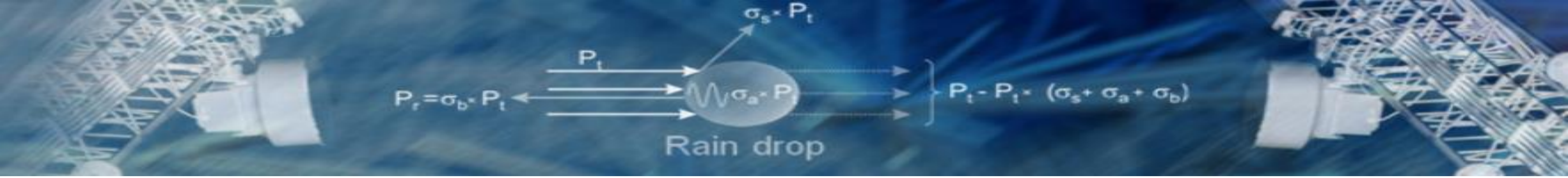


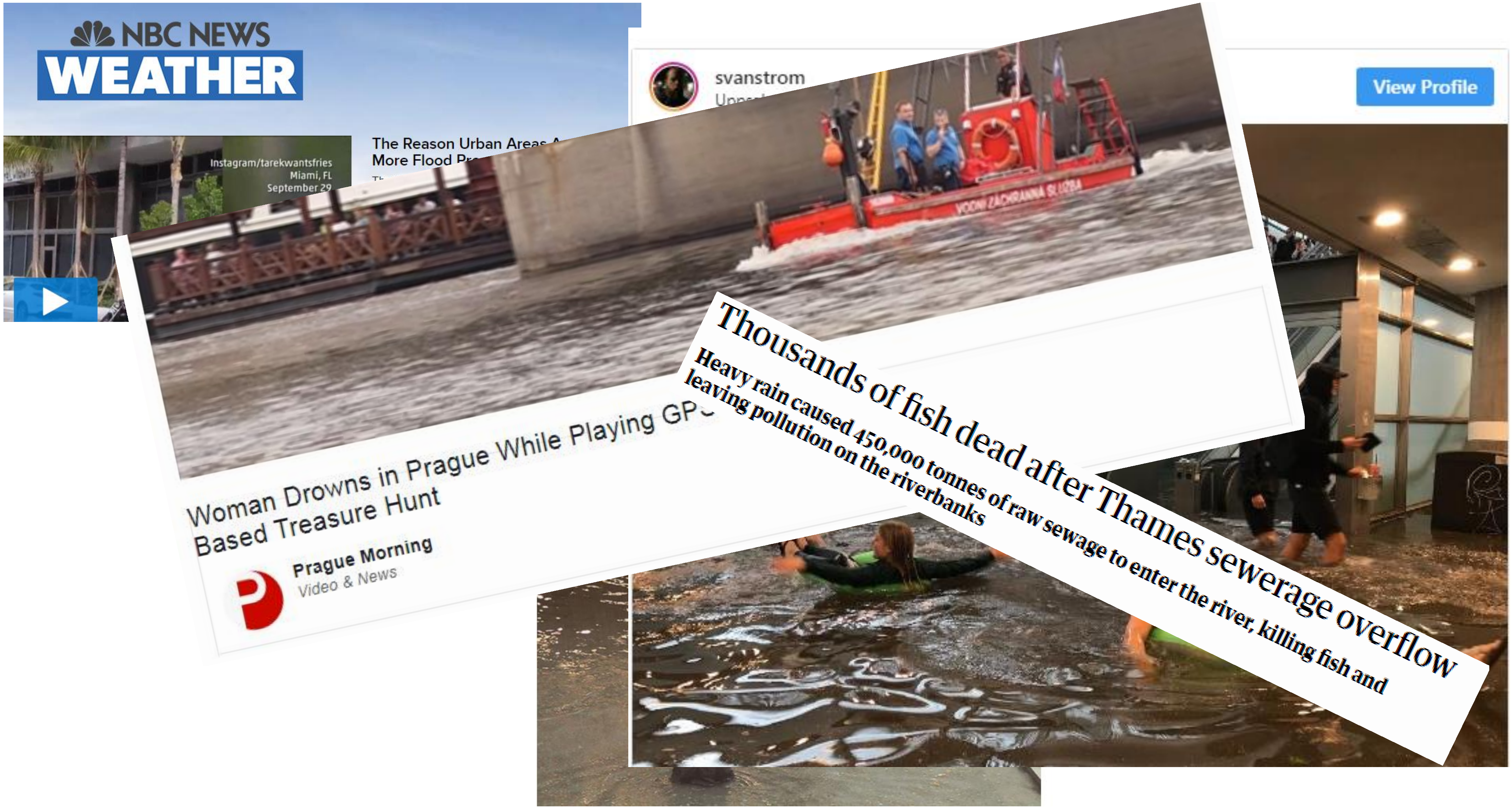
Commercial Microwave Links for Urban Rainfall-Runoff Modelling

Opportunistic rainfall data in Urban storm-water management

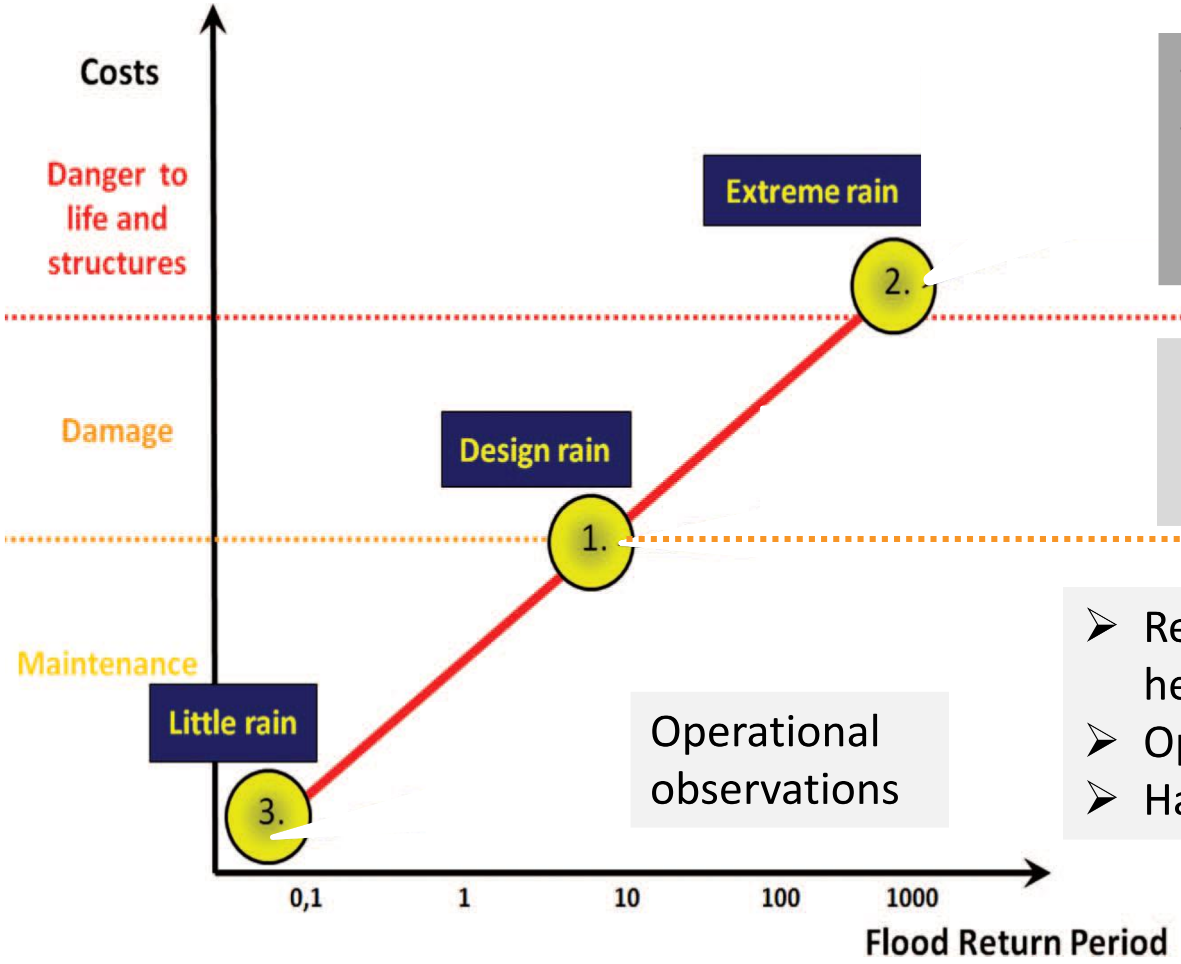
Vojtěch Bareš
Martin Fencl
Jaroslav Pastorek
Martin Mudroch
Pavel Pechač

