Macro- and microphysical characteristics of rain cells observed during SOS-CHUVA

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Introduction and Motivation

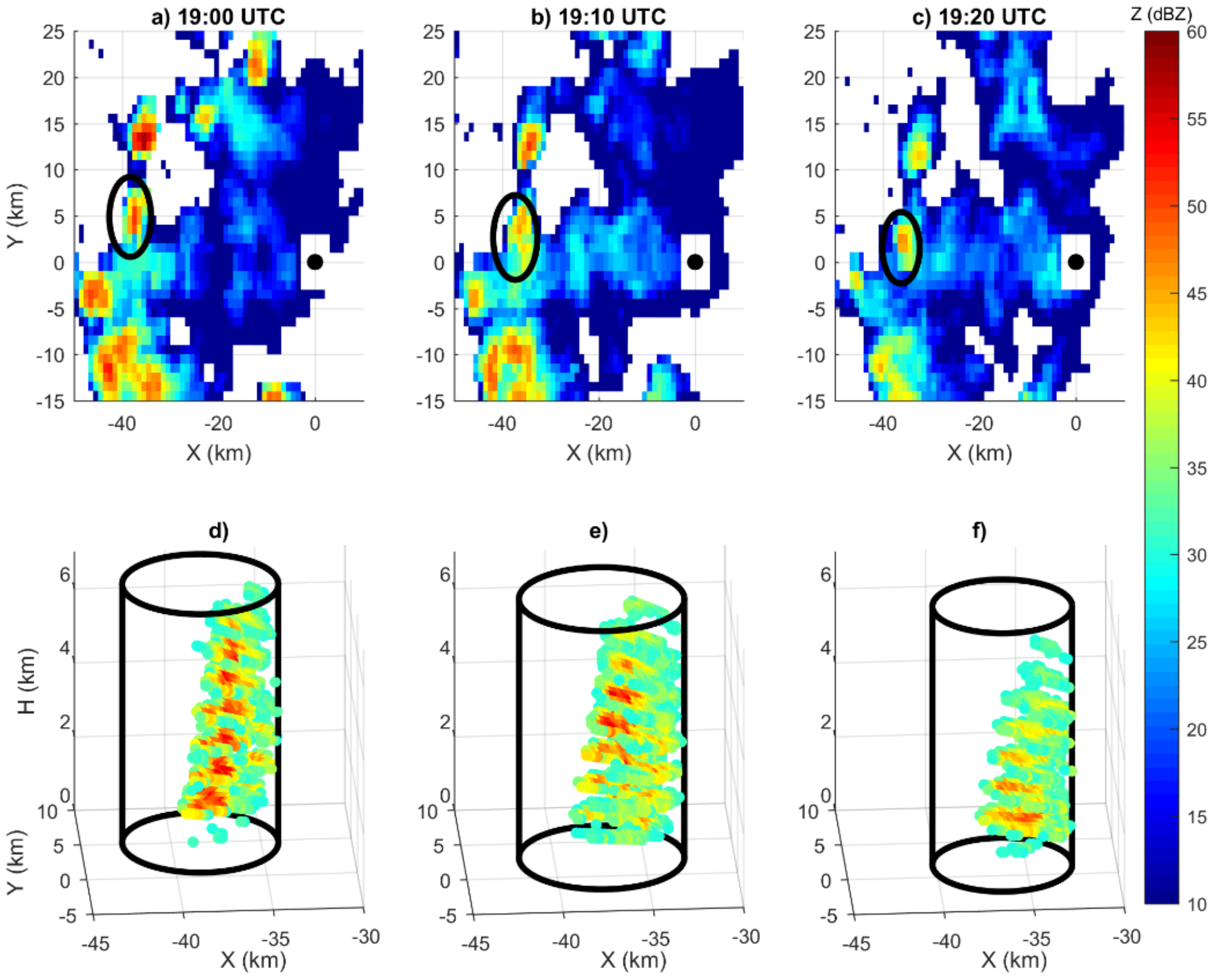
- The number and the impact of severe weather events is increasing due to the increase in population and climate change
- Development of objective Nowcasting Tools to support operators

Objective and Methodology

- The main goal is to use a weather radar to estimate macro- and microphysical properties of rain cells in Campinas, Brazil
- Similar to the phase space introduced in Heiblum et al. (2016)[1], it is defined the Center of Activity (COA - the rain cell altitude with the highest amount of water mass) combined with the Vertically Integrated Liquid (VIL).
- Tracking convective systems using the SOS-CHUVA X-band radar – summer of 2016/2017

[1]Heiblum, R. H., et al. (2016), Characterization of cumulus cloud fields using trajectories in the center of gravity versus water mass phase space: 1. Cloud tracking and phase space description, J. Geophys. Res. Atmos., 121, 6336–6355, doi:10.1002/2015JD024186.

