Cloudy Updraft Cores in the Giga-LES

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- Updraft cores are typically identified from 1D transects (aircraft) or 2D slices (cloud-resolving models), but such methods do not provide very much "cloud-type context."
- 3D updraft cores would provide such context, but is such an analysis worth the extra effort?
- Alison Sterling (UKMO) proposed a simple way to estimate vertical velocity using only the "unloaded" buoyancy. How does this estimate compare to that from a parcel model?

The Giga-LES

- System for Atmospheric Modeling (SAM)
- 204.8 x 204.8 km domain
- $\Delta x = \Delta y = 100$ m, $\Delta z = 50$ to 100 m
- 10^9 grid points
- A "virtual field campaign"

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Large-Eddy Simulation of Maritime Deep Tropical Convection

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- We use a cloudy updraft core definition similar to “updraft core” in Lemone and Zipser (1980):
  - Vertical velocity (w) > 1 m/s and cloud water/ice mixing ratio > 0.1 g/kg

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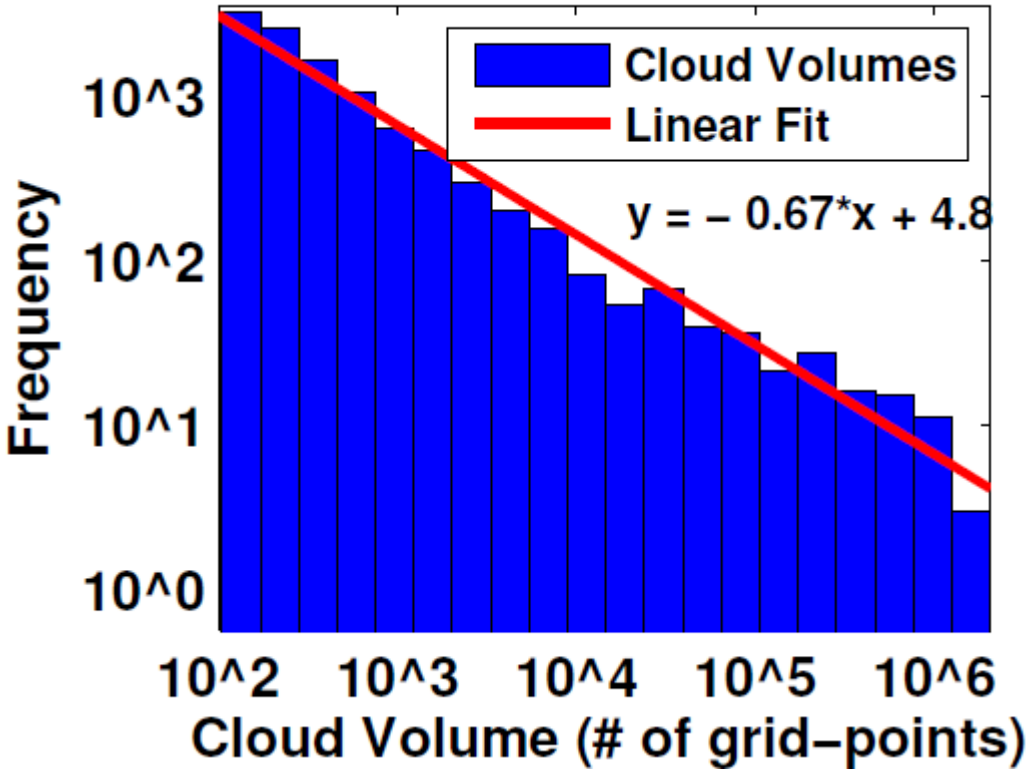
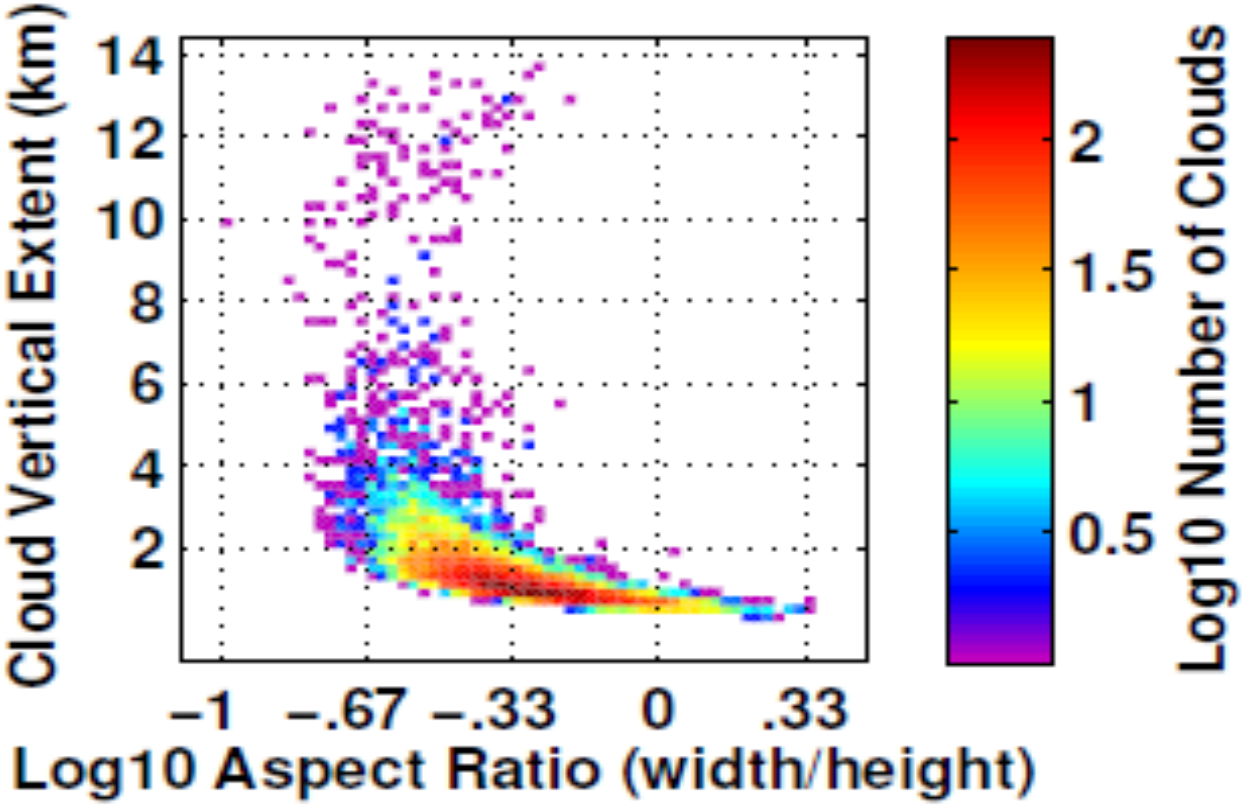
  - Vertical velocity (w) > 1 m/s and cloud water/ice mixing ratio > 0.1 g/kg
- Local core definitions, such as transect or single-level methods, provide little context in terms of updraft extent or life-cycle stage.

