Rotterdam urban hy
meteorological obs

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Hydro-Meteo-observatory Rotterdam

Objectives:

- Measuring small-scale rainfall variability
- Short-term high resolution rainfall forecasting (nowcasting)
- Numerical weather prediction and rainfall forecasting
- Hydrological response analysis and early-warning

Partners:

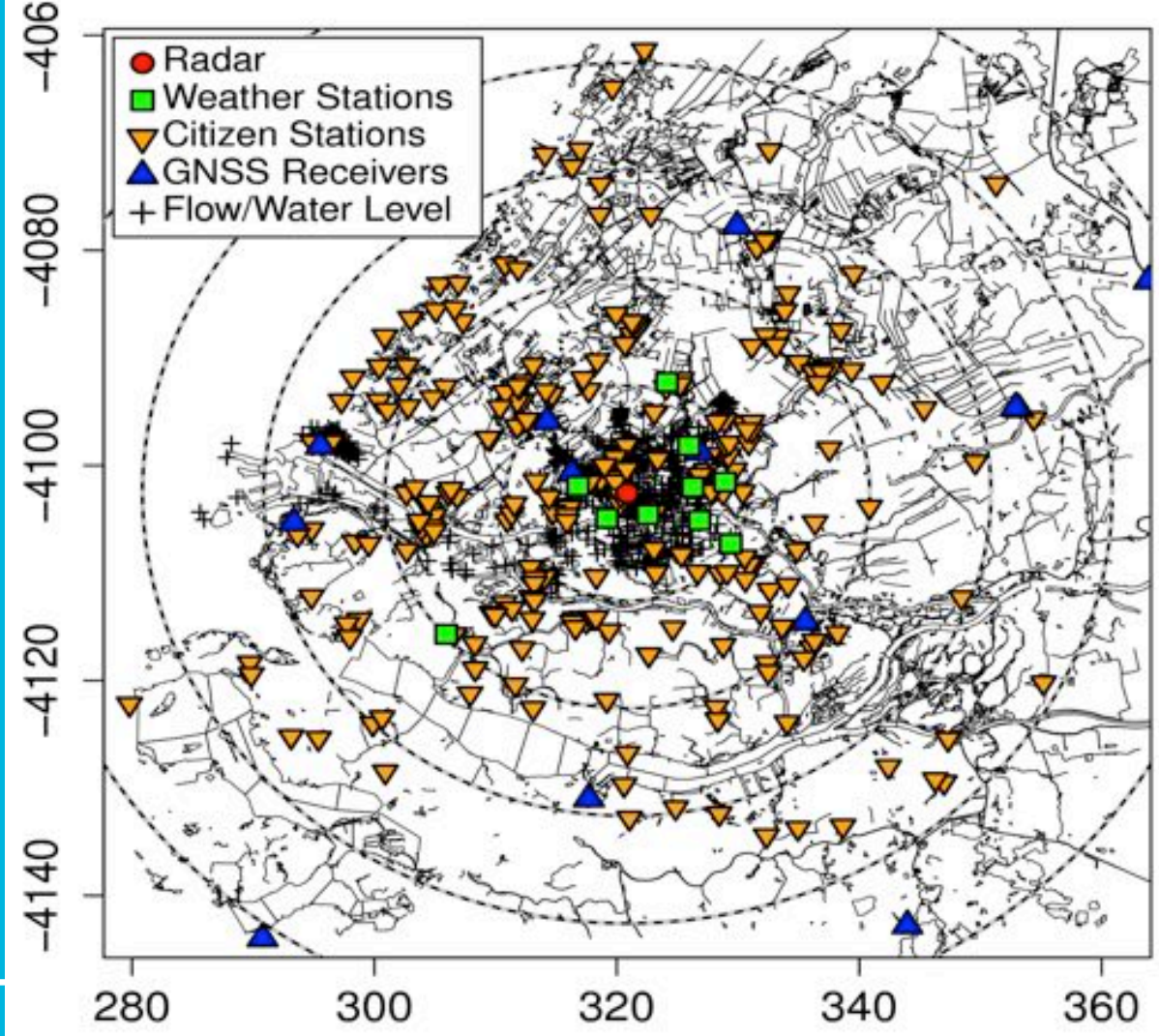
TU Delft: Deps Watermanagement ; Geosciences&Remote Sensing ; Microelectronics

Rotterdam City: Watermanagement ; Climate Resilience Program

Hydro-Meteo-observatory Rotterdam

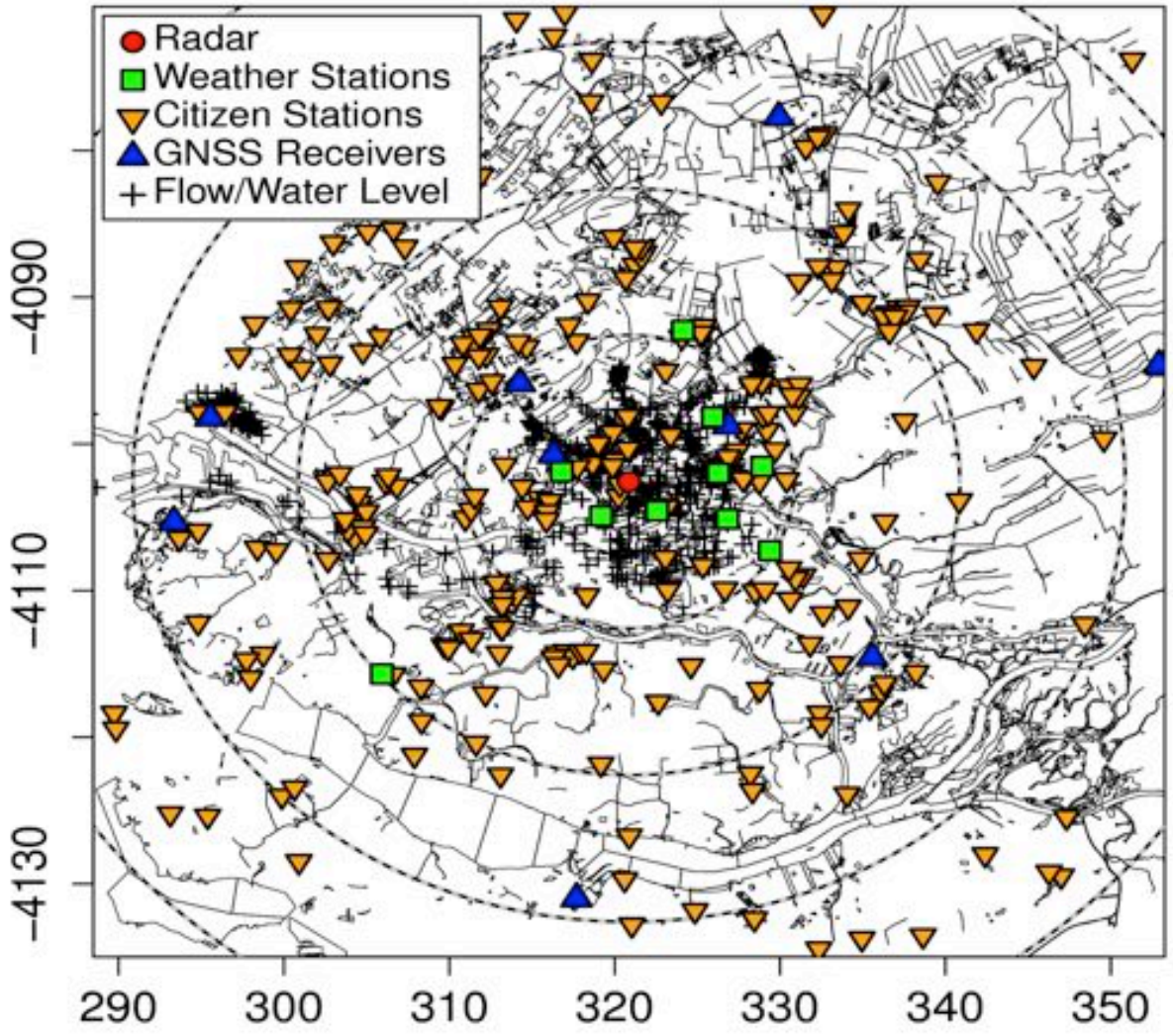
EU-funding support and international collaboration:

- MUFFIN (Multi-scale Urban Flood ForecastINg)
- FLoodCitiSense (Early warning service for urban pluvial floods for and by citizens and city authorities)
- BRIGAID (Bridging the Gap for Innovations in Disaster Resilience)



Hydro-meteorological observation network Rotterdam region

40km – 30 km – 20 km – 10 km – 5km range from radar position (Rotterdam city centre)



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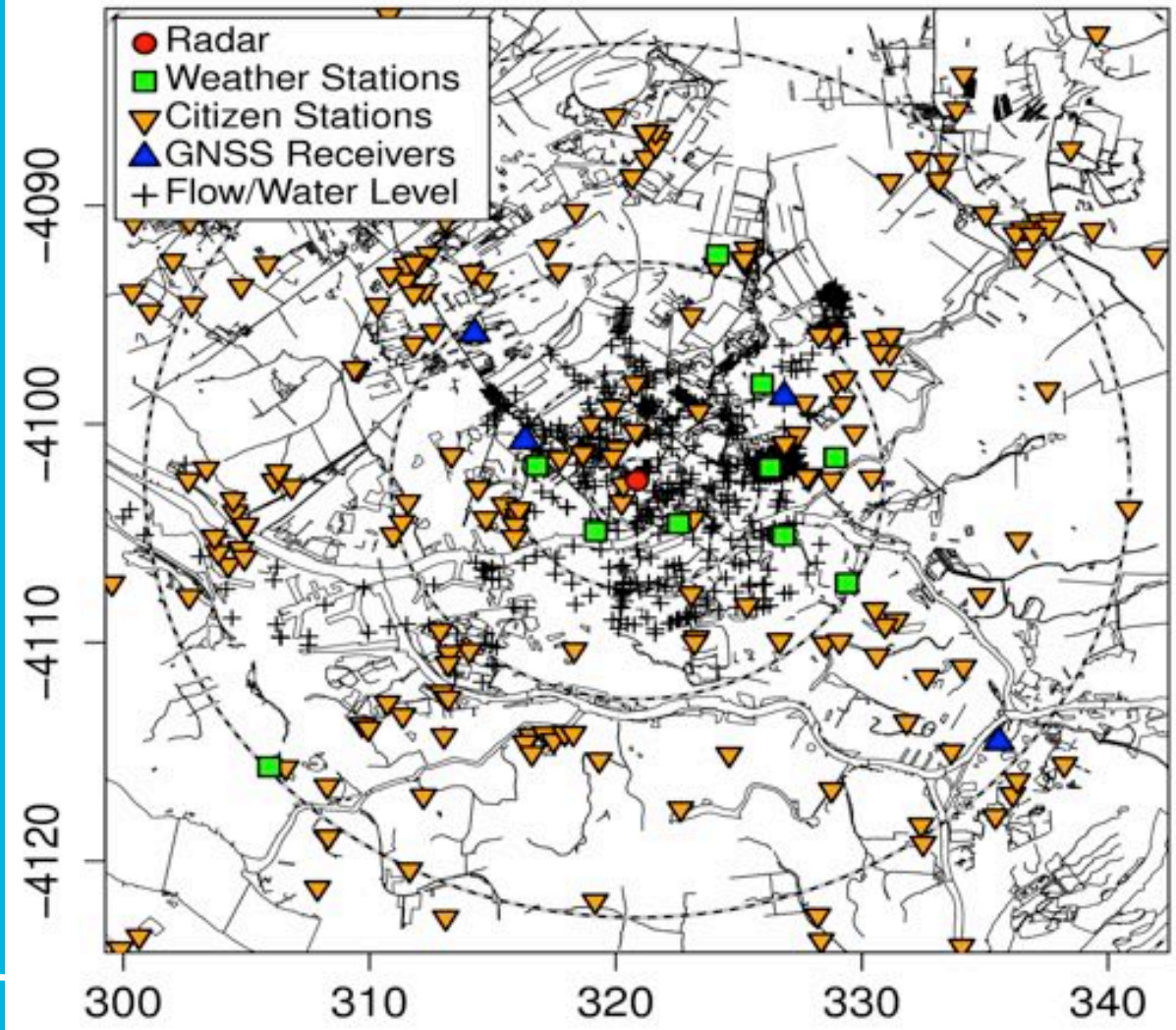

