# Impact of rainfall and model resolution on sewer hydrodynamics

**G. Bruni[a], J.A.E. ten Veldhuis[a], F.H.L.R. Clemens[a], [b]**

[a] Water management Department, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Stevinweg 1, 2628CN, Delft, NL

[b] Deltares, P.O. Box 177, 2600 MD Delft, The Netherlands

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# Problem statement

IMPROVEMENT OF RAINFALL ESTIMATE ACCURACY

ENHANCEMENT OF THE USE OF RADAR RAINFALL

X-BAND DUAL POLARIMETRIC RADARS TO INCREASE THE RESOLUTION AND ACCURACY

?

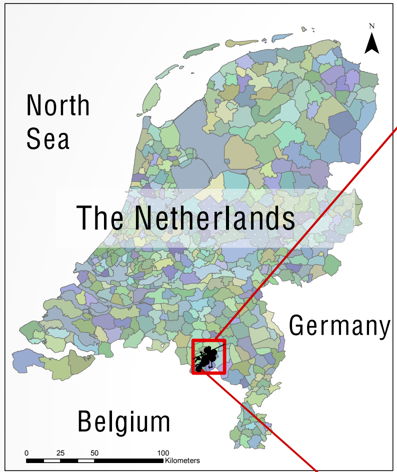
IMPROVEMENT OF THE DETAIL OF SEWER MODELS

