Observational Analysis of Aerosol Impacts on Deep Convective Cell Evolution Using Polarimetric Radar Measurements During TRACER

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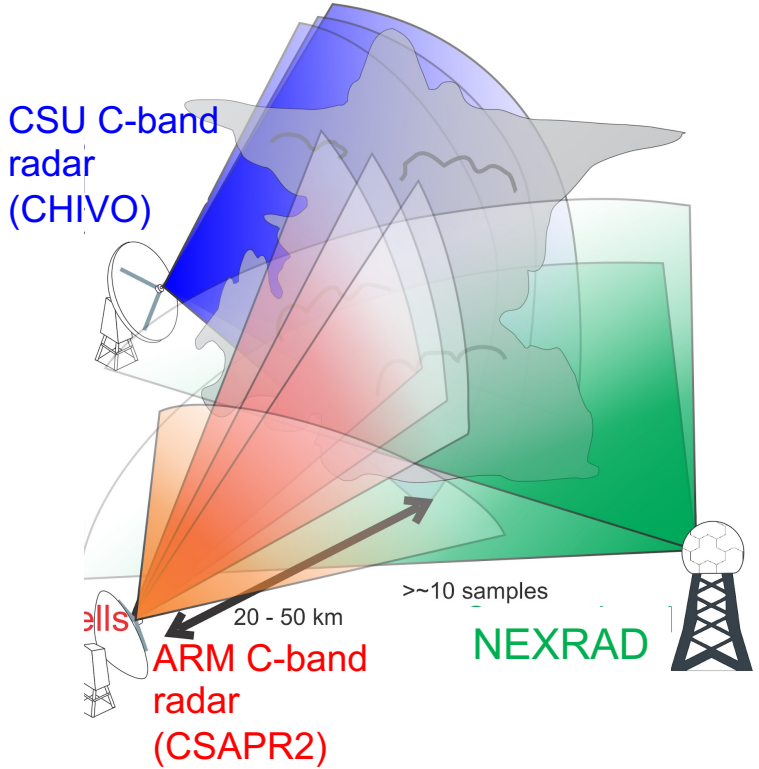
Introduction

Motivation

- One of the major challenges in studying cloud evolution and aerosol impacts is the ability to collect fine-scale observations of fast-evolving convective clouds.
- CSAPR2 performed fast update of cell tracking every 2 min during the Houston area during the TRACER field campaign in the summer in 2022.
- More than 1000 convective cells with various life stages were tracked.

Objective

- Investigate statistical characteristics of convective cell core properties with different aerosol environments.



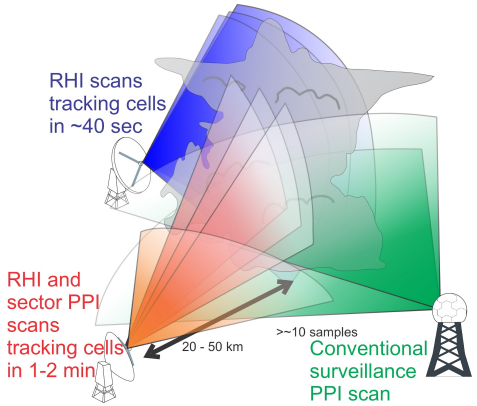
(Oue et al., 2022, adapted)

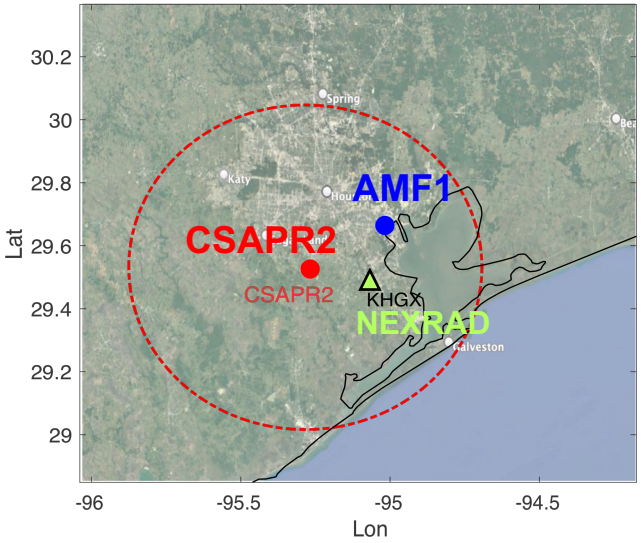
Data

- CSAPR2 cell tracking datasets during TRACER
  - From 2022/06/04 to 2022/09/20
  - Corrected for systematic biases and rain attenuation
  - 3 sector PPI and 4 – 6 RHIs every ~2 min
  - Reflectivity
  - Polarimetric observables
    - Z_{DR}: Hydrometeor particle size, wet graipel/hail signature in deep convection
    - K_{DP}: Hydrometeor particle size, water content, wet graipel/hail signature in deep convection

