USE OF RADAR IMAGES FOR THE DEVELOPMENT OF A PROPAGATION ORIENTED SPACE-TIME RAIN MODEL

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This contribution presents the specific analysis carried out on a very large and statistically meaningful database of pseudo-CAPPI (Constant Altitude Plane Position Indicator) radar images which aims at identifying the parameters of a comprehensive space-time model of the rain structures.
The model was originally intended for radio propagation purposes, but its application could be extended to other scenarios where the use of an analytical model easily adaptable to the local meteorological characteristics is of interest, such as hydrology, weather now casting and so on.
The basic assumption of the model is that in any location precipitations similarly organize in aggregates composed of rain cells of different size and peak rain rate [1]. What changes from one location to another one is the rain cell's probability of occurrence,. Specifically:

- Rain cells are defined as closed contoured areas where the rain intensity R exceeds 5 mm/h. They can be modeled as circularly shaped cells, in which the inner rain rate decades exponentially moving away from the cell's center: a rain cell is thus defined according to its peak value, R_M, and its equivalent radius , ρ_0 (for which $R = R_M/e$), following to the well established EXCELL model [2]. The rain cells' number density is analytically derivable from the local complementary cumulative distribution function of point rain rate, indicated in the following as $P(R)$.
- Multiple rain cells (more than one) usually cluster into areas of low intensity rain rate (aggregates).
- Consequently, many rain events almost uniformly distributed within the months which were collected in different years in the Padana valley (northern part of Italy) by an S-band Doppler radar (with a maximum operational range of 100 km) have been analyzed in order to identify:
  - the aggregates ($R > 1$ mm/h);
  - the probability density function of the distance between the barycenters of the aggregates;
  - the rain cells ($R > 5$ mm/h) and their EXCELL characteristic parameters, R_M and ρ_0;
  - the probability density functions of the number of rain cells (dauther cells) and of their inter-distance within each aggregate;
  - the probability density function of the fractional rainy area in the radar maps.

The sequences of radar pictures have been used not only to investigate the natural aggregative process of rain cells but also to derive information about the dynamic characteristics of precipitation: in fact, the temporal resolution of the radar images is 77 seconds, which greatly facilitates the tracking of each cell, separately.
The temporal evolution of some important rain cell parameters have been studied: among them the area and the average rain rate have been specifically addressed. While the analytical modeling of each single indicator was easily achievable, the one of their joint distribution, necessary for the complete description of the rain cells' temporal evolution, was not. Therefore, we focused our attention on the parameters of the corresponding synthetic exponential cell, i.e. R_M and ρ_0. In this case, on the contrary, the joint temporal evolution of such parameters for any rain cell was found to be very similar and to follow a definite hyperbolic behavior, as clearly indicated in Figure 1 (left side): the peak rain value R_M tends to decrease with the increase in the equivalent diameter ρ_0 and viceversa. Consistently with other authors' findings [3], this result highlights a diffusive trend of rain cells.
As the last step of the analysis of the precipitation dynamic, attention was devoted to the modeling of the joint evolution of the daughter cells pertaining to the same aggregate.
All the results achieved in this study, derived from the specific analysis of a set of radar precipitation maps, were utilized to devise a multi-cell model of the rain structures, named MultiEXCELL, that can be adapted to the meteorological features of any site, from the knowledge of the local $P(R)$, and can be made evolve in time [4]: an example of the synthetic rain fields generated by the MultiEXCELL model is shown on the right side of Figure 1. The worldwide generalization of some

parameters of the model would require further verification against similar analysis of radar images collected in different climates.

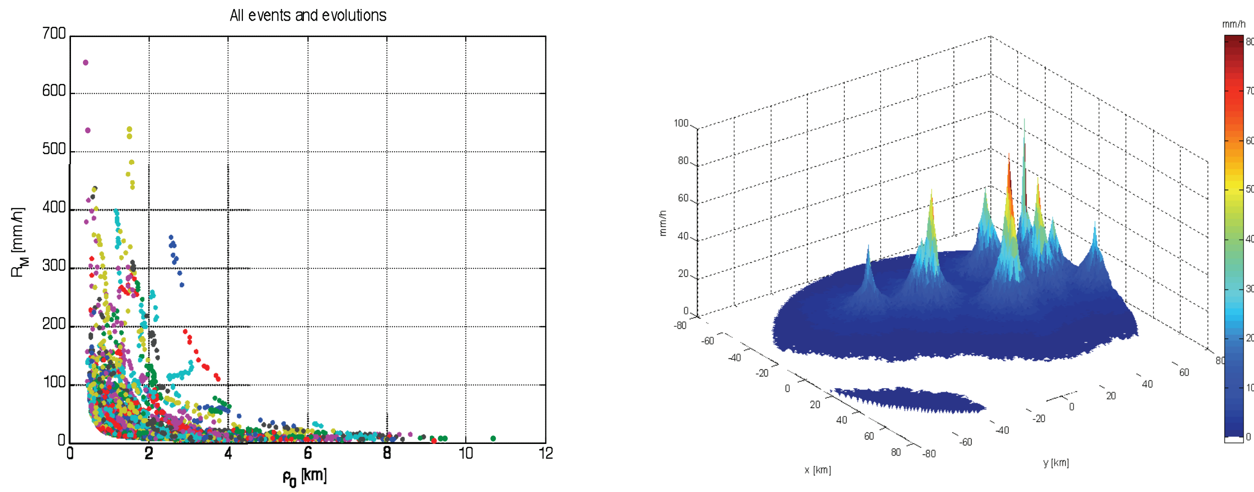

Figure 1. 742 joint evolutions (each one depicted in a different color) of the synthetic rain cell's parameters (R_M and ρ_0) derived from the radar rainfall maps (left side); example of the synthetic rain fields generated by the MultiEXCELL model (right side)

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