TRACKING UPDRAFTS USING POLARIMETRIC RADAR

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Abstract

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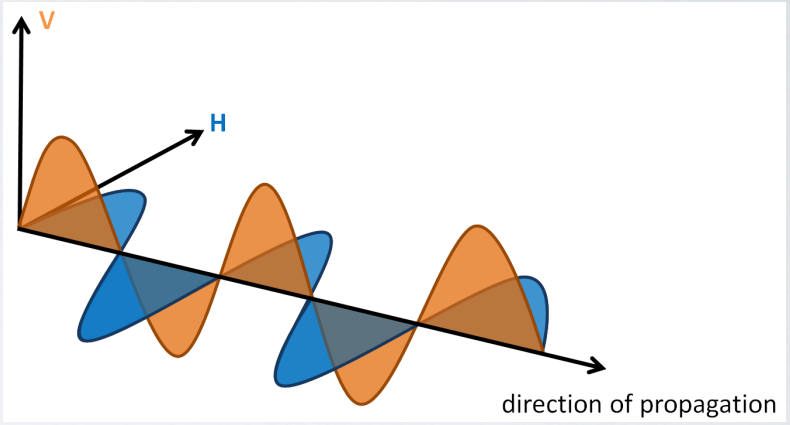
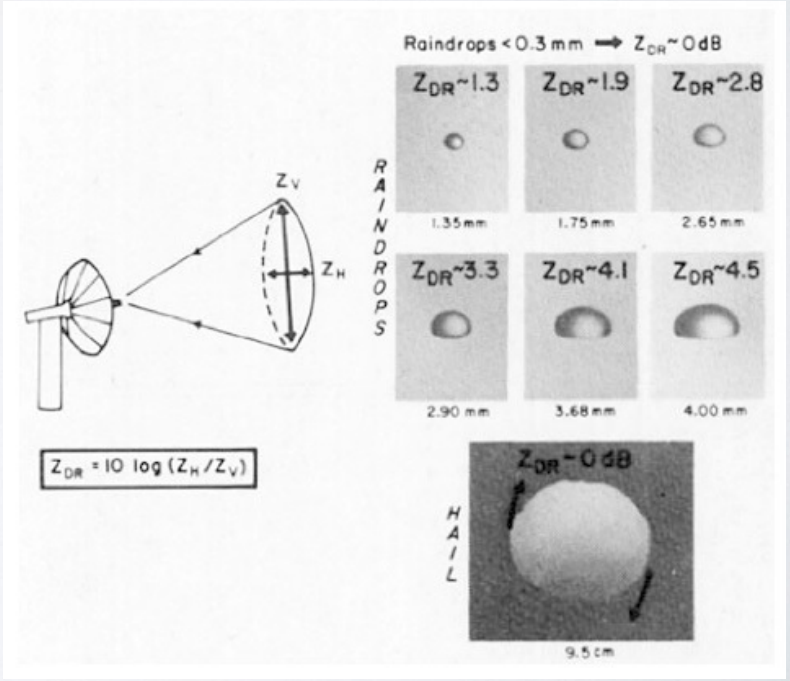
THE BIG PICTURE

- There are large gaps in our understanding of atmospheric processes
    - Cloud microphysics is a prime offender (esp. deep convective microphysics)
- Our models have limited fidelity
- We have lots of observations, but do we use them well?
    - Are we isolating the processes we are interested in constraining?

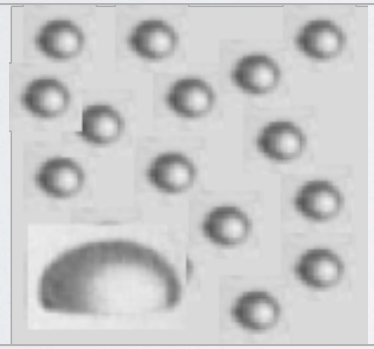
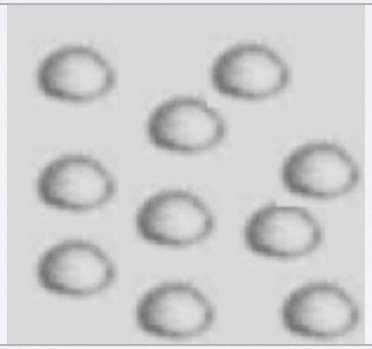
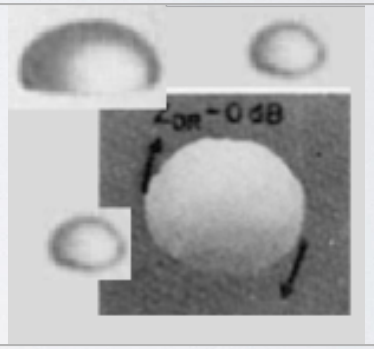
POLARIMETRIC RADARS

