Snowfall retrievals using mm-wavelength cloud radar measurements

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**Purpose:** Extending ARM column hydrometeor retrievals to include solid precipitation cases

**Approach:** $Z_e-S$ relations customized for the use with mm-wavelength radars. Using the Doppler information (moments and spectra) for quantitative retrievals in snowfall is limited because snowflake fall velocities do not exhibit clear size dependence (for D>2 mm or so). The Doppler information, however, provides valuable qualitative information on degree of snowflake riming thus separating “dry” snowfall from cases with substantial amounts of liquid water.

$Z_e-S$ relations at mm-wavelengths:

Modeling with realistic snowflake shapes, mass-size relations, drag coefficients, and experimental snowflake size distributions result in the relations shown here

**W-band snowfall retrievals**

Due to a shorter wavelength, the reflectivity at W-band changes slower than at K$_b$-band as snow rate increases. In spite of strong non-Rayleigh scattering effects, W-band radar measurements can still be used for quantitative estimates of snowfall. Combination of K$_z$ and W-band radars at the SGP site can potentially provide more accurate retrievals of snowfall compared with single frequency measurements because of possibility of independent estimates of snowflake characteristic size. Meanwhile, the W-band CloudSat radar provides a unique opportunity for global observations of snowfall.

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**MMCR-based snowfall retrievals**

An example of snowfall retrievals using the NSA MMCR measurements is shown in Fig. 2, for the case 27 September 2004. Relatively small observed vertical Doppler velocities (less than 1.5 m/s except for last half hour) indicate either no riming or very limited riming aloft. Attenuation in “dry” snow at K$_b$-band is small and can generally be neglected.

While vertical variability of instantaneous snowfall reflectivity and intensity can be rather substantial mean profiles are usually smooth (Fig. 3).

**Uncertainties of mm - wavelength radar snowfall retrievals**

Changes in microphysical properties of snowflakes and their size distribution details cause the variability in the $Z_e-S$ radar relations. Comparisons with controlled surface snowfall measurements indicate that uncertainties can be as high as a factor of 2 (or even higher), which is comparable to errors that are typical for cm-wavelength precipitation radars.

**Conclusions:**

- mm-wavelength vertically (or nadir) pointing radars can provide valuable information on snowfall
- snowfall vertical profile retrievals complement ARM cloud retrievals in the atmospheric column
- Doppler information (while not used for snow rate retrievals) provides information on snow riming
- uncertainties of snow retrievals with mm-wavelength radars are comparable with errors that are typical for precipitation radars