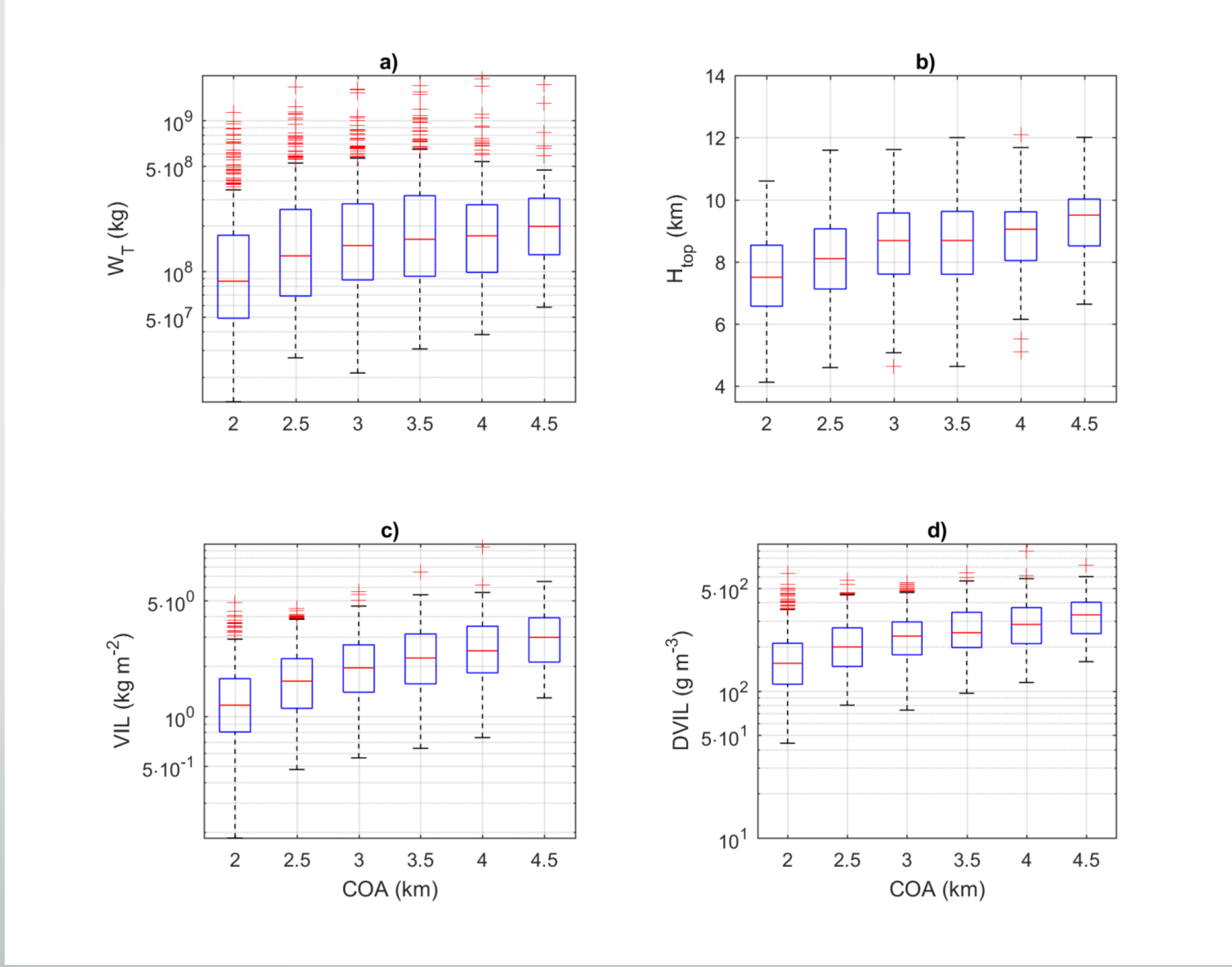
Methodology



- Tracking on 2 km CAPPIs ~34 dBZ (from the near mature to dissipation)
  - ForTraCC algorithm (Vila et al., 2008)[2]
- All clouds treated individually as a cylinder (R + 2 km), following the center of mass.
  - Z > 30 dBZ in Figures d-f
- It allows the examination of the 3D configuration in a Lagrangean way
- Total of 446 rain cells
- For each moment the COA and VIL were stored together with the 3D fields of the respective polarimetric and microphysical properties