- Polarimetric radars transmit/receive in multiple polarizations
- Polarimetric radar variables:
  - Z_{DR} : differential reflectivity
  - K_{DP} : specific differential phase shift
  - ρ_{HV} : co-polar correlation coefficient
- Plus, plain ol' vanilla radar reflectivity



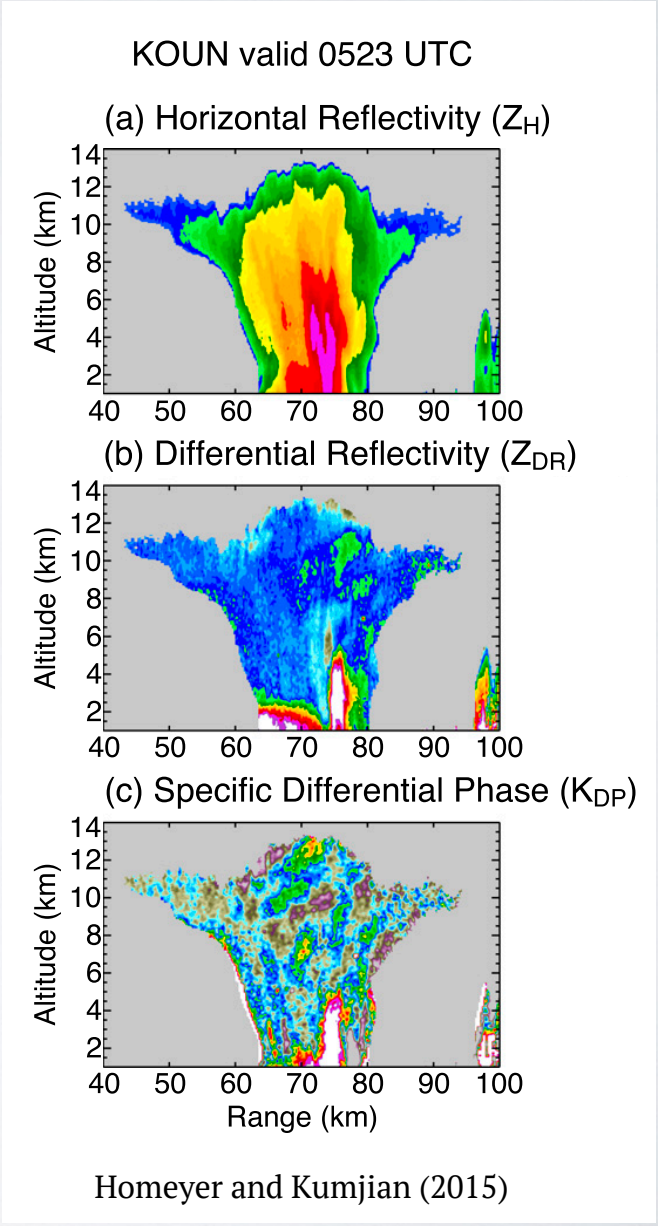


K_{DP} VS Z_{DR}

Lots of small/cloud drops, a few very large drops	Lots of medium-sized rain drops	?? Raindrops, Large Hailstones
		
High Z_{DR}, low K_{DP}	Medium Z_{DR}, High KDP	~ 0.0 dB Z_{DR} KDP dependent on rain and liquid-coated ice

KDP AND ZDR COLUMNS

- Positive ZDR and KDP often indicate the presence of liquid water (rain, water-coated hail/ graupel)
- Observed above the environmental 0°C level, this can indicate the presence of a convective updraft
- See, e.g. Bringi (1991), Conway & Zrnic (1993), Kumjian et al (2014).



