Pacific Northwest
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Probing Processes for Deep Convective Cloud Growth using LASSO-CACTI

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2023 ASR PI Meeting Breakout – LASSO

Contributions: William Gustafson

Acknowledgment: LASSO Team

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ASR Atmospheric System Research

ARM

Integrated Cloud, Land-Surface,& Aerosol System Study ICLASS

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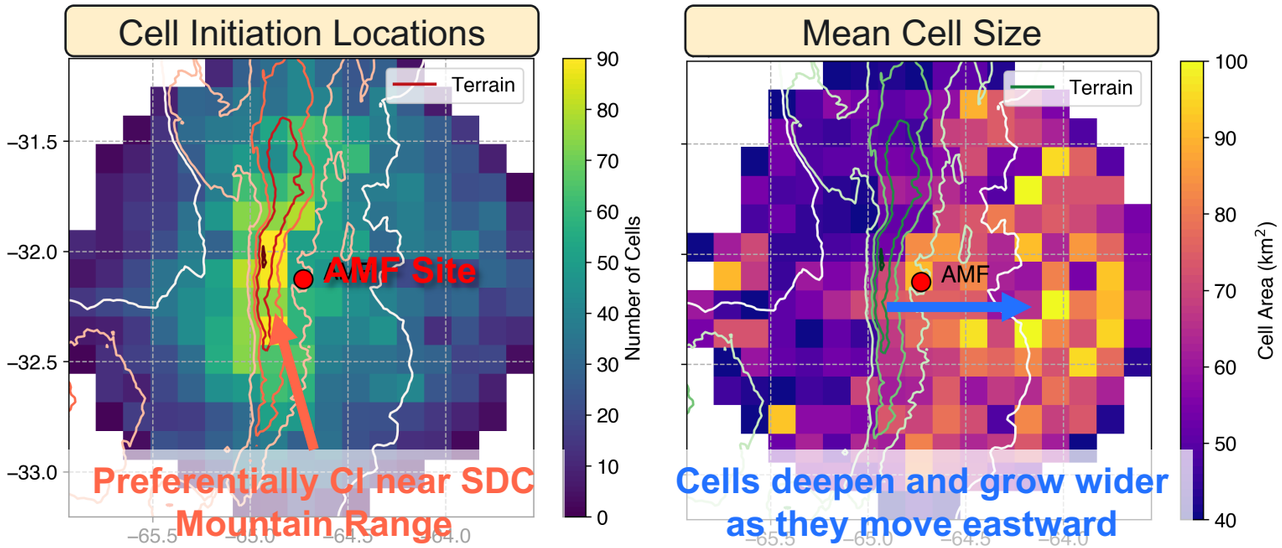
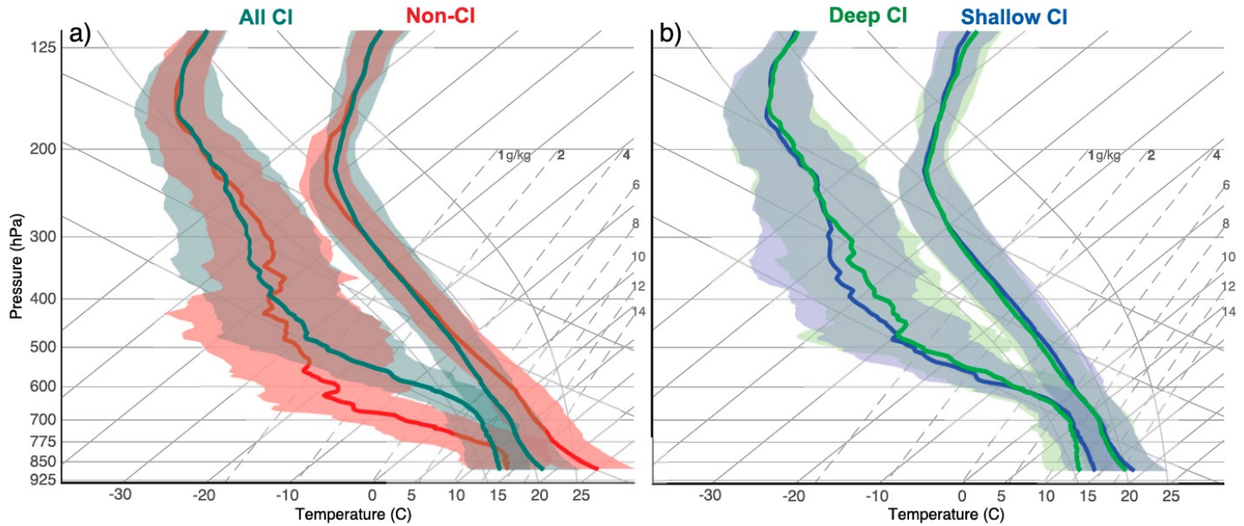
Motivation and Objective

- Deep convection initiation (DCI) and growth processes are poorly understood; near-cloud environmental factors and key cloud structures are difficult to observe
- **CACTI** (Varble et al. 2021) provided **large samples of DCI** and **growth** with collocated radar/satellite and environmental measurements (Feng et al. 2022)
- **Low/mid-level RH** strongly **differentiate CI** vs. **non-CI** events, pointing to **entrainment-driven dilution** processes, but do not differentiate deep vs. shallow CI (Marquis et al. 2023)
- **Goal:** Better understand processes controlling deep convective cloud growth under a variety of realistic environmental conditions using **LASSO-CACTI ensemble simulations**

