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Learning about the vertical structure of precipitation using neural networks and hydrometeor classes – going beyond an average profile in the Swiss Alps

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The use of radar for precipitation measurement in mountainous regions is complicated by many factors, especially beam shielding by terrain features, which, for example, reduces the visibility of the shallow precipitation systems during the cold season. Orography not only complicates the radar measurements, but also influences the dynamics and microphysics of precipitation occurring below the lowest visible radar beam, which often results in a different precipitation measurement at the ground.

A commonly applied technique to compensate for the lack of direct visibility with the radar is the extrapolation of measurements from aloft to the ground level, known as the vertical profile of reflectivity (VPR) correction. The operational VPR correction techniques that are currently in use are typically based either on mean VPRs measured in well-visible regions close to the radar, climatological VPRs, some idealised model VPR or a mixture of these. These techniques thus often assume spatio-temporal homogeneity of the vertical structure of precipitation and rely heavily on the reflectivity measurements.

Building on the availability of polarimetric data and a hydrometeor classification algorithm, this study applies machine learning methods to study the vertical profile of precipitation in Switzerland. Volumetric data from the operational polarimetric C-band radar located at Albis (∼938 m asl) were extracted for a total of 30 precipitation events covering a period of three years (2016-2018) and representing a broad range of microphysical situations.

From these volumetric data, vertical cones containing reflectivity data and hydrometeor proportions were extracted at regular spatial intervals in the well-visible regions close to the radar. The cones have a 4 km diameter at the base at 1000 m asl and 10 km diameter at the top at 10 km asl. They were extracted at one hour intervals and integrated temporally up to 30 minutes to obtain more robust VPR estimations. The data at different height levels from the extracted cones constituted the input for the training of artificial neural networks (ANN), which were asked to predict the increase or decrease in reflectivity between some height level y and the ground level y_0 ($GD_{y-y_0} = dBZ_y - dBZ_{y_0}$) using as predictors the hydrometeor proportions and reflectivity data from that same height level y and the height levels aloft. The dataset was split into 60% for training and 40% for model validation and testing. First results indicated that the GD fields showed smoother spatial behaviour than reflectivity fields suggesting that GD is more constant spatially, and the good potential for the use of GD_{y-y_0} between height levels for predictions at y_0 rather than reflectivity at y. This study presents the groundwork for the use of ANN models to study the vertical structure of precipitation as well as the results of this first experiment.