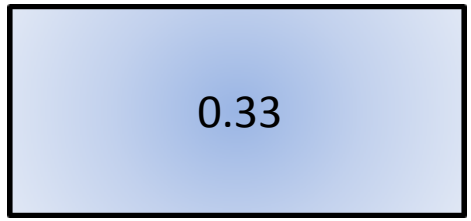
Distribution of 3D Cloudy Updraft Core Volumes



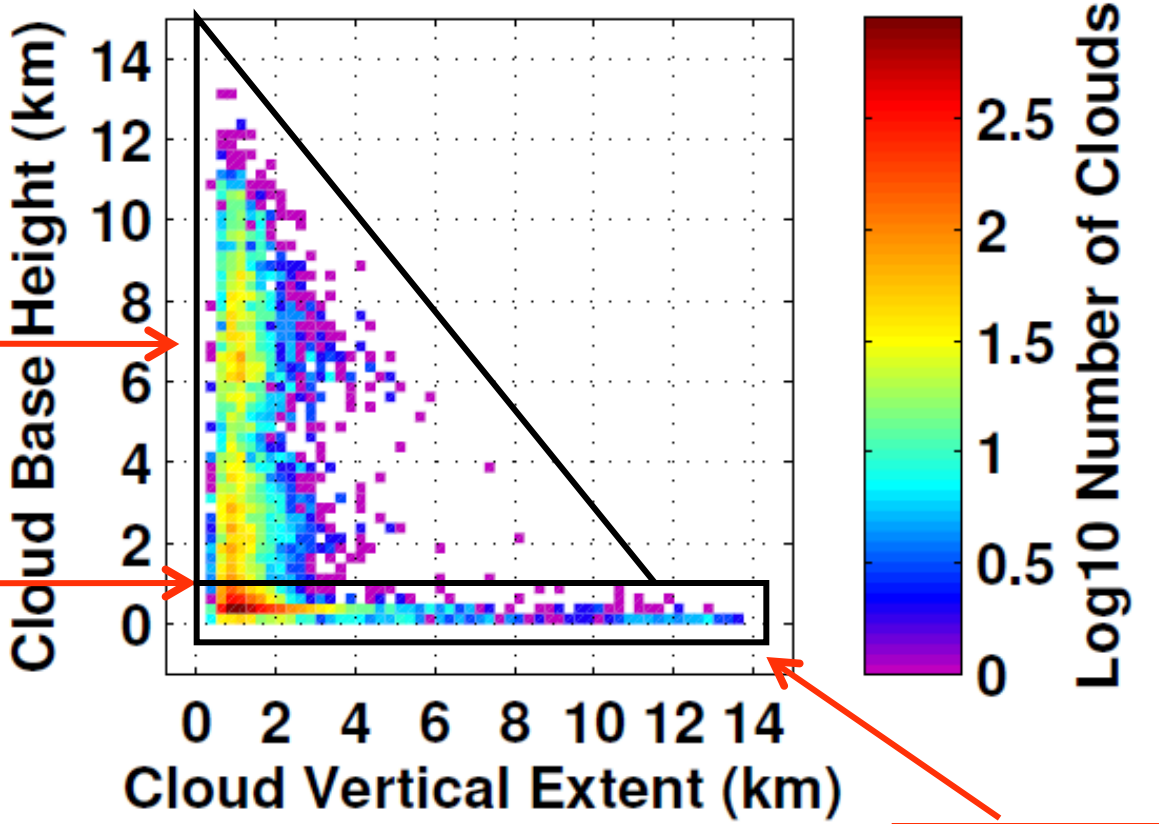
Largest volumes imply length dimension of O(10 km)

