Abstract.

We present work tracking convective updraft cells in thunderstorms that occurred in the vicinity of Houston, TX on June 8, 2013. Convective updrafts are identified and tracked from polarimetric radar observations by using columns of positive specific differential phase (KDP columns), a proxy for deep convective updrafts. Cells were tracked in numerical simulations of these storms using rain mixing ratio, which can be considered analogous to the KDP columns observed with the radar.

1 Introduction

– Introduction to ACPC. Concept of box closure (Rosenfeld et al., 2014). Shallow clouds. Ice-containing clouds. Deep convection, whose role in climate sensitivity is recently of increasing interest (e.g., Mauritsen and Stevens, 2015; Donner et al., 2016).

– Introduction to the concept of convective invigoration, convective clouds in a susceptible environment with an aerosol perturbation.

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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 transmit/receive in multiple polarizations

Polarimetric radar variables:

- $Z_{DR}$: differential reflectivity
- $K_{DP}$: specific differential phase shift
- $\rho_{HV}$: co-polar correlation coefficient

Plus, plain ol’ vanilla radar reflectivity
<table>
<thead>
<tr>
<th><strong>$K_{DP}$</strong></th>
<th><strong>$Z_{DR}$</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lots of small/cloud drops, a few very large drops</td>
<td>Lots of medium-sized rain drops</td>
</tr>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>High $Z_{DR}$, low $K_{DP}$</td>
<td>Medium $Z_{DR}$, High $K_{DP}$</td>
</tr>
</tbody>
</table>
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

KDP AND LIGHTNING

- An example of how KDP and lightning activity correlate in space/time
- Lightning & 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

NU-WRF
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