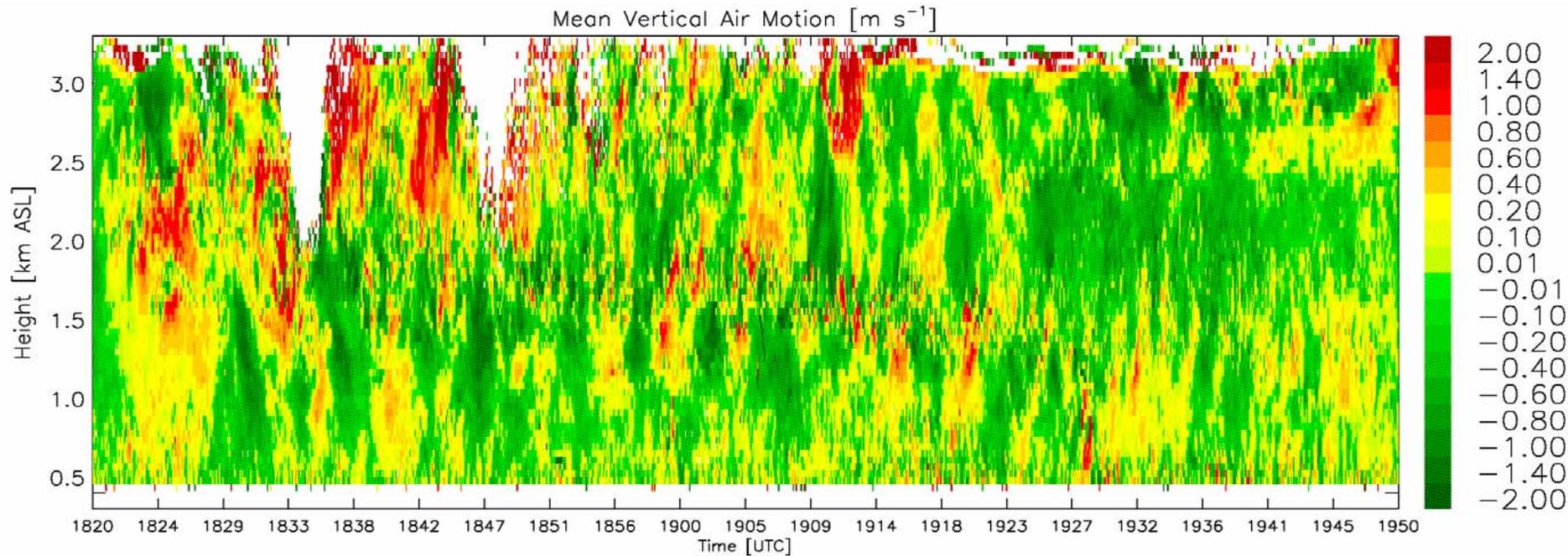


# Retrievals of Precipitation Parameters Using Non-Rayleigh Scattering at 95-GHz

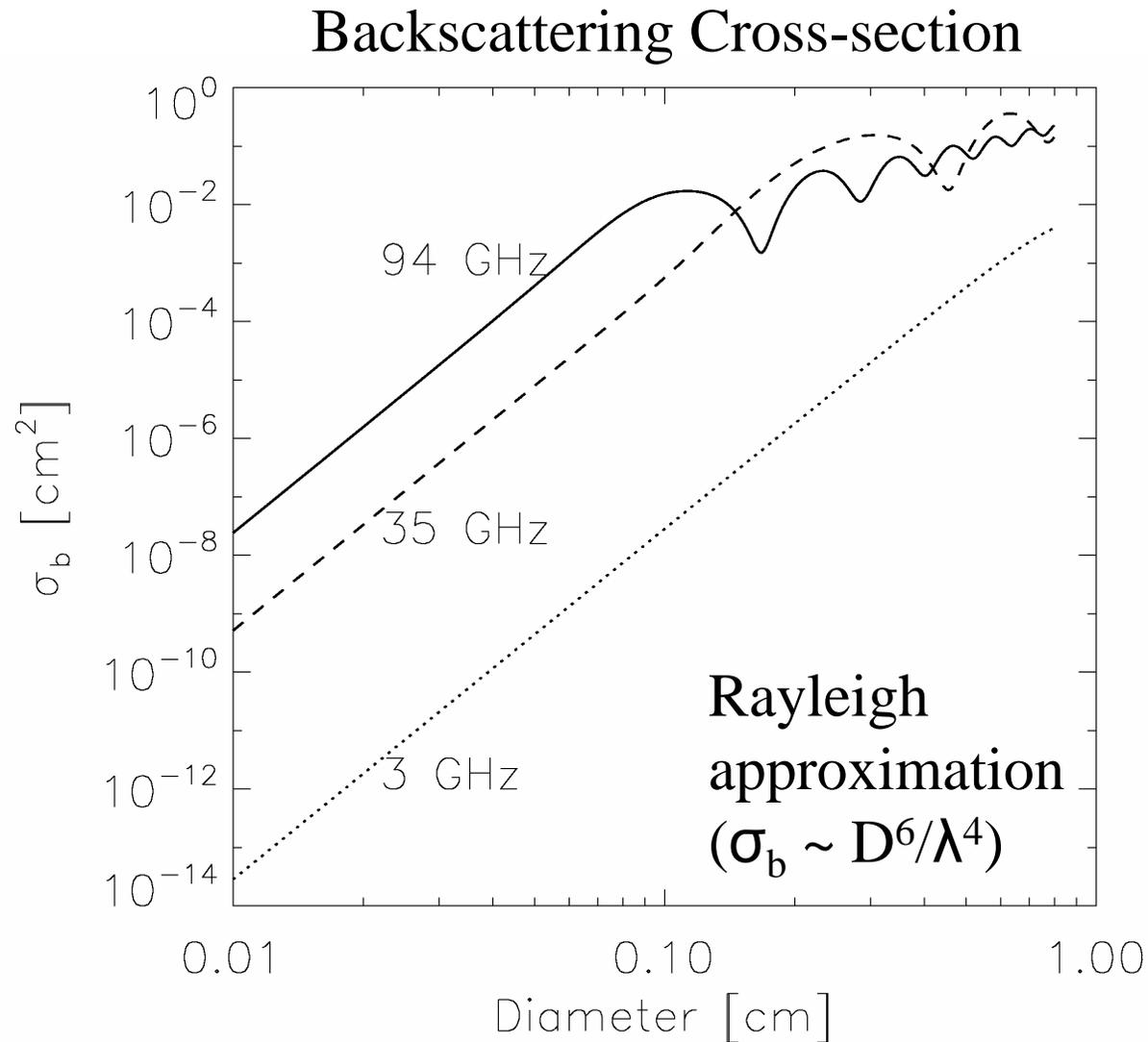


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# W-band Precipitation Retrievals

