3-D Applications of Disdrometer and Polarimetric Radar Measurements to Support GPM Algorithm Development

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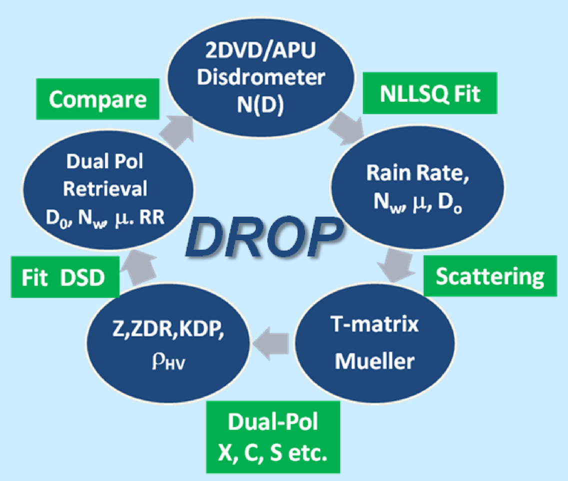
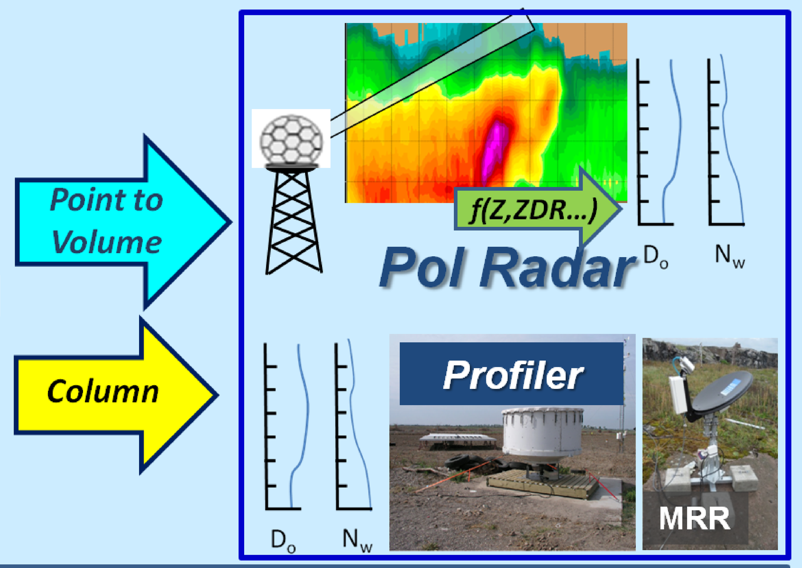
1. GPM Algorithm and Science Needs

- Multi-regime and cloud system PDFs of DSD (database)
- Spatial/temporal Correlation (e.g., representativeness, beam filling error)
- Vertical Structure and correlation properties (e.g., N_w, $D_{0,m}$, μ, profiles)

2. Instruments, Approach(es), and Methods

- Establish multi-platform Disdrometer and Radar Observations of Precipitation (DROP) NETWORK for retrieving coupled Drop Size Distribution (DSD e.g., D_0, D_m) and rain rate space/time variability at dense to distributed scales.
- Networked and redundant DSD and moment measurements, inter-instrument error characterization, DSD in polarimetric radar modeling, empirical extension to column and larger horizontal domain.

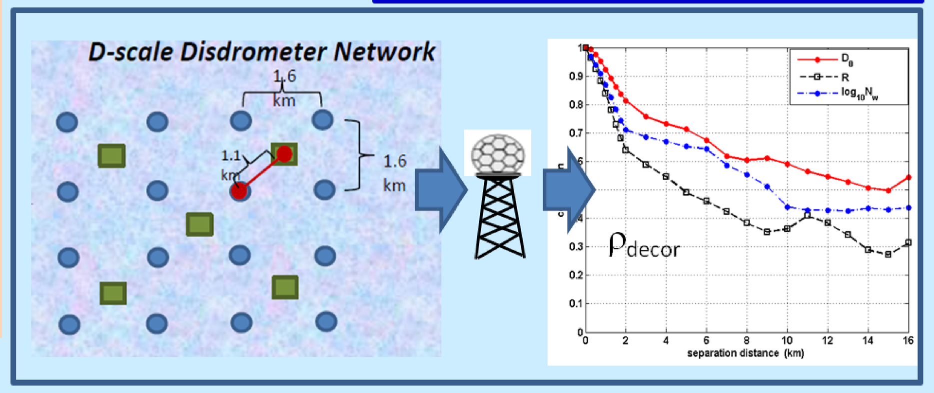




Polarimetric radar combined with disdrometer "reference" and scattering simulations (profiler and MRR constraints):