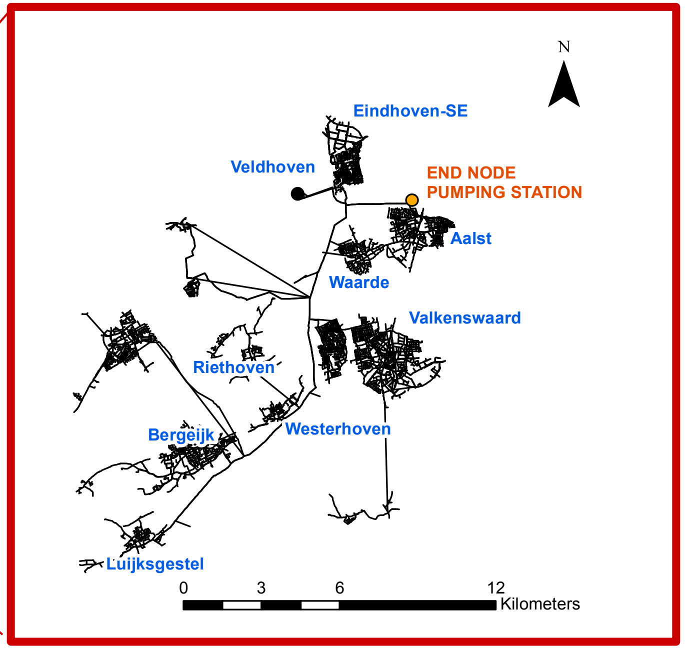
ACCURATE INFORMATION OF SEWER CHARACTERISTICS AND PROCESSES

DETAILED LAND USE INFORMATION

# Casestudy

## Eindoven area: Riool Zuid -> "Southern sewer system"

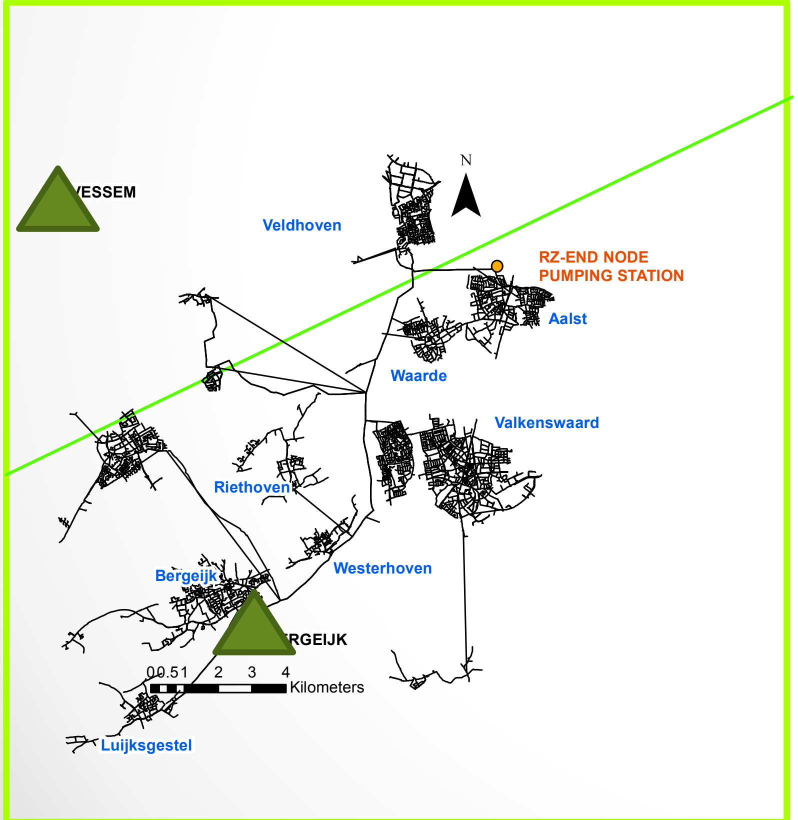


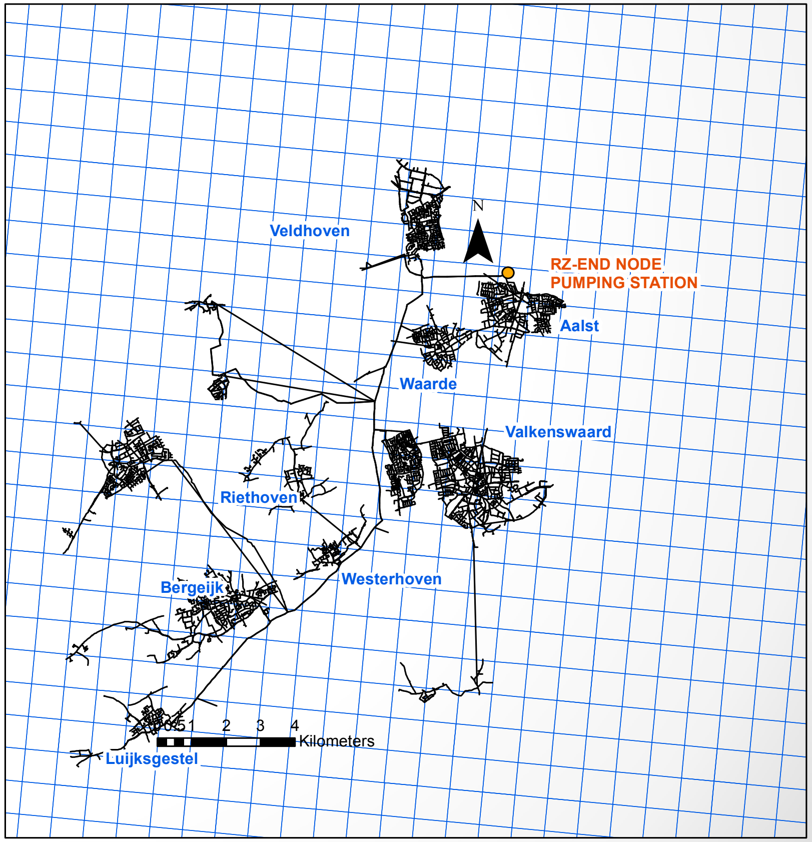

- it serves 9 municipalities (~3'000 to ~43'000 inhabitants)
- 18.6 km long free-flow conduit
- Sewer system detail: from~ 500 nodes to 3'800 nodes .

# Dataset-Rainfall

Ground measurements:
2 rain gauges
Bergeijk and Vessem

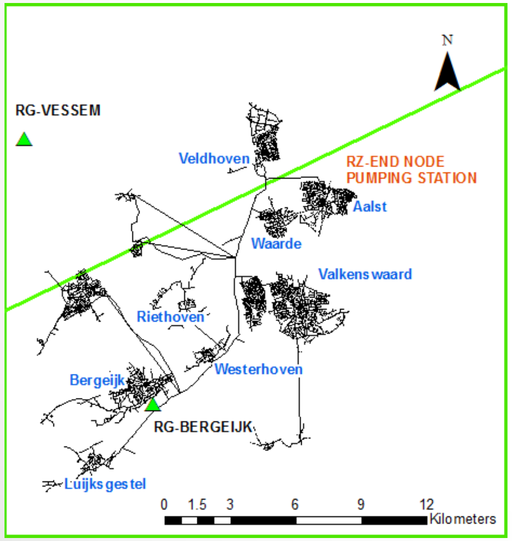



C-band radar data, KNMI

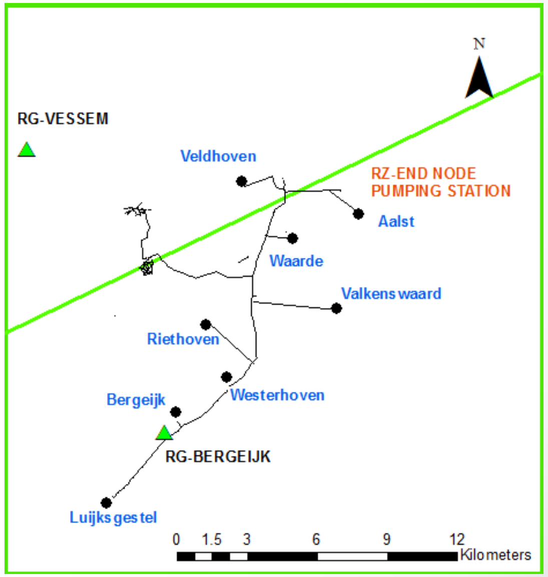


# Dataset- model specification

- Software package: Infoworks CS
- Runoff estimation model: Fixed RC (impervious areas) and Horton for infiltration losses (pervious areas)
- Runoff concentration: single linear resevoir (Desbordes)
- Sewer flow routing: dynamic wave approximation of the Saint-Venant equations




