ARM Summer Training and Science Applications

Can We See Precipitation Properties Conserved through the Melting Layer Report

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1.0 Can We See Precipitation Properties Conserved through the Melting Layer?

In stratiform rain cases, precipitation radars often observe an area of enhanced radar reflectivity near the 0°C isotherm concomitant with the melting layer (ML). This enhancement of the radar reflectivity is attributed to the melting of snow and ice particles into rain droplets, which have a higher dielectric constant than ice particles. The particle shape and sedimentation velocity also change dramatically and can be observed via radar polarimetric phase and Doppler velocity. Although many particle characteristics could be homogenized by melting, some may be conserved through the melting layer. In this study, we endeavour to determine whether any signals can be tracked through the melting layer and diagnose the associated precipitation processes.

We examine one stratiform event at 08:44 to 09:02UTC, 27 April 2011 at the ARM Southern Great Plains (SGP) megasite as a case study. This stratiform precipitation system is located after a surface front, with a weak pressure gradient, weak vertical wind shear, and weak low-level cold advection. In this case, a C-band Scanning ARM Precipitation Radar (CSAPR) located approximately 21km north northeast (9°) of the SGP Central Facility (CF) was operating a Range-Height Indicator (RHI) scan towards the CF direction with ~12s time resolution. A Ka-band ARM Zenith Radar (KAZR) provides vertical-oriented profiles at CF with ~4s time resolution. During this 18-minute period, the precipitation is stable with a well-defined melting layer seen by Precipitation Radar.

Figure 1 shows the time series of vertical maxima or minima of CSAPR measurements approximately co-located with the KAZR. The maxima of the reflectivity (Zh, blue) and the gradient differential phase (KDP, black) indicate the top of the melting layer. These two polarimetric variables show the strongest signature here due to their size dependence. At the top of the melting layer, lower-density ice particles have only just begun to melt from the surface, so they are larger on average. Maxima in differential reflectivity (ZDR, red) and minima in the correlation coefficient (Rhohv, green), both functions primarily of shape, are co-located at a lower altitude. This location corresponds to where irregularly shaped particles are observed, and a sample volume in which there is relatively low correlation between hydrometeors (i.e., where smaller ice particles have likely completely melted and larger particles are still in the process of melting).

The weak dry and cold air advection at lower levels (approximately 1-1.5km) leads to a reduction of the melting layer height, which is indicated by the decrease of the polarimetric parameters through time.

Around hour 8.825 the depths of the melting layer narrowed. This may be associated with a decrease of the ice particles' size seeding into the ML. Evidence was found from KAZR mean Doppler velocities (MDV) 100m above the melting layer (~1800m), lasting for 6 minutes, with reduced values in comparison to fall speeds that were present before and after this reduction. This signature propagates through the melting layer resulting in an observable decrease of the ML's depths. Below the ML, we observed an area of enhanced MDV, attributable to the evaporation of these smaller particles (as observed in Doppler spectra; not shown) and that created a predominance of larger (faster) drops (i.e., shifted MDV to greater values). Towards the ground, the further evaporation on the larger precipitation particles caused a reduction of the mean particle diameter and fall speeds. These features were well represented by the mean Doppler velocity and agree with the polarimetric observations and synoptic conditions.

In summary, we have found a conserved radar signal that can be tracked through the ML to the surface. The signal is likely related to the microphysical properties such as mean particle sizes. The smaller particle sizes could be tracked through ML via reflectivity, mean Doppler velocity, and velocity spectra.

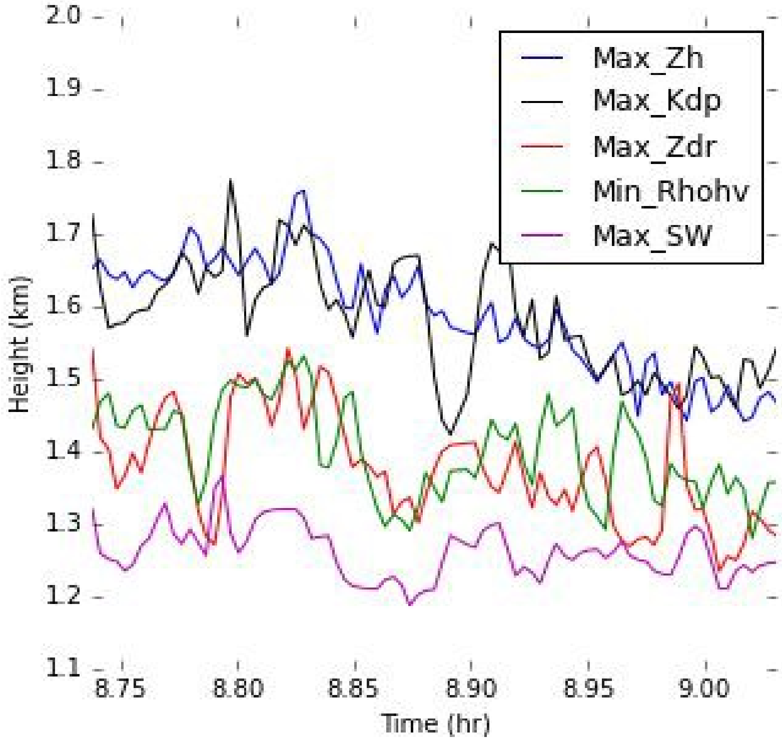

Figure 1. Time series of vertical maxima or minima (Rho_{hv}) from CSAPR RHI scans approximately at the location of SGP CF during a stratiform rain event on 27 April 2011 for 08:44 to 09:02UTC.