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Reducing bias in rainfall estimates from microwave links by considering variable drop size distribution

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Commercial microwave links (MWL) are point-to-point radio systems which are used in backhaul networks of cellular operators. For several years, they have been suggested as rainfall sensors complementary to rain gauges and weather radars, because, first, they operate at frequencies where rain drops represent significant source of attenuation and, second, cellular networks almost completely cover urban and rural areas. Usually, path-average rain rates along a MWL are retrieved from the rain-induced attenuation of received MWL signals with a simple model based on a power law relationship. The model is often parameterized based on the characteristics of a particular MWL, such as frequency, polarization and the drop size distribution (DSD) along the MWL. As information on the DSD is usually not available in operational conditions, the model parameters are usually considered constant. Unfortunately, this introduces bias into rainfall estimates from MWL.

In this investigation, we propose a generic method to eliminate this bias in MWL rainfall estimates. Specifically, we search for attenuation statistics which makes it possible to classify rain events into distinct groups for which same power-law parameters can be used. The theoretical attenuation used in the analysis is calculated from DSD data using T-Matrix method.

We test the validity of our approach on observations from a dedicated field experiment in Dübendorf (CH) with a 1.85-km long commercial dual-polarized microwave link transmitting at a frequency of 38 GHz, an autonomous network of 5 optical distrometers and 3 rain gauges distributed along the path of the MWL. The data is recorded at a high temporal resolution of up to 30s. It is further tested on data from an experimental catchment in Prague (CZ), where 14 MWLs, operating at 26, 32 and 38 GHz frequencies, and reference rainfall from three RGs is recorded every minute.

Our results suggest that, for our purpose, rain events can be nicely characterized based on only the maximum rain-induced attenuation of an event. Based on our experimental data, optimal results were achieved by classifying the rain events into three distinct groups with different power-law parameters for each group.

In general, the classification of rain events based on attenuation data enables to substantially reduce bias in MWL rainfall estimates due to the power-law model. Thus, when using MWLs for rainfall estimation, reference rain events should be first classified and model parameters of a power-law retrieval model should be fitted for each of class separately. However, this at least requires rainfall data in sub-hourly resolution. It seems very promising to further investigate methods to adjust local MWL rainfall estimates to rainfall observations from traditional sensors.

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