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

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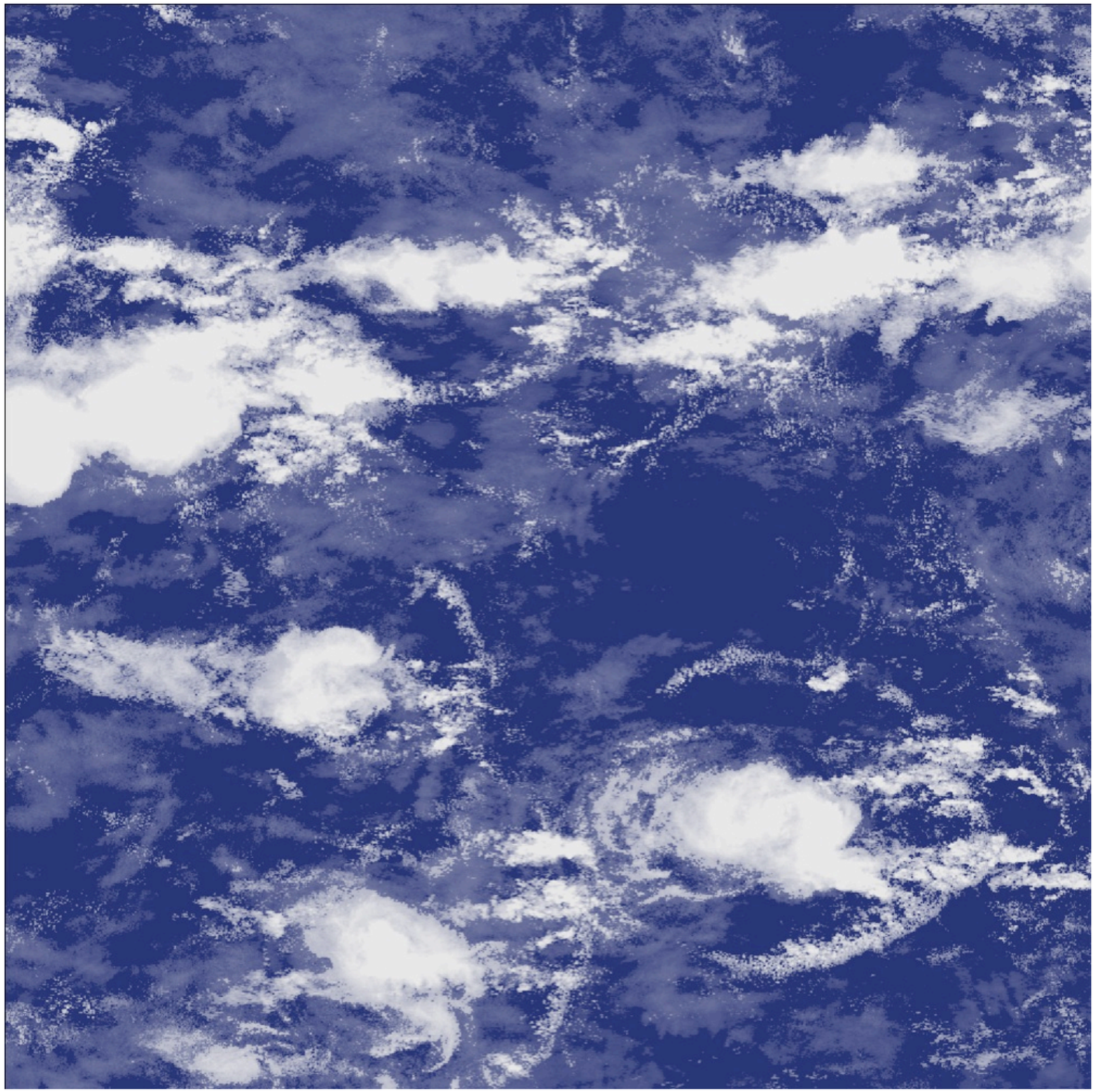
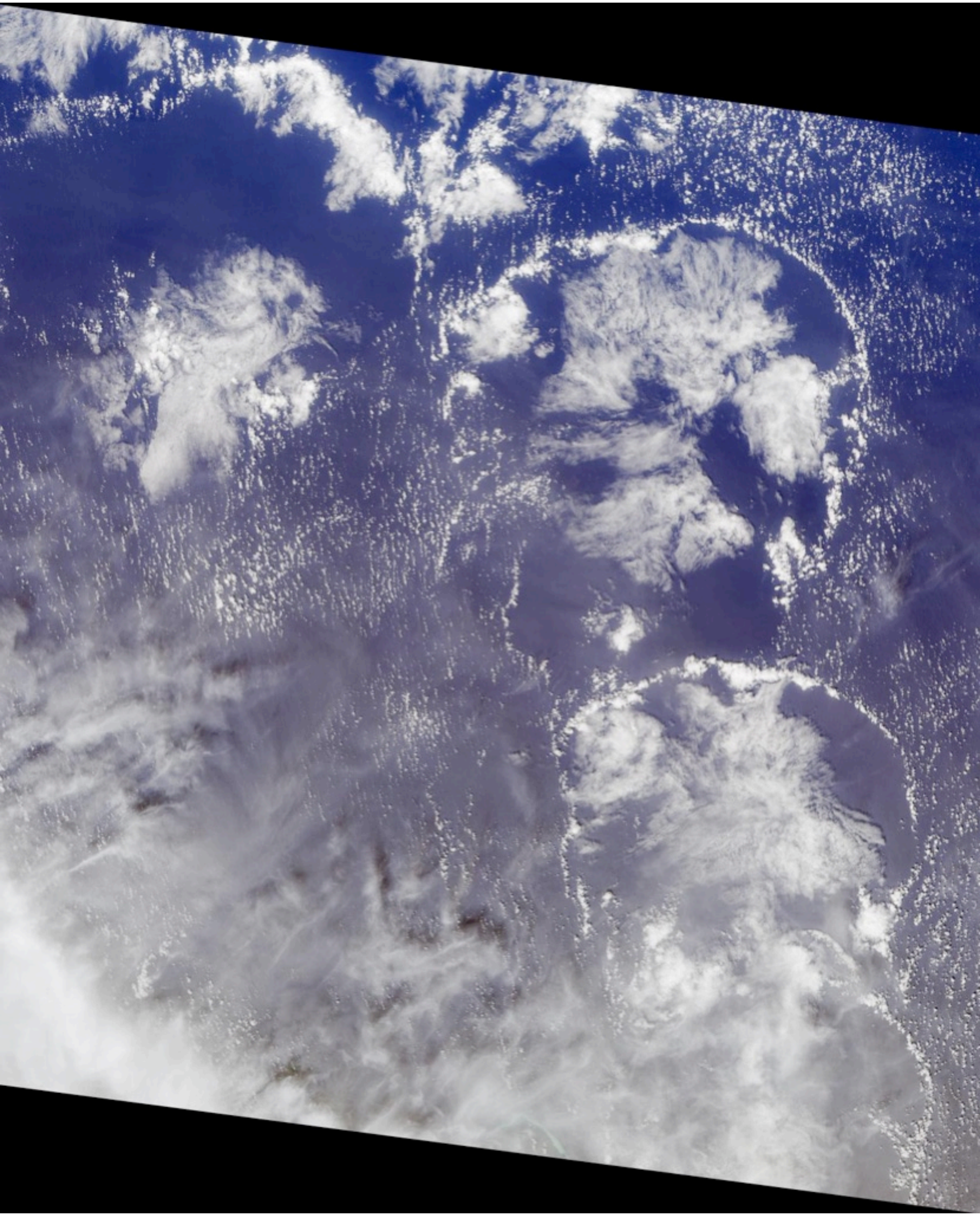
A large-domain LES of deep convection

