EXAMINING THERMODYNAMIC CONTROLS ON MESOSCALE CONVECTIVE SYSTEMS AND ISOLATED DEEP CONVECTION IN THE SOUTHEAST UNITED STATES

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Motivation

- Gain a better understanding of summertime convection in the South East US through the collection of in-situ thermodynamic data
- Develop a method to collocate and analyze environmental parameters from ERA5 Reanalysis with FLEXTRKR[1]
- Determine similarities between South East summertime convection and tropical convection
- Examine the influence of different thermodynamic parameters on South East summertime convection

Field Campaign

- Small radiosonde campaign conducted from June to August 2021 in the Charlottesville, VA region
- Specifically targeted days with nearby deep convection
- Initial sounding (Graw DFM-17) taken around an hour before convective initiation followed by slow-ascent, low-level soundings taken using Windsonds (Sparv Embedded)
  - Sampled cold pools, updrafts/downdrafts, and near-convective environment
- Collected data then stacked with NEXRAD Level II reflectivity to connect measured values with position relative to the cell(s)
  - Also included data from pre-convective soundings when available

Collocating ERA5 and FLEXTRKR[1]

- Track-based product from FLEXTRKR contains hourly positional, RADAR, and Stage IV precipitation data for convective systems from 2004 to 2017 across CONUS east of the Rocky Mountains
- FLEXTRKR Algorithm classifies convection as either a Mesoscale Convective System (MCS) or Isolated Deep Convection (IDC) based on each cold cloud system's characteristics
- Single level data from ERA5 can be stacked on these tracks to create a combined dataset containing both environmental parameters and storm-specific precipitation and RADAR data.
- Collocation of the two data sets was domain restricted to June, July, and August and used a nearest-neighbor approach based on the mean position of each track's cold cloud systems
- Initial focus on investigating effects of total column water vapor on MCS and IDC occurrence

References

1. Li, J., Feng, Z., Qian, Y., and Leung, L. R.: A high-resolution unified observational data product of mesoscale convective systems and isolated deep convection in the United States for 2004–2017, Earth Syst. Sci. Data, 13, 827–856, https://doi.org/10.5194/essd-13-827-2021, 2021.