Distribution of Aspect Ratios





Partition cloudy updraft cores into two groups



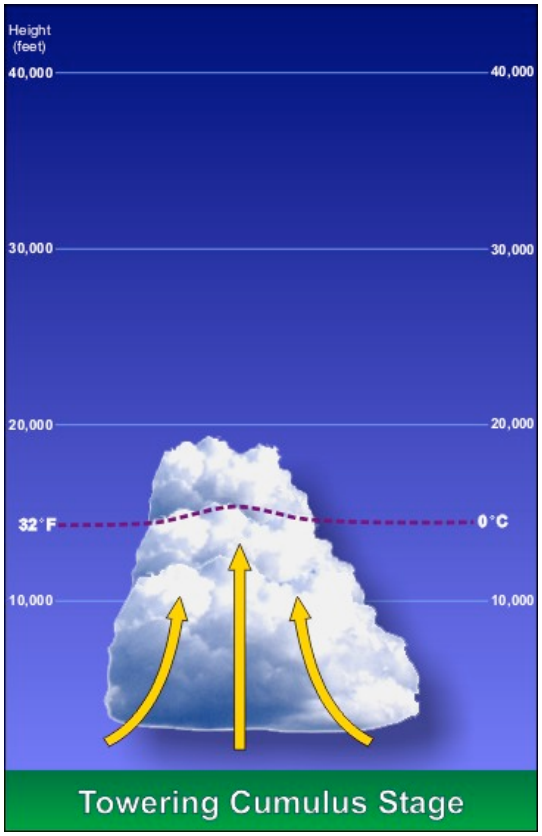
Dissipating

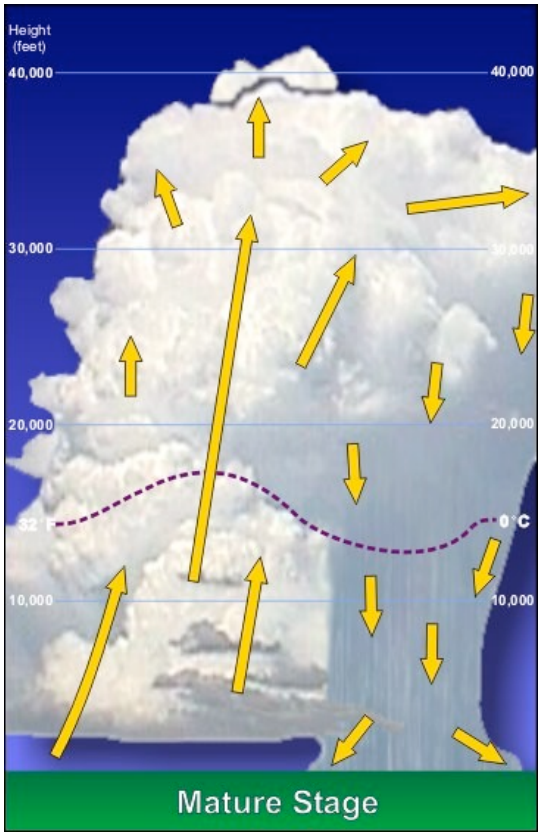
1 km cloud base height

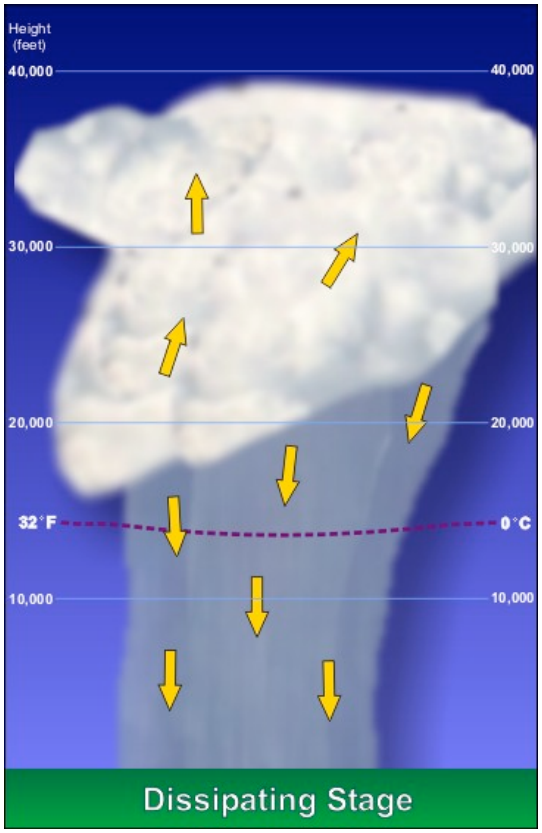
Active

Consistent with Romps (2010): active clouds are connected to lowest levels

The two groups reflect the life-cycle stages of convective cells



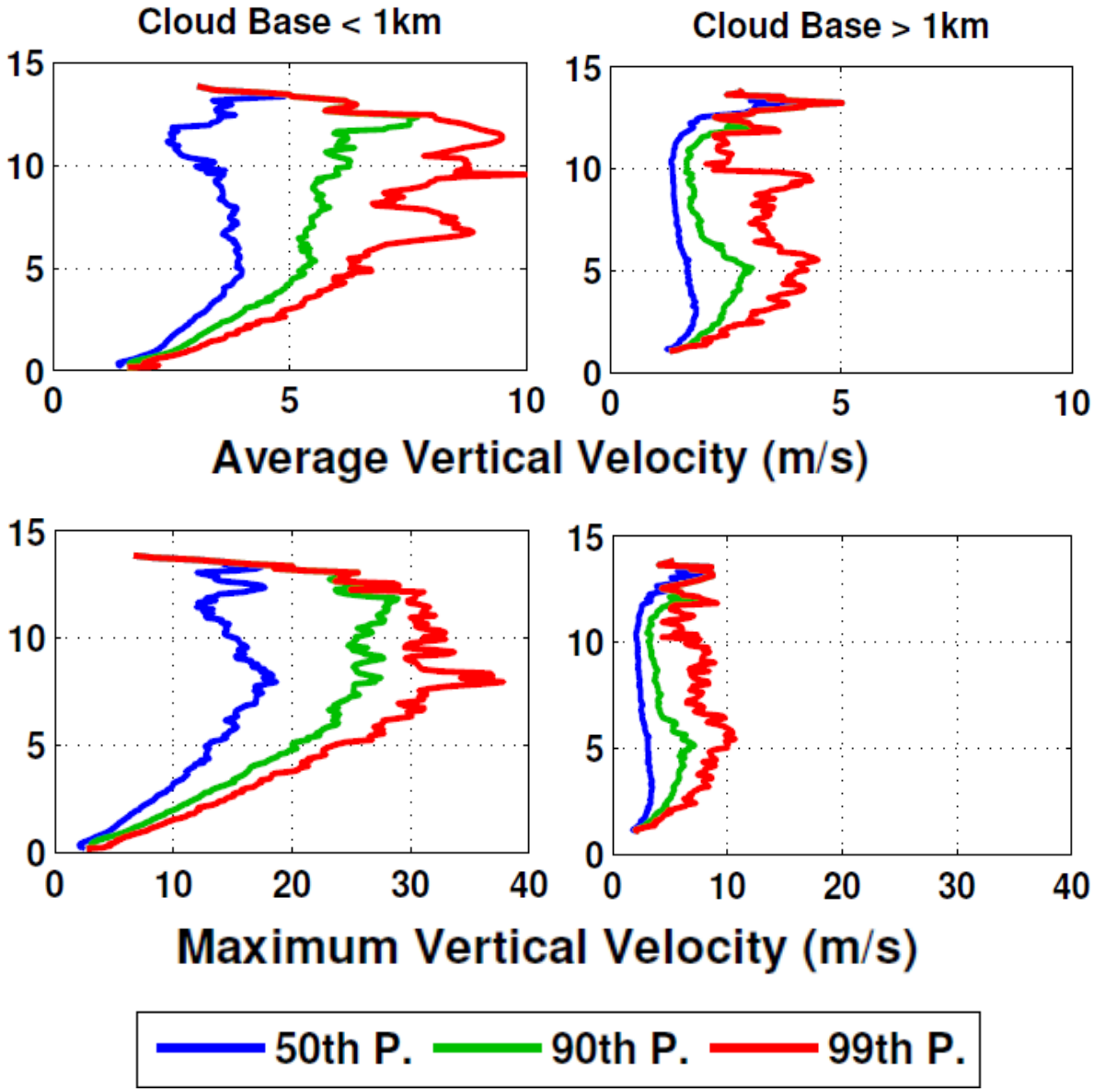




Low Cloud Bases