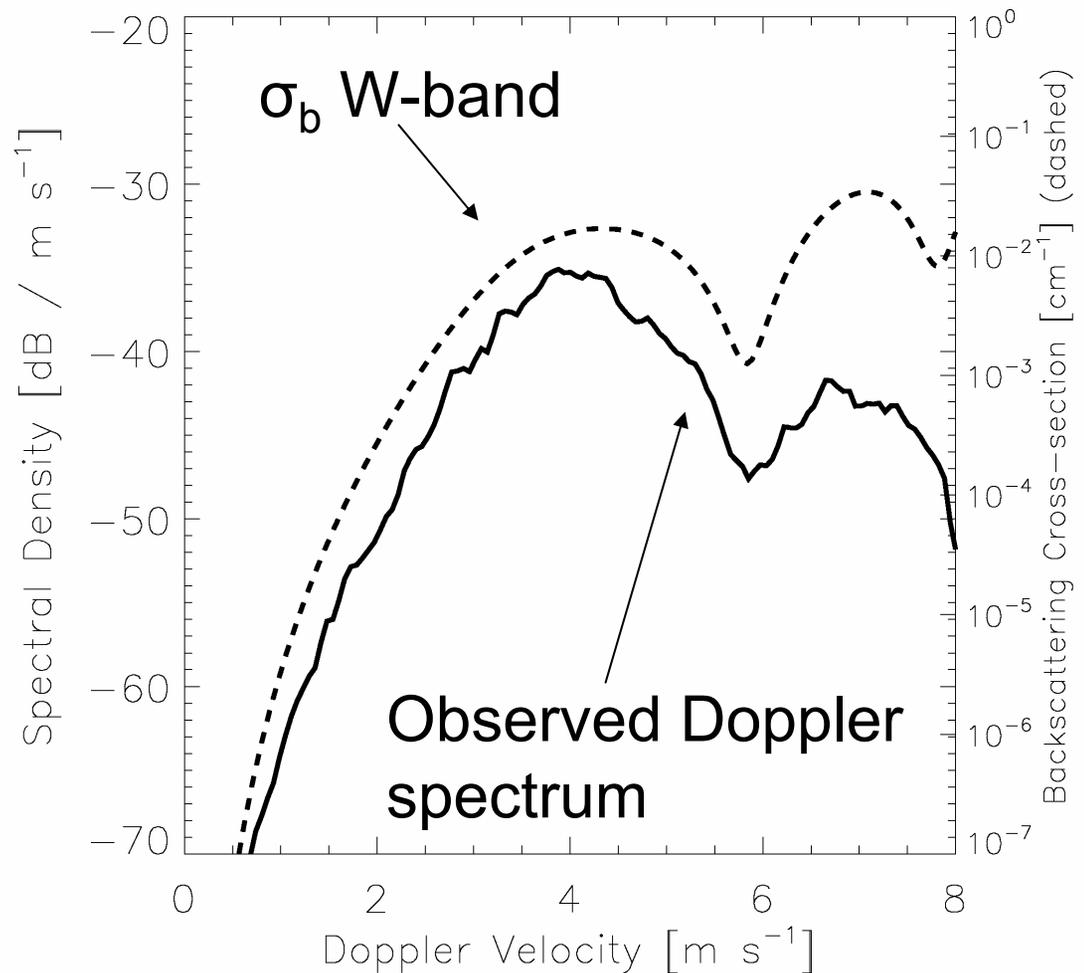
- Non-Rayleigh resonance effects → Opportunity for precipitation retrievals (e.g., Lhermitte 1988).
- W-band: Excellent resolution for the capture of DSD variability and vertical air motions.
- Applicable for ARM SGP W-band, Mobile W-band facilities.