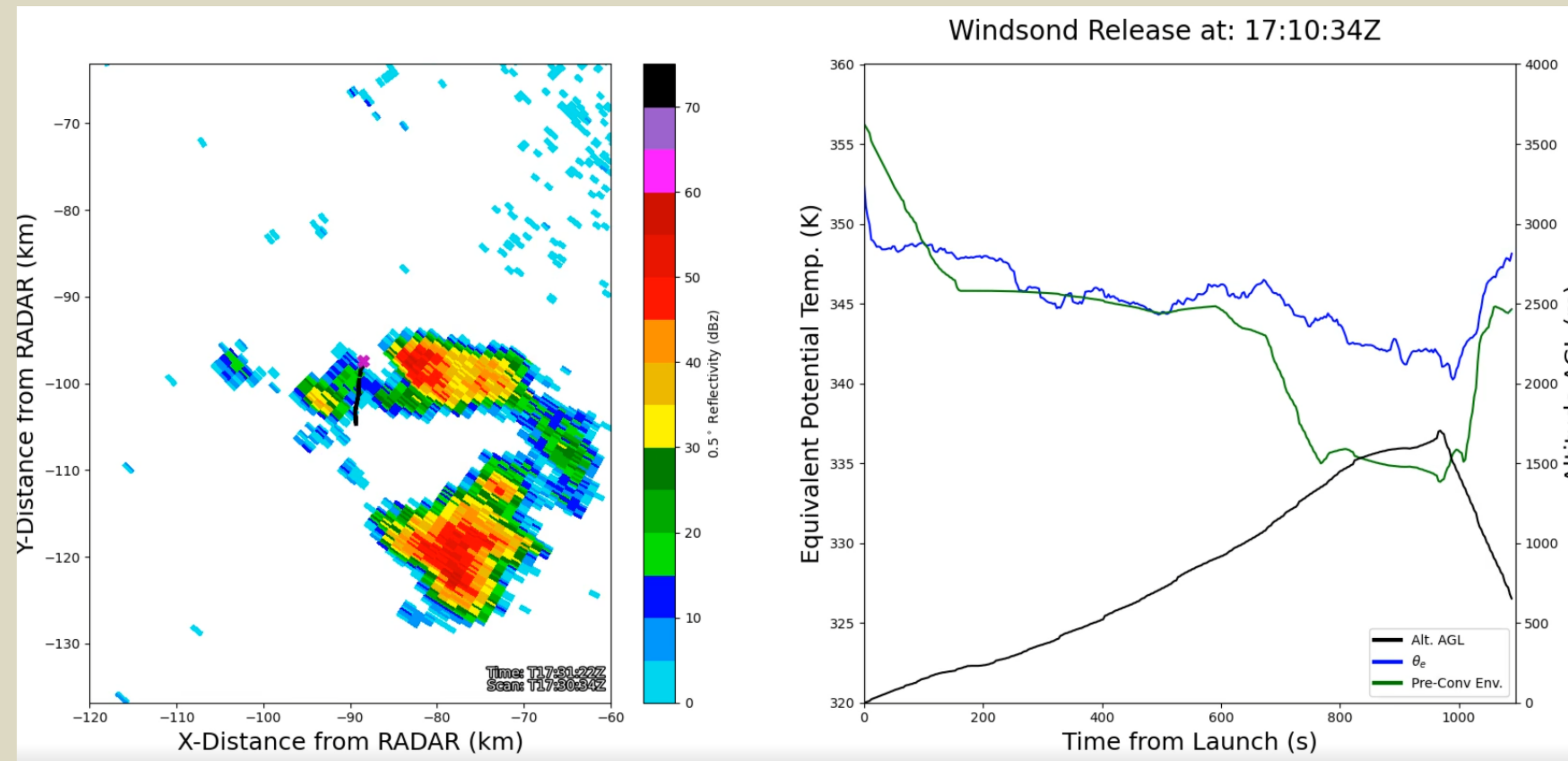

Figure 1: A radiosonde case from 1:10 PM EDT, July 11th. The Windsond was launched nearby a group of cells and sampled the near-convective environment. RADAR shown is 0.5° base reflectivity.

