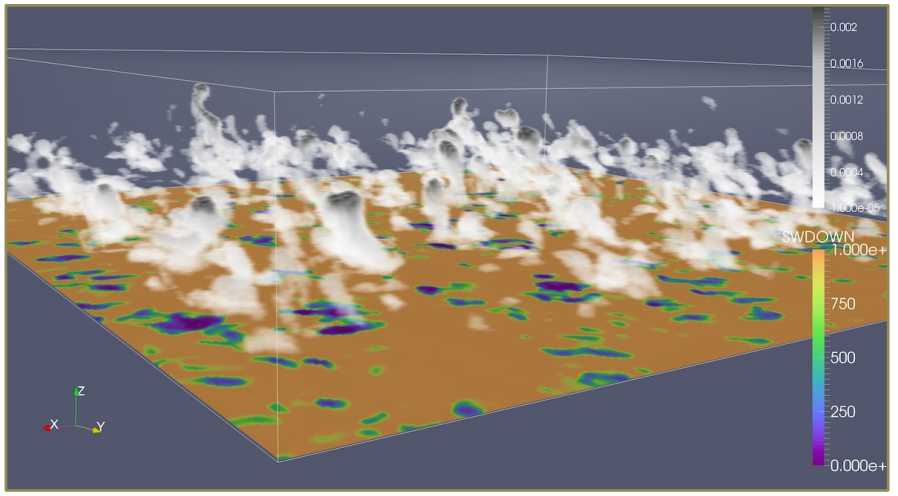
Reconciling Differences Between Large-Eddy Simulations and Doppler-Lidar Observations of Continental Shallow Cumulus Cloud-Base Vertical Velocity



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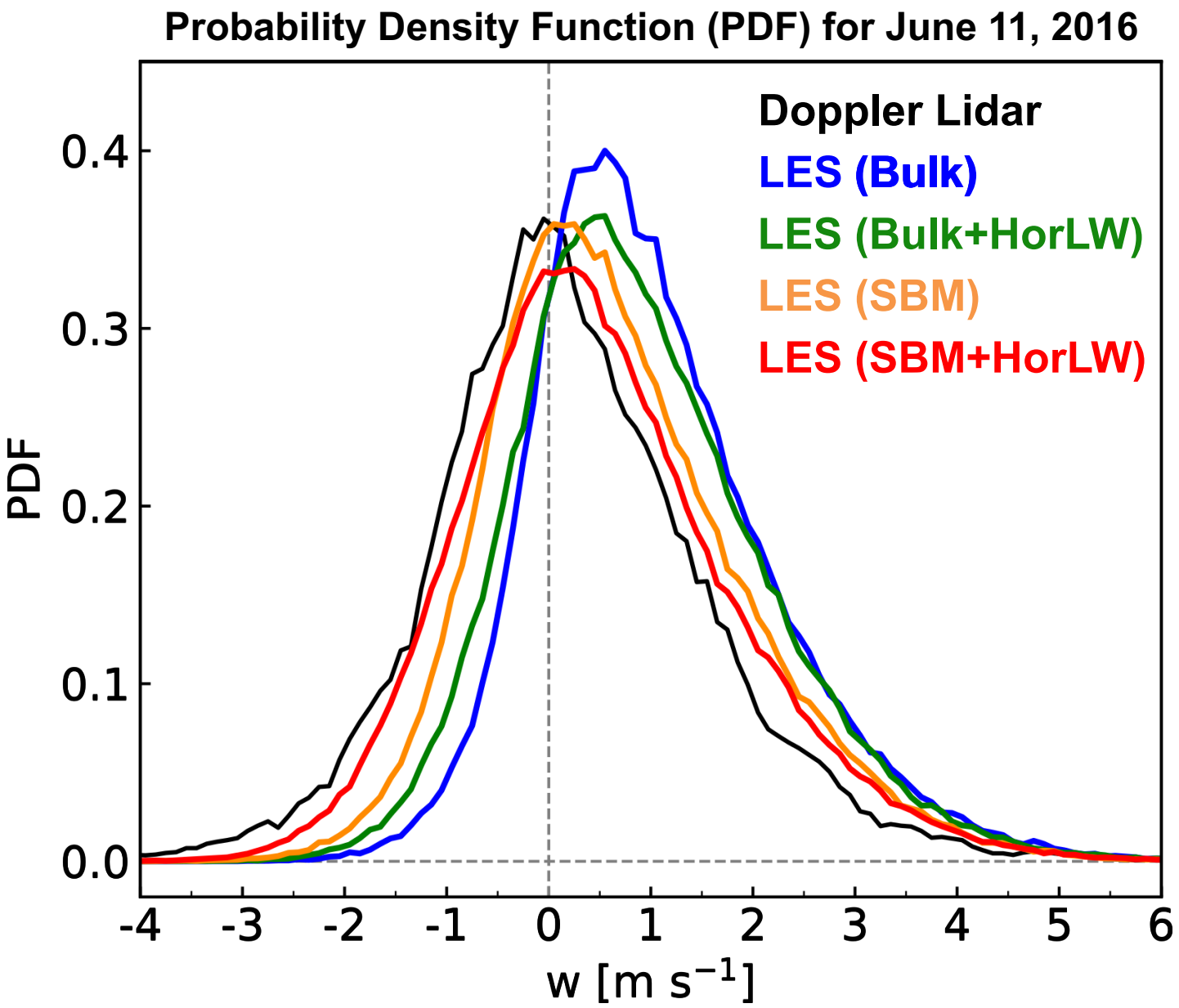
Shallow Cumulus Cloud-Base Vertical Velocity: SGP Doppler Lidars vs LES



