Active Rain Gauge Concept in Liquid Clouds using Vertically Oriented W-band and S-band Doppler Radars

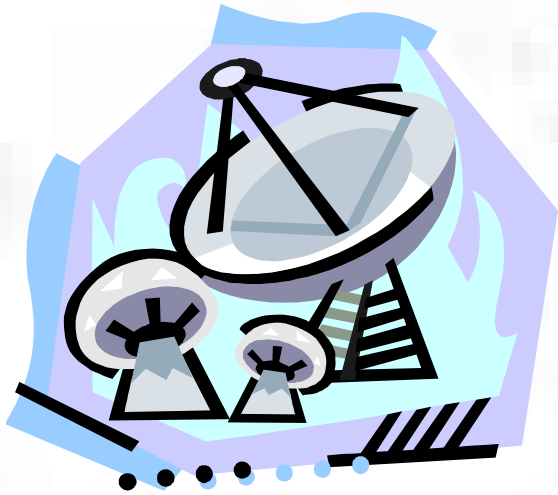
Leyda V. León, Sandra Cruz-Pol, PhD.,
University of Puerto Rico, Mayagüez Campus

and Stephen Sekelsky, PhD.
University of Massachusetts

CLiMMATE
CLoud Microwave Measurements of ATmospheric Events

Presentation Outline

- Problem Statement
- Theoretical Background
- Radar Equipment
- Rain Data
- Data Analysis
- Preliminary Results
- Future Work



Problem Statement

Doppler Spectrum

profiling rain gauge

2.8GHz (S)

light-heavy rain

Drop Size Distribution *N(D)*
Vertical Air Motion (VAM)

***C**loud **P**rofiling **R**adar **S**ystem (CPRS) 95GHz*

•33GHz (K_a)
•95GHz (W)