Feng et al. (2022) *MWR*

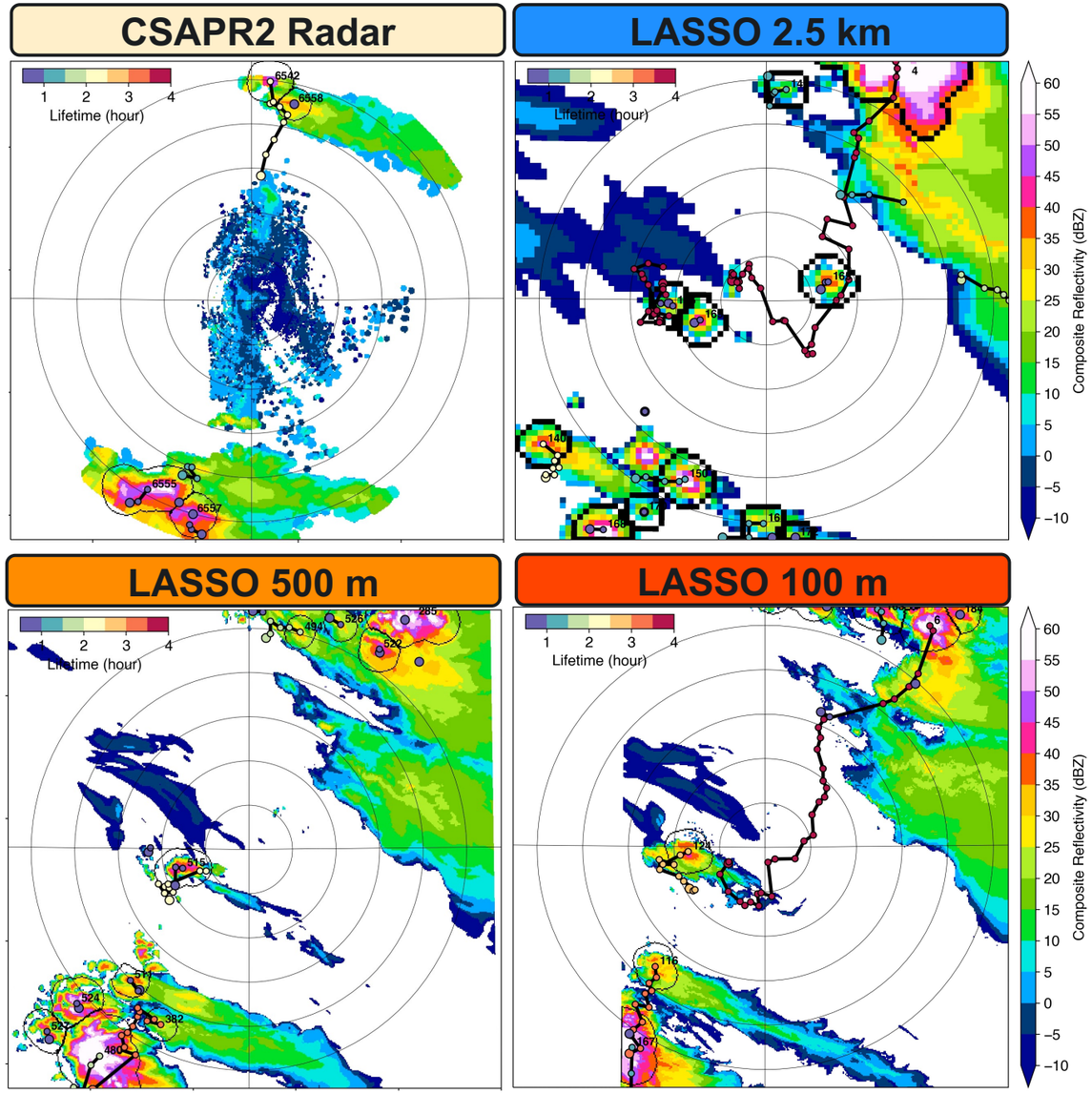




Marquis et al. (2023) *MWR*

Track Convective Cells in LASSO Simulations

- We applied **PyFLEXTRKR** (Feng et al. 2023) to track convective cells in LASSO simulations at CPM and LES grid spacings
  - **Radar** tracking: **Δ**x: 2.5 km & 500 m
  - **LASSO** tracking:
    - ✓ Native **Δ**x: 2.5 km & 500 m
    - ✓ Coarsen **Δ**x: 100 m → 500 m
- Environmental conditions for each tracked cell are obtained at CI locations in LASSO
- A total of 9 LASSO simulation days with 34 ensemble members are being analyzed