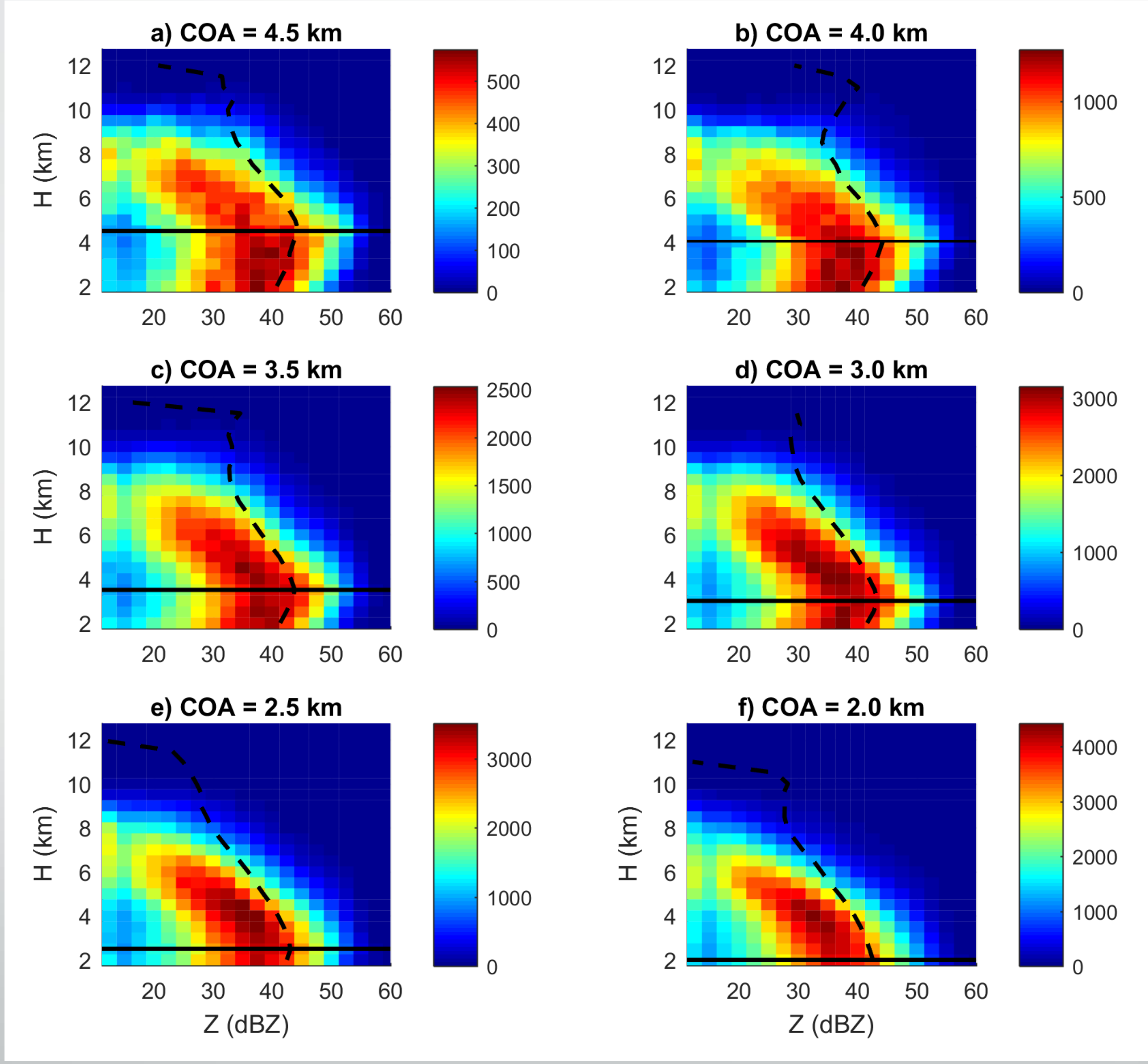
[2]Vila, D. A., Machado, L. A. T., Laurent, H. & Velasco, I. (2008). Forecast and Tracking the Evolution of Cloud Clusters (ForTraCC) Using Satellite Infrared Imagery: Methodology and Validation. *Weather Forecast*, 23(2), 233–245. doi:10.1175/2007WAF2006121.1.

