Diagnosing non-bright band precipitation in Met Office radar data using the linear depolarisation ratio

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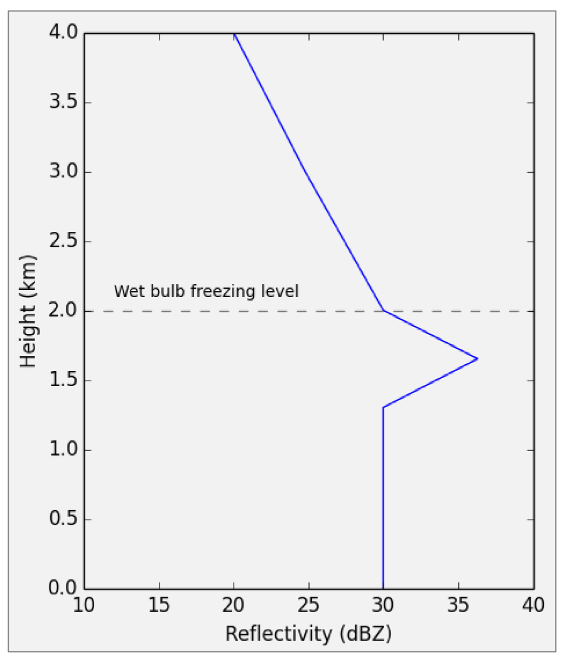
Introduction

Correcting for atmospheric vertical reflectivity profile (VPR) is an essential step in obtaining accurate radar precipitation measurements. However, the nature of the vertical reflectivity profile depends substantially on meteorological conditions. In the UK, as in much of Europe, the dominant precipitation type is stratiform, and vertical profiles generally display strong reflectivity enhancement close to the freezing level. However, in less common convective conditions, correcting for this "radar bright band" can cause significant underestimation of surface rainfall rates, during the very high impact events in which accurate estimates are most needed. This work focuses on the use of the linear depolarisation ratio (LDR) to distinguish between stratiform and convective precipitation, with the aim of improving operational VPR correction in the UK radar processing system.



