Exploring the role of new technologies in quantifying precipitation levels and urban flooding

Jörg Rieckermann

Urban Water Management

Eawag, Swiss Federal Institute of Aquatic Science and Technology

Motivation

«The Geysir of Hamburg»

Hamburgwasser

www.Bild.de


http://www.tagesschau.de/multimedia/bilder/thailand1108_mtb-1_pos-6.html#colsStructure

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Exploring the role of new technologies…

- Rainfall monitoring

http://pmm.nasa.gov

- Flood risk assessment in urban areas

X

Hazard potential	Vulnerability potential 1	2	3	4	5	6
0	0	0	0	0	0	0
1	1	2	3	4	5	6
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Precipitation monitoring

Problem

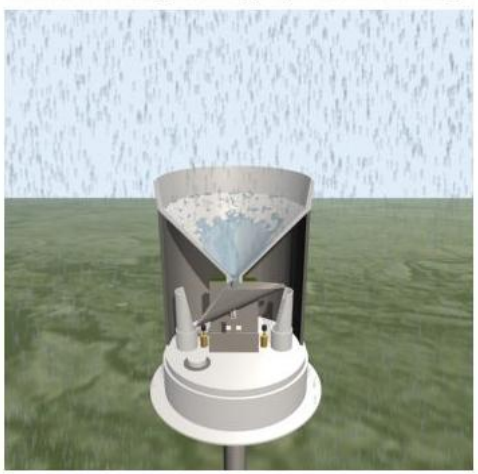
Rainfall is highly variable in space and time

Existing monitoring networks only provide limited data

Precipitation monitoring

various possibilities

- Rain gauge
  - Ground rainfall
  - Point measurement



benmeadows.com

Precipitation monitoring

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- Rain gauges
  - Ground rainfall
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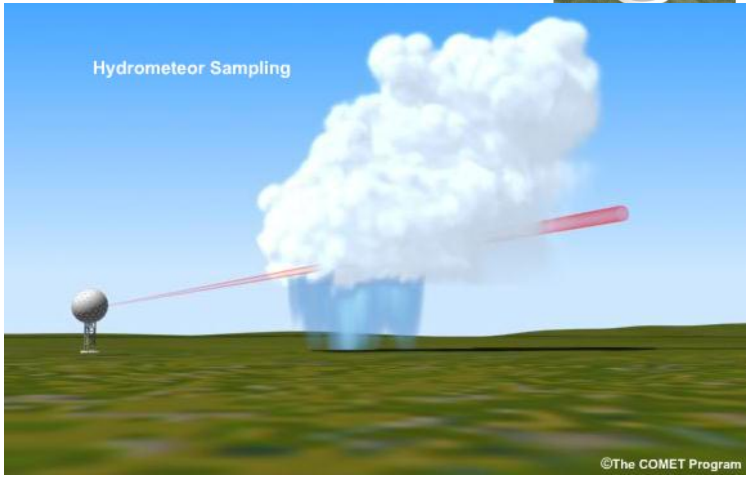
benmeadows.com, COMET program

- Weather radar and satellite
  - Spatial information
  - Volume measurement
  - Limited resolution



COMET program

Satellite

GPM (Global Precipitation Monitoring)

- Follow-up of TRMM
  - Start 2013
  - 60 deg inclination
  - 5x5 km2
  - 3 hourly data
  - NASA, JAXA, CNES, ISRO, NOAA, EUMETSAT

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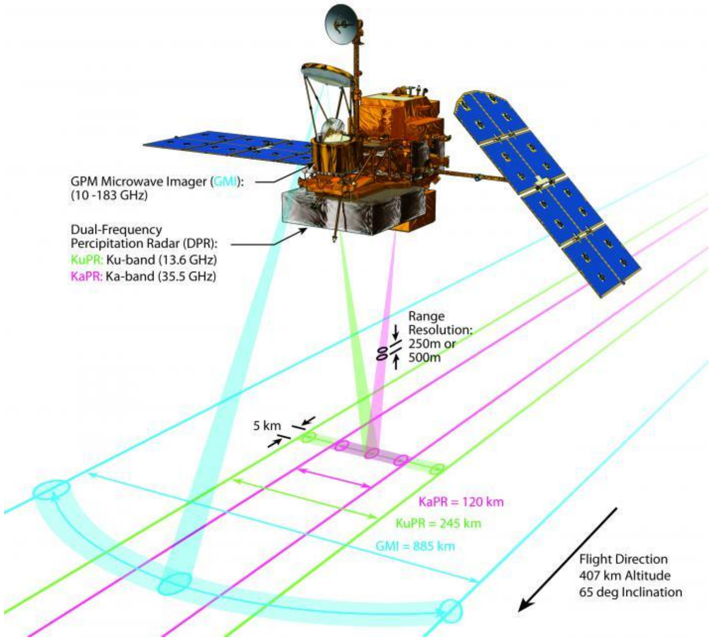
  - NASA, JAXA, CNES, ISRO, NOAA, EUMETSAT
- Core observatory
  - Precipitation radar (DPR)
  - Passive radiometers
- Improvements
  - Dual frequency precip. radar
  - light rain, snow and hail

http://pmm.nasa.gov/GPM



Local Area Weather Radar (LAWR)

Ship radar

- Specs
  - X-band, S-band
  - 20 - 60 km
  - 5 min resolution
  - Cheap, low data quality

Jensen (2011) Installation and application of a country-wide nework of LAWR X-Band radars in El Salvador

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  - Research

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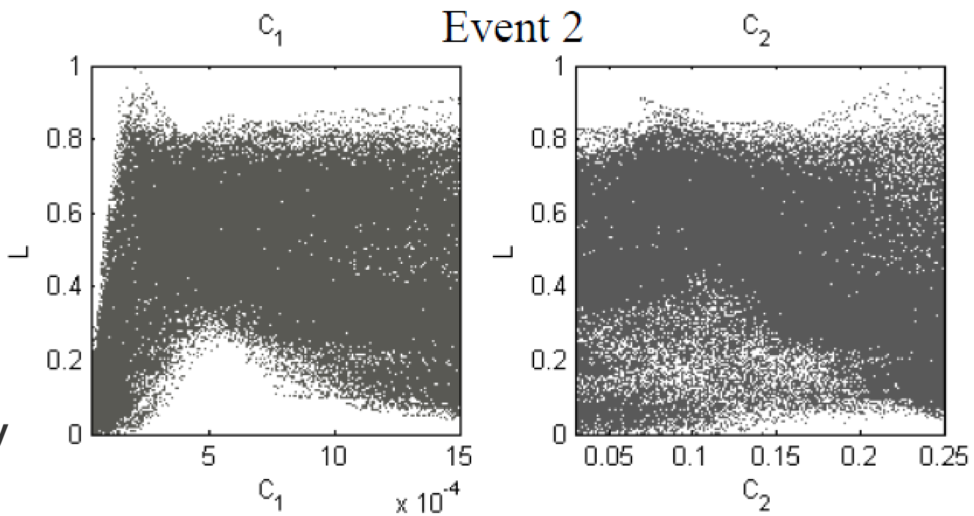