Higher Cloud Base

3D Cloudy Updraft Core Profiles



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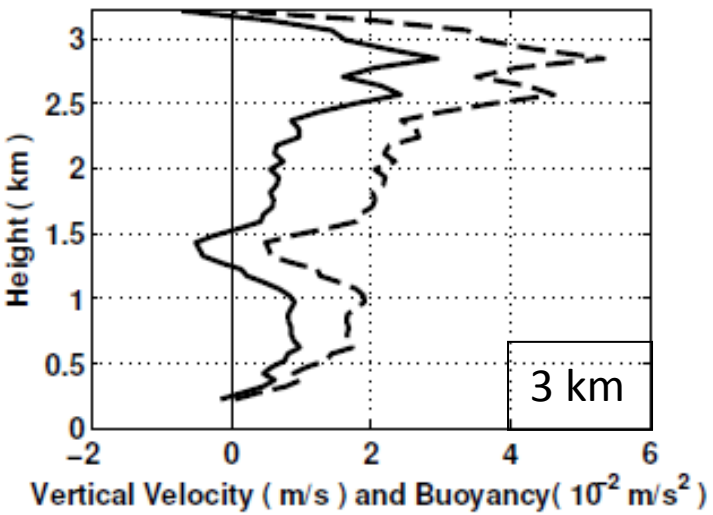
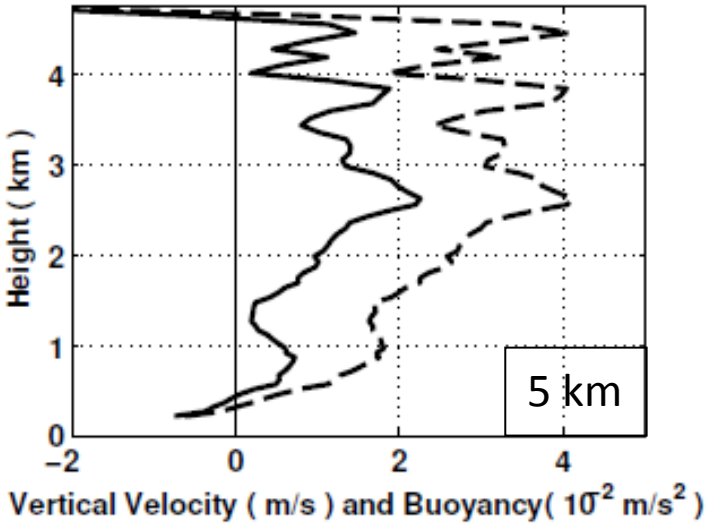
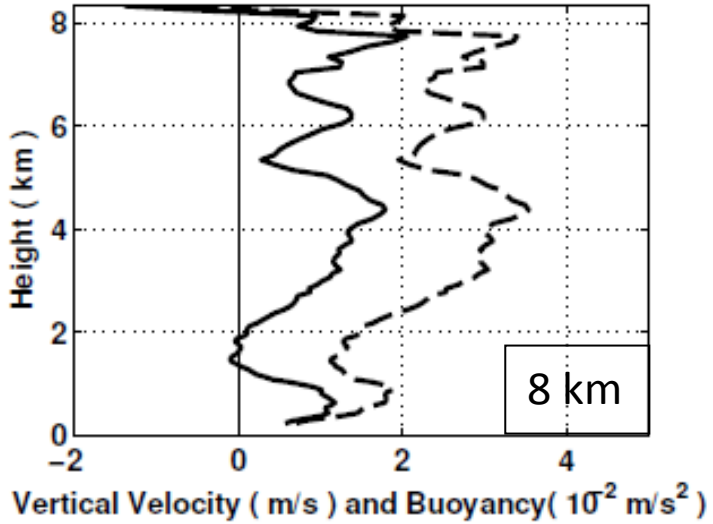
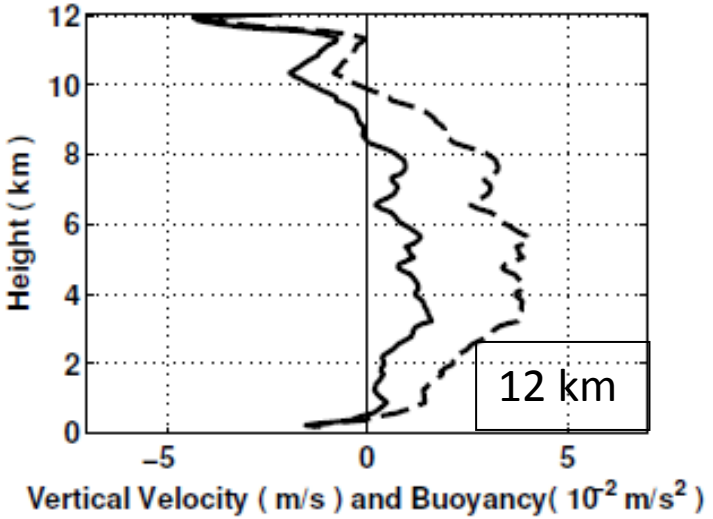
- How well can a parcel model reproduce W(z), given the total (loaded) buoyancy?
- Can the simple estimate $W = C * B_{unloaded}$ (suggested by Alison Stirling, UKMO) do as well?

