Storm and cell-scale polarimetric radar signatures of deep convective updrafts observed during MC3E

Marcus van Lier-Walqui

Columbia University
NASA Goddard Institute of Space Studies

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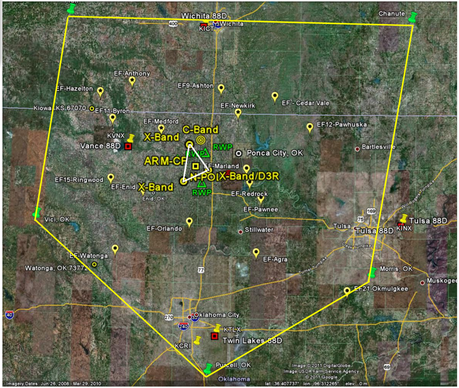
ARM MC3E

Midlatitude Continental Convective Clouds Experiment

- April 22 – June 6 2011
- In and about ARM Southern Great Plains (SGP) site, Oklahoma (and Kansas)
- Science goals: improve understanding of deep convective systems to aid in parameterized representations



ARM MC3E

Data:

- ARM C-band CSAPR radar (Lamont, OK)
- KVNX (Vance, OK) WSR-88D S-Band dual-pol radar
- 3-Doppler wind retrievals (X-,X-,C-band) provided by K. North (McGill)
- High-resolution model simulations with bin and multi-moment bulk microphysics

Days investigated:

- April 25: Moderate MCS with heavy rain & large drops
- May 20: Strong, large MCS
- May 23: Very strong updrafts, supercell formation along dryline, hail
- May 24: Supercell formation along dryline, tornados reported, small hail

Science plan

Analyze strong updraft cores

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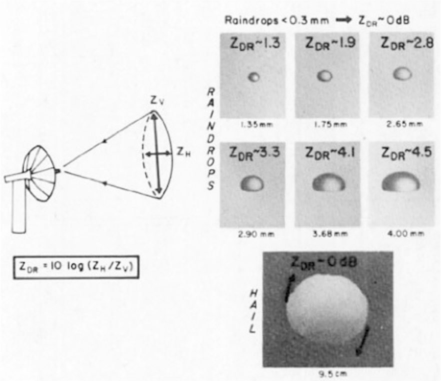
Use observational targets to constrain microphysics in simulations which use realistic (measured) aerosol distributions

Differential reflectivity

$$Z_{DR} = 10\log_{10}(z_{hh}/z_{vv})$$



From Wakimoto & Bringi (Monthly Weather Review 1988).

Differential reflectivity

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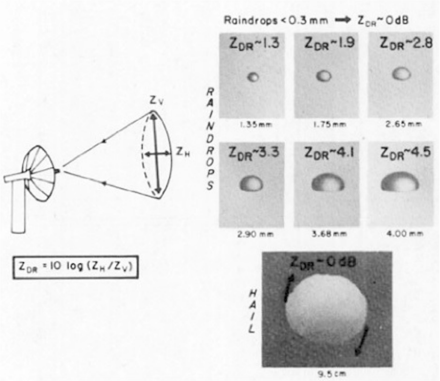
- Sensitive to oblateness of particles ∴ rain size (and N_0)



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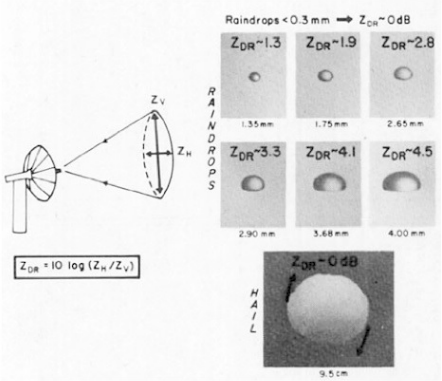

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Differential reflectivity

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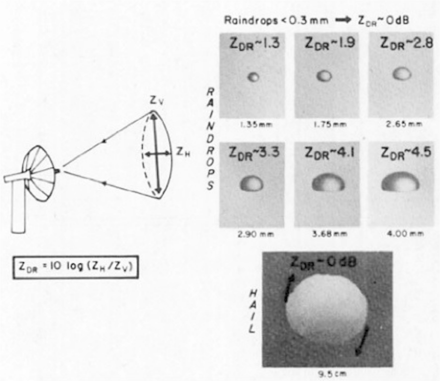
- Strongly affected by attenuation (important for C-, X-band)