- 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





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Cumulonimbus Vertical Velocity Events in GATE. Part I: Diameter, Intensity and Mass Flux

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Definitions of drafts and cores

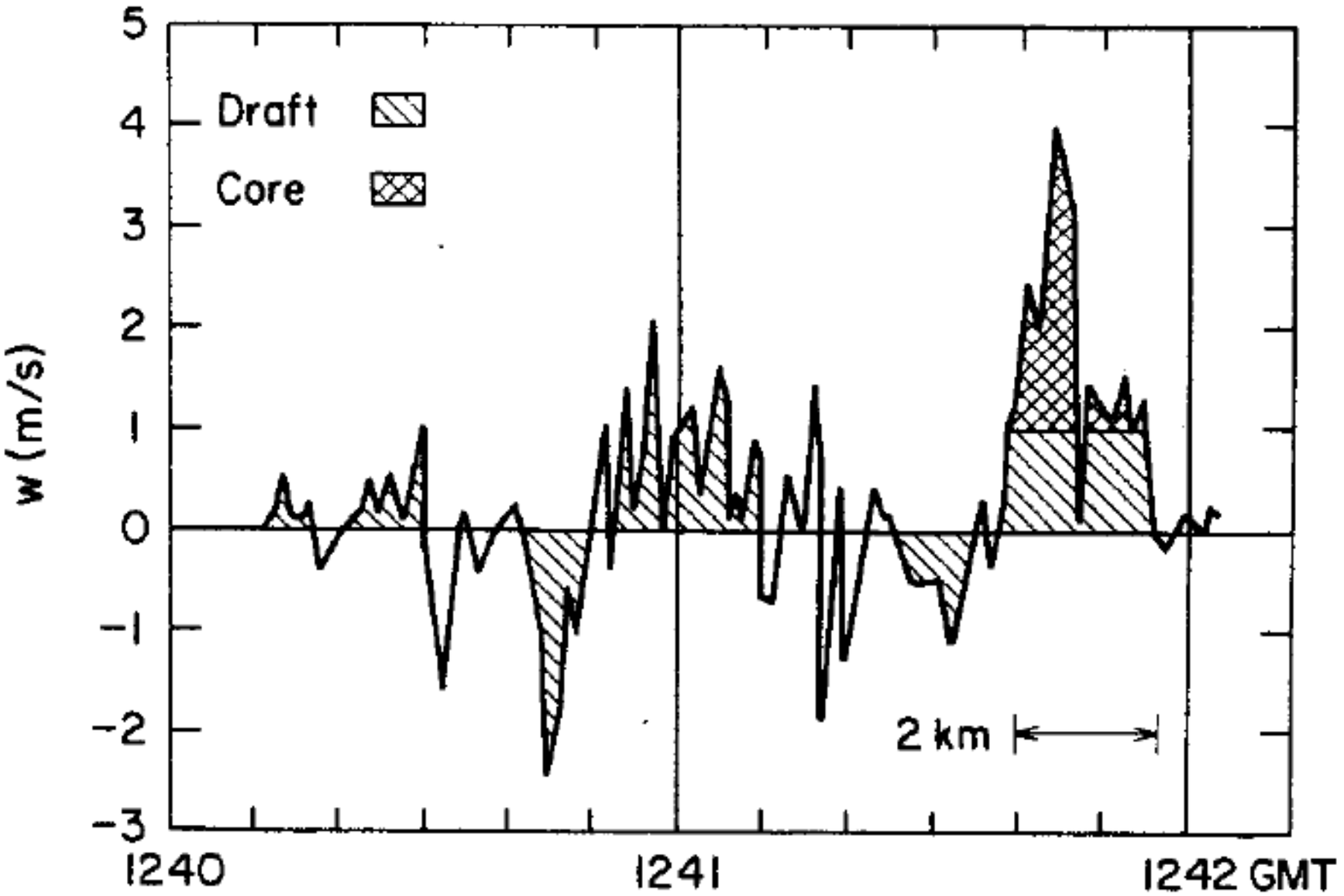


FIG. 2. Time series illustrating definition of drafts and cores, adapted from US C-130 at 5471 m, Day 257. An updraft has to reach 0.5 m s^{-1} and be positive for 0.5 km (~5 s) or more; a core has to have w of at least 1 m s^{-1} for 0.5 km or more. Downdrafts and downdraft cores are defined in the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

Core properties

Core diameter:

$$\int_{\text{core}} dx = D$$

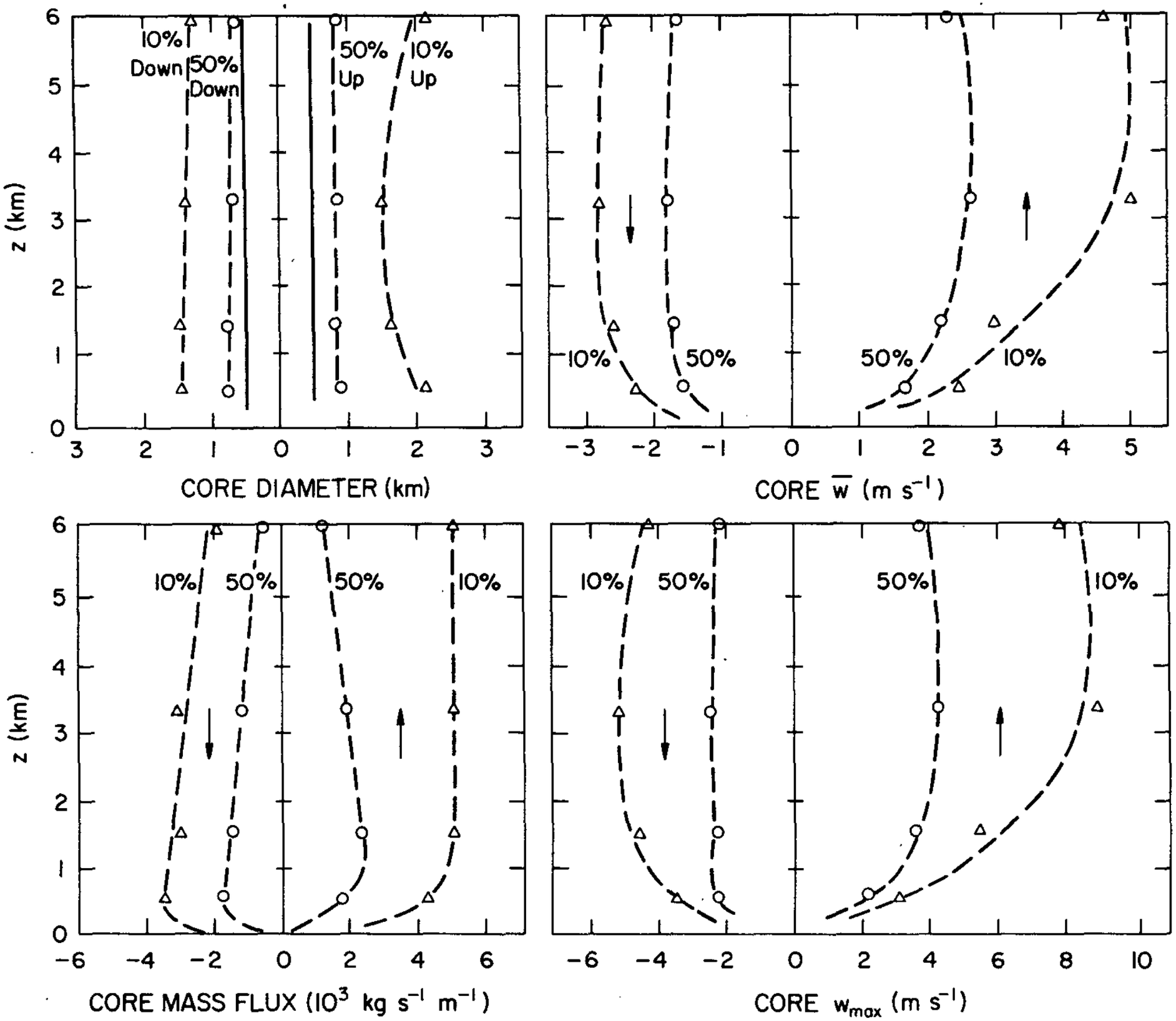
Core vertical velocity:

$$\frac{1}{D} \int_{\text{core}} w \; dx = \overline{w}$$

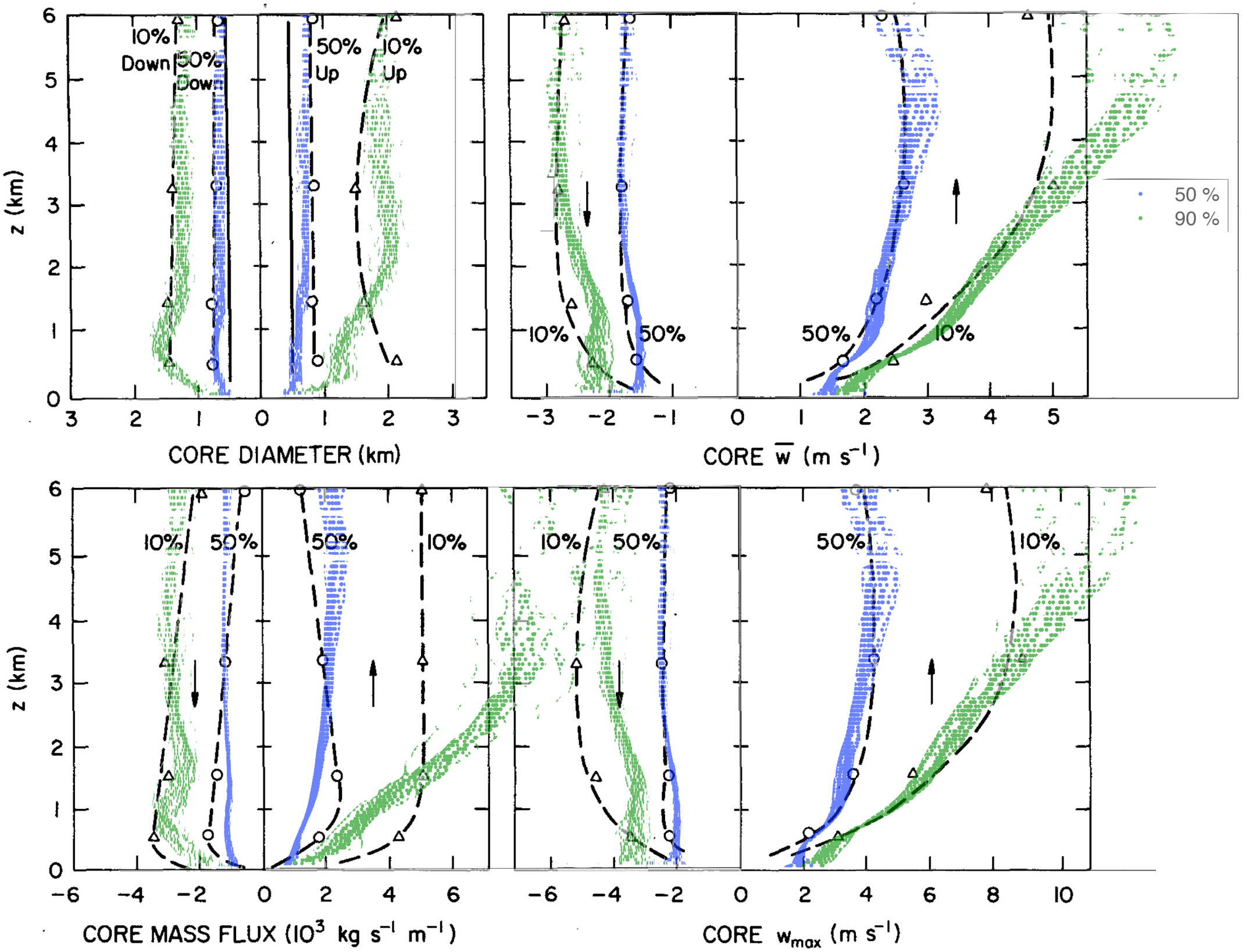
Core mass flux:

$$\int_{\text{core}} w \; dx = D \; \overline{w}$$

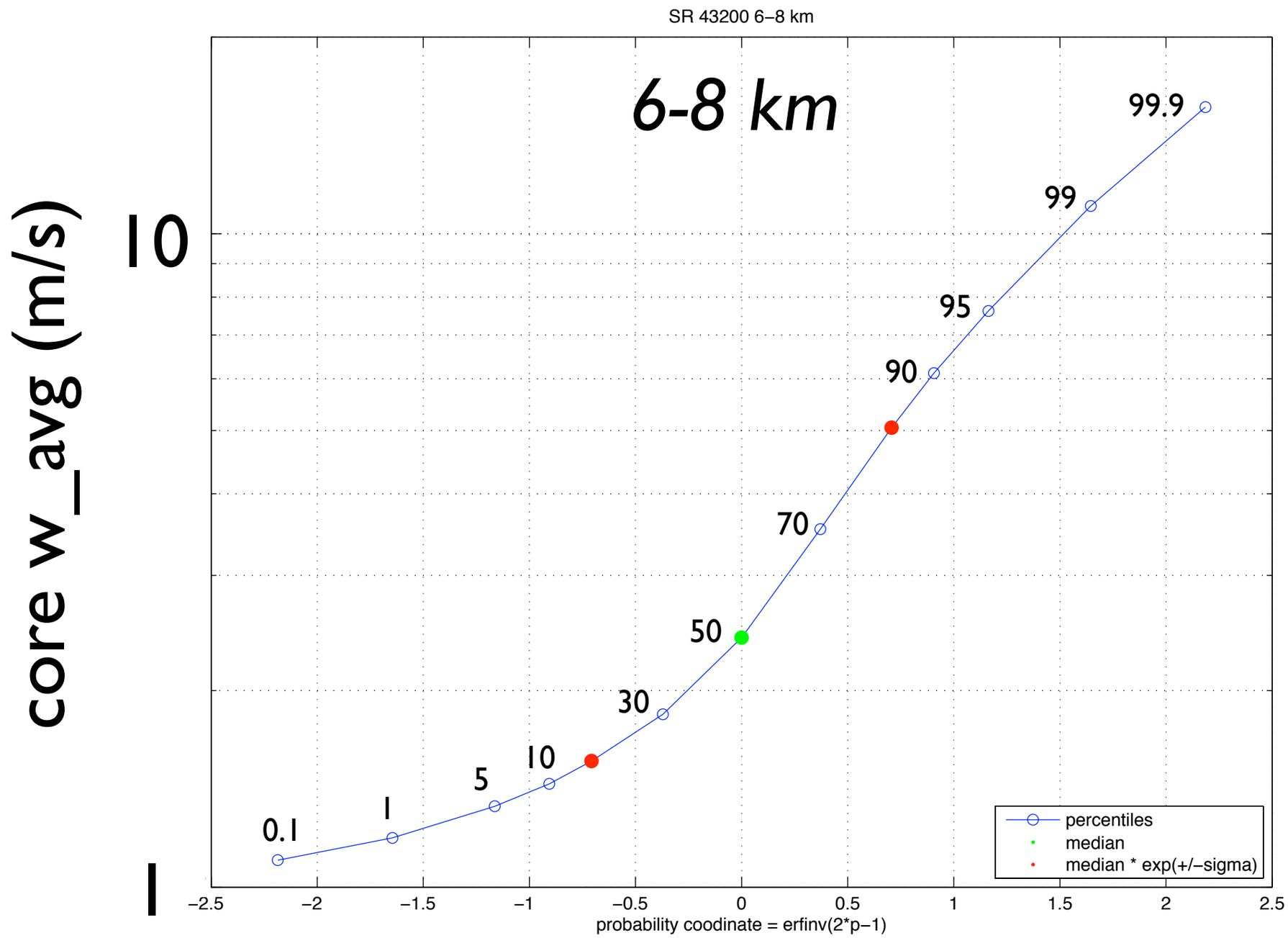
Profiles of core property PDFs



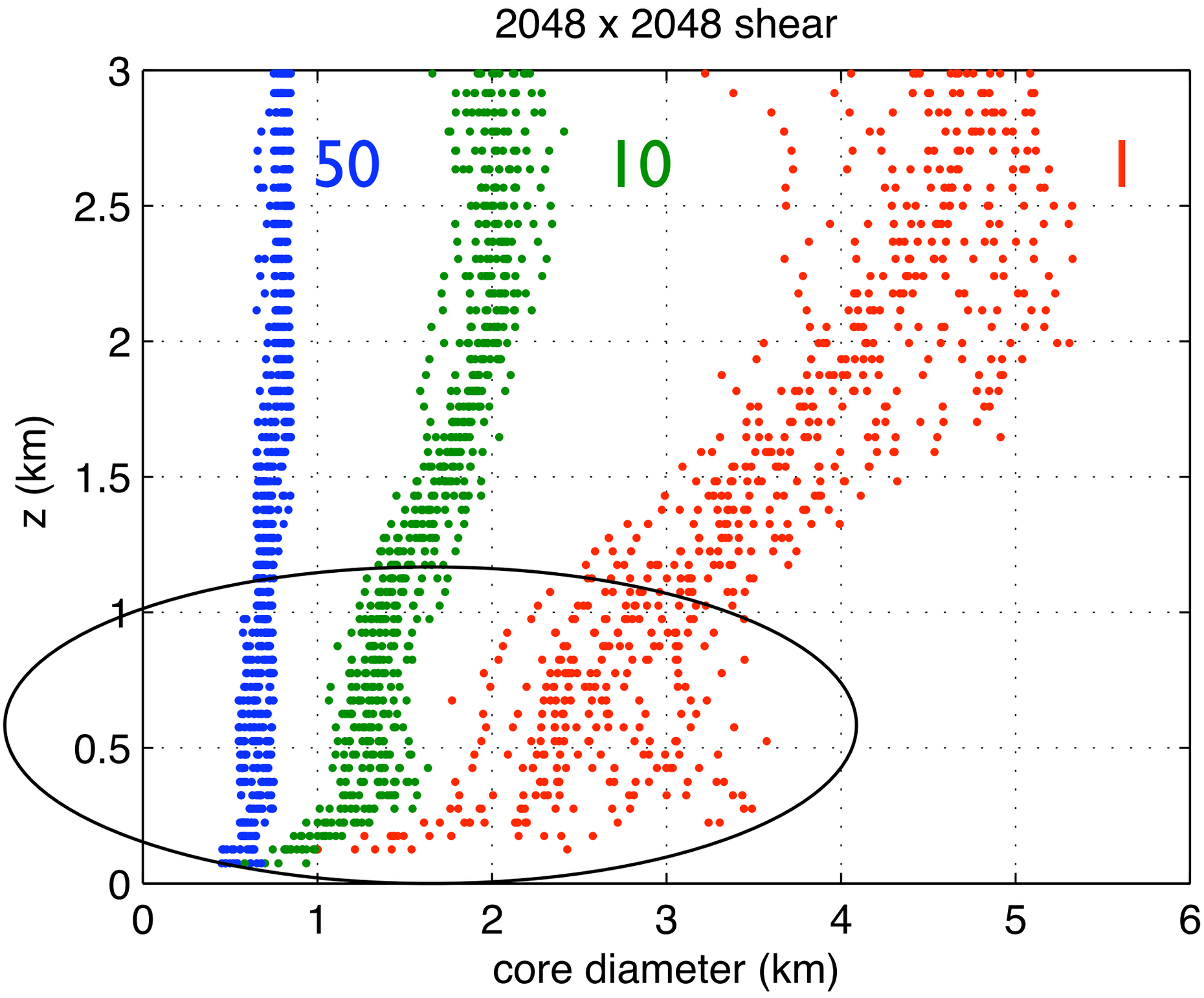
