Measuring rainfall in urban areas using commercial cellular telephone networks

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Outline



- Methodology
- ▶ Weather radar and commercial microwave link data
- ▶ Verification of link-based rainfall intensities
- Conclusions

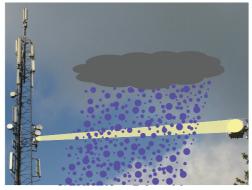
Methodology



Commercial cellular telephone network from one provider

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Methodology



Messer et al. (2006), Leijnse et al. (2007)

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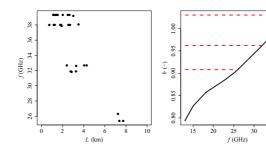
Methodology

$$\begin{split} R_{gsm} &= ak^b \\ A_m &= \int_0^L k(s) \mathrm{d}s = P_{ref} - P_{min} \\ R_{gsm} &\approx a \cdot \left[\frac{(P_{ref} - P_{min})}{L} \right]^b \\ \overline{R} &= a \left(1 + 0.5 b(b-1) C V_k^2 \right) \overline{k}^b \end{split}$$

- $ightharpoonup R_{gsm}$: link-based maximum rainfall intensity (mm/h)
- $ightharpoonup A_m$: path-integrated attenuation (dB)
- $ightharpoonup P_{min}$: minimum received power during 15 min (dBm)
- ▶ P_{ref}: reference level of received power (dBm)
- ▶ L: link length (km)
- ▶ a, b: coefficients

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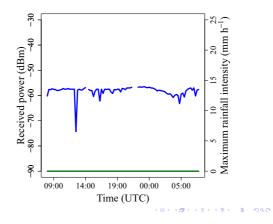
Methodology



Weather radar and commercial microwave link data



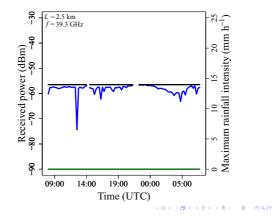
- ► Minimum and maximum received power over 15 min (10 Hz sampling)
- ▶ 18 days with on average 27 links
- ► At least 83% data availability per day
- ▶ June and July 2009
- Several rainy days
- Path-averaged radar rainfall intensities (5 min, 1 × 1 km²)

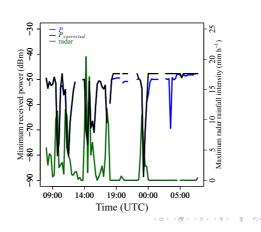


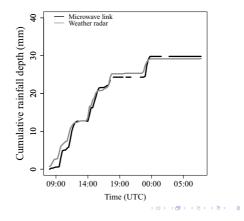
Correcting the minimum received power signal from a single link from one day (8-8 UTC):

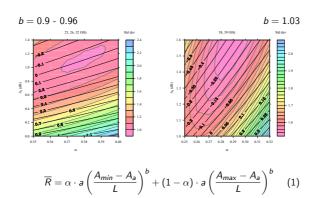
- ▶ Select a single link and all nearby links within 10 km
- ► A 15-min period is considered wet if several links have low minimum received powers.
- ▶ Repeat these steps for all other links and every 15-min period

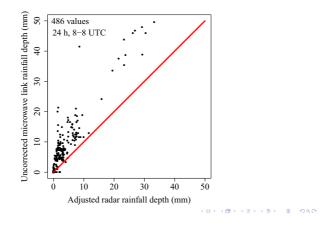


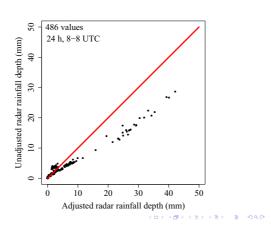


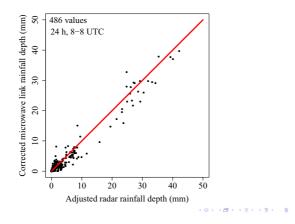


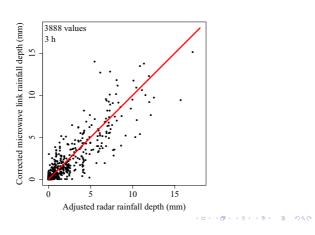


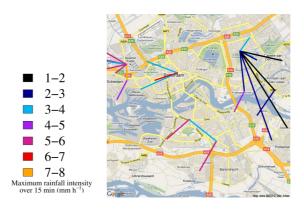














Conclusions



- ▶ 18 days of data from on average 27 commercial microwave links
- ► Combining nearby links leads to a good classification between dry and rainy spells (over 90%)
- ➤ Dynamics of link-based maximum rainfall intensities in good correspondence with those based on radar
- ► Verification shows that quantitative precipitation estimation using microwave links holds a promise

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