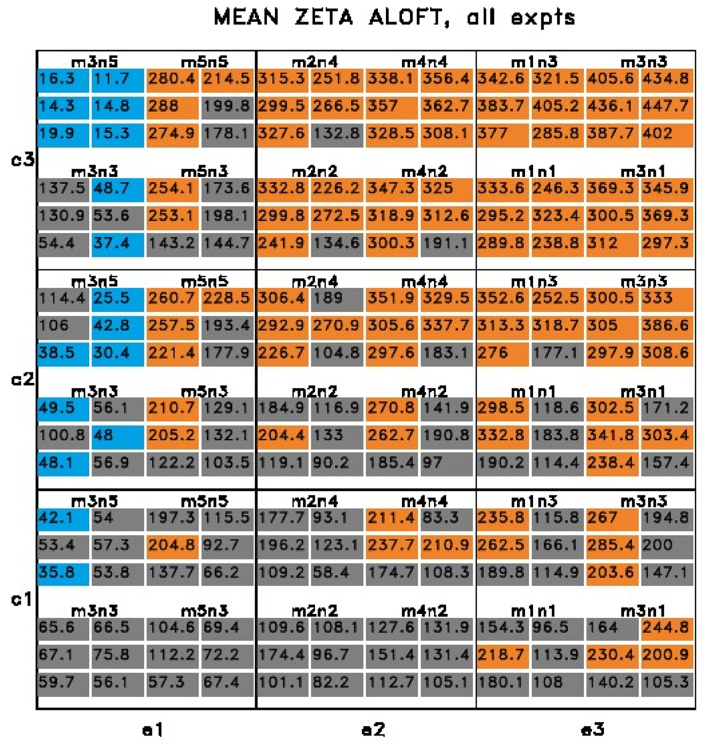


Peak updraft steadiness, 60 min to 120 min

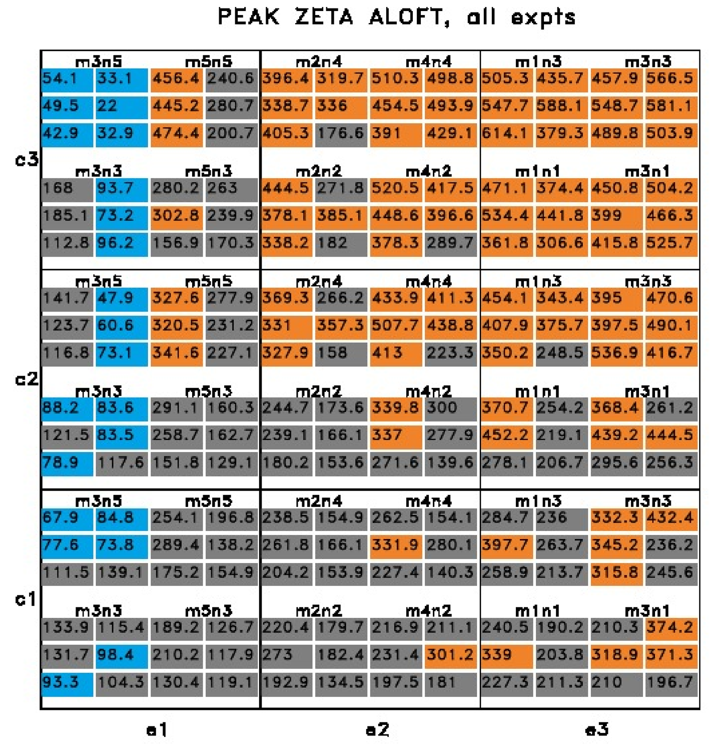




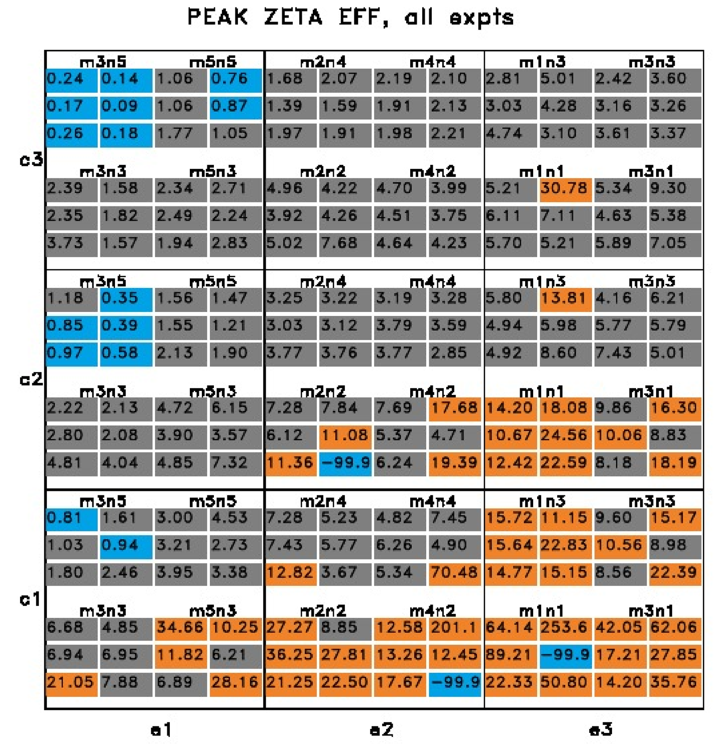
Mean peak ZETA (aloft) 60 min to 120 min