Allows a referenced extension of DSD retrievals to 3-D radar sampling domains

- Disdrometers + Dual-Pol Radar and Profiler: a unified 3-D DSD retrieval
- Spatial decorrelation studies using DROP + Radar (point-area error characterized by disdro/gauge network)

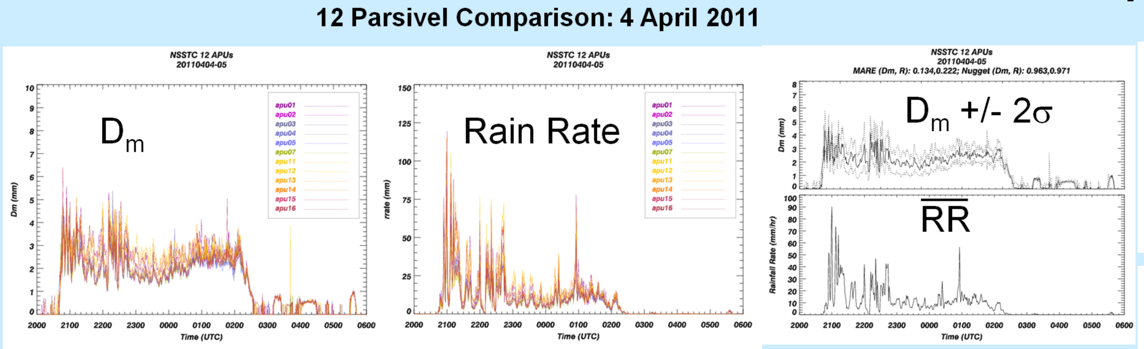


- Deployments Huntsville (2009—2011), LPVEX (2010), and MC3E (2011)

Instrument comparisons: Understanding characteristic behavior

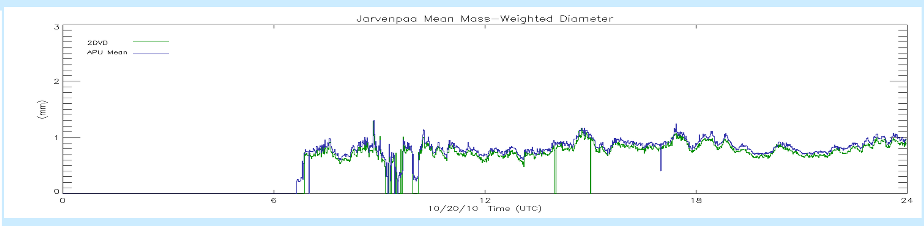
Parsivel disdrometers are a network "workhorse": Understanding their performance, to include a recent instrument upgrade, is necessary prior to using for quantitative DSD correlation work.

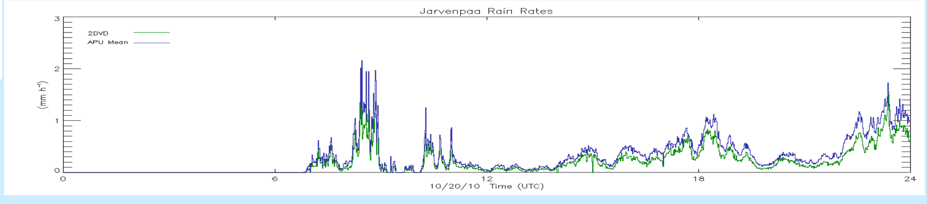
Intra-Parsivel network comparisons
12 Parsivel Comparison: 4 April 2011