- NEXRAD radar at Houston, TX (KHGX) – spatial distribution
  - Reflectivity, Z_{DR}, and K_{DP}

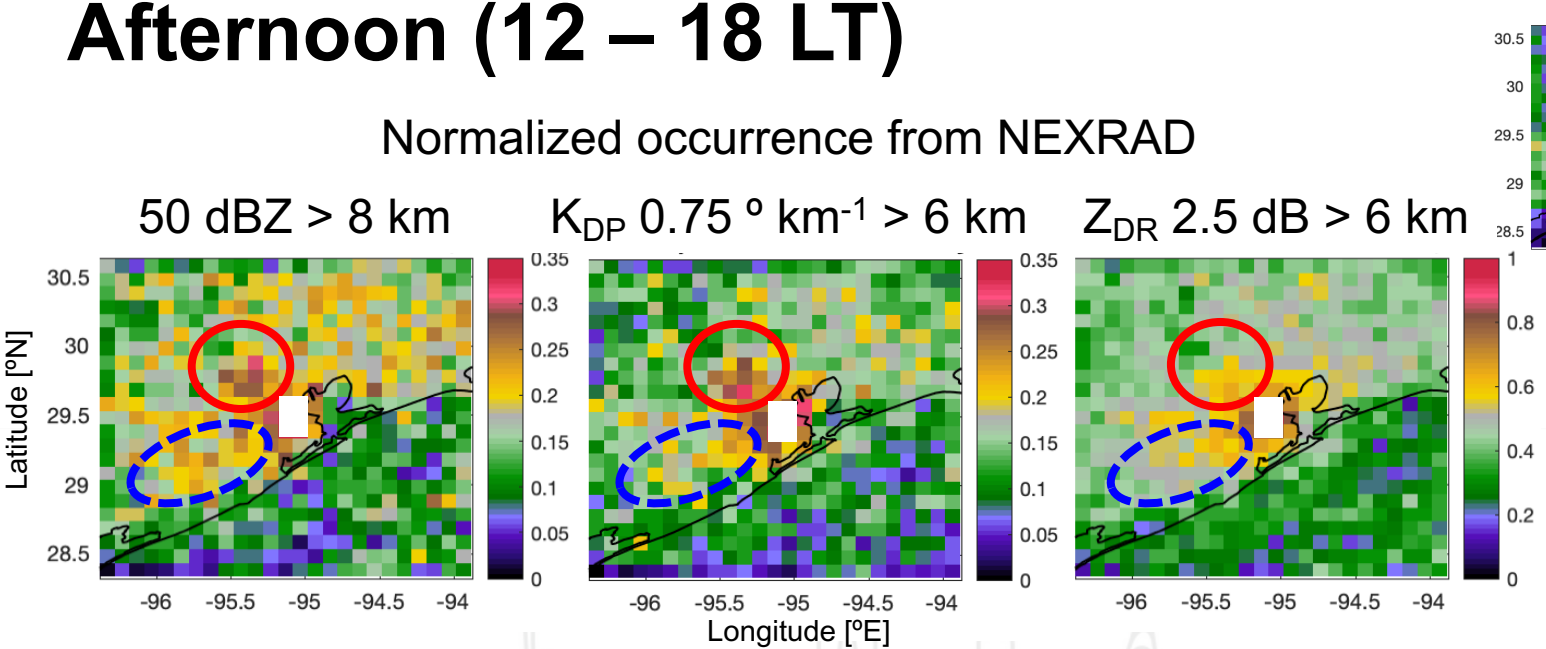
- CCN Number concentration from the ARM AOS CCN counter at AMF1

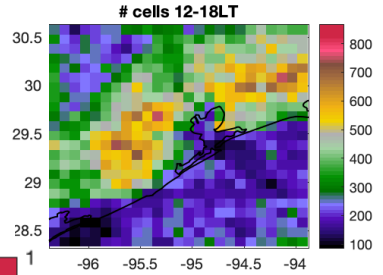




Results: Horizontal inhomogeneity in Afternoon (12 – 18 LT)

Normalized occurrence from NEXRAD





- Higher rates of cells developed deeper associated with larger K_{DP} and Z_{DR} in the urban area and SW coastal area in afternoon, suggesting vigorous convection possibly related to:
  - Urban heat
  - Pollution