Total Buoyancy, Unloaded Buoyancy

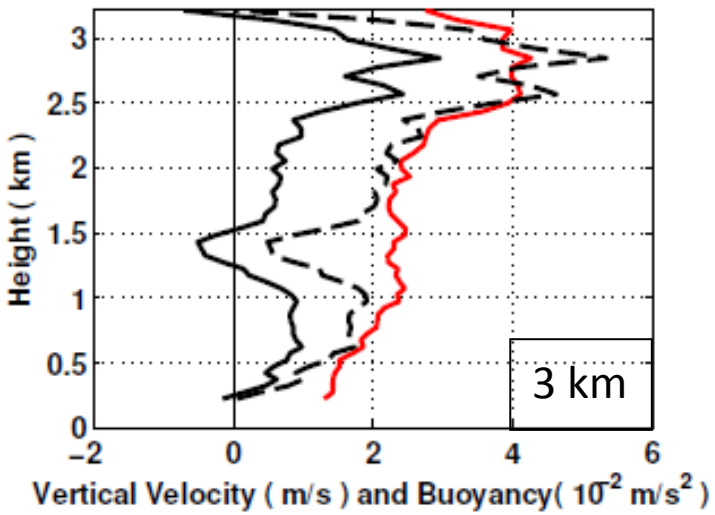


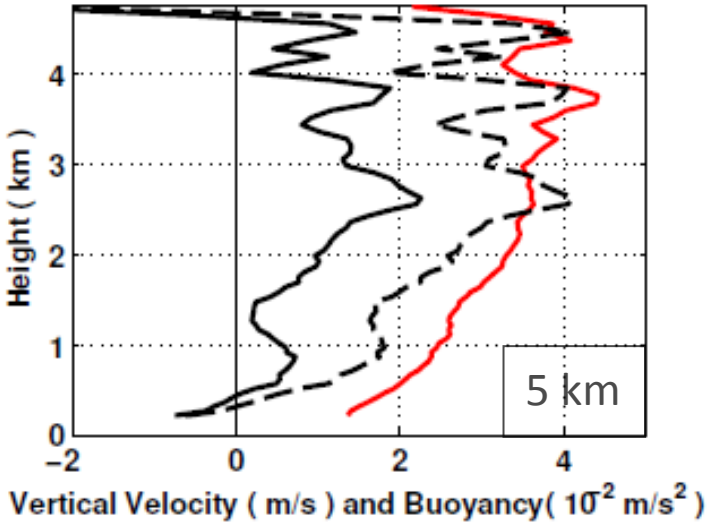


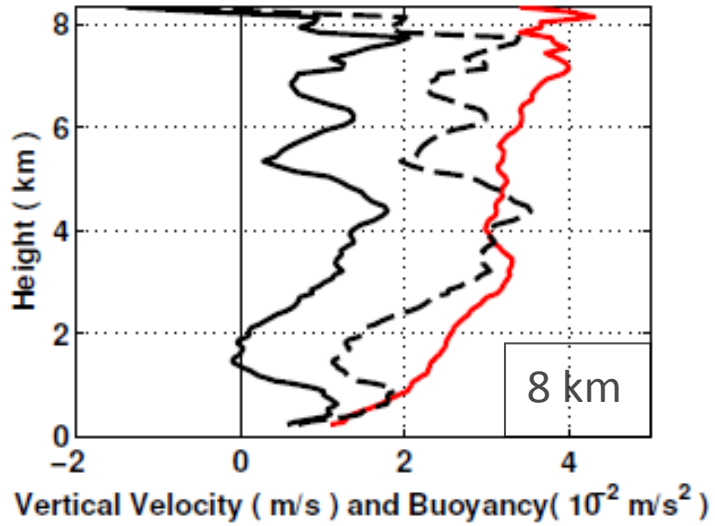


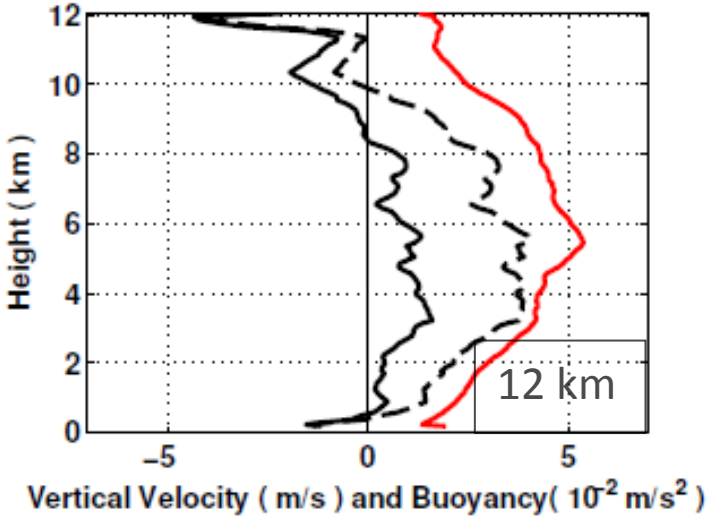


Total Buoyancy, Unloaded Buoyancy, Vertical Velocity









Parcel Model for Vertical Velocity

Use for each 3D cloudy updraft core

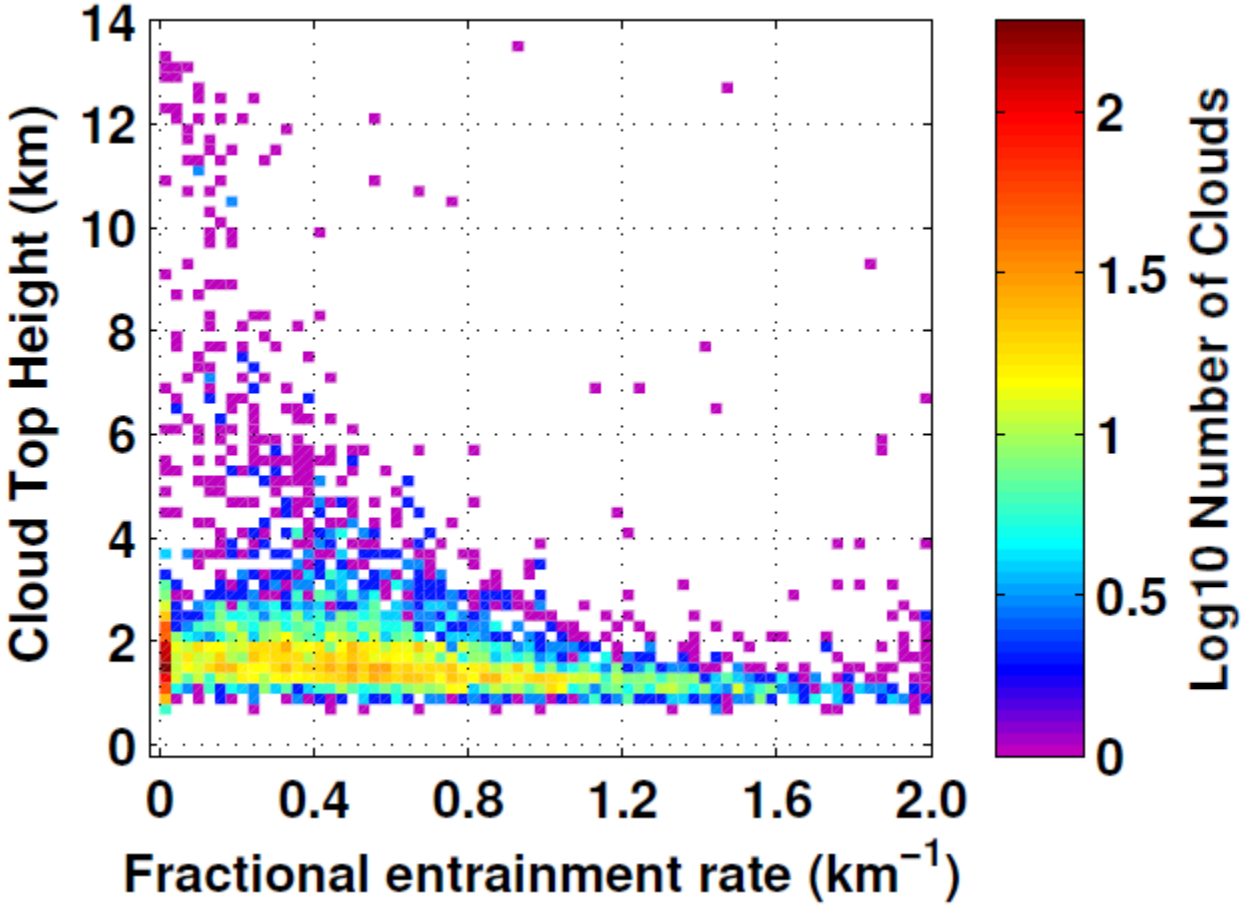
$$\frac{1}{2}\frac{dW^2}{dz} = aB - b\,\lambda\,W^2$$

