# CALIBRATION OF THE VU C-BAND POLARIMETRIC RADAR

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## 1. Introduction

New methods for calibration of reflectivity in polarimetric radars using redundancy in polarimetric variables in rain are now available (Gorgucci et al. 1992, Goddard et al. 1994, Gourley and Illingworth 2005, Gourley et al. 2009). These methods are based on the comparison of the rain rates calculated from the combination of reflectivity ($Z_H$) and differential reflectivity ($Z_{DR}$) and from the specific differential phase ($K_{DP}$) alone. Since the $K_{DP}$ is immune to calibration errors, the difference in the obtained rain rates is assumed to be due to the miscalibration of the $Z_H$.

The Valparaiso University C-band Polarimetric radar has been operating since 2007. Since then the radar has observed several different types of precipitating events, from lake effect snow, to severe thunderstorms, supercells, etc. However, in order to use the data in a quantitative way, the radar must be well calibrated. We will use here the technique described below known as consistency theory, to calibrate the radar reflectivity. The differential reflectivity is calibrated before, using observations at vertical incidence.

## 2. Method

The formulation we use here is the one used by Gourley et al 2009, in which the ratio $K_{DP}/Z_H$ is written as a function of $Z_{DR}$:

$$\frac{K_{DP}}{Z_H} = 10^{-5}(a_0 + a_1 Z_{DR} + a_2 Z_{DR}^{\ 2} + a_3 Z_{DR}^{\ 3}), \quad (1)$$

where the coefficients $a_i$ are specified for S, C and X-band radars. The theoretical value of $K_{DP}$ is calculated from equation 1 and integrated in range in order to obtain a theoretical value for the differential phase shift ($\Phi_{DP}$_th). This is then compared to the observed value of $\Phi_{DP}$ ($\Phi_{DP}$_obs). The value of the reflectivity is adjusted so that calculated and observed $\Phi_{DP}$ match.

The application of this method is only valid if there is no bias in $Z_{DR}$. This was achieved by pointing the radar vertically in rain. Also, eq.1 is only valid in rain, so the data is limited to observations below the freezing level. To ensure that no hail is being sampled we reject a whole ray if a single gate has a reflectivity higher than 50 dBZ. Since no attenuation correction was made, we limited the dataset to the rays where the total variation in $\Phi_{DP}$ is less than 12°. Rays where a single gate had a ZDR > 3.5 dB were also rejected so that resonance effects were excluded.

## 3. Results

3.1 Calibration of $Z_{DR}$

A case of stratiform widespread precipitation was observed by the VU radar on the 20 April 2009. These were the ideal conditions to verify the data quality and the calibration of the radar.

Figure 1 shows an example of $Z_{DR}$ as a function of altitude at vertical incidence at 1516 UTC. Below the melting level (~2150 m) $Z_{DR}$ is found to be approximately –4.7 dB. Other vertical measurements the same day show similar results. The intrinsic value of $Z_{DR}$ at vertical incidence in rain is 0 dB. This suggests a drift of -4.7 dB in $Z_{DR}$.

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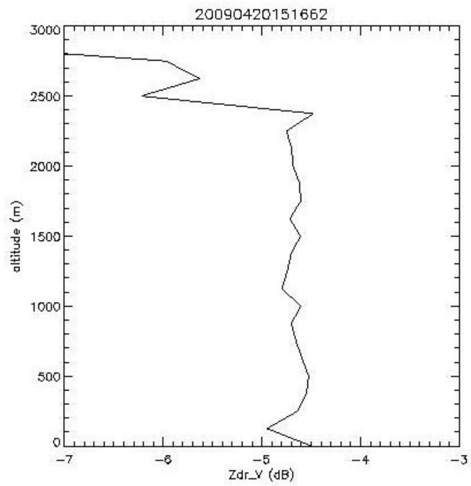


Figure1. $Z_{DR}$ at vertical incidence as a function of altitude (m) on the 20090420 at 1516 UTC.

3.2 Calibration of $Z_H$

Figure 2 shows the mean values of $\Phi_{DP}$_th (solid line) and $\Phi_{DP}$_obs (dashed line) as a function of range for one specific ray on the 20090420 at 1425 UTC. The calculated value for $\Phi_{DP}$ is clearly below the observed value, indicating that the measured reflectivity was too low.

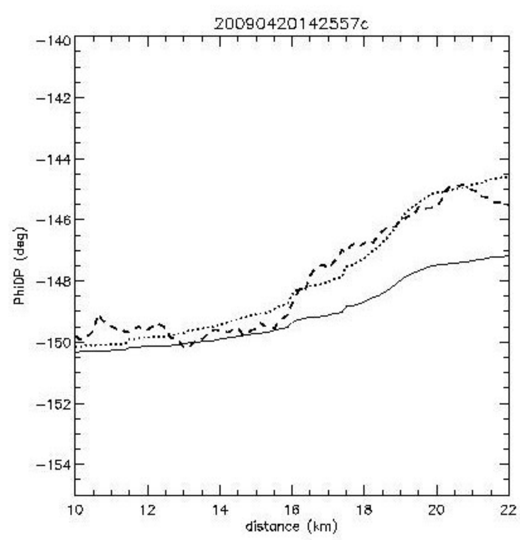


Figure 2. $\Phi_{DP}$_th (solid line), $\Phi_{DP}$_obs (dashed line) and $\Phi_{DP}$_th calculated with a correction of +2.5 dBz in reflectivity (dotted line) as a function of range for one ray on the 20090420 at 1425 UTC. Elevation is 1.5°.

The dotted line in figure 2 shows $\Phi_{DP}$_th calculated with a reflectivity corrected by +2.5 dBz. The dotted and dashed lines show good agreement.

**4. Conclusion and Perspectives**

We used measurements at vertical incidence and consistency theory for the calibration of $Z_{DR}$ and $Z_H$ respectively. Our results suggest that a drift in $Z_{DR}$ of -4.7 dB and in $Z_H$ of -2.5dBz is present. These are preliminary results since this is an ongoing study as we apply the same process to more data.

Moreover, we plan to calibrate the radar reflectivity using a tethered metal sphere. This will also be an opportunity to compare both calibration methods and evaluate the performance of the consistency theory.

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**5. References**

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