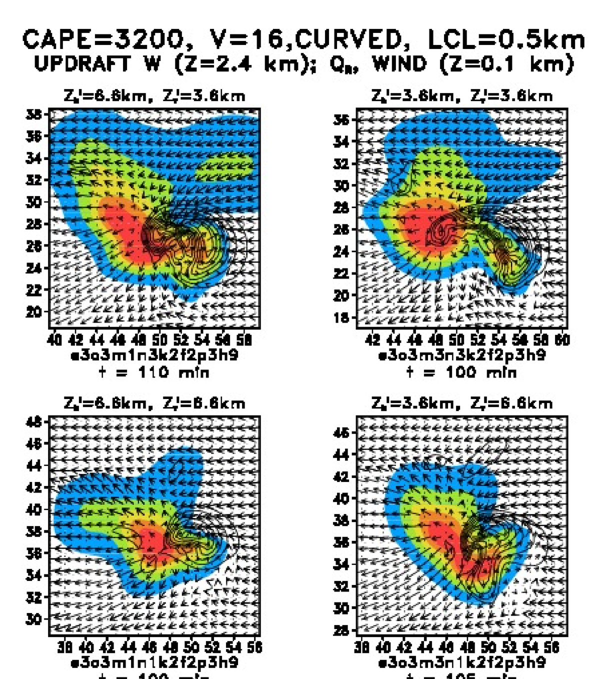
Extreme peak ZETA (aloft) 60 min to 120 min



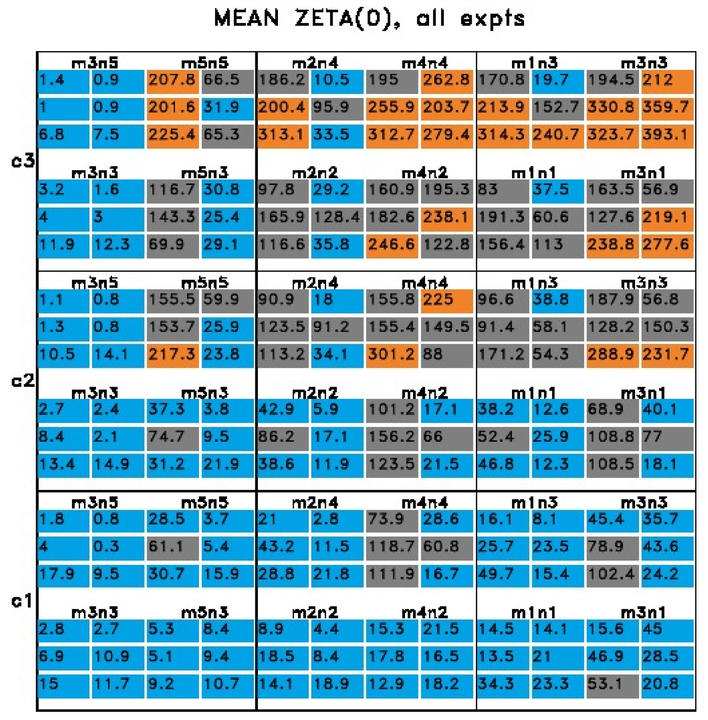
Peak ZETA (aloft) efficiency vs. SRH 60 min to 120 min



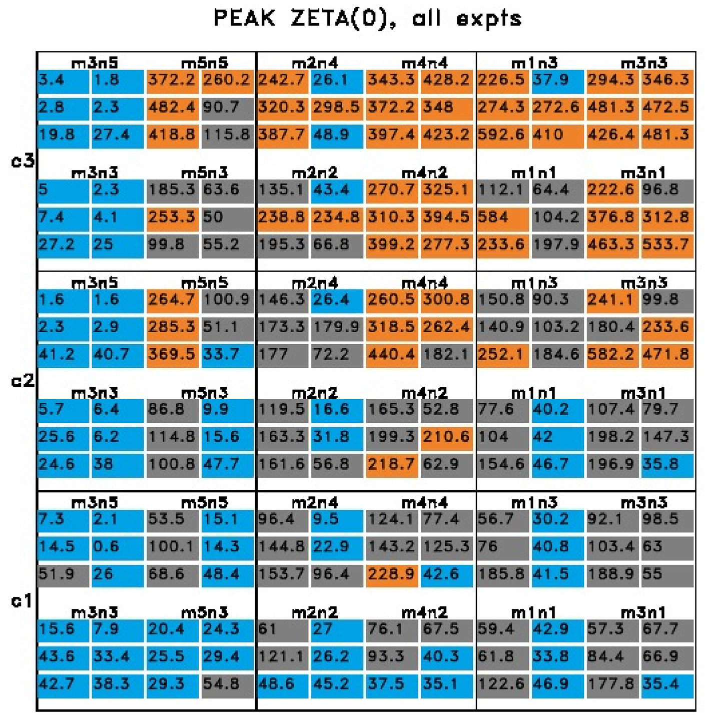
Peak ZETA (aloft) steadiness 60 min to 120 min