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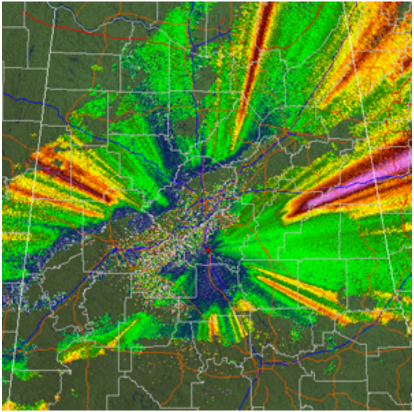
Polarimetric variables – Φ_{DP} & K_{DP}

Differential Phase (Φ_{DP})& Specific Differential Phase (K_{DP})

Difference in phase shift between horizontal and vertical signals

Φ_{DP}



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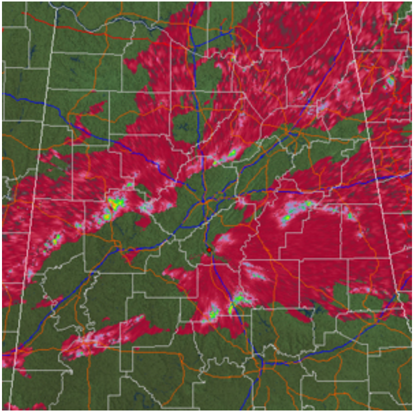

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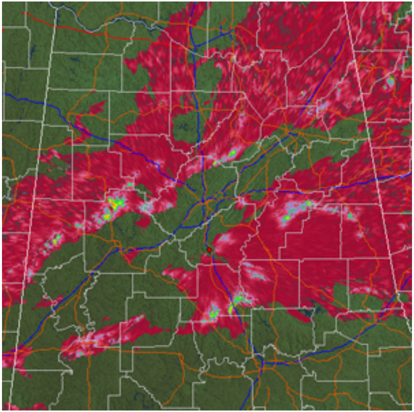

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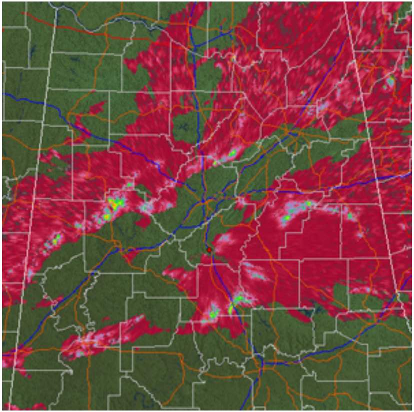

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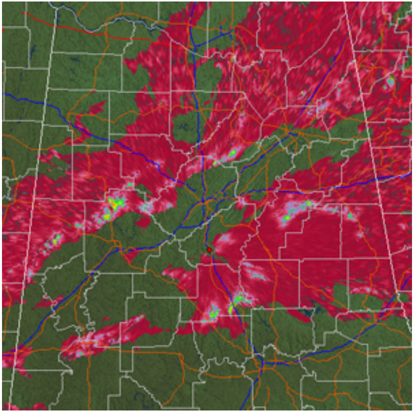
K_{DP}



Polarimetric variables – Φ_{DP} & K_{DP}

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Difference in phase shift between horizontal and vertical signals

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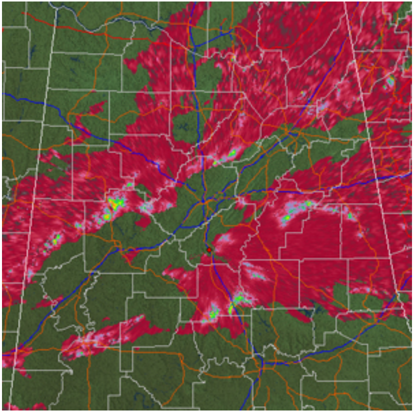
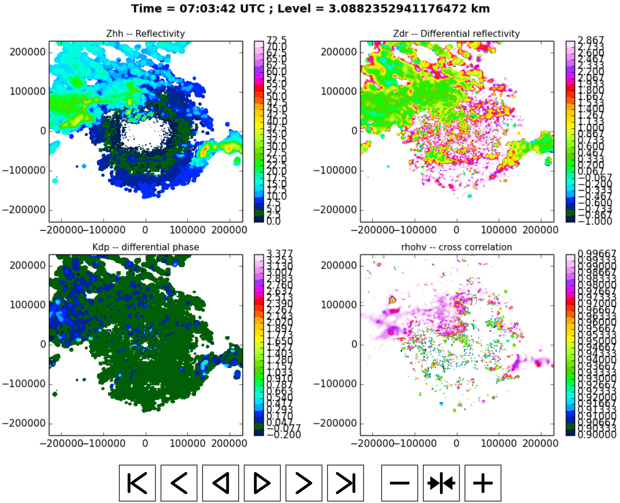
- Sensitive to (rainwater) concentration
- K_{DP} = range derivative of Φ_{DP}

