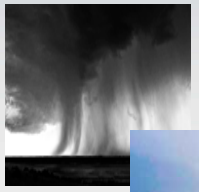
Precipitation Bragg Scatter in Radar Observations at Zenith

A. R. Jameson[1] and A. B. Kostinski[2]

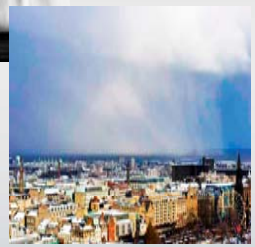
[1]RJH Scientific, Inc., El Cajon, CA; [2]Dept. of Physics, Michigan Technological University, Houghton, MI

Precipitation is Clustered

Rain



Snow



Structures in Resonance with the Radar Wavelength Produce Bragg Scatter

Measure Using ρ_{12}

$$\rho_{12} = \left|\left\langle E^*(\vec{r}_1)\, E(\vec{r}_2)\right\rangle\right| \propto \left|\sum_{i\neq m}\sum_{m\neq i} a_i a_m e^{(-/2k\bullet\Delta r_{im})}\right|$$

so that when there are enhanced numbers of particles at $\Delta r_{im} = \frac{n\lambda}{2}$,

where n is an integer, $\rho_{12} \neq 0$ and

$$\rho_{12} = \langle I_B \rangle = \frac{\bar{N}^2 \overline{a^2 2\pi}}{Vk} F_B$$

where $\langle I_B \rangle$ is the average Bragg scatter power, $\bar{N}$ is the mean number of scatterers in sample volume, V, k is the wave number, $\overline{a^2}$ is the mean squared backscattered amplitude of the particles and F_B is the 'Bragg factor' having to do with the Fourier transform of the pair-correlation function in the direction of propagation.

Or letting $\mathfrak{F}$ be the fractional contribution of Bragg scatter to the total backscattered power,

$$\mathfrak{F} = \frac{\rho_{12}}{\sqrt{Z_1 Z_2}}$$

Bragg Scatter is Important

$$R \propto \bar{N};\ W \propto \bar{N};\ \text{etc, as is } Z = \bar{N}\overline{D^6}$$

But when Bragg scatter is present

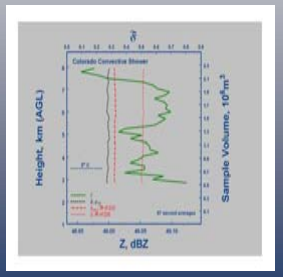
$$Z = \bar{N}\overline{D^6} + \bar{N}^2 F_B \overline{D^6}$$

so that *Z* will be too large for the actual *R*, *W* etc.

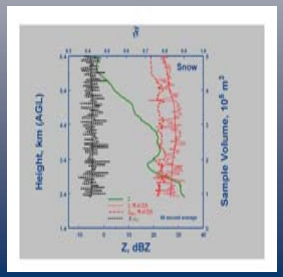
Bragg Scatter is Observed in Horizontal Scans and Should Also Appear in Zenith Observations

And IT DOES in both a

convective shower



and in snow



Implications

- **Bragg scatter affects observations at zenith and are likely even in nadir observations from space or aircraft**
- **The amount of Bragg scatter appears to be insensitive to the size of the sample volume**
- **Bragg scatter affects quantitative estimates of precipitation using *Z* alone, Z-Z_{DR} techniques, dual-frequency techniques but not so much the Z_{DR}-K_{DP} approach.**

Jameson, A.R., 2011: Precipitation Bragg scatter in radar observations at nadir. *J. Appl. Meteor. Clim.,* in press.

_____, 2011: Statistical reliability of neighboring range bin estimates of coherent fractional contributions to radar backscattered power. *J. Appl. Meteor. Clim.,* 50, 745- 749.

_____, 2010: On the temporal characteristics of radar coherent structures in snow and rain. *J. Appl. Meteor. Clim.,* 49, 1891-1893.

_____ and A. B. Kostinski, 2010: Direct observations of coherent backscatter of radar waves in precipitation.,*J. Atmos. Sci.*, 67, 3000-3005.

_____ and _____, 2010: On the enhanced temporal coherency of radar observations in precipitation. *J. Appl. Meteor. Clim.,* 49, 1794-1804.

_____ and _____, 2010: Partially coherent backscatter in radar observations of precipitation. *J. Atmos. Sci.,* 67, 1928-1946.