Model lumping

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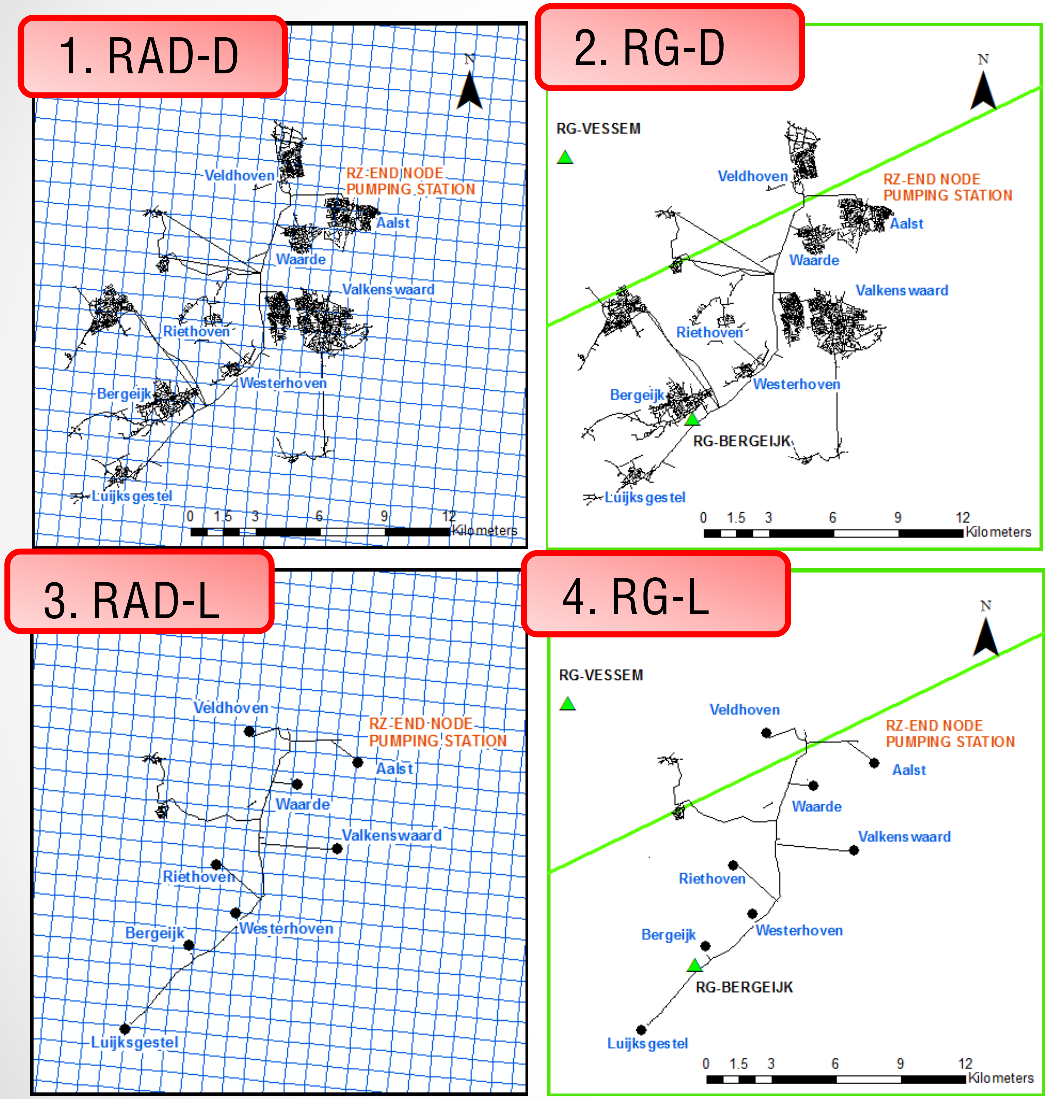
# Methodology




## Simulated scenarios

1. RAD-D: distributed sewer model with radar rainfall in input

2. RG-D: distributed sewer model with rain gauge rainfall in input

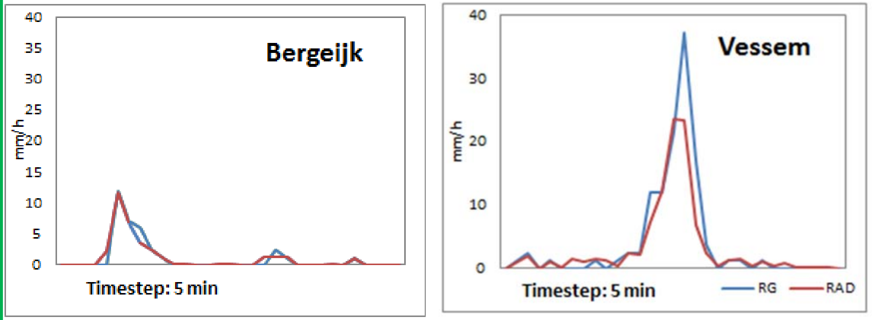
3. RAD-L: lumped sewer model with radar rainfall in input