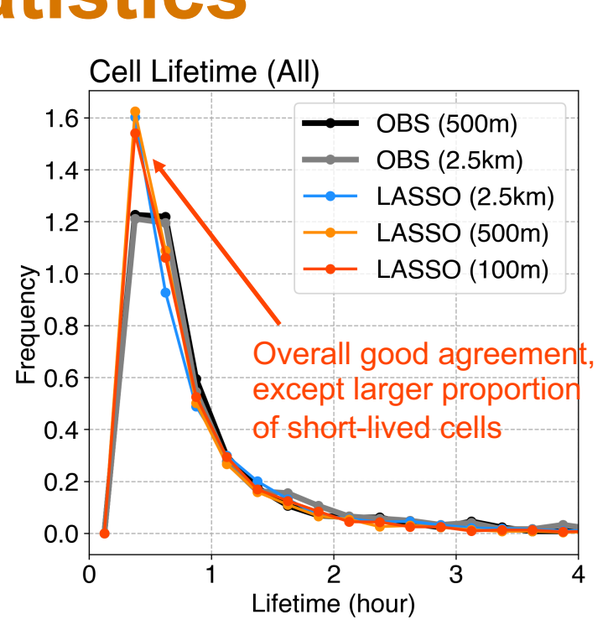


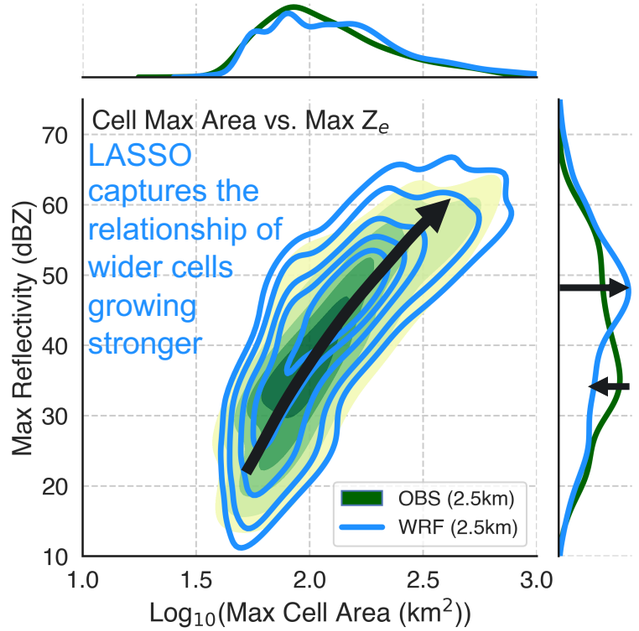
PyFLEXTRKR on GitHub

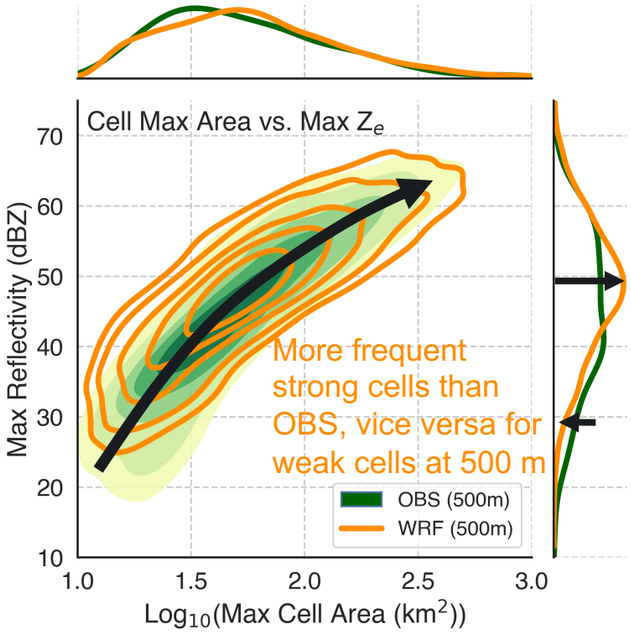
See poster by Zhe Feng on Tuesday (Session 1)

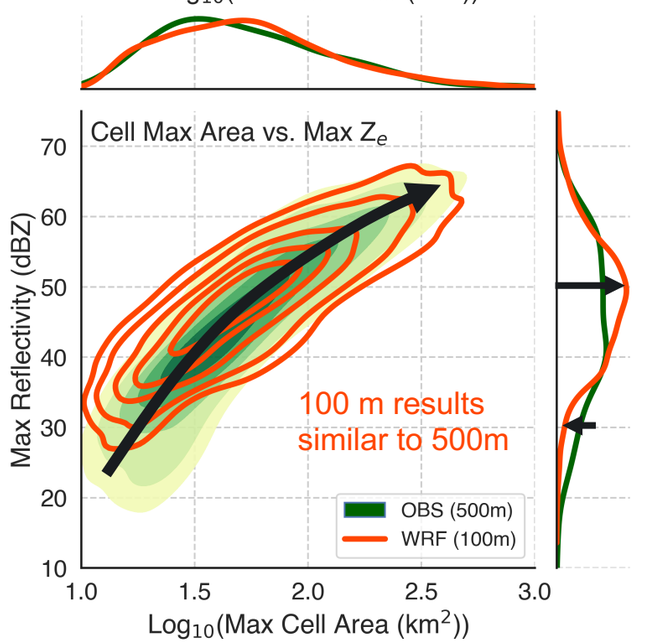
LASSO Reproduces Important Observed Convective Cell Statistics

- Model cell lifetime agrees well with observations, except for larger proportion of short-lived cells
- LASSO captures relationship between wider and more intense cells, but has more frequent strong cells than OBS
- Ongoing work examining resolution sensitivity on convective updraft characteristics to ambient environments