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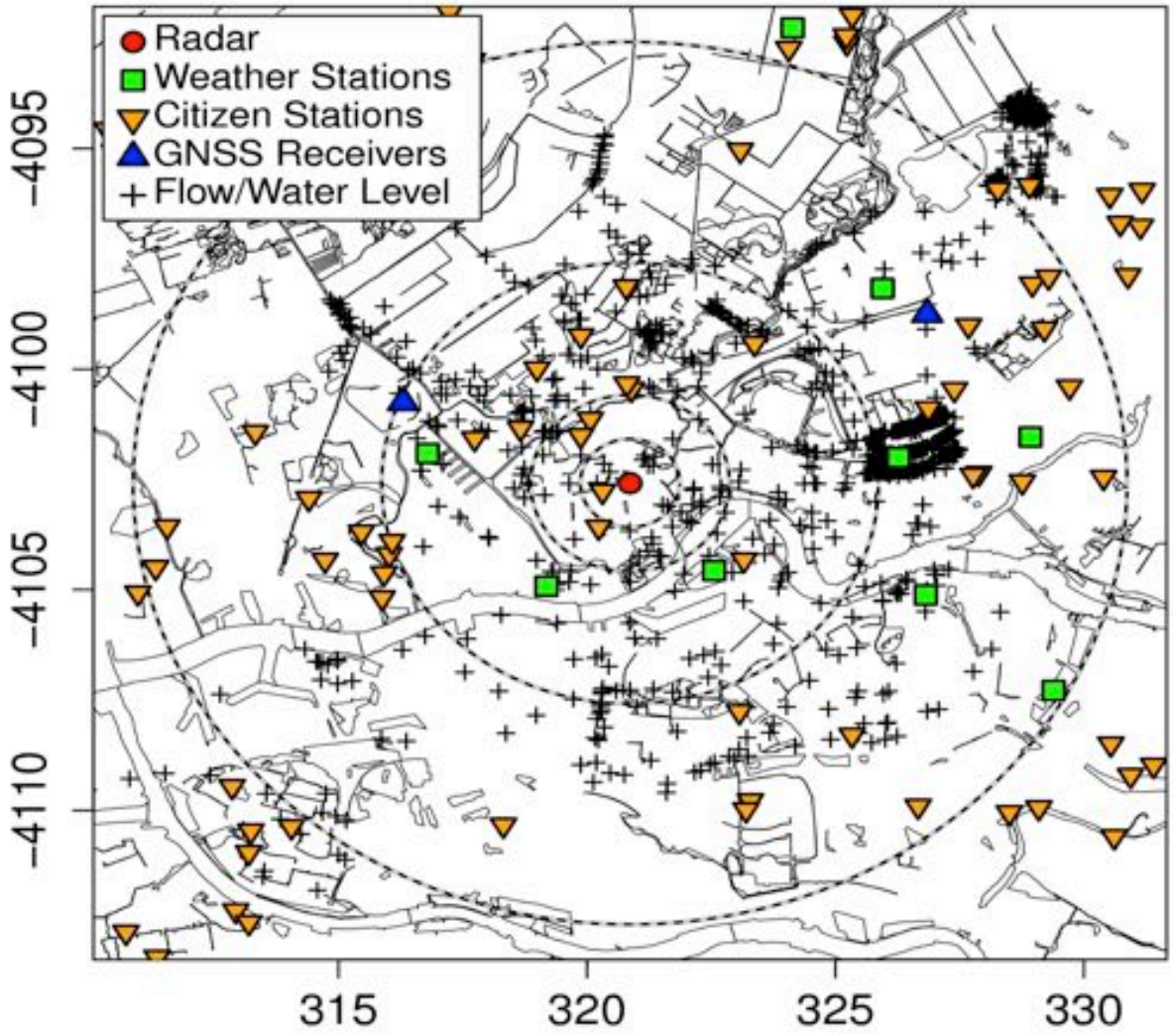

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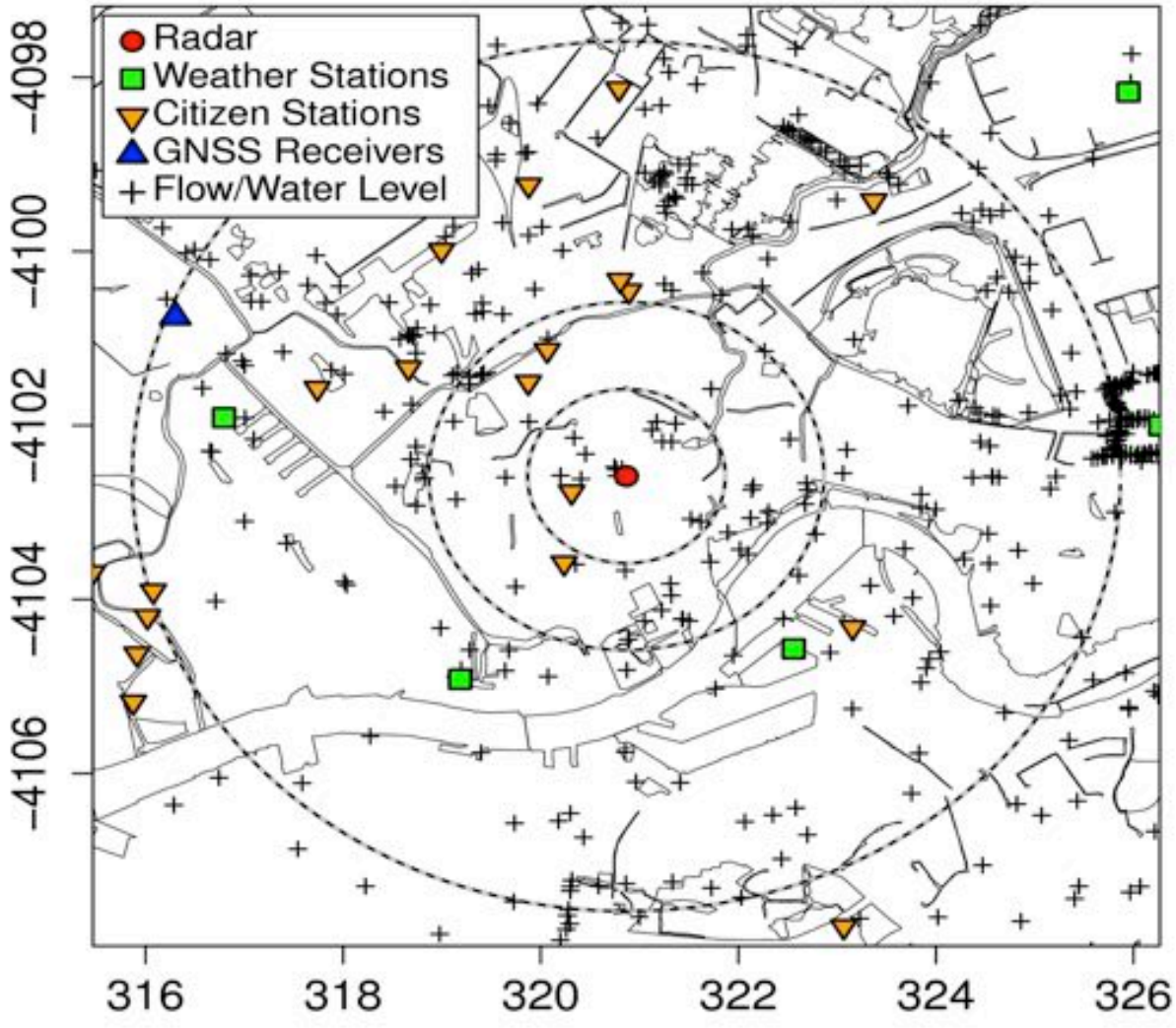

Hydro-meteorological observation network Rotterdam region

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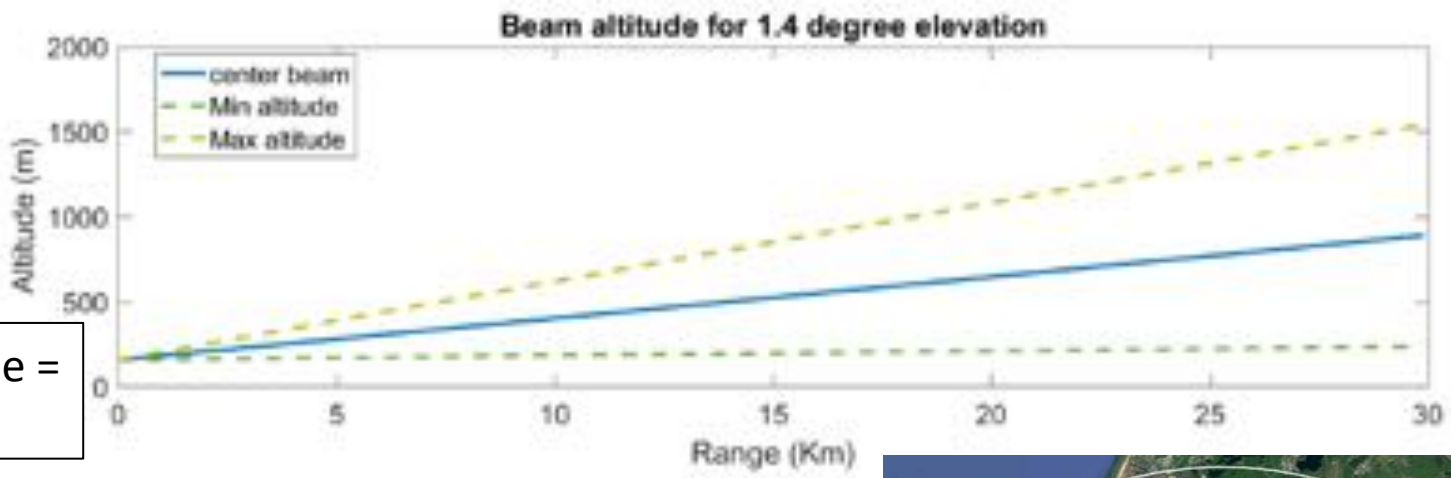
Available instrumentation

- Polarimetric Xband radar
- MRR: vertical profiling radar
- Weather stations: 8 operational (Campbell) + 5 additional to be installed (Davis)
- GNSS receivers for water vapour estimation: 4 single frequency, 14 dual frequency (from Nov. 2017)
- 50-60 Amateur weather stations (Netatmo, Wunderground)
- 6 Disdrometers (installed on pumping stations, status under investigation)
- 20 Water level sensors at overflow weirs
- 100+ water level/flow sensors at pumping stations