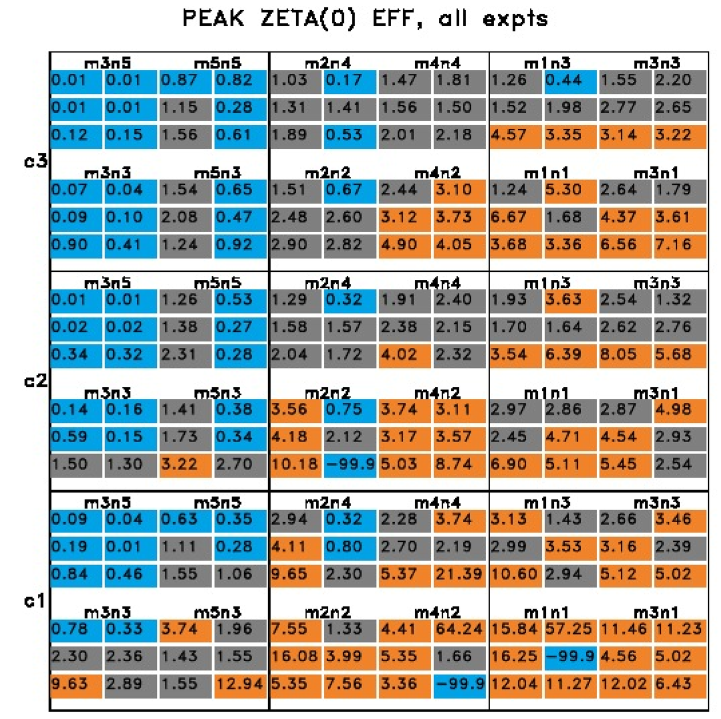
Mean peak ZETA (z=0) 60 min to 120 min



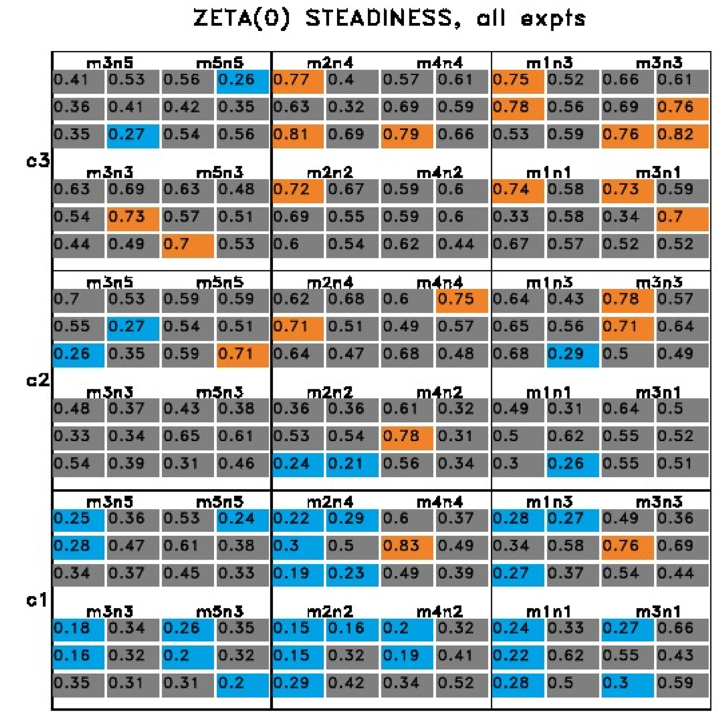
Extreme peak ZETA (z=0) 60 min to 120 min



Peak ZETA (z=0) efficiency vs. SRH 60 min to 120 min



Peak ZETA (z=0) steadiness 60 min to 120 min



Future Work

- * Study sensitivity to finer grids, higher-moment microphysics schemes;
- * More fully explore combinations of LCL and LFC heights;
- * More fully explore sensitivities to other values of total PW;
- * Explore effects of straight hodograph wind profiles;
- * Explore impacts of more complex profile shaping of free tropospheric relative humidity;
- * Add explicit electrification module to allow study of storm flash rates and flash type;
- * Assess reliability of results using ensembles of perturbed initial fields, while retaining the integrity of the parameter space design;
- * Extend approach to LES to study tornado likelihood, character;
- * Extend approach to aerosol, trace species chemistry and its variability (requires adding several new dimensions to the parameter space).

Acknowledgments

- NSF Grant ATM 0126408 supported the COMPASS project.
- For more info, see website sti.usra.edu/COMPASS..

- This document is copyright Eugene W. McCaul, Jr.; all rights reserved.

- This work is dedicated to advisor Dr. Douglas K. Lilly (1929-2018). "Illegitimi non carborundum."