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

Recent urban water collection systems face many problems related to rainfall



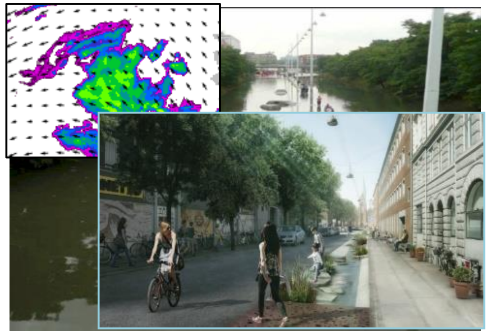
Storm-water management domains



- Early flood warning
- Design rains for urban re-design, climate projections

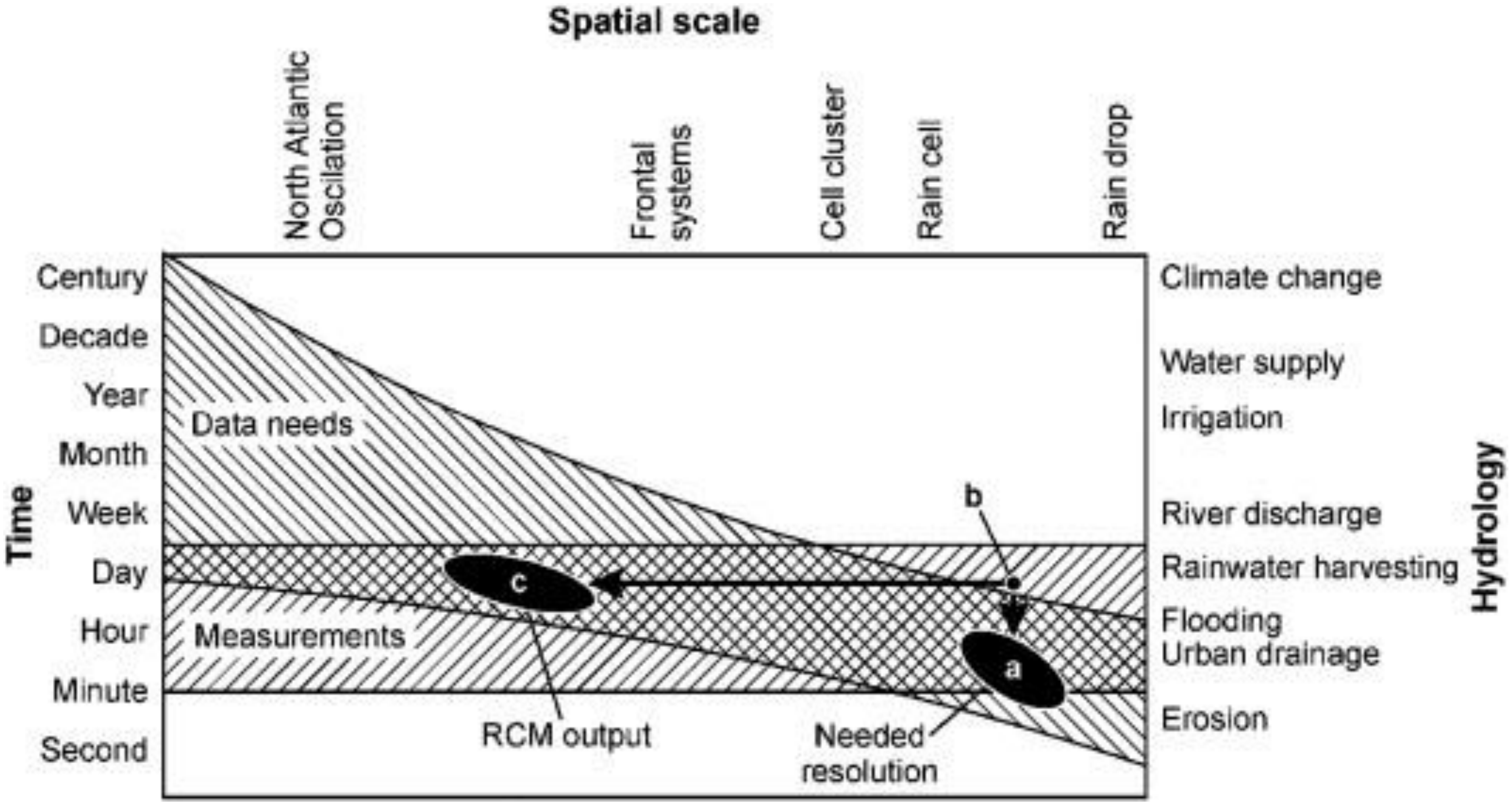
- Operational observations
- Design rains

- Reduce pollution and health risks
- Optimize operation costs
- Harvest rain water



Fratini, C.F., et al. (2012). Three Points Approach (3PA) for urban flood risk management: A tool to support climate change adaptation through transdisciplinarity and multifunctionality. Urban Water J. 9 (5), 317.