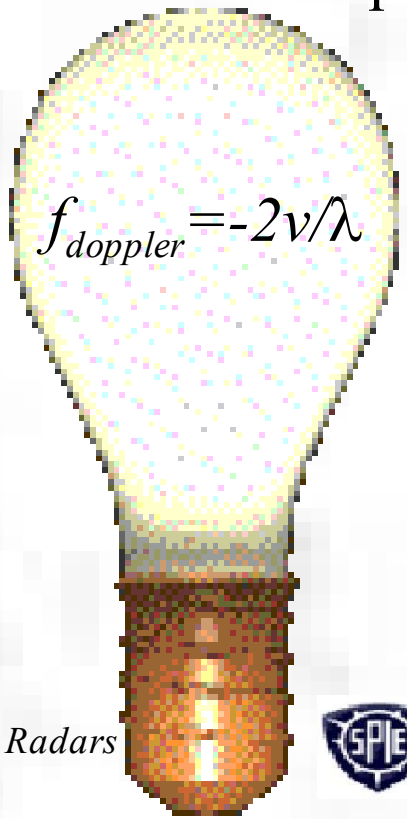
Attenuati

light-moderate rain

Doppler Spectra

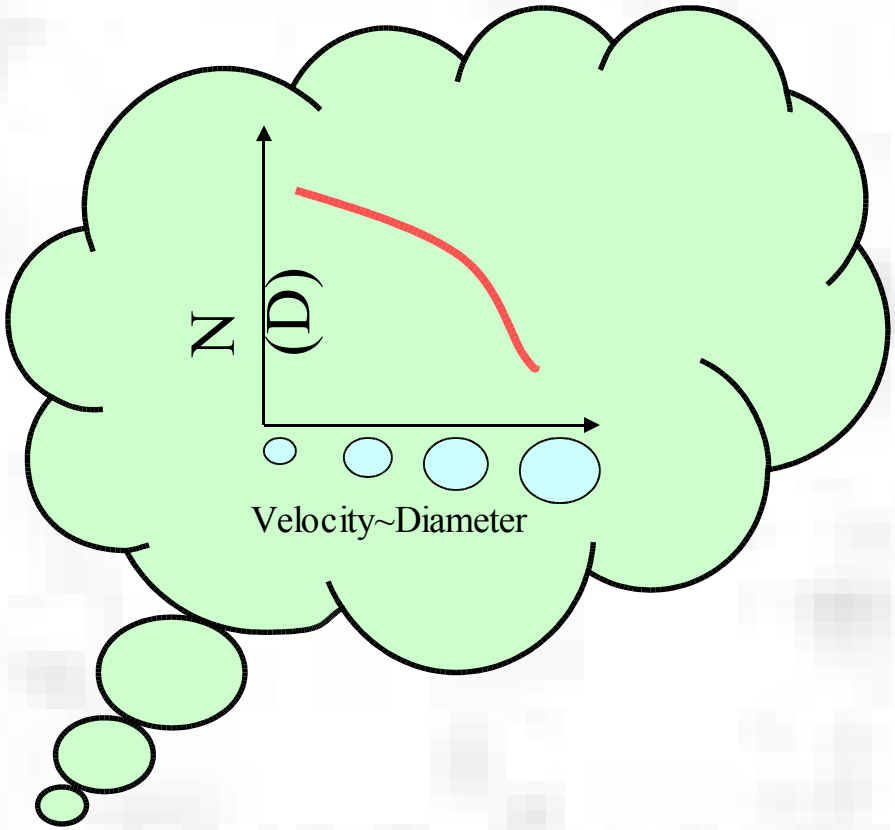
➔Doppler radar measures velocity using the $f_{doppler}$ to estimate the rain-rate. This $f_{doppler}$ is related to the raindrops Terminal Velocity, that is used to estimate the drop size distribution *N(D)*.

$$S(v)=N(D)\sigma(D)(dD/dv)$$



Drop Size Distribution *N(D)*

$$N(D) = N_o e^{-aR^b D}$$



- Exponential Distribution
- Marshall-Palmer Drop Size Distribution:

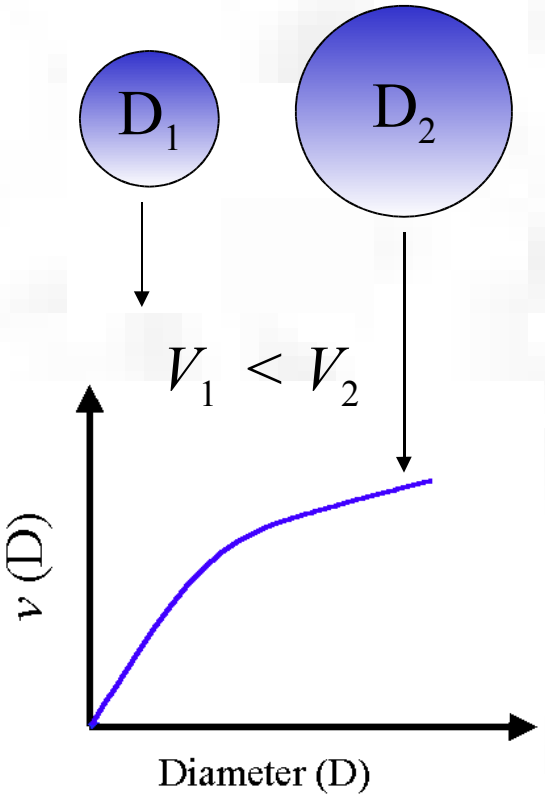
a=4.1, b=-2.1, N_o=8000

** N(D) is the drop size distribution

Backscattered Coefficient $\sigma_b(D)$

Mie Formulation

$$\sigma_b(D) = \frac{\pi \xi_b D^2}{4}$$



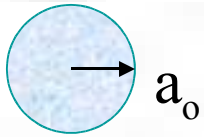
Drop Shape Correction

Green's Model

* approximate the raindrop's shape for **heavy rain**

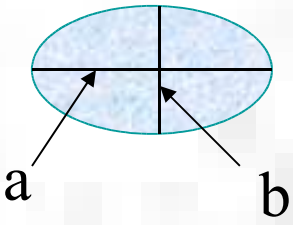
** where $B=\rho a_o^2 g' \sigma^{-1}$

σ=72.75 g/s^2, g′=980 cm/s^2, and ρ=0.998 g/cm^3



Spheres

⇓

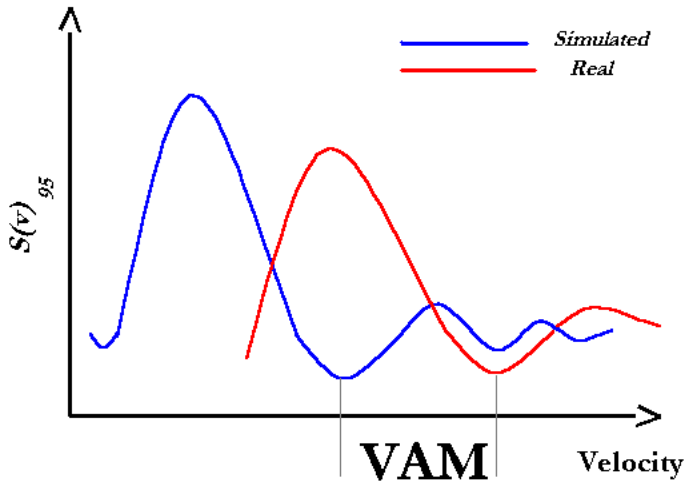


Oblate Spheroids

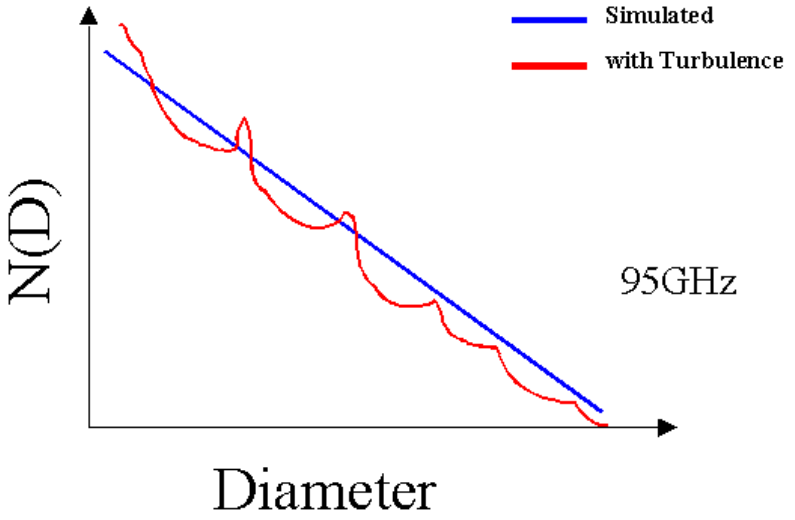
$$\left(\frac{a}{ao}\right)^2 - 1 = \frac{4}{17}\left(\sqrt{\frac{17B}{4}+1}-1\right)$$

Effects to Remove

Vertical Air Motion (VAM)