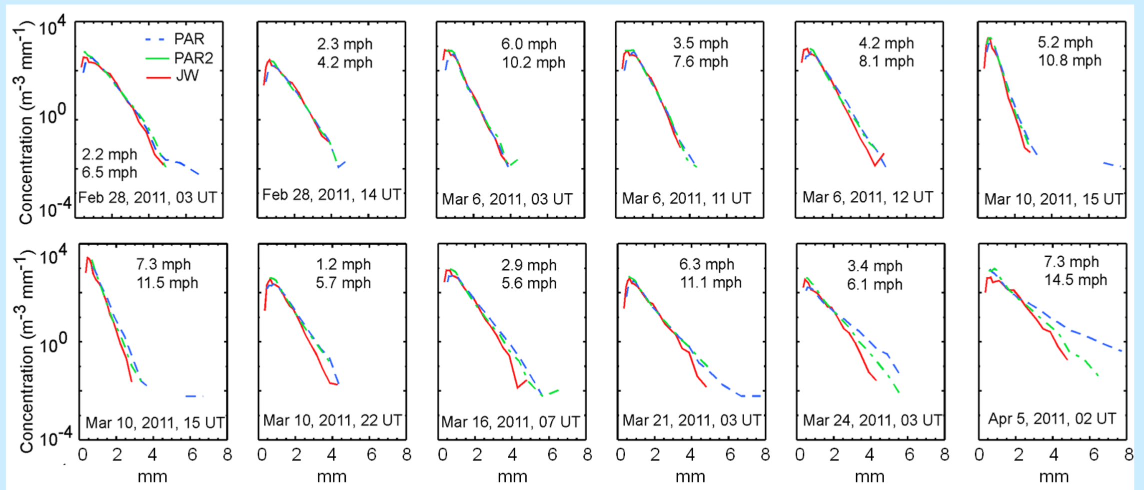
- 12 collocated Parsivel-1 (PAR-1) disdrometers
- Noise/systematic differences evident in RR and D_m. As in previous comparisons to JW and 2DVD, caution warranted for rain rates exceeding 10 mm/hr.
- Nugget *for this event* was 0.96 (0.97) for D_m (RR); average absolute error of 13% (22%) for D_m (RR) (relative to mean). D_m error worse in heavy rain

PAR-1 performance vs 2DVD in LPVEX *light rain*





PAR-1 and 2DVD were very well correlated with PAR-1 exhibiting a positive bias of 30% (10-20%) in rain rate (D_m)



- Recent "upgrade" to PAR2

Excellent agreement with gauges

Better sensitivity to small drops (0. 2-0.6 mm)

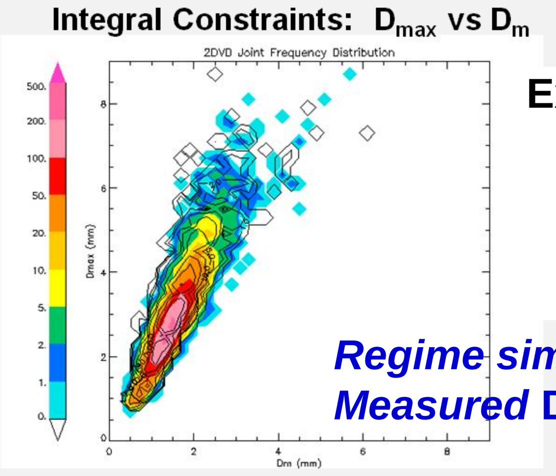
Relative to JW, better estimate of gamma shape parameters.

Some mitigation of PAR-1 "large-drop tail"

No sensitivity of results to observed winds

3. Ensemble DSD Behavior and Gamma Parametric Correlations

Integral Constraints: D_{max} vs D_m

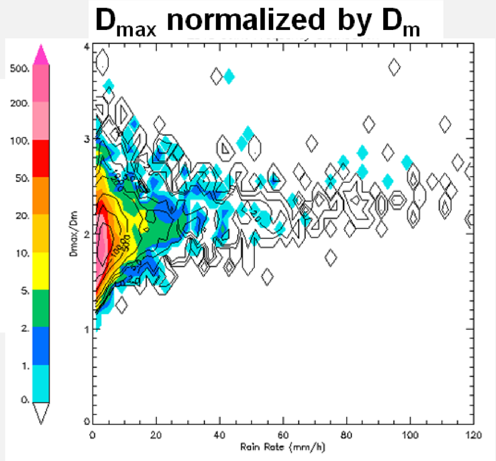


Examine:
5000 1-min. samples- MC3E 2DVDs (shaded)
7500 1-min. samples N. AL 2DVDs (contour)

Regime similarity
Measured D_{max} = aD_m*

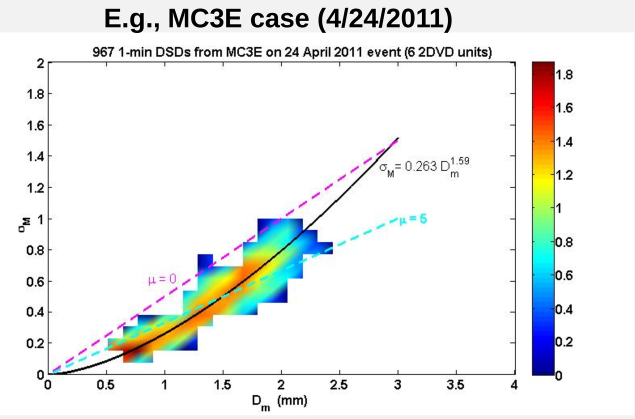
Regime similarity in Measured D_{max} vs. D_m