Rainfall data requirements in urban hydrology

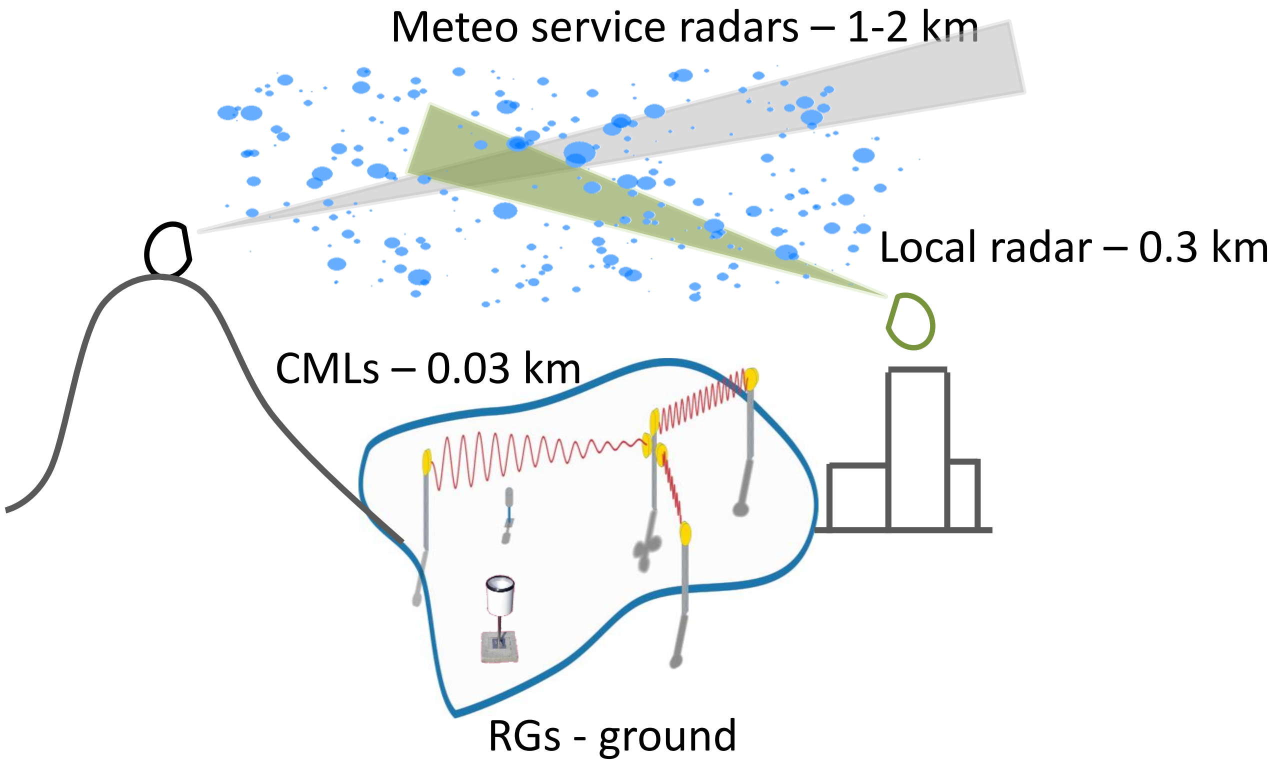


Willems P. et al. (2012). Climate change impact assessment on urban rainfall extremes and urban drainage: Methods and shortcomings. *Atmospheric Research.* 103, 106-118

Urban rainfall monitoring with Commercial microwave links

Features of CML rainfall observation system:

- CMLs provide close-to-ground path-integrated QPEs
- CML lengths are mostly between 0.1 – 20 km



Urban rainfall monitoring with Commercial microwave links

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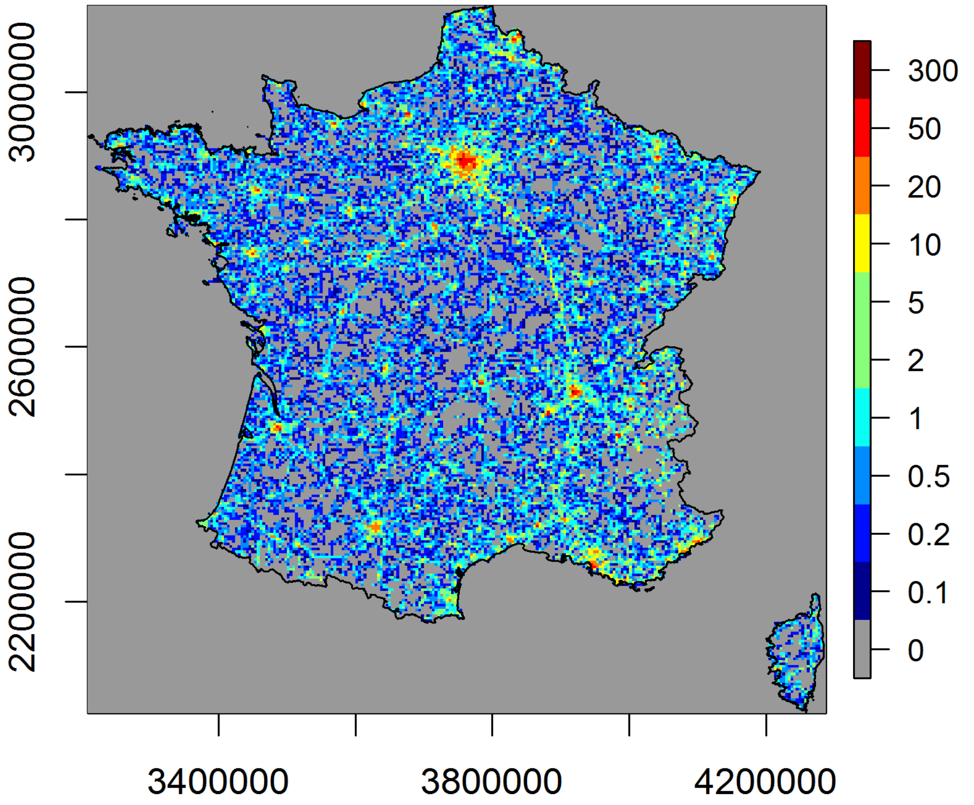
- CML network is densest in populated areas