K_{DP}



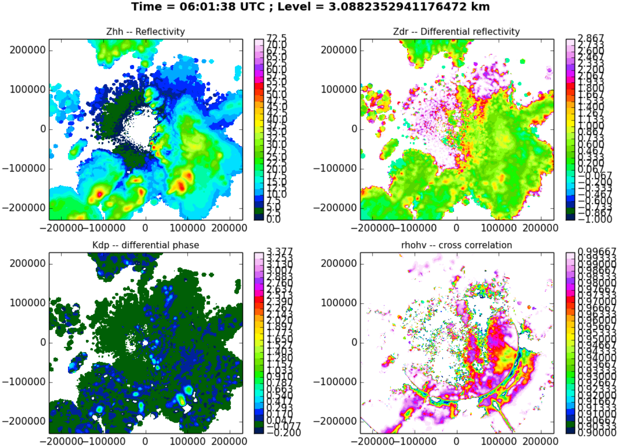
April 25, 2011

MCS case, nonlinear/trailing stratiform.

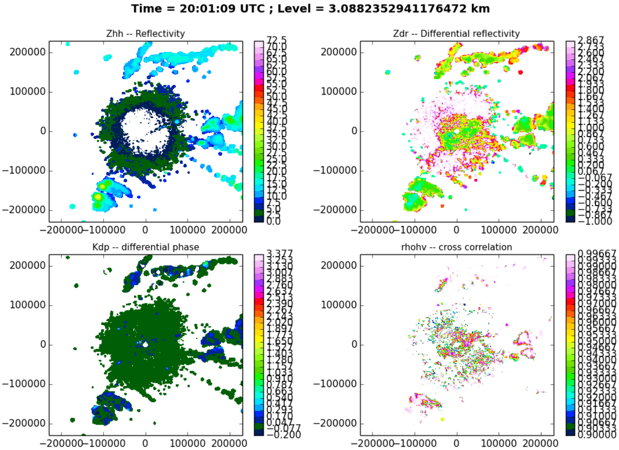


May 20, 2011

MCS, trailing stratiform/bow echo.