Profiles of core property PDFs vs LES



Cumulative distribution of core average updraft speed

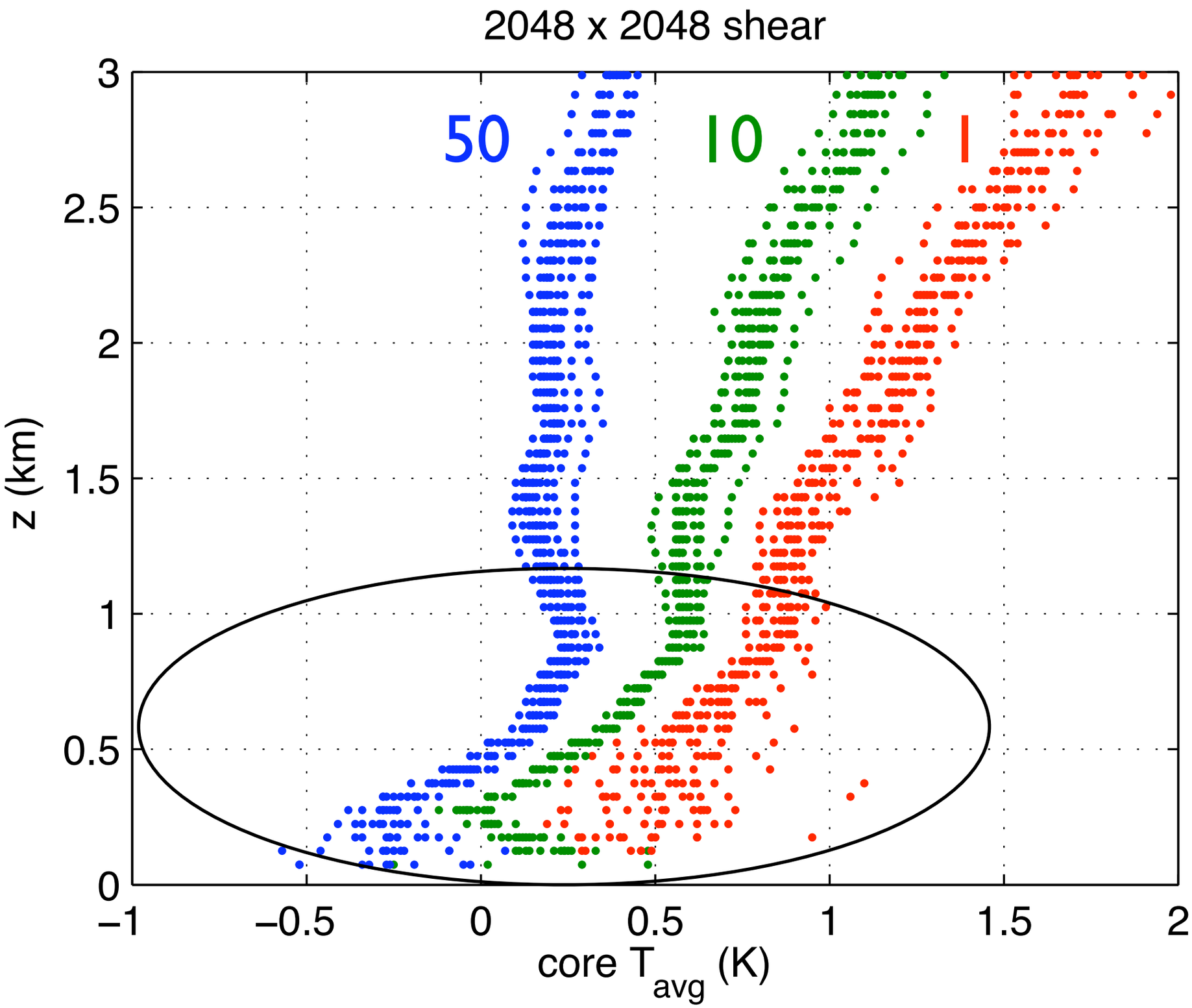


Core diameter varies most near cloud base

