Evaluating Aerosol Indirect Effects on Convective Cells from a Joint Modeling and Radar Simulator Perspective

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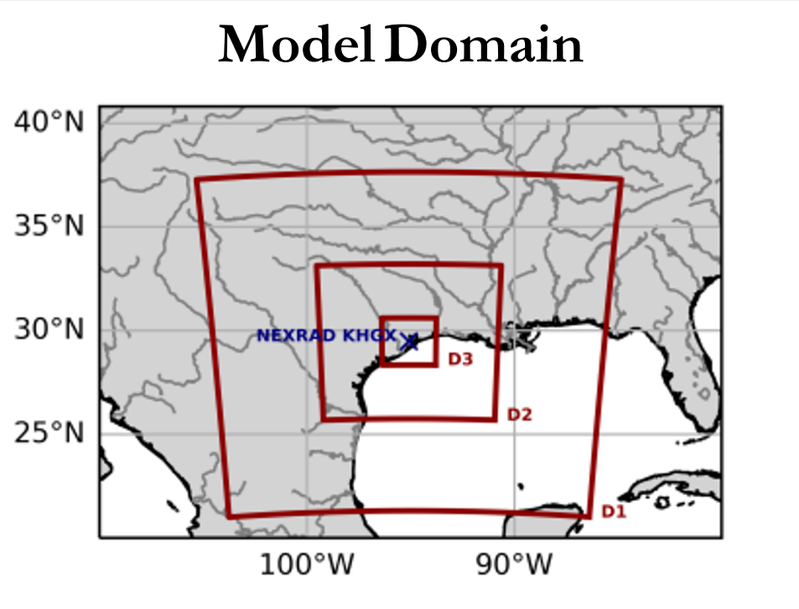
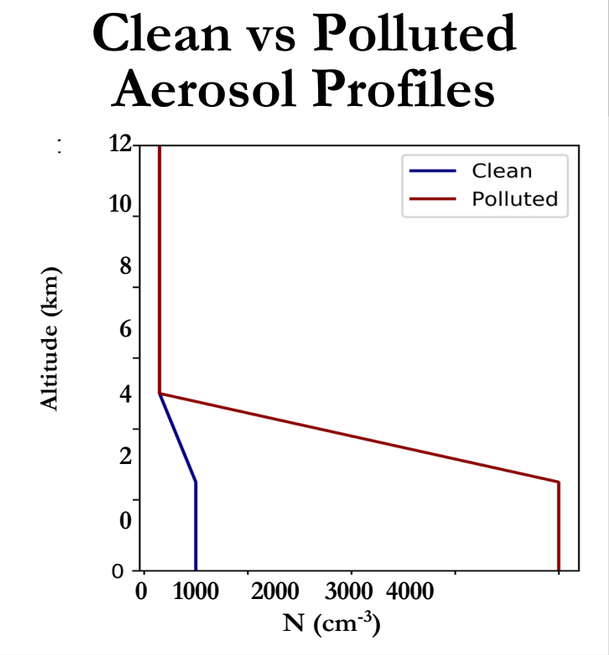
Recent Pre-TRACER Modeling Efforts

1. **Determining the predominant microphysical processes impacting isolated deep convective cells as a function of aerosol loading and lifecycle using the Aerosol, Cloud, Precipitation and Climate (ACPC) initiative simulations of convective cells.**
   (ACPC Simulations - Marinescu et al. 2021, van den Heever et al. 2021)

2. **Determining optimal radar sampling strategies for TRACER through the use of Observing System Simulation Experiments performed using a radar simulator, cell tracking technique, and the ACPC MIP model data.**