D_{max} normalized by D_m



"a" ~ 2.0 (similar to previous studies); increases as f(RR)
Uncertainty in "a" due to large drop sampling

Looking for μ constrained by D_m, σ_m…….
E.g., MC3E case (4/24/2011)



Similar relationships Huntsville, MC3E, Darwin, Finland, MC3E……

$$(\sigma_m/D_m)^2 = 1/(4+\mu)$$

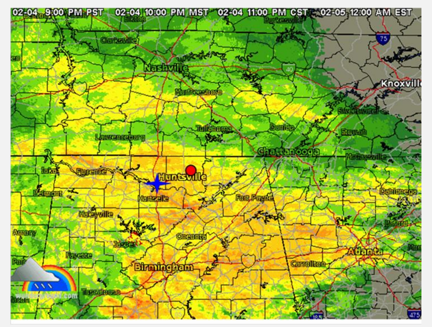
Can we define a consistent μ – D_m relationship?
Cf. Christopher Williams DSD WG Poster

4. Combined radar, disdrometer, profiler approaches for retrieving 3-D DSD variability

A. Correlation Length Studies: Cold Season strat/conv. vs. MC3E convective event

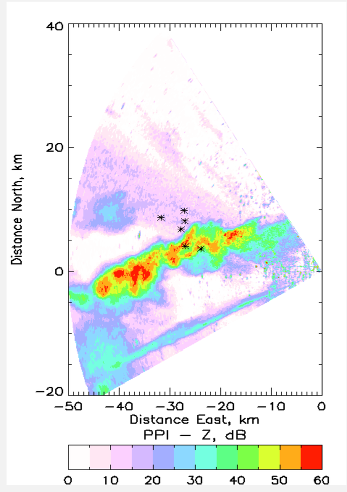
Disdro/Gauge - Radar/satellite error characterization- quantify regime point-to-area variance of rainfall rate and DSD

ARMOR Radar 2-25-09 (Huntsville)



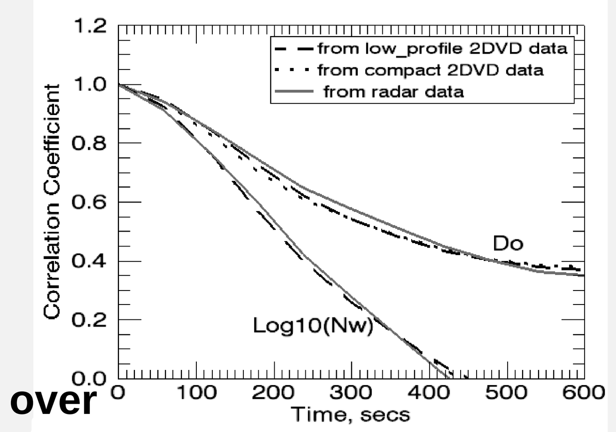
Cf. *Thurai, Bringi, Carey, Gatlin, Schultz and Petersen, 2011, JHM submitted*