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Nielsen (2011) GLUE based uncertainty estimation of urban drainage modeling using weather radar precipitation estimates

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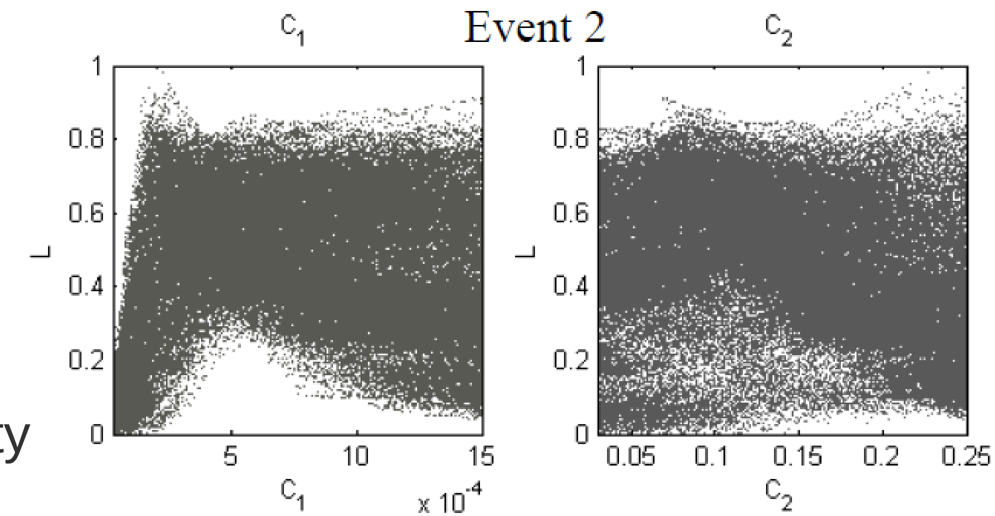

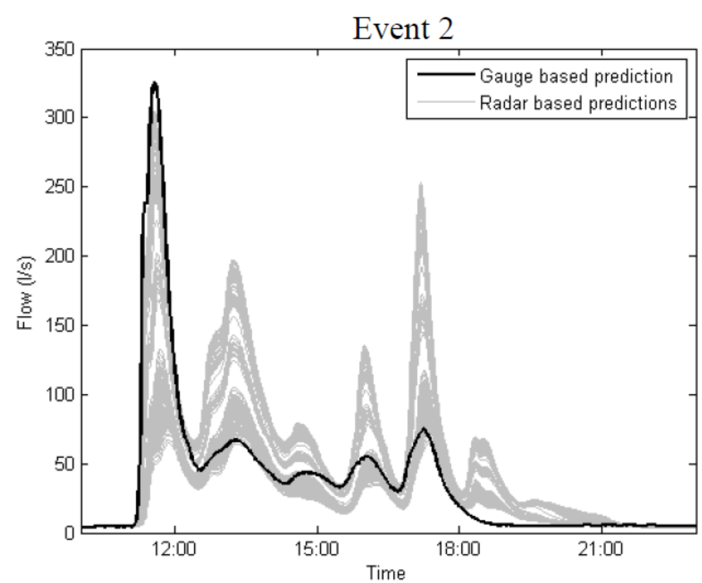

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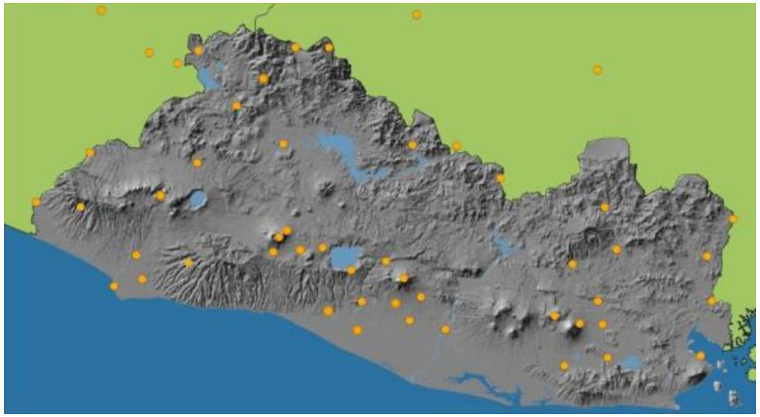
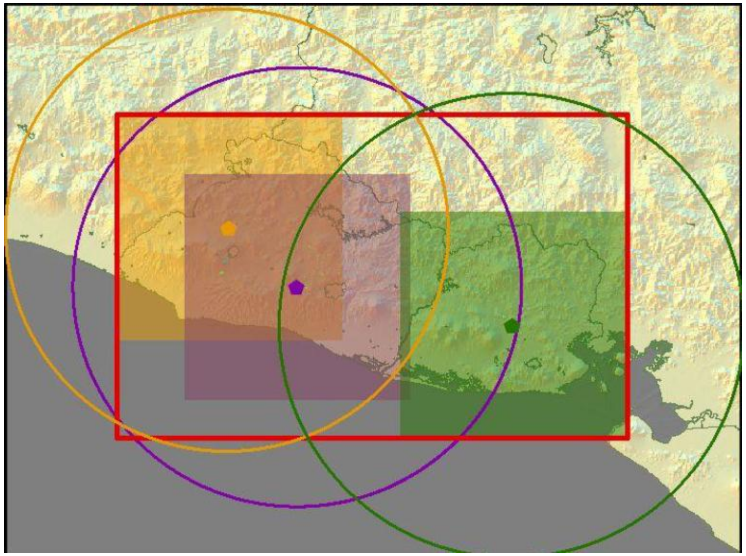
- El Salvador
  - NWS
  - 3 LAWRs, 6 months, $0.45 Mio





Jensen (2011)

