Convective cells characterization using combined observations from scanning dual-polarization Doppler radars and the GOES satellite

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INTRODUCTION

Convective clouds serve as a primary mechanism for the transfer of thermal energy, moisture, and momentum through the troposphere, significantly affecting the large-scale atmospheric circulation and impacting the probability of cloud formation. The Geostationary Operational Environmental Satellite R series (GOES-R) Advanced Baseline Imager have been extensively used to study convective initiation using VIS and IR imagery along with observations from the Next Generation Weather Radar (NEXRAD) network.

The TRacking Aerosol Convection interactions ExpeRiment (TRACER), supported by the US Department of Energy, and the Experiment of Sea Breeze Convection, Aerosols, Precipitation and Environment (ESCAPE), supported by the National Science Foundation, took place in the Houston, TX region from October 2021 through September 2022. The high-temporal-resolution 2nd-generation C-band Scanning ARM Precipitation Radar (C-SAPR2), operated using a multiscale agile adaptive sampling strategy which allowed to track convective cells throughout their lifecycle.

Focusing on isolated cells, a comparative study between radar integrated observables (e.g., cloud top height, height of 40 dBZ echo, normalized VIL, cells area) and the GOES observables (e.g., cells area, brightness temperature (T_b)) and their temporal evolution is performed.

METHODS

Convective cell detection:

Based on Vertical Integrated Liquid (VIL), and brightness temperature (T_b) thresholds.

Parallax correction:

Correction is applied to GOES images to match with the radar images. Radiosoundings launched during the campaign are used to retrieve the correct cloud top height (cth) of the minimum of the brightness temperature.

Convection characterization

CSAPR2 radar was able to follow a single cell during its lifecycle.
The characteristics of the minimum of the brightness temperature within the cell are compared with some integral variables on the radar images.
Comparison between cooling rate and vertical velocity is performed.
Temporal evolution of the cell is observed.

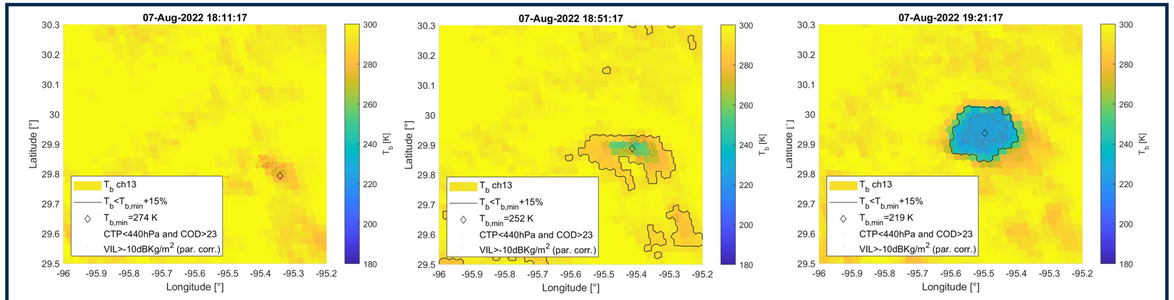

Figure 1. Time evolution of the cell, the red contour is the VIL, parallax corrected, the color map is the infrared T_b while the black contour is the cell contour at 15% more than the minimum T_b

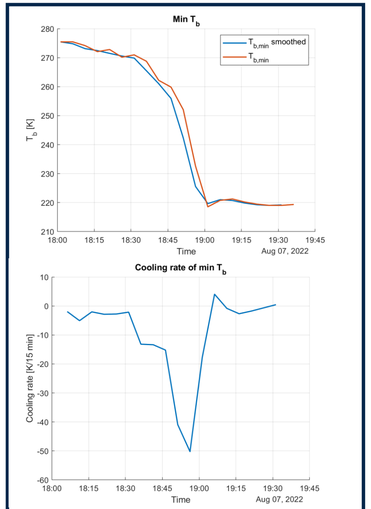

Figure 2. Minimum from the GOES infrared channel in the top image, cooling rate of the cell in the bottom image (derivative of the above).

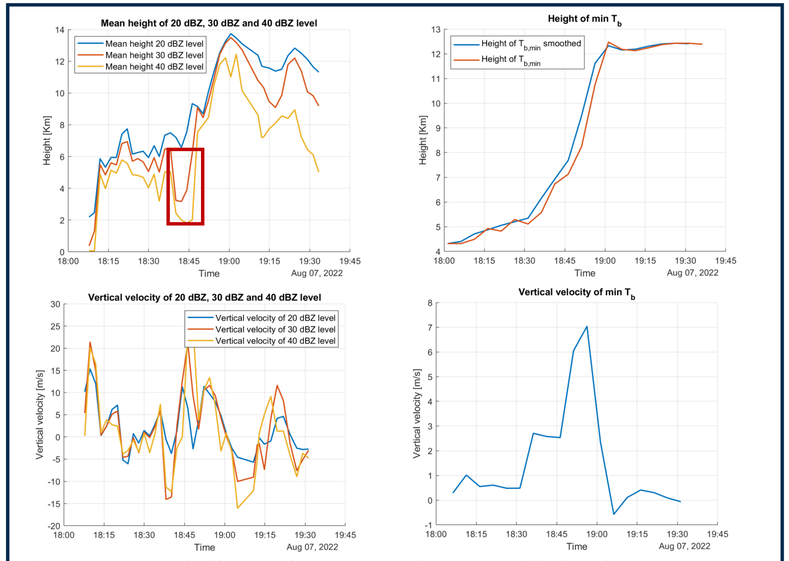

Figure 3. Height of different reflectivity levels from the CSAPR2 RHIs (red box to enhance when the radar is not exactly following the core) and of the minimum T_b retrieved from soundings. In the bottom row the derivative, representing a proxy for vertical velocity.

RESULTS

- An isolated cell has been detected and characterised. The evolution of this isolated cell lasts more than one hour
- In the time series of the minimum of the brightness temperature within the cell, as the cell start growing, an abrupt decay in temperature is observed
- The cooling rate is obtained differentiating the temperature time series (Figure 2). The cooling rate time series has similarities with the updraft velocity (bottom panel of Figure 2 and the bottom right panel of Figure 3).
- Not a single point is followed in time in the subsequent frames, but in every frame the local minimum is found, the cell contoured and the features of the cell evaluated
- The comparison between ground based radars and geostationary images is consistent, although the impact of microphysics in the reflectivity field is not accounted for

CONCLUSION AND FUTURE WORK

- To better characterise such type of cells, more convective cores have to be analysed and some statistics has to be produced
- As fututre work, it will be investigated how much microphysical processes weight onto the cell cooling rate and updraft velocity
- Since this has been focusing on isolated cells, a robust algorithm to identify isolated cells that last for a reasonable time has to be produced