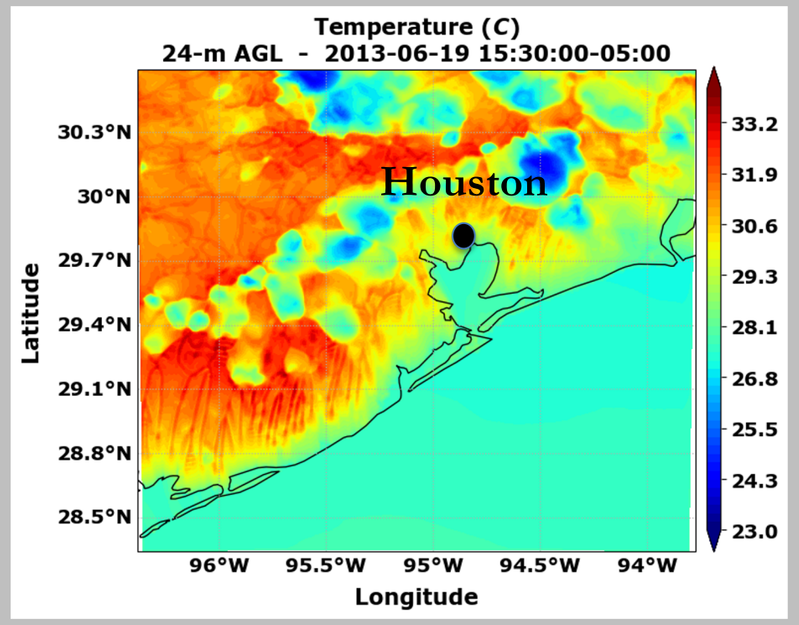


Case Study Simulations of Isolated Convection

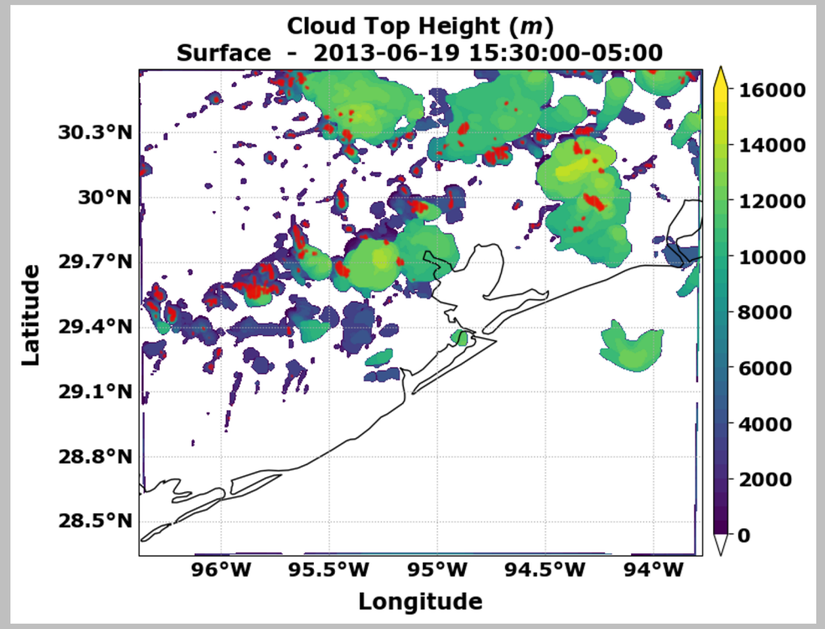
Houston, TX 19-20 June, 2013

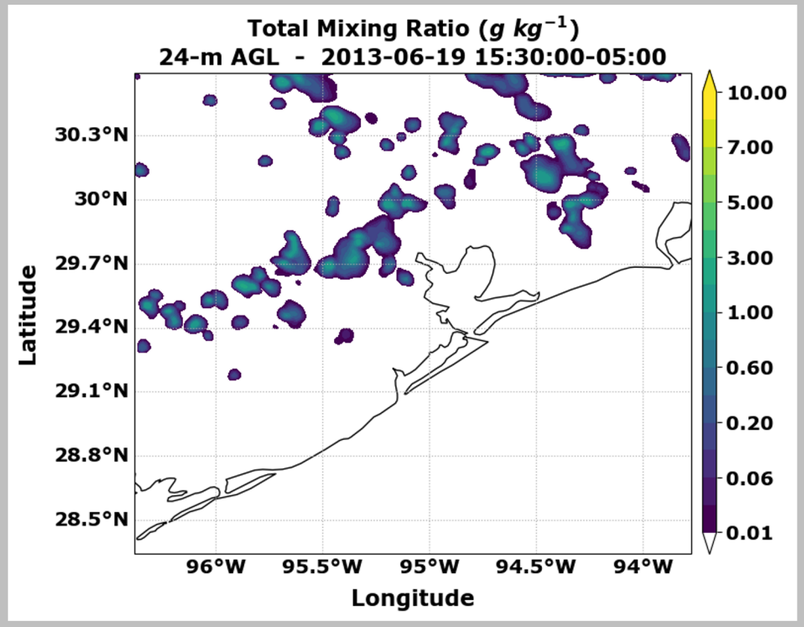
Run with Horizontal Grid Spacing of 500m

from Regional Atmospheric Modeling System (RAMS)