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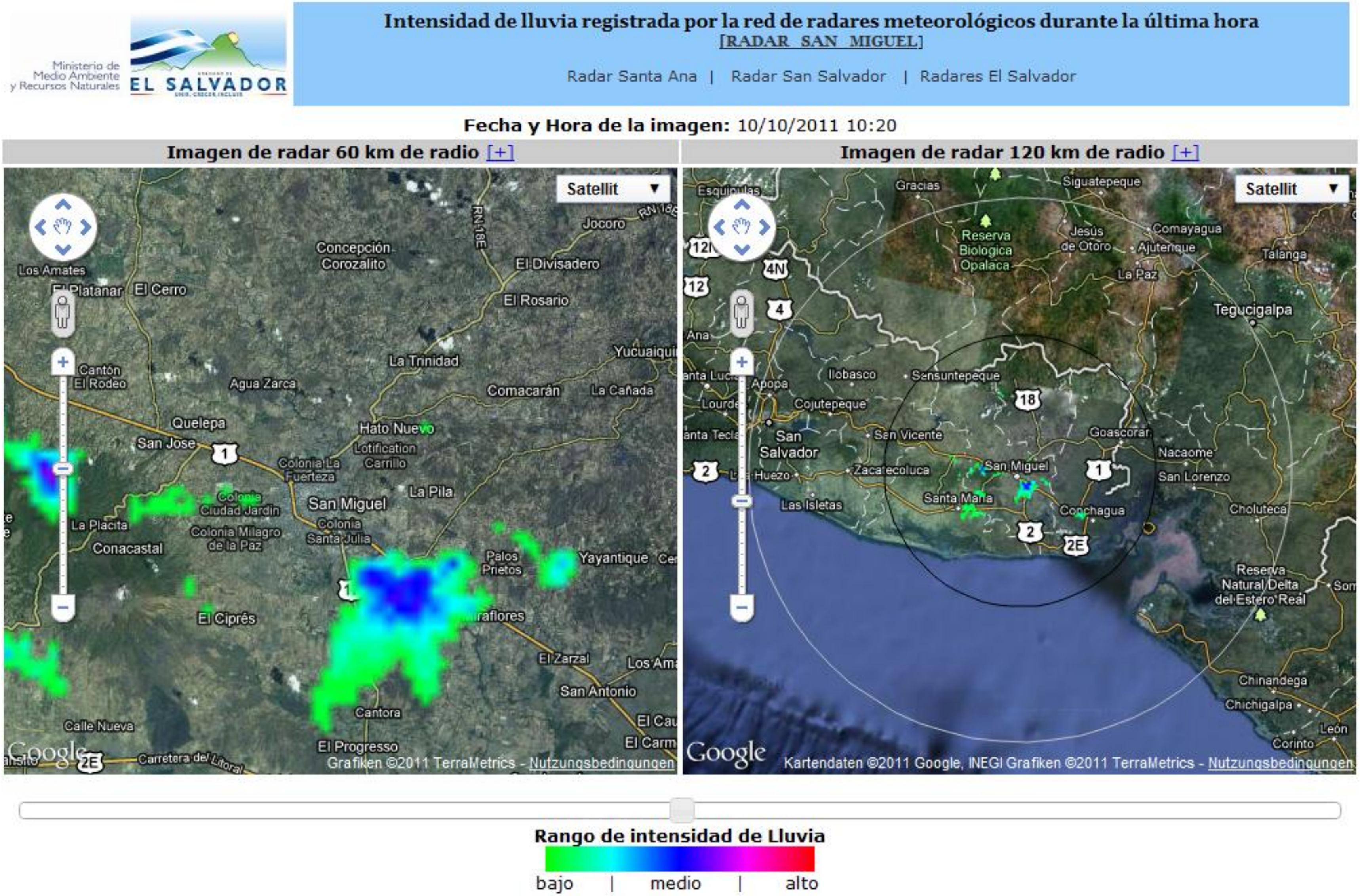

http://www.snet.gob.sv/googlemaps/radares/radaresSV.php

Precipitation monitoring

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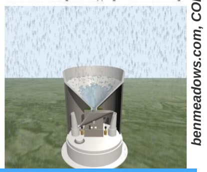
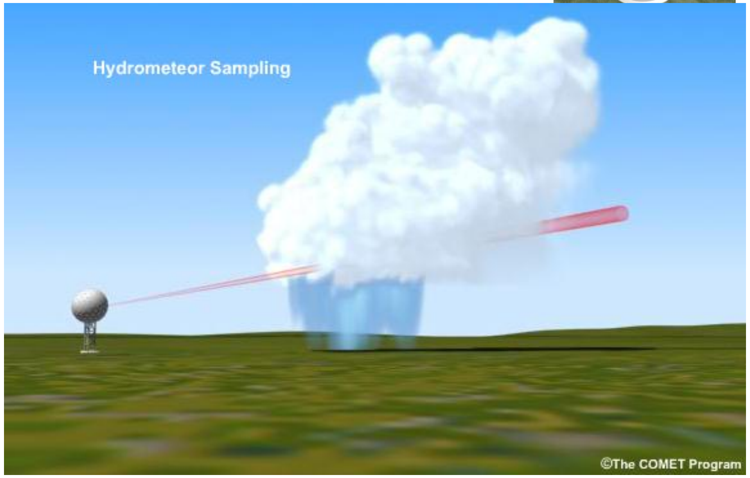


benmeadows.com, COMET program



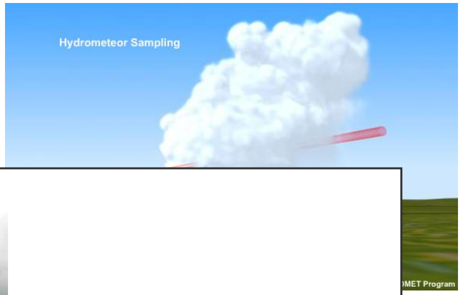
COMET program

Precipitation monitoring

various possibilities

- Rain gauge
  - Ground rainfall
  - Point measurement
- Weather radar and satellite
  - Spatial information
  - Volume measurement
  - Limited resolution
- Disdrometer
  - Rain, snow, …
  - Point measurement