Turbulence Effect



Radars Equipment

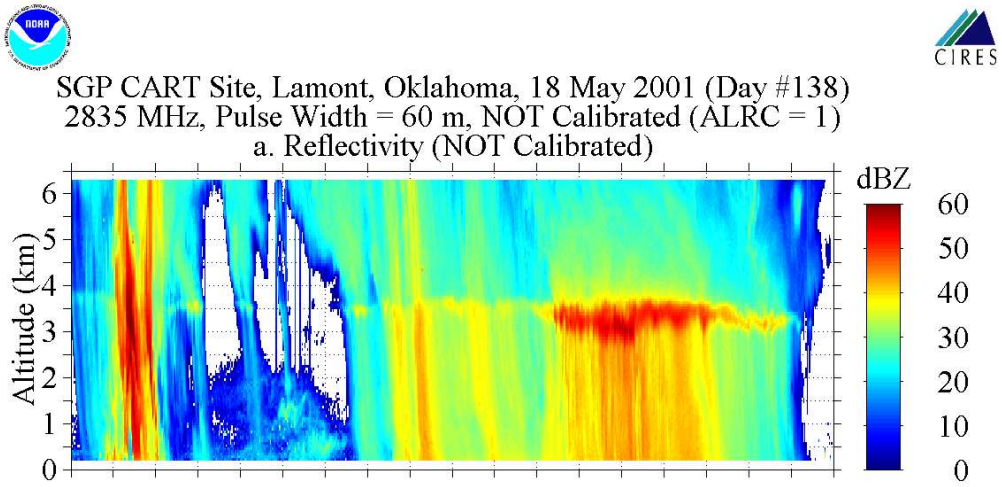
Parameter	S-band	W-band
Frequency(GHz)	2.835	94.92
Tx polarization	V	V OR H
Rx polarization	V	V OR H
Peak Power(kW)	0.38	1.5
Average Power(W)	7.6	15
Antenna	3m dish with shroud	1m lens
Two way 3dB antenna beamwidth (°)	3.2	0.2
Range resolution (m)	105 or 495	30 or 75
Noise Figure (dB)	2.6	13
dBZ_e (R=1km, 30s)	-40	-59