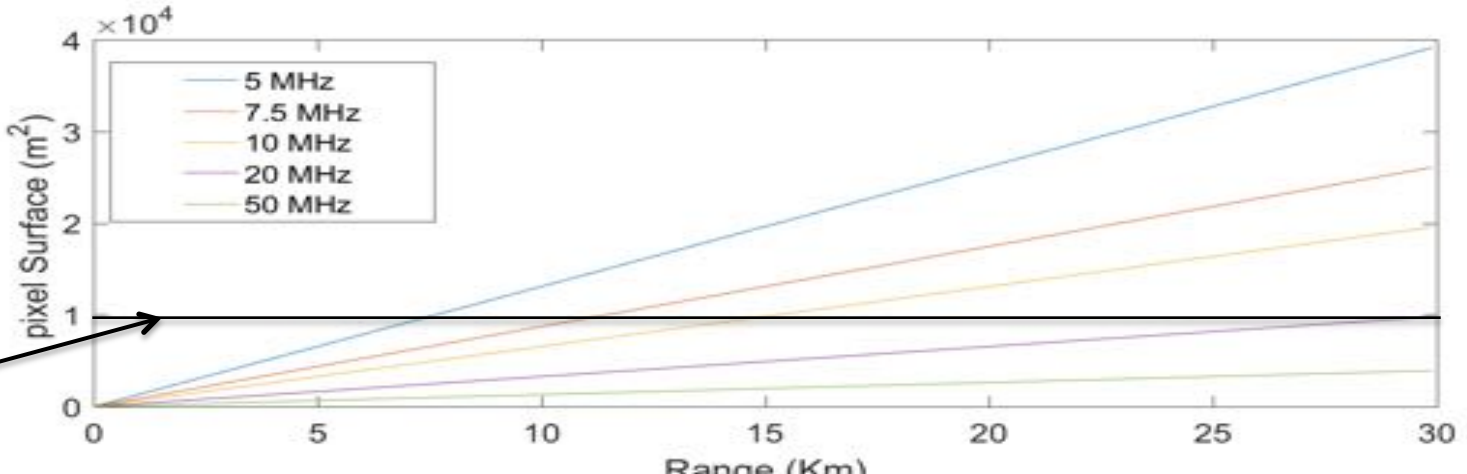
Polarimetric X-band radar

Some numbers:

- Altitude radar: 156 m
- Blind zone near radar (min range): 200m
- 1 full PPI/min (6 degrees per second)
- constant elevation angle (1.4°)
- beam width 2.5 degrees
- FMCW radar: frequency excursions 5-50MHz
- 20 m range resolution ((range 3 - 30m for 50-5MHz)
- max range: 30 km
- Data formats: 1 min NetCDF



Radar altitude = 156 m

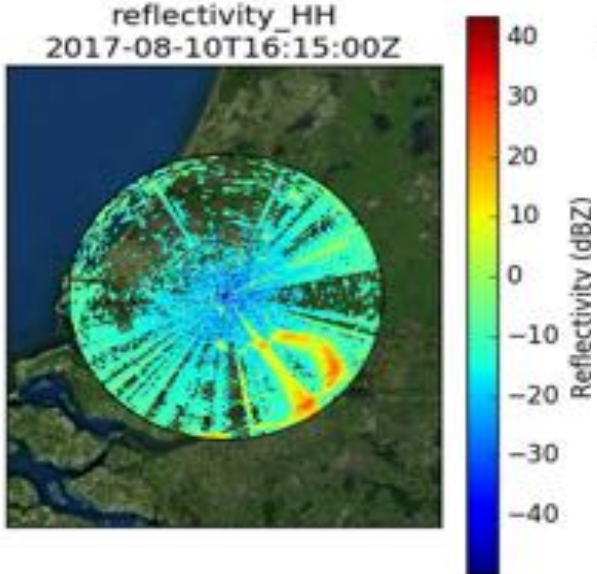


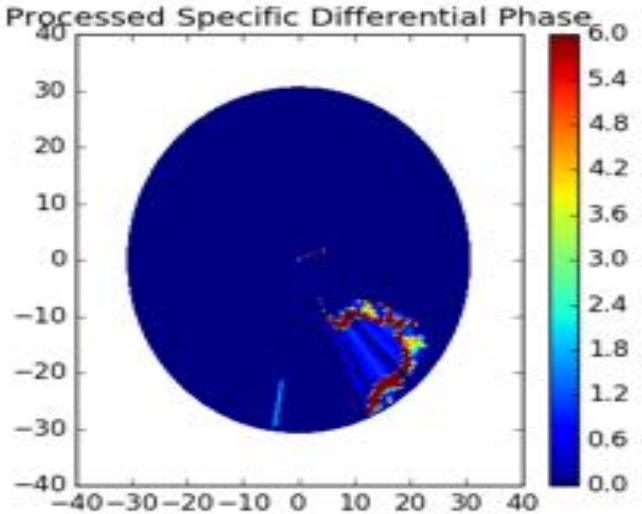
Pixel surface area: 100 m2

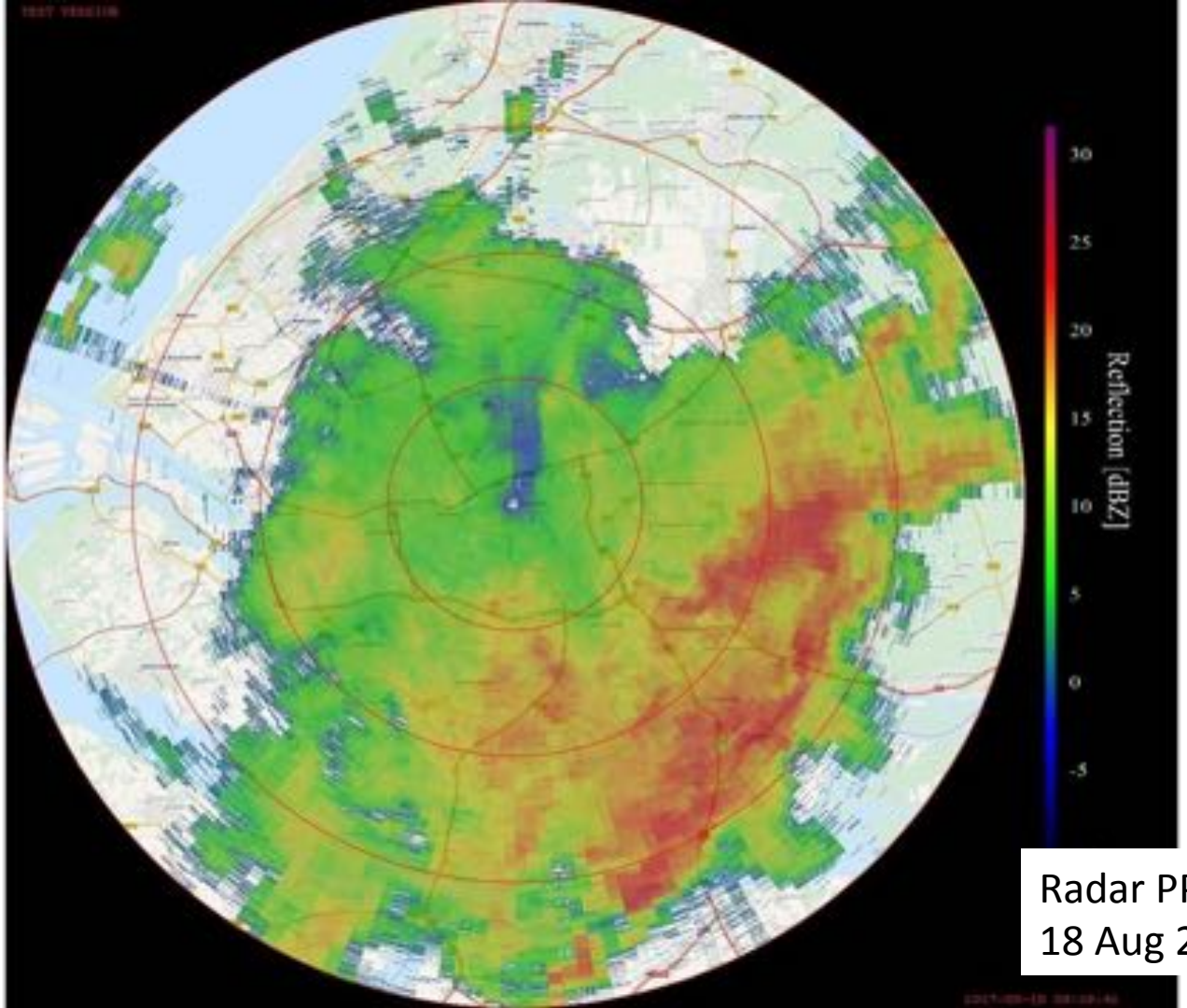
Polarimetric X-band radar

Rainfall estimation:

- via specific differential phase (KDP)
- via radar reflectivity (R)
- interpolated







Radar PPI Reflection HH
18 Aug 2017, 9.39-9.48h

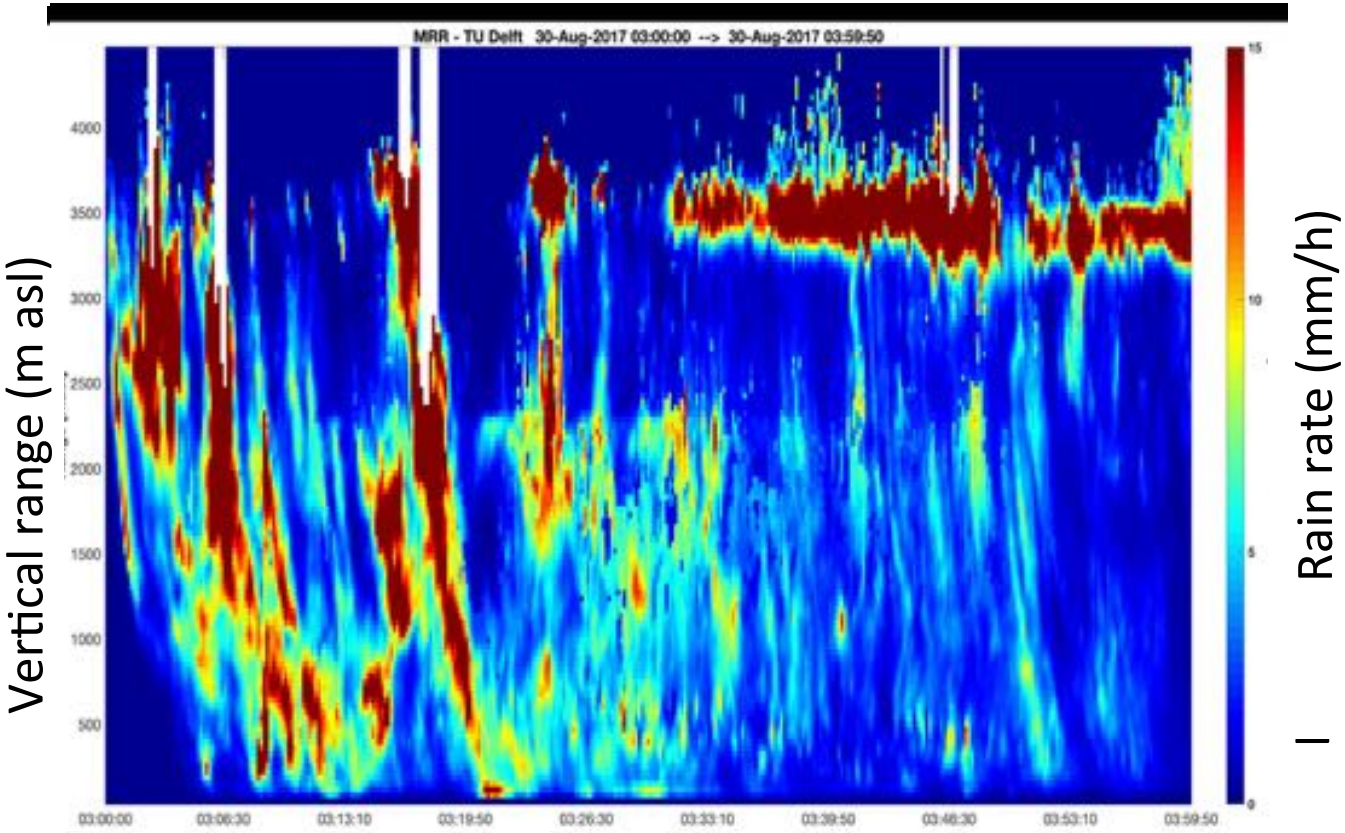
MRR: vertical profiling radar

Objectives:

- Precisely measure hydrometeors from **urban** rainfall events with **high vertical and spatial resolution**
- learn more about the drop size distribution, liquid water content and rain rate for **high-impact events**

Vertical profile of Liquid Water Content:
Product of total volume of all droplets with density of water, divided by the scattering volume

- 0 - 4000 m vertical range
- Over 60 min time

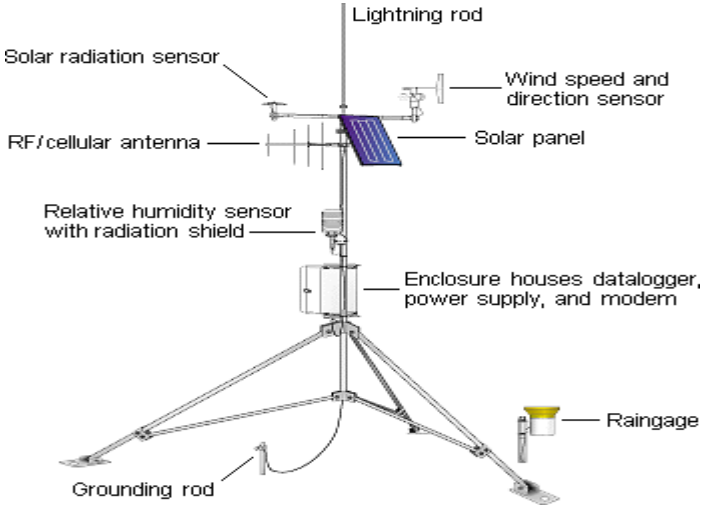


Rain rate: derived from liquid water content and fall velocity (Doppler spectra)

Network of weather stations

Disdrometers (?)

Davis (MQ)

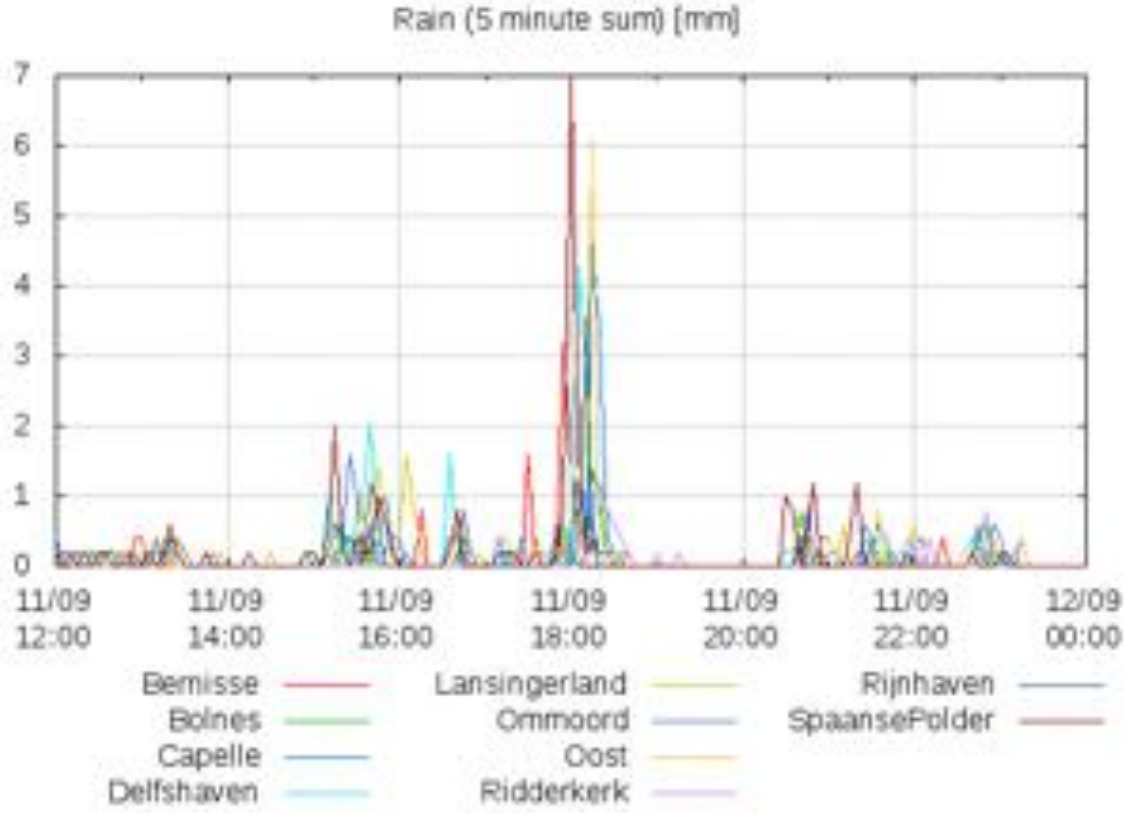


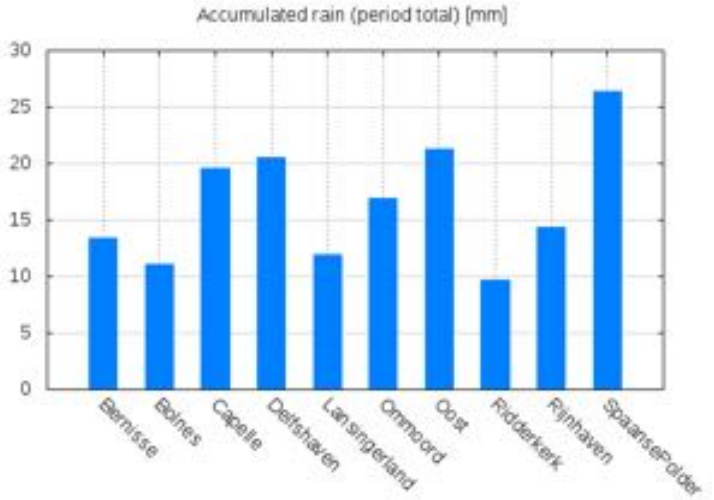
Netatmo (LQ)

Campbell (HQ)

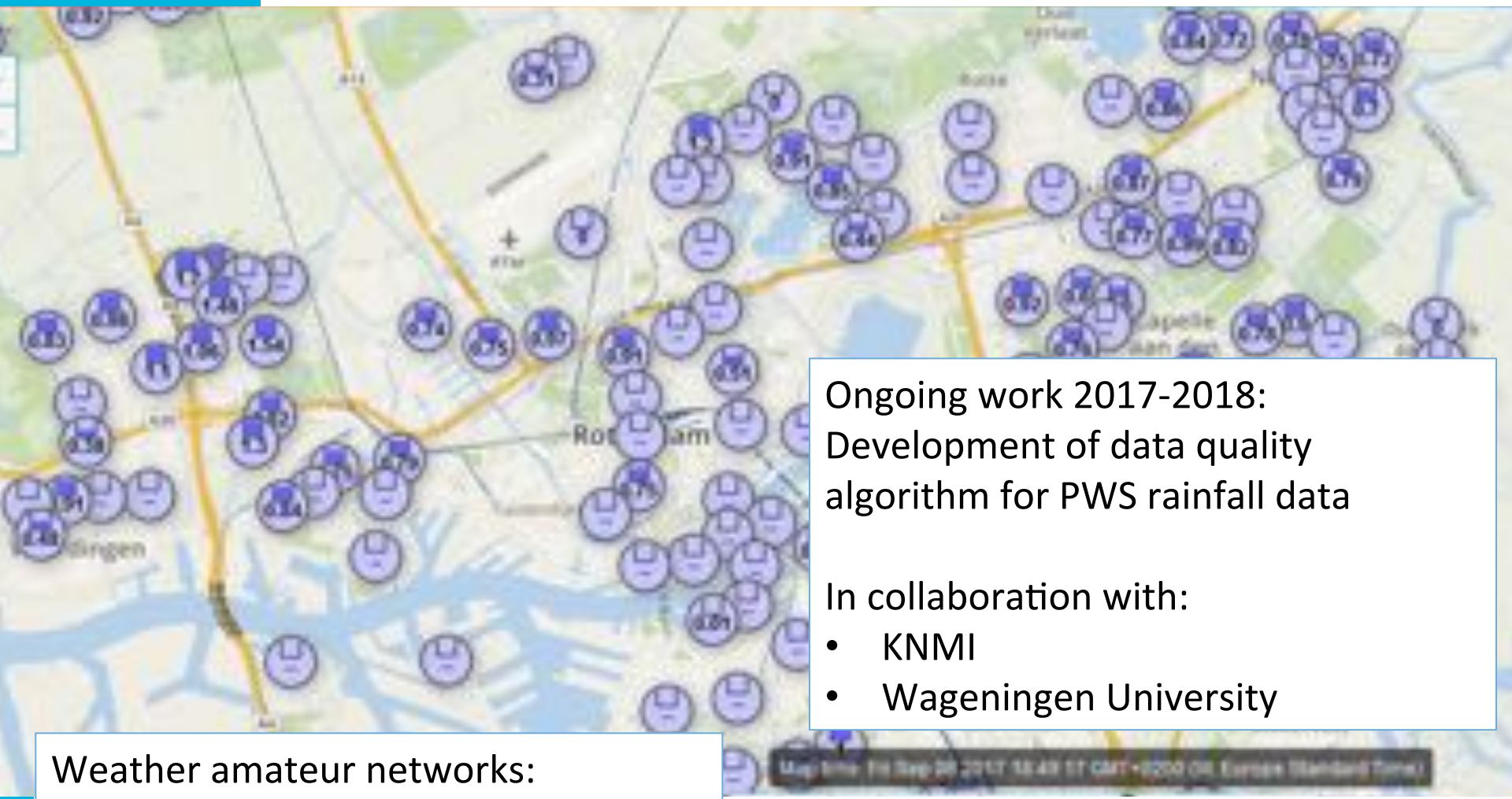
Network of weather stations

www.weather.tudelft.nl





Rainfall:
retrieval of tipping times
Data communication: LoRa
(Long Range, wireless data communication)



Ongoing work 2017-2018:
Development of data quality algorithm for PWS rainfall data

In collaboration with:

- KNMI
- Wageningen University

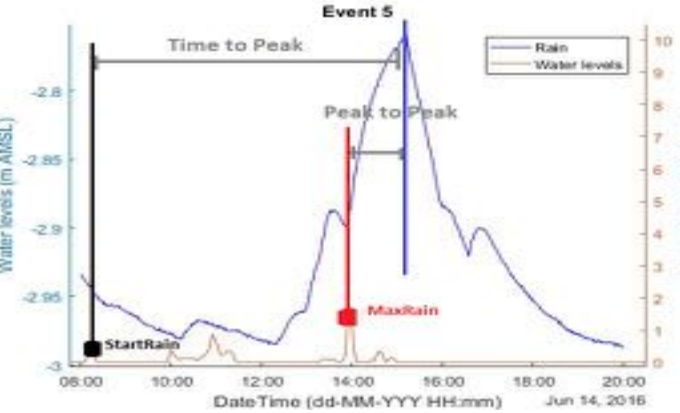
Weather amateur networks:
personal weather station data (PWS)

