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Identification of hydrometeor mixtures in polarimetric radar measurements and their linear de-mixing

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The issue of hydrometeor mixtures affects radar sampling volumes without a clear dominant hydrometeor type. Containing a number of different hydrometeor types which significantly contribute to the polarimetric variables, these volumes are likely to occur in the vicinity of the melting layer and mainly, at large distance from a given radar. Motivated by potential benefits for both quantitative and qualitative applications of dual-pol radar, we propose a method for the identification of hydrometeor mixtures and their subsequent linear de-mixing. This method is intrinsically related to our recently proposed semi-supervised approach for hydrometeor classification.

The mentioned classification approach [1] performs labeling of radar sampling volumes by using as a criterion the Euclidean distance with respect to five-dimensional centroids, depicting nine hydrometeor classes. The positions of the centroids in the space formed by four radar moments and one external parameter (phase indicator), are derived through a technique of k-medoids clustering, applied on a selected representative set of radar observations, and coupled with statistical testing which introduces the assumed microphysical properties of the different hydrometeor types.

Aside from a hydrometeor type label, each radar sampling volume is characterized by an entropy estimate, indicating the uncertainty of the classification. Here, we revisit the concept of entropy presented in [1], in order to emphasize its presumed potential for the identification of hydrometeor mixtures. The calculation of entropy is based on the estimate of the probability (p_i) that the observation corresponds to the hydrometeor type i ($i = 1, \cdots 9$). The probability is derived from the Euclidean distance (d_i) of the observation to the centroid characterizing the hydrometeor type i. The parametrization of the $d \rightarrow p$ transform is conducted in a controlled environment, using synthetic polarimetric radar datasets. It ensures balanced entropy values: low for pure volumes, and high for different possible combinations of mixed hydrometeors.

The parametrized entropy is further on applied to real polarimetric C and X band radar datasets, where we demonstrate the potential of linear de-mixing using a simplex formed by a set of pre-defined centroids in the five-dimensional space. As main outcome, the proposed approach allows to provide plausible proportions of the different hydrometeors contained in a given radar sampling volume.

[1] Besic, N., Figueras i Ventura, J., Grazioli, J., Gabella, M., Germann, U., and Berne, A.: Hydrometeor classification through statistical clustering of polarimetric radar measurements: a semi-supervised approach, Atmos. Meas. Tech., 9, 4425-4445, doi:10.5194/amt-9-4425-2016, 2016.