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Improving discharge predictions and uncertainty estimates in a small urban catchment using commercial microwave links

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Rainfall observations with high spatio-temporal resolutions are required for a wide range of urban hydrological applications. The requirements on rainfall data are particularly high when predicting discharges in catchments with short lag times between rainfall and runoff peaks. Commercial microwave links (CMLs) can help in this regard, as they densely cover urban areas and can provide quantitative precipitation estimates (QPEs) at high temporal resolution. This study i) investigates how to reduce systematic errors in CML QPEs using rainfall and runoff observations commonly available in urban areas and ii) evaluates the potential of CML QPEs for modeling discharge and its uncertainty in a small urban catchment.

The catchment is located in a suburb of Prague (CZ), has an area of 1.3 km^2 (35 % impervious surfaces) and is drained by a stormwater sewer system. Rainfall data are retrieved from 16 CMLs operated between 25 and 39 GHz, four municipal rain gauges located outside of the catchment, and three temporarily deployed rain gauges located at the border of the catchment. Discharge is measured at the outlet of the catchment. The dataset spans the period between July 2014 and October 2016 during which we observed 46 rainfall events with the average rainfall depth exceeding 2 mm. We randomly selected 23 events and used them for optimizing CML QPEs, whereas the remaining 23 events were used in the subsequent validation stage for evaluating the CML performance. CML QPEs are optimized using rainfall data observed by rain gauges at different distances from the catchment. Furthermore, we investigate how to optimize CML QPEs by comparing simulated and observed discharges. Rainfall data are propagated through the rainfall-runoff model and the simulated discharges are compared to the those observed at the outlet of the catchment. Finally, uncertainties in the simulated discharge are estimated by extending the deterministic hydrodynamic model by a stochastic error model explicitly accounting for model bias (Pastorek et al., 2022).

The results show that discharge simulations with CML QPEs outperform simulations with the rain gauges used alone and are only slightly worse than the benchmark simulations with three rain gauges located in the catchment (1 gauge per 0.5 – 1 km^2). The best performance is achieved with CML QPEs optimized by the three closest municipal rain gauges (about three km from the catchment); CML QPEs optimized by the observed discharges achieve only slightly worse performance. The estimated discharge uncertainty reflects well different quality of the input rainfall data, i.e. the width of uncertainty bands increases when more distant RGs are used to

optimize CML QPEs. We also show that even a single rain gauge located 8 km from the catchment, which is simply too far to be used alone for rainfall-runoff modeling, can efficiently reduce systematic errors in CML QPEs. Overall, the results show that CMLs can complement existing monitoring networks and significantly improve rainfall-runoff modeling including uncertainty estimation.

References:

Pastorek, J., Fencl, M., Bareš, V., 2022. Uncertainties in discharge predictions based on microwave link rainfall estimates in a small urban catchment. Journal of Hydrology 129051. https://doi.org/10.1016/j.jhydrol.2022.129051