Current idealised VPR

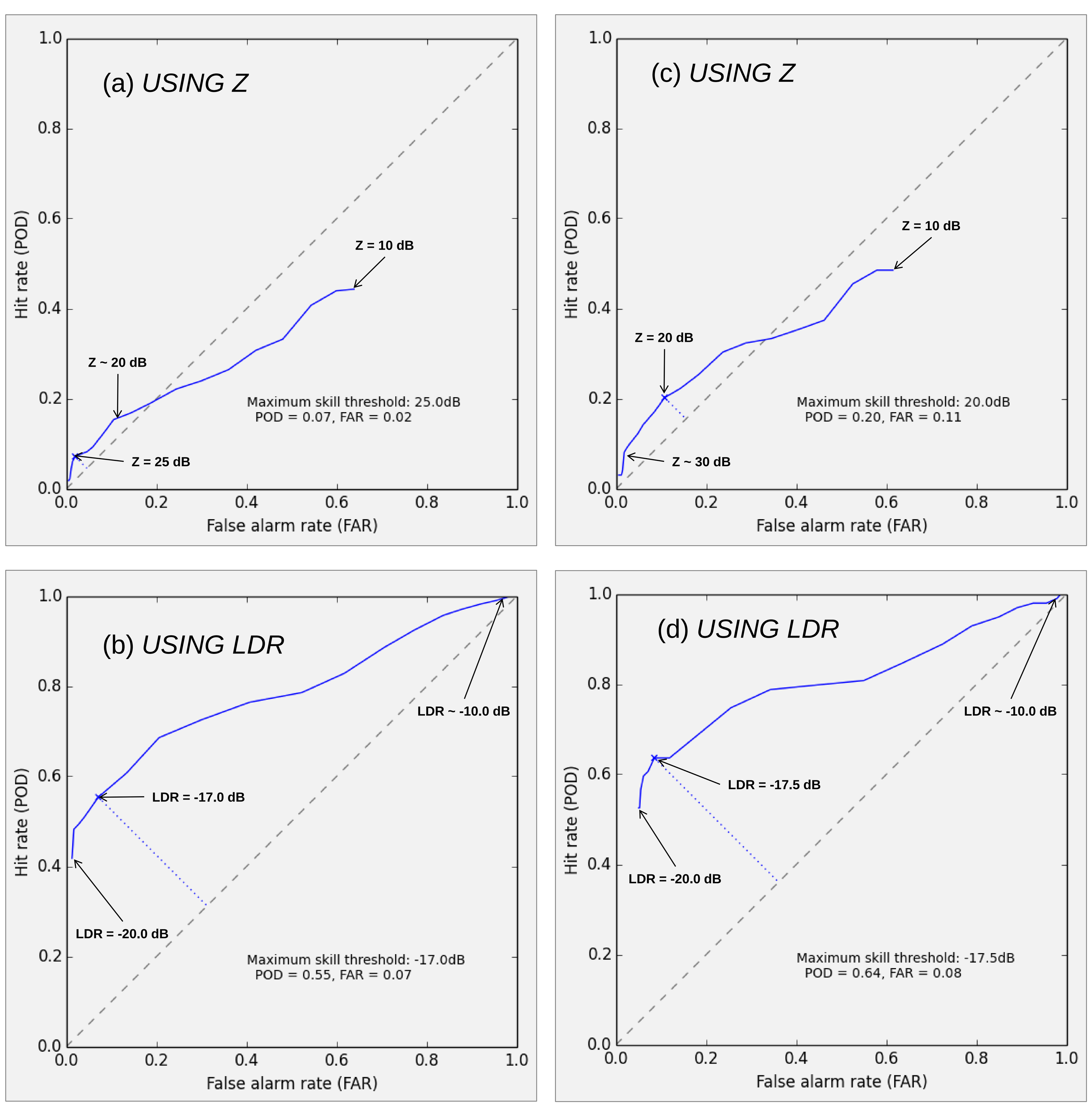
The UK operational VPR correction (Kitchen et al 1994) distinguishes between convective and stratiform precipitation using a reflectivity threshold. If reflectivity is greater than 30 dBZ at 1.5 km above the wet bulb freezing level, no VPR correction is applied. All other cases are treated as stratiform and corrected using an idealised bright band profile (see figure, left), which is fitted to the measured reflectivity at each radar pixel.

Dataset

The Met Office research radar at Wardon Hill performs a range height indicator (RHI) scan in LDR mode every 10 minutes. An archive of these scans was built up over two study periods, in autumn 2014 and summer 2015. Stringent quality control was applied to select the final RHI dataset of around 1550 independent scans..

From each RHI, vertical profiles of reflectivity and LDR were extracted at 1 km horizontal and 100 m vertical resolution. To preserve fine vertical structure, only profiles in the range 5-15 km from the radar were used. The final dataset, comprising around 1800 classifiable profiles, was used to test the skill of LDR peak value in distinguishing between three observed VPR types.