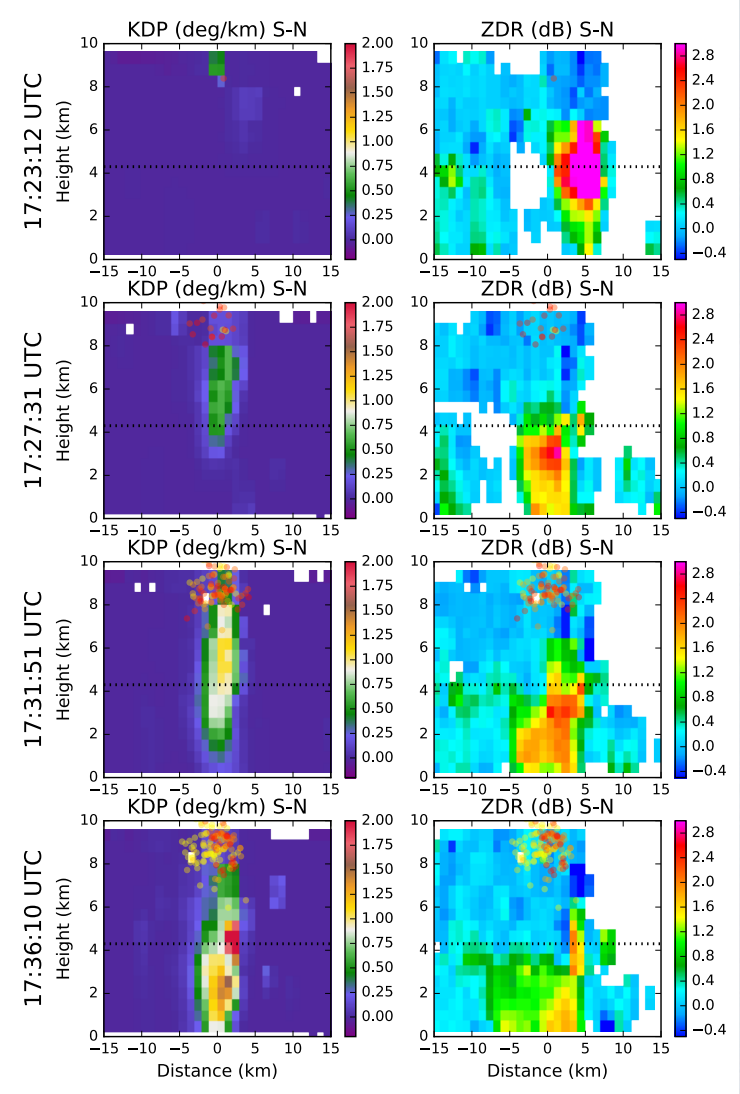
Homeyer and Kumjian (2015)

KDP AND LIGHTNING

- An example of how KDP and lightning activity correlate in space/time
- Lighning & KDP columns, Oklahoma May 20 2011