4. RG-L: lumped sewer model with rain gauge rainfall in input

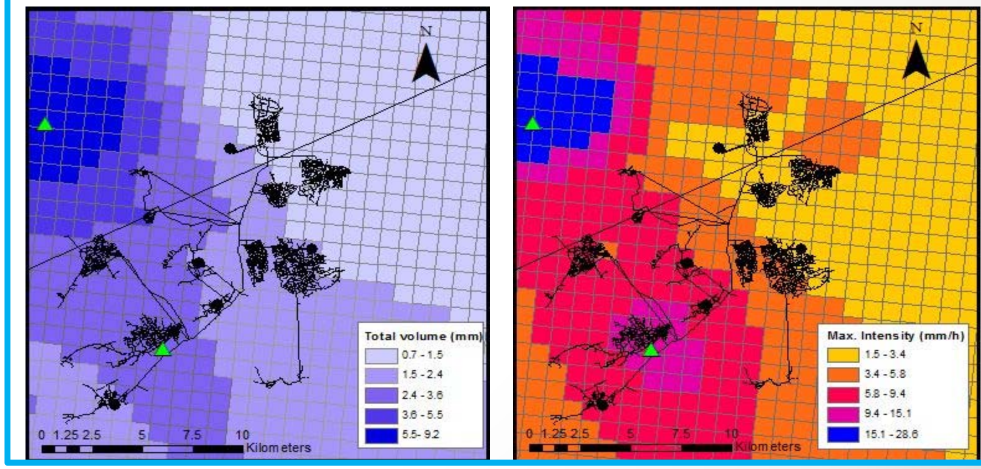
# Rainfall selection- Event 1

| Date | Duration | Total volume range (mm) | | Maximum intensity range (mm/h) | |
|---|---|---|---|---|---|
| (dd-mm) | (h) | RG | RAD | RG | RAD |
| 12-7 | 2.50 | 9.9-2.8 | 9.2-0.7 | 37.2-12 | 28.6-1.5 |