Results



COA is related to the systems water amount and H_{top}

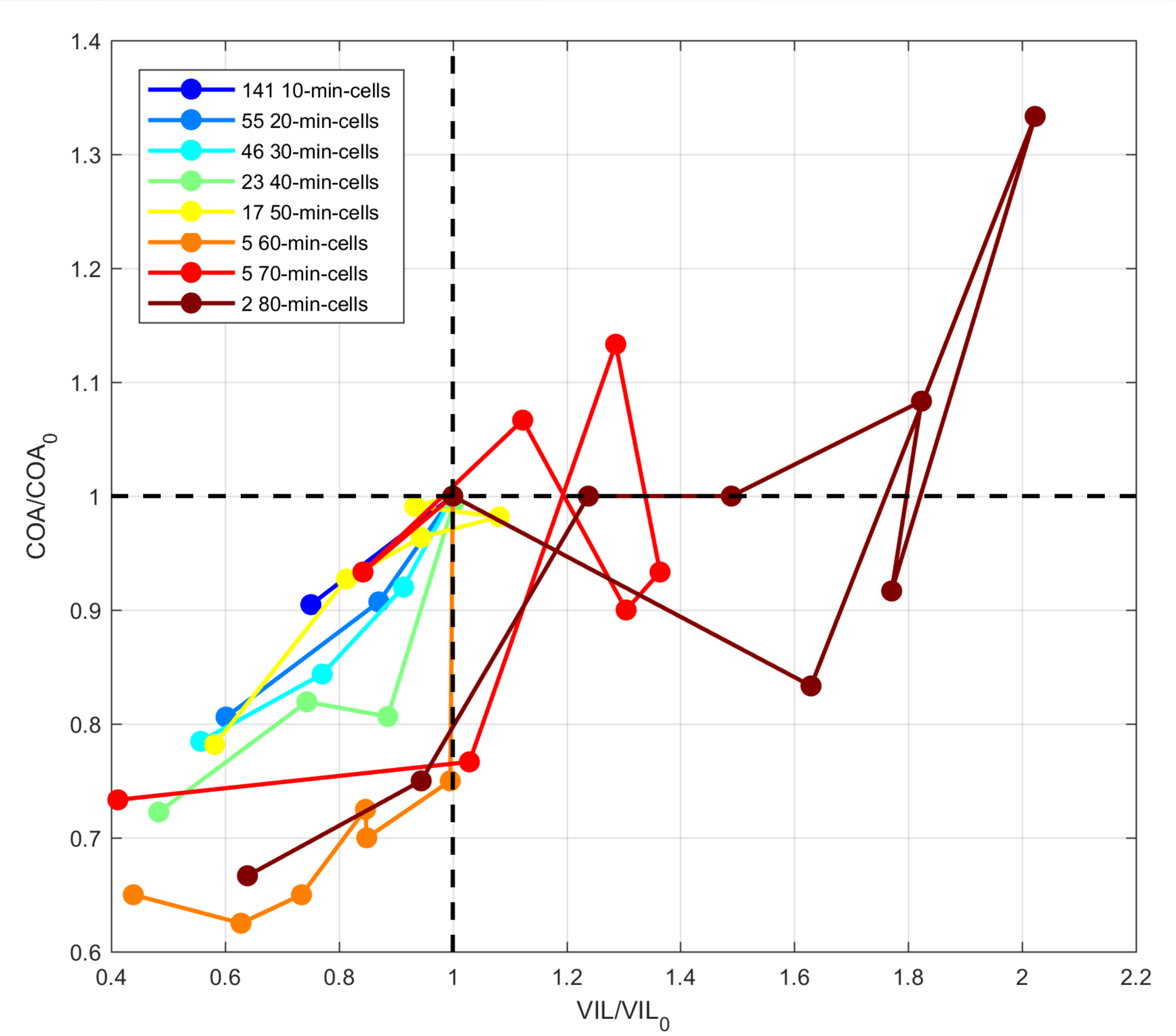
Results



COA captures systems overall appearance

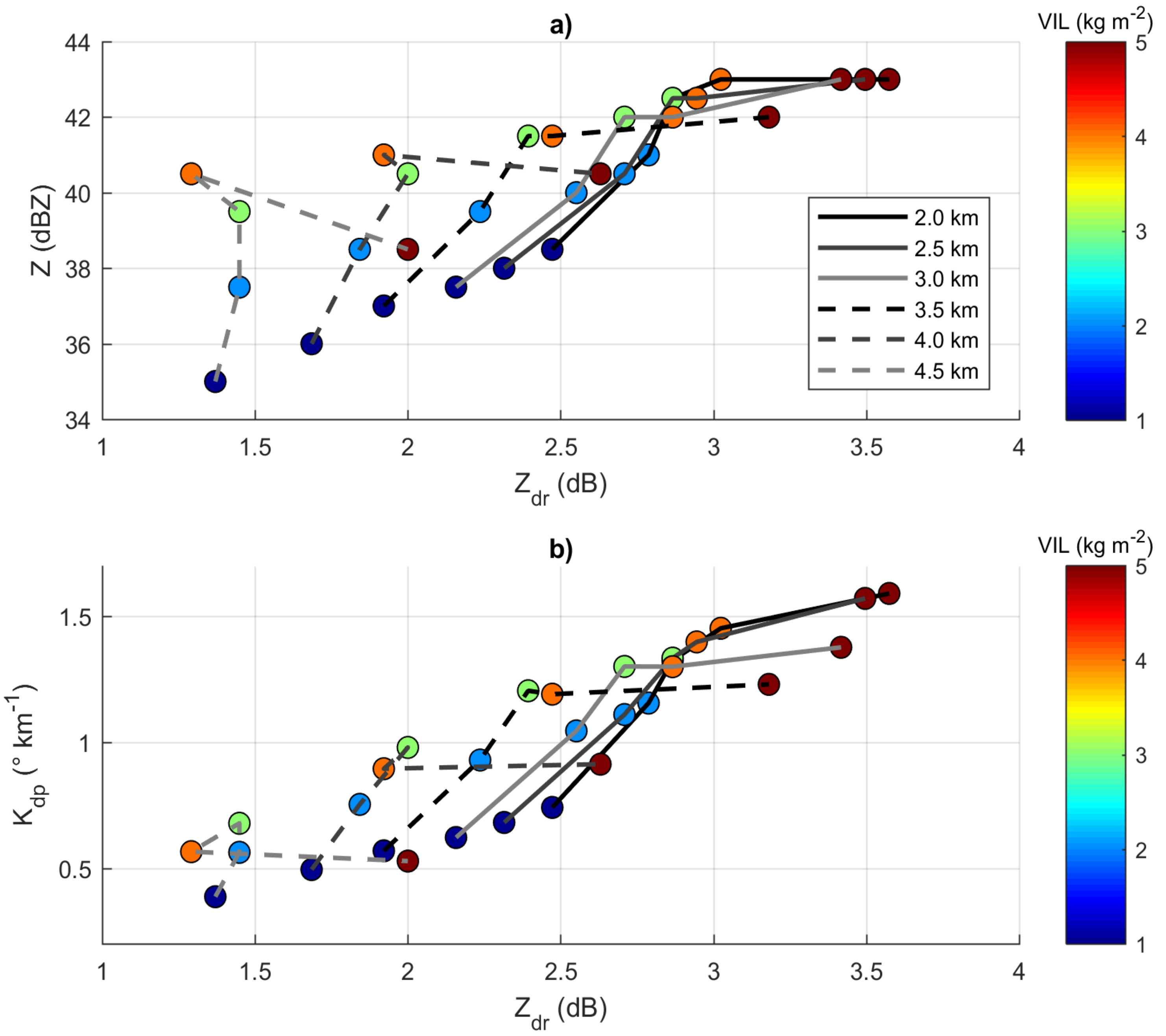
Results

Only non-merger/split



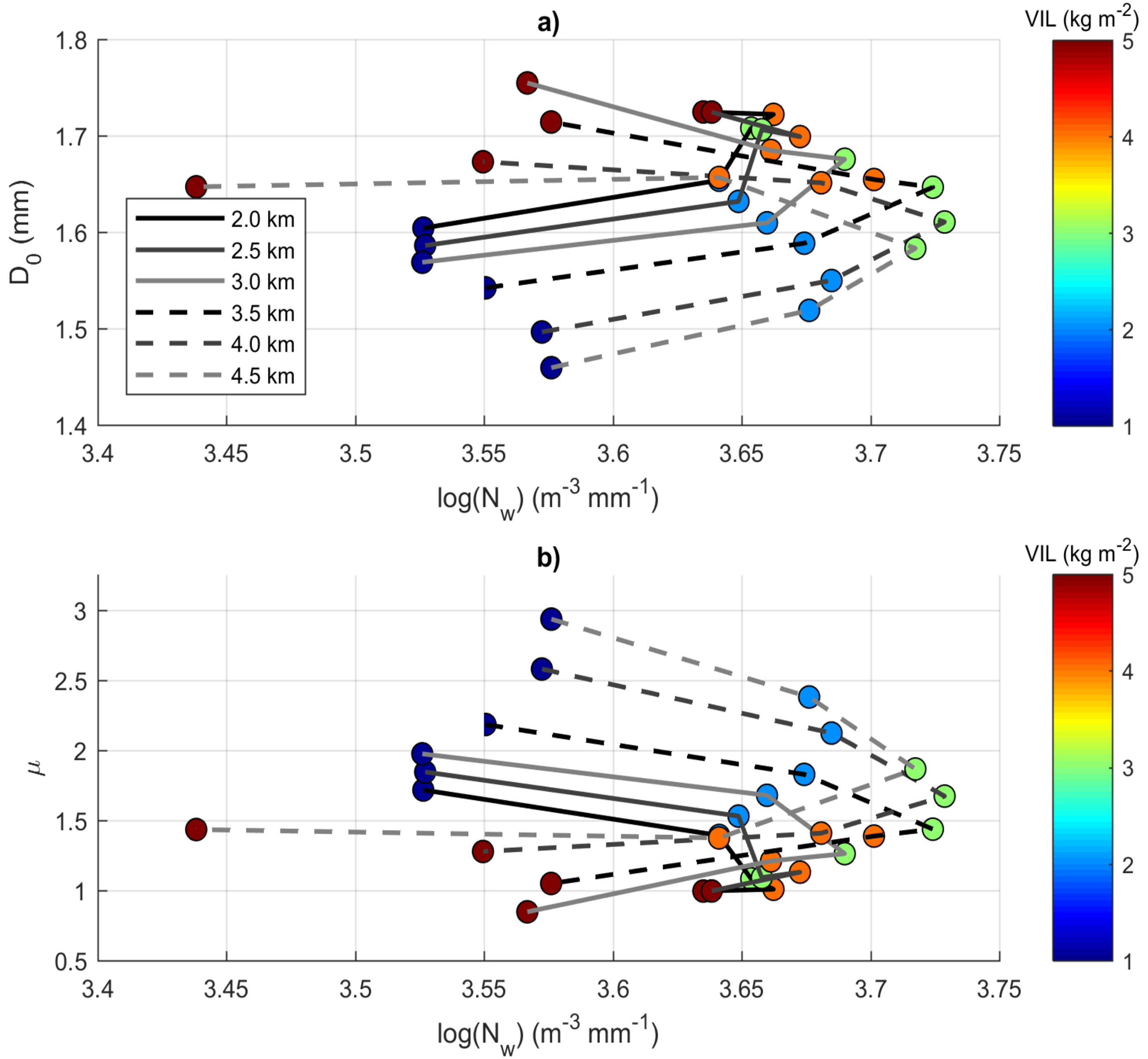
Decaying COA and VIL for both short- and long-lived cells.
Long-lived cells retain more relative VIL with decaying COA

Results



- VIL and COA can be used to constrain microphysical analysis
- Figures are for the rain cells core, at the COA level (median properties)
  - 1 km layer around COA
  - $Z > 30$ dBZ; $Z_{dr} > 0.5$ dB; $K_{dp} > 0$ ° km^{-1}; $\rho_{HV} > 0.97$ – focus on rain droplets
  - Elevation angles ≤ 15°
- No stratiform events, no merger/splits detected by ForTraCC
  - 291 rain cells remained
- Z, Z_{dr} and K_{dp} grow with VIL and decaying COA
  - Overall phase space
  - Individual rain cells will have different trajectories