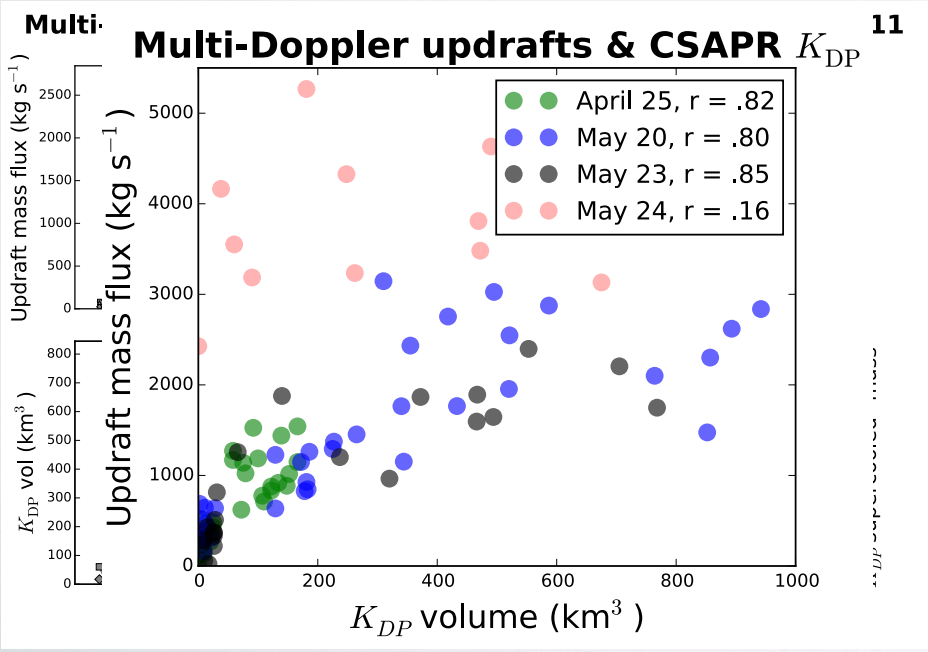
CONVECTIVE UPDRAFTS: KDP COLUMNS

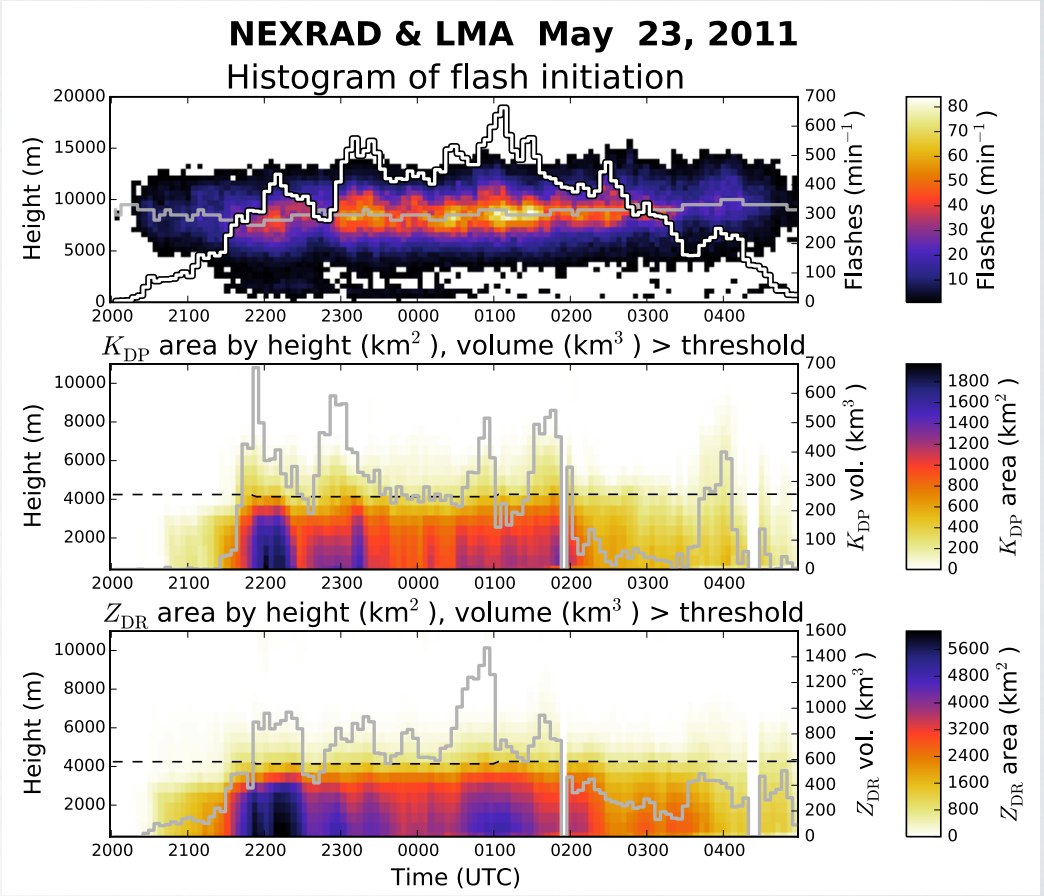
- Typically, ZDR columns show up first (recirculated drops in nascent updraft)
- KDP columns show up next indicating substantial rain or liquid-coated hail mass
- Lightning peaks then shortly thereafter (mixed-phase microphysics of mature updraft)



KDP COLUMNS

- KDP columns correlate with updraft mass flux
- KDP and ZDR correlate with lightning