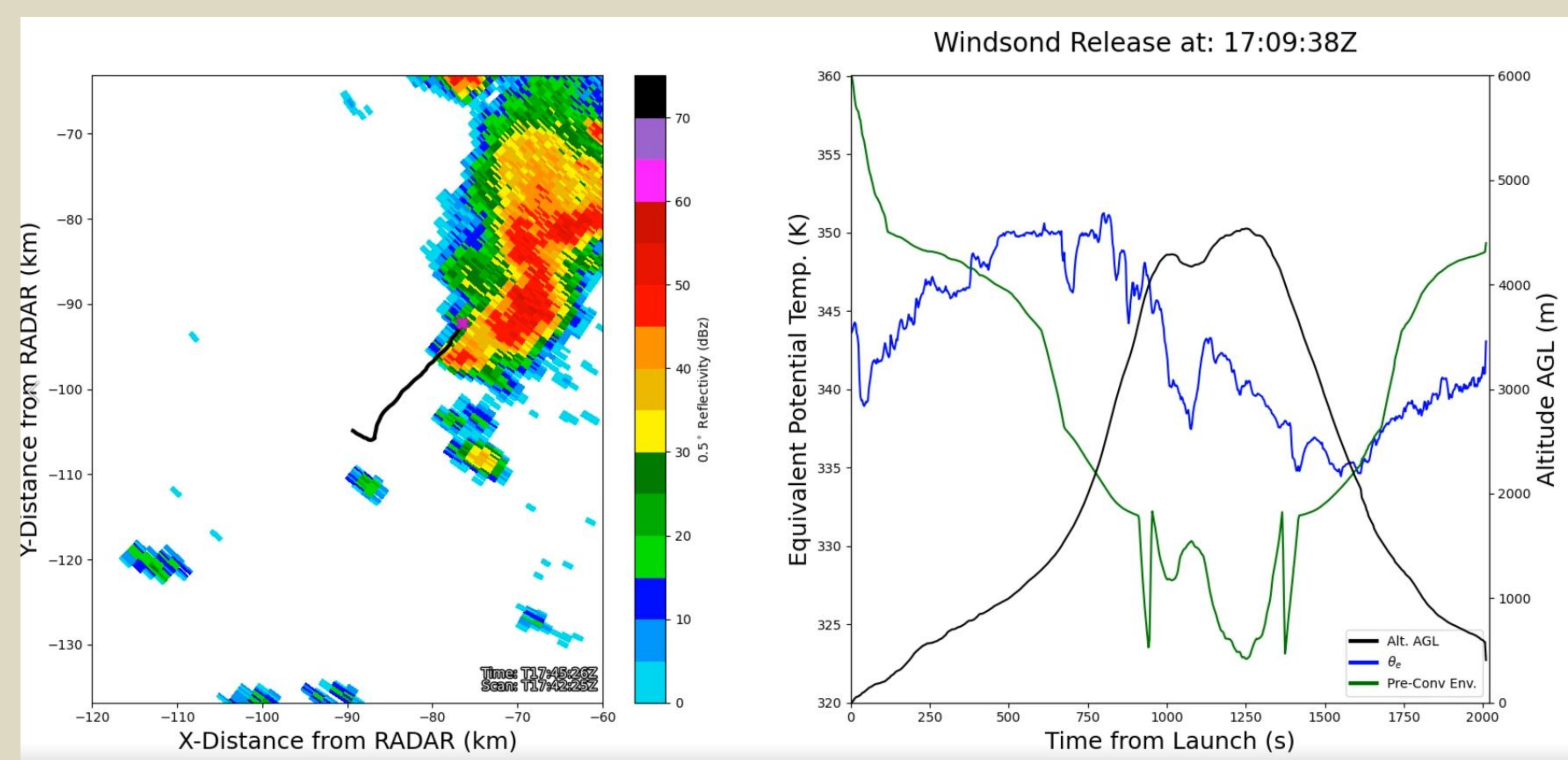

Figure 2: A radiosonde case from 1:09 PM EDT, July 17th including a pre-convective sounding. The Windsond achieved a rapid ascent rate shortly after launch. The surface temperature was depressed from 35°C to 29°C compared to the pre-convective launch. RADAR shown is 0.5° base reflectivity.