**Storm evolution** at Bergeijk and Vessem rain gauges vs overlapping radar pixels

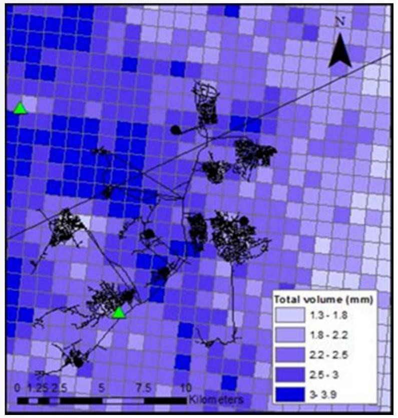


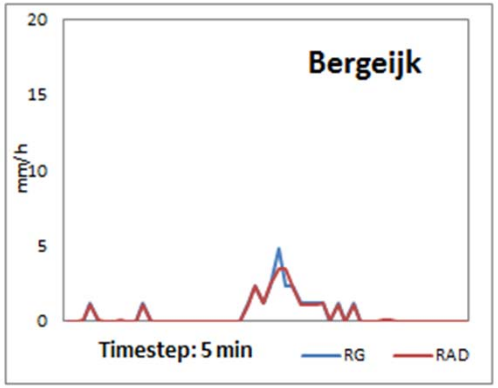

Radar storm **accumulation and maximum intensity**

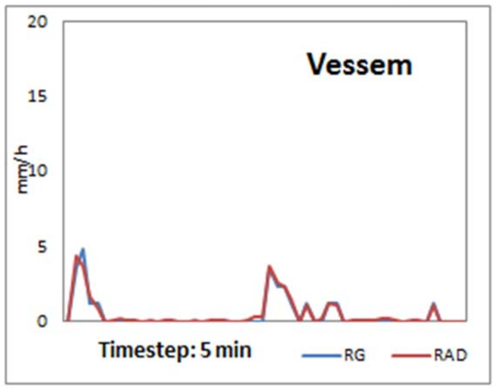


# Rainfall selection- Event 2, 3 and 4

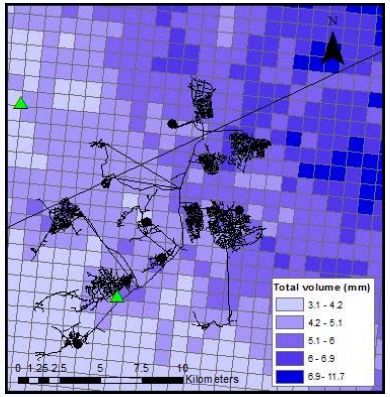
## Event 2

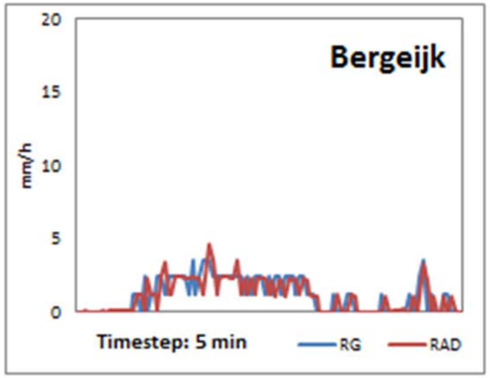


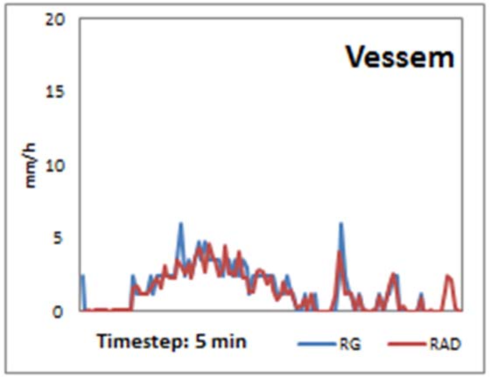



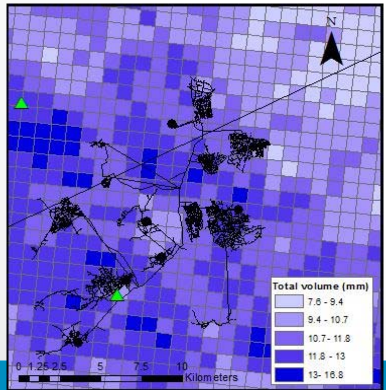

## Event 3

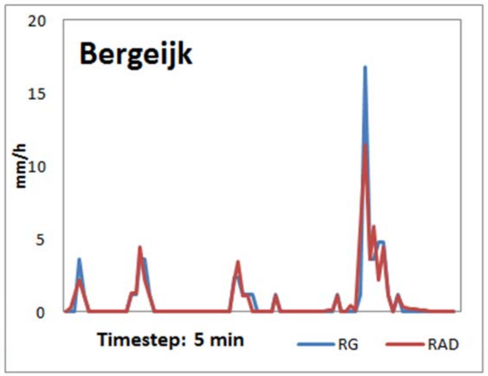