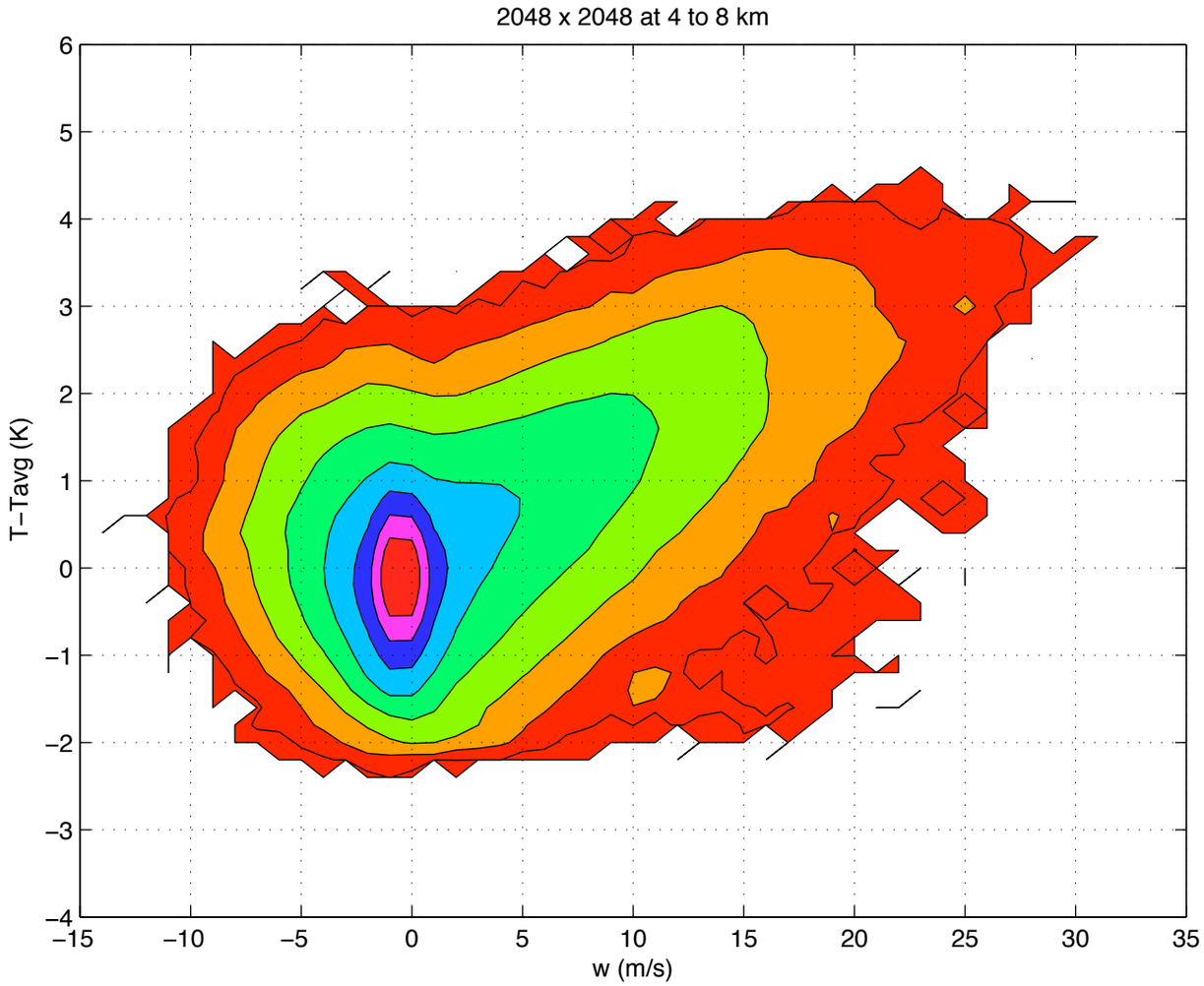


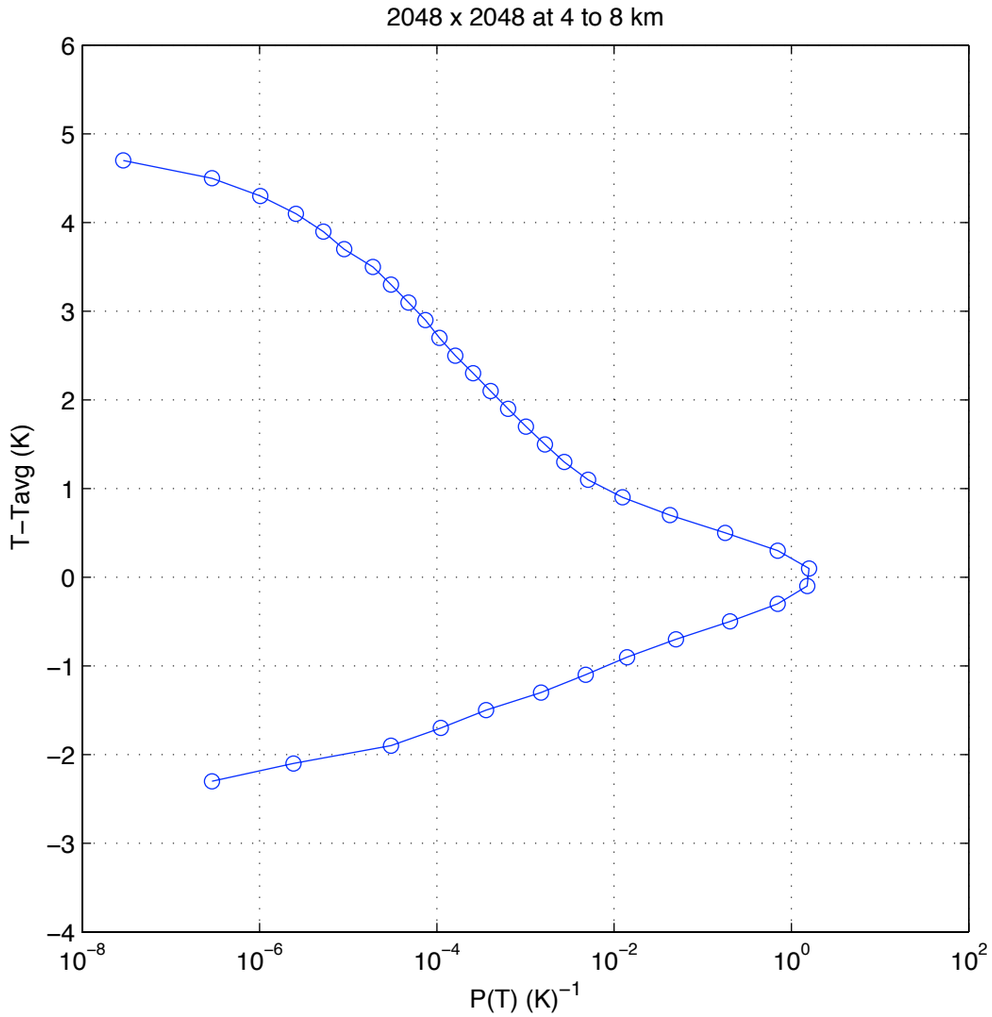
Updraft core statistics for temperature deviations (~ buoyancy)

