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From solid hydrometeors to liquid precipitation at the ground level: polarimetric radar and machine learning

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The relationship between the dominant microphysical processes in the ice phase (e.g. aggregation and riming) and the quantity of liquid precipitation at the ground level has not been extensively studied. In fact, it is often assumed that the local variations of liquid precipitation at the ground level are mostly influenced by warm rain processes (e.g. breakup, coalescence). In this contribution we explore and make use of the links between the respective proportions of solid hydrometeors aloft and the estimated liquid precipitation at the ground level.

The solid-phase hydrometeor statistics are obtained by applying a semi-supervised classification on the dual-pol radar datasets acquired by the MeteoSwiss Monte Lema radar. These datasets relate to 7 events of intense precipitation with significant hydrological response, over the valley of the Maggia river, Ticino, Switzerland. The precipitation intensity data are the product of merging the radar estimated liquid precipitation with the corresponding raingauge measurements.

In the first part of this study we focus on the evaluation of the relationship between the precipitation intensity and the percentages of crystals (%CR), aggregates (%AG) and rimed particles (%RP) in the vertical column above the corresponding ground level pixel (1 km2). Various regression approaches indicate a relevant co-fluctuation between the solid-phase hydrometeor proportions and the intensity of liquid precipitation at the ground. This relationship is rather non-linear and therefore non-linear functions are fitted to the data: %CR-QPE, %AG-QPE and %RP-QPE.

The next step is to use machine learning to automatically estimate the liquid precipitation at the ground level from the proportions of solid hydrometeors. Namely, a neural network with one hidden layer, has as input %CR, %AG and %RP as well as the non-independent parameters derived from these three (e.g. lower resolution, entropy, anisotropy), and provides liquid precipitation at the ground level as output. The neural network is trained and tested by means of cross validation, using the datasets analyzed in the first part. This approach, which is characterized by a high reliability due to the weaker clutter contamination of the solid phase measurements, provides complementary information to conventional QPE methods. This can be very relevant in the case of complex terrain.