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Fuzzy-logic detection and probability of hail exploiting short-range X-band weather radar

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Abstract. This work proposes a new method for hail precipitation detection and probability, based on single-polarization X-band radar measurements. Using a dataset consisting of reflectivity volumes, ground truth observations and atmospheric sounding data, a probability of hail index, which provides a simple estimate of the hail potential, has been trained and adapted within Naples metropolitan environment study area. The probability of hail has been calculated starting by four different hail detection methods. The first two, based on (1) reflectivity data and temperature measurements and (2) on vertically-integrated liquid density product, respectively, have been selected from the available literature. The other two techniques are based on combined criteria of the above mentioned methods: the first one (3) is based on the linear discriminant analysis, whereas the other one (4) relies on the fuzzy-logic approach. The latter is an innovative criterion based on a fuzzyfication step performed through ramp membership functions. The performances of the four methods have been tested using an independent dataset: the results highlight that the fuzzy-oriented combined method performs slightly better in terms of false alarm ratio, critical success index and area under the relative operating characteristic. An example of application of the proposed hail detection and probability products is also presented for a relevant hail event, occurred on 21 July 2014.

Keywords: weather radar, X-band, hailstorm, detection methods, data processing, urban hydrometeorology.