The 5-site **Doppler Lidar (DL)** statistics suggests **insufficient downdrafts in Large-Eddy Simulations (LES).**

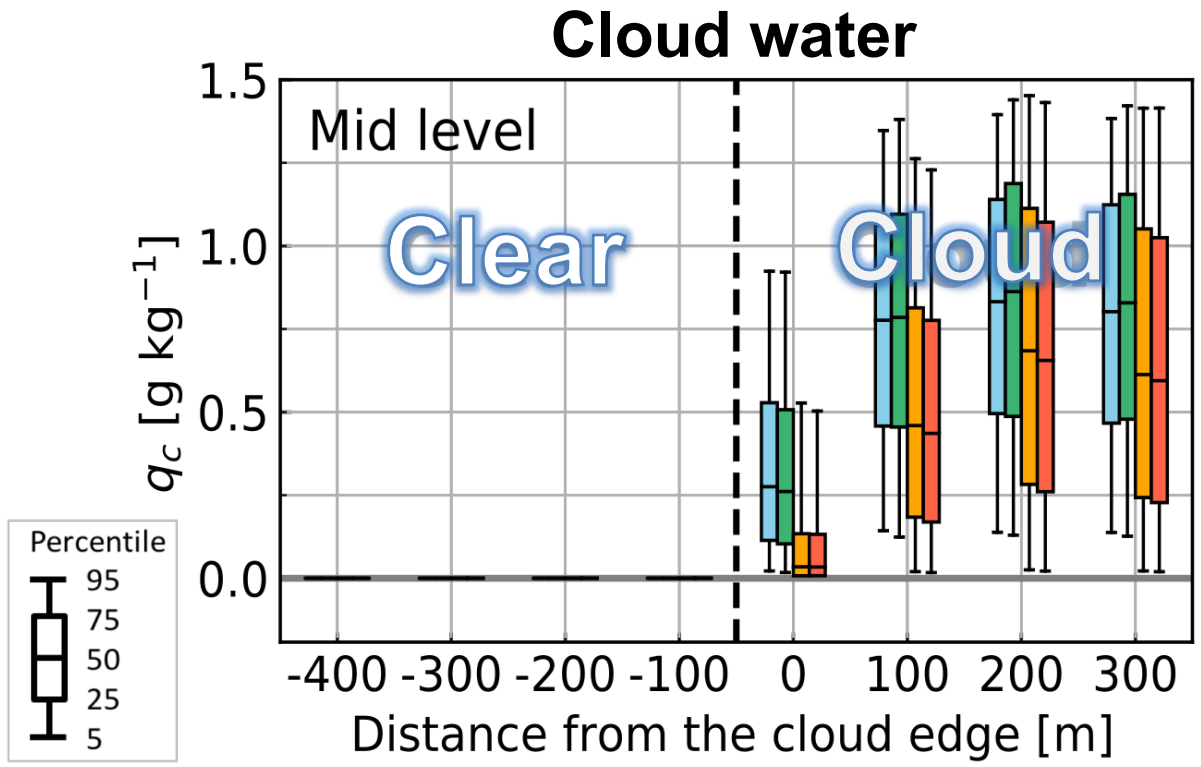
- Similar difference in 10-day composite; Similar DL PDF for 2-year statistics
- No sensitivity to large-scale forcing, grid spacing, choice of dynamical core…

