Part 1: Low- and upper-level shear variation effects on squall lines

- Cloud Model 1 (CM1; Bryan and Fritsch 2002; MWR) simulations of sheared quasi-2D squall lines
- (a) – cross section of 2.5 km deep cold pool used to initiate quasi-2D squall lines
- (b) – three different low-level (0-2.5 km) and upper-level (2.5-10.0 km) shear magnitudes
- (c) – vertical profile of CAPE (blue line) and passive tracer layer (shading) for measuring entrainment-driven dilution
- (d) – vertical profile of -CIN (blue line) and passive tracer layer (shading)

- (a) – larger low-level “broad” (w ≥ 5 m s⁻¹) and upper-level “core” (w ≥ 20 m s⁻¹) updraft areas in stronger low-level shear simulations
- (b) – little sensitivity of updraft area to upper-level shear variations

- Taller, more vertically aligned updrafts in stronger low-level shear simulations
- Reduced entrainment-driven dilution for updrafts in stronger low-level shear simulations
- Stronger peak updrafts in stronger low-level shear simulations

Conclusions

- Squall line updraft properties are more sensitive to variations in low-level shear as opposed to variations in upper-level shear
- Simulations with stronger low-level shear exhibited updrafts that were wider, less dilute, stronger, and taller
- Results build upon Alfaro and Khairoutdinov (2015; JAS) and Alfaro (2017; JAS)

Part 2: LCL height variation effects on unsheared deep convection

- Cloud Model 1 (CM1; Bryan and Fritsch 2002; MWR) simulations of unsheared deep convection
- Three different LCL heights:
  - LCL₁ = 0.5 km
  - LCL₂ = 1.5 km
  - LCL₃ = 3.0 km
- Slight decrease in convective available potential energy (CAPE) as the LCL height was raised

- (a) – larger dry updraft area (Aₜ) at LCL for higher LCL simulations
- (b) – larger moist updraft area (Aₘ) above LCL for higher LCL simulations
- (c) – less entrainment-driven dilution (i.e., larger PTₘₐₓ) in higher LCL simulations
- (d) – larger buoyancy (Bₘₐₓ) in higher LCL simulations

- Convection takes longer to develop in higher LCL simulations
- Longer-lasting, deeper, stronger, and more buoyant deep convection in the higher LCL simulations

- Rising and expanding dry thermals/updrafts below LCL have a greater vertical distance to traverse before reaching saturation and forming clouds in higher LCL environments (Williams and Standiford 2002; PHY)
- This process “sets the stage” for wider moist updrafts above the LCL
- Resulting clouds in higher LCL environments are wider, less dilute, stronger, and deeper

Alfaro (2017; JAS) and Alfaro (2015; JAS)