"Clean" Simulation Snapshot at 3:30pm Local



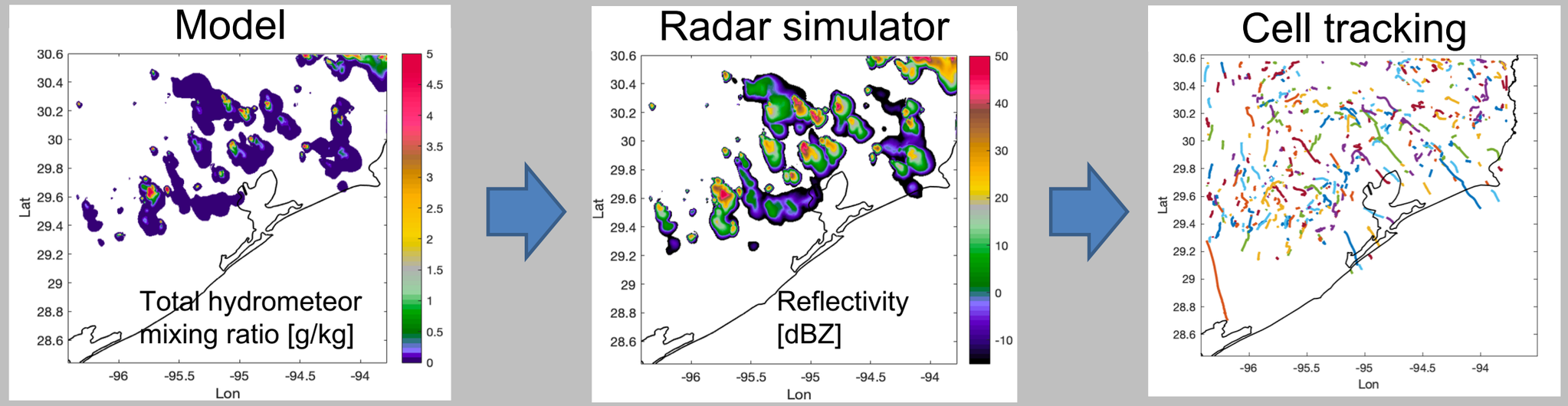


Convective Cell Tracking

- **Using the "*tracking and object-based analysis of clouds*" (*tobac*) algorithm on the RAMS simulations.** *(Heikenfeld et al. 2019)*

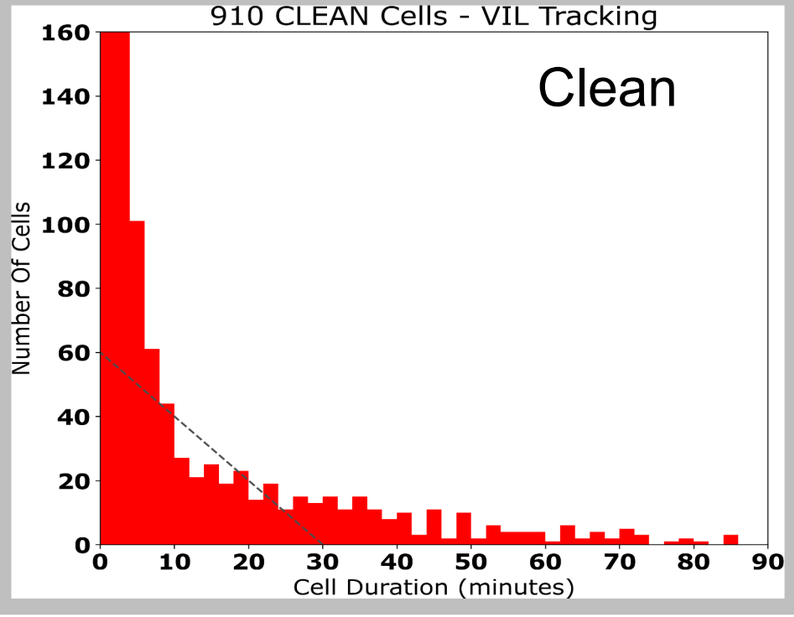
- **Experimenting with *tobac* cell tracking based on radar-derived quantities from the "*Cloud resolving model Radar SIMulator*" (*CR-SIM*).** *(Oue et al. 2020)*

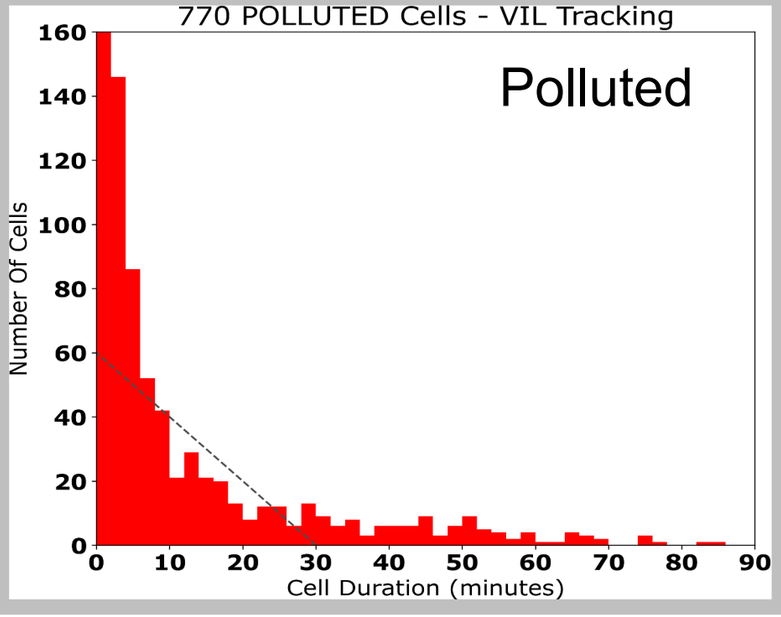
- ***tobac* has been applied to CR-SIM fields of Vertically integrated liquid (VIL) for Z_h > 0 dBZ.**