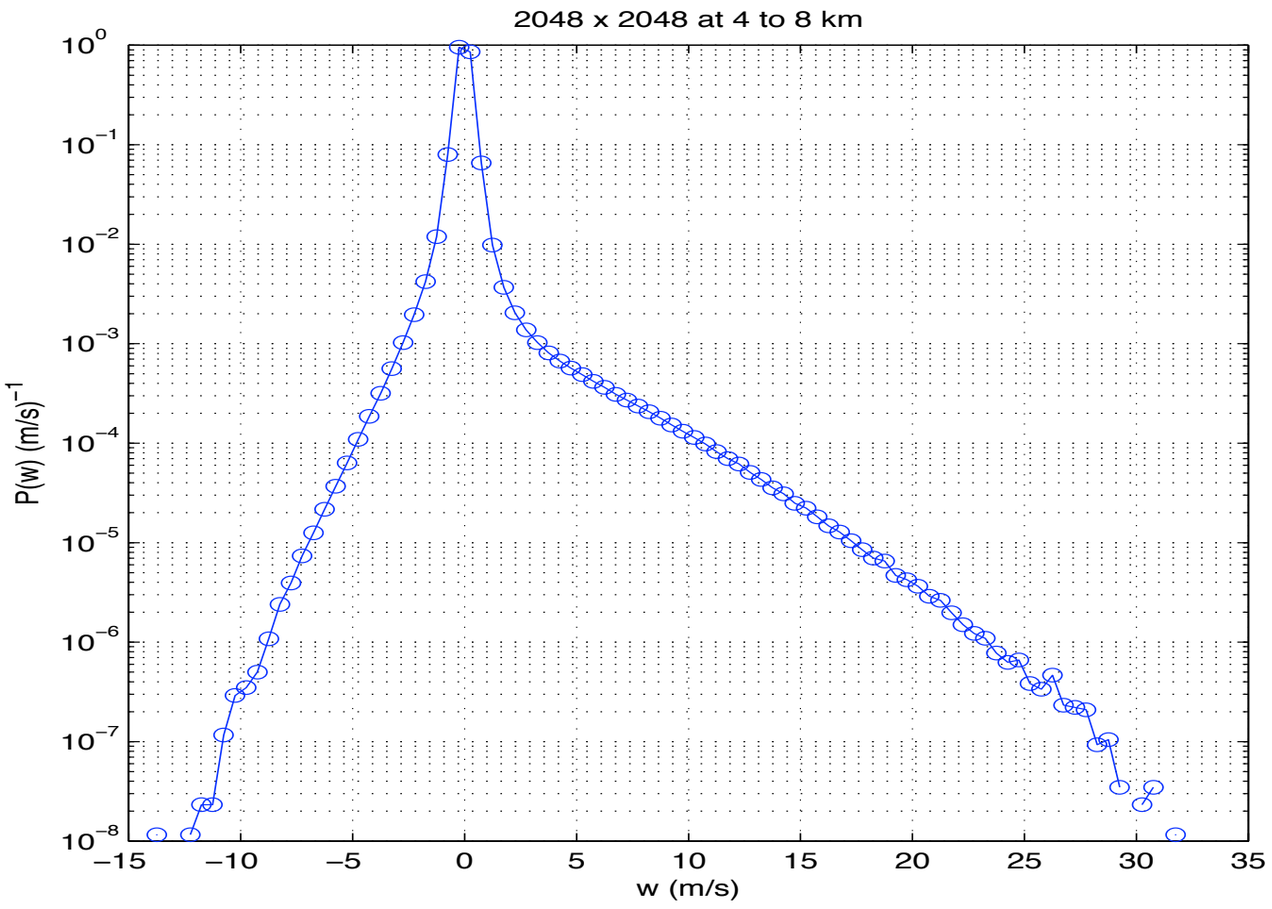
What is the role of buoyancy below cloud base?



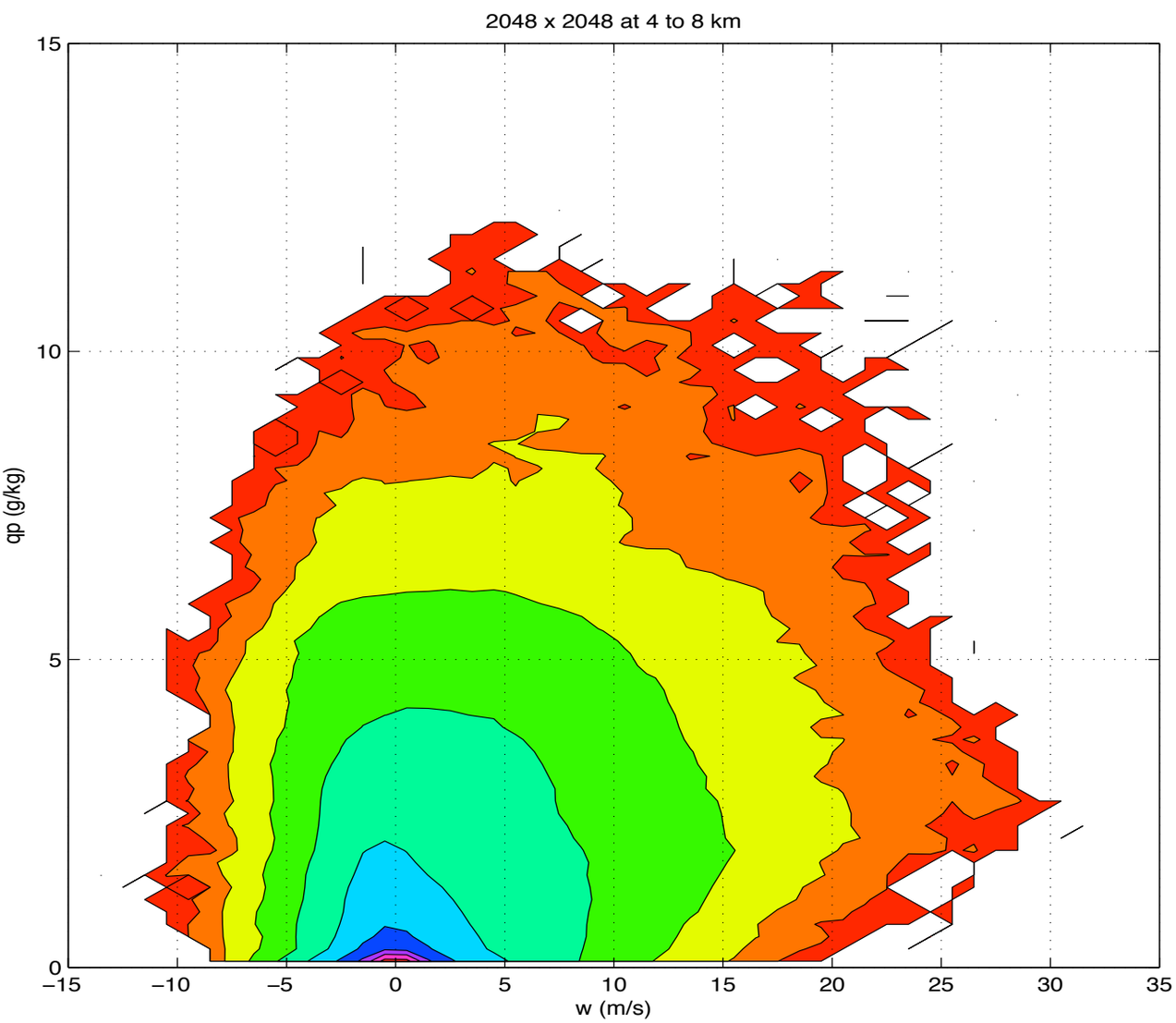
Joint PDFs of vertical velocity, temperature deviations, and precipitating condensate

