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X-band weather radar monitoring products in Naples urban area: raingauge-based calibration, hail detection and lightning nowcasting

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Naples urban area, one of the most populous in Italy, is often affected by severe weather associated with convective storms, flash flood and mood slides as well as other damages caused all year around by hail, lightning and wind gusts. In this respect, X-band weather radars' capability to monitor precipitation at high spatial and temporal scales is of outmost importance and stimulates a significant interest within both meteorological and hydrological community.
Since November 2011, one innovative X-band low-cost miniradar system has been installed and tested in Naples metropolitan area. The radar, named WR-10X, belongs to the Campania Center for Marine and Atmospheric Modelling and Monitoring (CCMMMA) of the University of Naples "Parthenope" and is located at the top of Castel Sant'Elmo (40.8438°N, 14.2385°E, 280 m a.s.l.). WR-10X is able to observe rainfall fields over a circular area that has a radius of 72 km.
In this work, some preliminary results are described, showing usefulness and potentiality of such mini-system at urban scale in terms of rain estimation, hail warning and lightning nowcasting.
Accuracy assessment of quantitative precipitation estimates provided by WR-10X has been performed means of 24-h cumulative rainfall data from about 50 raingauges. In order to describe the systematic errors of radar estimates as a function of radial distance, a time-space correlation approach based on an exponential model has been adopted. According to its geographical features, the study area has been divided into four subregions; for each of them, an exponential regression explicitly dependent on the distance from radar has been trained on a dataset consisting of 55 rainy events.
During the test period on WR-10X, in order to obtain a radar-based Probability of Hail (POH) index, two different experimental hail detection products have been developed. The first one combines the reflectivity measurements with aerological data, whereas the other one uses the Vertically-Integrated Liquid Density product. In order to find the optimal threshold values to discriminate between hail and severe rain, an extensive intercomparison between the outcomes of the two methodologies and ground truth observations of hail has been performed, using a 2x2 contingency table and statistical scores. The relationship between the output of the two methodologies and POH has been derived through a heuristic approach, using a third-order polynomial fitting curve.
To face the third aim of this work, the difference between the maximum height of a reflectivity echo value found by WR-10X equal to a specific threshold (i.e. 35 or 40 dBZ) and the altitude of a given isotherm (i.e. -10 or -15°C) has been correlated with lightning activity observed in the following 10 minutes. The relationship between this difference and the probability of lightning strikes occurrences has been expressed through fourth-degree polynomials.
The results show that WR-10X reflectivity data could be very suitable for hydrological and early monitoring application at urban scale.