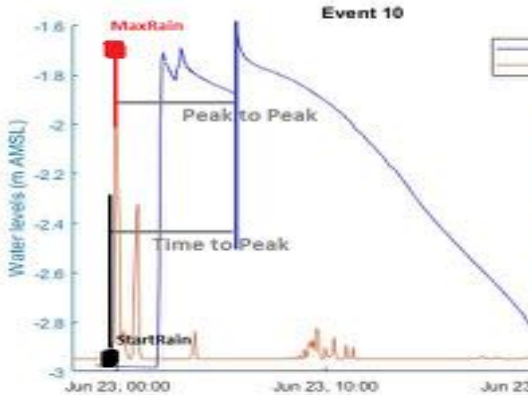
Hydrological response analysis

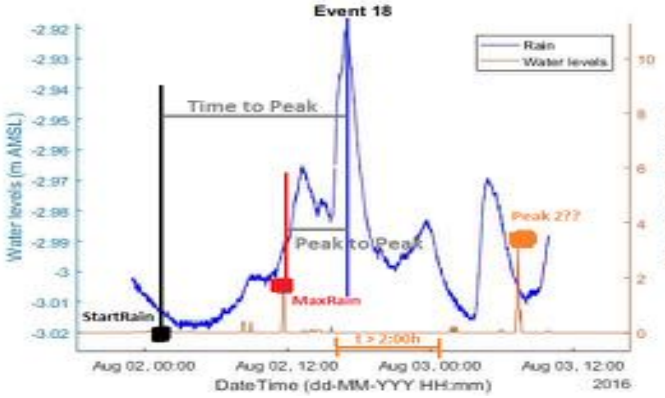
- Water level sensors at CSOs: 21 locations, in 13 sewer districts

- Flood observations by citizens (call centre data)

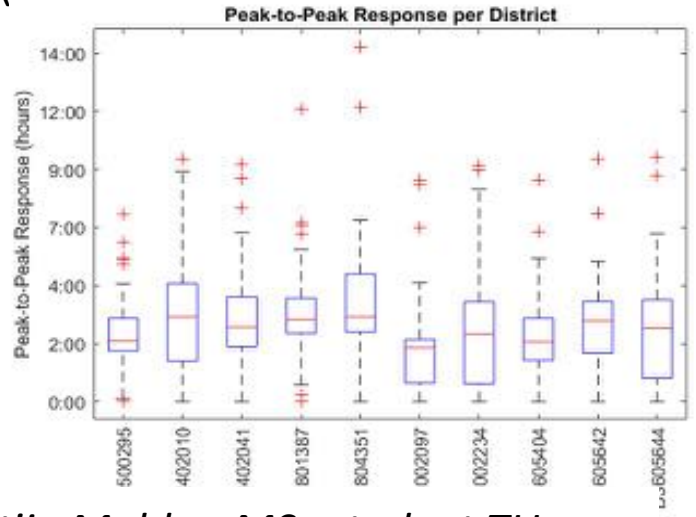
- Impact of green-blue solutions: green roofs, permeable pavements, bio-retention/rain gardens







Figures: Response time analysis; water level (blue), rainfall (red) (Example for District 5, 3 events)



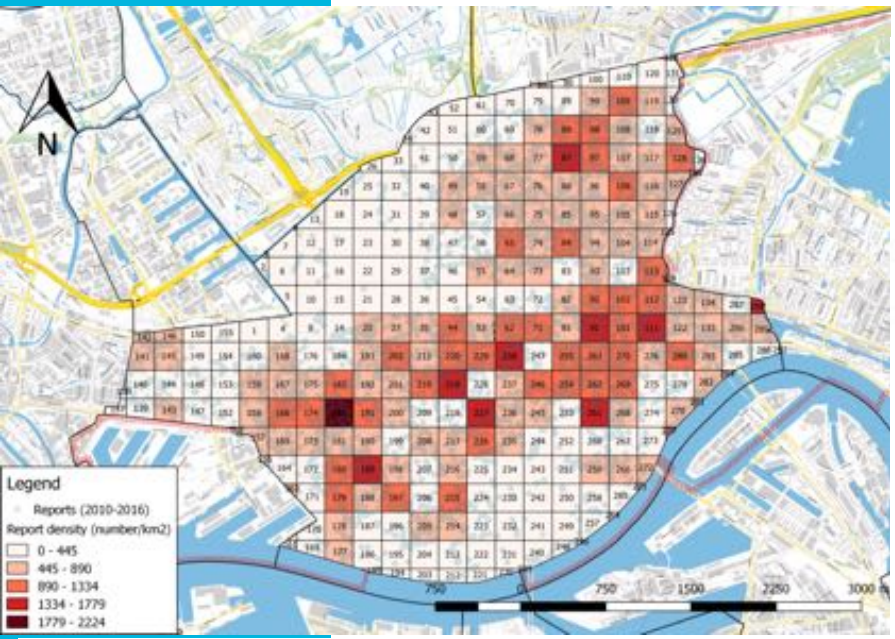
Water levels at cso-weirs - Response time analysis, preliminary conclusions:

- RT varies between < 1 to > 4 h (25-75% range)
- No significant correlations with area size, imp. degree

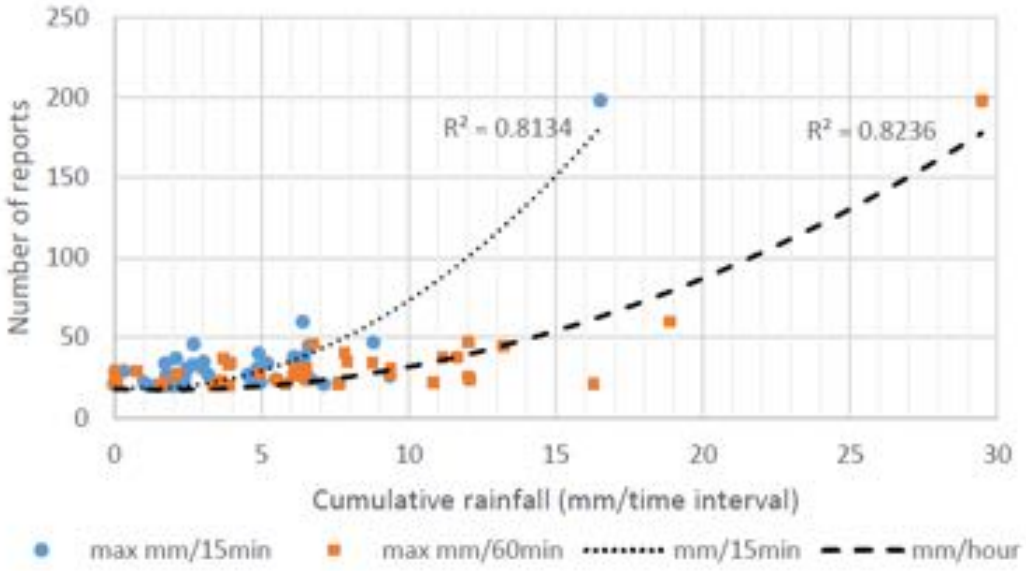
Courtesy: Martijn Mulder, MSc student TU

Crowdsourcing: citizens' flood observations

Objective: to identify critical thresholds for early warning



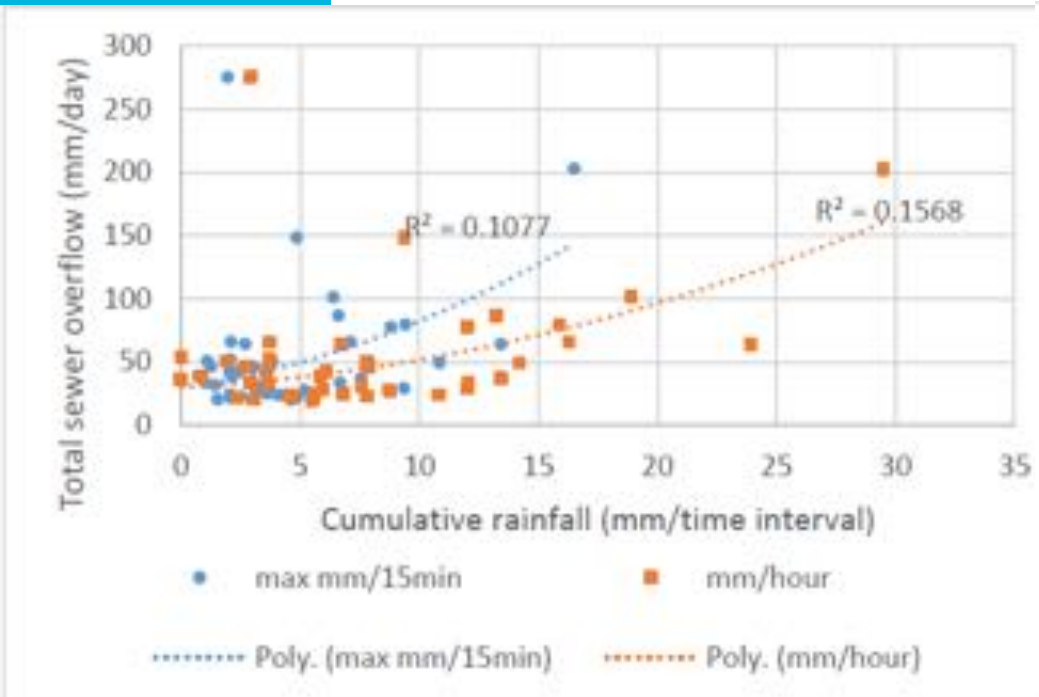
Density of flood reports, 2010-2016

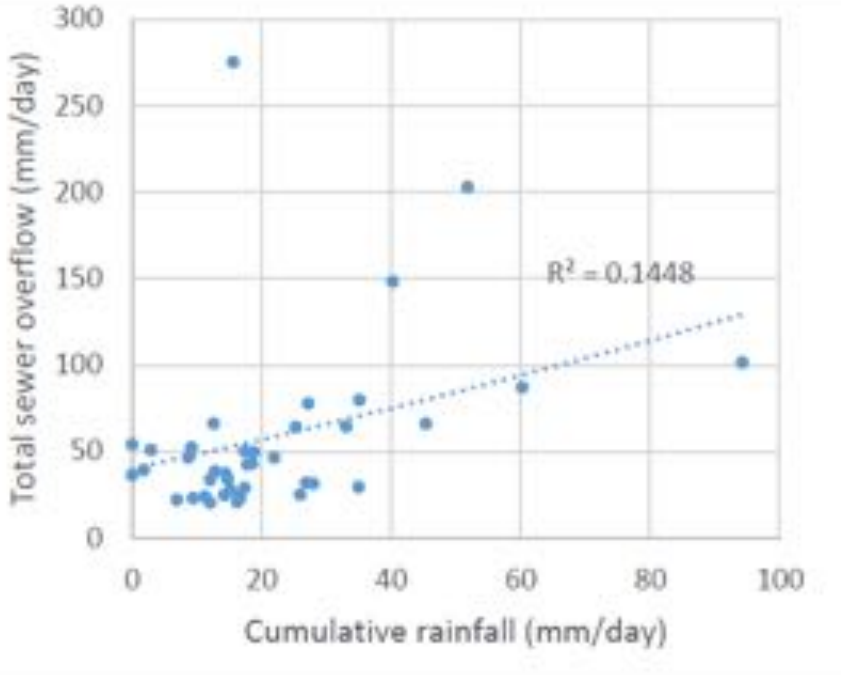


Courtesy: Christian Bouwens, MSc student TU Delft

Hydrological response analysis : Overflow pumping

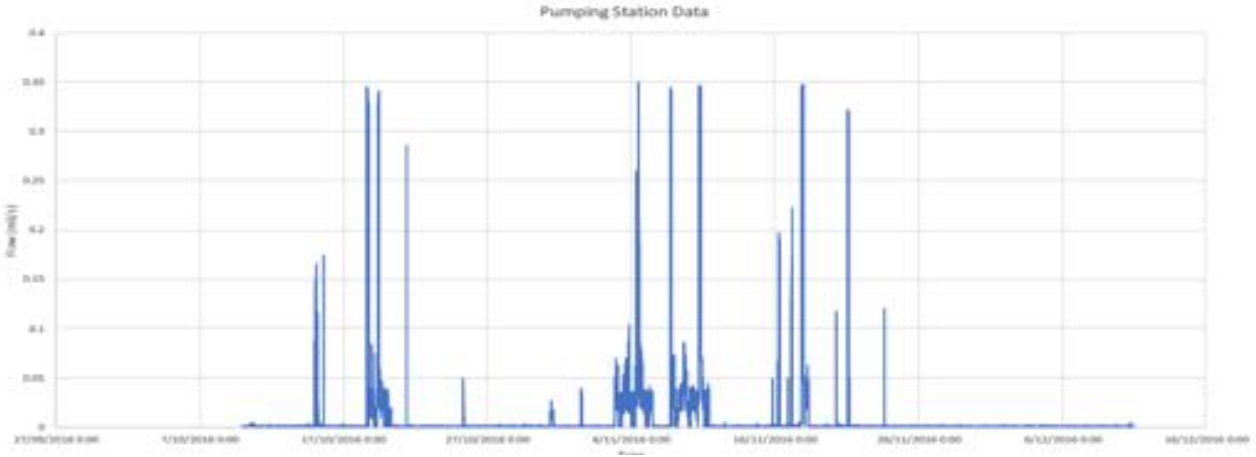
Objective: to identify critical thresholds for early warning





