Urban rainfall estimation employing commercial microwave links

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Introduction

In the Rain Sense kickstart project of the Amsterdam Institute for Advanced Metropolitan Solutions (AMS), sensors and citizens are preparing Amsterdam for future weather. Urban areas often lack rainfall information. Hence, new rainfall measurement techniques are important. E.g., the number of observations may be increased by employing microwave links from operational cellular telecommunication networks. Rain-induced attenuation and, subsequently, path-averaged rainfall intensity can be retrieved from the signal's attenuation between transmitter and receiver of a link (Figure 1). Although this new potential source of rainfall information is promising (e.g. Messer *et al.* (2006), Leijnse *et al.* (2007), Overeem *et al.* (2013)), its quality needs to be demonstrated more extensively, which is done here for Amsterdam.

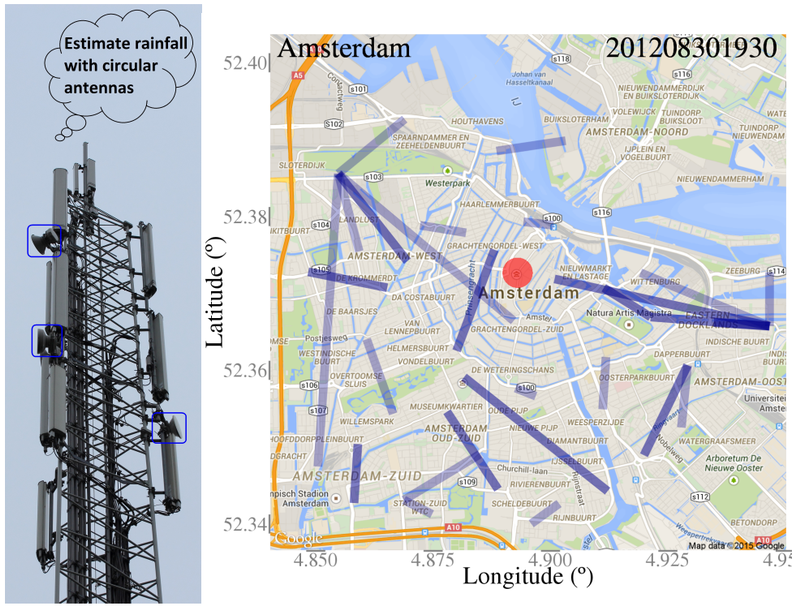

Figure 1: *Map with locations of microwave links used for rainfall estimation in Amsterdam, The Netherlands. The red circle shows the location for which rainfall time series have been extracted.*

Results

Figure 2 shows that the links are able to detect a rainfall gradient across Amsterdam. The gradient and the rainfall values match fairly well with those of the gauge-adjusted radar data set. Next, link-based rainfall intensities are computed for the center of Amsterdam for this day. They agree well with the radar-based ones (Figure 3).