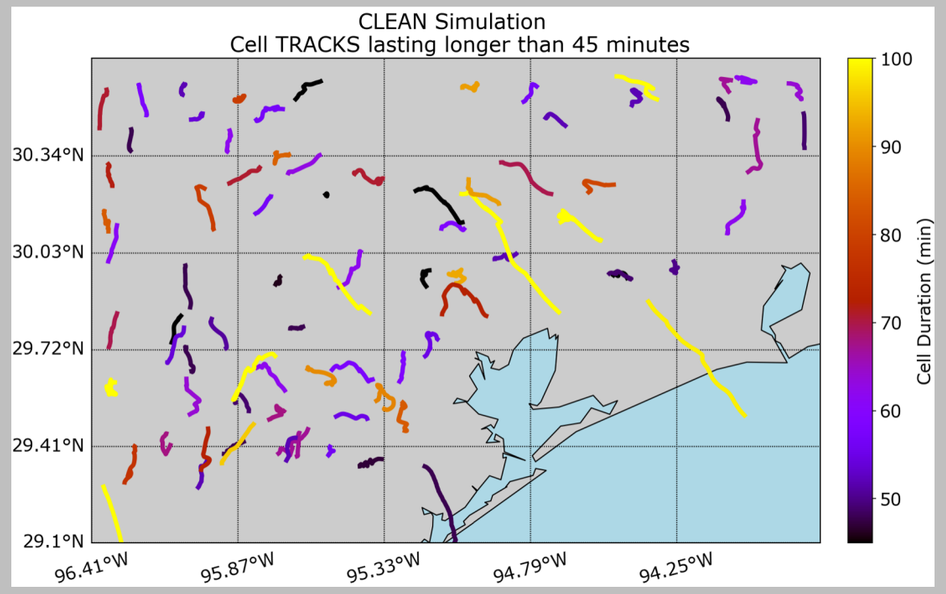


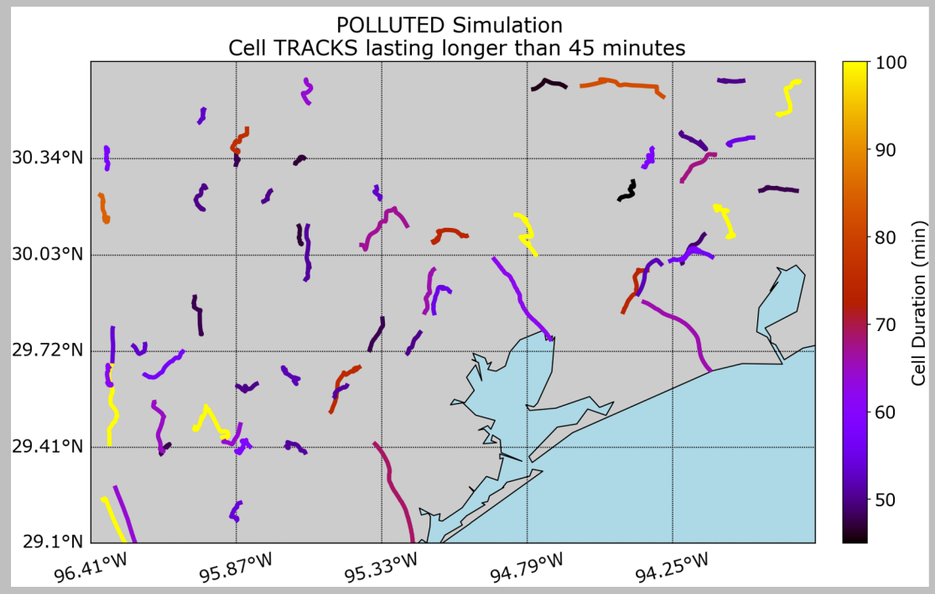
Convective Cell Count Histograms and Cell Tracks

There are more identified total cells and long-lived cells in the clean simulation compared to the polluted simulation. This is likely due to aerosol modulation of hydrometeor size distributions and their impact on radar identification.