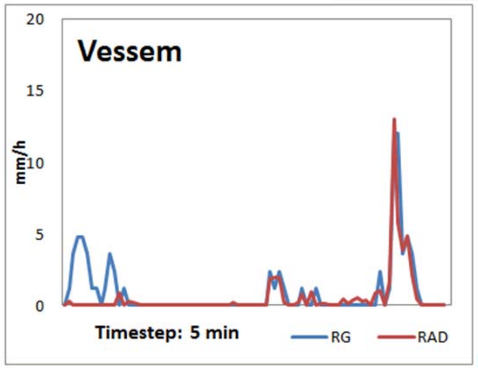



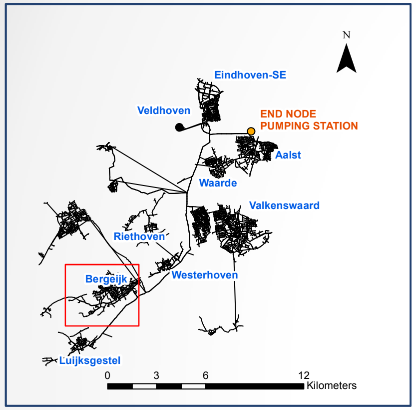

## Event 4



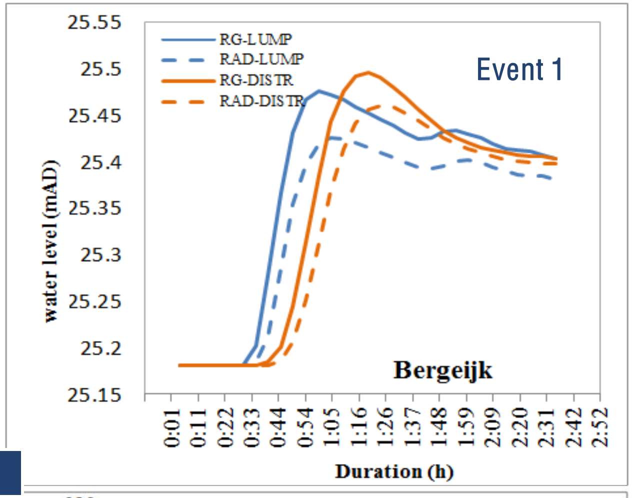



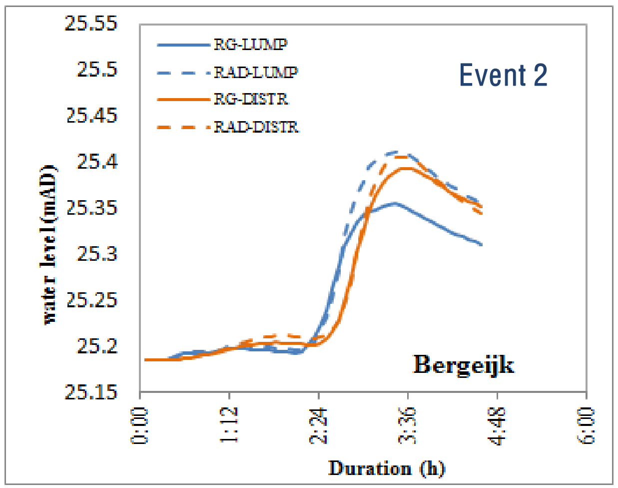



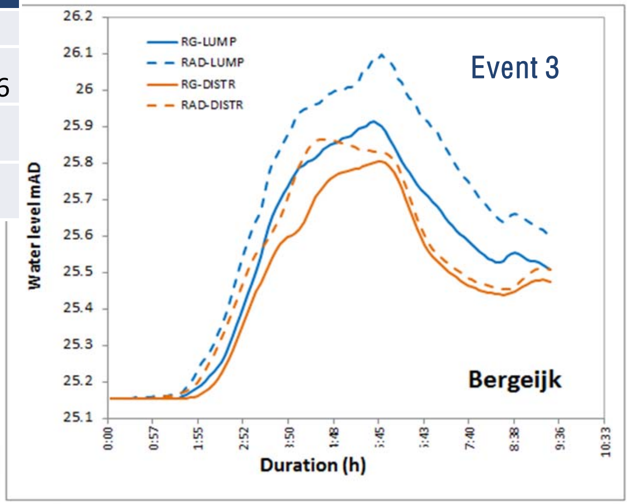
# Results-1
# Water level results at Bergeijk

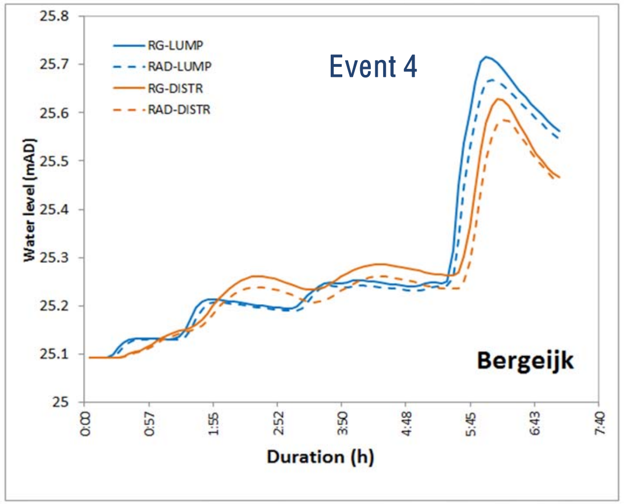



| MSE | EV1 | EV2 | EV3 | EV4 |
|---|---|---|---|---|
| RG-D vs RAD-D | 0.029 | 0.005 | 0.059 | 0.012 |
| RG-L vs RAD-L | 0.001 | 0.00001 | 0.013 | 0.00006 |
| RAD-L vs RAD-D | 0.053 | 0.010 | 0.259 | 0.021 |
| RG-L vs RG-D | 0.061 | 0.012 | 0.166 | 0.027 |