DOE-ARM SGP-CART

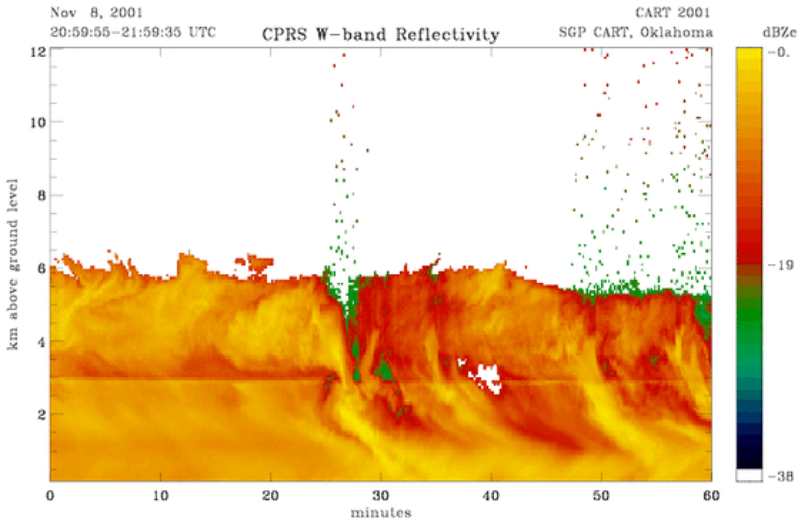
at Oklahoma

Rain Data

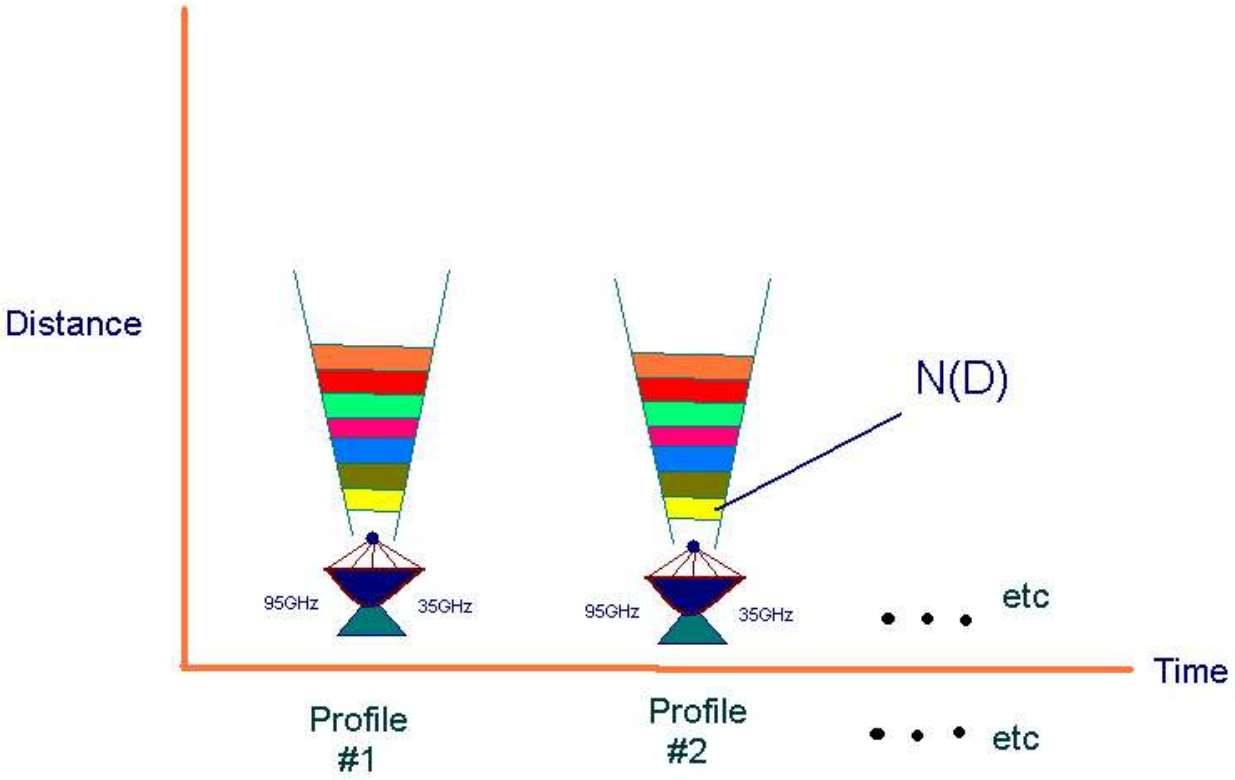
S-Band radar



W-Band radar

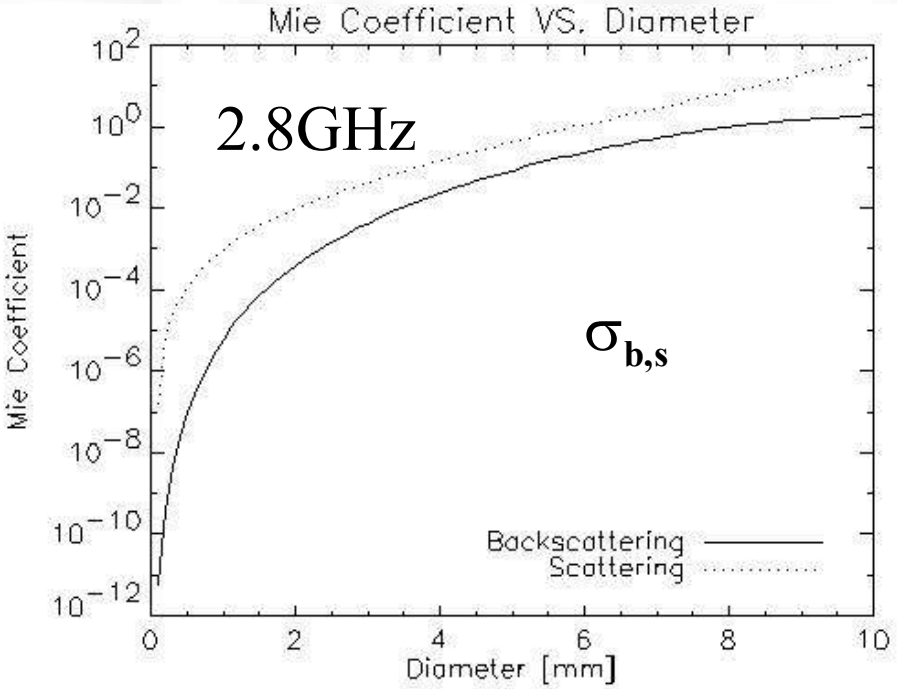