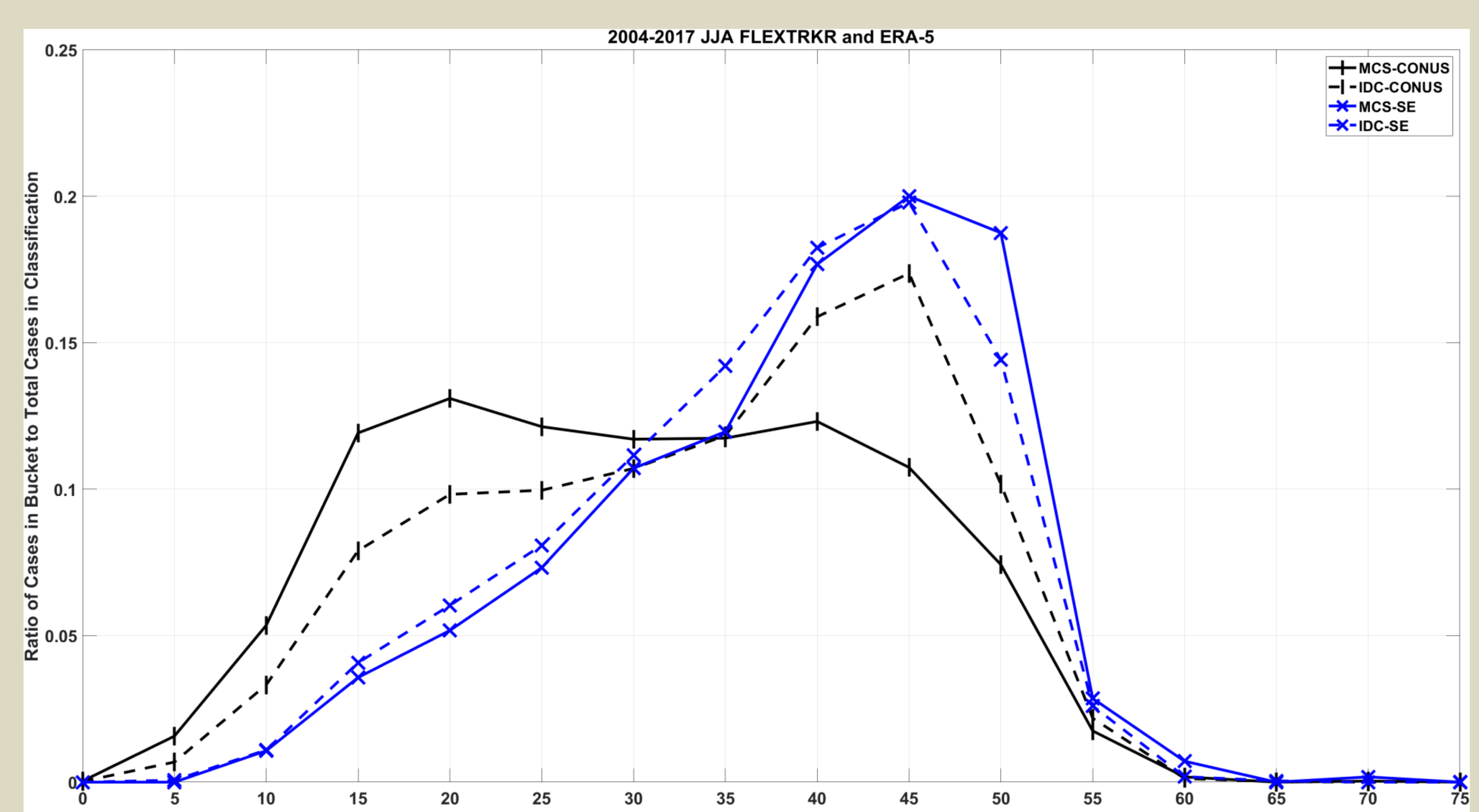

Figure 3: Distribution of the ratio of cases in each bucket to the total case count for each classification. Value of TCWV used is the value occurring with the maximum per track of convective area normalized mean convective precipitation rate from FLEXTRKR. Constrained to east of Rockies for CONUS and JJA months. CONUS domain set as (25-50 N, 105-75 W). SE domain set as (30-40 N, 85-75 W).

Results/Discussion

- Radiosonde launches were successfully conducted on 8 days for a total of 17 samples
- July 11th Case (Figure 1) captured data surrounding existing convection
  - Sample shows moistening of air above 1 km (Top of ABL at pre-convective sounding)
- July 17th Case (Figure 2) captured data from young convective updraft
  - Rapid ascent collocated with weak reflectivity and high differential reflectivity (ZDR) indicate a newly forming updraft
  - Initial descent shows drop in θ_e
  - θ_e during ascent indicative of little entrainment into updraft
  - Observed cold pool depth at launch of around 1 km and at descent of around 2 km with θ_e depression of ~5 K
- Collocation of FLEXTRKR with ERA5 TCWV shows the proportion of total tracks in each classification that occur in each TCWV bucket (Figure 3)
  - For CONUS, after reaching around 10-15 kg m^{-2} TCWV, MCS tracks (2802 total) occur at mostly equal rates for each bucket; IDC tracks (287,368 total) instead increase in frequency until a maxima at 45 kg m^{-2}
  - For SE region, both MCS (560 total) and IDC (68,976 total) tracks show a stronger and more equivalent response to increasing TCWV, peaking at 45 kg m^{-2}
  - Are non-thermodynamic parameters more important for MCS tracks outside of the SE? Is convection more tropical/thermodynamically-driven in the SE region?

Future Work

- Current framework is pathway towards exploring questions about the thermodynamic controls and structure of summertime south-east storms
- Further radiosonde launches, with a focus on ensuring capture of the pre-convective environment
  - Simultaneous launches (Swarmsond)
  - Sampling of non-convective days
- In-situ measurement of convective precipitation corresponding to sampled cells using a surface station downwind of launch site
- Quantifying magnitude of entrainment into convective updrafts or downdrafts using launches that enter the regions of interest and have data from a pre-convective sounding available
- Further refinement of the FLEXTRKR collocation methods
  - Average of surrounding points instead of nearest-neighbor approach
  - Collocation with other thermodynamic observations, where available (radiosondes and AIRS)
- Detailed comparison using FLEXTRKR/ERA5 collocation of thermodynamic environments around IDCs vs MCSs