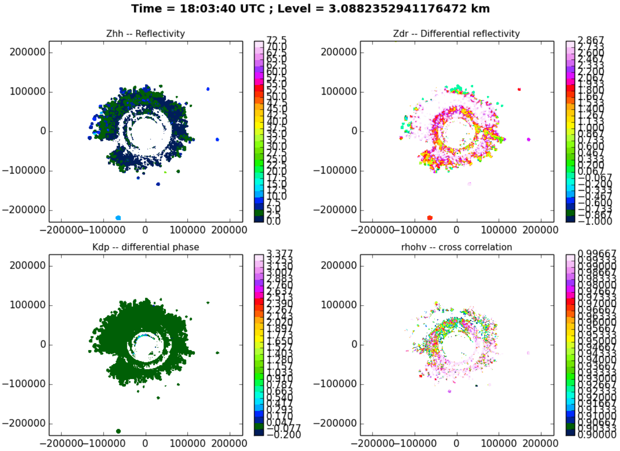


Supercell case,
forming along dryline

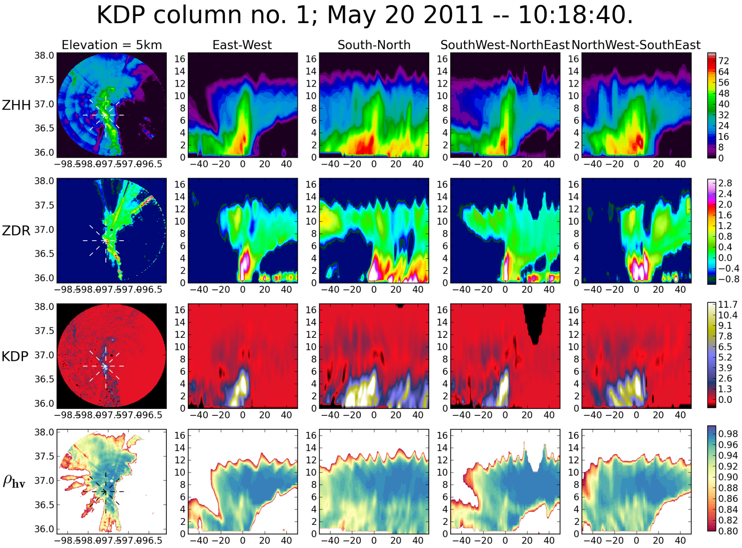


May 24, 2011

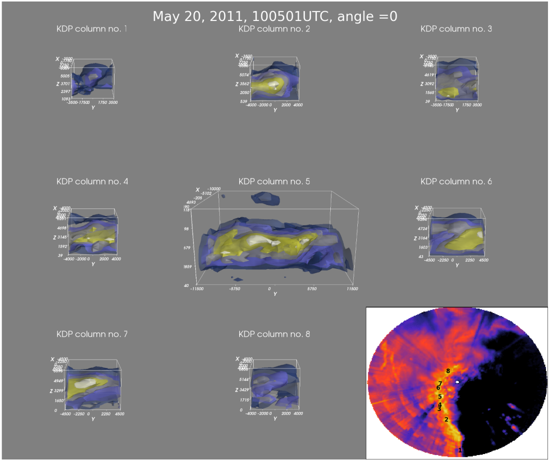
Supercell/broken line/leading stratiform.



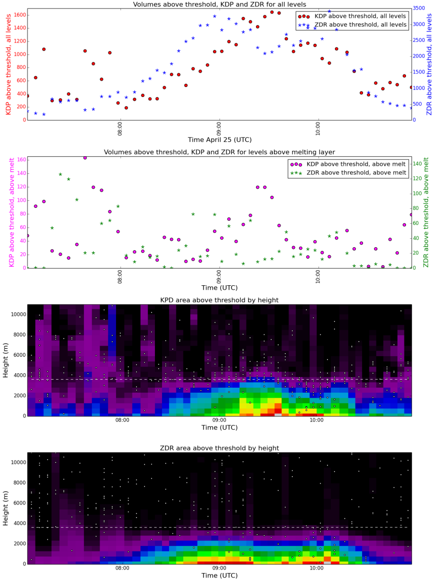
KDP & ZDR columns



KDP columns – 3D visualization

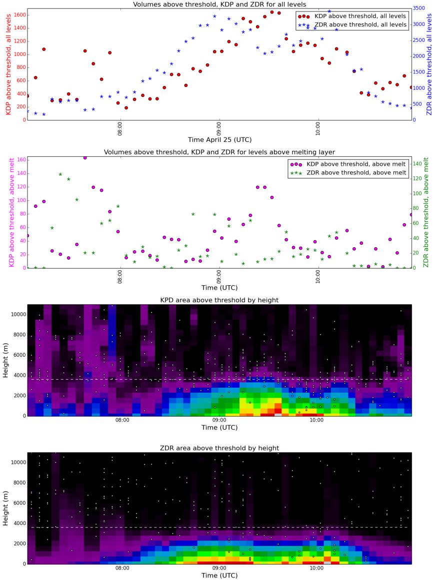


Bulk statistics on KDP and ZDR features, April 25



Bulk statistics on KDP and ZDR features, April 25

Volume enclosed by $ZDR = 2.0$ and $KDP = 1.0$ thresholds



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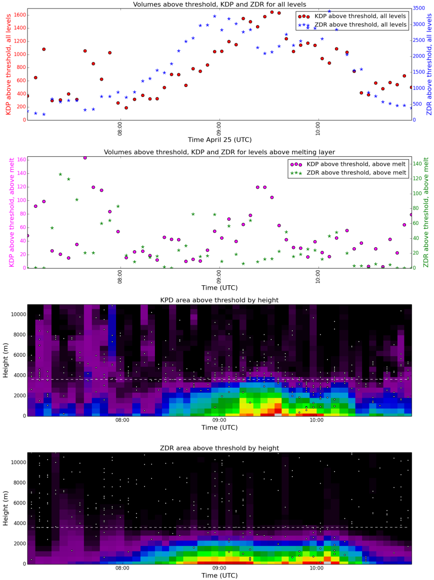