IDENTIFICATION OF NON-BRIGHT BAND PROFILES | *IDENTIFICATION OF STRONG CONVECTIVE PROFILES*



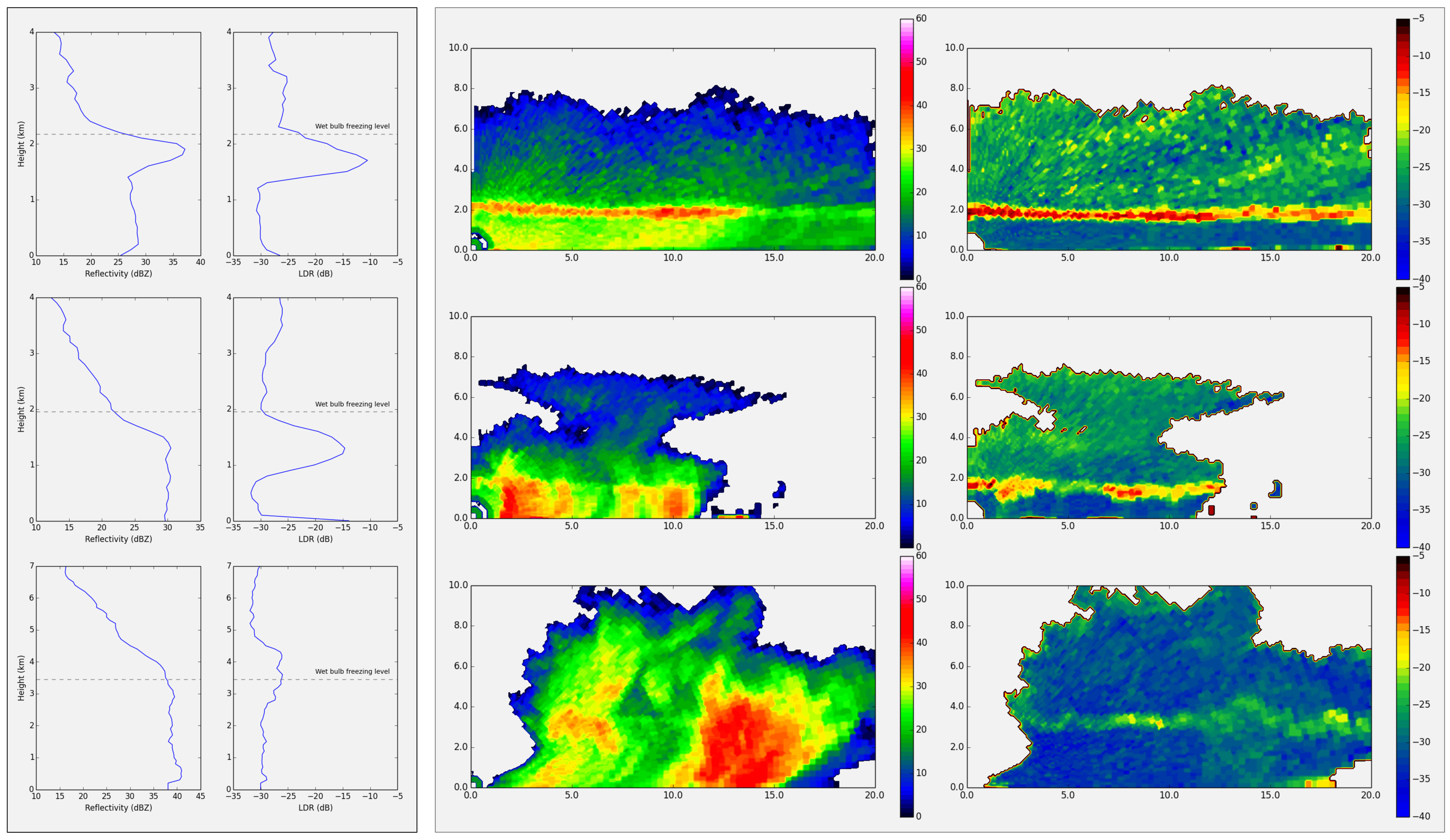


Figure 1 (above): examples of the three types of vertical profile observed in the RHI sample: stratiform (top), weak convection (middle) and strong convection (bottom). The right panel shows RHI data for reflectivity and LDR, with range and height axes in km. In the left panel, average vertical profiles of reflectivity and LDR from ranges 5-10 km are displayed.