benmeadows.com, COMET program

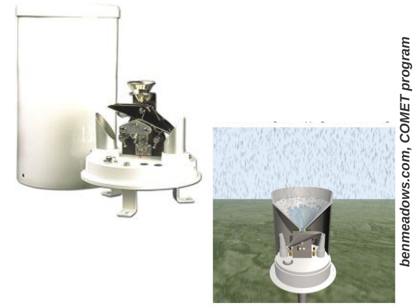


ott.com, thiesclima.com

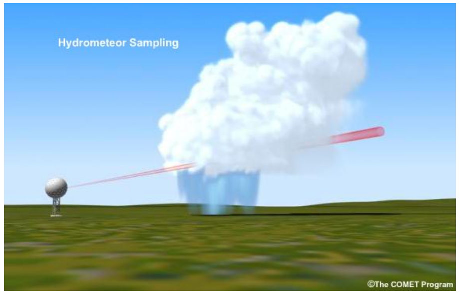
Precipitation monitoring

various possibilities

- Rain gauge



- Weather radar and satellite



- Disdrometer

Microwave links from telecommunication networks

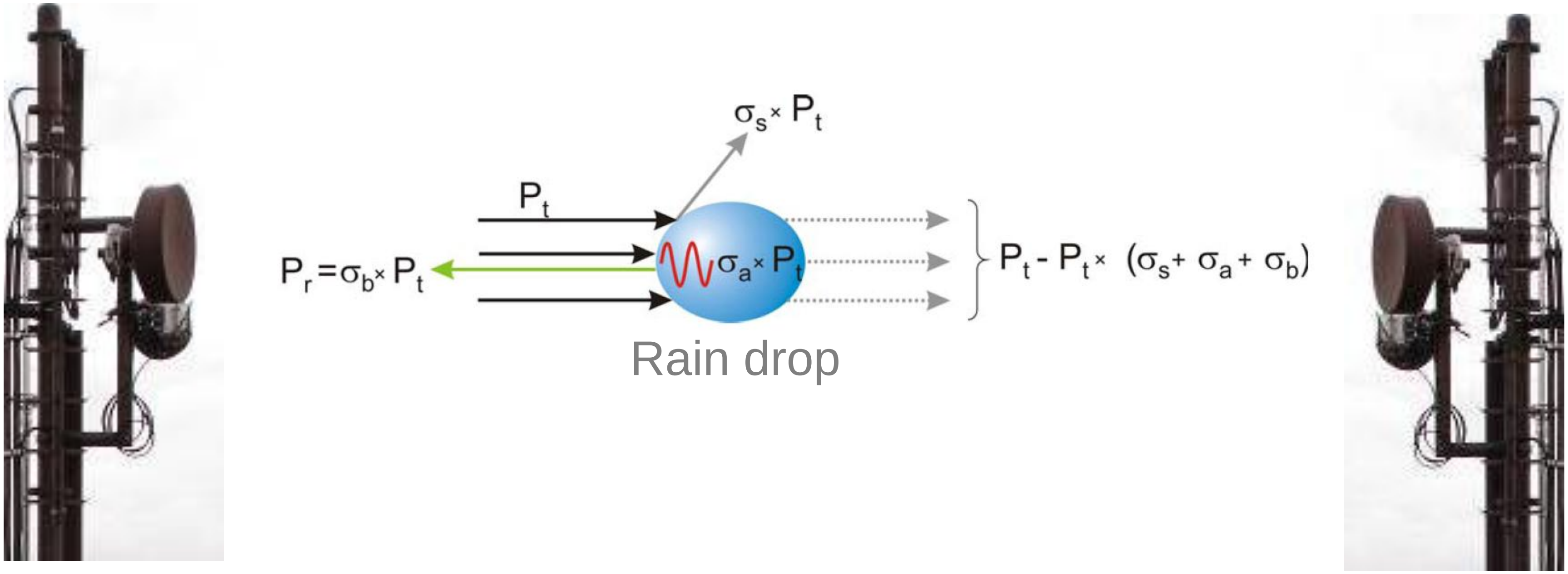
Use existing infrastructure for precipitation monitoring!

Microwave links from telecommunication networks

Use existing infrastructure for precipitation monitoring!

Electromagnetic wave propagation

Raindrops attenuate the transmitted signal from microwave links (MWL)



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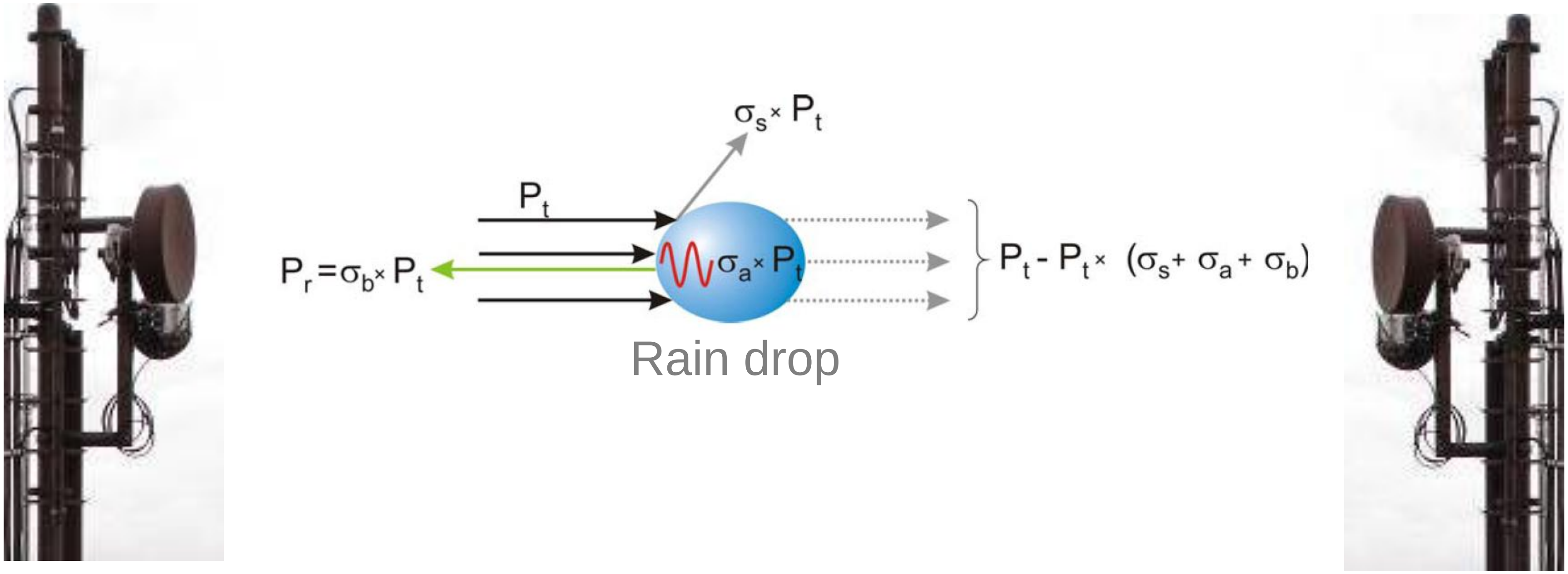
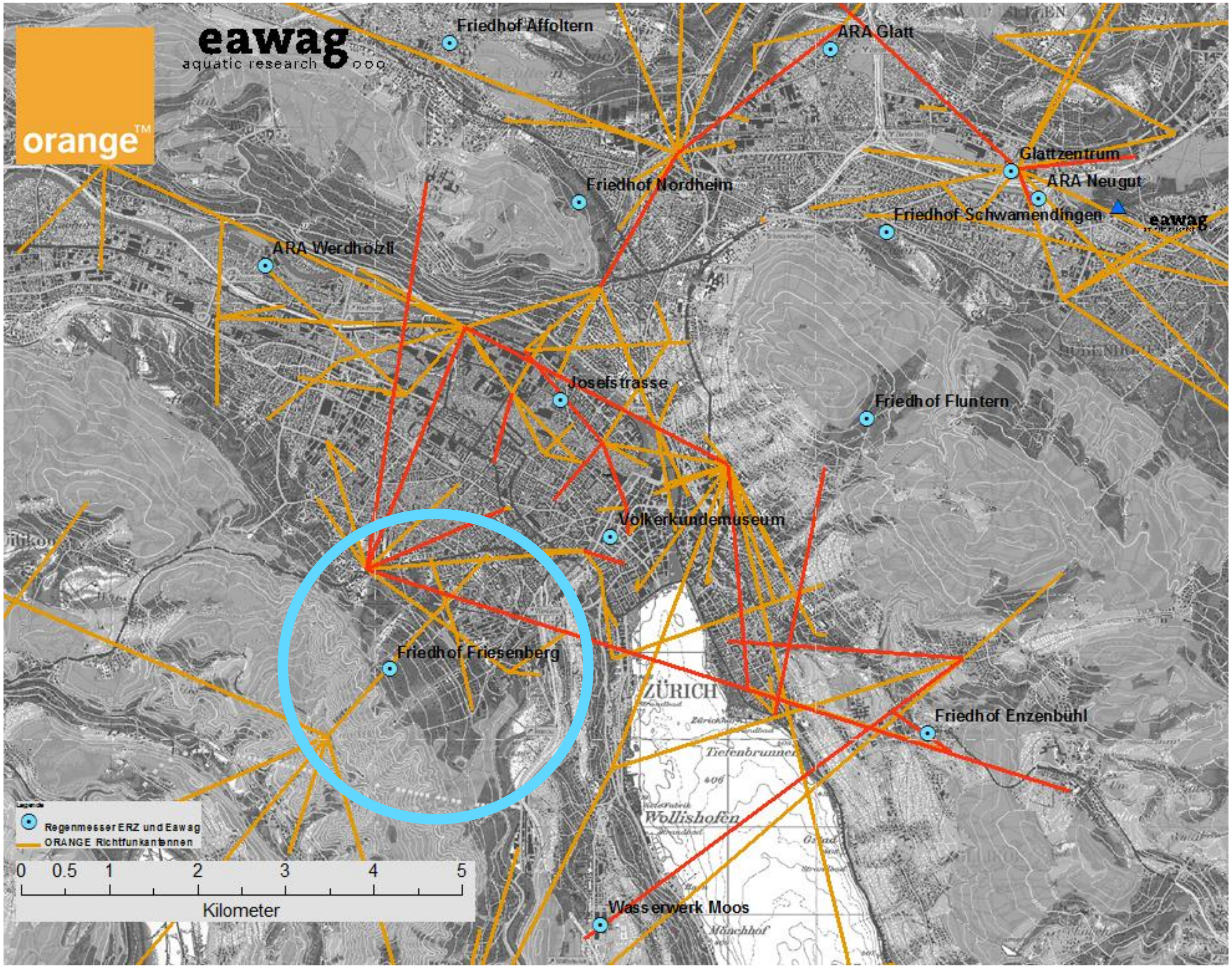


