EGU21-15850
https://doi.org/10.5194/egusphere-egu21-15850
EGU General Assembly 2021
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Investigation of the relationship between differential phase shift and path integrated attenuation in the melting layer of precipitation of X-band radar

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The RadAlp experiment at the Grenoble region in the French Alps aims to advance the radar remote sensing techniques of precipitation in high mountain regions. Since 2016, two dual-polarimetric X-band radars, one on top of Mt Moucherotte (1901 m asl) and another in the Grenoble valley (220 m asl) are operated by Metro France and IGE respectively. High spatio-temporal variability of precipitation (e.g. intensity and phase) in the complex terrain requires high-resolution observations. X-band radar provides high spatial and temporal resolution imagery which makes it ideal for use in complex terrain but also comes with significant attenuation problems during heavy precipitation and in the melting layer (ML). The development of polarimetric techniques, especially differential phase shift (□DP) has helped to mitigate the power signal attenuation problem to a certain extent. The □DP is immune to attenuation due to rainfall, radar calibration errors and partial beam blockage, making it an attractive parameter for quantitative precipitation estimation (QPE) through attenuation correction of the reflectivity (Z). The □DP, however, is quite noisy and requires regularization. An iterative algorithm based on maximum allowed step sizes provides a robust solution in □DP regularization. In this study, we aim to understand the relationship between differential phase shift (□DP) and path integrated attenuation (PIA) at X-band. This relationship is crucial for quantitative precipitation estimation (QPE) using polarimetric techniques. Furthermore, this relationship is still poorly documented within the melting layer due to the complexity of the hydrometeors' distributions in terms of phase, size, shape and density. We use the mountain reference technique (MRT) for direct PIA estimations associated with the decrease in returns from mountain targets during precipitation events as compared to dry periods. The quasi-vertical profiles from the valley-based radar (XPORT) help to identify, characterize and follow the evolution of the melting layer. For the mountaintop radar (MOUC) stratiform events (59 days between Nov 2016 to Dec 2019) where the O° elevation angle beam passes through the melting layer are considered. The PIA/ □DP ratios at different strata of the ML, snow-ML interface and ML-rain interface are studied. Initial results show that the PIA/ □DP ratio peaks at the levels of cross-correlation coefficient (ρHV) minima, remains strong in the upper part of the ML and tends to 0 towards the top of ML. Additionally, its value in rain (0.32 dB per deg) below the ML matches closely with the specific attenuation vs specific phase (k-KDP)

relationship (0.29) derived from the disdrometer at ground level. Its value increases steadily in the lower part of ML (peaks around 0.70 dB per deg), remains strong in the upper part of ML (0.5 - 0.6 dB per degree), and decreases rapidly to 0.13 dB per degree above the ML (in snow).