# W-band Precipitation Retrievals

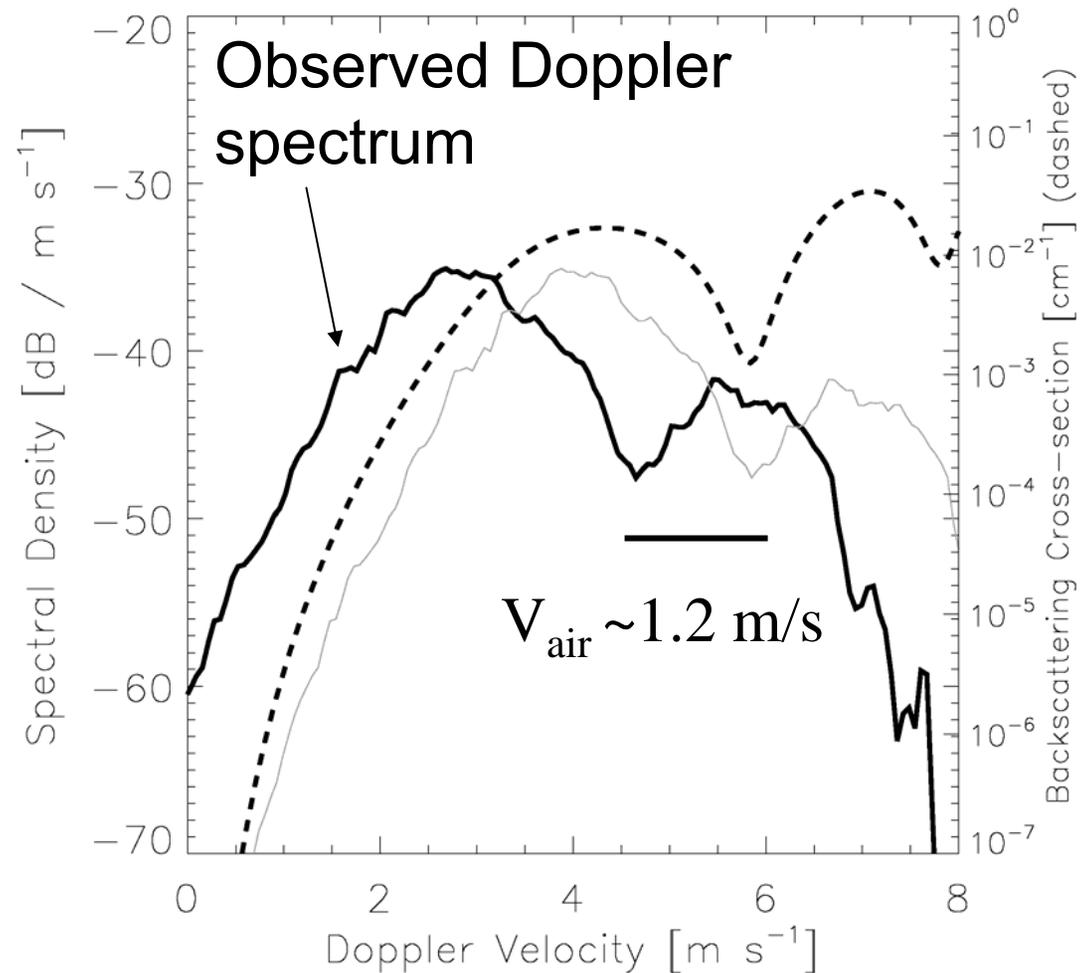
- Oscillations at W-band occur within typical raindrop sizes.
- Reflected in bulk features of max/min in Doppler spectrum from a vertically pointing radar (right).
- Map drop size to Doppler spectrum using known drop fall speed relation.

$$S_d(v) = \sigma_b(D)N(D)\frac{dD}{dv}$$



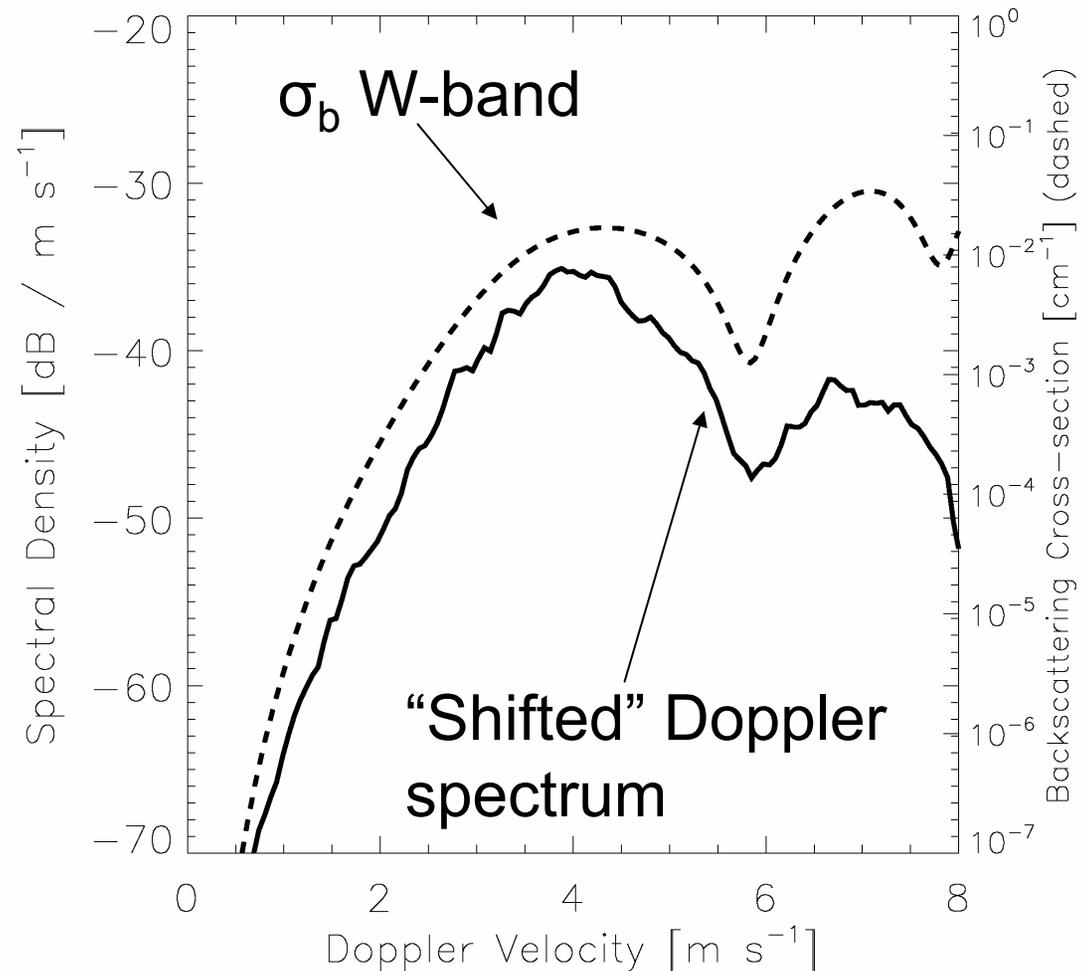
# W-band Velocity Retrievals

- Mean vertical air motions; ‘Shift’ in Doppler spectra features (right).
- Recommendation that the minimum serves as the reference location.
- Minimum location less sensitive to factors including DSD variability, subvolume turbulence.