Impact of green-blue solutions

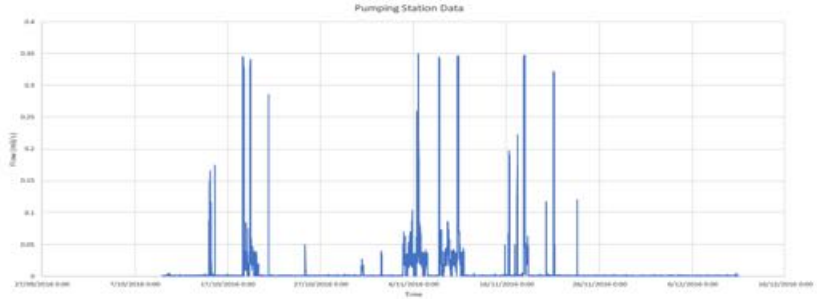
Study area: 1.32 km2



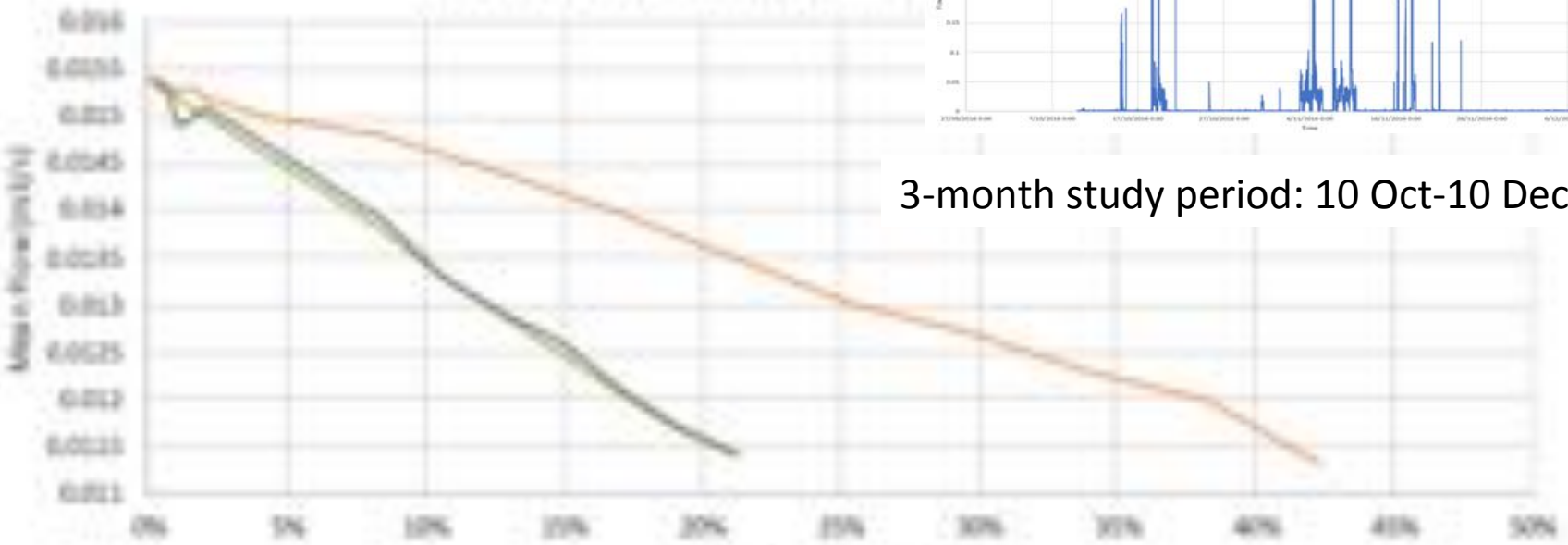
3-month study period: 10 Oct-10 Dec 2016, mild rainfall events (no CSO overflows)

Courtesy: Jack Hill, visiting student Univ of Melbourne

Impact of green-blue solutions

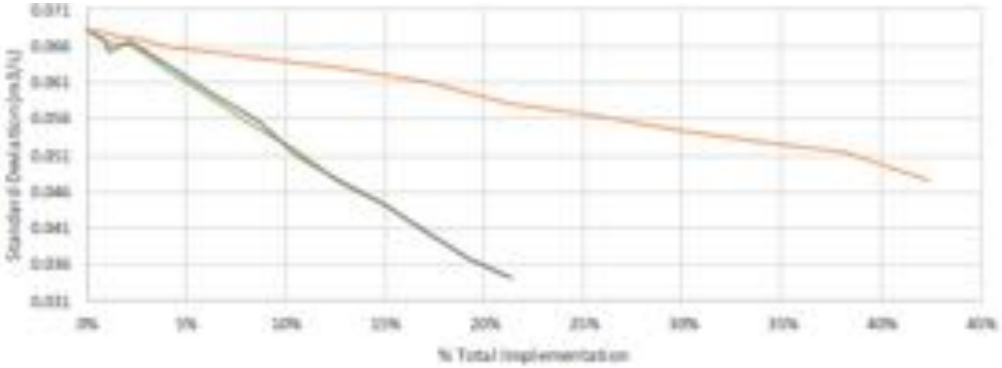


3-month study period: 10 Oct-10 Dec 2016

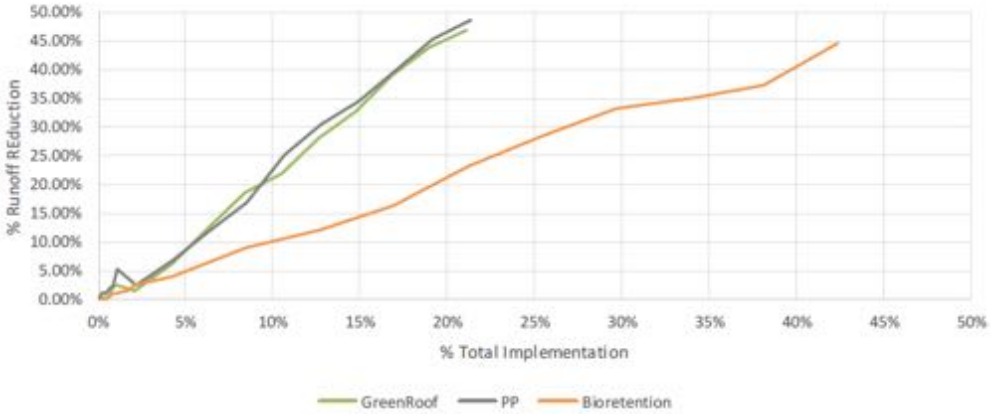


% Total implementation: area implemented/total area

Impact of green-blue solutions



Flow variability
(expressed as STD)



% Peak runoff reduction:
Q_99%-ile (x% impl)/
Q_99%-ile (0% impl)

% Total implementation: area implemented/total area

Impact of green-blue solutions

Some preliminary conclusions:

1-2-3 June 2018

- green roofs and permeable pavements more effective than bioretention (larger storage capacity)
- location of implementation is important: larger impact close to system outlet than far from system outlet

Hydro-Meteo-observatory Rotterdam

Future work

- Analysing small-scale rainfall variability, space-time characteristics
- Obtain high accuracy rainfall estimates
- Develop early-warning tool to support urban flood response (low-cost rainfall sensors, citizen science project)
- Hydrological response analysis: predictors for peak flow variability, runoff ratios, impact of imperviousness and green blue solutions
- Short-term high resolution rainfall forecasting (nowcasting)
- Numerical weather prediction: WRF for urban environment

Merci de votre attention

Thank you!

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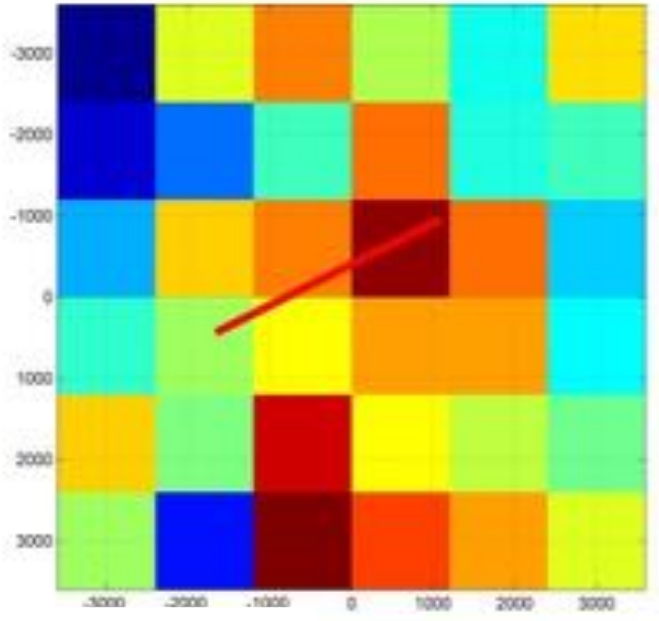
Herman Russchenberg, Marc Schleiss, Nick van de Giesen, Robert Banks, Xin Tian, Elena Cristiano, Andreas Krietemeyer

