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 $u$, 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 C), 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, 2184 expts. Nomenclature example: a02c068e1625f8g19h1, where $a$ denotes CAPE (1=800, 2=2000, 3=5000 J/kg), $b$ denotes hodo radius (1=8, 2=12, 3=16 km), $c$ denotes buoyancy profile shape, $d$ denotes shear profile shape, $e$ and $f$ denotes LCL and LFC altitudes (2=0.5, 6=1.6 km, with k=6 featuring an 0.5 km LCL and 1.6 km LFC, with a molot adiabatic profile between), $g$ denotes 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, 2 mesh stretched thru 20 km, sponge layer up to 24.5 km, dt=30.0 s, all data saved every 5 min.
- Spherical warm bubbles with 5K warm used to initialize.
- All stratiform layers have theta-e independent of z, pL cases have 321 K, pk cases have 354 K.
- All stratiform layers have small positive lapse rates of theta, to ensure Ri stays large enough to prevent spontaneous mixing, 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 60 t 120 min: 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.

Assess and tabulate means and extremes of many storm attributes. Used RAMS 3b with 1-moment microphysics, Smagorinsky-Lilly turbulence schemes, with no Coriolis.

Future Work

- Study sensitivity to finer grids, higher-moment microphysics.
- More fully explore combinations of LCL and LFC heights.
- More fully explore sensitivities to other values of total PW.
- Explore effects of stratiform 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.

Acknowledgments

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- For more info, see website at usra.edu/COMPASS.
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- This work is dedicated to advisor Dr. Douglas K. Lilly (1929-2018). "Illegitimi non carborundum."