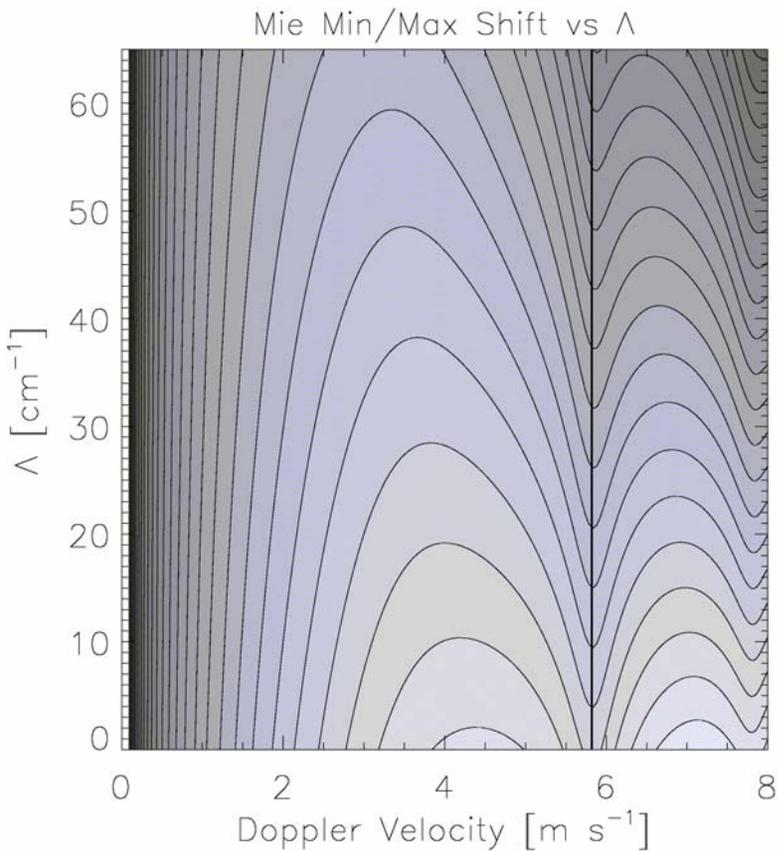


# W-band Velocity Retrievals

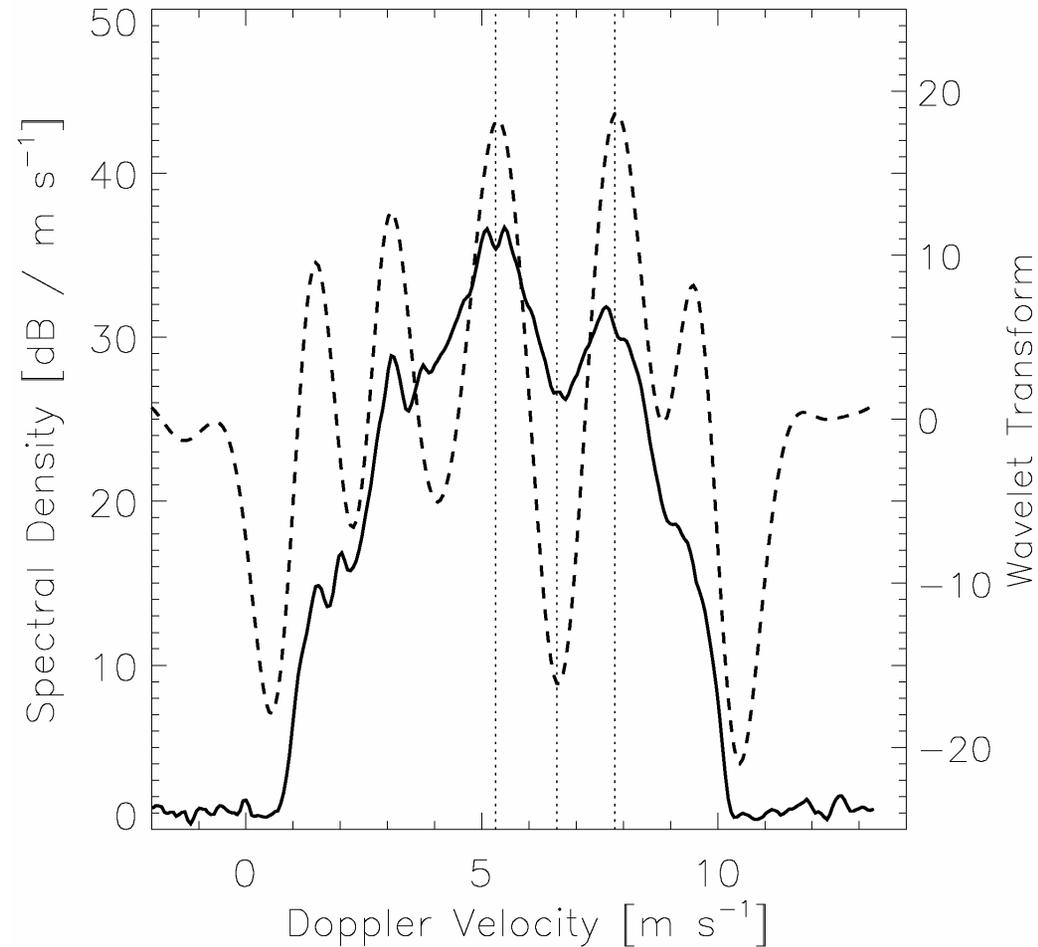
- Automate ‘valley’ identification using CWT technique well-matched to the bulk spectral features.
- Insensitive to partial attenuation in rain; sufficient drop sizes required.
- Accuracy can be achieved to within 10-20 cm/s.



