Estimating runoff coefficients using weather radars

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Motivation for the study

Aim of Ph.D. study:

- Develop methods to adjust weather radar QPE by the use of in-situ sewer sensors measurements.

Expected outcome:

- Minimize the uncertainty of flow and water level forecasting for real time control applications of waste water treatment plants and sewer systems.
Motivation for the study

In-situ sewer sensor adjustment of weather radar data in urban drainage
Methodology

Basic principle:

- Different rainfall structures over an urban drainage area will result in different runoff hydrographs in a down stream point.

SYSTEM IDENTIFICATION!

Acc. rainfall = 5 mm

Runoff coefficient = 0.4

Acc. runoff = 2 mm

Runoff coefficient = 0.2

Flow sensor

Acc. rainfall = 5 mm

Runoff coefficient = 0.4

Acc. runoff = 1 mm

Runoff coefficient = 0.2

Flow sensor
Methodology

Central assumptions:

- Unambiguity between precipitation and runoff in a point downstream
- Consistency between the mean runoff coefficient and runoff coefficients at subcatchment level
Methodology

Under the assumption of unambiguity it is possible to set up a system of linear equations

\[ A \mathbf{x} = \mathbf{b} \]

\[ A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}, \quad \mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}, \quad \mathbf{b} = \begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_m \end{bmatrix} \]

Optimization algorithm (minimization of Least Squared Error)

\[ LSE = \min \left( \sum (RO_{cal,n}(\varphi_m) - RO_{meas,n})^2 \right) \]
Case study area and data

Viby Catchment

- 669 ha combined sewer
- Large basin volumes and very limited amount of CSO.
  => Conservation of mass
- 1 min. flow measurements

Weather radar data

- C-band (Distance approx. 15 km)
  - Spatial resolution: 500 m
  - Temporal resolution: 5 min.
  - Standard Marshall Palmer
    \[ A = 220 \quad B = 1.6 \]
- Bias adjusted on event basis
### Results – estimated runoff coefficients

<table>
<thead>
<tr>
<th>Period</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
<th>AWM</th>
<th>STD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep. 2011 – Jan. 2012</td>
<td>0.25</td>
<td>0.31</td>
<td>0.32</td>
<td>0.24</td>
<td>0.23</td>
<td>0.22</td>
<td>0.57</td>
<td>0.26</td>
<td>0.11</td>
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<tr>
<td>Apr. 2012 – Aug. 2012*</td>
<td>0.11</td>
<td>0.33</td>
<td>0.50</td>
<td>0.20</td>
<td>0.22</td>
<td>0.25</td>
<td>0.68</td>
<td>0.28</td>
<td>0.14</td>
</tr>
<tr>
<td>Sep. 2011 – Aug. 2012*</td>
<td>0.10</td>
<td>0.31</td>
<td>0.48</td>
<td>0.21</td>
<td>0.22</td>
<td>0.24</td>
<td>0.70</td>
<td>0.27</td>
<td>0.15</td>
</tr>
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* Extended amount of ground clutter.

* Feb. – Mar. 2012 excluded due to snow

- **Summer period is dominating**
- **Number of events**
- **Accumulated runoff**
  - Apr. 2012 – Aug. 2012: 453,094 m³
Results – robustness analysis

All events are classified and ranked after the spatial rainfall variability of the event.

- Spatial rainfall variability described by the coefficient of variation \( CV = \frac{\sigma}{\mu} \).
- A high CV value indicates high spatial rainfall variability.
Results – robustness analysis – full periods

One year data

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CV threshold: 0.20
Discussion – aerial photos

Subcatchment C3: Estimated runoff coef.: 0.48

Subcatchment C5: Estimated runoff coef.: 0.22
Conclusion

• The study has proven that it is possible to identify realistic runoff coefficients by the use of corresponding measurements of the rainfall variability and storm water runoff.

• The estimated runoff coefficient are found reasonable when compared to aerial photos.

• The method gives stable results over a data period of one year.

• The method is relatively sensitive to the input data, so an extensive data treatment is needed.

• The method requires large spatial variation of the accumulated rainfall values.

• It is very interesting that it is possible to say something about the distribution of the hydrological parameters on the basis of the system responds to different rainfall events.
Thank you for your attention…

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