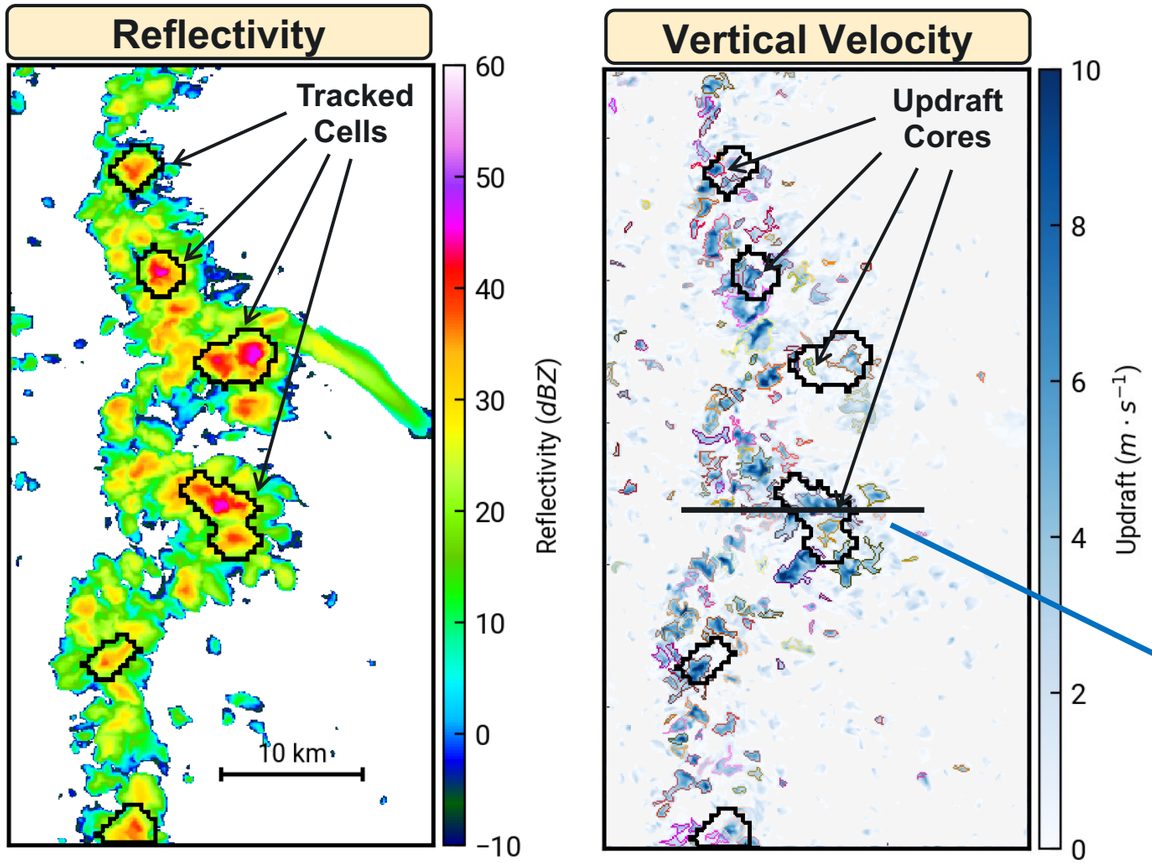








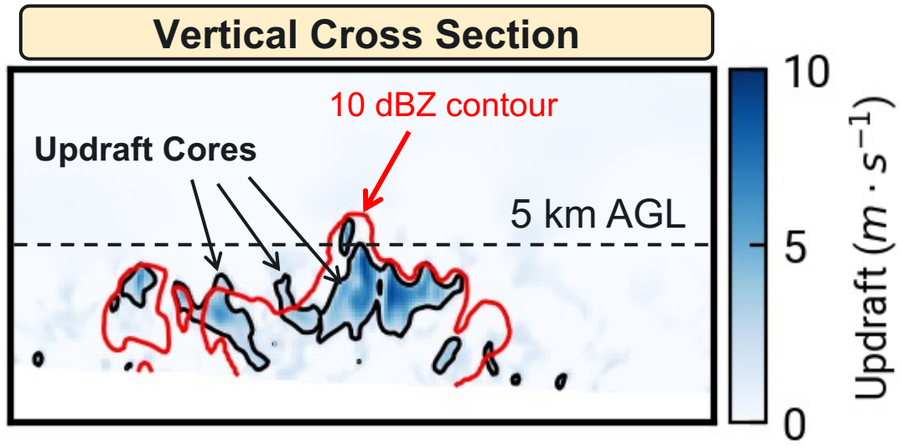
Deriving Updraft Statistics in Tracked Cells



Δx = 100 m

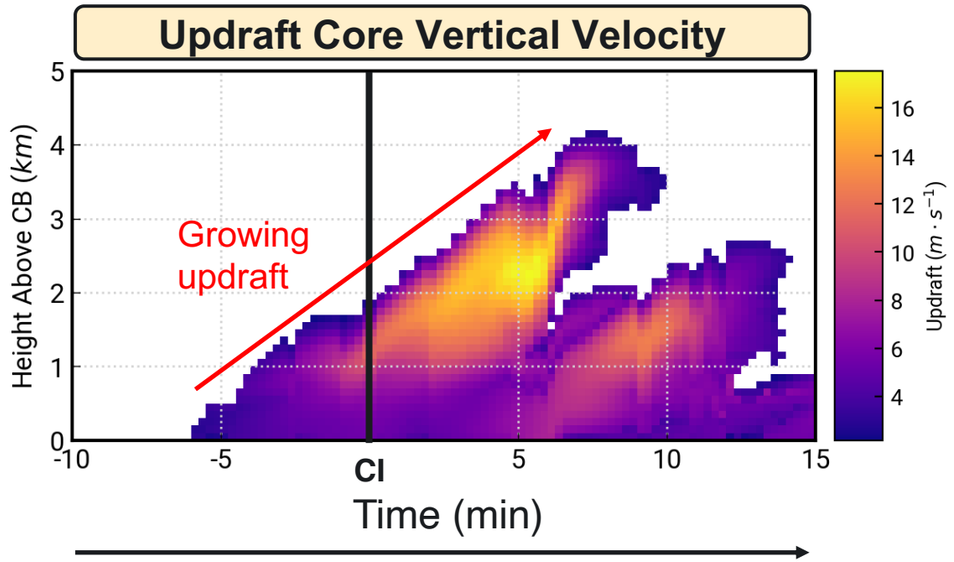
Updraft core: > 2 m/s updraft, > 0.01 g/kg of cloud water

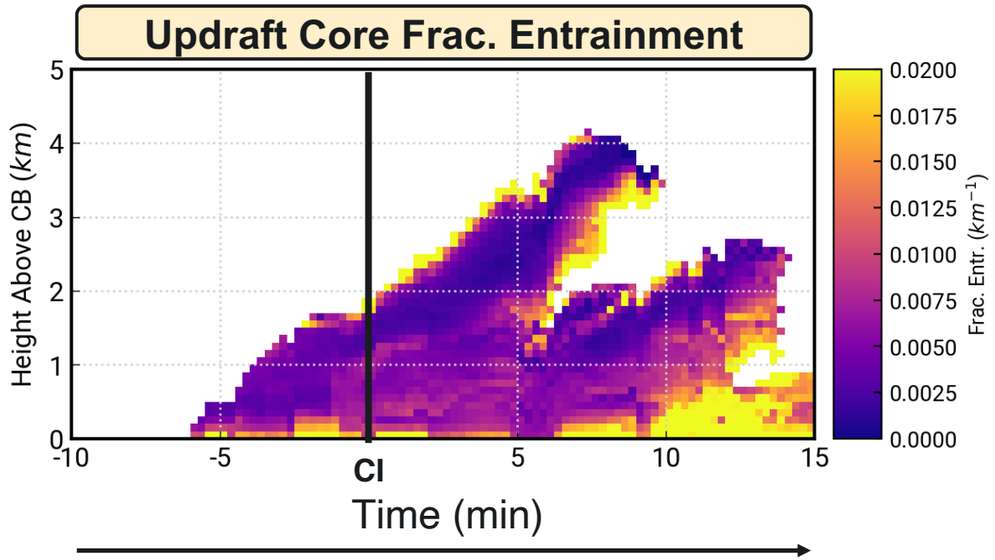
- Identify **updraft cores** within each tracked cell mask
- Calculate and save a suite of **updraft profile statistics**:
  - Width, strength, fluxes
  - Thermodynamics, environments



