Supervised classification and estimation of hydrometeors from dual-polarized C-band weather radar

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New generation of dual-polarized weather radar systems may offer the opportunity to detect and identify different classes of hydrometeors present in stratiform and convective storms. This important feature depends on the fact that polarimetric radar measurements are highly sensitive to physical properties of hydrometeors like composition, size, shape and orientation (Bringi and Chandrasekar, 2001). Hydrometeor classification may facilitate to study rain-cloud microphysics, to detect hailstorms and to choose the correct algorithm for precipitation rate retrieval. Last but not least, hydrometeor identification may also be useful for flight assistance and weather nowcasting.

Polarimetric signatures depend also on the frequency used by the radar system. The consequence is that S-band signals differ substantially from C-band signals, especially as far as differential reflectivity and specific differential phase are concerned. As a matter of fact, most scientific literature about hydrometeor classification describes classification techniques designed for S-band radar data (Vivekanadan et al., 1999; Zrnic et al., 2001; Liu et al., 2005). Only recently some works related to C-band measurements have been presented (Baldini et al., 2004; Galletti et al., 2005; Marzano et al., 2006). The interest of assessing C-band hydrometeor classification may also emerge from the consideration that most mid-to-high latitude weather radars operate and are planned at C-band. Generally speaking, C-band radar systems may offer some advantages such as higher sensitivity, reduced antenna size and overall lower cost with respect to that of an S-band system with similar characteristics. On the other hand, rainfall path attenuation cannot be disregarded when inverting radar measurements at C-band frequencies and above (e.g., Testud et al., 2001; Vulpiani et al., 2005). Dual-polarized weather radars may offer the advantage of polarization diversity and differential phase shift measurements to correct for precipitation path attenuation effects in a fairly effective way.

In this work, a model-based fuzzy-logic classification method for C-band polarimetric radar data is presented. Membership functions (MBFs) are designed for best fitting

simulation data at C-band and they are derived for ten different hydrometeor classes by means of a radar scattering model, based on T-Matrix numerical method. The fuzzy logic classification technique, named Fuzzy Radar Algorithm for Hydrometeor Classification at C band (FRAHCC), uses here a reduced set of polarimetric observables, i.e. Zhh and Zdr, and it is finally applied to data coming from radar sites located in Gattatico and S. Pietro Capofiume in Northern Italy. Numerical and experimental results clearly show the improvements of hydrometeor classification, obtained by using FRAHCC with respect to the direct use of fuzzy-logic based algorithms specifically tuned for S-band radar data. Moreover, the bistatic mode of available C-band rainfall observations allows to implement a path-integrated attenuation correction procedure based either on a composite radar field approach or, more rigorously, on a bistatically-constrained algorithm for attenuation compensation. Impact of these correction procedures on hydrometeor classification is qualitatively discussed within the considered case study.