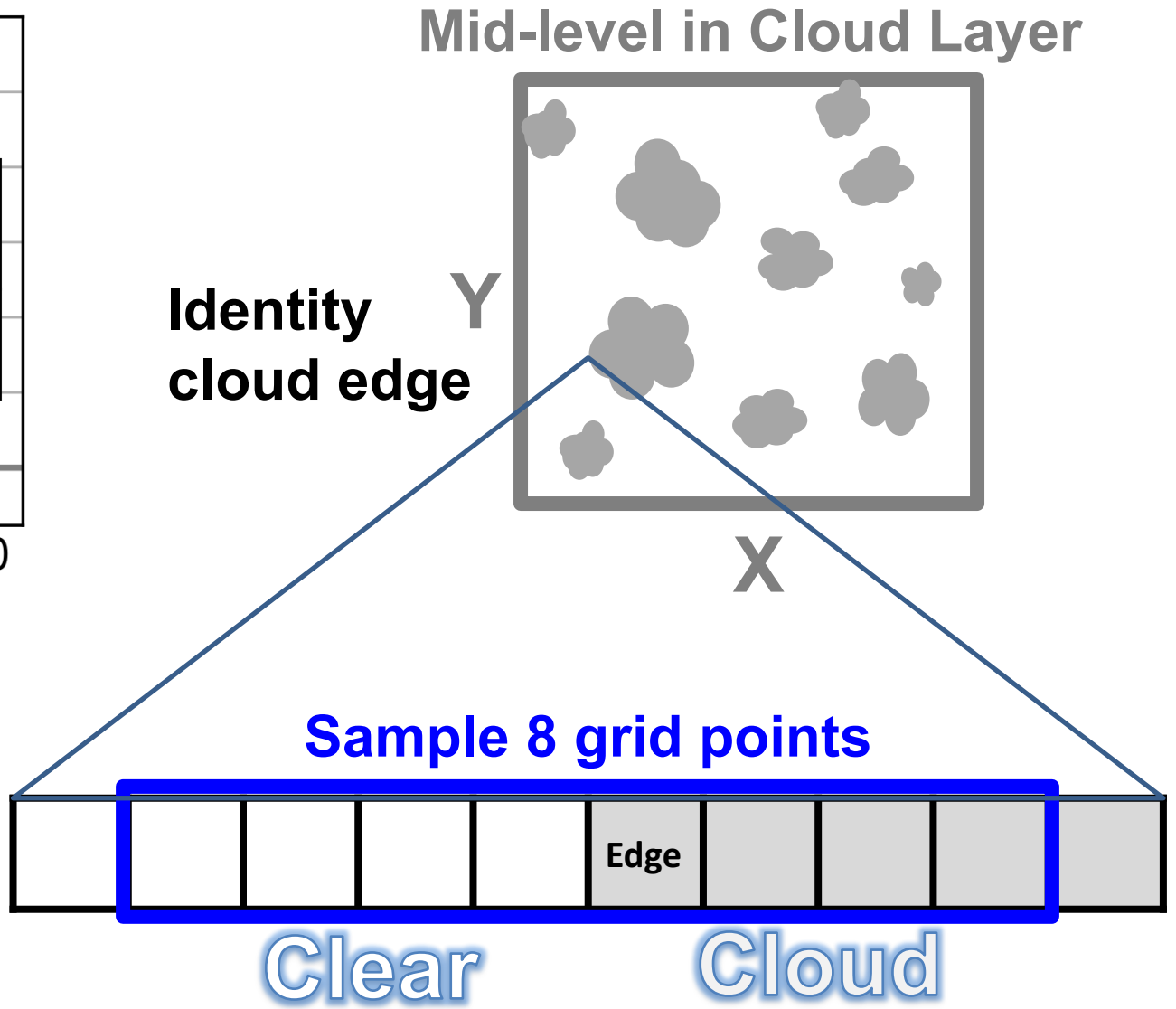
LES can more closely reproduce observations by improving physics to use:

Spectral-Bin Microphysics (SBM)
Horizontal Longwave Radiation (HorLW)

