First analyses of rainfall patterns retrieved by a newly installed X-band radar over the Metropolitan area of Cagliari (Sardinia, Italy)

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Abstract

The growing urbanization and aggregation of metropolitan territorial communities, sustainable development, citizen engagement, economic and cultural attractiveness and governance are among the most important issues for modern cities. The increasing complexity of these problems and technological development are leading to an urgent need and the opportunity to radically rethink the way we build and manage our cities.

The recent institution of the Metropolitan area of Cagliari, that counts more than 500 thousands inhabitants, stimulated the government of the Sardinian region to fund an innovative project (*Tessuto Digitale Metropolitano*), that will be developed jointly between the Center for advanced studies, research and development in Sardinia and the University of Cagliari. Specifically, the project aims at studying and developing innovative methods and technologies to offer new smart solutions to improve the attractiveness of the city, the management of resources and the safety and quality of life of citizens. These objectives can be pursued through the synergic use and experimentation of advanced communication infrastructures and widespread sensors, and the development of innovative vertical solutions. Among the others, the improvement of citizens' safety against environmental risks is a priority objective, with a special regard to the development of monitoring and prediction systems of extreme precipitation events. In general, common characteristic of these phenomena is that their occurrence cannot be predicted with sufficient accuracy using traditional weather forecasting methods nor monitored by punctual traditional tipping buckets raingauges.

This introduces the need for rainfall monitoring continuously in time and space, both to check their evolution in real time, and to dispose the necessary measures of civil protection. At the same time, the analysis of past observations, in terms of patterns and principal directions, allow to forecast (nowcasting) the occurrence of similar phenomena 30 minutes- 1hour ahead the rain hits the ground.

Following these premises, the Department of Civil, Environmental Engineering and Architecture (DICAAR) of the University of Cagliari installed a weather radar (figure 1, left panel) over the tower-shaft elevator of a building of the Faculty of Engineering and Architecture, University of Cagliari (Lon 9.108720°, Lat 39.228991°). The radar is the SuperGauge model, produced by Envisens Technologies: it is an X-band radar characterized by a single elevation and single polarization, with 1 minute resolution in time and 60 m resolution in range. The radar can monitor an area within a radius of 30 km, with an azimuth resolution linearly increasing with distance up to 1500 m at the maximum distance (30 km). Hence, from the current position the instrument can monitor the whole Cagliari metropolitan area. Each scan is then processed to return the retrieved rainfall field in a regular grid with 60x60 meter grid-cells every minute.

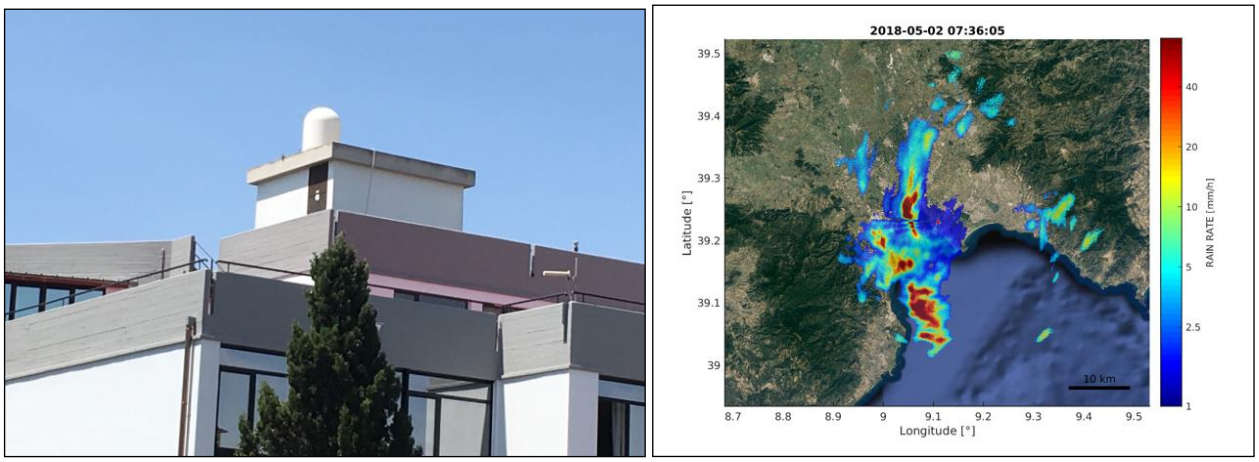

Fig 1: Left: Radar installation site. Right: Rainfall field observed during the 02-05-2018 event.

The radar position was decided in order to limit electromagnetic interferences and minimize the ground clutter effects, which in turns are due to morphology and surrounding buildings. Initially, the radar was set with 0° elevation for the antenna. The first instrument run was during the rain events occurred throughout Sardinia at the beginning of May 2018, which showed high rainfall rates and precipitation volumes. Meteorological models correctly forecasted the storm occurrences and the civil protection issued several warnings of severe weather conditions; as a consequence, several damages were registered. A snapshot of the rainfall field as recorded by the radar during the event of 02-05-2018 is reported in figure 1 (right panel), showing some areas where the rainfall rate exceeds 40 mm/h.

The comparison between the above observations and those collected by the National Radar Network supports the correct functioning of the instrument, at least in terms of registered rainfall patterns. Some adjustments and calibration are still needed: first, in order to minimize the ground clutter, hence improving the quality of the measurements, the elevation angle will be increased up to 3°. Second, rainfall observations inferred by the radar will be accurately adjusted taking the advantage of the Sardinia's rain gauges network.

When retrievals of other events will be collected and available, some nowcasting procedures will be implemented in order to use radar observations also to issue real time warnings. Traditional methods, based on cell tracking, area tracking, and stochastic algorithms will be compared to innovative methods, based on machine learning. Finally, radar and rain gauge data will be integrated with the sensor network envisaged by the abovementioned project, aimed at monitoring multiple environmental parameters (temperature, water level, wind speed, relative humidity). This complete data set will improve the forecast reliability, not only in terms of precipitation fields but also for many other quantities related to environmental security.

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