

# WRRF influent generator model for flowrate and quality prediction from combined sewer systems based on a data-driven methodology

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## Introduction Context

Modelling in wastewater treatment domain

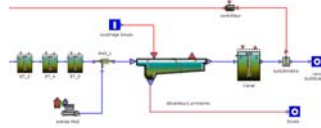


Water Resources  
Recovery Facility  
(WRRF) design

• Operation  
optimization



• Systems control



• Management  
• Decision making

**Realistic  
input  
data**



## Introduction

- Influent generator:  
A model to generate realistic flowrate and pollutant concentration dynamics at the inlet of WRRF.

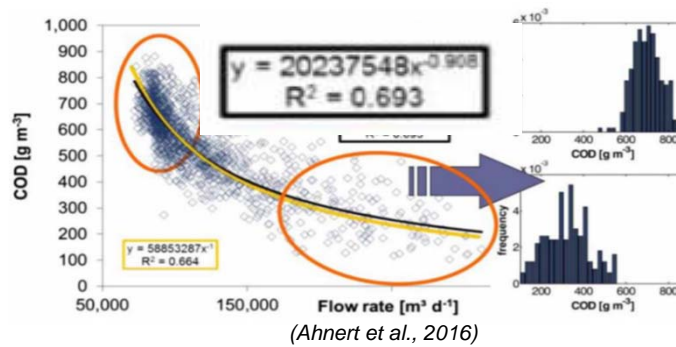
### Objectives

- ✓Realistic:  
Flowrate  
Water quality
- ✓Routine data-driven:  
Without more investment
- ✓Flexible and adaptable  
Generating range (long-term, short-term)  
Time resolution (hourly, daily)

## Introduction

Statistic/empirical  
'black box'

Phenomenological  
(generating mechanisms)  
'grey box'



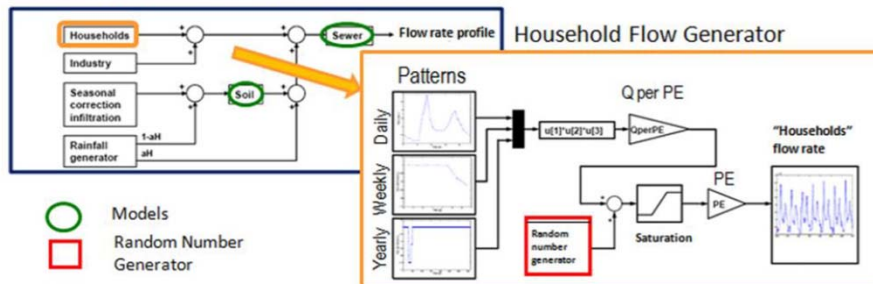
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### Architecture of the Flow Generator



Gernaey et al. (2005), further developed by Flores-Alsina et al. (2012)

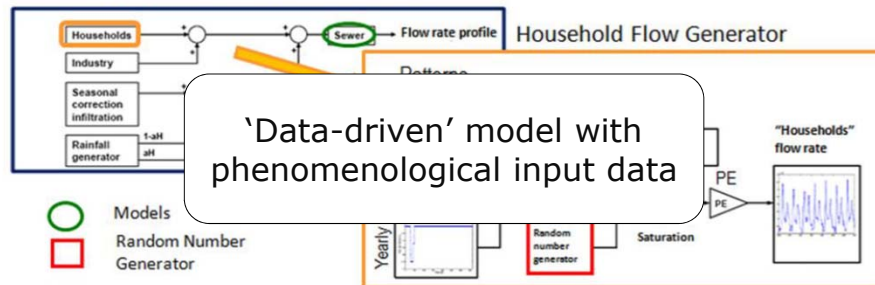
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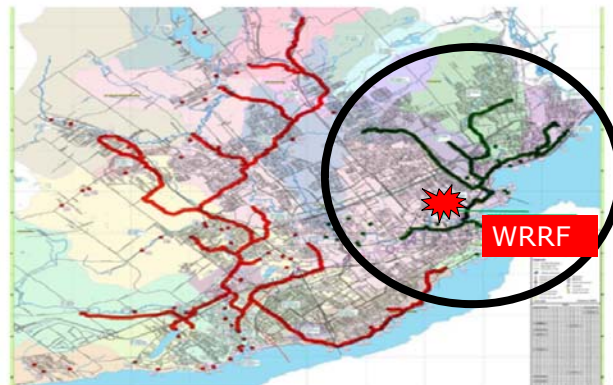