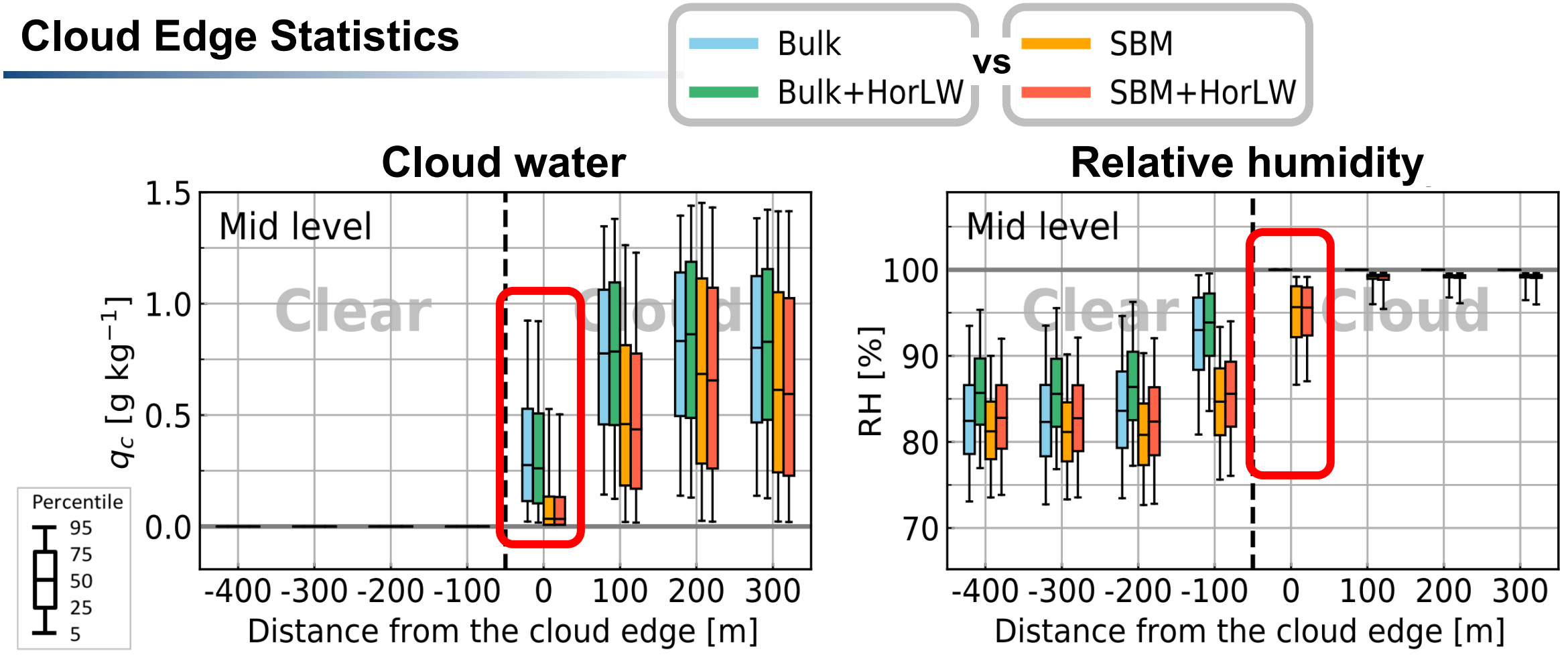
particularly when **used together**.

