Polarimetric radar measurements of a large-scale smoke plume from distant Canadian wildfires

*Robert Schrom[1]

1. NASA GSFC/USRA

Characterizing both shape and orientation distributions of particles in the atmosphere can be aided by polarimetric radar measurements. In the case of a roughly horizontally homogeneous distribution of particles, the azimuthal variability of the polarimetric radar measurements can also provide unique information about the particle shapes and orientation. A large smoke plume over the midwestern United States, originating from a series of wildfires in western Canada during August 2018, provides such a case. S-band polarimetric radar measurements intercepting this plume on 8 August 2018 show a clear azimuthal pattern of maxima and minima in the reflectivity (Z_H), differential reflectivity (Z_{DR}), differential phase (Φ_{DP}), and correlation coefficient (ρ_{HV}). The maxima in Z_{DR}, Z_H, and ρ_{HV} occur for the azimuthal angles roughly perpendicular to the wind flow, suggesting oriented prolate-like smoke particles within the plume. In addition, asymmetries in the azimuthal distribution of Φ_{DP} indicate that the simultaneously transmitted radiation exhibits unique depolarization signatures at different viewing angles, with the maximum depolarization occurring where Z_{DR} is maximized. These signatures suggest that the particles have a specific preferred orientation: their long axes are aligned roughly parallel to the wind, and they have a non-zero mean canting angle with respect to the surface. Potential applications of these measurements for charactering the smoke particle properties as well as applications to hydrometeor measurements are also discussed.

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