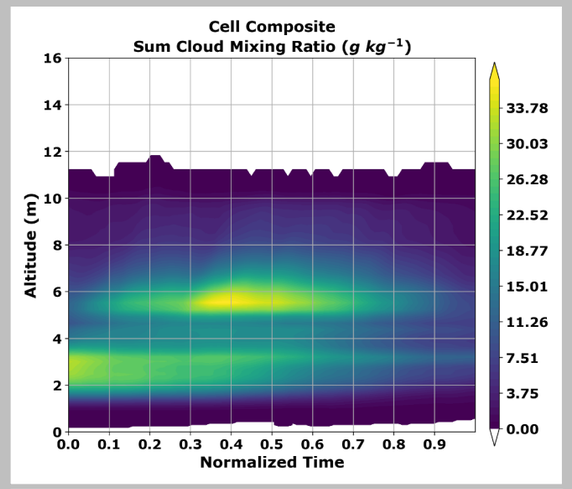


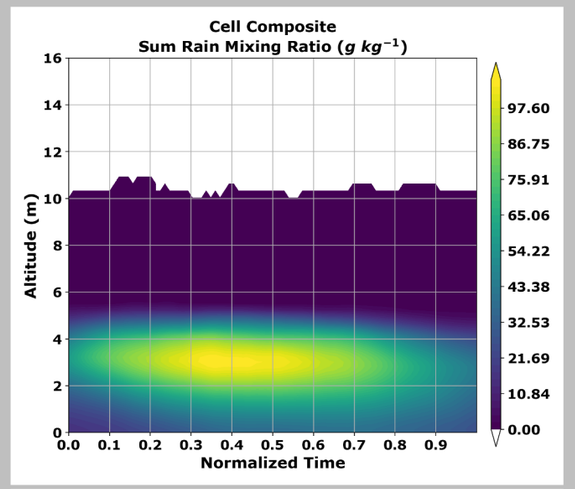


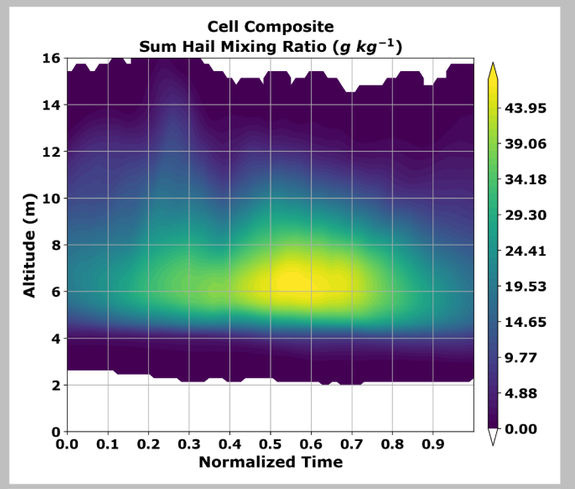
Time-Height Profiles of Tracked Cell Composites

Cloud Water | Rain | Hail

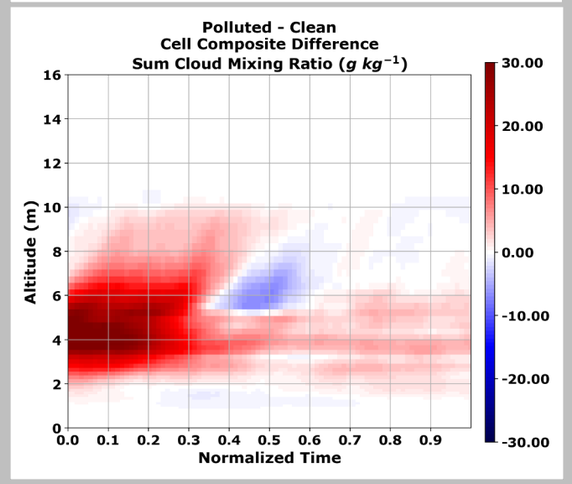
CLEAN

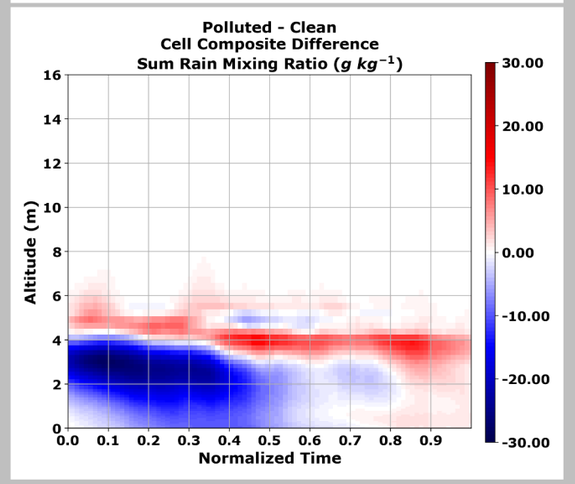


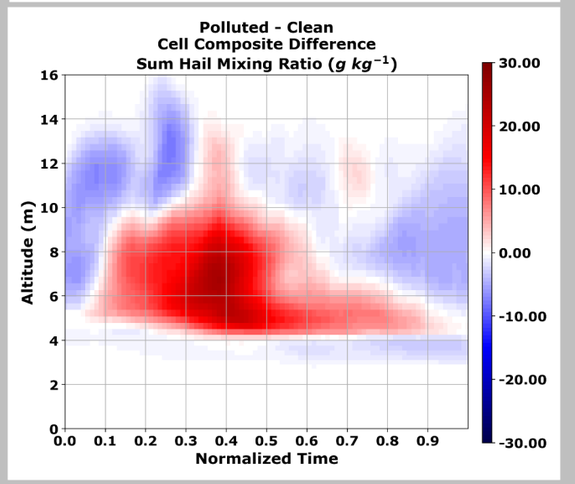




DIFFERENCE
POLLUTED - CLEAN







Aerosol loading in the tracked cells indicates the following:

(1) Greater total cloud water over most of cell lifetime

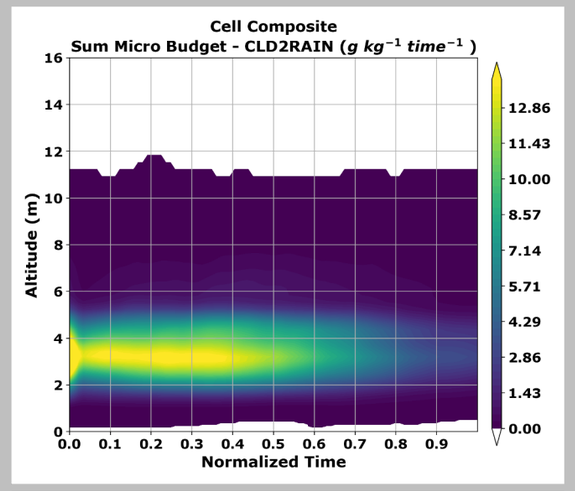
(2) Reduced overall rain production, production higher aloft and extended in time