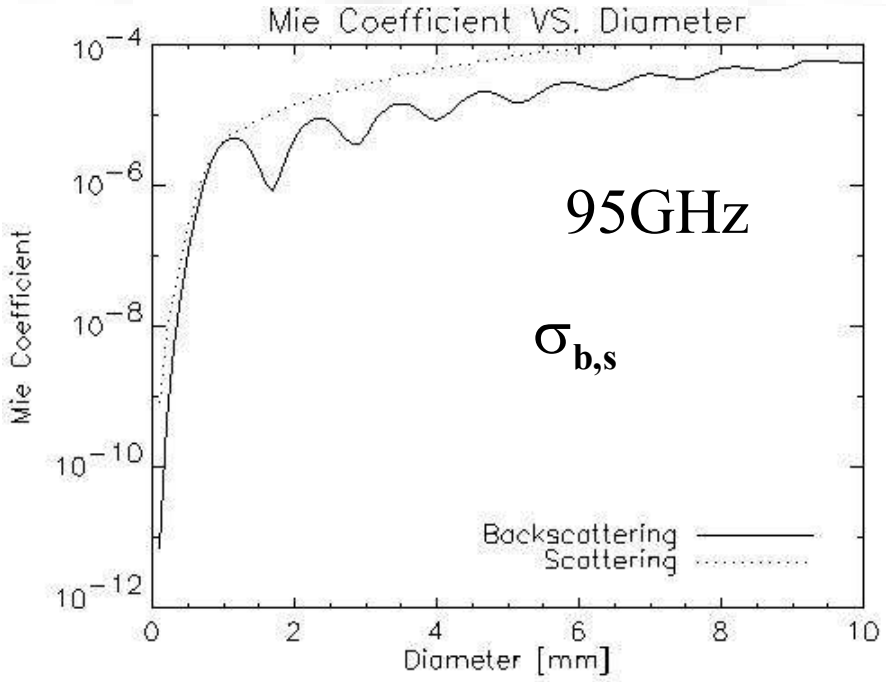
Data Analysis



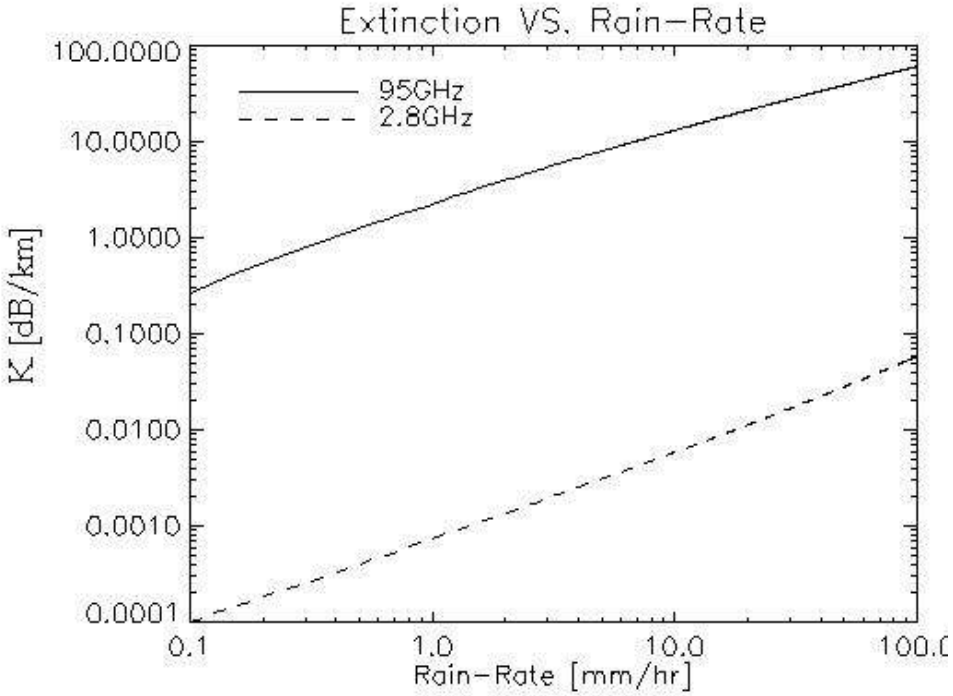
- Simulated Parameters
  - DWR
  - VAM
  - Turbulence
  - N(D)

