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Hydrometeor classification from polarimetric radar measurements: a clustering approach

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Hydrometeor classification is the process that aims at identifying the dominant type of hydrometeor (e.g. rain, hail, snow aggregates, hail, graupel, ice crystals) in a domain covered by a polarimetric weather radar during precipitation. The techniques documented in the literature are mostly based on numerical simulations and fuzzy logic. This involves the arbitrary selection of a set of hydrometeor classes and the numerical simulation of theoretical radar observations associated to each class. The information derived from the simulation is then applied to actual radar measurements by means of fuzzy logic input-output association. This approach has some limitations: the number and type of the hydrometeor categories undergoing identification is selected arbitrarily and the scattering simulations are based on constraining assumptions, especially in case of solid hydrometeors. Furthermore, in presence of noise and uncertainties, it is not guaranteed that the selected hydrometeor classes can be effectively identified in actual observations.

In the present work we propose a different starting point for the classification task, which is based on observations instead of numerical simulations. We provide criteria for the selection of the number of hydrometeor classes that can be identified, by looking at how polarimetric observations collected over different precipitation events form clusters in the multi-dimensional space of the polarimetric variables. Two datasets, collected by an X-band weather radar, are employed in the study. The first dataset covers mountainous weather conditions (Swiss Alps), while the second includes Mediterranean orographic precipitation events collected during the special observation period (SOP) 2012 of the HyMeX campaign. We employ an unsupervised hierarchical clustering method to group the observations into clusters and we introduce a spatial smoothness constraint for the groups, assuming that the hydrometeor type changes smoothly in space. The optimal number of hydrometeor classes (nopt=7) is obtained by taking into account the separability of the clusters as well as their spatial smoothness. The content of the clusters is interpreted a-posteriori, leading to the following hydrometeor classes: light rain, rain, high intensity rain, melting snow, ice crystals, aggregates, rimed ice-particles. A quantitative comparison with in-situ measurements shows that the proposed hydrometeor classification method performs better than a classical fuzzy logic algorithm in the detection of ice phase hydrometeors.