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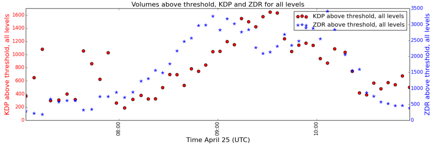
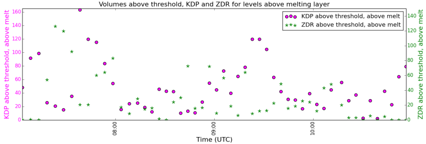
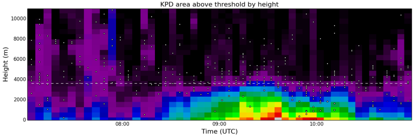
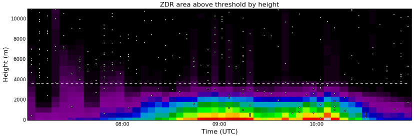
Area enclosed by $KDP = 1.0$ threshold, by height









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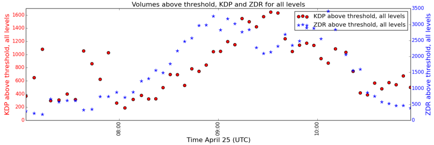

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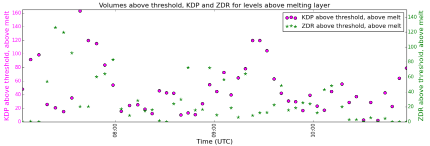

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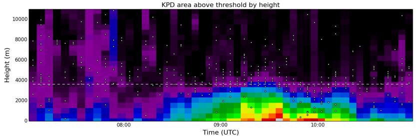
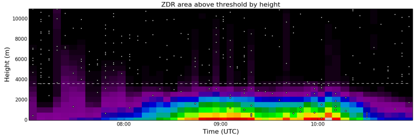
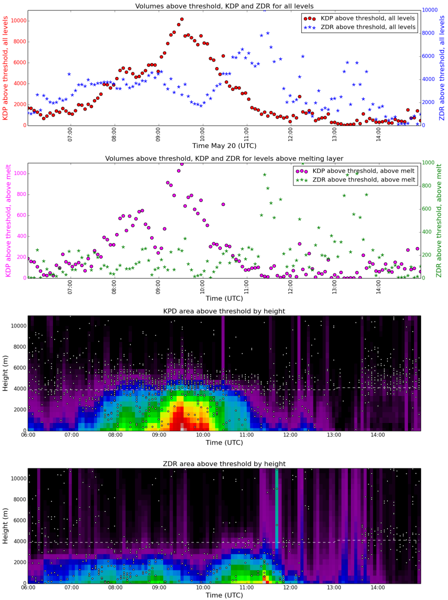


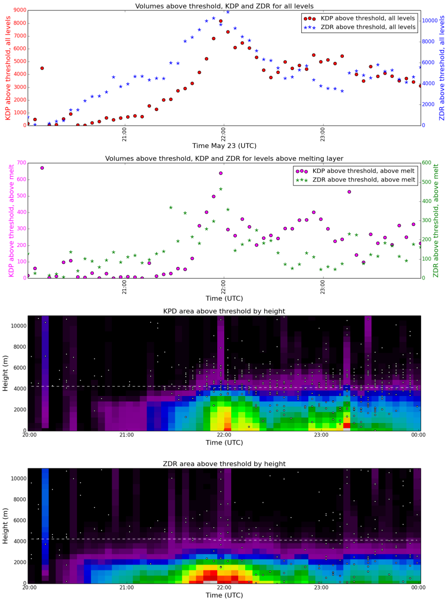
Area enclosed by $ZDR = 2.0$ threshold, by height



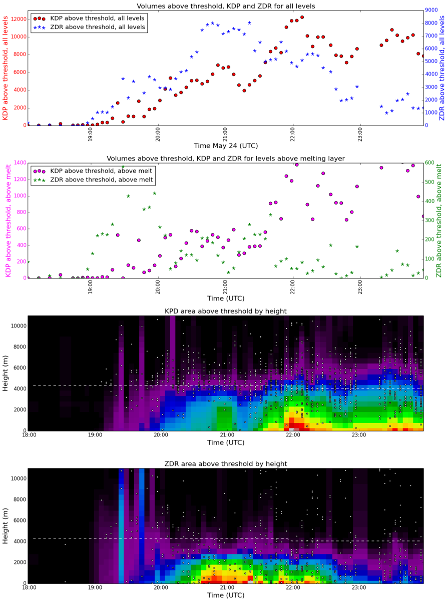
Bulk statistics on KDP and ZDR features, May 20



