Probabilistic Forecasting For Urban Water Management

An Urban Case Study: Aarhus, Denmark

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What we’ll cover?

- 50th percentile
- 95th percentile
Background

Is Heavy Flooding In St. Lucia A Glimpse Into The Future Of The Caribbean?
What have we done?

- Developed a method for estimating the uncertainty in the rainfall forecast
- Compared rainfall forecast from NWP model with observed rainfall from rain gauges
- Compared two approaches for quantifying the uncertainty in the rainfall forecast
- Use the probabilistic information as input to a hydrological hydraulic model
What assumptions have we made?

- Observed rainfall is the ‘real’ rainfall
- Sewer model is fit for the purpose
- Complete temporal dependence between lead – times
  - Hence comparison of LHS results to the quantile approach
Case Study - Aarhus, Denmark

- Population: 250,000
- High quality data for the sewer system
- Archived rainfall forecasts
- Long records of observed data
- Good rain gauge coverage
Model Case Study

- 1926 manholes
- 1657 pipes
- 196 weirs
- 83 basins
- 26 pumps

Complex network
Rain gauge network

- 3 rain gauges
- Volumetric resolution = 0.2mm
- Temporal resolution = 1 minute
- Duration = 10 years of data

NWP model data

- Grid resolution = (6.2x11.1) km
- Study area = 138 km²
- Temporal resolution = 1 hr
- Duration = 2 years of data

**Legend**

- rain_gauges
- Model area
- Forecast coverage
- Thiessen polygon
Motivation - Fact

Discrepancy between the forecasted and observed rainfall
Forecast = 0 ("no rain")

- Probability of observing "rain"
  - Lognormal distribution
- Probability of observing "no rain"
  - Estimate probability from data
Forecast \(> 0\) ("rain")

- Probability of observing "rain"
- Probability of observing "no rain"
- Bivariate distribution
- Functional relationship to estimate the probability

Transformed observations

\[ \rho = 0.4908 \]

Areal forecasted rainfall (mm)
Areal observed rainfall (mm)

Forecasted rainfall >0, Observed rainfall >0

Probability

Best
LHS and Direct Quantile Approach

Rainfall Forecast

Forecast Ensemble

50th percentile
95th percentile
Comparison of max. WL over 2D grid

50\textsuperscript{th} percentile of max WL (m)

95\textsuperscript{th} percentile of max WL (m)
Results from hydrodynamic model

- Ensemble of water depths (LHS approach)
- 50th percentile quantile approach
- 95th percentile quantile approach

Comparing the LHS approach with the quantile approach, the LHS approach shows a wider range of water depths, indicating higher variability in the model predictions.
LHS approach

Direct quantile approach

50th percentile

95th percentile
Final thoughts

- Making decisions under uncertainty is one of the most difficult management decisions but is the most important one!!!

- Addressing uncertainty as a reality shifts the question:
  1. Should a flood warning be issued?
  2. With what confidence it might succeed?
Questions?

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