Vertical velocity statistics for LES of deep and shallow convection and stratocumulus

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A large-domain LES of deep convection

- Idealized GATE (tropical ocean) simulation with shear.
- Used a CSRM (SAM) with 2048 x 2048 x 256 ($10^9$) grid points and 100-m grid size for a 24-h LES.
LES “visible image” 180 km x 180 km
Cumulonimbus Vertical Velocity Events in GATE. Part I: Diameter, Intensity and Mass Flux

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Fig. 2. Time series illustrating definition of drafts and cores, adapted from US C-130 at 5471 m, Day 257. An updraft has to reach 0.5 m s$^{-1}$ and be positive for 0.5 km (~5 s) or more; a core has to have $w$ of at least 1 m s$^{-1}$ for 0.5 km or more. Downdrafts and downdraft cores are defined in the same way. Note that the draft at the right has two cores.
Core properties

Core diameter:

\[ \int_{\text{core}} dx = D \]

Core vertical velocity:

\[ \frac{1}{D} \int_{\text{core}} w \ dx = \overline{w} \]

Core mass flux:

\[ \int_{\text{core}} w \ dx = D \overline{w} \]
Profiles of core property PDFs vs LES

- CORE DIAMETER (km)
- CORE \( \bar{w} \) (m s\(^{-1} \))
- CORE MASS FLUX \( (10^3 \text{ kg s}^{-1} \text{ m}^{-1}) \)
- CORE \( w_{\text{max}} \) (m s\(^{-1} \))
Cumulative distribution of core average updraft speed

SR 43200 6–8 km

core w_avg (m/s)

6-8 km

probability coordinate = erfinv(2*p-1)

percentiles

median

median * exp(±sigma)
Core diameter varies most near cloud base
Updraft core statistics for temperature deviations (~ buoyancy)
What is the role of buoyancy below cloud base?
Joint PDFs of vertical velocity, temperature deviations, and precipitating condensate
w-T pdfs (buoyancy)
w-precip pdfs (drag)
Summary

- Updraft and downdraft core statistics from aircraft measurements can be used to evaluate LES results.
- Could similar statistics be derived from cloud radar measurements?
- Joint pdfs of vertical velocity with quantities such as buoyancy, precipitating condensate, or liquid water content would also be useful.