Hydrometeor scattering and adsorption: $$A = 4.343\int_0^\infty Q_t(D)N(D)dD$$

Empirical model: $$A = a \cdot R^b \longrightarrow R = \alpha \cdot k^\beta$$

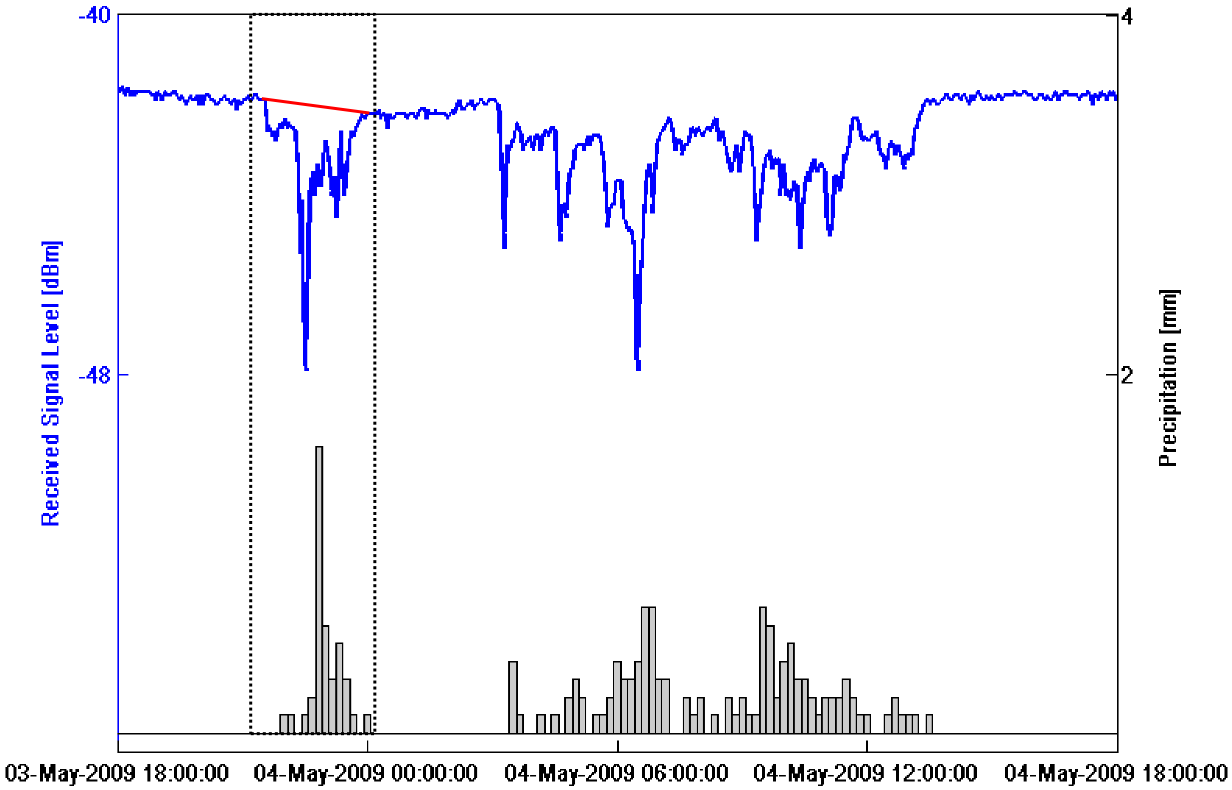
Case study Zurich

Collaboration with **ORANGE** and Zurich sewer operator (ERZ)