Results

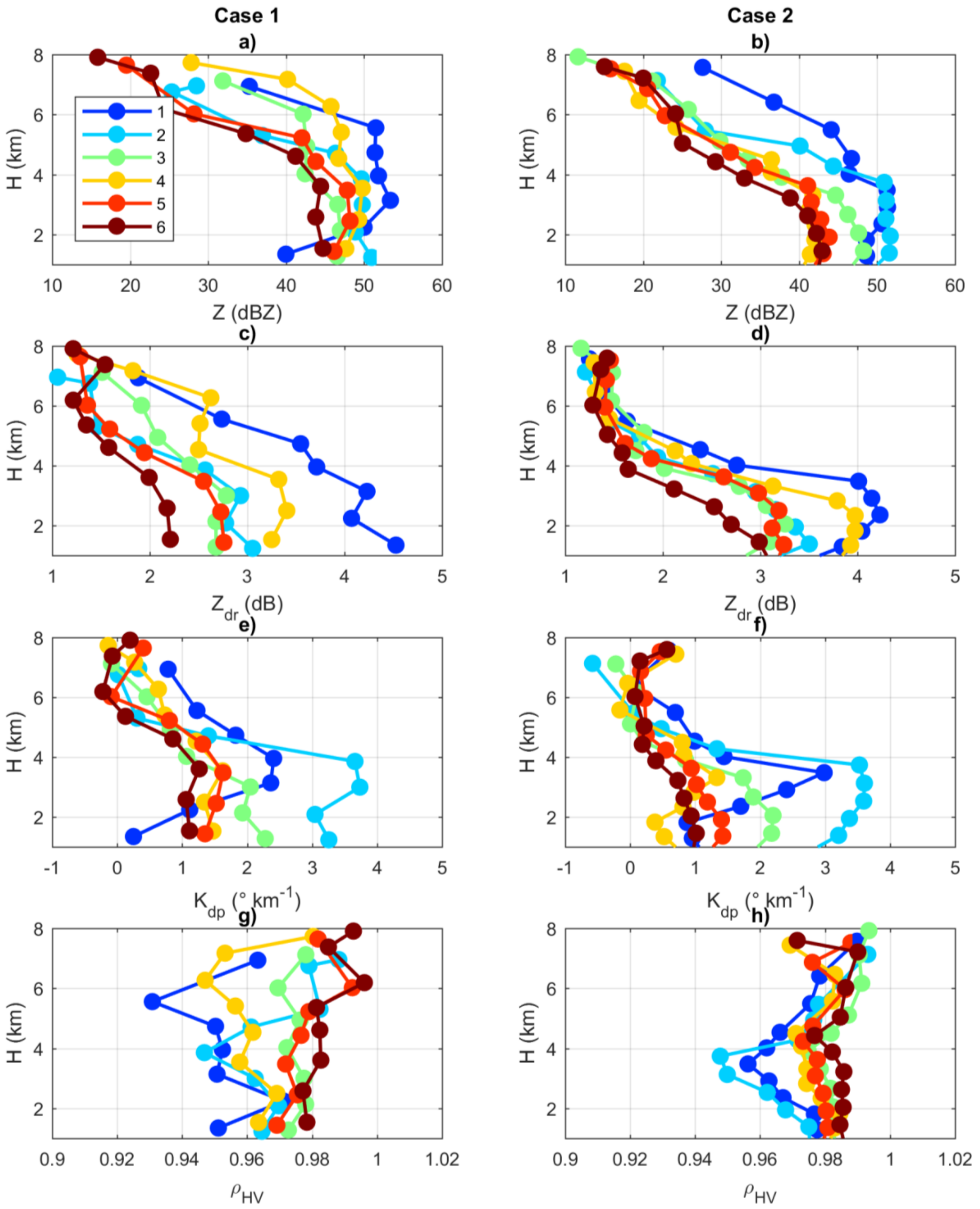


- The Gamma DSD is estimated from the volumetric fields of *Z*, *Zdr* and *Kdp* following Kalogiros et al. (2013)[3].
- Shift close to VIL = 3 kg m^{-2}
  - Reminds a "maritime-like" to "continental-like" transition
  - Shift is close to the capping in previous slide – still nuclear if physical or methodological

[3]Kalogiros, J., Anagnostou, M. N., Anagnostou, E. N., Montopoli, M., Picciotti, E. & Marzano, F. S. (2013). Optimum estimation of rain microphysical parameters from X-band dual-polarization radar observables. *IEEE Trans. Geosci. Remote Sens.*, 51(5), 3063–3076. doi:10.1109/TGRS.2012.2211606.

Results

Case # and time steps (UTC)	COA (km)	VIL (km m^{-2})	H_{top} (km)	New/Split/Merger/ Continuity	Total Accumulated Rainfall (mm)	A (km^2)
Case 1						
17:40	4.5	6.49	9.0	New	78	14
17:50	3.5	2.49	8.6	Continuity	267	41
18:00	4.0	2.08	9.0	Continuity	404	36
18:10	3.5	3.41	9.5	Merger	763	133
18:20	3.5	2.60	9.1	Continuity	1014	85
18:30	3.5	1.76	9.1	Split	1131	34
Case 2						
18:50	4.5	2.41	6.6	New	73	18
19:00	2.5	2.13	7.0	Continuity	209	22
19:10	2.0	1.04	7.0	Continuity	302	26
19:20	2.0	0.74	7.0	Merger	350	19
19:30	2.0	0.86	7.0	Continuity	413	20
19:40	2.0	0.66	7.1	Continuity	480	27