*Selected a 3-h period with large number of CIs, output at 15 s

Obtaining Updraft Evolution for Tracked Cells

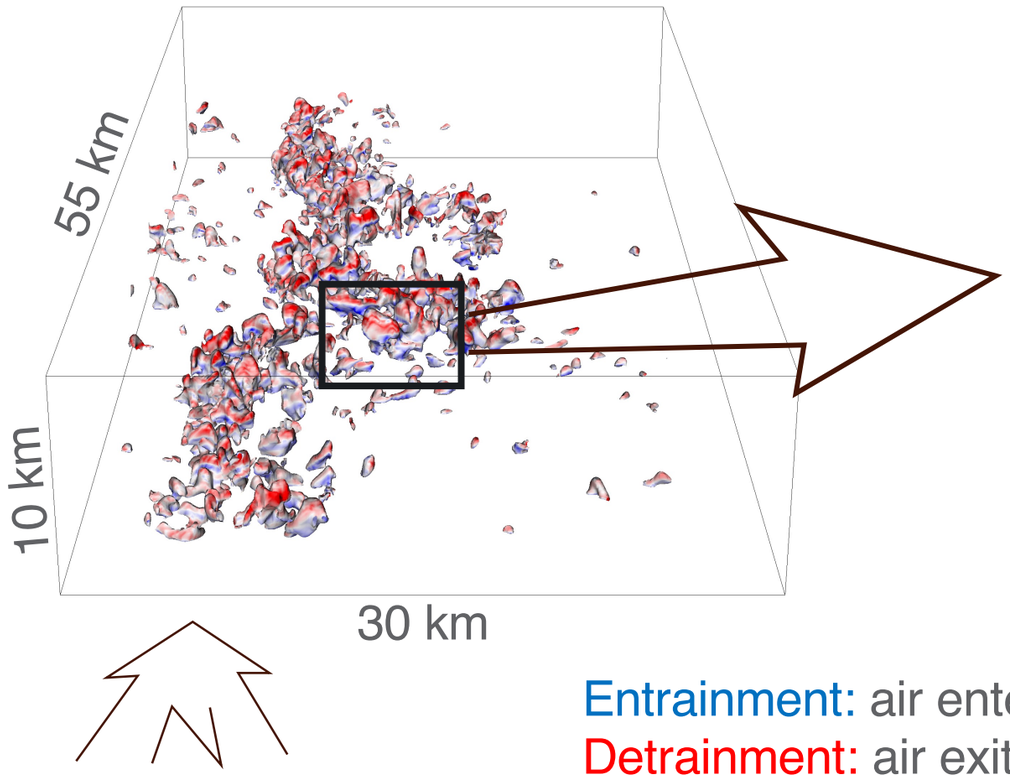


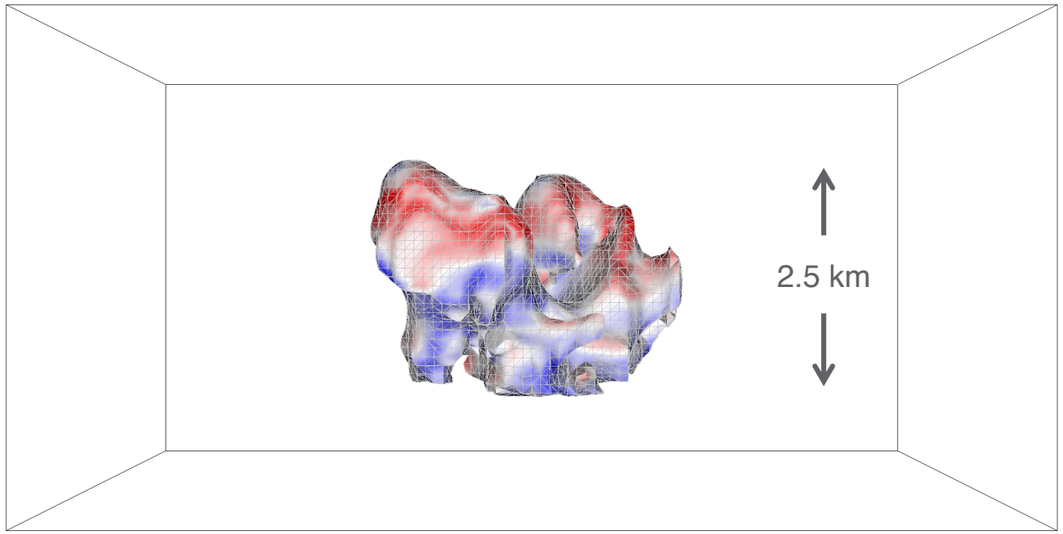


- Extend updraft statistics prior to the time of CI (i.e., when cell is first detected)
- Examine complete updraft evolution