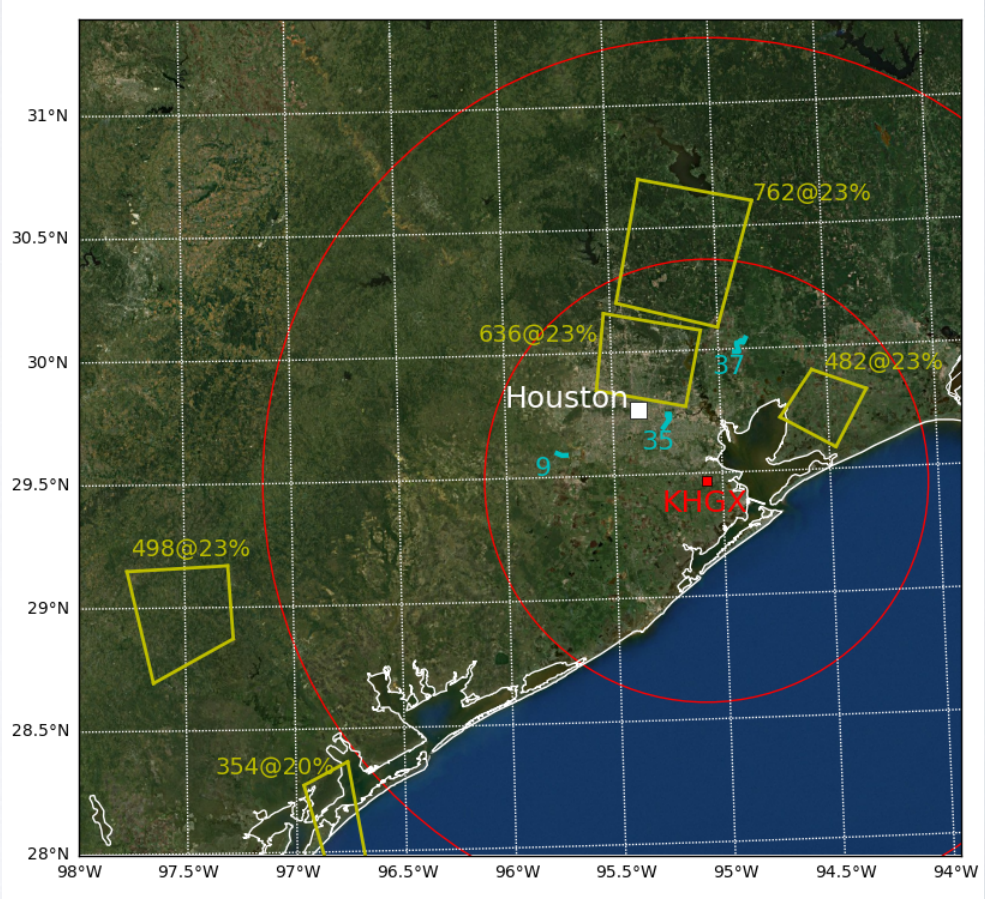
van Lier-Walqui et al. 2016

PROBLEMS WITH PREVIOUS KDP COLUMN ANALYSIS

- Bulk analysis over a wide field
  - Multiple updrafts at various points in lifecycle
  - Difficult to separate, say, aerosol effects from other meteorological effects on deep convection
  - an alternative: track a updraft cell in time

EFFECTS OF AEROSOLS ON CONVECTION: HOUSTON

- Houston TX NEXRAD radar (KHGX)
- Houston TX Lightning Mapping Array
- Satellite analysis of CCN (courtesy D. Rosenfeld)
- June 08 2013



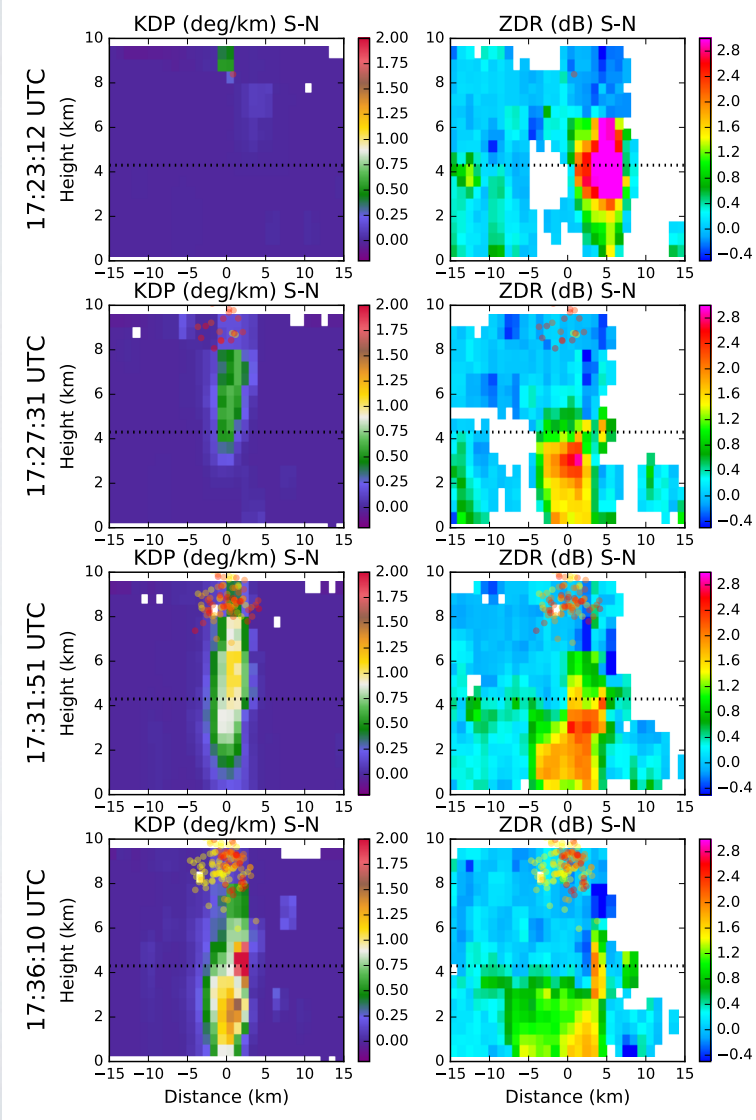
TRACKING

- Multiply KDP by height above melting level, integrate in slab
- Track in time using freely available software (TrackPy)
- Analyze radar, lightning and DSD retrievals

