Structure of DSD Parameters Retrieved from Profilers

Collaboration with the NASA PMM DSD Working Group:
V.N Bringi, Larry Carry, Rob Cifelli, Brenda Dolan, Ziad Haddad, Robert Meneghini, Joe Munchak, Walt Petersen, Ali Tokay, Anna Wilson, and David Wolff

Christopher Williams
CIRES, University of Colorado at Boulder and NOAA ESRL Physical Sciences Division

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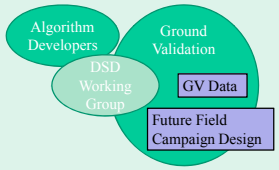
1. DSD Working Group: Bridging Algorithms and GV

General Objective: Investigate the correlation between DSD parameters using GV data sets that support, or guide, the assumptions used in satellite retrieval algorithms.

Rational: Understanding the correlations between DSD parameters will reduce the degrees of freedom in the algorithms that must retrieve rain rates when constrained by a finite number of satellite observations.

With guidance from Algorithm Developers, we are using previously collected GV data (point, columnar, and spatial GV data sets) to address three objectives:



Objective A. Develop physically based relationships (or correlations) between DSD parameters to reduce the spread of retrieved rain rates with as few DSD parameters as possible.

Example Questions:

If the DSD is parameterized by two correlated DSD parameters (N_w and D_m), what is the spread in R given D_m and $N_w(D_m)$?

How much of this variability be explained by adding a third DSD parameter (μ)?

Objective B. Investigate the degrees of freedom needed to describe the vertical structure of N_w, D_m, and μ.

Example Questions:

Is it sufficient to describe DSD parameters at the top or bottom of the column?

How much vertical variation is observed?

Objective C. Investigate relationships between observed snow particles and bulk quantities.

Example Question:

What are observed maximum to mean diameter ratios for different snow regimes?

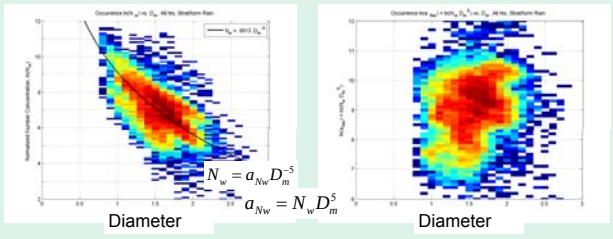
Moving Forward: If GV data cannot address these objectives, then new GV data will be collected in future GV field campaign.

2. Data Set

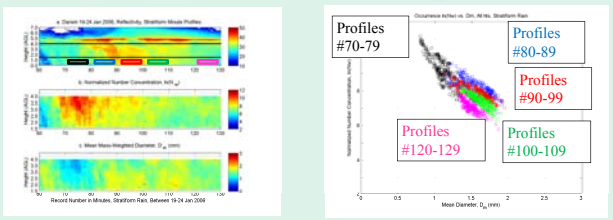
- Darwin, 50 MHz / 920 MHz profilers during TWP-ICE
- Stratiform rain, ~900 1-minute observations
- Retrieval method:
  - -Vertical air motion estimated by 50 MHz profiler
  - -Shift and deconvolve the 920 MHz profiler spectra
  - -No fitting is performed (no assumed gamma distribution)
  - -Output is a discrete N(D) at each range gate
  - -Disdrometer-like output: number of drops in each diameter

3. Frequency of Occurrences

N_w vs. D_m | $a_{Nw} = N_w D_m^5$ vs. D_m

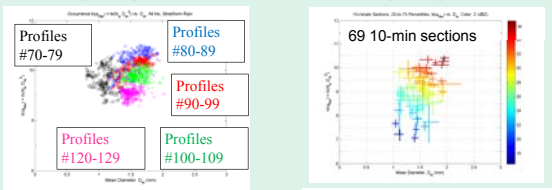


4. 10-Minute Time-Ht Sections



5. $a_{Nw} = N_w D_m^5$ vs. D_m

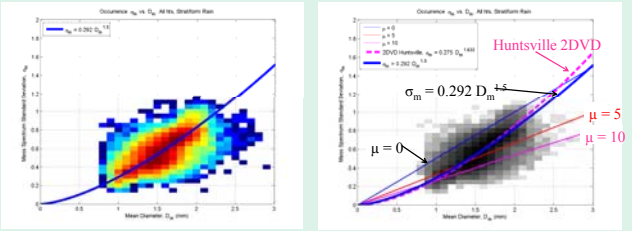
$a_{Nw} = N_w D_m^5$ | $a_{Nw} = N_w D_m^5$



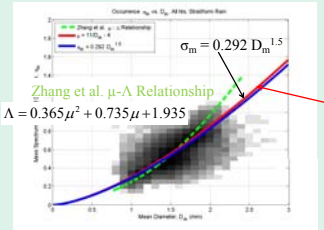
a_{Nw} is confined to a 'small' region

$N_w D_m^5$ still has a Z dependence

6. σ_m vs. D_m



7. μ - D_m Relationship



There is a relationship: $\frac{\sigma_m^2}{D_m^2} = \frac{1}{4+\mu}$

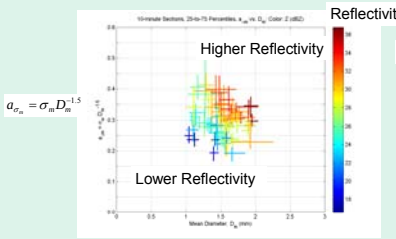
Using the approximation: $\sigma_m^2 \approx 0.09 D_m^2$

D_m and μ are related: $0.09 D_m \approx \frac{1}{4+\mu}$

And $\mu \approx \frac{11}{D_m} - 4$

This μ - D_m relationship can be used to determine an initial μ value with other observations pulling the solution off this most frequent observed relation.

8. 10-Minute Time-Ht Sections



69 10-min sections

$\sigma_m D_m^{-1.5}$ still has a Z dependence

9. Concluding Remarks

Normalizing N_w and σ_m by power-law relationships removes correlations with D_m :

$N_w = a_{Nw} D_m^{-5} \rightarrow a_{Nw} = N_w D_m^5$

$\sigma_m = a_{\sigma_m} D_m^{1.5} \rightarrow a_{\sigma_m} = \sigma_m D_m^{-1.5}$

a_{Nw} and a_{σ_m} may show regime dependent signatures

Potential Initial μ - D_m relationship: $\mu \approx \frac{11}{D_m} - 4$