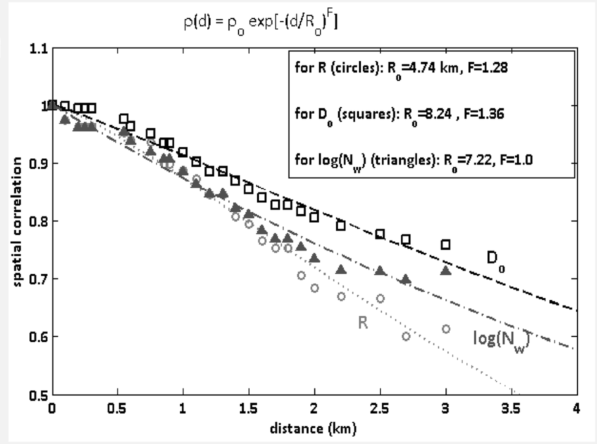
NPOL (MC3E) 4-24-11

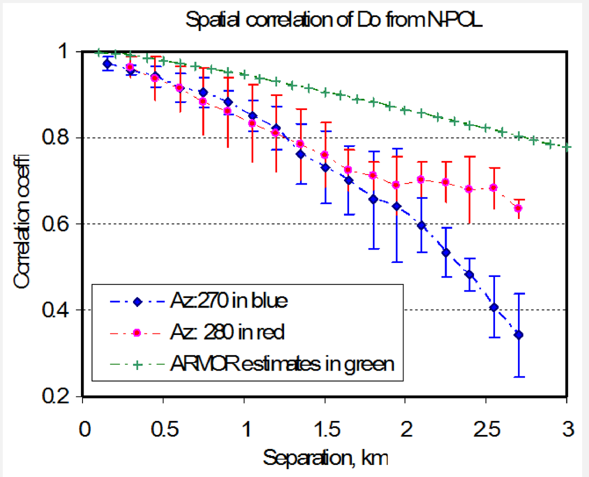


DSD, RR Space Time Variability

- Huntsville: 4-10 s sectors over 2DVD (15 km from radar)
- Time and space correlation along rays and in sector







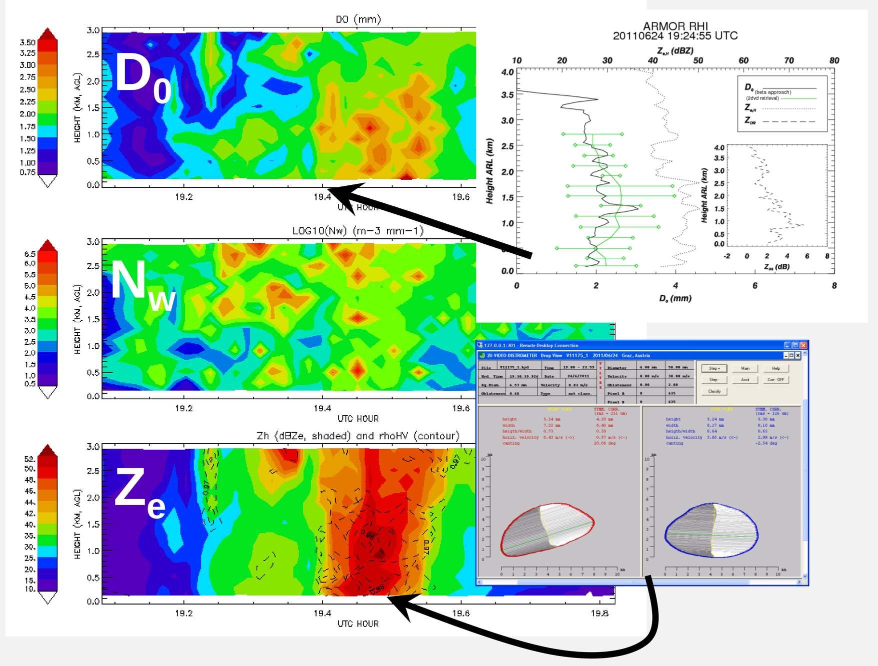
MC3E: "Directional" gate-to-gate correlation properties along rays at two azimuths (270°, 280°)

Cold Season event (stratiform with embedded convection)
- Rain rate decorrelates faster than D_0 or N_w (as in previous studies)
- Spatial decorrelation distance (R_0) and fit parameter (F) for rain rate similar to previous studies (Moreau et al., 2009, Gebrimichael and Krajewski, 2004)- *R_0 4-5 km and fit parameter (F) of 1.3-1.5 robust?*