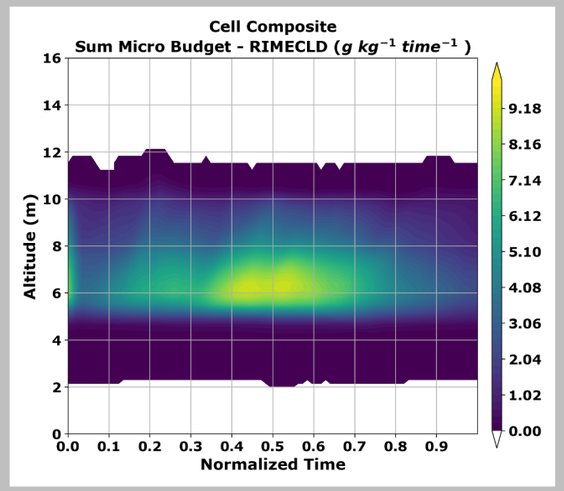
(3) Delayed hail formation, but overall increase during center of cell lifetime.

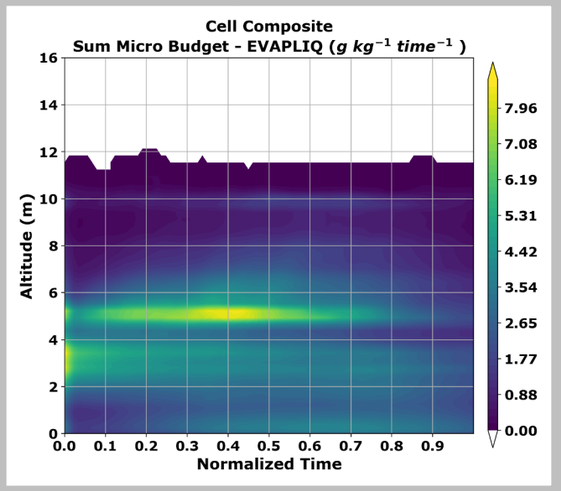
Time-Height Profiles of Tracked Cell Composites

Cloud to Rain Conversion | Riming Cloud Water | Evaporation

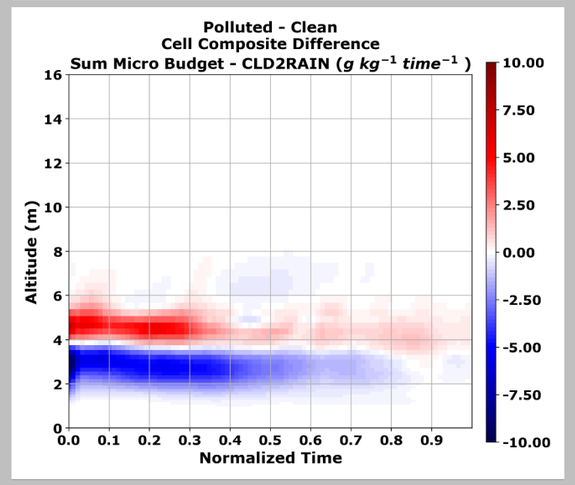
CLEAN

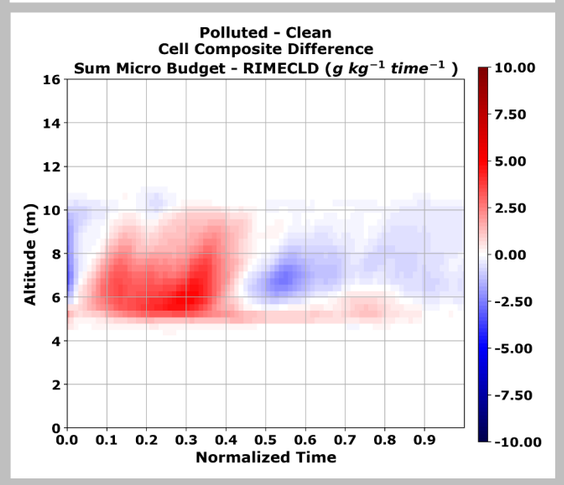


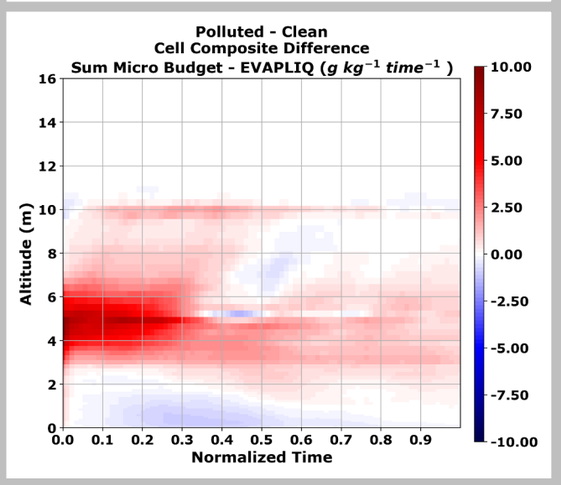




DIFFERENCE *POLLUTED - CLEAN*







Aerosol loading in tracked cells indicates the following:

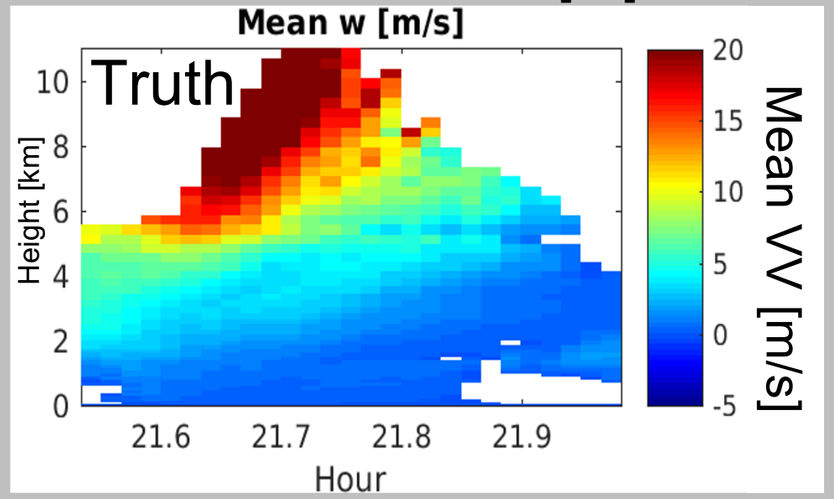
(1) Net reduction in conversion from cloud water to rain water, and shift toward higher altitude.

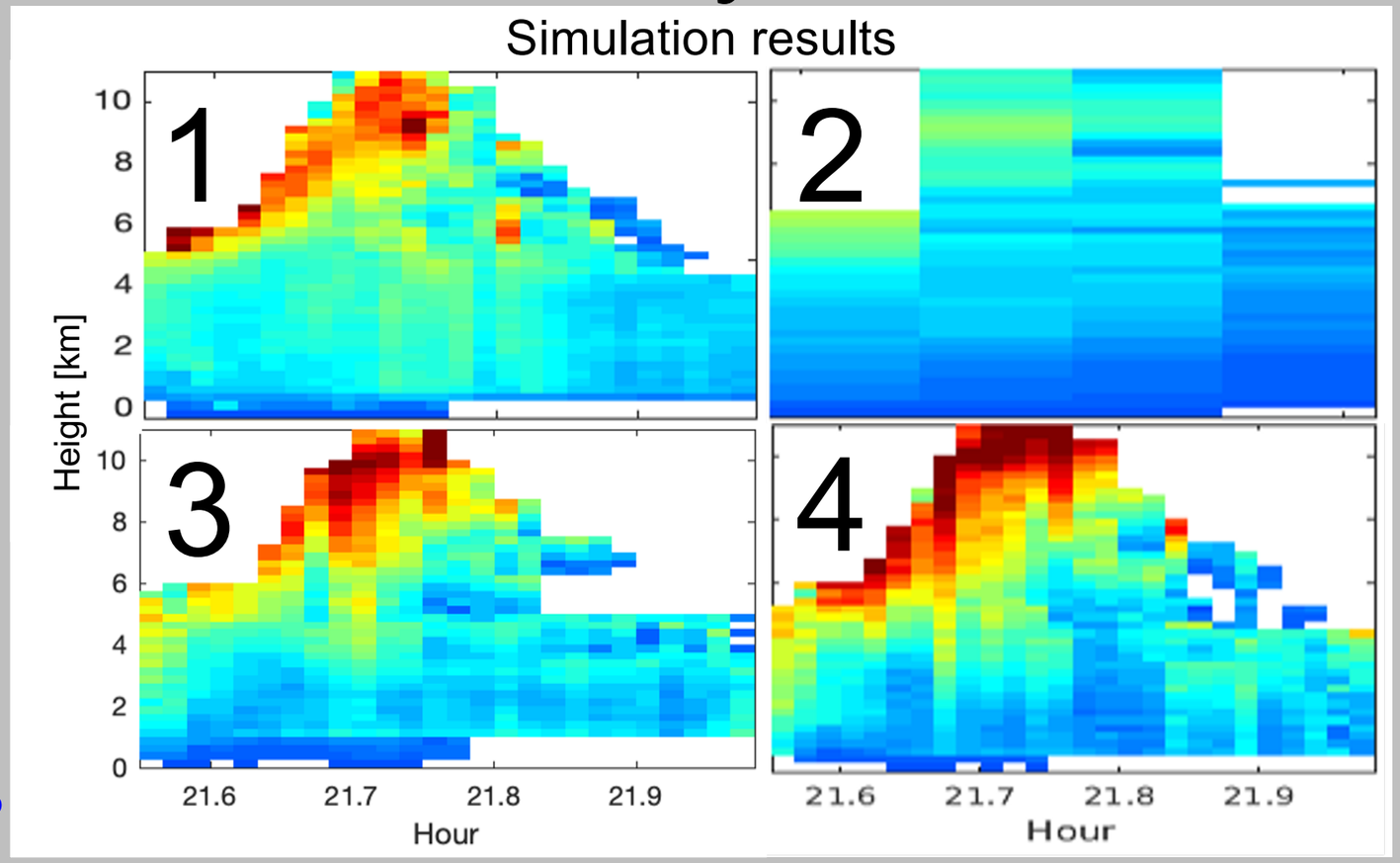
(2) Riming increases in 1st half of cell lifetime, likely resulting in more hail shown on previous slide.