Z

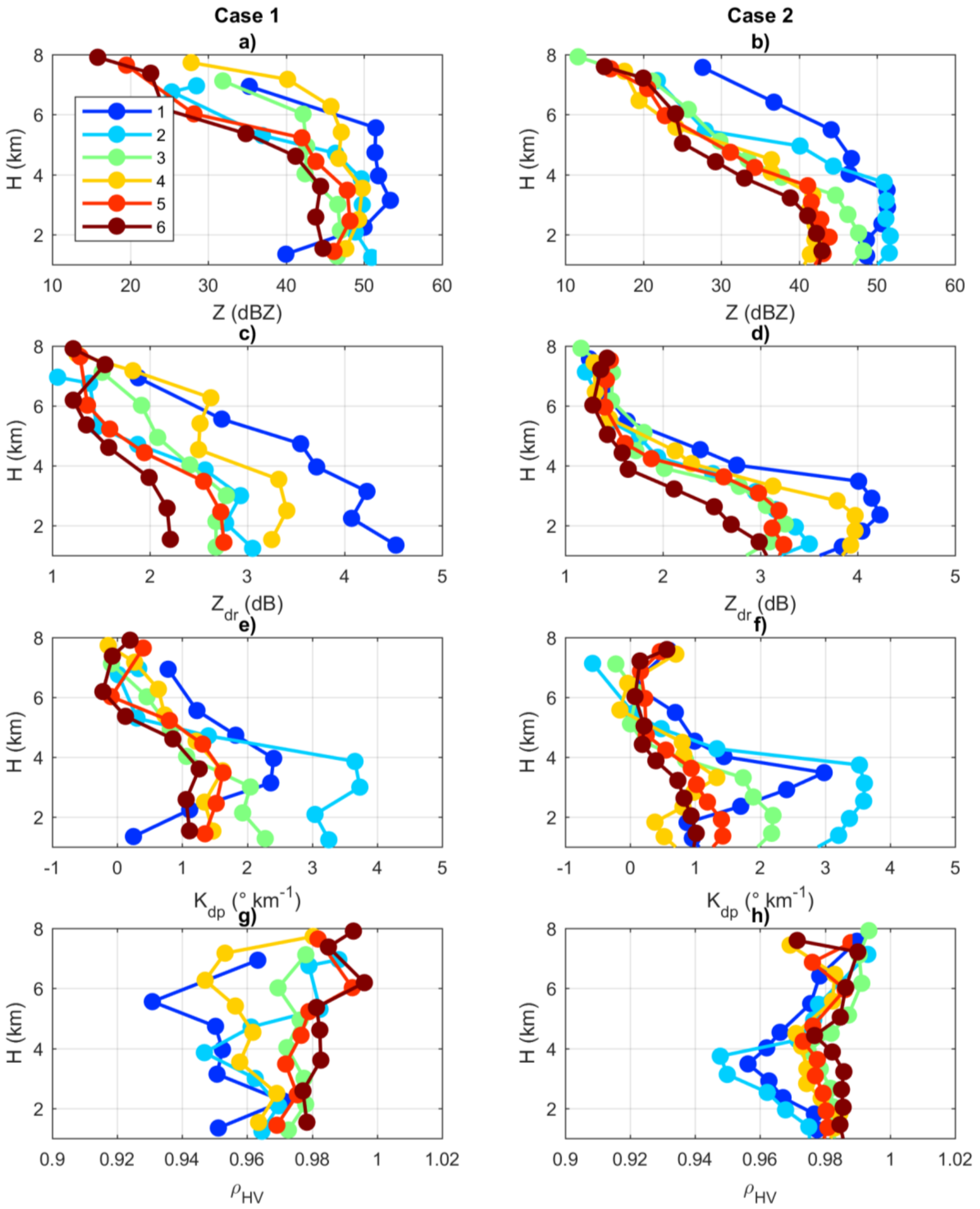
Z_{dr}

K_{dp}

ρ_{HV}

- Vertical profiles of polarimetric variables
  - Cell core – Z above 75% percentile below 4.5 km, Z_{dr} column criteria from Carlin et al. (2017)[4] between 4.5 km and 8 km
- Different vertical profiles for slow- (Case 1) and fast-decaying (Case 2) COA
- High COA related to Z_{dr} column
  - Favor higher Z and Z_{dr} above 4.5 km
  - More hydrometeor mixture
  - Consistent with more intense system – Case 1 produced more than double the overall rainfall of Case 2

[4]Carlin, J.T., Gao, J., Snyder, J.C., & Ryzhkov, A.V. (2017). Assimilation of ZDR Columns for Improving the Spinup and Forecast of Convective Storms in Storm-Scale Models: Proof-of-Concept Experiments. Mon. Wea. Rev., 145, 5033–5057. doi:10.1175/MWR-D-17-0103.1.



Z

Z_{dr}

K_{dp}

ρ_{HV}

- Case 1 profiles also resemble profiles of highly electrically active systems in Brazil (Mattos et al., 2016)[5]
  - In the first time steps – our methodology might capture systems right before the first lightning

[5]Mattos, E. V., Machado, L. A. T., Williams, E. R., & Albrecht, R. I. (2016). Polarimetric radar characteristics of storms with and without lightning activity. *J. Geophys. Res. Atmos.*, 121, 14,201–14,220. doi:10.1002/2016JD025142.

Conclusions

- Introduced the VIL/COA combination to study rain cells
- May tell about the systems life cycle, appearance and microphysical characteristics
- Can be useful to roughly estimate microphysical properties from non dual polarization radar
- Could be useful for operational purposes – VIL/COA can indicate systems life cycle stage, intensity and electrical activity

Thank you!

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