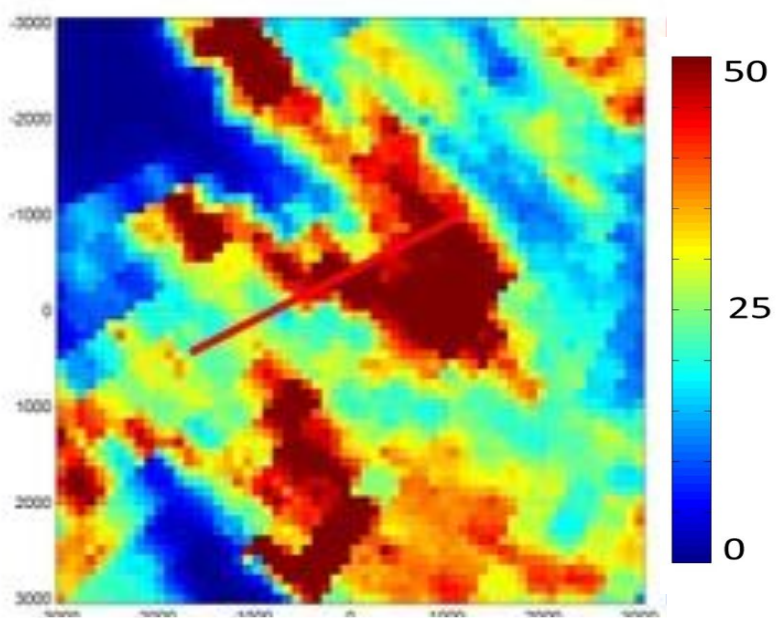
Backup slides

National Weather Radar
1x1 km^2, 5-15 min

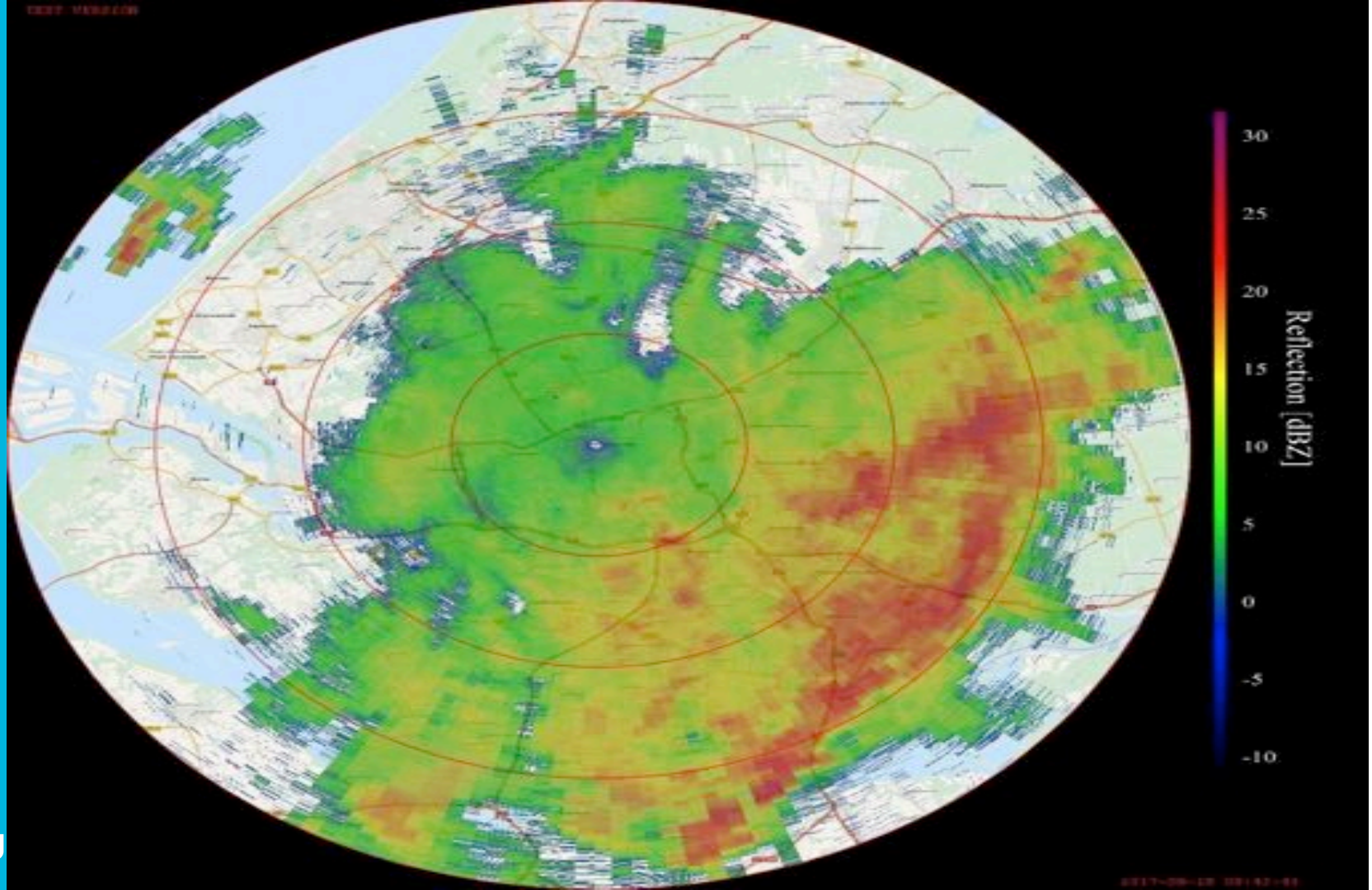


Courtesy: KNMI

Polarimetric X-band radar
100x100 km2, 1 min



Courtesy: H.W.J. Russchenberg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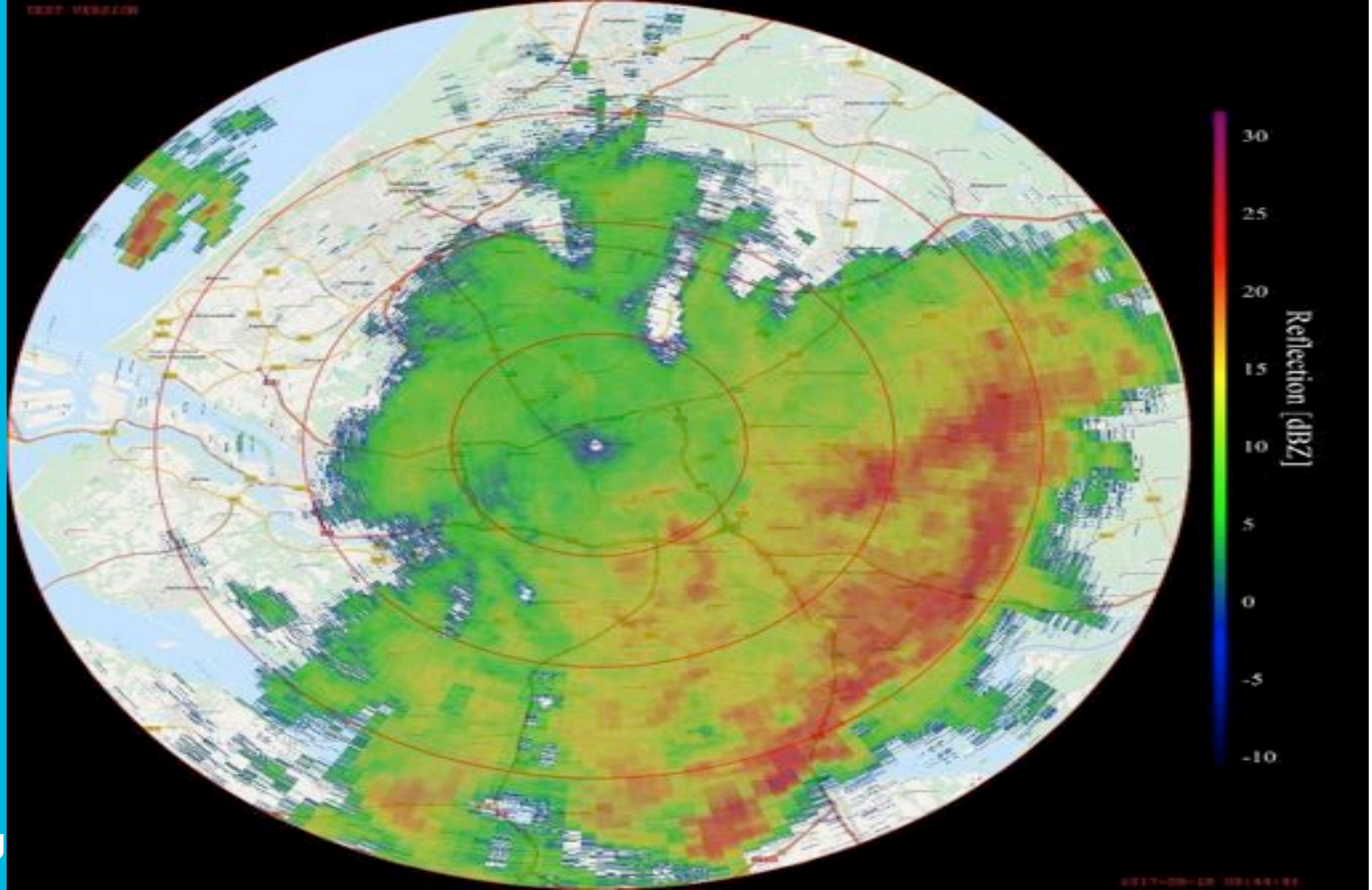
Reflection [dBZ]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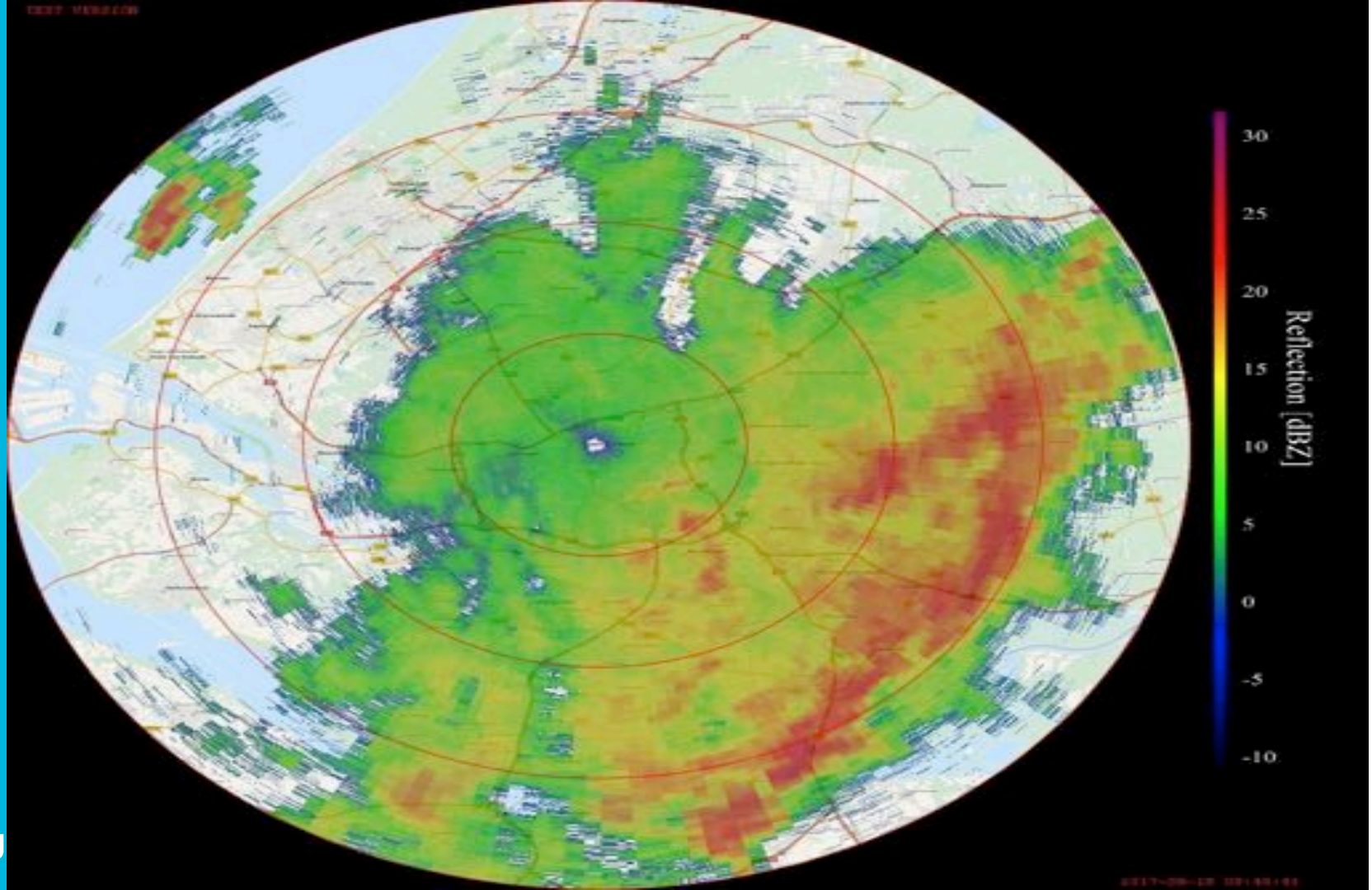