# W-band Velocity Retrievals



Locations of non-Rayleigh minima and maxima as a function of the slope parameter for an exponential DSD.



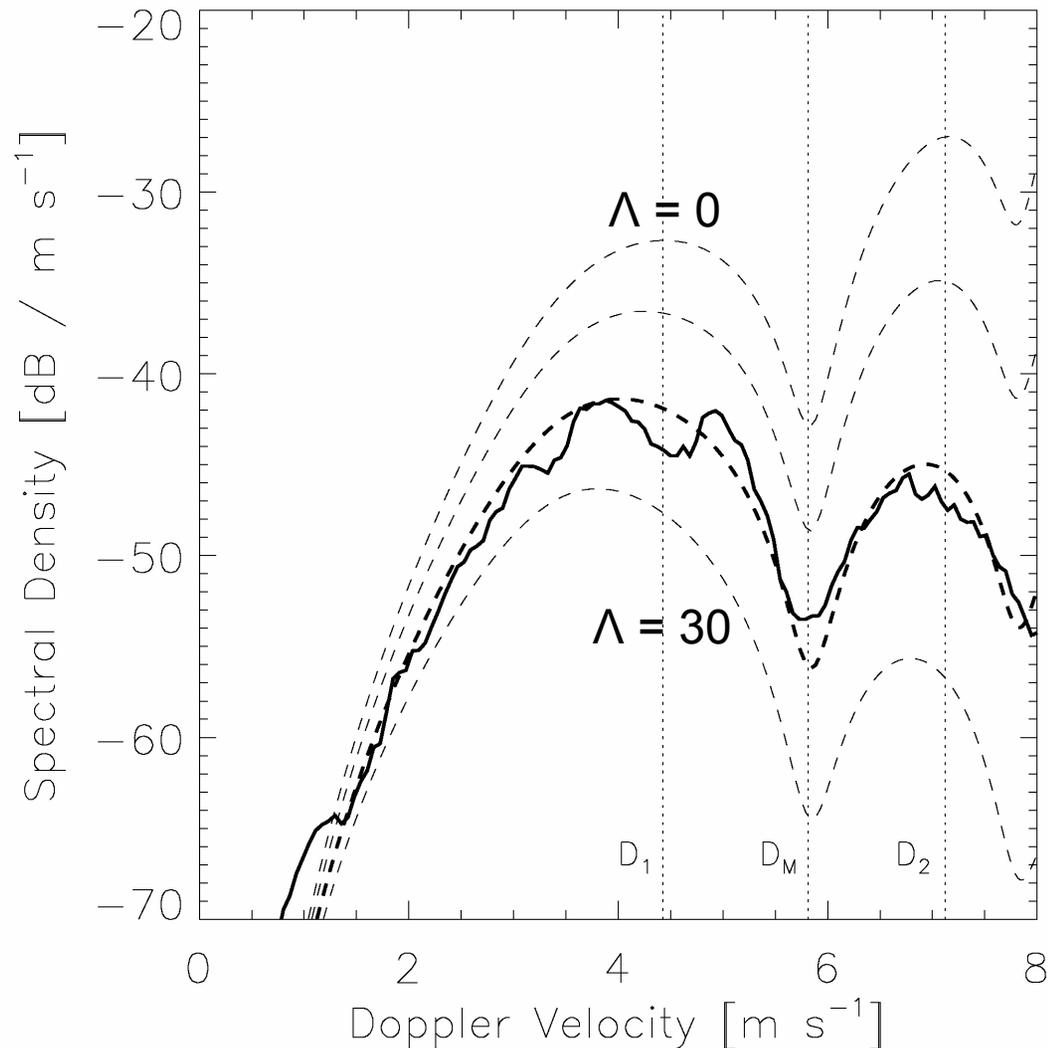
Example of an observed Doppler spectrum (solid line) and its CWT performed at a scale of 8 (thick dashed line).

# W-band Slope Retrievals

$$S_d(v) = \sigma_b(D)N(D)\frac{dD}{dv}$$
$$N(D) = N_o e^{-\Lambda D}$$

- DSD variability impacts locations of bulk and fine-scale spectral features.
- For an exponential DSDs, relative intensity / location of the peaks will depend *only* on the slope parameter  $\Lambda$  (right).

$$\Lambda = \frac{10\log_{10}\left(\frac{S_{do}(v_1)}{S_{do}(v_2)}\right) - 10\log_{10}\left(\frac{S_{dc}(v_1)}{S_{dc}(v_2)}\right)}{4.343(D_2 - D_1)}$$

