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Attenuation of the five cm wavelength radar in melting hail and heavy rain

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Presented are quantitative estimates of attenuation and differential attenuation of 5 cm wavelength radiation (C band) obtained by comparison with measurements at 10 cm wavelength (S band) which are much less affected by attenuation. The data originated from two almost collocated radars in central Oklahoma. To avoid biases in estimates the slopes with respect to range of differences in reflectivities and differential reflectivities are assumed to represent the degree of attenuation. Observations on a day with no reports of hail on the ground and on a day with large hail up to 3/4" diameter on the ground are contrasted.

The same preferential sizes and hydrometeor types (causing the bulk of attenuation) were present in both days. The one-dimensional polarimetric model of melting hail (Ryzhkov et al. (2009)) suggests that the likely size range contributing most to attenuation is 5 to 15 cm. Attenuation Ah has a wide range of values (1 to 4 dB/km) and is highly variable. The specific differential attenuation ADP are within 0.2 to 2 dB/km which is also above the range common to pure rain. Neither Ah nor ADP exhibit a tight dependence on the specific differencial phase of C band KDPc that could be used to reliably restore attenuated signals on either day. The median ratios of Ah/KDPc and ADP/KDPc on a day with no hail on the ground (Ah/KDPc=0.66 dB deg-1 and ADP/KDPc=0.175 dB/deg) are lower by over a factor than the ratios on a day with large hail (Ah/KDPc=1.45 dB/deg and ADP/KDPc=0.36 dB/deg). On both days the specific differential phases estimated at C band and S band are consistent. This implies that the dominant contribution to specific differential phases comes from similar hydrometeor species and that these are mainly within the size range of Rayleigh scatterers (at C band). Unexpected is a relatively tighter relation between Ah and ADP wherein the "median line" is the same for both days. Such a relation could serve as basis for correcting attenuation along radials where the differential attenuation is easier to estimate? Localized values of Ah, ADP, Ah/KDPc, and ADP/KDPc in storms containing large drops and melting hail can be much higher than the values averaged over the propagation path through the storm. Substantial backscatter differential phase in these regions complicates estimation of propagation differential phase. This suggests special treatment of such areas (hot spots) in attenuation correction schemes.

A very important fact is the definitive possibility to deduce bulk properties of hydrometeors by comparing the volumetric fields of the polarimetric variables obtained at S and C band. Such comparisons to pin point the type, size orientation, and phase of hydrometeors in the storm's volume. Studies of polarimetric radar data at two wavelengths would improve understanding of precipitation evolution, and could be applied to polarimetric observations at a single radar wavelength. This is not an advocacy for operational two wavelength system; rather it is a call for scientific inquiry with multiple wavelength radars.

Reference

Ryzhkov, A., S. Ganson, A. Khain, M. Pinsky, and A. Pokrovsky, 2009: Polarimetric characteristics of melting hail at S and C bands. 34th Conf. Radar Meteorol., Williamsburg, VA, 4A.6. [Available online at http://ams.confex.com/ams/34Radar/techprogram/paper_155571.htm.]