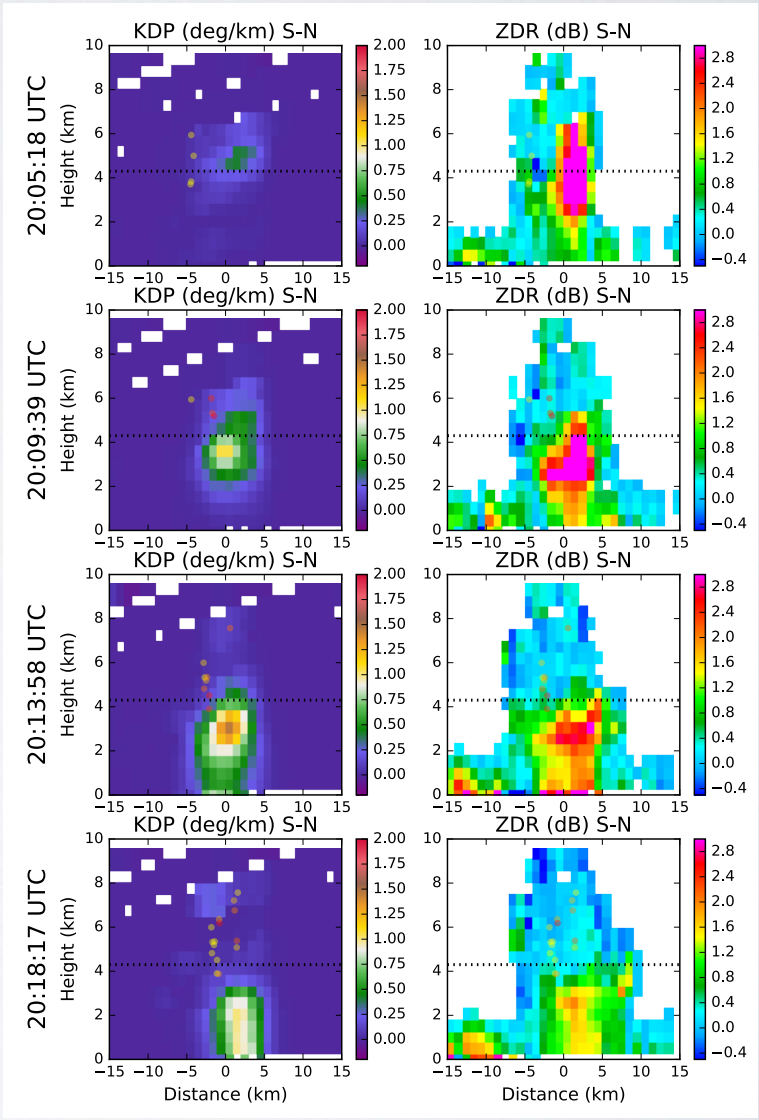
- Three examples:
  - Column no. 9
  - Column no. 35
  - Column no. 37