Cloud Edge Statistics





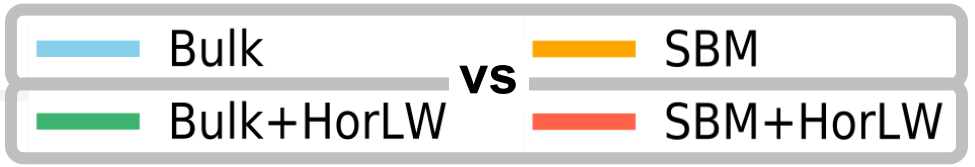
Cloud Edge Statistics



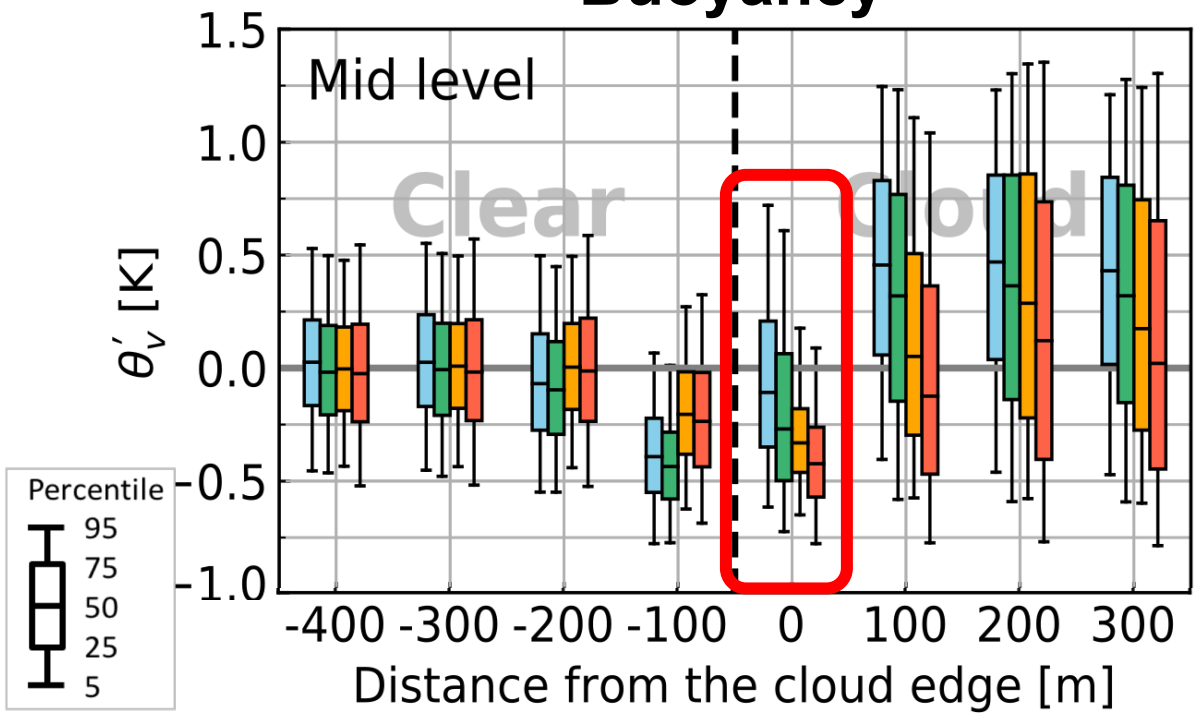
SBM runs: smaller liquid water & subsaturated air near the cloud edge because of its ability to treat droplets in subsaturated air.

Bulk runs: entire droplets evaporate in subsaturated air (unless the evaporation saturate the air).