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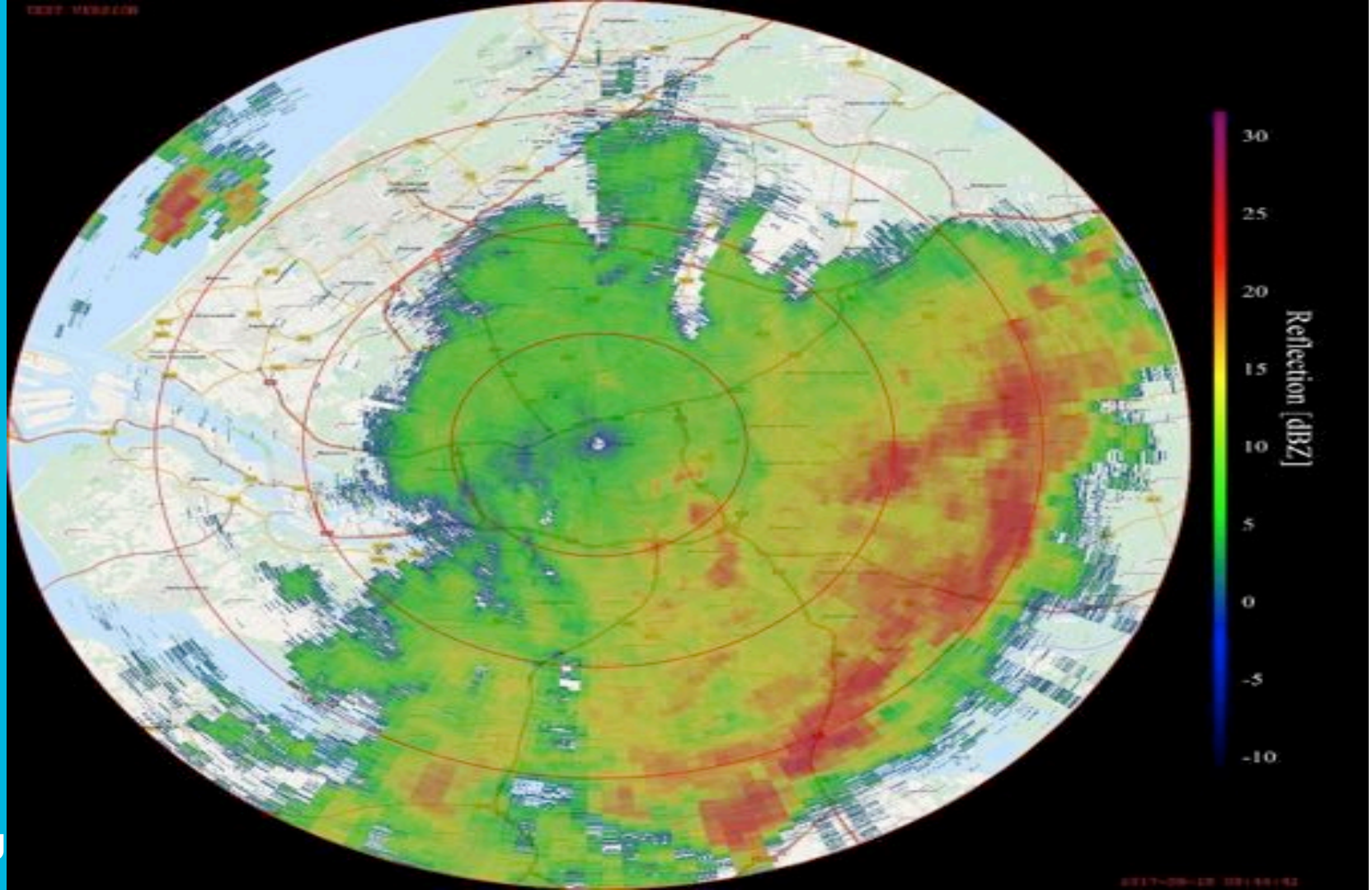
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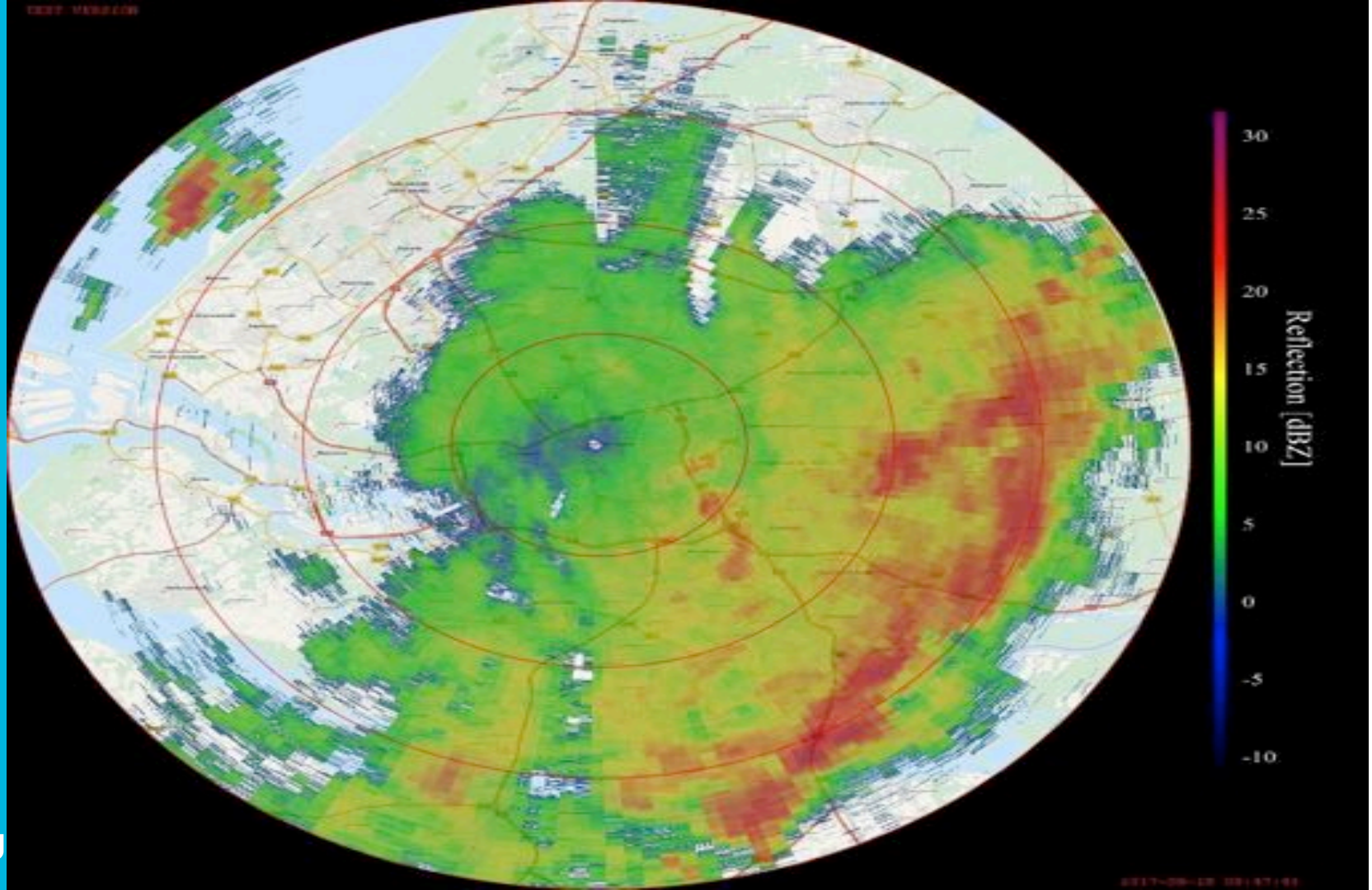
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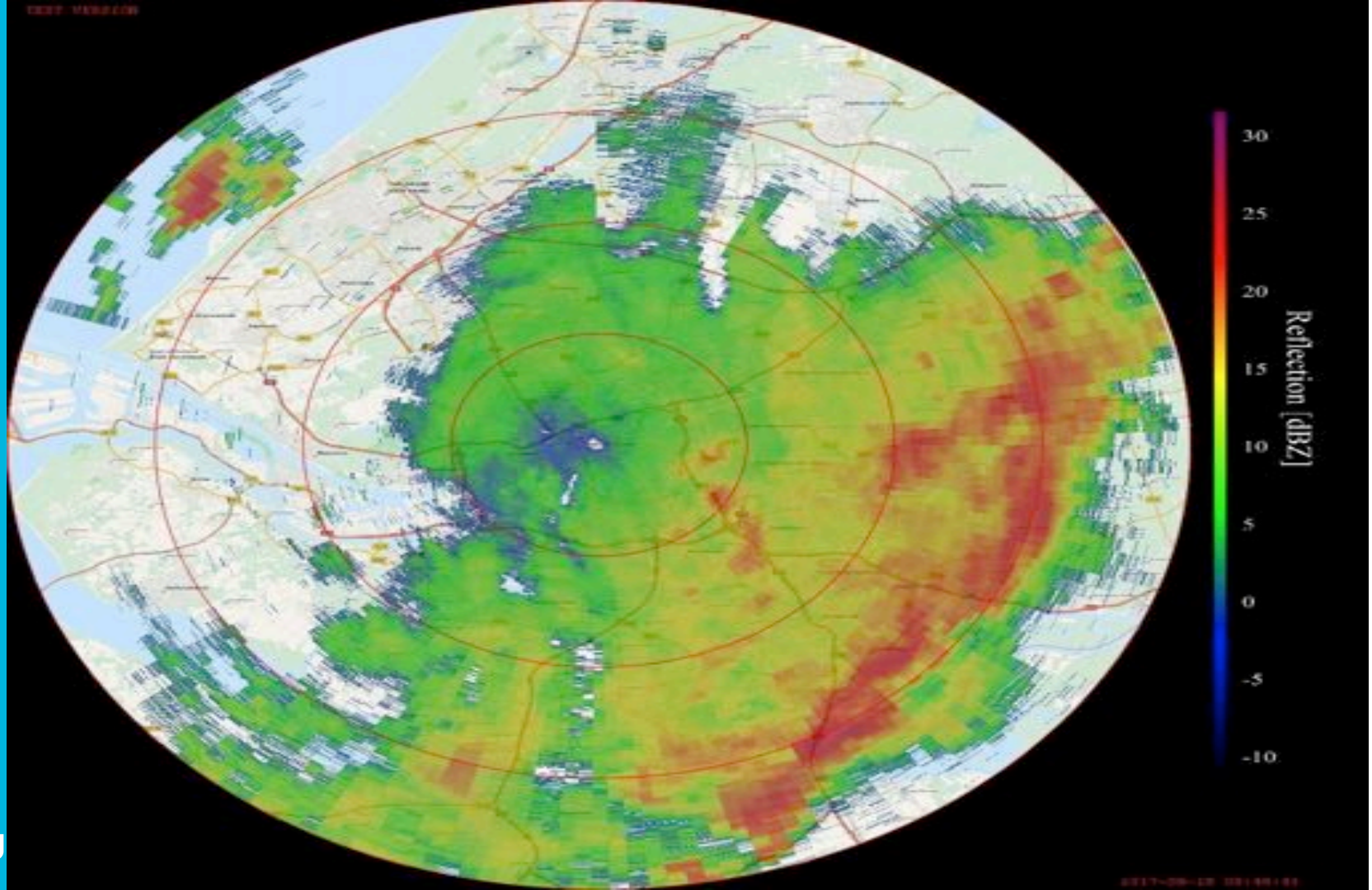
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