Assessment of operational polarimetric radar data for freezing-level height estimation

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The accurate detection and characterisation of the freezing-level have several benefits, mainly for quantitative precipitation estimation (QPE) because at longer distances from the radar, mixed-phase hydrometeors may induce considerable errors in radar rainfall estimates (Giangrande, et al., 2008). Knowing the freezing level height is crucial not only for hydrometeor classification algorithms (due to the importance of separating liquid from solid precipitation) but also for the application of attenuation correction algorithms in liquid precipitation.

There is a long-recognized association between melting hydrometeors and bright bands in reflectivity measurements that can be exploited to estimate freezing levels heights (Brandes & Ikeda, 2004). Besides this, lower values of the copolar cross-correlation coefficient ($\rho_{HV}$) and high values of differential reflectivities ($Z_{DR}$) are typical signatures found in the melting layer measured by polarimetric weather radars.

Another important feature in the freezing-level estimation is the observation of the vertical structure of precipitation. The methodology presented by Ryzhkov, et al. (2016) allows visualising the vertical structure of precipitation by using quasi-vertical profiles (QVP) of the polarimetric variables in a time-versus-height format. This allows the monitoring of the temporal evolution of precipitation and the freezing level. Although several algorithms for the detection of the freezing level based on plan position indicator (PPI) scans have been proposed in the literature (Giangrande, et al., 2008) or (Matrosov, et al., 2007), there are only a few methods based on vertical profiles (or QVPs). For instance, Trömel, et al. (2014) introduce an investigation of the backscatter differential phase in the melting layer using the QVP and Rico-Ramirez & Cluckie (2007) presents an algorithm to detect the extent of the bright band using high-resolution Vertical Reflectivity Profiles (VRP) of precipitation, among others. Therefore, a study of the variation of the rain in this format for all the polarimetric variables presents new benefits in the characterisation of the freezing level with operational polarimetric weather radars.

A one-year analysis of rainfall events collected by an operational polarimetric radar in the UK is presented. The aim of the analysis is to estimate freezing-level heights based on several polarimetric signatures. The polarimetric radar datasets were obtained from the Chenies radar located at the northeast of London. This C-band weather radar is part of the UK weather surveillance radar network were measurements of reflectivity ($Z_{HH}$), differential reflectivity ($Z_{DR}$), differential phase ($\Phi_{DP}$), correlation coefficient ($\rho_{HV}$) and radial velocity ($V$) at multiple elevation scans ranging from 4° to 90° were collected.

Retrievals from these measurements are examined to introduce an algorithm that identifies the distinctive polarimetric signatures of the freezing level. Furthermore, as Doppler velocity scans at 90° are available, it is possible to take into account this variable to estimate the height of the freezing level.

Keywords: Operational Polarimetric Radar, Freezing-level, Vertical Structure of Precipitation