Number of CMLs per 4 x 4 km²



Urban rainfall monitoring with Commercial microwave links

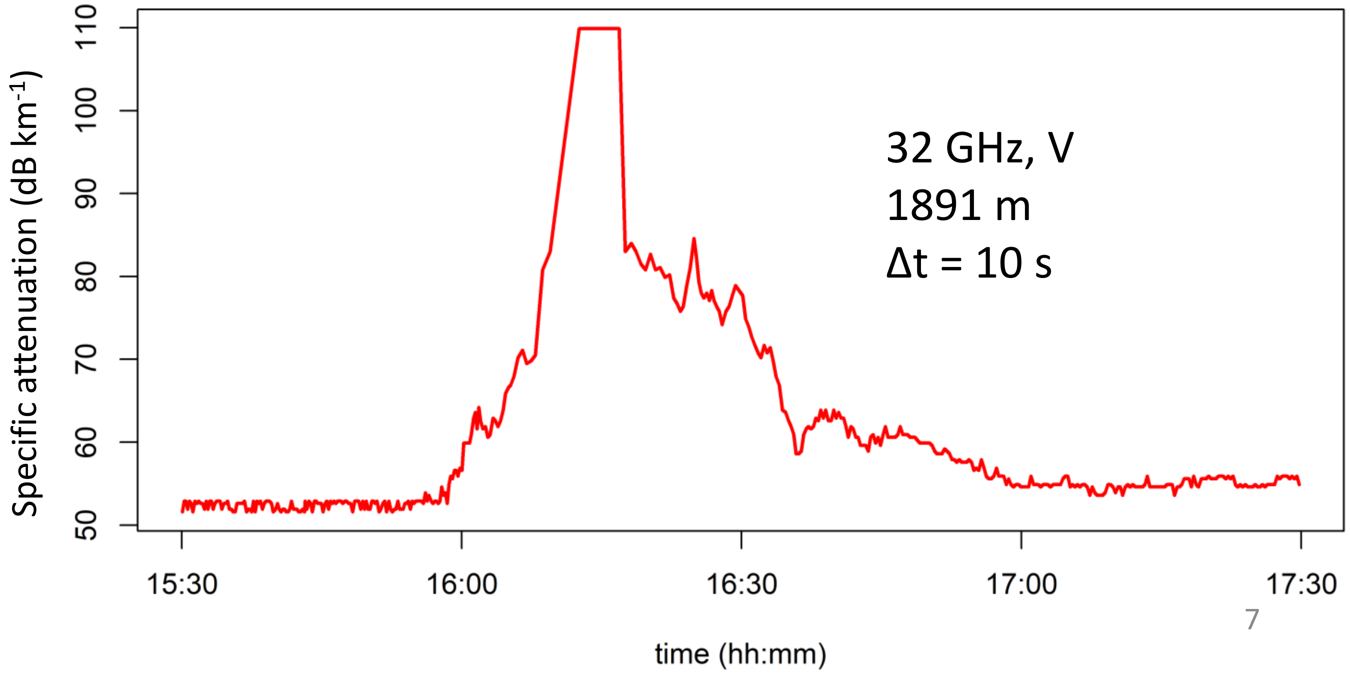
Features of CML rainfall observation system:

- CMLs provide close-to-ground path-integrated QPEs
- CML lengths are mostly between 0.1 – 20 km
- CML network is densest in populated areas
- SNMP data acquisition can provide data with minimal delay with Δt = 10 s

How can CML observations improve urban rainfall-runoff modeling?

How to make this data accessible to (and useful for) urban water utilities?

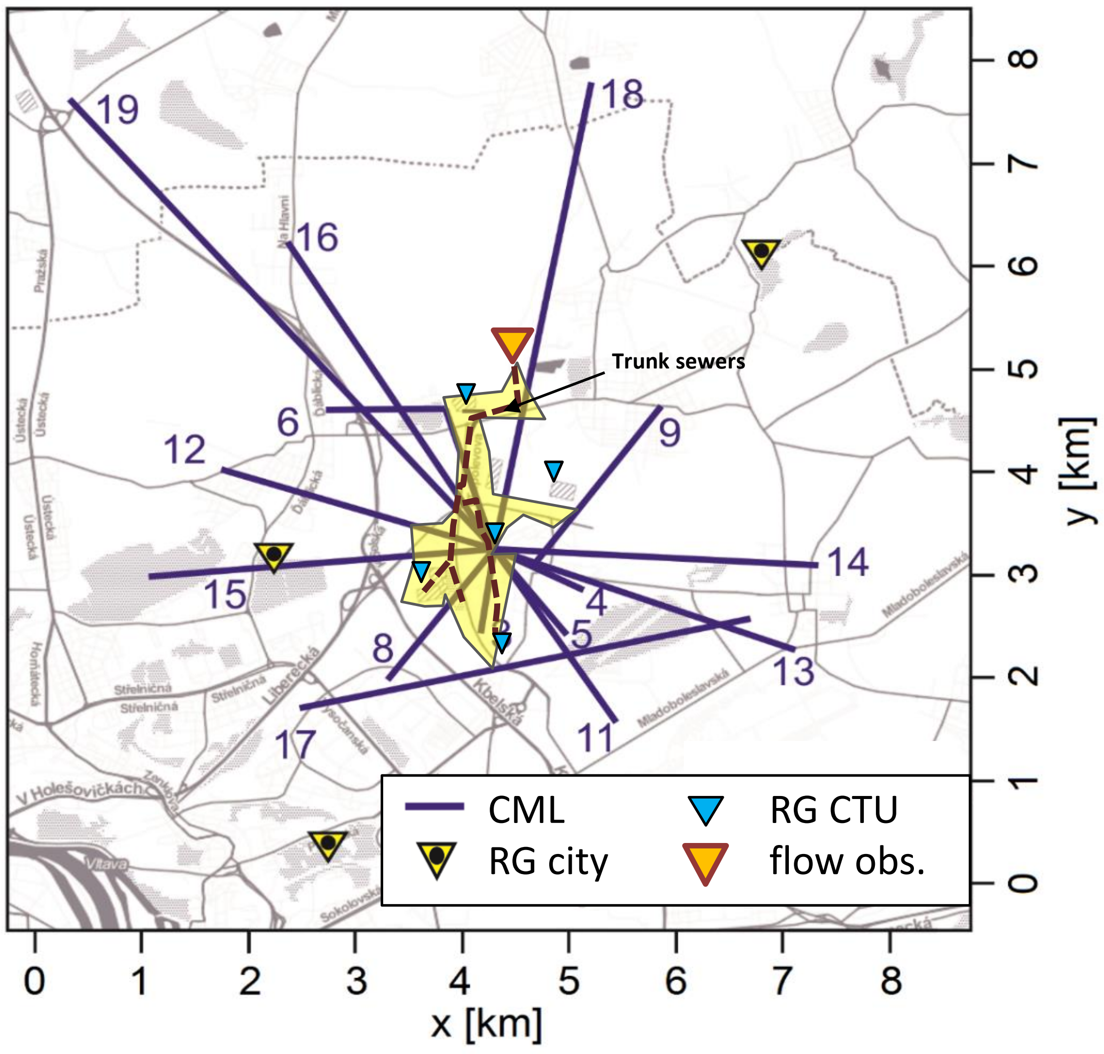
CML outage during heavy rainfall (≈ 5 min per year)



Small urban catchment scale Prague

Validation using data set spanning over 3 seasons

Urban catchment Prague-Letnany



Catchment:

- Area 1.3 km^2 drained by storm-water sewer with slopes < 1.5 %.
- Residential and industrial land use
- 35 % of impervious surfaces

Observations:

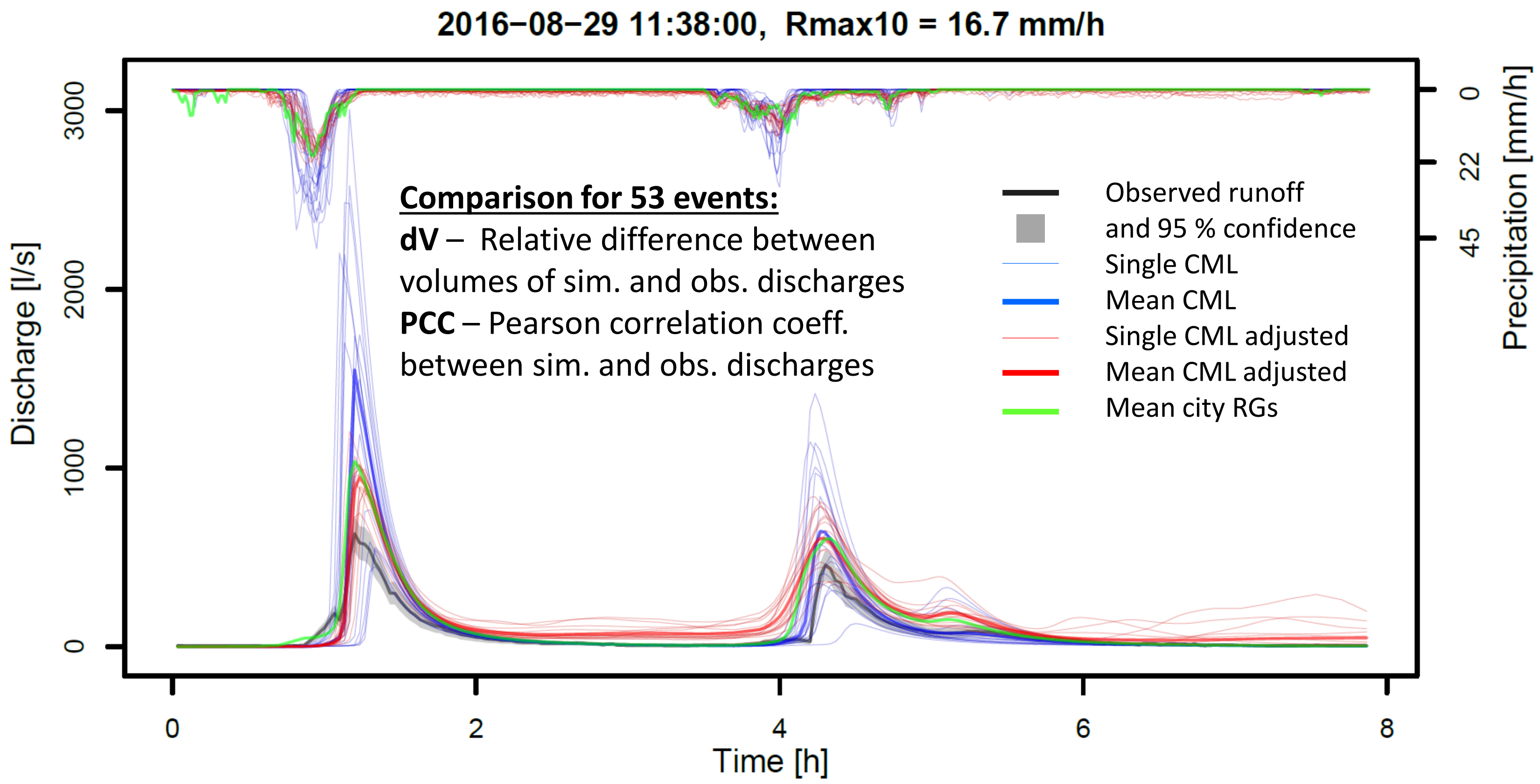
- In-sewer flow meter
- 8 tipping bucket rain gauges
- 19 CMLs (25, 32, 38 GHz)
  L = 0.6 – 5 km, Δt = 10 s

Rainfall-runoff model:

- SWMM distributed rainfall-runoff model describing surface flow and pipe flow (1D)

Small urban catchment scale Prague

Comparing simulated and observed runoff

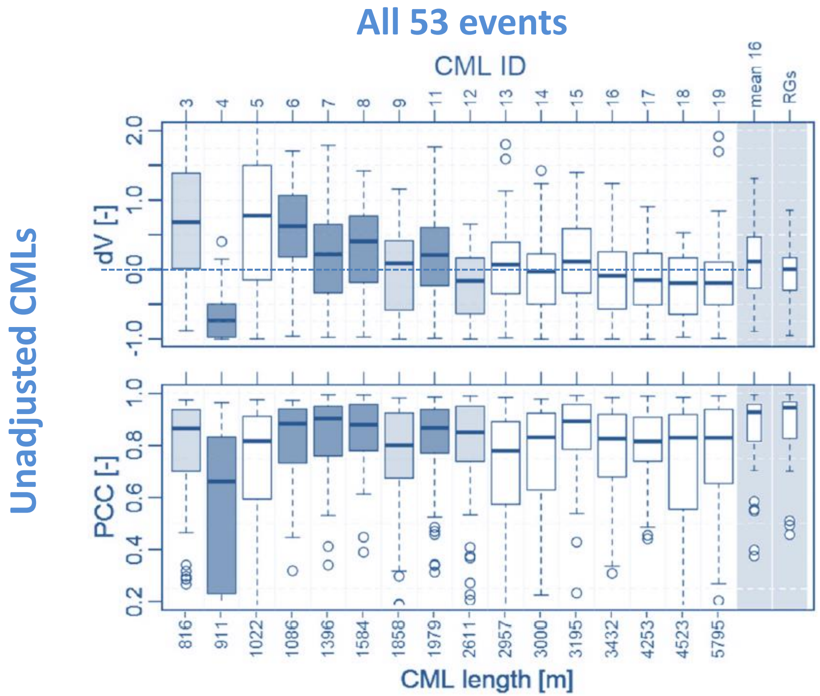


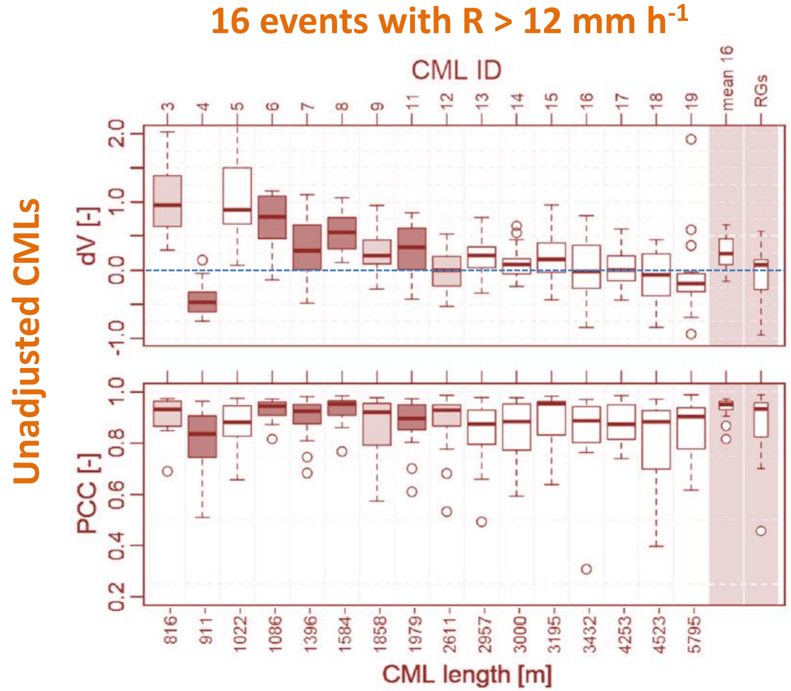
- Unadjusted CML describe reliably event dynamic but they are biased
- Adjusted CMLs perform similarly to rain gauges used for the adjustment