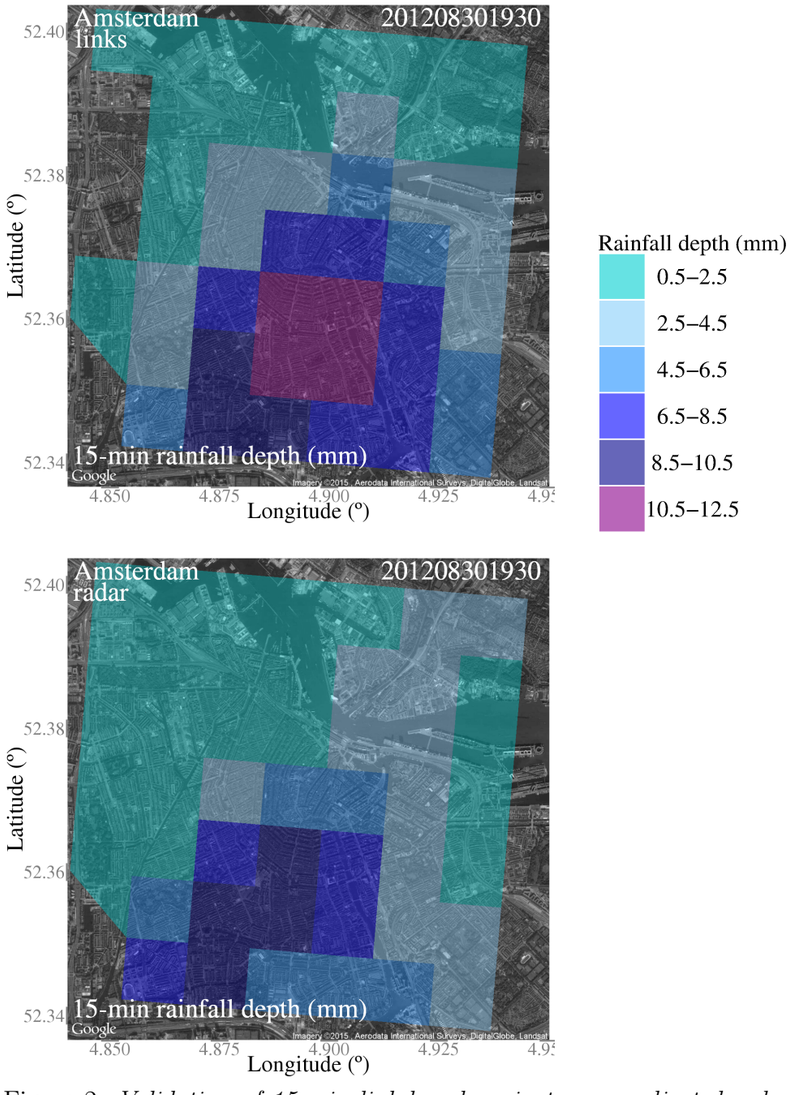

Figure 2: *Validation of 15-min link-based against gauge-adjusted radar rainfall maps. Spatial resolution is 0.9 km^2.*

Finally, link-based and radar-based cumulative rainfall depths are obtained for the year 2012. Although the dynamics of rainfall depths from radar and links are often comparable, sometimes sudden jumps in the link rainfall depths are found. This leads to a large overestimation by links over the entire year. The annual rainfall sum is 1831 mm for links compared to 1180 mm for radar. Plausible causes for this overestimation are dew formation on the antennas and melting precipitation at the link path or the antennas. Correction methods will be developed.

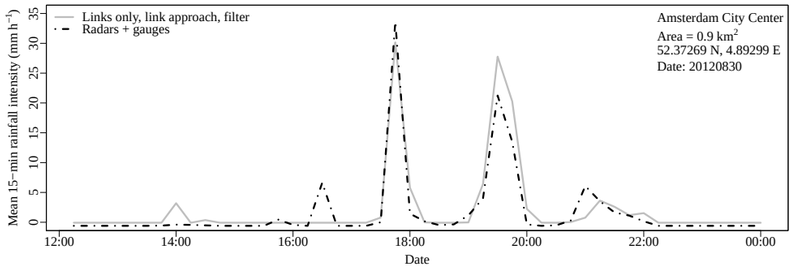

Figure 3: *Validation of link-based against gauge-adjusted radar rainfall intensities for the city center of Amsterdam for one rain event.*

Outlook

The Rain Sense kickstart project aims to combine data from many different sensors and to use information provided by citizens in an active way through smartphone apps and in a passive way through social media posts. Sensor information will be integrated, visualized and made accessible to citizens to help raise citizen awareness of urban water management challenges and promote resilience by providing information on how citizens can contribute in addressing these. In the end city-wide high-resolution rainfall maps will be derived, blending rainfall information from microwave links and weather radars. This information will be used for urban water management.

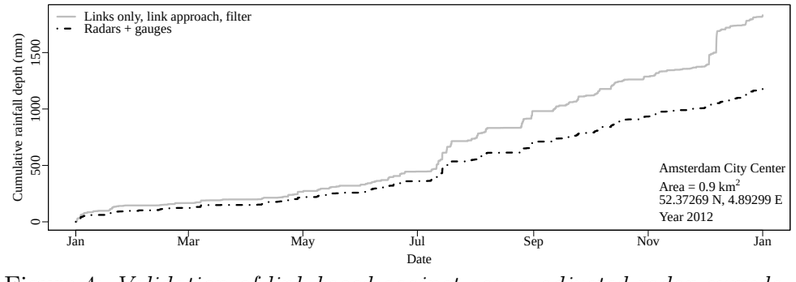

Figure 4: *Validation of link-based against gauge-adjusted radar cumulative rainfall depths for the city center of Amsterdam for the year 2012.*

References

Leijnse, H., Uijlenhoet, R., and Stricker, J.N.M., 2007. Rainfall measurement using radio links from cellular communication networks, *Water Resour. Res.*, **43**, W03201.
Messer, H.A., Zinevich, A., and Alpert, P., 2006. Environmental monitoring by wireless communication networks, *Science*, **312**, 713.
Overeem, A., Leijnse, H., Uijlenhoet, R., 2013. Country-wide rainfall maps from cellular communication networks, *Proc. Nat. Acad. Sciences*, **110**, 2741-2745, http://www.pnas.org/content/110/8/2741.