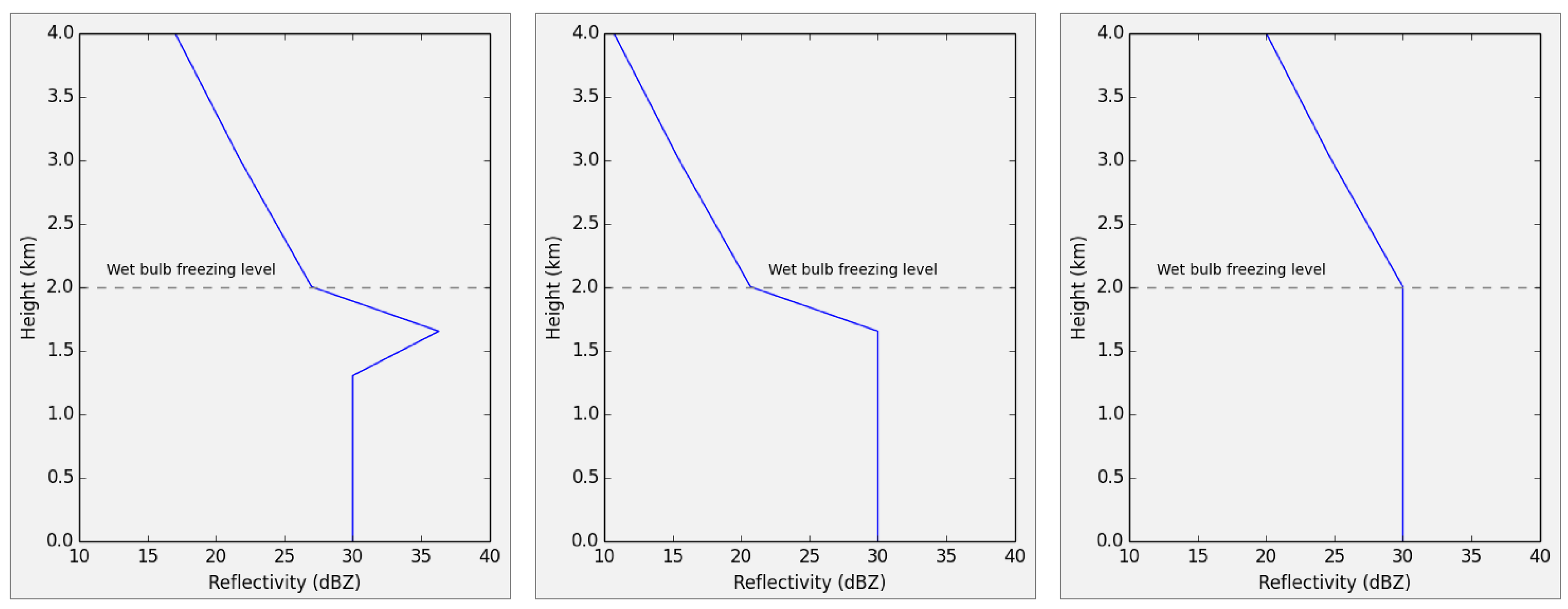


Figure 2 (left): schematics of the three observed profile shapes on the S-C spectrum . Stratiform rain (left), weak convection (middle) and strong convection (right). LDR peak value was tested as a criterion for both thresholds.

Observed VPRs

Three types of vertical reflectivity profile were observed in this dataset (figure 2). Stratiform profiles exhibit strong bright bands in reflectivity and LDR. Weak convective profiles have smaller LDR peaks, and reflectivities in the melting layer are not enhanced above those in the rain, although there is a drop in reflectivity close to freezing level mirroring that of the stratiform profile. Strong convective reflectivity profiles drop off more slowly above the freezing level, and the melting layer LDR peak is very small.

The three VPR types were defined as follows:

1. Stratiform: peak-to-rain reflectivity difference exceeding 3 dB
2. Weak convective: peak-to-ice reflectivity difference exceeding 6 dB
3. Strong convective: otherwise

To avoid contamination from shallow very light rain, profiles with rain-level reflectivities of less than 20 dBZ were excluded from this analysis..

Figure 3 (left): ROC curves for high level reflectivity (top) and peak LDR (bottom). Left: identification of non-bright band profiles. Right: identification of strong convection.

Results and conclusions

Vertical profiles in the range 5-15km were classified by reflectivity peak size, as described above. LDR peak and high-level reflectivity values were then extracted and ROC curves plotted to illustrate the skill of each quantity. The whole sample was split at each classification threshold in order to calculate POD and FAR.

LDR shows skill at discriminating between stratiform (1) and convective (2,3) profiles (figure 3b). The highest skill is at a threshold of -17.0 dB. Peak LDR is also successful at isolating strong convection (3) from other (1,2) profile types (figure 3d), with the most skilful threshold at -17.5 dB. High level reflectivity (figures 3a and 3c), by contrast, has no skill in distinguishing between profile types, and the current threshold of 30 dBZ has a POD of zero for this sample. LDR therefore has the potential to improve operational convective diagnosis in the UK radar processing system.

References

Kitchen, M., R. Brown and A. G. Davies, 1994: Real-time correction of weather radar data for the effects of bright band, range and orographic growth in widespread precipitation. QJRMS, 120, 1231-1254.

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