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Improving rainfall quantitative estimates by combining microwave links of different lengths

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Abstract

Rainfall retrieval from commercial microwave links (CMLs), point-to-point radio connections widely used as cellular backhaul, is a promising method which can be used to either complete existing monitoring networks (Stránský et al, 2018) or provide standalone rainfall observations where standard instruments are sparse or missing completely (Doumounia et al., 2014). The method is based on robust power-law relation between rainfall intensity and radiowave attenuation caused by raindrops along the path between transmitter and receiver. Nevertheless, raindrop path attenuation needs to be first separated from other sources of attenuation, particularly so called wet antenna attenuation (WAA). The WAA is caused by water film forming on the surface of CML antennas or their radomes and is related not only to the rainfall but also other environmental variables such as wind, humidity or temperature and furthermore to the antenna hardware properties (e.g. radome shape or coating). Thus, WAA is difficult to quantify. There have been several models suggested (for an overview see e.g. Schleiss et al., 2013) to estimate and correct for WAA, nevertheless, different studies came to contradicting conclusions regarding the relation between WAA and rainfall intensity. Thus, WAA remains one of the major sources of uncertainty in CML rainfall estimates. The bias due to WAA is especially pronounced by shorter CMLs of (sub)kilometer lengths where WAA represent substantial part of total attenuation. On the other hand, short CMLs having similar length scales as urban catchments are potentially the most informative ones for applications such as urban drainage modeling.

This contribution suggests a novel approach where attenuation from different CMLs is combined to reduce bias due to WAA while preserving ability of CMLs to reproduce rainfall temporal patterns. Three short CMLs (610- 910 m) covering well small urban catchment (2.3 km^2) are adjusted to hourly rainfall intensities from a long CML (2.61 km). Modified procedure of Fencl et al., (2017) is used for adjusting. CML rainfall estimates at one-minute temporal resolution spanning over period from August to October 2014 are compared with areal rainfall from four rain gauges located in the catchment. Nash-Sutcliffe efficiency index and relative error in cumulative rainfall is used to evaluate performance of the CMLs during each of the 13 rain events (rainfall depth > 5 mm) occurring within the experimental period. Furthermore, areal rainfall obtained by averaging precipitation estimates from three short CMLs is assessed.

The first results show that the shorter CMLs perform substantially better when adjusted to the long CML even when the long CMLs is on average biased. Nevertheless, the overall bias of the longer CML propagates to adjusted rainfall estimates (Fig. 1, top). The NSE for best performing adjusted short CML (S1) ranges between 0.44 and 0.72 with median 0.66. The NSE for mean rainfall from three short CMLs is between 0.38 and 0.76 with median 0.61. These are substantially better results than for short unadjusted CMLs (Fig. 1, bottom-left). The adjusted short CMLs also outperform the single long CML to which they were adjusted. The results demonstrate that combined use of long and short CMLs can improve CML rainfall estimates. This is especially useful for catchments where traditional rainfall observations are sparse or missing completely. Nevertheless, the current method suffers from WAA affecting longer CMLs to which shorter ones are adjusted. Our further research, therefore, focuses on eliminating effect of WAA on long CMLs using information from short CMLs, i.e. extending presented method by a pre-step where short

CMLs are first (before being adjusted) used for quantification and correction for WAA affecting long CMLs.

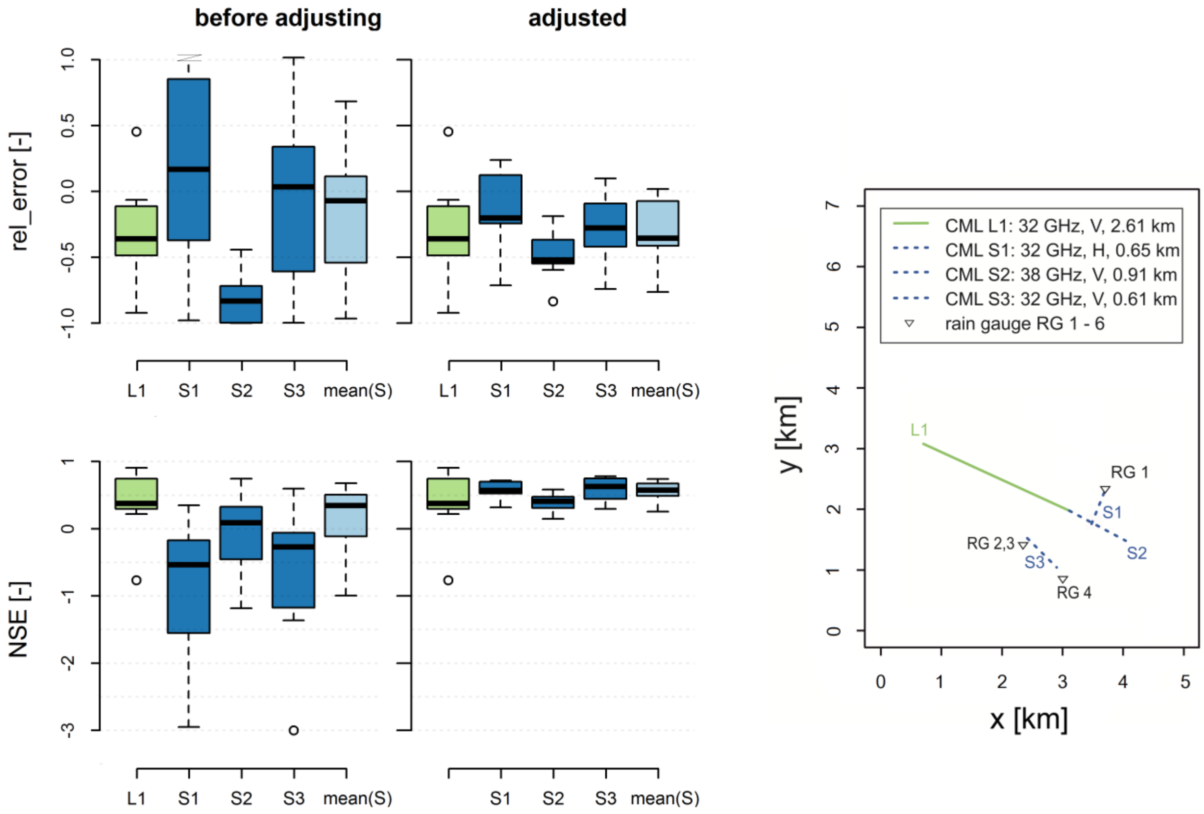

Fig 1: Relative error (top) and Nash-Sutcliffe efficiency index (bottom) evaluated on one long CML (L1), three short (S1-S3) CMLs, and mean rainfall from the three short CMLs (mean(S)) Performance statistics is evaluated for each of the 13 rain events. Adjusted rainfall estimates (right) have substantially higher NSE than before adjusting (middle). Experimental layout of four CMLs and five RGs (right).

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