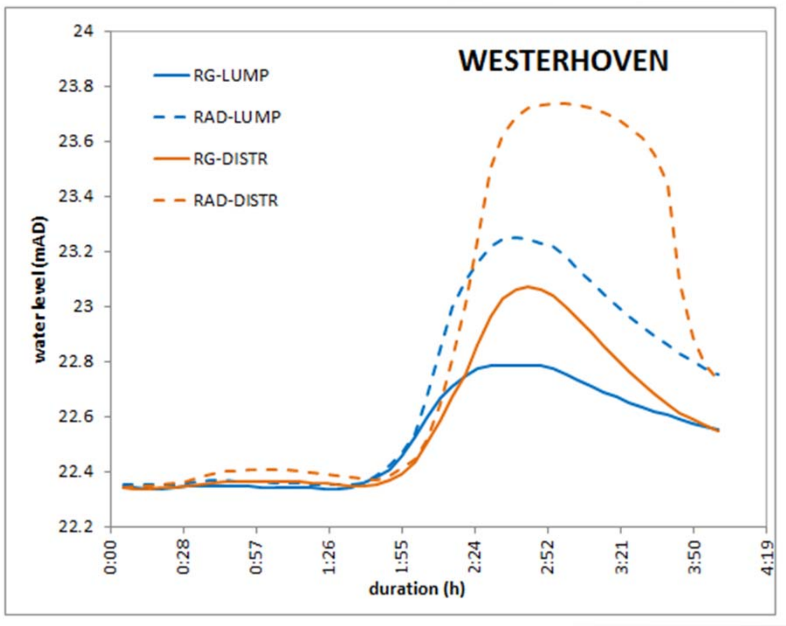



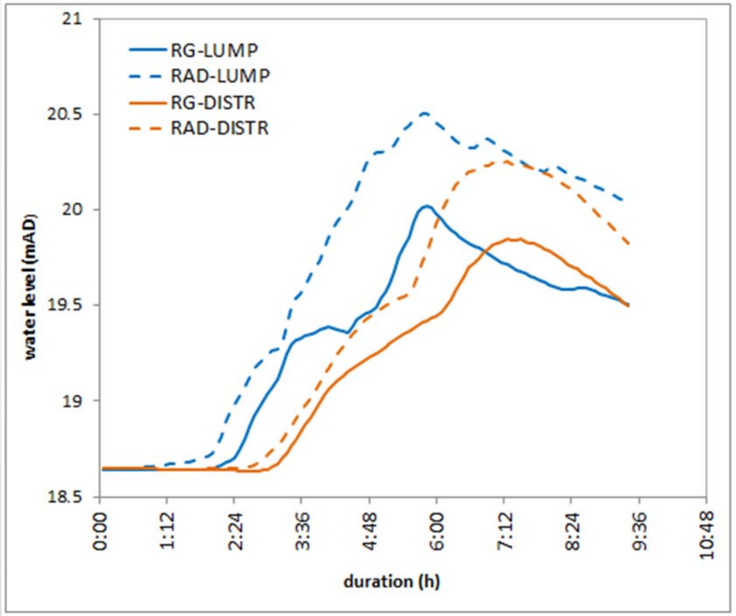



# Results-2

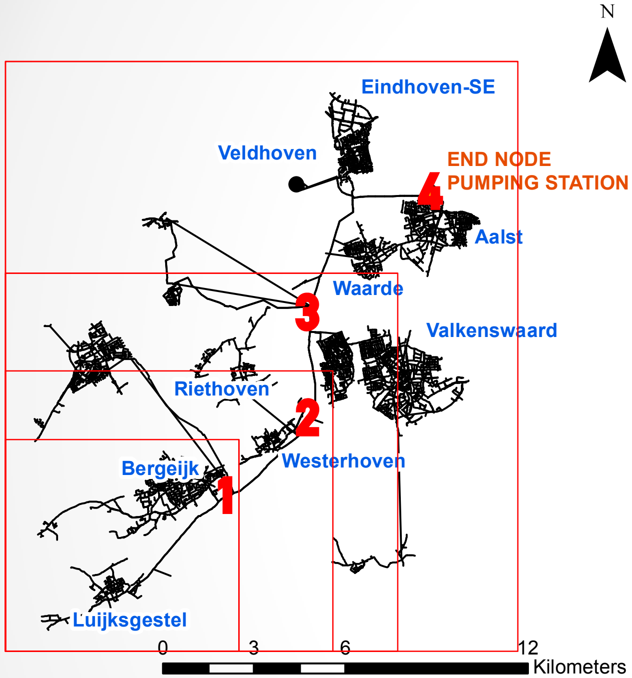
## Water level results at Westehoven-Event 2