(3) Evaporation increases aloft likely due to smaller droplets on cloud edges.

(4) Evaporation decreases near the surface due to reduced rain production.

Best Radar Scan Strategy for Multi Doppler Vertical Velocity Retrieval



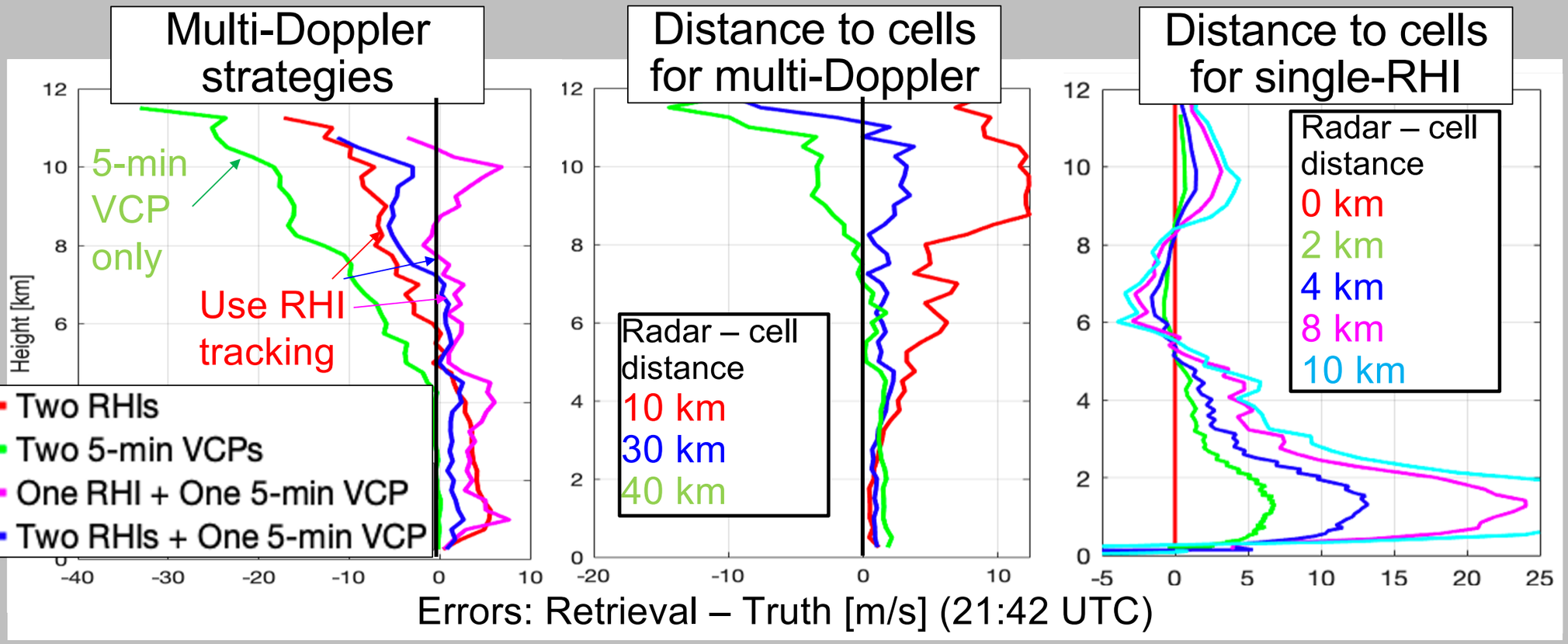


Simulations

1) Two RHI tracking radars
2) Two conventional VCP radars (5 min)
3) One conventional VCP radar and 1 RHI tracking radar
4) Two RHI tracking radars + 5-min VCP

- RHI tracking improves the vertical velocity (VV) retrieval compared to the use of conventional VCPs only.
- The convectional VCP can be used for further improvement.

Best Radar Scan Strategy for Vertical Velocity Retrieval



- RHI tracking improves the upper-level VV retrieval well.
- Radars need to be placed at a certain distance (> ~20 km) for the multi-Doppler retrieval.
- Single RHI VV retrieval is useful for cells close to the radar.

Summary

- Working to identify the most promising radar-based cell tracking criteria and thresholds initially using RAMS, CR-SIM, and tobac.
- Using cell composites to identify most prolific aerosol-induced changes in microphysical quantities.
- Aerosol loading generates a shift from warm-phase processes and hydrometeors toward mixed-phase quantities which may impact radar-based retrievals.
- RHI tracking captures polarimetric variable structures and improves upper-level multi-Doppler updraft retrievals.
- Single-RHI updraft retrievals provide small uncertainties above 6 km, where the multi-Doppler retrievals have large uncertainties.
- Suggesting the complementary use of Multi-Doppler and single-RHI retrievals.