Bulk statistics on KDP and ZDR features, May 23

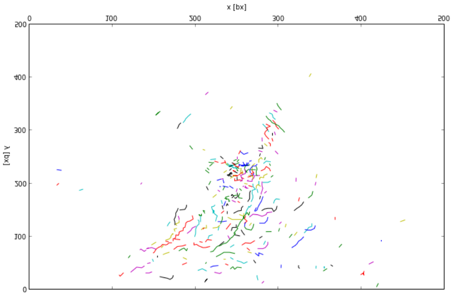


Bulk statistics on KDP and ZDR features, May 24

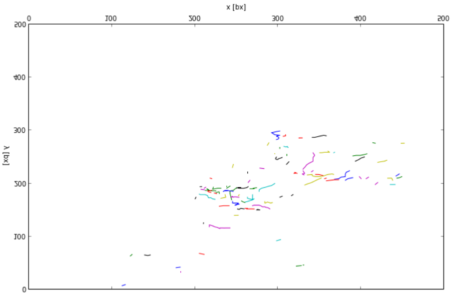


Tracking KDP columns with TrackPy

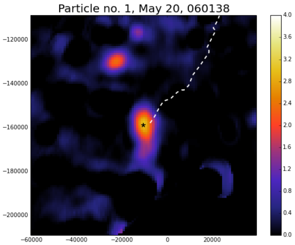
May 20, 2011

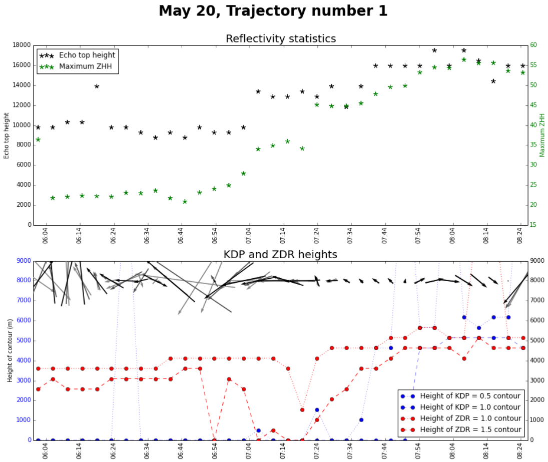


May 23, 2011



Cell-tracking statistics





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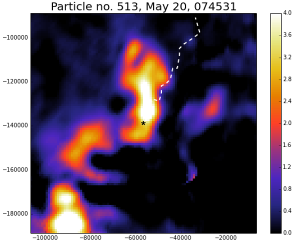