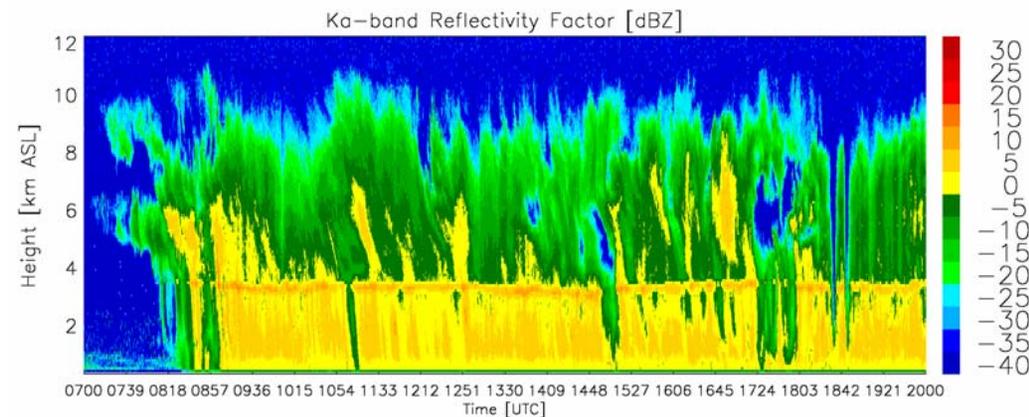
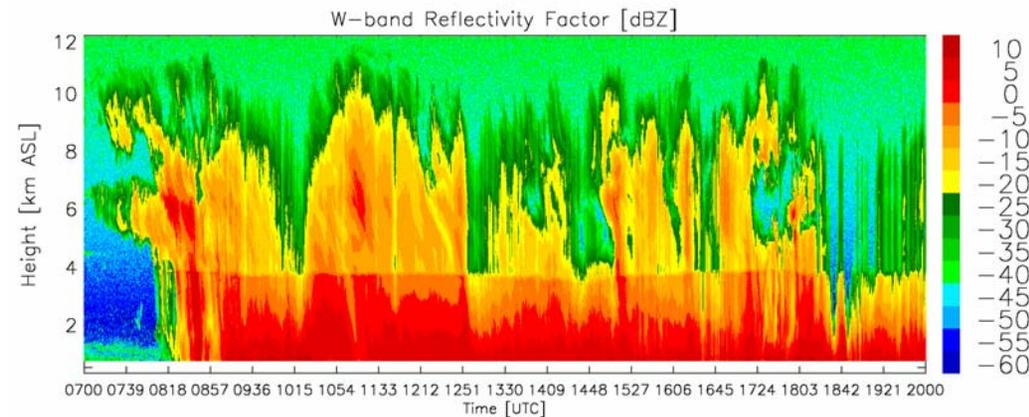
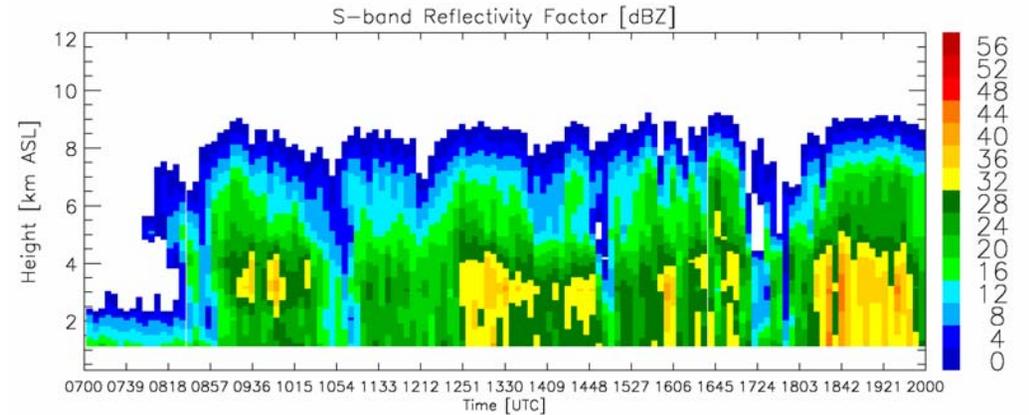


# WACR Retrievals

## ARM SGP

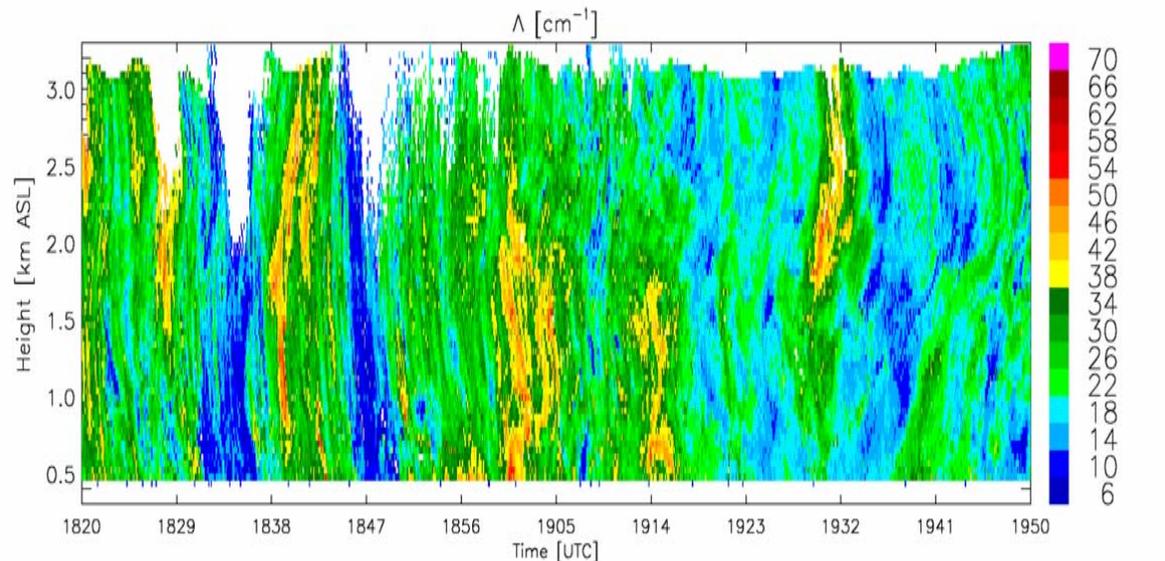
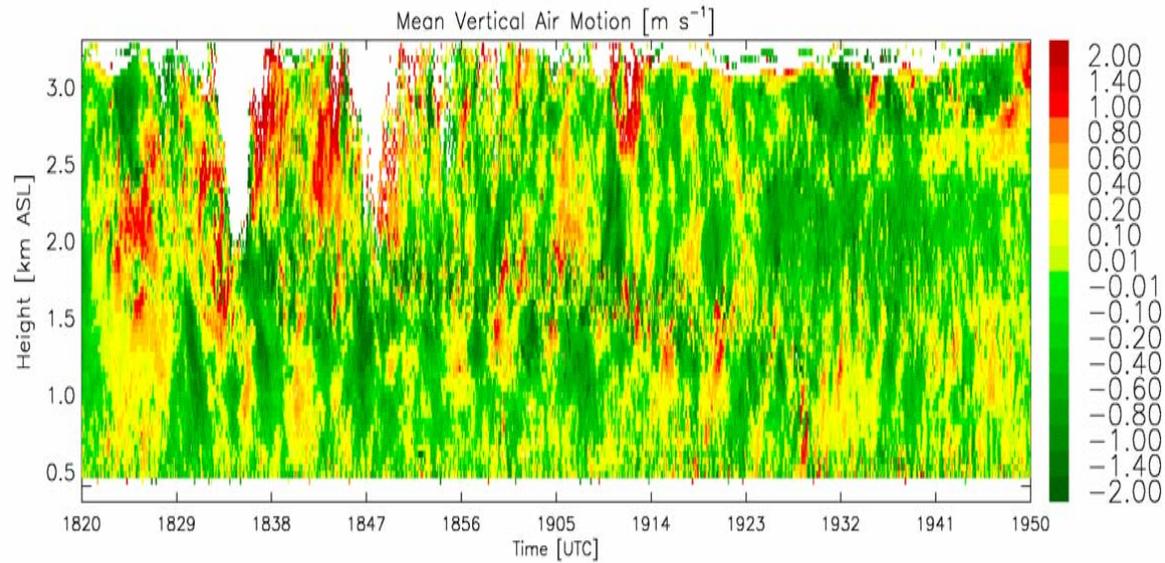
### Lamont, OK

