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Rainfall retrieval from E-band commercial microwave links

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Use of commercial microwave links (CMLs) as rainfall sensors was suggested about decade ago. Since then, several studies have confirmed that CMLs operated at frequencies between 20 – 40 GHz, which were up until now most commonly used by mobile network operators as cellular backhaul, can provide reliable rainfall intensity estimates. However, continuously increasing demand on data traffic force mobile network operators utilizing higher frequency spectra. New generation of CMLs operated at E-band (60 – 90 GHz) is, therefore, gradually completing current networks and often even replacing older (20 – 40 GHz) devices. However, up until now, there has not been any studies reported, which would investigate potential of these devices for rainfall retrieval. Compared to lower frequency devices, CMLs operated at E-band are more sensitive to rainfall, nevertheless the relationship between attenuation and rainfall is not anymore linear for these frequencies. Furthermore, attenuation along their path is noticeably influenced by water vapor. Finally, E-band CMLs has usually full-duplex configuration with two channels operating in one direction at 71 – 76 GHz and in the second direction at 81 – 86 GHz with duplex separation 10 GHz. Thus, rainfall intensity can be estimated using standard attenuation-rainfall model but also the model based on differential attenuation, which is, in theory, insensitive to wet antenna effect.

This contribution presents first results from 4.88 km long CML operated within cellular backhaul of T-Mobile, CZ at 73.5/83.5 GHz. Attenuation records are acquired by specially designed server sided application (Fencl et al., 2015). Rainfall intensities are estimated using i) standard and ii) differential attenuation model and compared to reference rainfall obtained from three rain gauges located along the CML path. Dataset spanning over 50 days from October to December 2018 is analyzed. The period was characterized by occurrence of light and moderate rainfalls. Heavy rainfalls were unfortunately not observed during the period.

The standard attenuation model perform for both channels surprisingly good. Relative error in cumulative rainfall is 4.4% resp. -13.9%. The relative error in cumulative rainfall depth estimated by differential attenuation model is -24.8%. This is probably because differential attenuation model is for a 73.5/83.5 GHz CML approximately five times less sensitive to rainfall intensity than standard attenuation-rainfall model. The results show that E-band CMLs are capable to reliably capture light and moderate rainfalls, which is in contrast to 20 – 40 GHz CMLs, which are often substantially biased during lighter rainfalls due to wet antenna effect. It can be, however, expected that rainfall estimates during heavy rainfalls, which are often characterized by high spatial variability will be more affected by non-linear attenuation-rainfall relationship. Nevertheless, radiowave attenuation by raindrops is at E-band sufficiently high to enable use of short (sub-kilometer) CMLs for rainfall retrieval, which will be less prone to errors due to rainfall spatial variability.

Fencl, M., Rieckermann, J., Sýkora, P., Stránský, D. and Bareš, V.: Commercial microwave links instead of rain gauges: fiction or reality?, Water Sci. Technol., 71(1), 31–37, doi:10.2166/wst.2014.466, 2015.