Differential reflectivity calibration from vertically pointing radar observations of hydrometeors in the solid phase

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In cold environments, such as the polar or mountainous regions, the conventional method for Z_{DR} calibration based on vertically pointing measurements in light rain is not viable, due to the scarcity of liquid precipitation.
The algorithm presented here uses the same scan geometry, but it focuses on a section of the vertical column further away from the radar, without assuming prior information on its hydrometeor population.

After averaging Z_{DR} over the 360° azimuthal rotation, the distribution of the mean values is analyzed for each of the range gates, in order to identify a region of limited variability.
This is accomplished by imposing conditions on metrics such as the distribution overlap between adjacent radar volumes and interquantile ranges.
The Z_{DR} bias used for the calibration is computed from the selected region.
When the presence of a melting layer is detected in the scan, only values above its altitude are used for the analysis.
The possibilities of a constant (campaign-dependent) and time-varying bias are investigated.

The datasets used for developing the calibration algorithm were collected by the X-band dual-polarization Doppler radar of EPFL-LTE, deployed during field campaigns in diverse locations: Davos (Switzerland), Dumont d'Urville station (Adélie Land, Antarctica), Gangneung (South Korea), Martigny (Switzerland), Montbrun (France) and Payerne (Switzerland).

To assess the quality of the newly defined calibration, we analyzed the Z_{DR} distribution in dry snow, extracted from RHI scans at particular elevation angles.
The typical signatures of this hydrometeor type have been described in the scientific literature, and a comparison with benchmark values is possible.

Additionally, we took advantage in Payerne of a second X-band dual-polarization Doppler radar, belonging to MeteoSwiss, which was deployed at a distance of approximately 4 km.
Overlapping RHI scans, at one specific azimuth angle, are available for the duration of the campaign.
The Z_{DR} values measured by the two radars in volumes sufficiently close in space and time and observed from a similar elevation angle were compared.

Overall, the innovative technique presented in this study is designed for radar systems with vertical scanning capabilities, but with no access to the light rain measurements necessary for the conventional differential reflectivity calibration.
Although methods of calibration from solid hydrometeors already exist in the scientific literature, the target systems for which they are usually developed are operational radars that are not able to perform vertical scans.
Owing to its different aim, our technique retains the advantages from the average over the 360° azimuthal rotation.

Keywords: Differential reflectivity calibration, Dual-polarization weather radar, Remote sensing