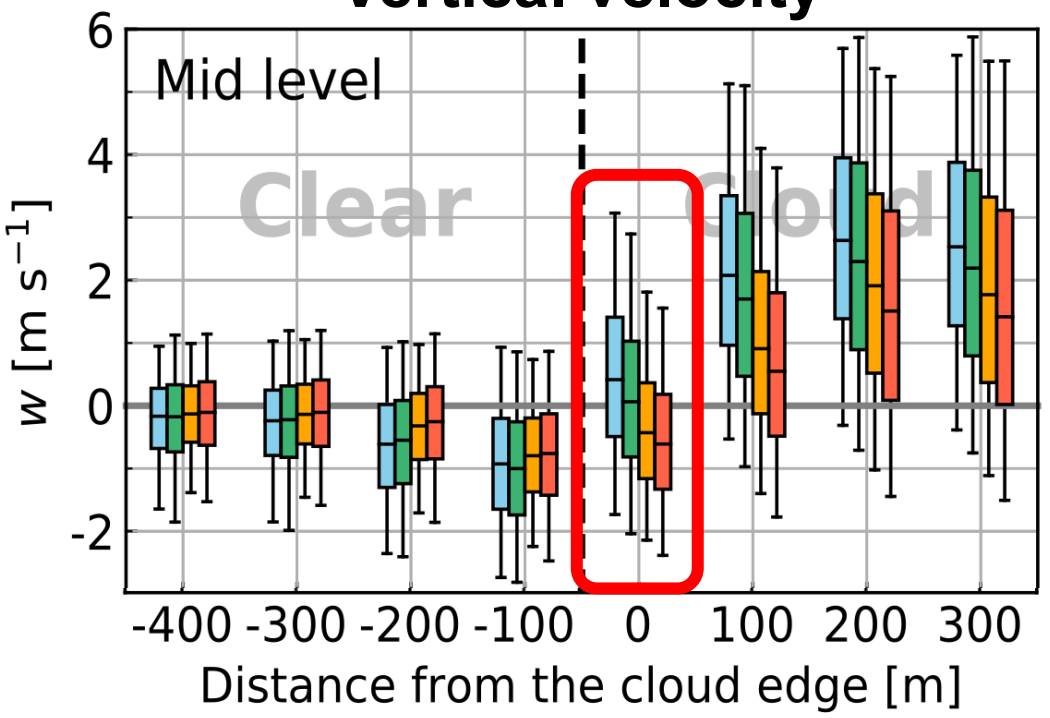
Cloud Edge Statistics



Buoyancy



Vertical velocity

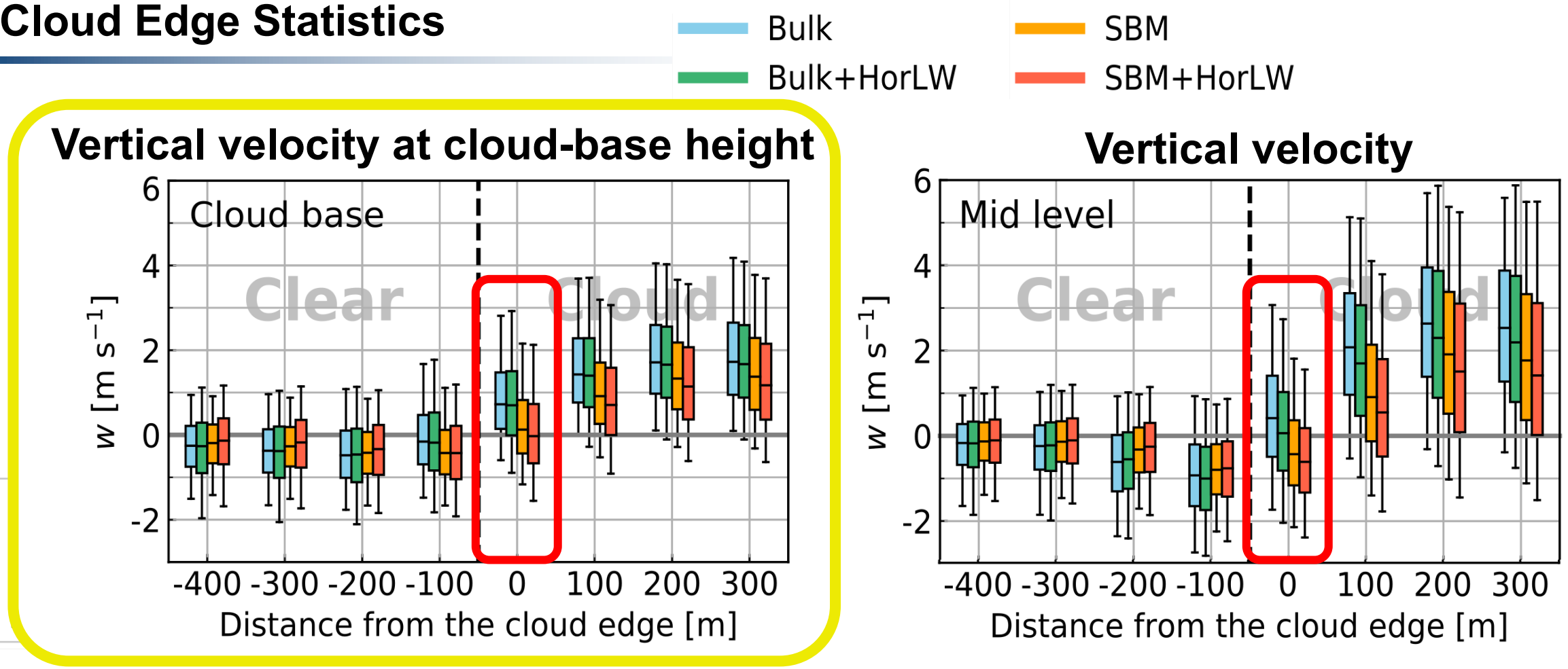


SBM leads to evaporation and cooling in “cloudy” region.

HorLW cools cloudy regions near the edge.

Negative buoyancy and downdrafts that help the downdrafts reach the cloud-base height.

Cloud Edge Statistics



SBM leads to evaporation and cooling in “cloudy” region.