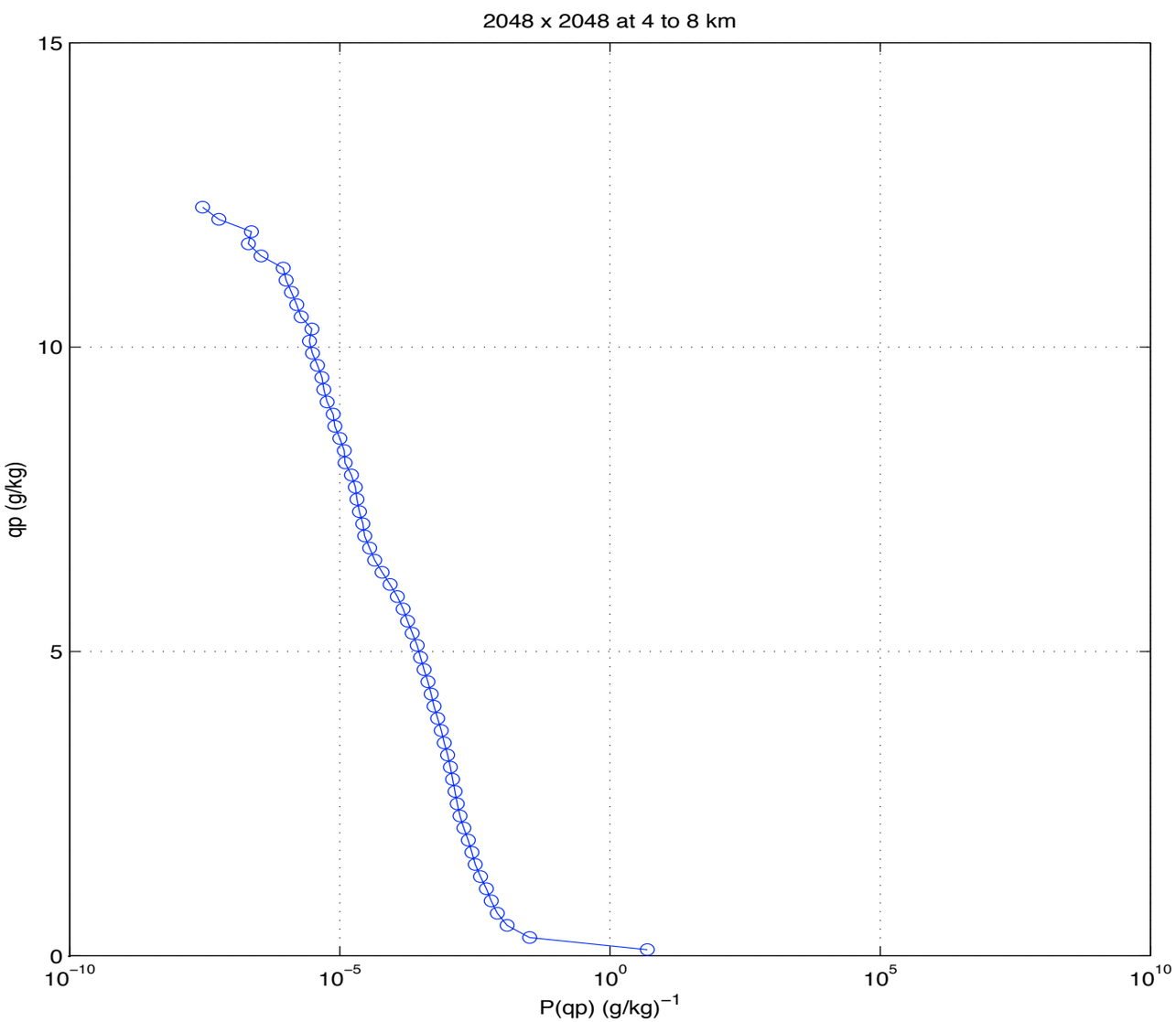


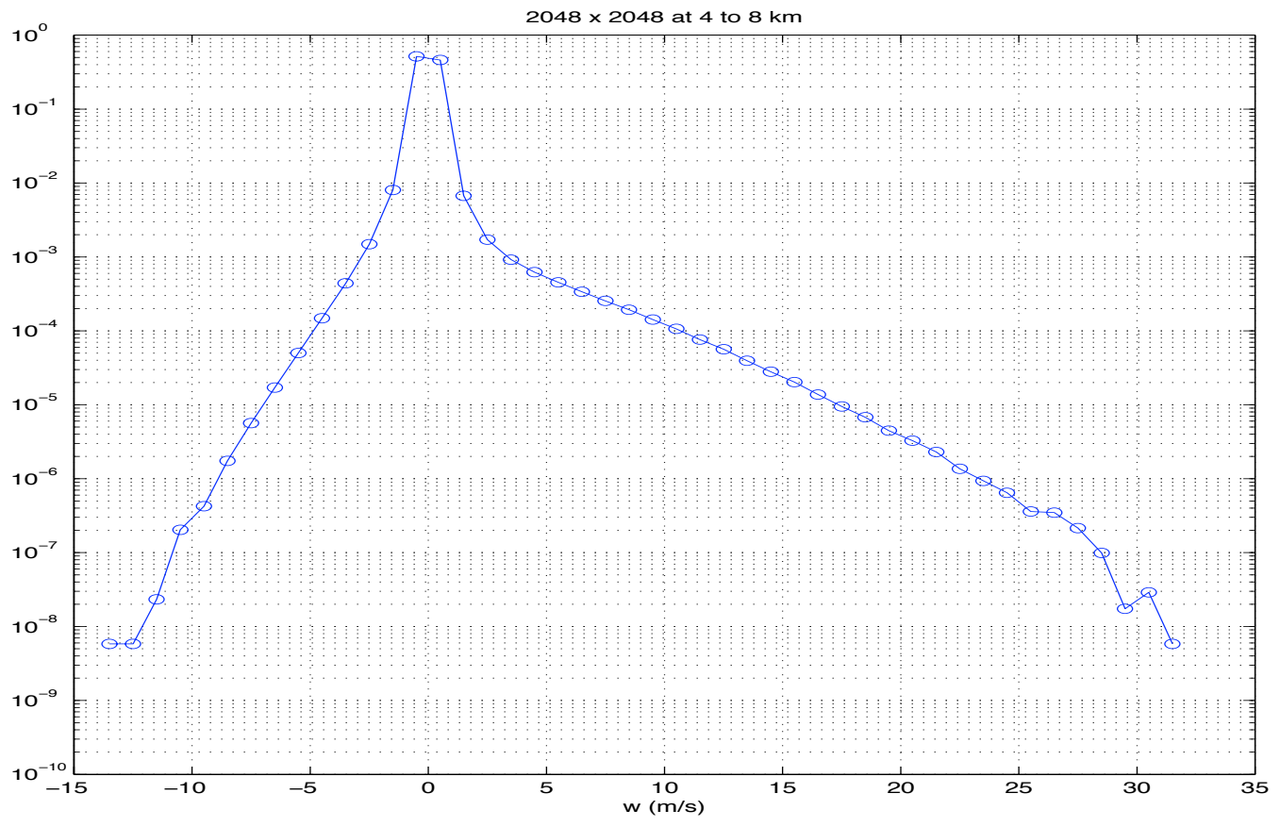




w-T pdfs (buoyancy)







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.