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# Country-wide rainfall maps from cellular communication networks

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Accurate rainfall observations with high spatial and temporal resolutions are needed for hydrological applications, agriculture, meteorology, and climate monitoring. However, the majority of the land surface of the earth lacks accurate rainfall information and the number of rain gauges is even severely declining in Europe, South-America, and Africa. This calls for alternative sources of rainfall information. Various studies have shown that microwave links from operational cellular telecommunication networks may be employed for rainfall monitoring. Such networks cover 20% of the land surface of the earth and have a high density, especially in urban areas.

The basic principle of rainfall monitoring using microwave links is as follows. Rainfall attenuates the electromagnetic signals transmitted from one telephone tower to another. By measuring the received power at one end of a microwave link as a function of time, the path-integrated attenuation due to rainfall can be calculated. Previous studies have shown that average rainfall intensities over the length of a link can be derived from the path-integrated attenuation. Here we show how one cellular telecommunication network can be used to retrieve the space–time dynamics of rainfall for an entire country.

A dataset from a commercial microwave link network over the Netherlands is analyzed, containing data from an unprecedented number of links (2400) covering the land surface of the Netherlands (35500 $km^2$). This dataset consists of 24 days with substantial rainfall in June - September 2011. A rainfall retrieval algorithm is presented to derive rainfall intensities from the microwave link data, which have a temporal resolution of 15 min. Rainfall maps (1 km spatial resolution) are generated from these rainfall intensities using Kriging. This algorithm is suited for real-time application, and is calibrated on a subset (12 days) of the dataset. The other 12 days in the dataset are used to validate the algorithm. Both calibration and validation are done using gauge-adjusted radar data. Validation results reveal that the global evolution of rainfall fields can be accurately retrieved from the microwave link data. Hence, it is confirmed that microwave links can be useful for real-time rainfall monitoring over large areas. This is particularly interesting for those countries where few surface rainfall observations are available.