Entrainment & Detrainment …

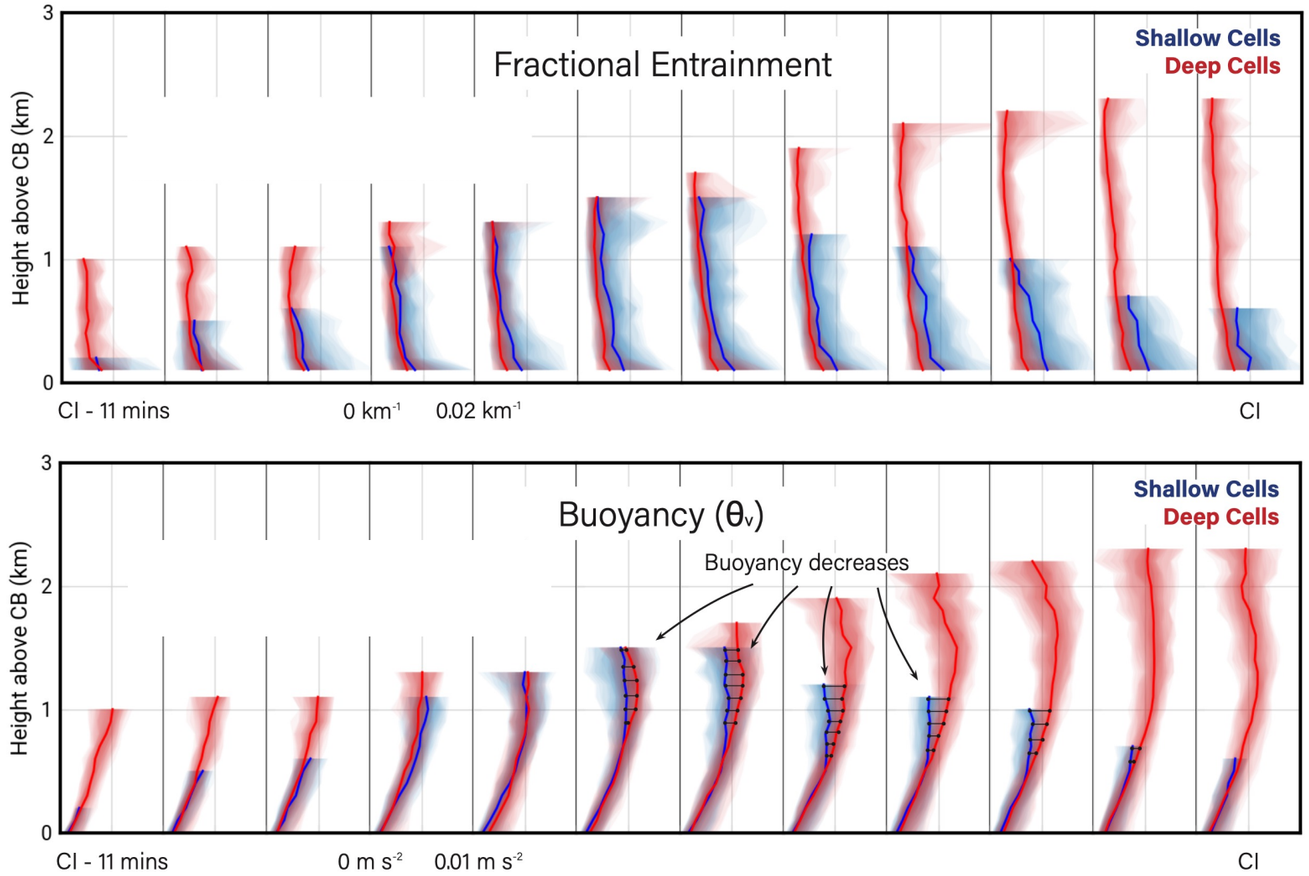
… is calculated on the 2 m/s updraft, 0.01 g/kg cloud water surface using the “direct” method of Dawe and Austin (2011)