Total buoyancy from cloudy updraft core

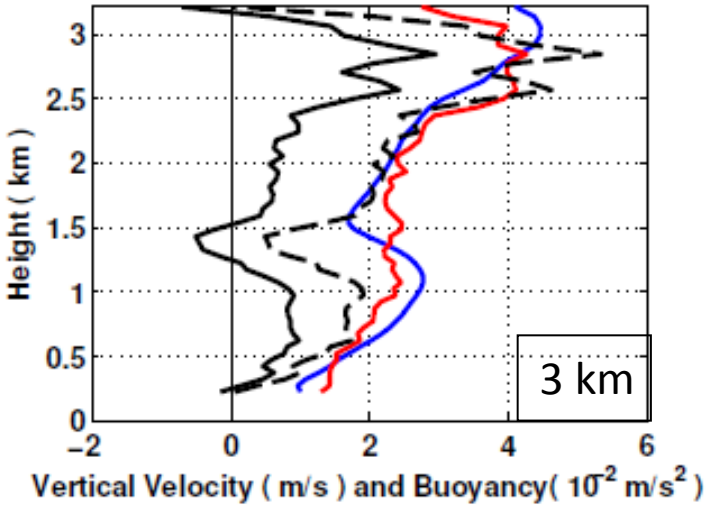
Iterate to find the fractional entrainment rate that…

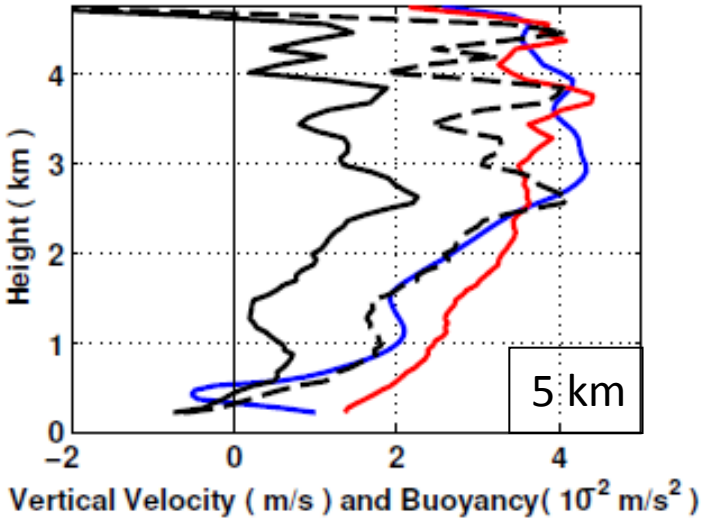
…gives the best W profile (min. RMS error)

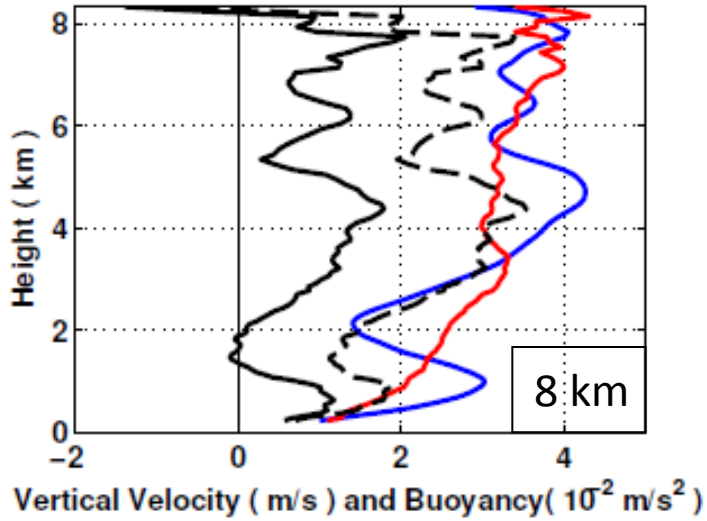
Entrainment rates from parcel model best-fit to cloudy updraft W