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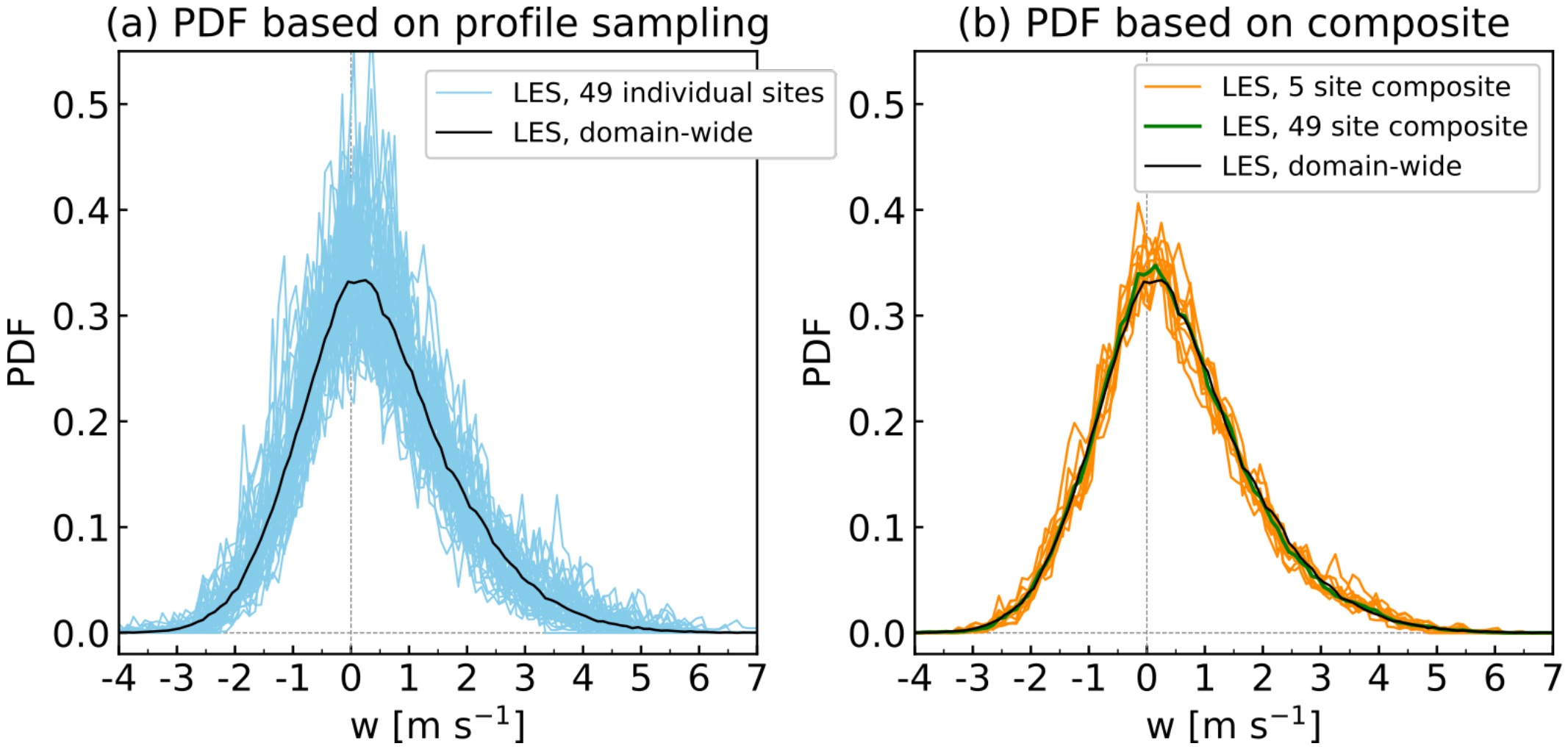
Summary

- ARM SGP Doppler Lidar measurements suggest deficiency of cloud-base downdrafts in LES.
- LES can more closely reproduce observations only after improving the model physics:
  - **Spectral-bin microphysics** that can treats droplets in subsaturated air; thus, more evaporative cooling can be present in “cloudy” region
  - **Horizontal longwave radiation** that cools cloudy regions near the edge

  both of which increase negative buoyancy and downdrafts in cloudy regions near the edge, that helps the downdrafts reach the cloud base.
- The dense Doppler Lidar network was necessary for the model diagnostics.

Poster #17 in Session B2, Wednesday 5pm–

Profiling Measurement Test using Virtual Profiling Sites in LES



Increasing the number of sites from one to five halved error of resulting PDF.