Case study Zurich

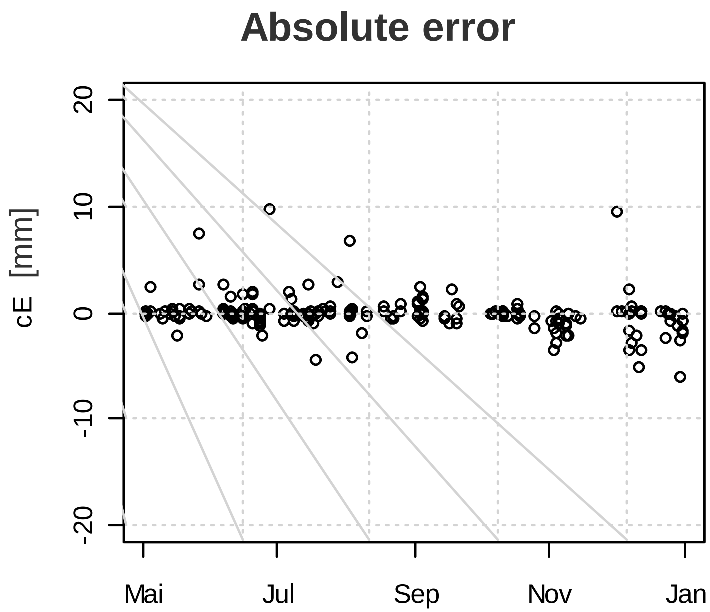
Data Pre-processing

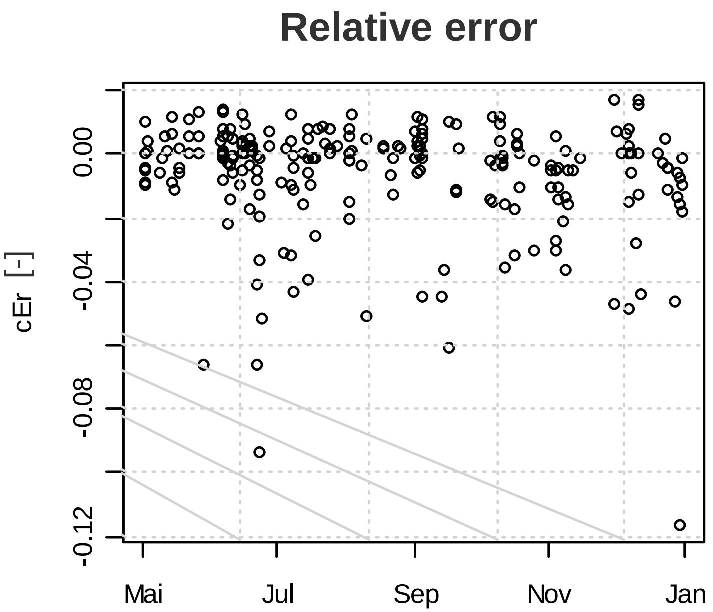


1. Baseline separation
2. Calculation of rain rate from differential attenuation

Results (1)

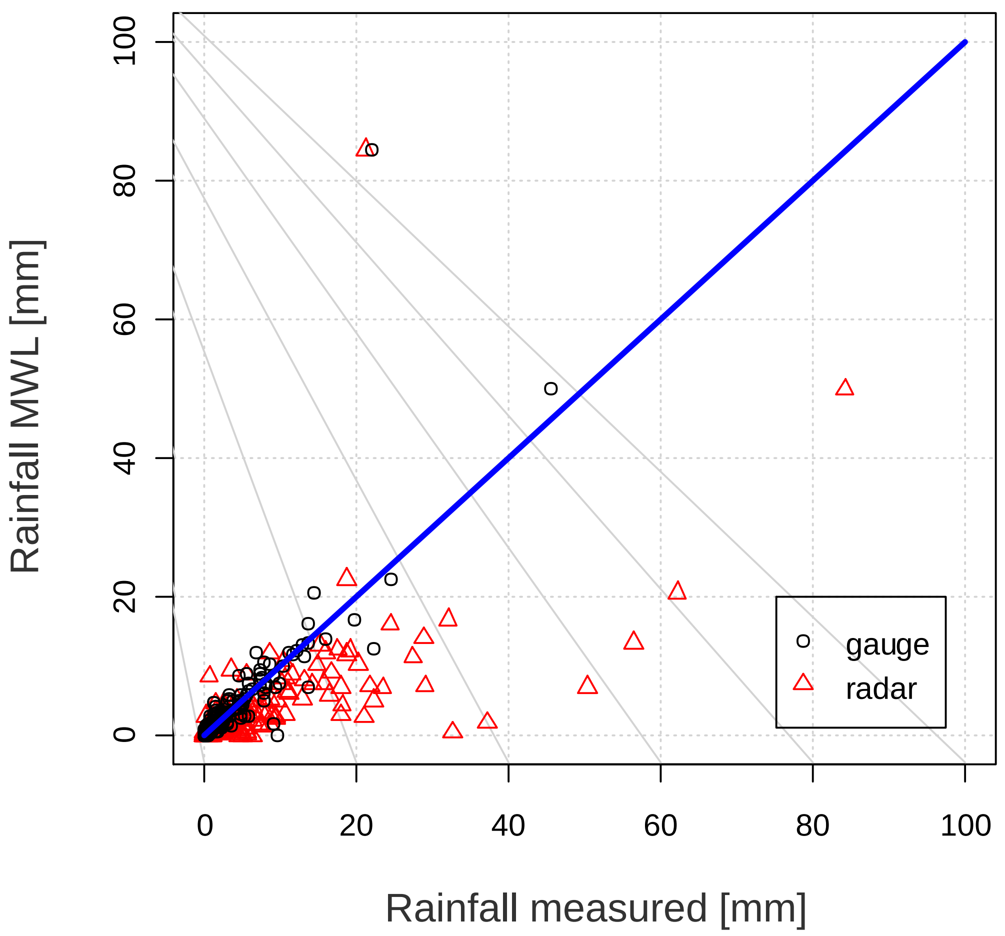
Accuracy, comparing MWL to Rain gauge over time





Results (2)