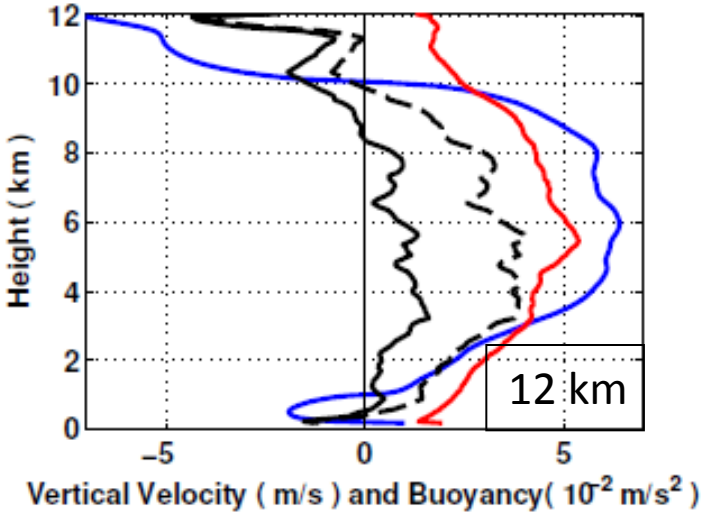


Updraft Core Vertical Velocity, Parcel Model Vertical Velocity

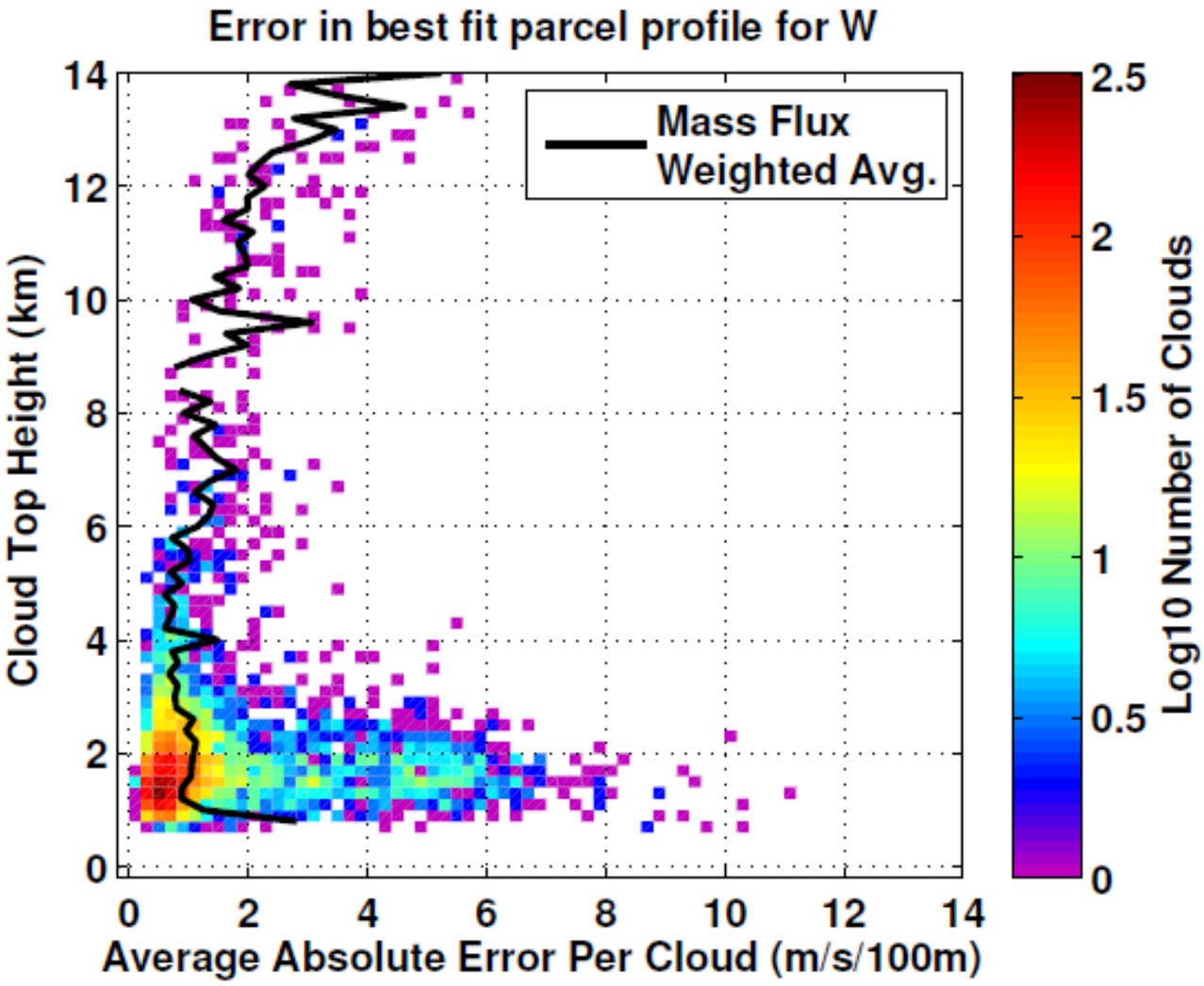




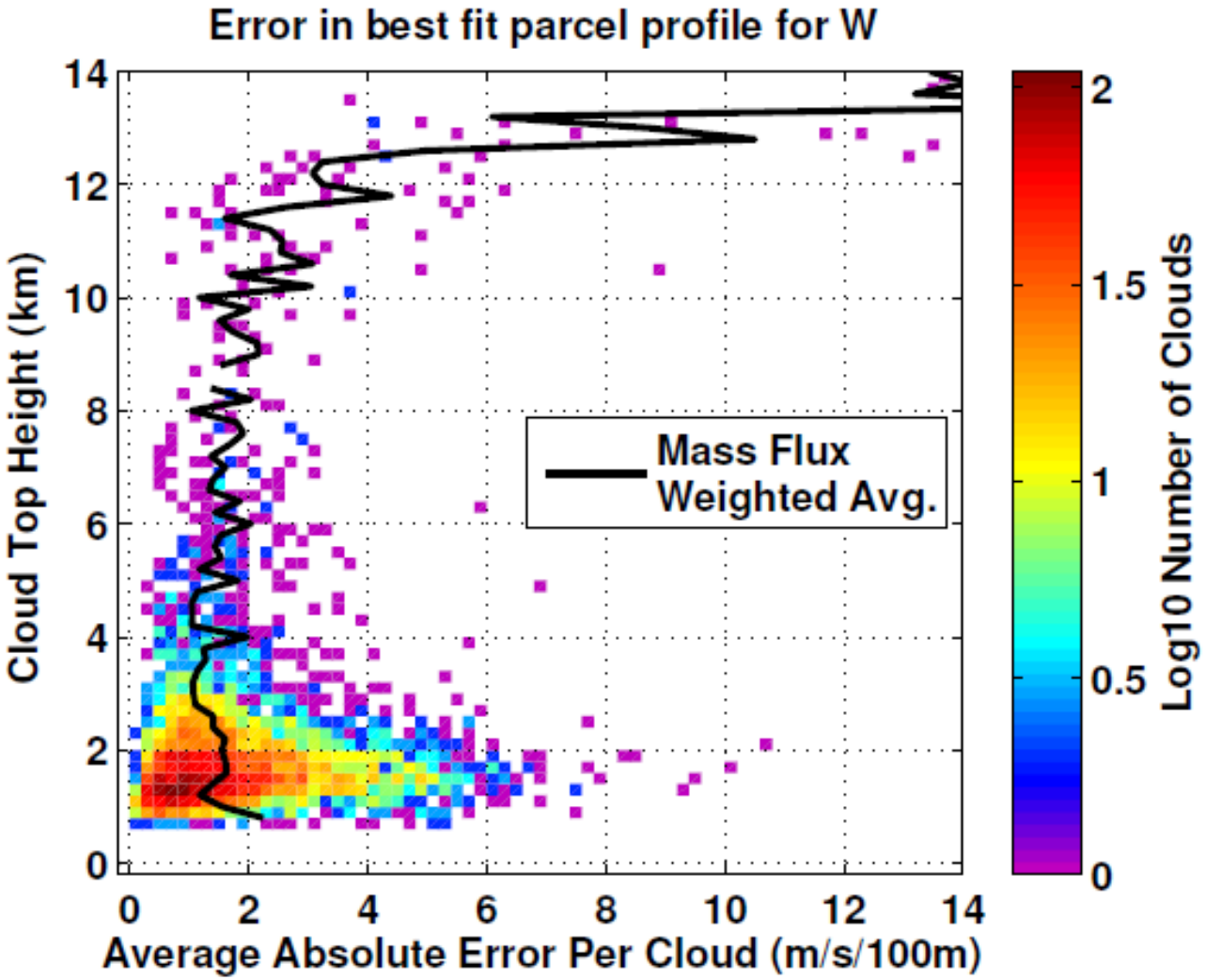




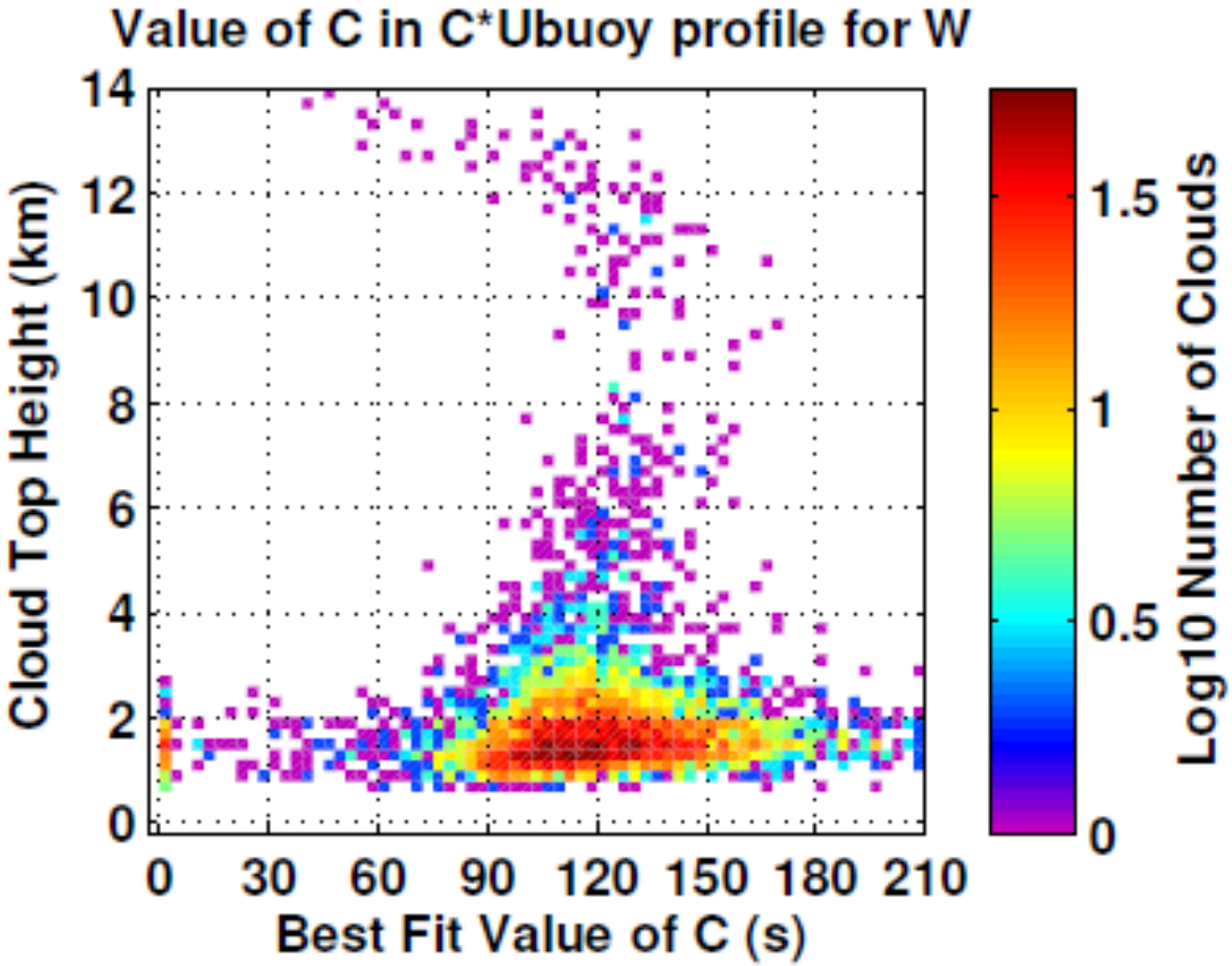
Error in parcel model W



Error for W = C * $B_{unloaded}$ (C=120 s)



For W = C * $B_{unloaded}$, what is C?



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- The MAE for Alison Stirling's estimate $W = C * B_{unloaded}$ is only slightly larger, and W requires only the "unloaded" buoyancy.
- Analyzing 3D cloudy updraft cores provides context, such as cloud base, cloud vertical extent, and cloud shape, that is not available from 1D and 2D core analyses.