Pastorek, J., et al. (2019). Commercial microwave links for urban drainage modelling: The effect of link characteristics and their position on runoff simulations. *Journal of Environmental Management.*

Small urban catchment scale Prague

Comparing simulated and observed runoff





- Longer CMLs are less biased, shorter CMLs (1 – 1.5 km) have highest PCC
- CMLs are better for modeling runoff during heavy rainfalls
- QPEs averaged from all CMLs are most reliable input for runoff modeling

➢ Short CMLs corresponding to catchment scale capture very well runoff dynamics, but are sensitive to systematic errors related to hardware (quantization, wet antenna attenuation)

- CML adjustment to RGs reduce bias but destroys PCC (CMLs resemble RGs)

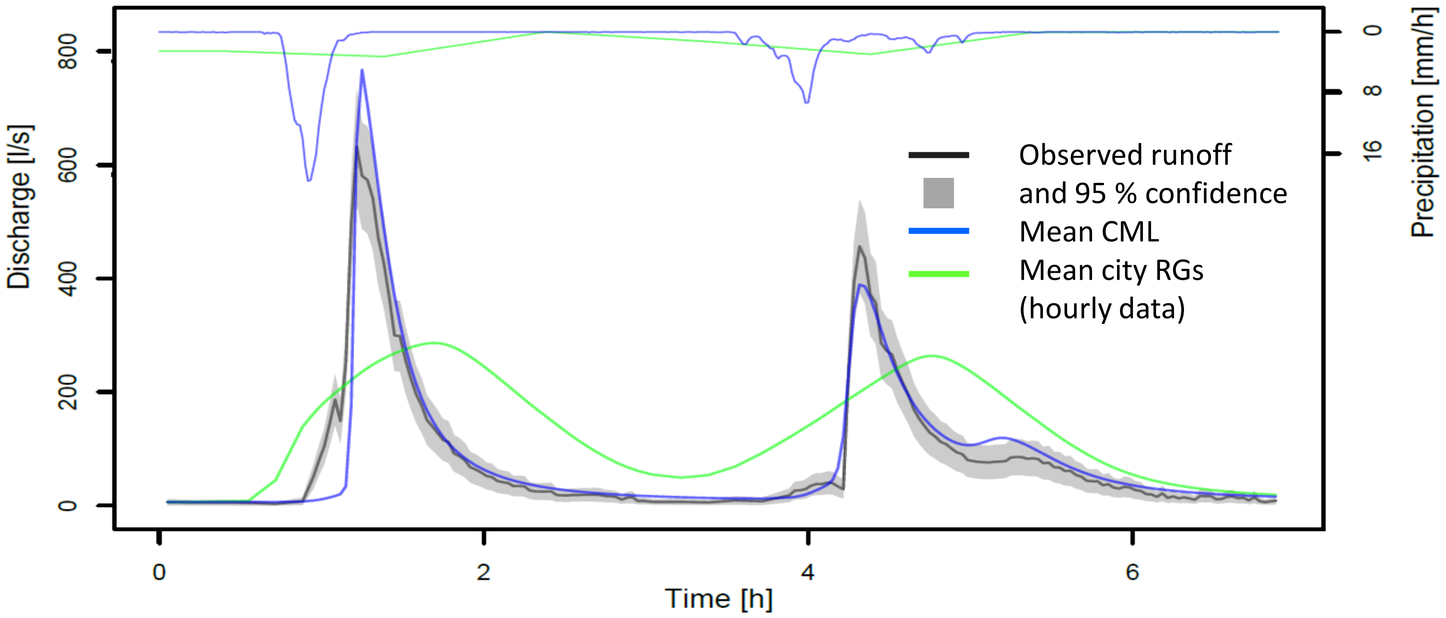
Small urban catchment scale Prague

Improved wet antenna attenuation correction

- Evaluation of different wet antenna attenuation (WAA) models
- WAA model calibration with observations from existing permanent networks

Pastorek, J., et al. (2020, *under review*). Precipitation Estimates from Commercial Microwave Links: Practical Approaches to Wet-antenna Correction, *Geoscience and Remote Sensing Letters.*

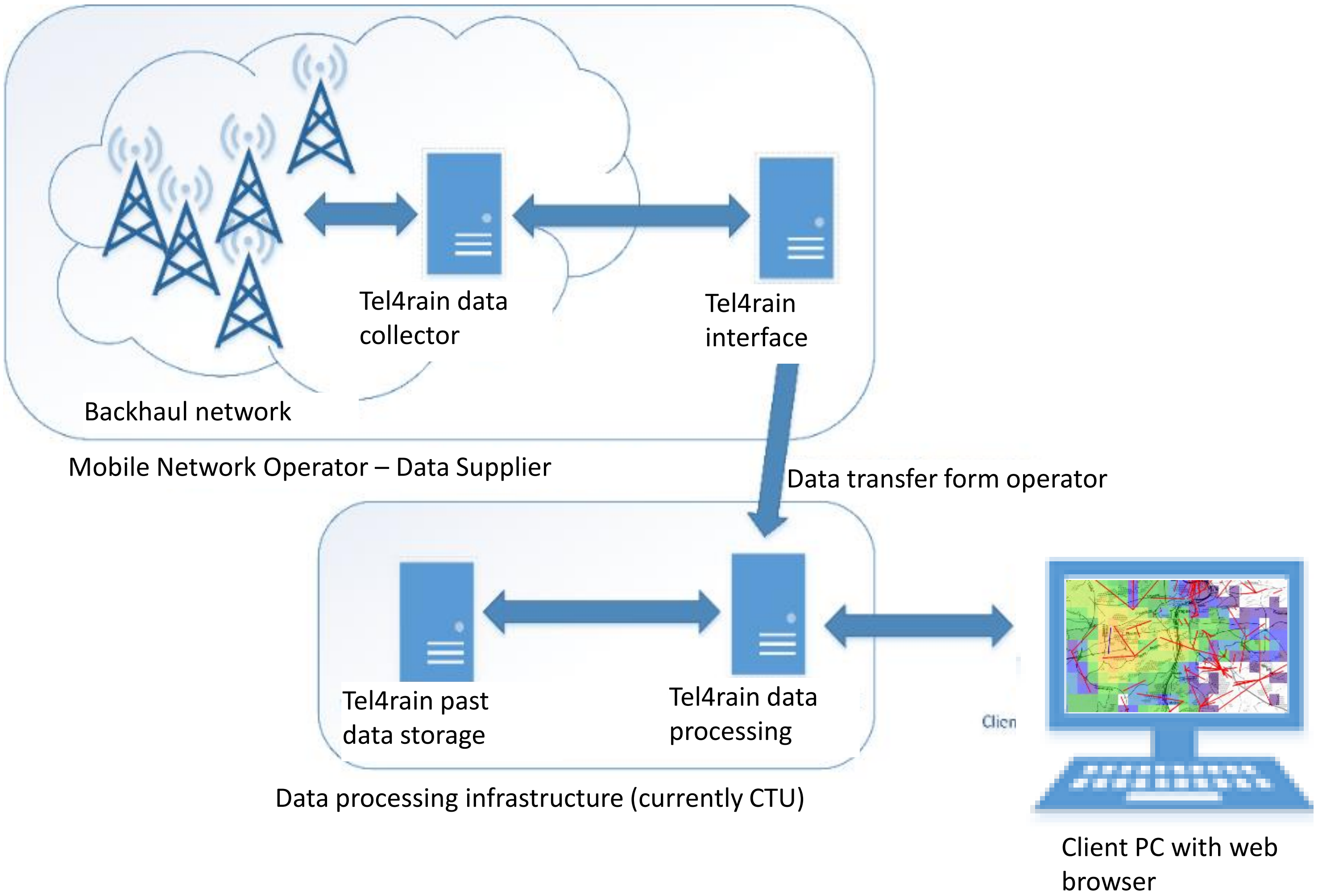
CMLs (mean QPEs) with WAA correction calibrated to hourly RG data:



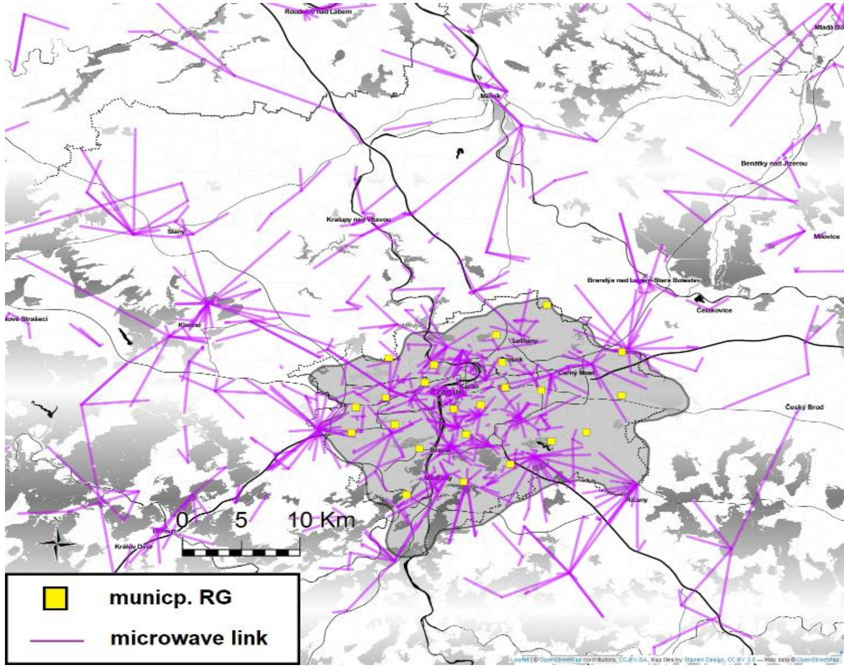
- CML based runoff simulations are comparably good to simulations with experimental RG network (5 RGs temporarily installed into the catchment)

Operational monitoring at city scale

- Real-time gridded CML product at Δt = 1 min
- Project involves T-Mobile + Prague water utility



Domain - Prague region



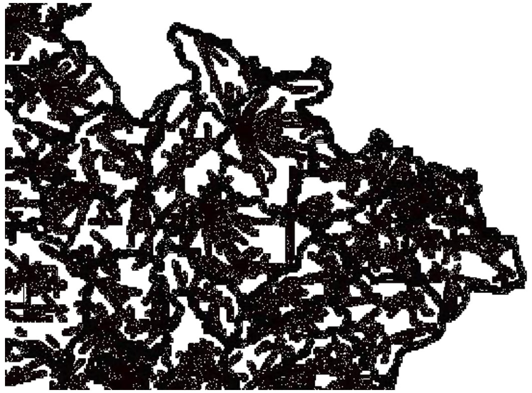
- 800 CMLs + 23 RGs
- CML QPEs with delay ≈ 1 min

Online tour

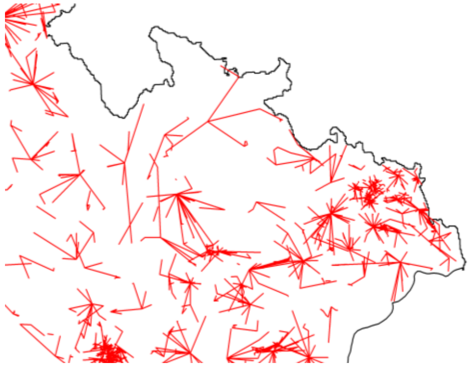
http://dev2.tel4rain.cz

Challenges related to network development

Business-related (network operation outsourcing)

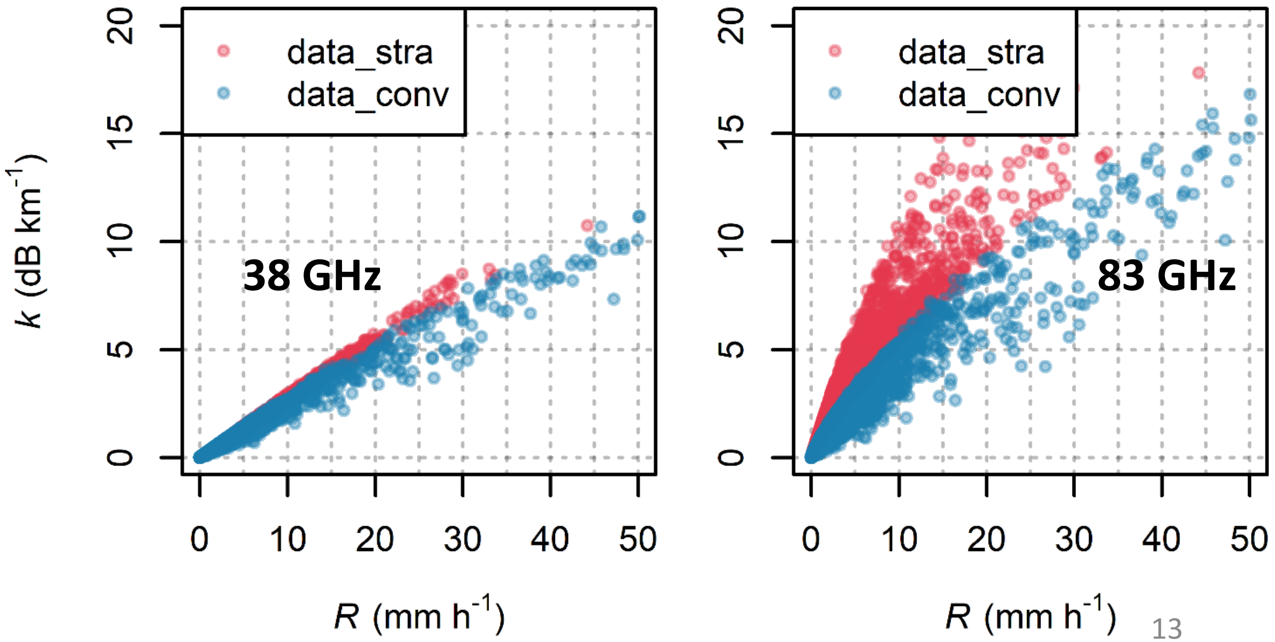


2015-2016



2017-2018

Technology-related (E-band CMLs)