Accuracy, comparing MWL to Rain gauge and Radar

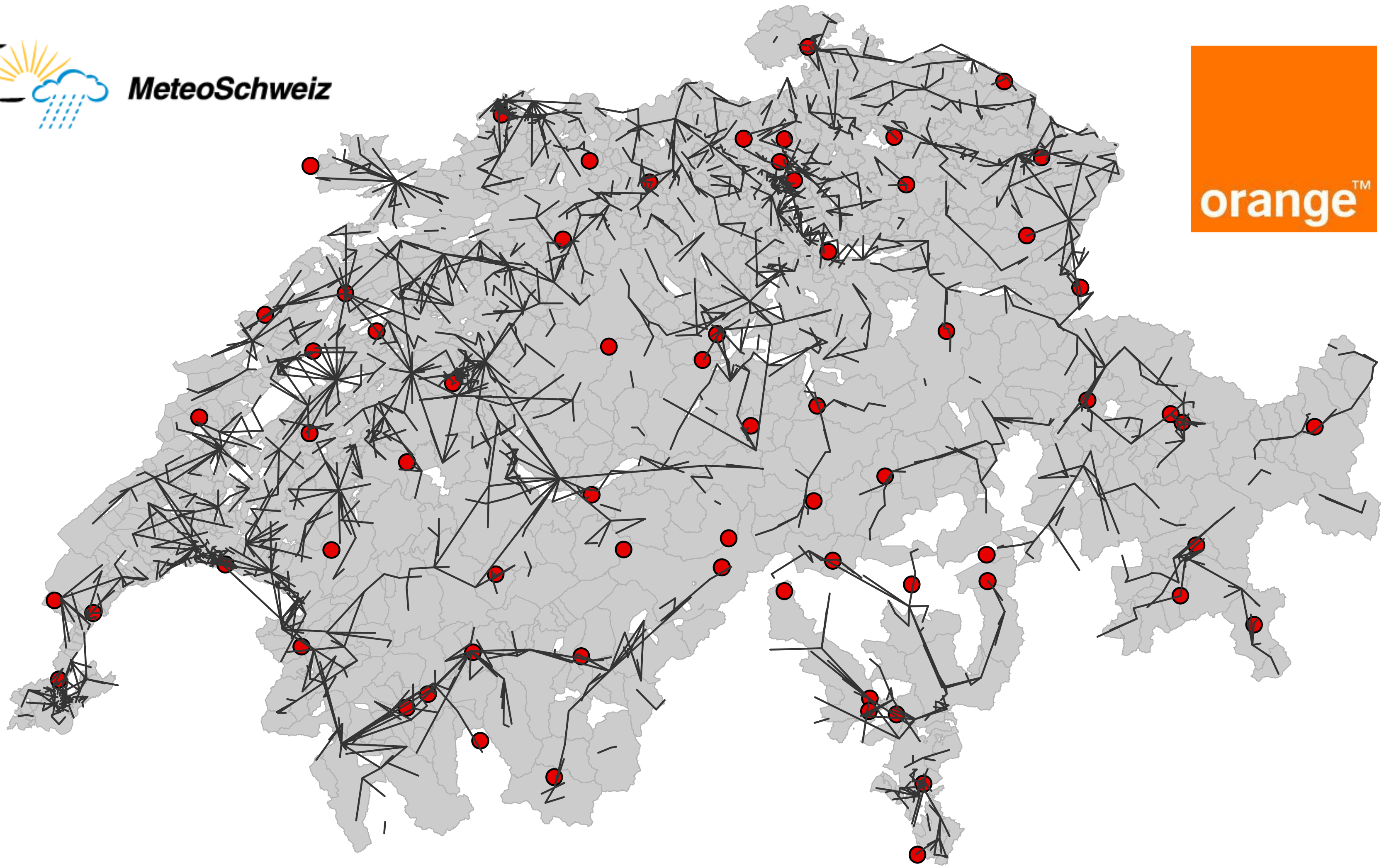


eawag aquatic research

Microwave links from telecommunication networks

Spatial distribution, Meteoswiss A-Netz vs. ORANGE Network

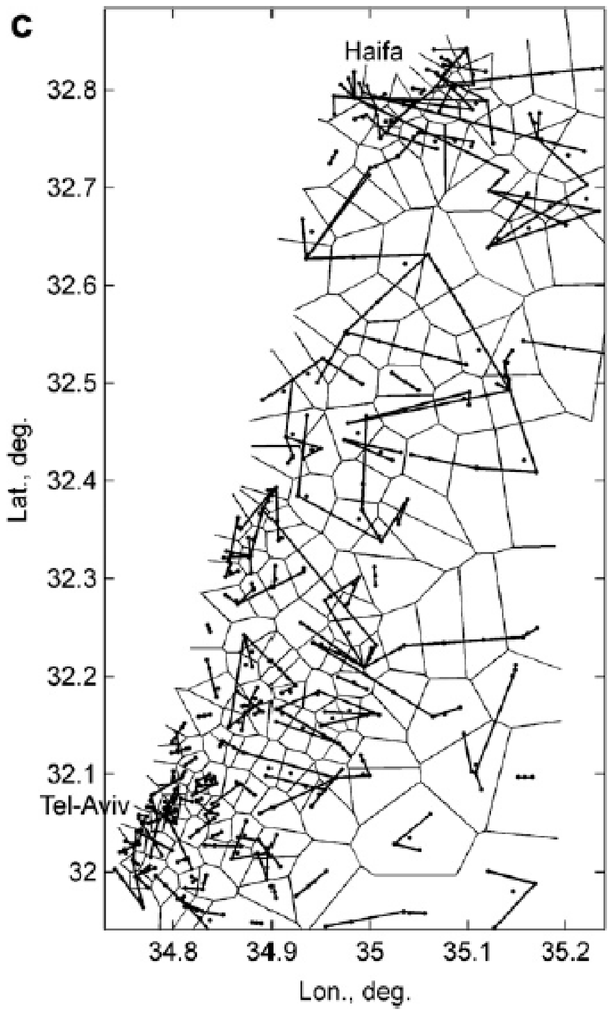
MeteoSchweiz



orange™

Microwave links from telecommunication networks

Spatial distribution, Israel



Zinevich et al. (2008) Estimation of rainfall fields using commercial microwave communication networks of variable density

Microwave links from telecommunication networks

Discussion

- PRO
  - Existing infrastructure
  - Spatial distribution of MWL, dense network in urban areas
  - Near-surface precipitation
- To do
  - Wet antenna attenuation
  - Comprehensive uncertainty assessment
  - Detection of snow, sleet, hail
- CON
  - Telecom operators: General data availability (no business case)
  - Antenna manufacturers: hardware, data logging
  - Long-term historical data, mobile internet

Exploring the role of new technologies…

- Rainfall monitoring

http://pmm.nasa.gov

- **Flood risk assessment in urban areas**

Hazard potential X Vulnerability potential	1	2	3	4	5	6
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Flood risk assessment

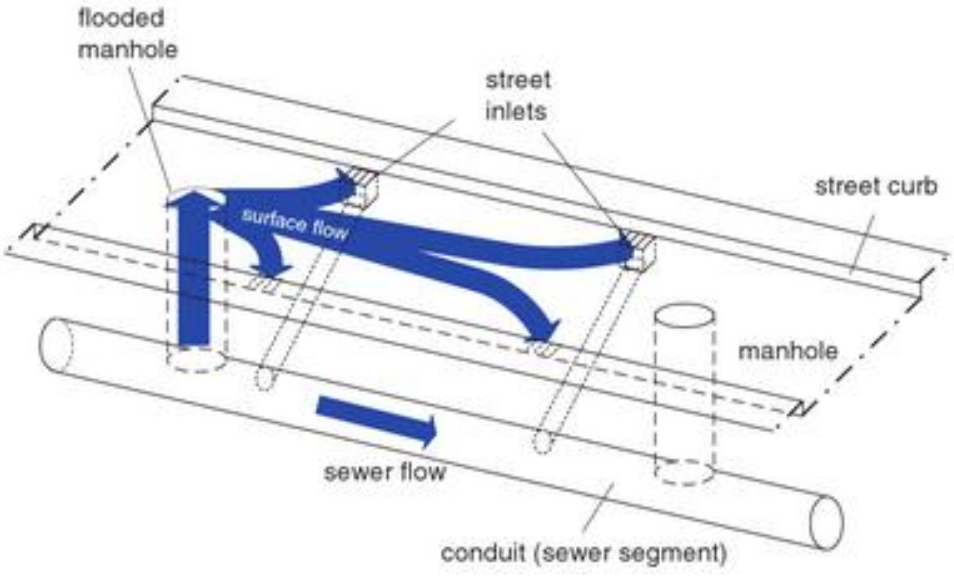
Example, state-of-the-art

www

Flood risk assessment

Requirements

- Numerical simulation model
  - Complex: Hydrodynamic, 1D/2D



Schmid, T. et al. (2009)

