Polarimetric Scattering Analysis of Snow and Ice Particles Using Field Measurements by 2D-Video Disdrometer

Cameron Kleinkort*[1], Gwo-Jong Huang[1], V. N. Bringi[1], and Branislav M. Notaroš[1]
(1) Electrical & Computer Engineering Department, Colorado State University, Fort Collins, CO
cameronk@rams.colostate.edu, gh222106@engr.colostate.edu, bringi@engr.colostate.edu, notaros@colostate.edu

In general, it is very difficult to explain all of the polarimetric radar measurables in winter precipitation simultaneously using spheroidal shape models with specified densities and orientation distributions. In fact, even for Rayleigh scattering, where the spherical or spheroidal shape assumption is reasonable for reflectivity computation, it is not sufficient for computing the full scattering matrix and related radar measurables, required for radar-based particle classification. So, even at the S-band (all WSR-88D radars), some radar observables significantly depend on the shape and composition of particles, and sophisticated computational electromagnetics (CEM) methods are needed for scattering computations. With the advent of optical imaging disdrometers that can measure fall speed along with projected particle views in two planes, we can reconstruct more realistic 3D shapes of hydrometeors when compared to spheroidal approximations.

The 2D-video disdrometer (2DVD) provides 2D contours of a snow particle or another hydrometeor such as a rain drop or a hailstone in two mutually orthogonal cross sections, obtained by cameras A and B, respectively. The reconstructed shapes – after a suitable generation of the surface mesh composed of generalized curved quadrilateral patches – are used as input to the method-of-moments surface-integral-equation (MoM-SIE) CEM modeling technique to compute the scattering matrices and polarimetric radar observables on a "drop-by-drop" basis. We compute "drop-by-drop" scattering matrices of hydrometeors to arrive to the radar measurable set using the 2DVD data over a larger time interval involving thousands of different drops, so that this kind of time averaging (or integration) should yield radar parameters that simulate actual radar observations.

We have developed a method for 3D shape reconstruction of snow particles from two orthogonal contour images provided by the 2DVD using a "stacked ellipses" interpolation method. In particular, after obtaining scan line data from the 2DVD, contours are made for cameras A and B. The contours in two orthogonal planes (front and side views) are then reconstructed into a 3D shape via a "stacked ellipses" method, where an ellipse is created for each horizontal scan line received from the 2DVD. The size of the step from one scan line to the next is determined by the resolution of the cameras and the fall speed of the snowflake. The minimum and maximum value of each scan line in one direction is determined for each camera. These two min-max pairs correspond to the minor and major axis of one ellipse. The ellipses are then stacked on top of each other and connected with quadrilateral patches that are the height of the scan line step. This geometry is then imported into commercial ANSYS ICEM CFD software and re-meshed with a more uniform size quadrilateral mesh to later be evaluated in our MoM-SIE code.

The 2DVD-based computations are compared against those using the T-matrix method for idealized spheroidal shapes for ice particles in place of the more complicated and realistic 3D shapes, as well as those based on high-resolution images of hydrometeors collected by a collocated multi-angle snowflake camera (MASC) and 3D shape reconstruction by the visual hull image processing method.