- May 1, 2007 classic ‘stratiform’ event.
- Predominantly light (1-5 mm/hr) rainfall rates with moderate rainfall rate periods (10-20 mm/hr).
- Well covered by ARM SGP instruments, cloud radar and nearby KVNK NEXRAD radar.



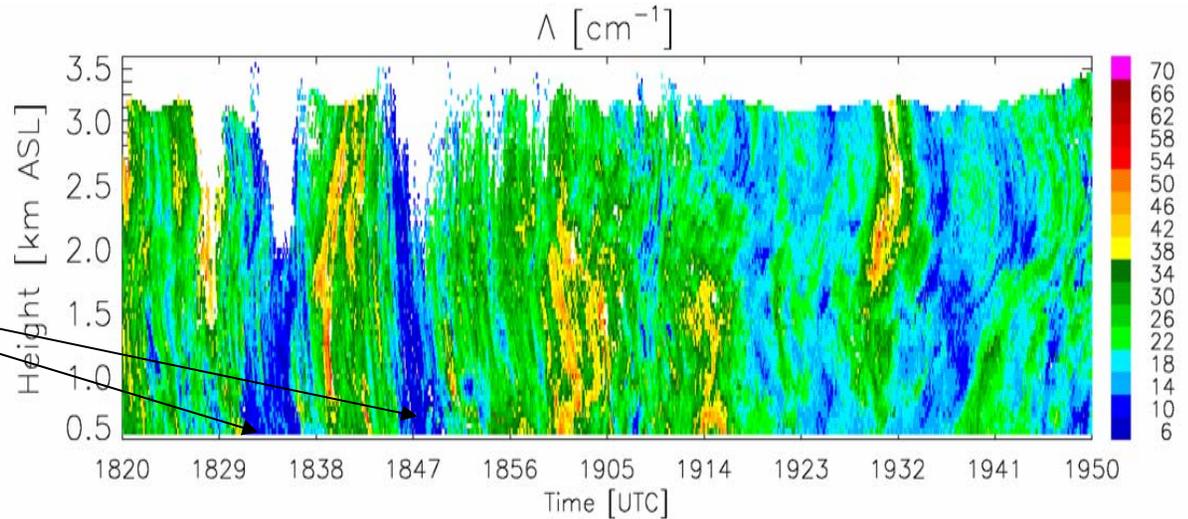
# WACR Retrievals

- Very high spatial correlation of the retrieved parameters.
- Retrieved mean vertical velocities range from  $\pm 2.5$  m/s
- Event characterized by net downward motion (1-10 cm/s)
- Common to observe small, intense wavelike structures