Entrainment: air entering surface
Detrainment: air exiting surface

Timeseries of Vertical Profiles

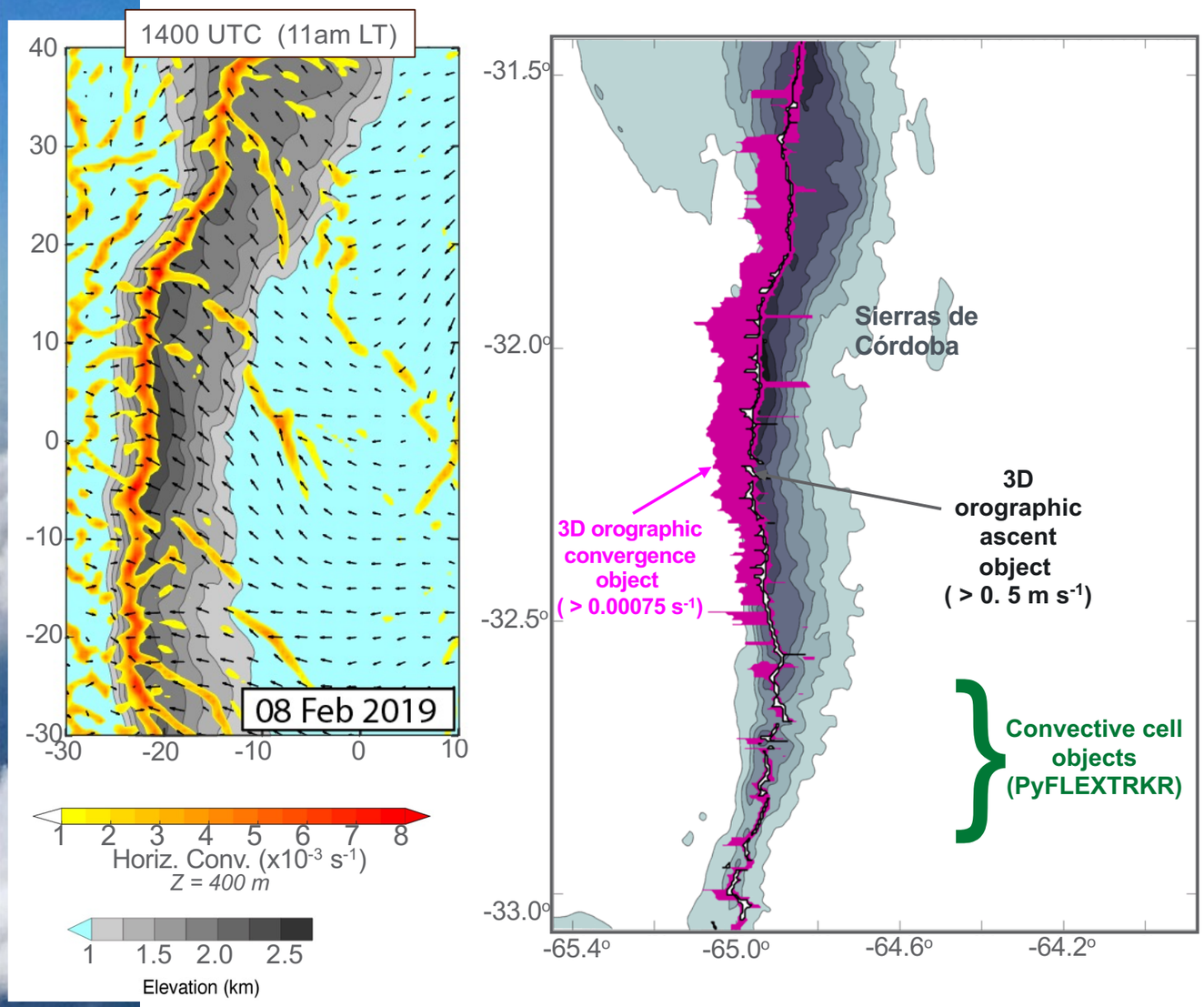


Cells separated into shallow & deep categories

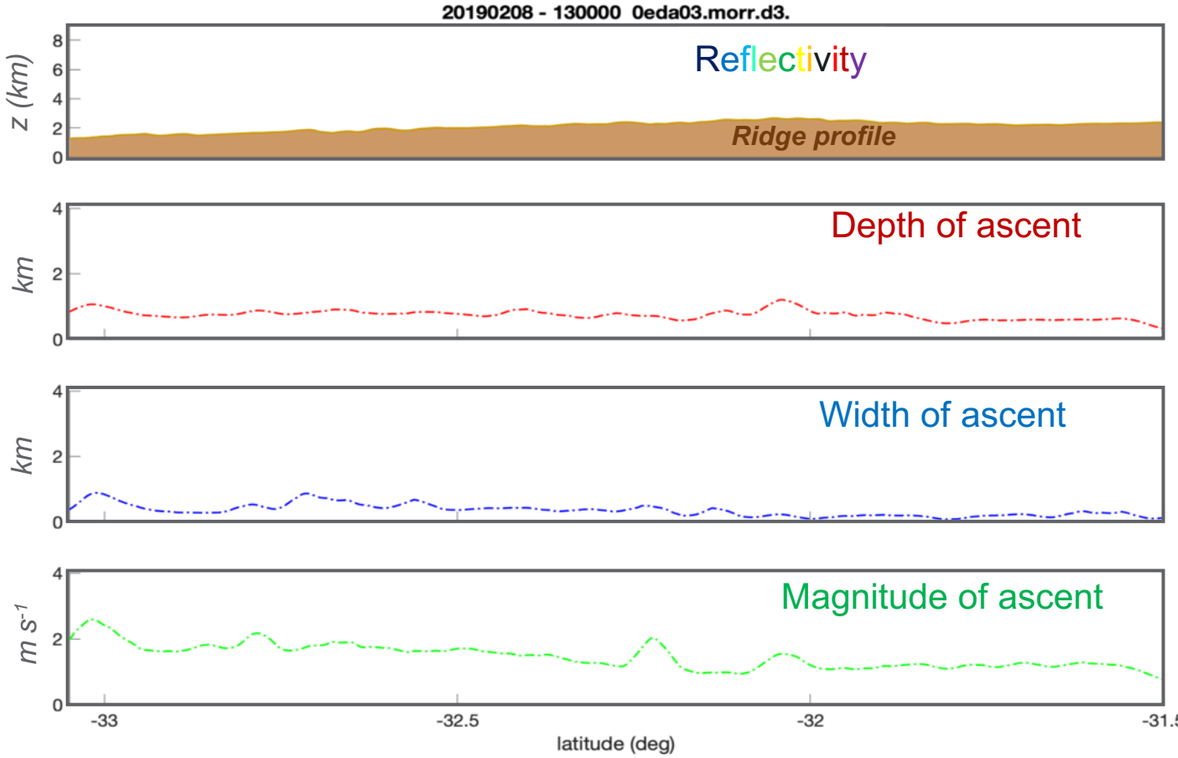
- Shallow cells entrain cooler environmental air in greater quantities relative to their VMF
- This dilutes the shallow cells more than the deep ones
- Buoyancy of shallow cells drops, followed by the updraft speeds, and subsequent decay of the updrafts.

See poster by Enoch Jo on Wednesday (Session 4)

Relating Orographic Ascent to DCI



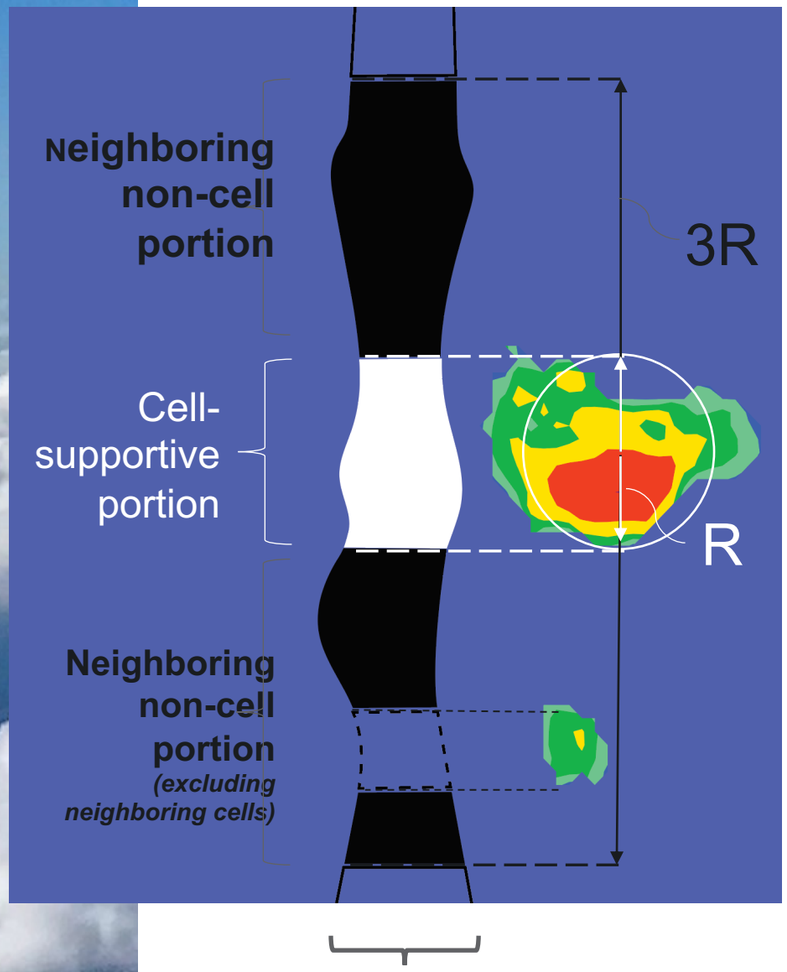
Along-ridgeline properties of orographic ascent swath & cell development