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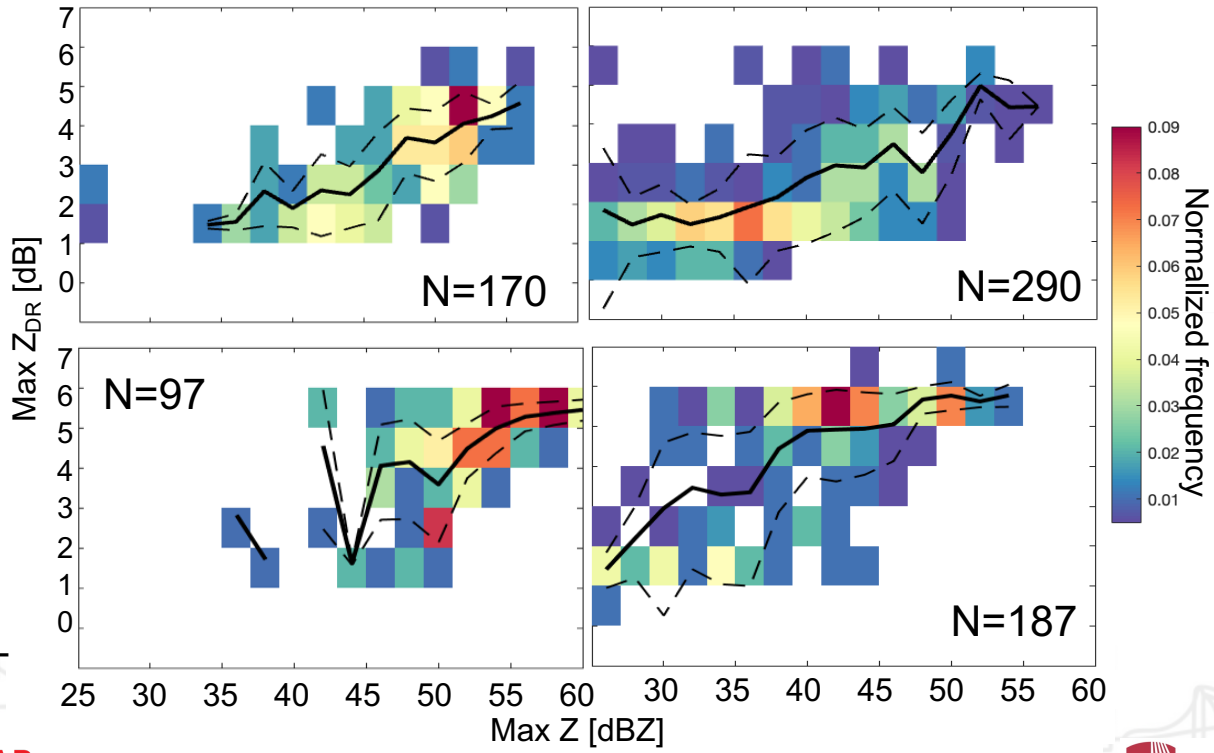
Results: Z_{DR} with CCN environments

Deep cells
(30 dBZ top > 6 km)

Shallow cells
(30 dBZ top < 6 km)

Lower CCN (<900 cm^{-3})

Higher CCN (>1300 cm^{-3})



12 – 18 LT

- Convective cells developed nearby the CCN measurement site were classified into higher and lower CCN environments.
- Larger Z_{DR} (large raindrops) at a given Z was observed in higher CCN environment for both deep and shallow convective cells.

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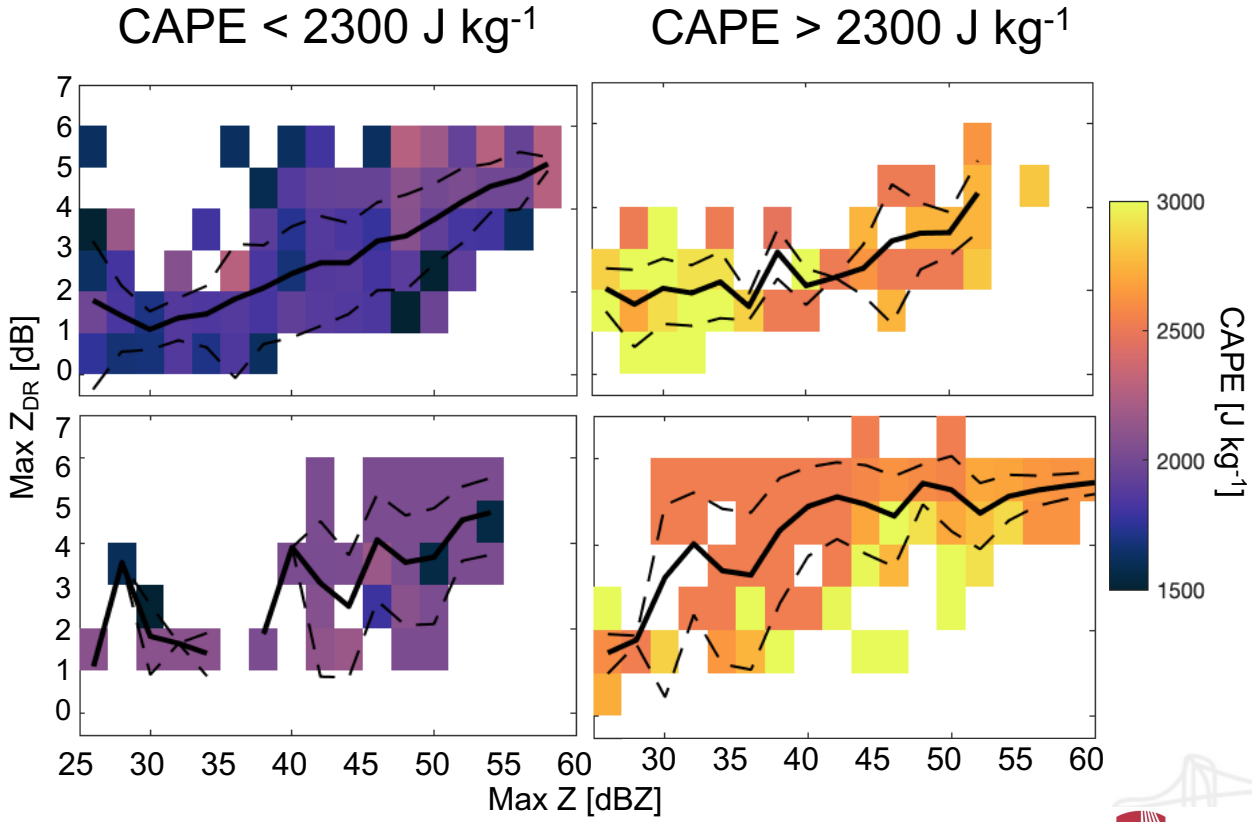
Results: Z_{DR} with CCN and CAPE