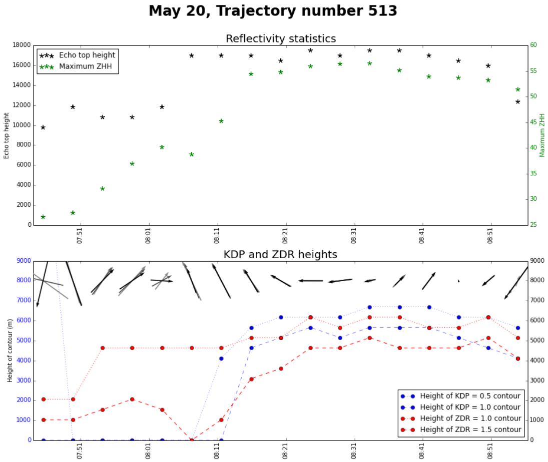

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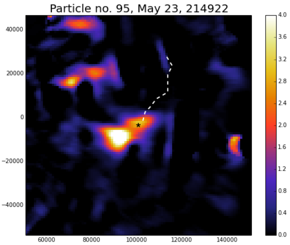
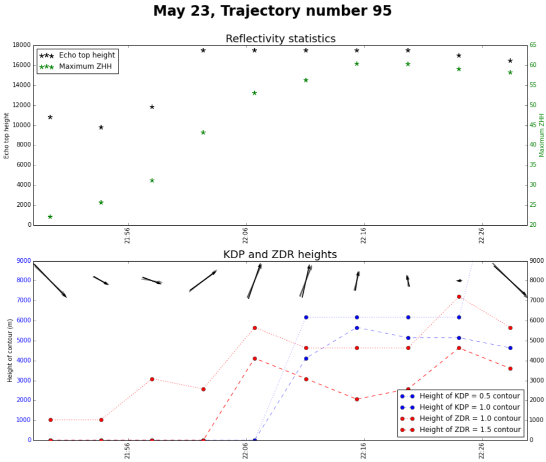
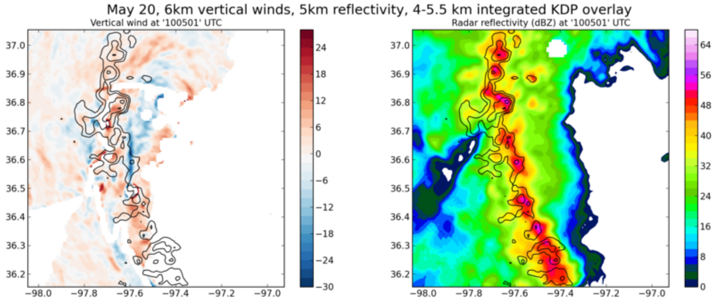




Correlation between updraft & KDP

Winds: 3-doppler retrieval (K. North); Contours: KDP; Reflectivity: CSAPR



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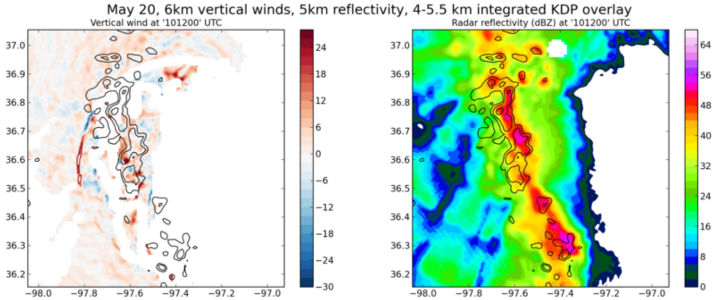
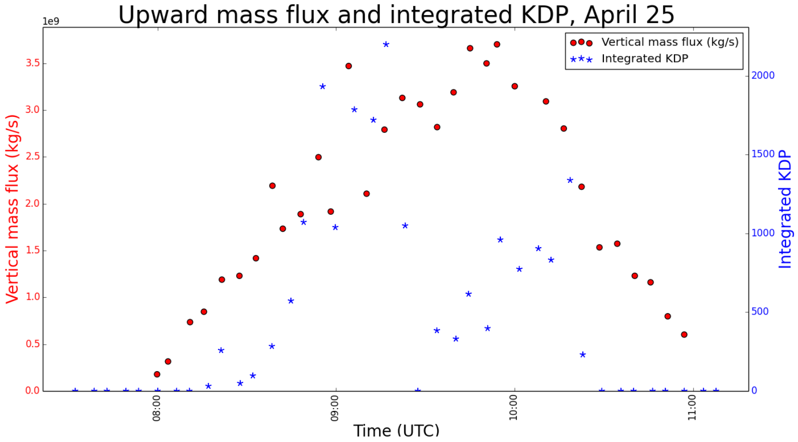
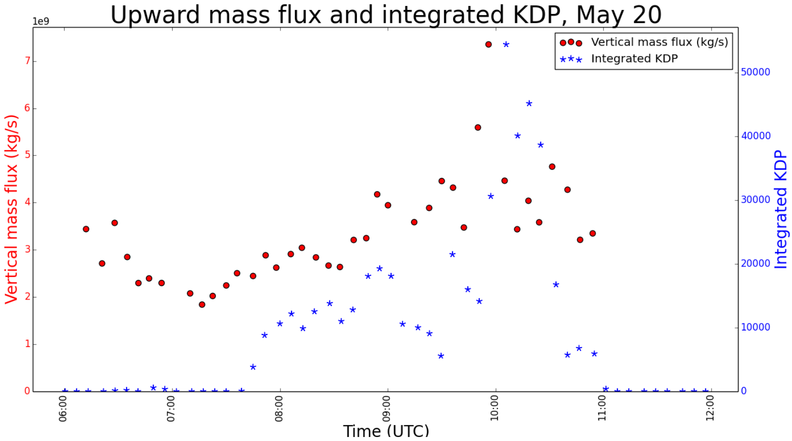