<u>Other calculated metrics</u>: along-ridge vertical mass flux, CAPE, CIN, LFC, LCL, shear, q_{vap} & RH,…. *and more!*

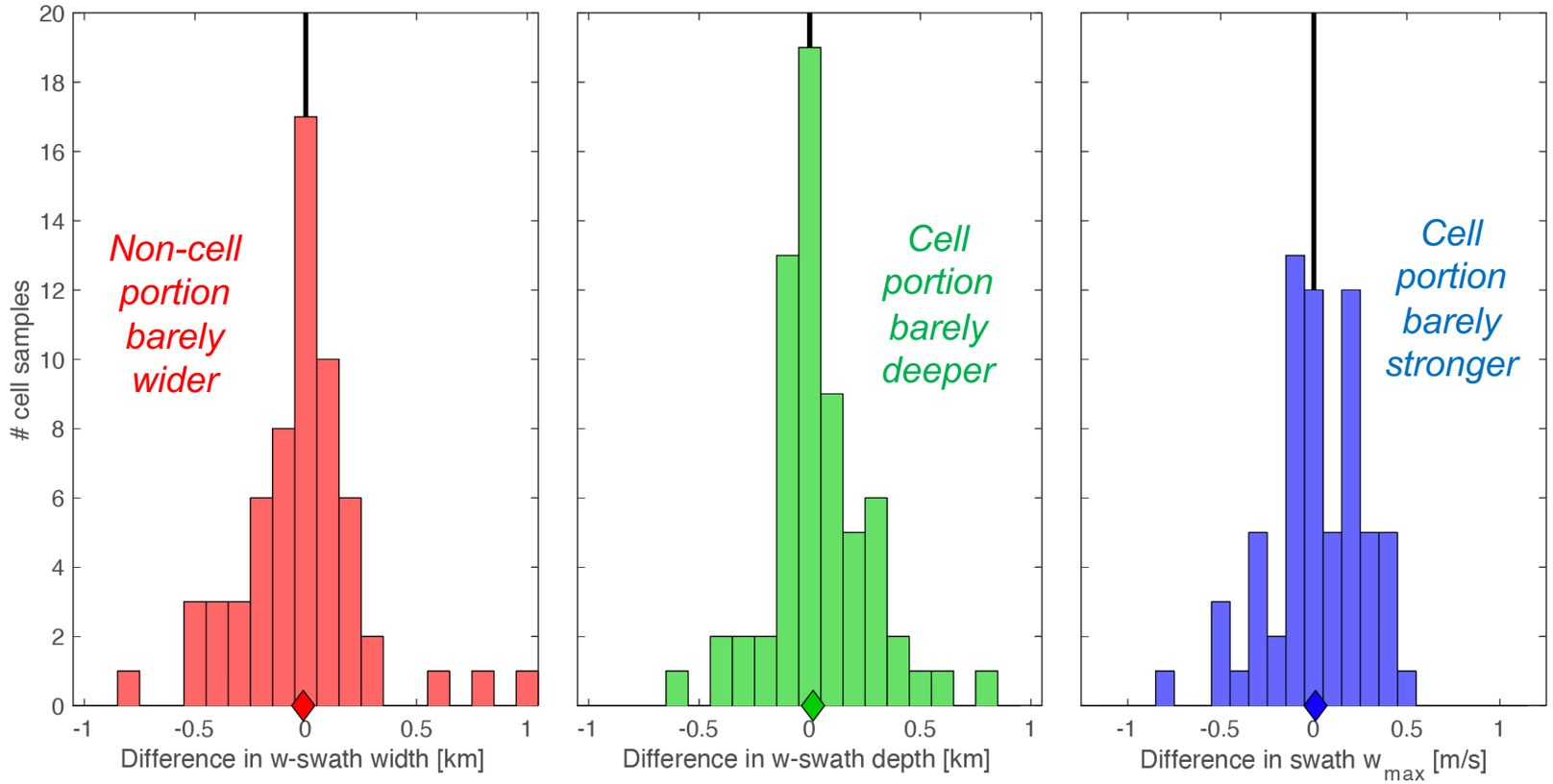
Does orographic ascent structure (in)directly affect location of DCI?

Kinematic characteristics:



Orographic Ascent ($w > 0.5$ m s^{-1})

Mean of cell containing portion - mean of non-cell portion (@ CI – 30 min)



Very small differences @ CI – 30 min (and CI – 15 min)

See poster by Jim Marquis on Wednesday (Session 4)

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Ongoing work

- Examining how **model resolution** affects the relationships between near-cloud environments and updraft characteristics
- Quantifying how **entrainment-driven dilution**, which controls convective cloud depth and precipitation, affects updrafts
- Examining correlations between **orographic ascent structure** and low-level cloudy updraft properties