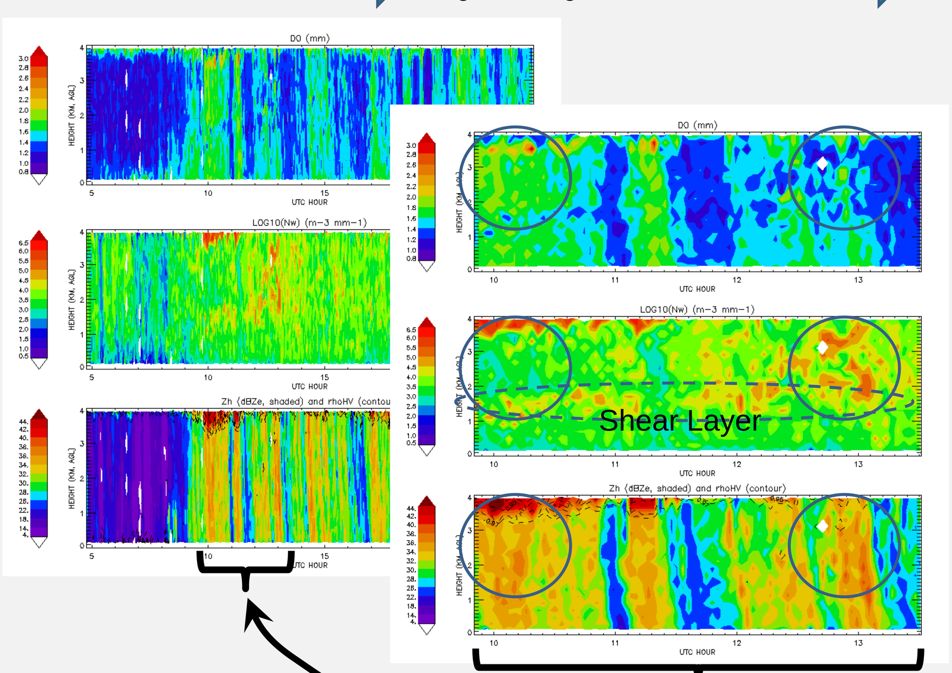
MC3E: Along ray correlation properties
- Azimuthal/Directional variability
- System regime dependence: More rapid decorrelation in convection relative to widespread Huntsville event

B. Column DSD character by storm type: Polarimetric Radar estimates

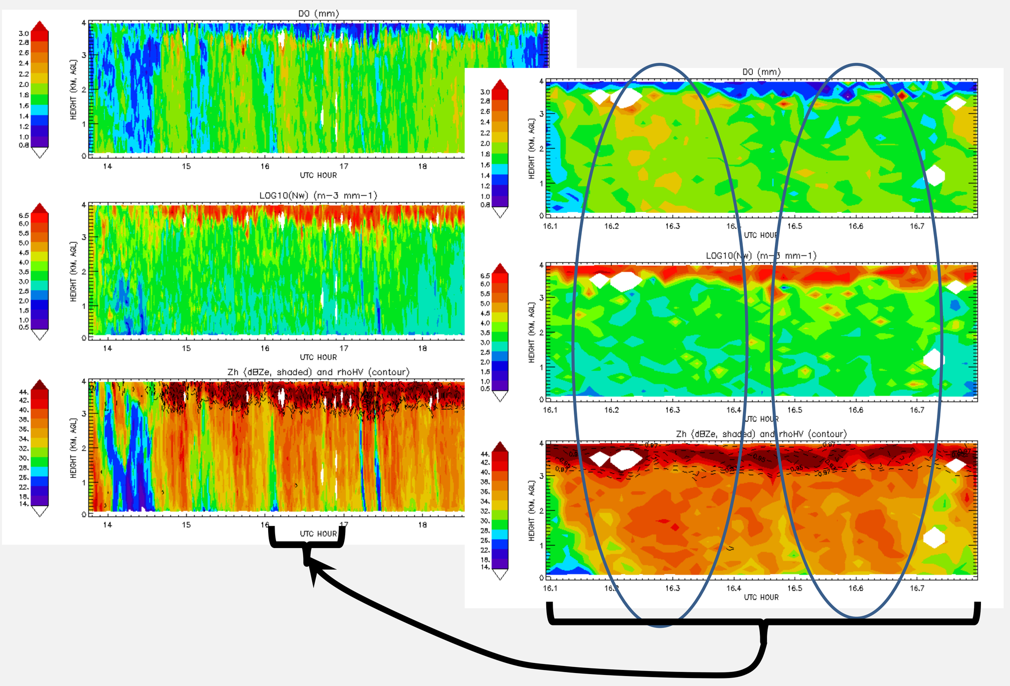
7500 min 2DVD N(D) ➡ NLLSQ fit, truncated Gamma ➡ N_0,μ,D_0 in T-Matrix ➡ Pol Variable DSD Fits (D_{max} = 3*D0 assumed)



DSD Profile variability and the occurrence of large-drops in flanks and core of a southeastern U.S. convective cell



24 Hr sampling of DSD variability in TS Lee. Variability in D_o and N_w with time, melting level intensity and shear- but in similar Z_e.



June 28, 2011 Heavy MCS convective and stratiform precipitation. Note1-3 km level variability in N_w and D_0 trends- in similar Z_e.

Conclusion: We are gaining a) a better understanding of DSD instrument/measurement uncertainty which facilitates a more careful, application of specific instruments; b) identifying systematic DSD parametric behavior; and c) using measurements to describe 3-D precipitation/DSD variability in a host of meteorological regimes.

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