Vertical mass flux vs. KDP columns, April 25 2011



Vertical mass flux vs. KDP columns, May 20 2011



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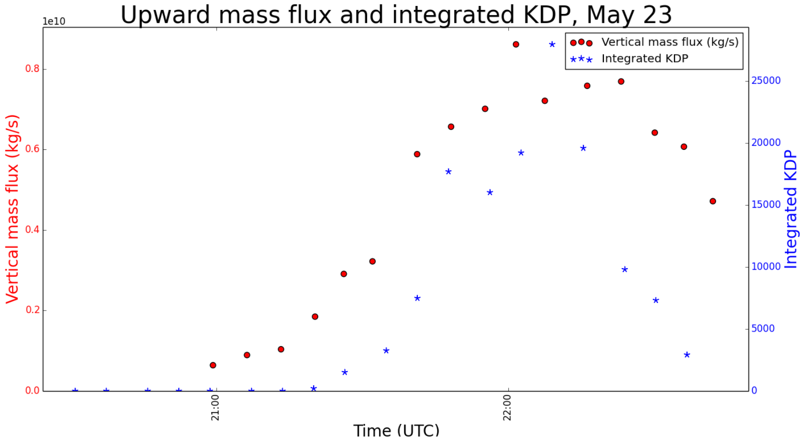
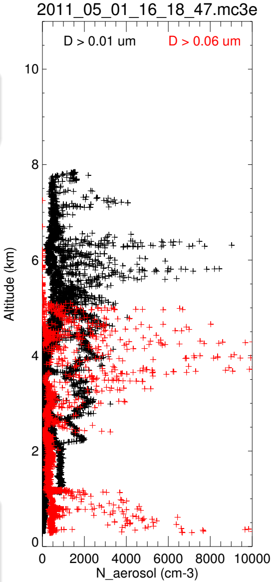


Aerosol Observations

Univ. of North Dakota Citation data (PI Mike Poellot)

- Only 5/1 has both UHSAS data (> 0.06 um) and CPC data (> 0.01 um)
- First look at archived data, not screened for in-cloud periods
- Need to examine some inconsistencies seen so far (e.g. N>0.06 greater than N>0.01), check our processing

Goal: use what we can from this data, with SGP surface measurements, to initialize cloud-resolving simulations with size-resolved microphysics



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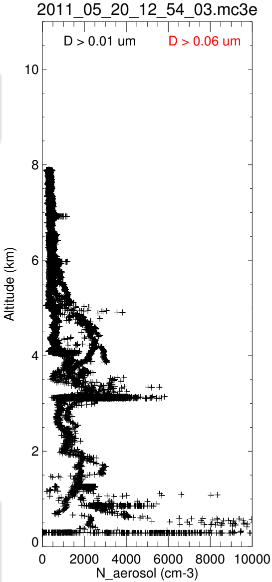

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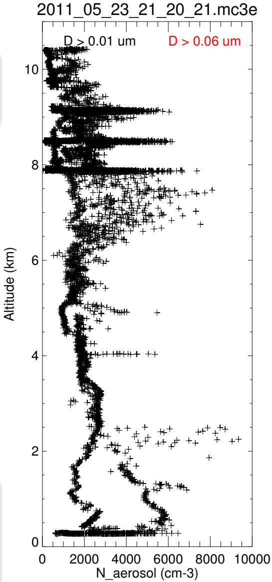

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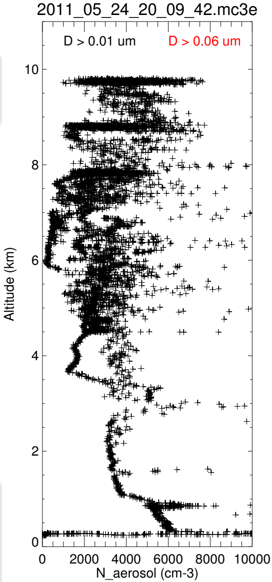

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Acknowledgements

PI: Ann Fridlind
Co-I: Wei-Kuo Tao
Co-I: Andy Ackerman
Collaborators:

- Derek Posselt (U. Michigan)
- Scott Collis (ANL)
- Jonathan Helmus (ANL)
- Kirk North (McGIll)
- Xiaowen Li (NASA GSFC)
- Di Wu (NASA GSFC)

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Thanks also to:

- Alexander Ryzhkov
- Scott Giangrande
- Matt Kumjian

References I