E-band CMLs

- are more sensitive to light rainfalls
- … and to drop size distribution
- can detect water vapor

Fencl, M., et al. (2020). Atmospheric observations with E-band microwave links: Challenges and Opportunities. *Atmospheric Measurement Techniques Discussion*

Conclusions

Runoff simulations with CML QPEs

- capture very well temporal dynamics of discharges
- are more reliable during heavy rainfalls
- require wet antenna attenuation correction to simulate reliably volumes

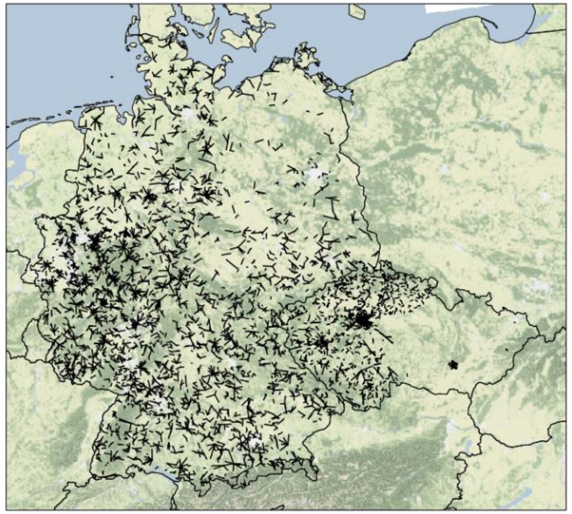
Wet antenna attenuation models

- can be calibrated with existing rain gauge networks
- but how to select appropriate model without rain gauges?

CML rainfall observation system

- Online data in real-time (≈1-min delay) till the end of 2020
- Integration of city rain gauge data (WAA correction)
- Further research on E-band CMLs is needed to integrate them efficiently

Sprailink project



Pražské vodovody a kanalizace

T Mobile

GAČR CZECH SCIENCE FOUNDATION

TEL4RAIN

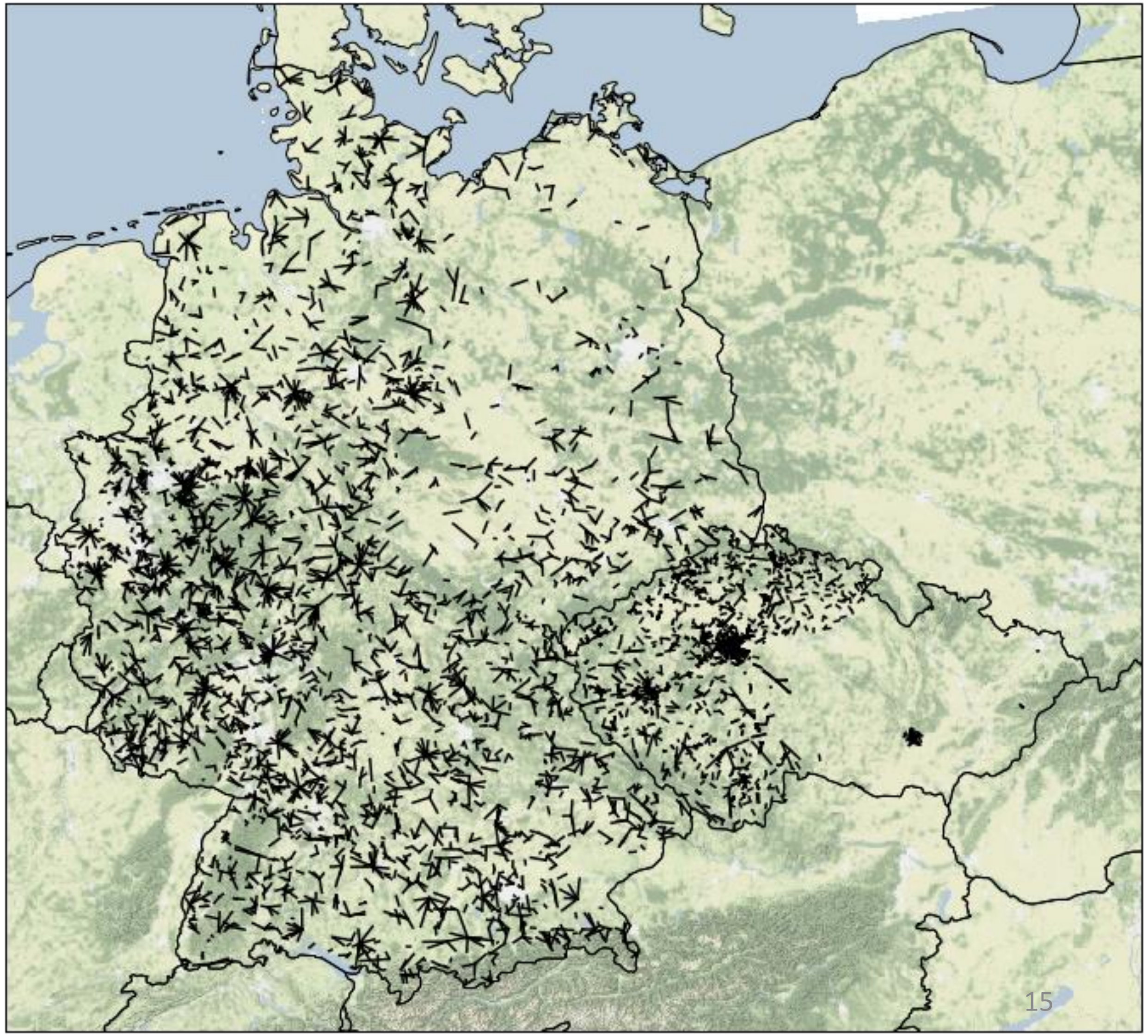
Outlook: SpraiLink project

GAČR CZECH SCIENCE FOUNDATION

DFG Deutsche Forschungsgemeinschaft

Spatial rainfall estimates using improved observations from commercial microwave links and statistical data fusion

- Improved CML error models and spatial QPEs
- Improved WAA models
- E-band rainfall retrieval
- Joint CZ-DE rainfall maps



Duration:
2020 - 2022

Involves:
- Czech Technical University
- Karlsruhe Institute of Technology (in GaPa)
- University of Augsburg
- Technical University of Munich