CIRES
Colorado
University of Colorado at Boulder

Relationships between DSD Parameters Observed at Multiple GV Sites

Collaboration with the NASA PMM DSD Working Group:
V.N Bringi, Larry Carry, Patrick Gatlin, Ziad Haddad, Liang Liao, Robert Meneghini, S. Joe Munchak, Stephen W. Nesbitt, Walt Petersen, Simone Tanelli, Ali Tokay, Merhala Thurai, Anna Wilson, and David Wolff

Christopher Williams
University of Colorado Boulder
Cooperative Institute for Research in Environmental Sciences (CIRES)

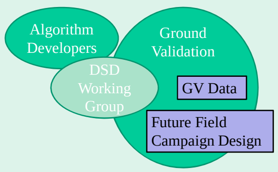
Poster # 240
NASA Precipitation Measurement Mission (PMM) Science Team Meeting
18-20 March 2013, Annapolis, MD

1. DSD Working Group: Bridging Algorithms and GV

General Objective: Use Ground Validation (GV) data to investigate relationships between DSD parameters that support, or guide, the assumptions used in satellite retrieval algorithms.

Rationale: Relationships between DSD parameters, if found, can be used to constrain the unknowns in satellite algorithms.

One of the DSD WG's objective is to develop physically based relationships between DSD parameters.



2. Mass Spectrum Parameters

A gamma shaped raindrop size distribution (DSD) can be described using three parameters: N_w, D_m, and μ:

$$N(D;N_w,D_m,\mu) = N_w f(\mu)\left(\frac{D}{D_m}\right)^{\mu} \exp\left(-\frac{(4+\mu)}{D_m}D\right)$$

It is difficult to estimate μ and D_m from individual DSD spectra because μ and D_m are not independent in the above equation. Changes to one parameter causes the other parameter to change. See Chandrasekar & Bringi (JTECH, 1987, **4**, 464-478) for more details.

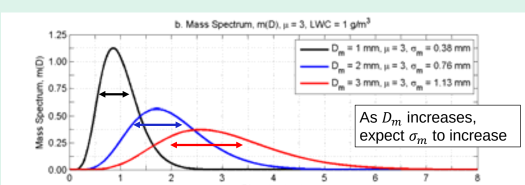
This study investigates relationships between Mass Spectrum Parameters without assuming a DSD shape.

Mean Diameter

$$D_m = \frac{\sum_{D_{min}}^{D_{max}} \left(N(D)D^3\right) D dD}{\sum_{D_{min}}^{D_{max}} \left(N(D)D^3\right) dD}$$

Mass Spectrum Variance

$$\sigma_m^2 = \frac{\sum_{D_{min}}^{D_{max}} (D-D_m)^2 \left(N(D)D^3\right) dD}{\sum_{D_{min}}^{D_{max}} \left(N(D)D^3\right) dD}$$



3. Data Sets

- Instrument: 2-Dimensional Video Disdrometer (2DVD)
- 1-minute surface drop size spectra, N(D)
- NASA Ground Validation (GV) field sites:

Name	Location	Duration	# units	Minutes
Huntsville	Alabama	23 month	3	20,954
MC3E	Oklahoma	3 months	5	5,175
GCPEx	Canada	4 months	2	972
LPVEx	Finland	4 months	3	2,454
			Total	29,555

4. Frequency of Occurrences

The plot below shows the frequency of occurrence of the observed σ_m vs. D_m for 20,954 spectra from Huntsville.

If we assume a gamma shape DSD, there is a relationship between $\sigma_m - D_m - \mu$ (also assuming $D_{max} = \infty$):

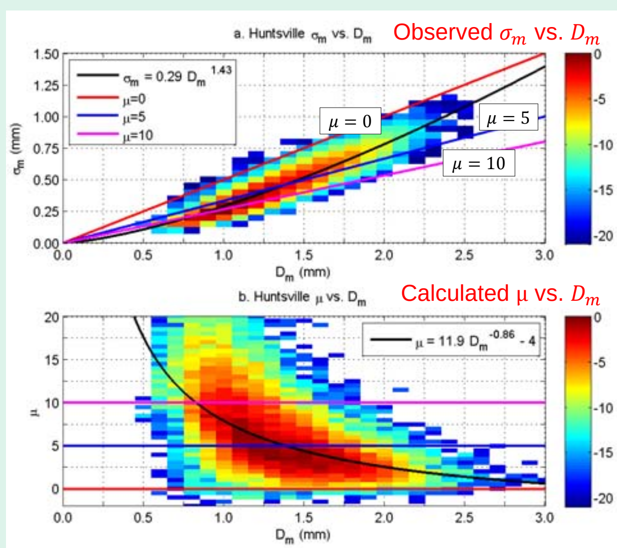
$$\sigma_m^2 = \frac{D_m^2}{\mu+4}$$

Lines of constant μ = 0, 5, and 10 are shown on $\sigma_m - D_m$ plot.

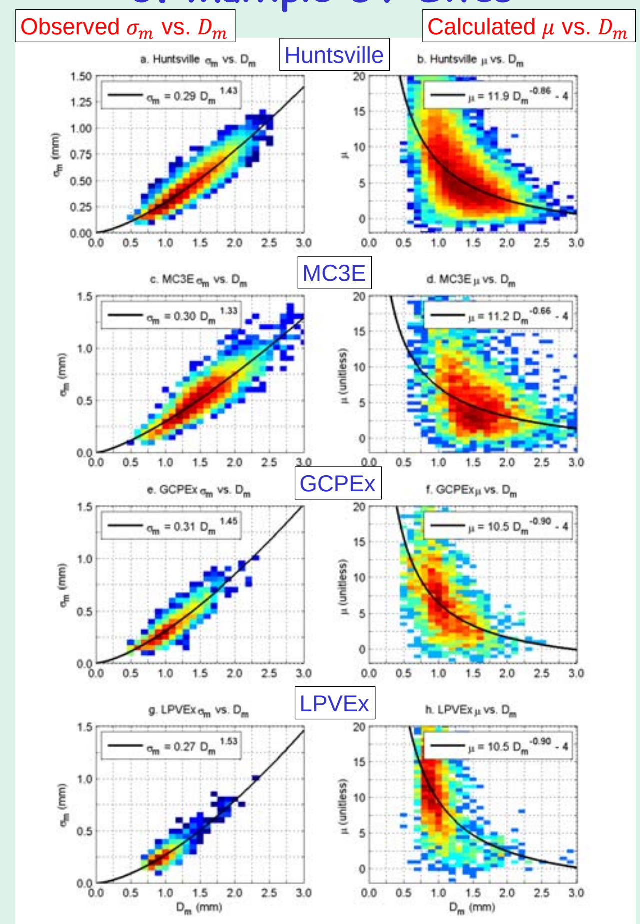
Can calculate μ for each observation using:

$$\mu = \frac{D_m^2}{\sigma_m^2} - 4$$

Can easily convert between σ_m and μ



5. Multiple GV Sites



6. Concluding Remarks

A power-law relationship was observed between the mass spectrum mean diameter D_m and mass spectrum standard deviation σ_m with the approximate form:

$$\sigma_m \sim 0.29 D_m^{1.5}$$

Assuming a gamma shaped DSD, the $\sigma_m - D_m$ power-law relationship can be expressed as a $\mu - D_m$ power-law:

$$\mu \sim \frac{12}{D_m} - 4$$

The power-law relationship was observed at four different locations (Alabama, Oklahoma, Canada, and Finland).