Larger Z_{DR} for higher CCN was observed in higher CAPE environments.

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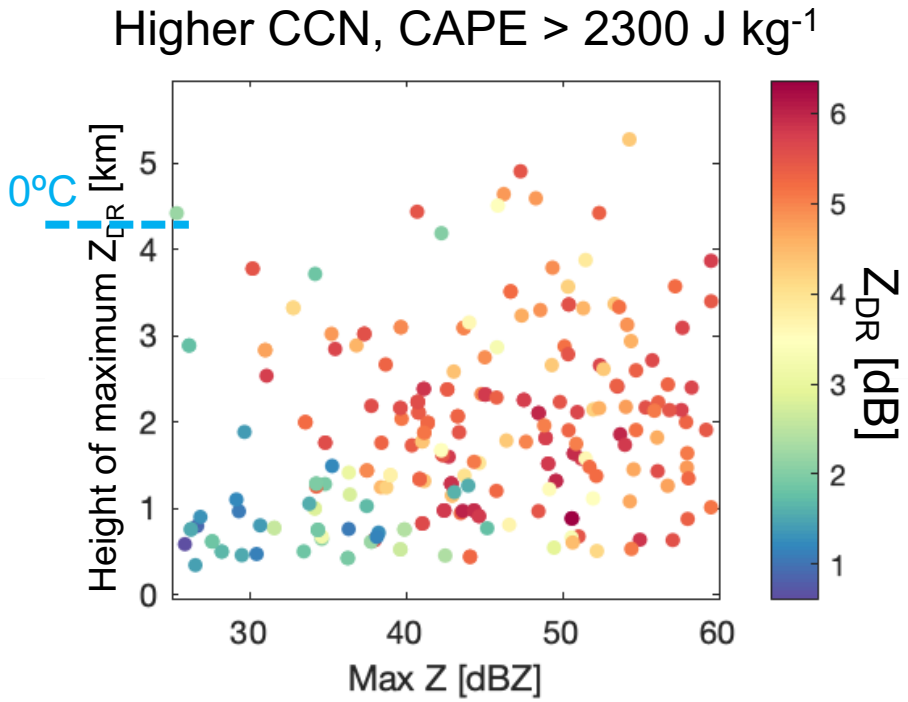
Results: Height of larger Z_{DR}



- Heights of larger Z_{DR} extended to just above environmental freezing level.
- This suggests that wet hail/gaupel contributed to large Z_{DR}. They could also contribute to large raindrops at lower altitudes.

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Summary

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- ❑ Statistical characteristics of convective cell evolution were investigated using NEXRAD and CSAPR2 data from June to September 2022 in Houston.
  - Areal inhomogeneity: Convective cells in the urban area developed deeper associated with larger K_{DP} and Z_{DR}, suggesting effects of urban heat and/or pollution.
  - Larger Z_{DR} (suggesting larger raindrops) with higher CCN and higher CAPE. This is consistent with Aerosol-Cloud-Precipitation-Climate Model Intercomparison Project simulation results.
- ❑ Need for individual convective cell evolutions accounting for different environments and dynamical characteristics.