Relationships between DSD Parameters Observed at Multiple Field Sites

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1. Motivation

In order to estimate the vertical air motion within precipitating clouds using DOE ARM vertically pointing radars, the retrieval process must simultaneously estimate five parameters: (1) vertical air motion, (2) turbulence, and the raindrop size distribution (DSD) (3) intensity, (4) mean size, and (5) spread.

If there are correlations between DSD parameters, then the DSD could be described with two free parameters and a constraining relationship – reducing the number of parameters in the retrieval process from five to four.

A relationship between DSD parameters is observed using surface disdrometer data from four field campaigns including the Mid-Continental Convective Cloud Experiment (MC3E).

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.

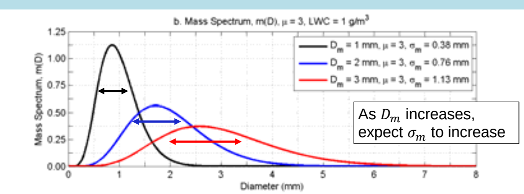
This study investigates relationships between Mass Spectrum Parameters without assuming a DSD shape.

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 $D_{max}=\infty$):

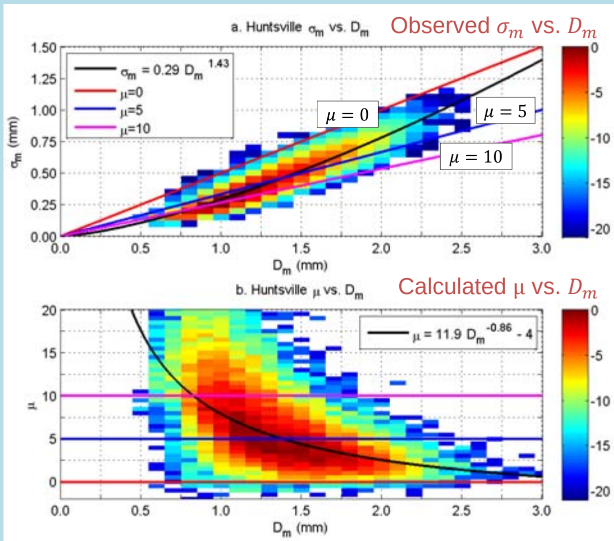
$$\sigma_m^2=\frac{D_m^2}{\mu+4}$$

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

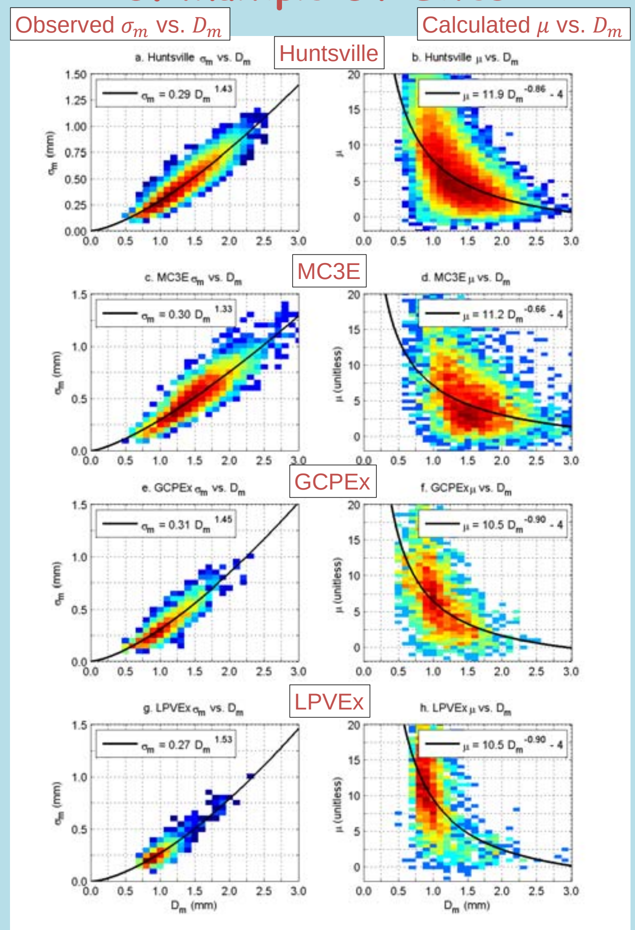
Can calculate μ for each observation using:

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

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).