

## **An improved model for snowfall measurement using high spectral resolution lidar and millimeter wavelength radar**

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A lidar-radar technique to measure the downward flux of snow at an altitude of  $\sim 100\text{m}$  is described. The ratio of radar to lidar cross sections can be used to define an effective-diameter-prime, which is proportional to the fourth root of the average mass-squared over the average projected area of the snowflakes. If one assumes a crystal shape this can be converted into an effective-diameter which is the average mass over the average area of the flakes. Multiplying the lidar measured projected area times the effective-diameter yields the mass of the particles. The product of this mass and the radar measured vertical velocity then provides the vertical flux of water.

In past work we have tested this measurement approach with data acquired in the high Arctic. High Spectral Resolution Lidar and 35 GHz cloud radar measurements were used to compute the time-integrated flux of water at 100 m above the surface. This result was compared with Nipper gauge measurements. Best agreement were achieved when the crystals were assumed to be bullet-rosettes. However, because the conversion from effective-diameter-prime to effective-diameter is dependent on the ratio of crystal thickness to diameter, the results are strongly dependent on the assumed crystal morphology.

In the current approach, we represent particles with an equivalent oblate spheroid having the same mass and the same projected area as the ice crystal. These particles will have nearly the same

effective-diameter-prime and fall velocity as the equivalent snowflakes. Particle aspect ratio is assumed to be related to particle diameter by a power law function of diameter. Modified gamma distributions of particle size are assumed.

Lidar-radar measurements of the effective-diameter-prime and radar measurements of fall velocity are compared to model computations shown to determine the coefficient in the aspect ratio vs diameter power law. This comparison provides an aspect ratio measurement for each sample volume and removes the need to assume an ice crystal shape

The lidar-radar snowfall measurements are in reasonable agreement with the Nipper gauge observations. Limitations of the method include the need for time-averaging to reduce the influence of vertical air motion on the fall velocities. In addition, the lidar-radar retrievals of aspect ratio fail when cloud water droplets and snowflakes are both present at the measurement level.