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Tomography applied to radiobase network for real time estimation of the rainfall rate fields

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Recently we proposed a novel remote sensing method for rainfall rate estimation in real time by means of tomographic processing applied to power attenuation measurements made across the microwave links defined by radiobase station networks for mobile communication systems.
In this paper we present a new tomographic algorithm that has been specifically developed for the typical topology of the urban radiobase station networks. Such algorithm has been tested on simulated specific attenuation (K) maps based on true polarimetric weather radar data. We assumed 18, 23, and 38 GHz for the carrier frequencies of the radiobase network and the weather data gathered by the POLAR55 C polarimetric radar located in Rome, Italy.
Simulation results of rainfall rate estimation applying the new tomographic algorithm to the current radiobase station configuration over the main Italian cities are presented. We simulated the attenuation measurements along the microwave radiolinks by using true polarimetric weather radar measurements (mainly absolute reflectivity ZH and ZV) to which the well known Z-K relationships have been applied. The specific attenuation maps are then used to simulate the power attenuation measurements along the true microwave radiolink network.
We made several simulations using different rainfall events and different radiolink network topologies to test the reconstruction performance of the presented tomographic algorithm. We found out that the number of possible microwave radiolinks of the current urban network is much higher than the number of links that is generally sufficient to provide a quite good estimate of the specific attenuation map. This implies that the radiolink number, that generally is available in a radiobase network of a mobile communication system for a medium-size urban area like that of the main Italian cities, is certainly sufficient for a rainfall estimation system based on the proposed tomographic processing.
The importance of this approach for rainfall monitoring is self-evident, since it would allow to provide high-density rainfall estimates exploiting an existing infrastructure for measurements with a very limited additional cost. In fact high density radiobase station networks for mobile communication systems (i.e. GSM, GPRS, UMTS) are nowadays available, especially in populated urban areas and along the major roads and communication routes. Such radio networks encompass a high number of microwave radio links of different lengths (from hundreds of meters to dozens of kilometers), depending on the relative disposition of the radiobase stations.
The proposed approach could be used to monitor the rainfall rate over critical areas - like dense urban areas or strict valleys crossed by busy motorways - that are generally characterized by the presence of dense radiobase networks but often not (completely) visible by other remote sensing systems such as weather radars that, though more expensive, are limited by orography: in fact, the choice of a radar site in orographically complex areas is often the result of a difficult compromise among different requirements, while the distributed approach of the tomographic network has not this kind of drawback.