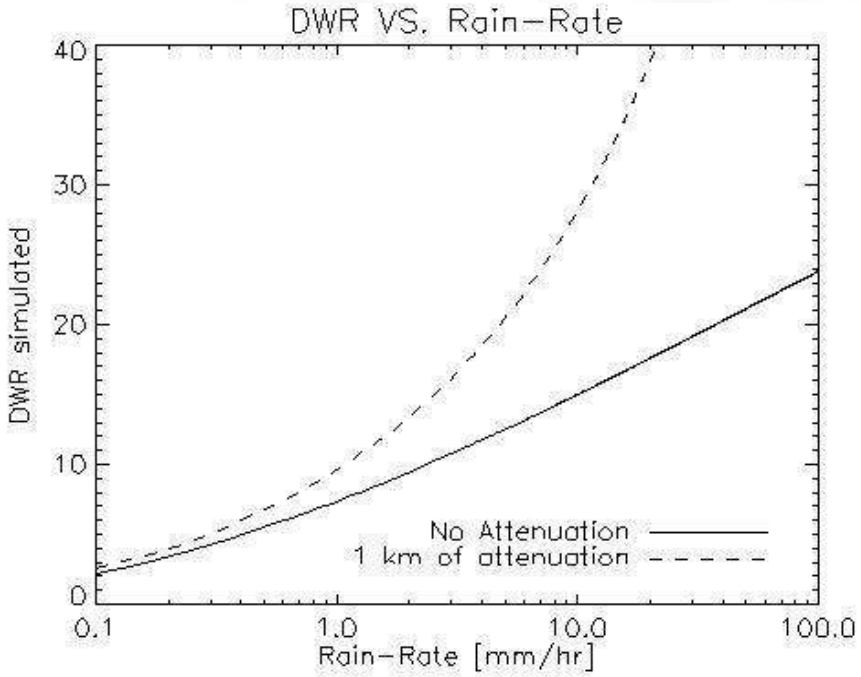
Preliminary Results 1





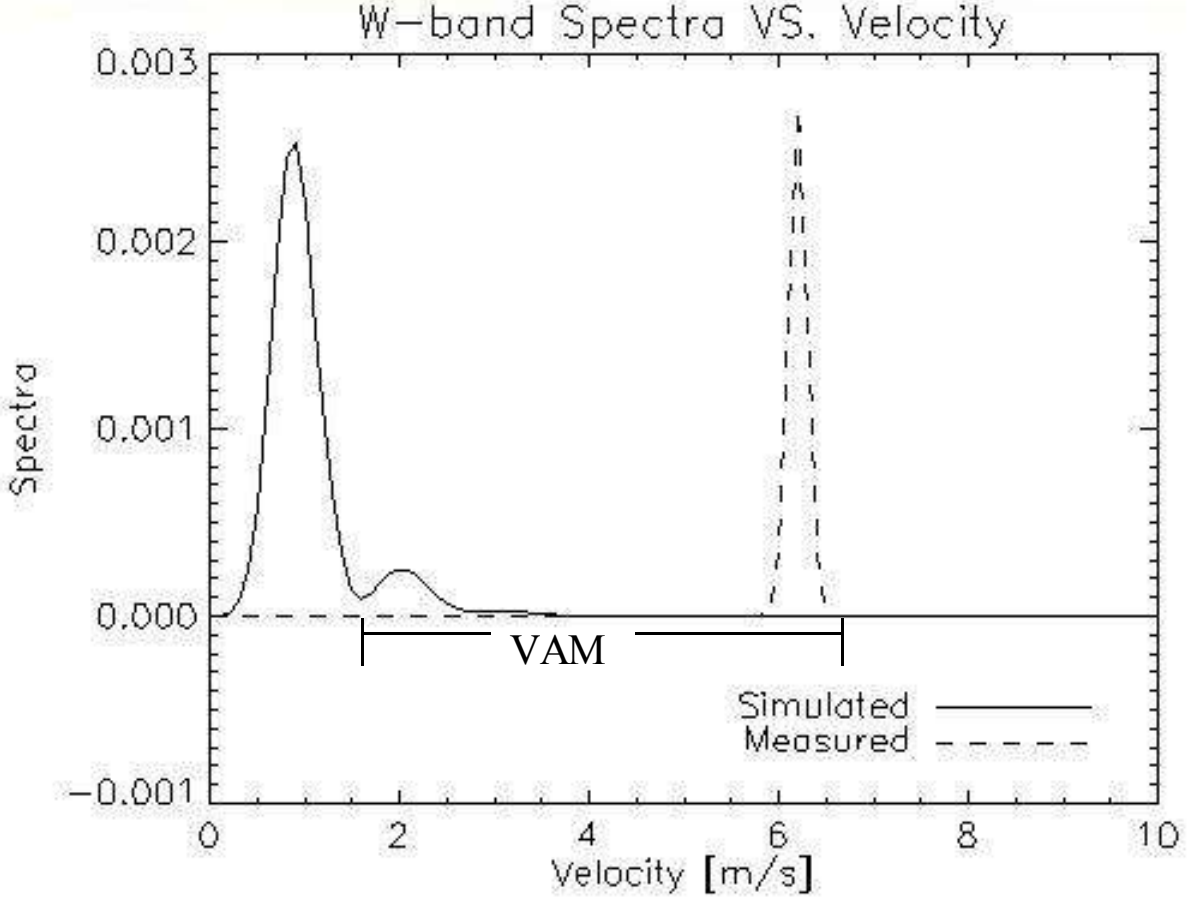
Preliminary Results 2





Rain-Rate=10.3914 mm/hr

Preliminary Results 3



Future Work

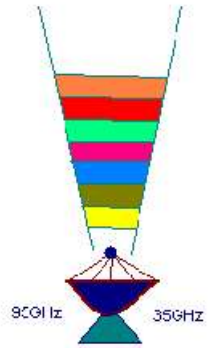
Eliminate Turbulence

Retrieve DSD for the first range cell

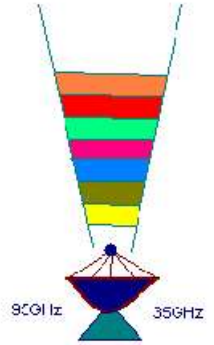
Use this *N(D)* to simulate next range cell

Repeat for all the profile

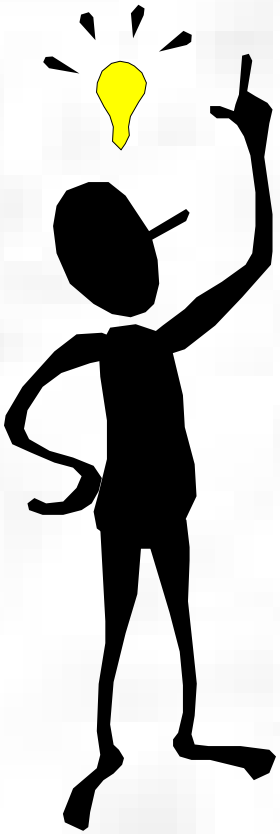
Go to next profile using adjacent cell *N(D)* for simulation



Profile #1



Profile #2



COMMENTS??