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Performance evaluation of the retrieval of a two hours rainfall event through microwave tomography applied to a network of radio-base stations

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Critical precipitation events occurred over the Italian territory have been often characterized by high intensity and very fast development, frequently over small catchment areas. The detection of this kind of phenomena is a major issue that poses remarkable problems that cannot be tackled completely only with 'standard' instrumentation (even when available), such as a weather radars or raingauges. Indeed, the rainfall sampling modalities of these instruments may jeopardize the attempts to provide a sufficiently fast risk alert:
- the point-like, time-integrated way of sampling of raingauges can completely/partially miss local rainfall cores of high intensity developing in the neighborhoods. Moreover, raingauges provide cumulated rainfall measurements intrinsically affected by a time delay.
- In the case of weather radars, several factors may limit the advantages brought by range resolution and instantaneous sampling: precipitation might be sampled at an excessive height due to the distance of the radar site and/or the orography surrounding the valleys/catchments where the aforementioned kind of events is more likely to form up; distance may limit the resolution in the cross-range direction; beam screening due to orography causes a loss of power that is interpreted in the farther range bins as a reduced precipitation intensity.
In this context, a positive role for flagging the criticality of a precipitation event can be played by signal attenuation measurements made along microwave links, as available through the infrastructure of a mobile communications network. Three are the interesting features of such networks: 1) the communications among radio-base stations occur where point-to-point electromagnetic visibility is guaranteed, namely along valleys or between tops/flanks of hills or mountains; 2) the extension of these links (few kilometres) is perfectly compatible with the detection of severe but localized precipitation events; 3) measurements can be made on a practically continuous-time basis.
In the past years, we showed that new scenarios for tomographic rainfall monitoring have been disclosed by the availability of widespread networks of radio-base stations for mobile communications (i.e. GSM, GPRS, UMTS). Such networks could be employed as the backbone of a low cost system able to provide 2D estimates of rainfall in real time. Monitoring capabilities increase in more populated sites, as urban areas, where such radio links form up a dense network that can be exploited to get detailed information also about structure and evolution of rainfall phenomena.
In 2010, we presented a novel tomographic processing method for rainfall rate estimation, specifically adaptable to the dense and asymmetric topologies of urban networks of radio-base stations. In this paper, we show its application to a simulated time sequence of specific attenuation (K) maps, derived from true weather radar data gathered during a rainfall event specifically selected to evaluate the performance of the tomographic retrieval in critical conditions. The event was in fact very localized and intense and lasted two hours. 12 GHz is assumed for the carrier frequency of the radio-base network. We show the reconstruction performance of the 2D K fields achieved resorting first to a symmetric, regular network and then to a couple of totally asymmetric ones.