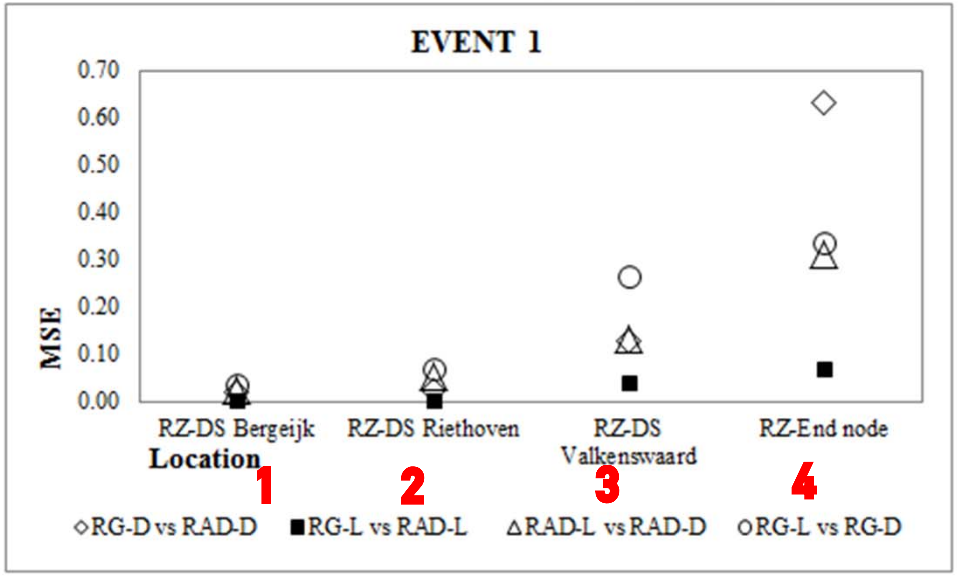


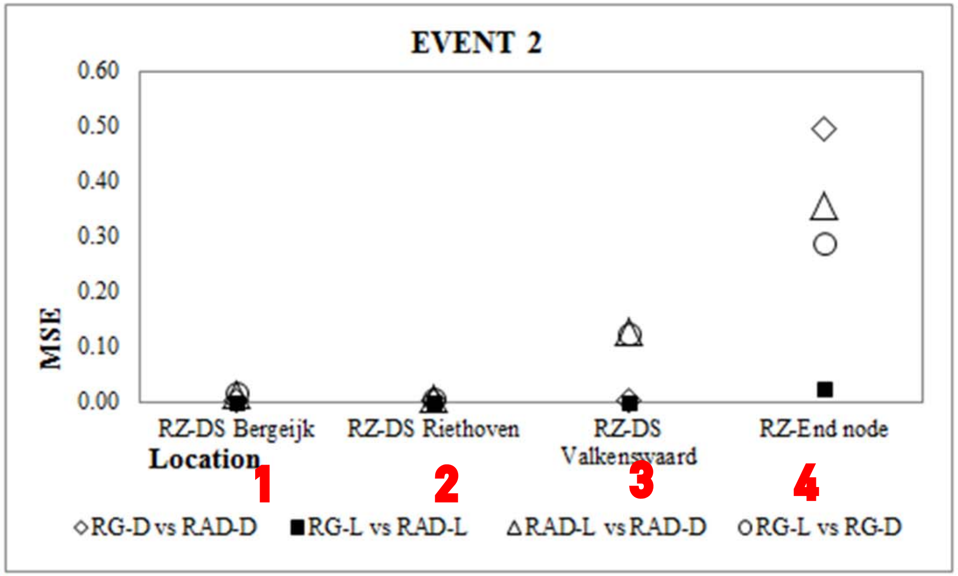

## Valkenswaard- Event 3



# Results 3- differences along the main conduit

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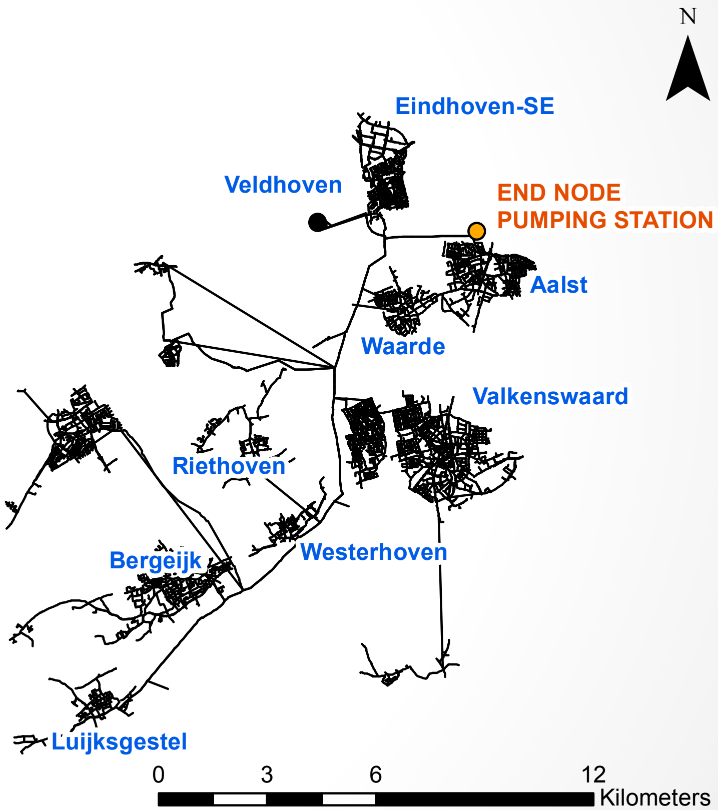
# Conclusions

- The impact of model structure on water levels is higher at locations close to rain gauges, i.e. when the rain gauge does accurately describe the storm evolution;
- The effect of rainfall resolution on model results becomes significant at locations far from the ground measurements: rain gauge fails to describe rainfall structure;
- The difference found in all six scenario pairs increases in the downstream direction, since the rain gauge is not representative of rainfall occurred at large distance (> 4 km), and the lumping of larger catchments introduces higher error.

# Thank you!

# Main characteristics of Riool Zuid sewer system:

| | Type of connection to Riool Zuid (mm) | Runoff area (ha) | Average slope (m/m) | Population - |
|---|---|---|---|---|
| Luijksgestel | Gravity | 39.4 | 0.0020 | 2936 |
| Bergeijk | Gravity | 173.8 | 0.0010 | 10749 |
| Westerhoven | Pump | 29.5 | 0.0030 | 2045 |
| Riethoven | Pump | 24.7 | 0.0030 | 2346 |
| Valkenswaard | Gravity | 392.5 | 0.0003 | 34430 |
| Waalre | Pump | 105.0 | 0.0030 | 6118 |
| Veldhoven | Pump | 422.0 | 0.0003 | 43158 |
| Eindhoven | Pump | 180.5 | 0.0010 | 10087 |
| Aalst | Orifice | 212.0 | 0.0040 | 11150 |



## Brandes spatial adjustment (BRA)*

This spatial method was proposed by Brandes (1975). A correction factor is calculated at each rain gauge site. All the factors are then interpolated on the whole radar field. This method follows the Barnes objective analysis scheme based on a negative exponential weighting to produce the calibration field:

$$C_{\mathrm{BRA}} = \frac{\sum_{i=1}^{N} w_i \,(G_i/R_i)}{\sum_{i=1}^{N} w_i} \qquad w_i = \exp \frac{-d_i^2}{k}$$

where $d_i$ is the distance between the grid point and the gauge i. The parameter k controls the degree of smoothing in the Brandes method. It is assumed constant over the whole domain.

The parameter k is computed as a function of the mean density  of the network, given by the number of gauges divided by the total area. A simple inverse relation has been chosen:

$k = (2\delta)^{-1}$

The factor 2 was adjusted to get an optimal k for the full network.

The optimal k was estimated by trial and error based on the verification for the year 2006. The same relation between k and  is used for the reduced networks.

*J.W. Wilson and E.A.Brandes, 1975
E. Goudenhoofdt and L. Delobbe, 2009