

Classification of meteorological and non-meteorological targets with principal component analysis applying conventional and polarimetric measurements and their texture

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Classification of hydrometeor types based on measured conventional quantities (dBZ, V, W, SQI) and frequently available polarimetric quantities (ZDR, LDR, RHO, KDP or PHI) at each radar bin has been found to give useful information for the purposes of quantitative precipitation estimation (QPE). Even more significant seems to be the obvious ability of radars equipped with polarization diversity to diagnose and quantify specific precipitation types and phenomena (e.g. hail, melting snow, attenuation) and non-meteorological targets (e.g. birds, insects, sea clutter, external emitters). The type of scattering medium should be diagnosed by applying a probabilistic scheme for the purpose of quality control of hydrological radar products. A useful application of radars can also be the production of specific diagnostic of birds and insects, e.g., for the purposes of flight safety and preventive actions against immigration of pest insects. Thus detailed classification of non-meteorological targets is important but so far not much work has been devoted to it. It also appears that fuzzy single bin member functions are not necessarily sufficient for a detailed classification of radar targets even with the extended set of polarimetric quantities. We have extended the existing polarimetric fuzzy classification schemes in two aspects: (1) The number of target classes has been increased to several dozens. Examples of such fine-tuned classes are nocturnal songbird migration, arctic duck migration, anomalous sea clutter, daytime insect migration and melting convective snow. Frequency distributions of the quantities given above were calculated for each class. As is already known many of the polarimetric quantities exhibit quite different probability distributions (membership functions) when various target classes are compared. (2) In addition to single bin properties we also observe the texture of all the measured quantities in a small region surrounding each bin. A number of filters that quantify various textural properties of the local pixel neighborhood like graininess or presence of borders were designed and applied to a manually selected and classified set of radar observations. The resulting high-dimensional (up to 85) data set was studied with Principal Component Analysis (PCA) to identify a subset of dimensions with optimal resolving power for each class. The obtained PCA hyperellipsoids provide a natural metric for non-local class member functions. The selection of training areas from PPI and RHI images of a polarimetric C band radar has been performed by very experienced radar researchers and by applying external weather data. The classification used is conditional with respect to the signal processing applied in the sense that only bins with available dBZ data after Doppler filtering have been accepted as objects for classification. Unfortunately no validation results applying independent data sets are yet available while writing this but the results with dependent data are quite promising.