SUGGESTIVE CONTRASTS

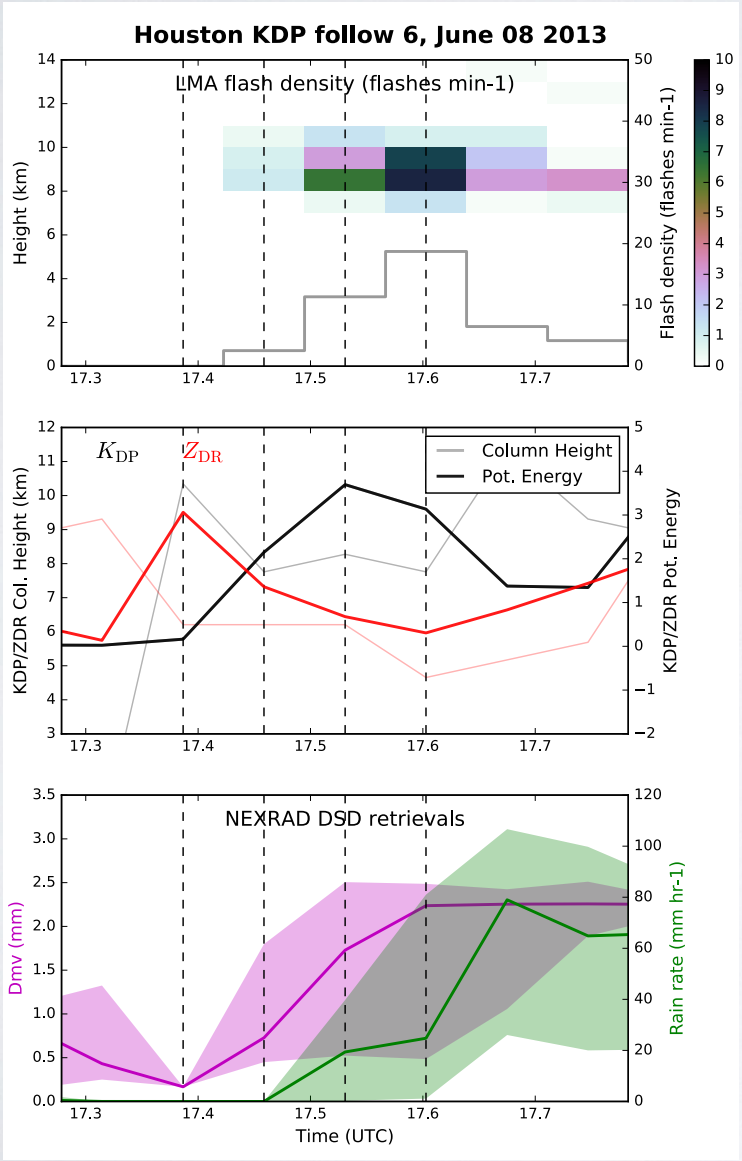
Column 6

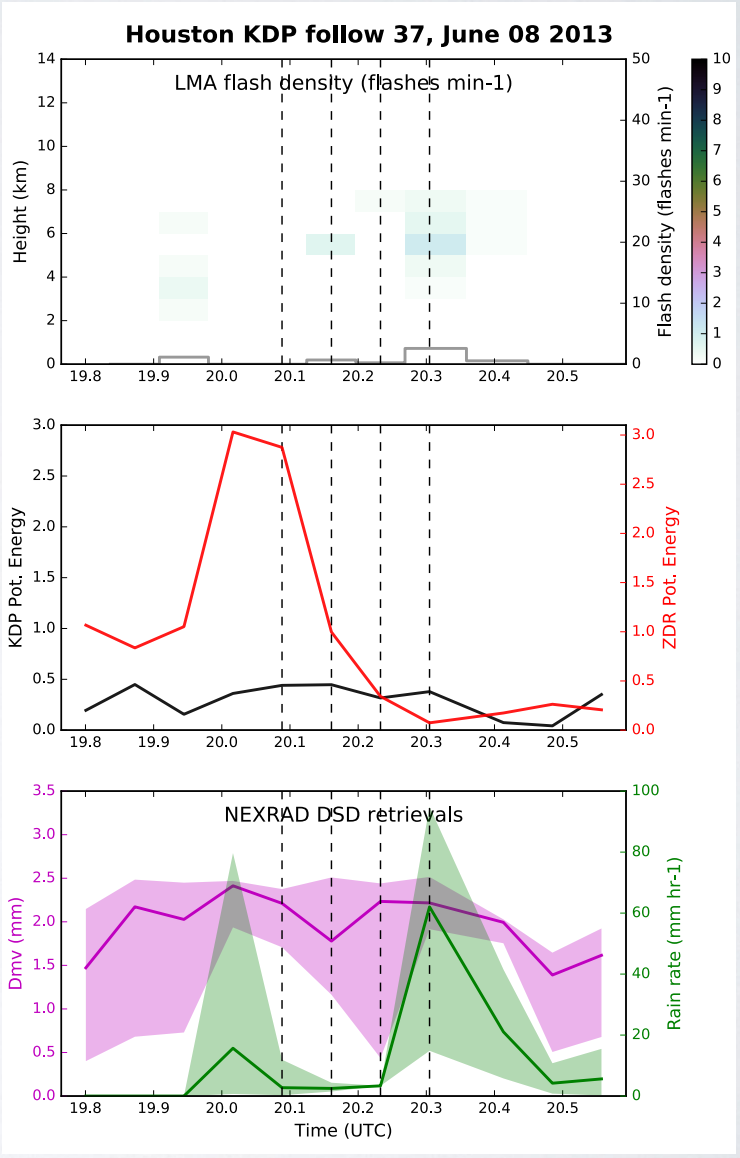


Column 37



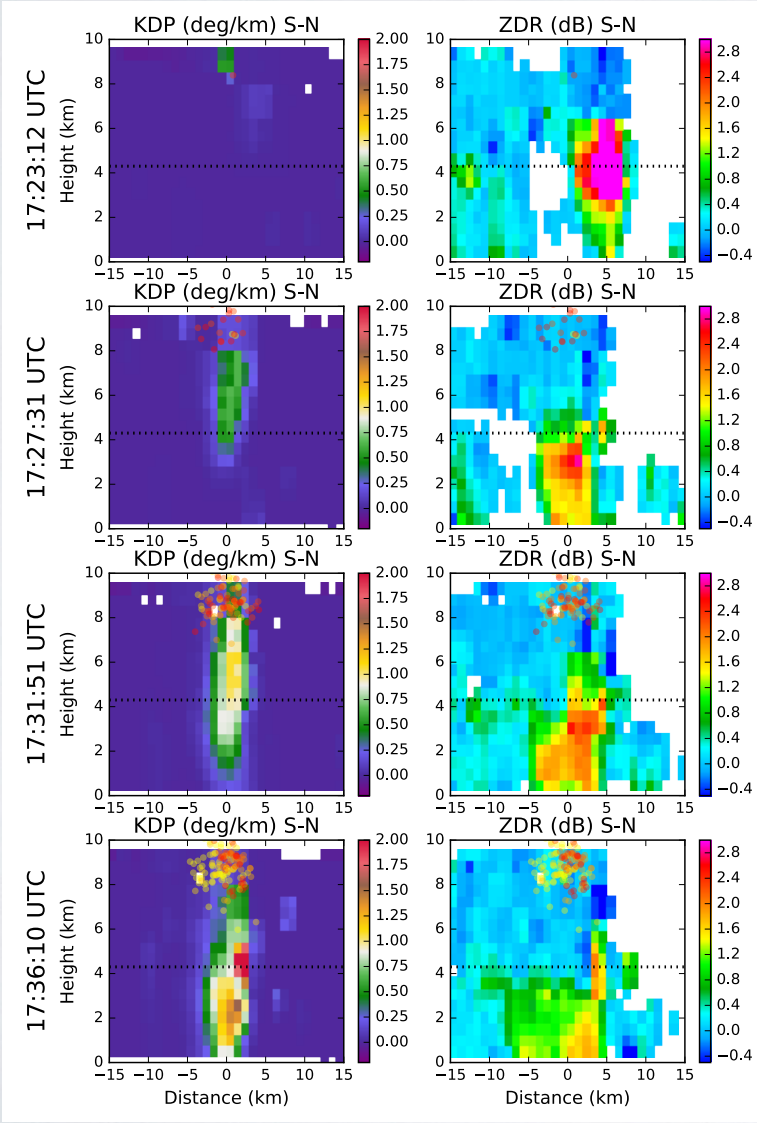
SUGGESTIVE CONTRASTS II





OBSERVED VS. MODELED

NEXRAD



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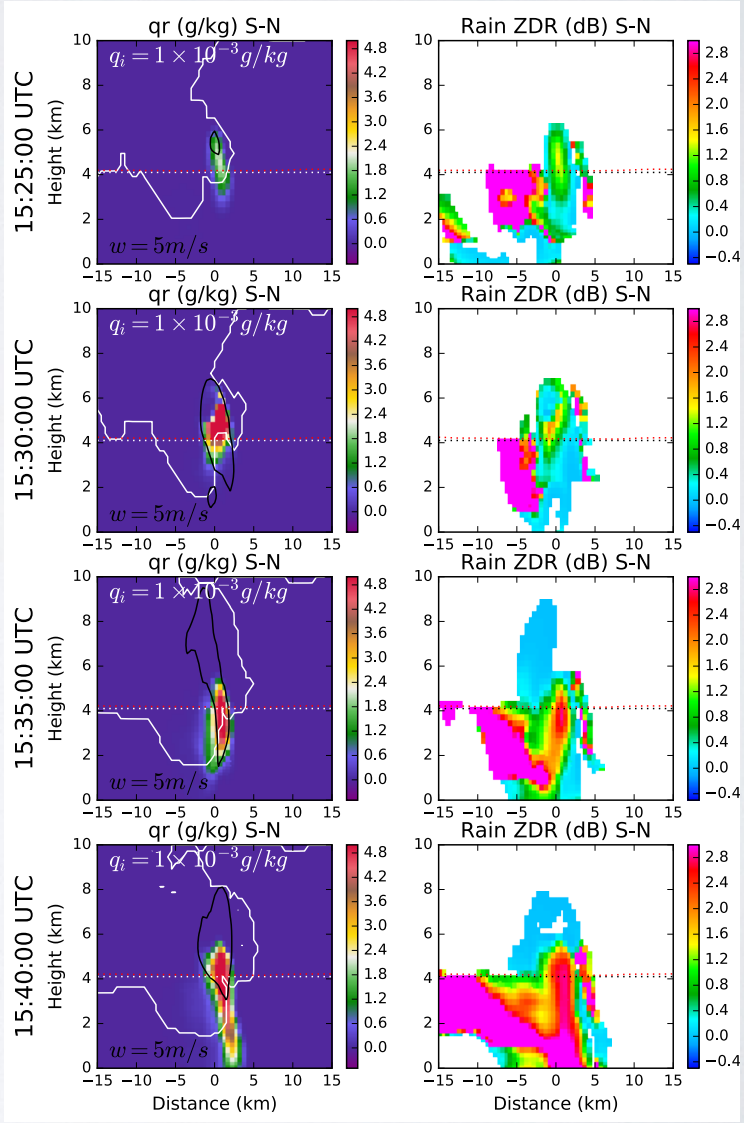

CONCLUSIONS

- Polarimetric radar observations provide crucial insights into deep convective microphysics
- Tracking KDP columns allows for comparison of evolution of individual updraft cells
- Some suggestion of possible aerosol effects on deep convective microphysics
- We need higher temporal and spatial resolution to improve tracking and effectively analyze observed microphysics