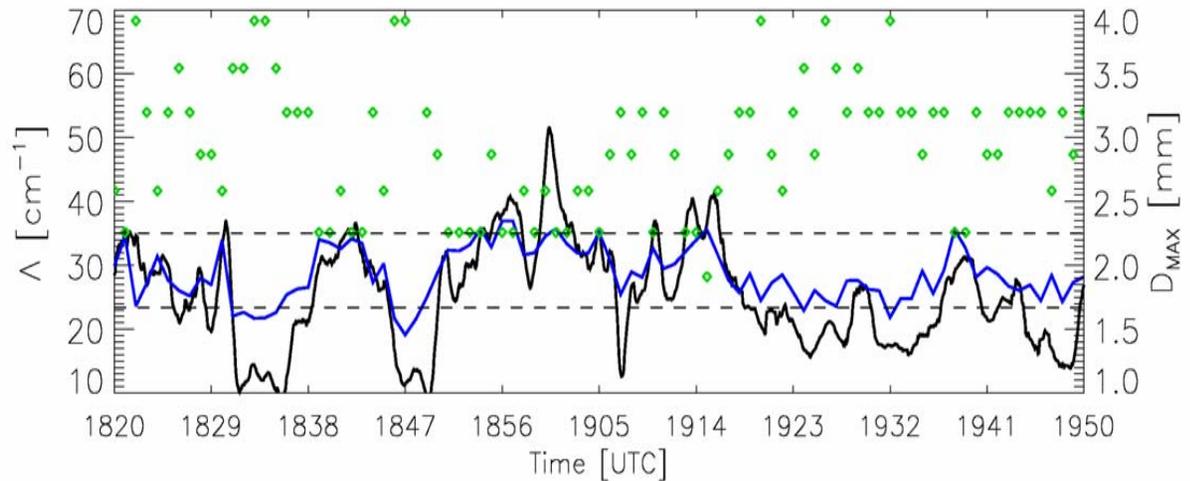


# WACR Retrievals

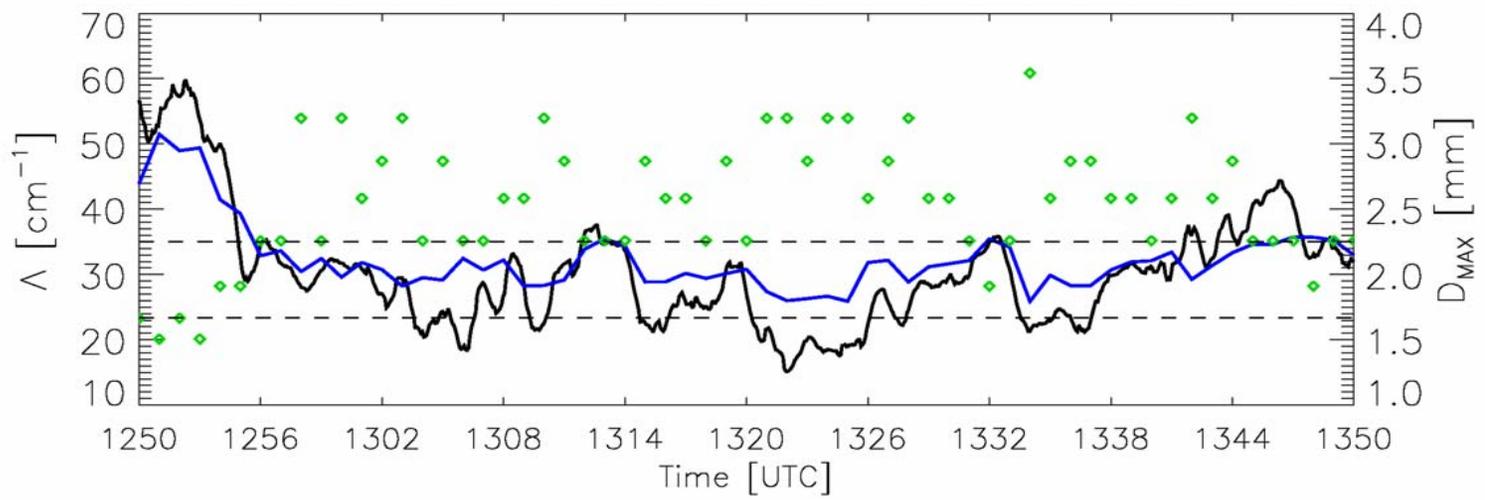
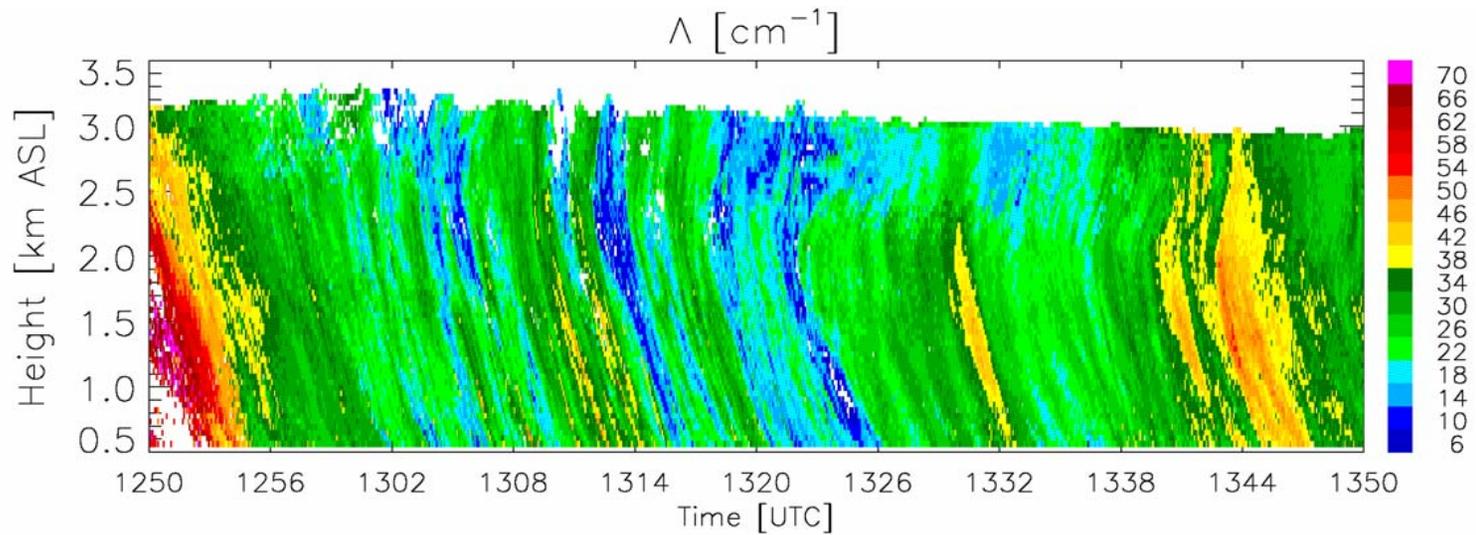
Rainfall Rate  
~ 20 mm/hr



ARM SGP Central  
Facility Joss-  
Waldvogel  
disdrometer, (blue  
curve), WACR  
retrieval (black curve)



# WACR Retrievals



# Event Findings

- High resolution retrievals of slope and velocity from non-Rayleigh techniques capture several complex structures in stratiform precipitation.
- Slope retrievals at low levels are shown in good agreement with surface disdrometer measurements.
- Retrievals viable for a wide range of rainfall rates.
- Strong compliment to various ground-based radar and profiler measurements.
- Longer-term analysis ongoing on mobile datasets; Velocity and slope as compared with other available parameters.