Flood risk assessment

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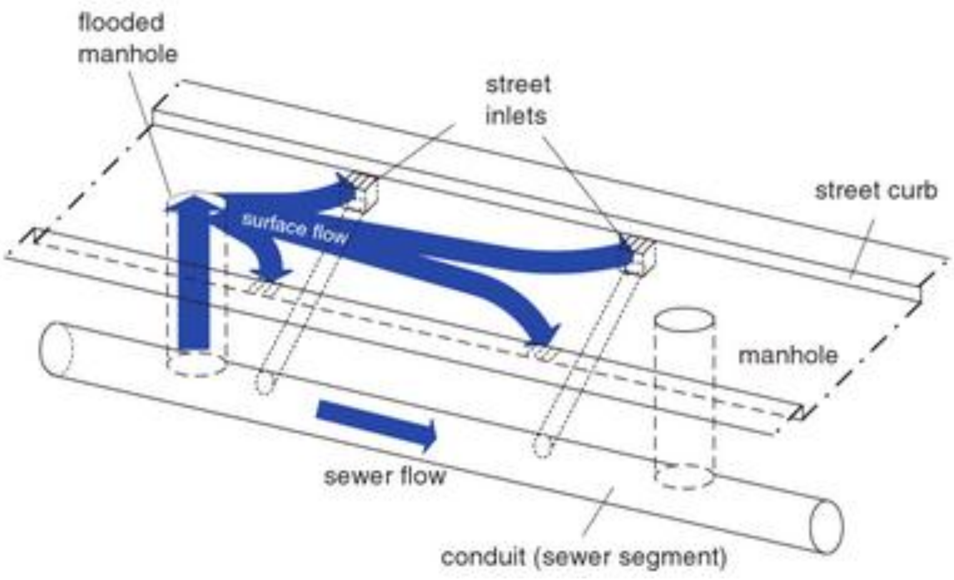

Schmid, T. et al. (2009)

Hamburgwasser

Flood risk assessment

Requirements

- Numerical simulation model
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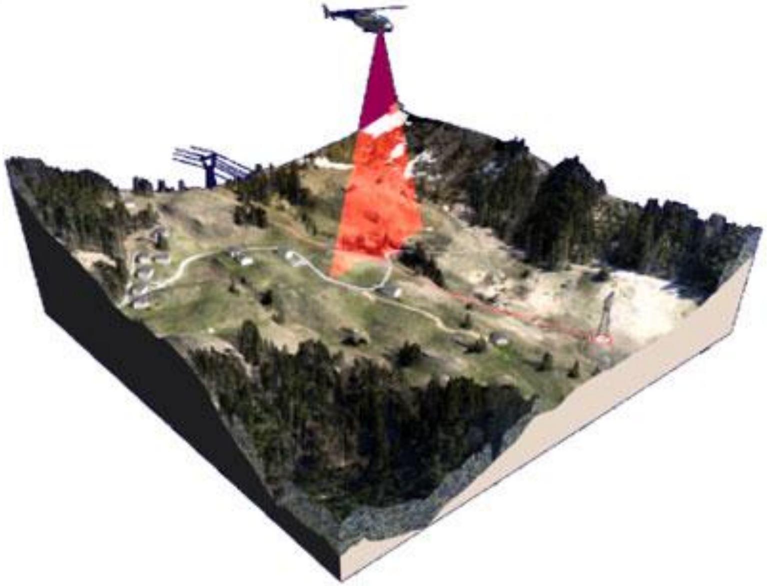
  - (too) Simple: GIS
- Digital elevation model
  - LIDAR (laserscanning, ~cm)
  - SAR (radar, ~dm)
    - TanDEM-X (~2m rel)



http://www.eranet.gr/geodata

http://www.dlr.de/

Flood risk assessment

Requirements

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  - (too) Simple: GIS
- Digital elevation model
  - LIDAR (laserscanning, ~cm)
  - SAR (radar, ~dm)
    - TanDEM-X (~2m rel)
- Urban drainage system
  - «Black hole»
  - No remote sensing technology
  - Discharge data for model calibration

http://www.tagesschau.de/multimedia/bilder/thailand1108_mtb-1_pos-6.html#colsStructure

Discussion/Conclusions

Exploring the role of new technologies…

- Precipitation monitoring in SEE
  - Automated weather stations are mandatory
  - MWL could complement observations
    - Existing infrastructure, spatial distribution, …
  - Satellite and LAWR not recommended (for urban hydrology)

- Flood risk assessment in urban areas
  - Simulation models are available
  - Good terrain data are mandatory
  - (Digital) Information on urban drainage network insufficient

- Climate change?
  - «Stationarity is dead!»

Discussi

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POLICYFORUM

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks.

P. C. D. Milly,[1*] Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Systems for management of water throughout the developed world have been designed and operated under the assumption of stationarity. Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering. It implies that any variable (e.g., annual streamflow or annual flood peak) has a time-invariant (or 1-year–periodic) probability density function (pdf), whose properties can be estimated from the instrument record. Under stationarity, pdf estimation errors are acknowledged, but have been assumed to be reducible by additional observations, more efficient estimators, or regional or paleohydrologic data. The pdfs, in turn, are used to evaluate and manage risks to water supplies, waterworks, and floodplains; annual global investment in water infrastructure exceeds U.S.$500 billion (*1*).

The stationarity assumption has long been compromised by human disturbances in river basins. Flood risk, water supply, and water quality are affected by water infrastructure, channel modifications, drainage

An uncertain future challenges water planners.

In view of the magnitude and ubiquity of the hydroclimatic change apparently now under way, however, we assert that stationarity is dead and should no longer serve as a central, default assumption in water-resource risk assessment and planning. Finding a suitable successor is crucial for human adaptation to

that has emerged from climate models (see figure, p. 574).

Why now? That anthropogenic climate change affects the water cycle (*9*) and water supply (*10*) is not a new finding. Nevertheless, sensible objections to discarding stationarity have been raised. For a time, hydroclimate had not demonstrably exited the envelope of natural variability and/or the effective range of optimally operated infrastructure (*11*, *12*). Accounting for the substantial uncertainties of climatic parameters estimated from short records (*13*) effectively hedged against small climate changes. Additionally, climate projections were not considered credible (*12*, *14*).

Recent developments have led us to the opinion that the time has come to move beyond the wait-and-see approach. Projections of runoff changes are bolstered by the recently demonstrated retrodictive skill of climate models. The global pattern of observed annual streamflow trends is unlikely to have arisen from unforced variability and is consistent with modeled response to climate forcing (*15*). Paleohydrologic studies suggest that small changes in mean climate might produce large changes in extremes (*16*), although

Milly et al. "Stationarity Is Dead: Whither Water Management?", Science 1 February 2008: Vol. 319 no. 5863 pp. 573-574 DOI: 10.1126/science.1151915

Thank you!

Hamburgwasser