*Gernaey et al. (2005), further developed by Flores-Alsina et al.(2012)*

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## Methodology

- Case study → Combined sewer system

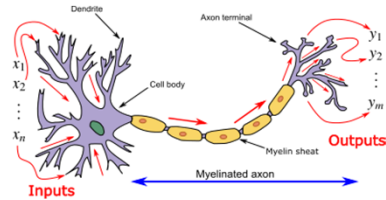


### Available dataset

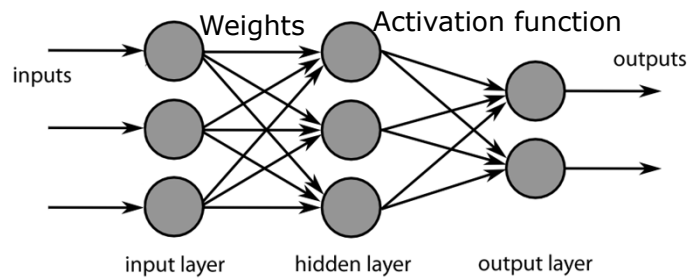
- Hourly measurements (2014-2018) Flowrate, Weather
- Daily measurements (2011-2018) Flowrate, COD, Weather

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## Methodology Artificial Neural Network (ANN)

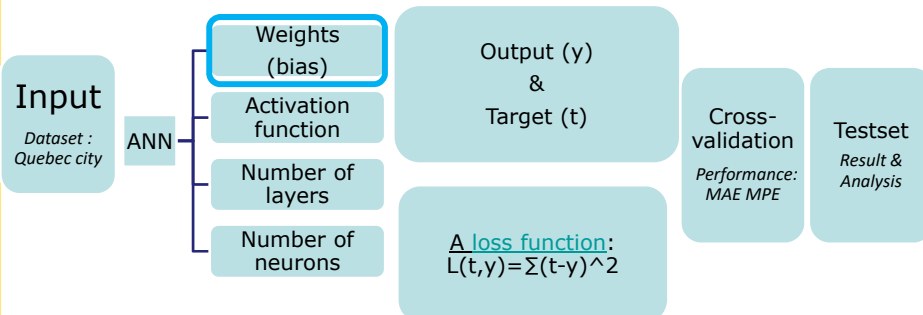
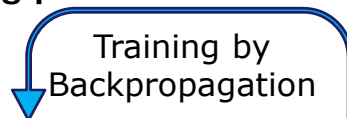


Inspiration from the biological learning process



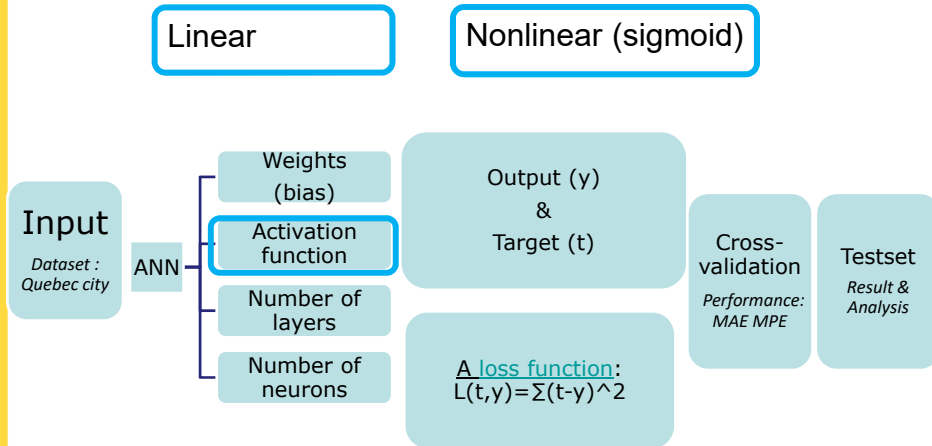
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## Methodology ANN training procedure



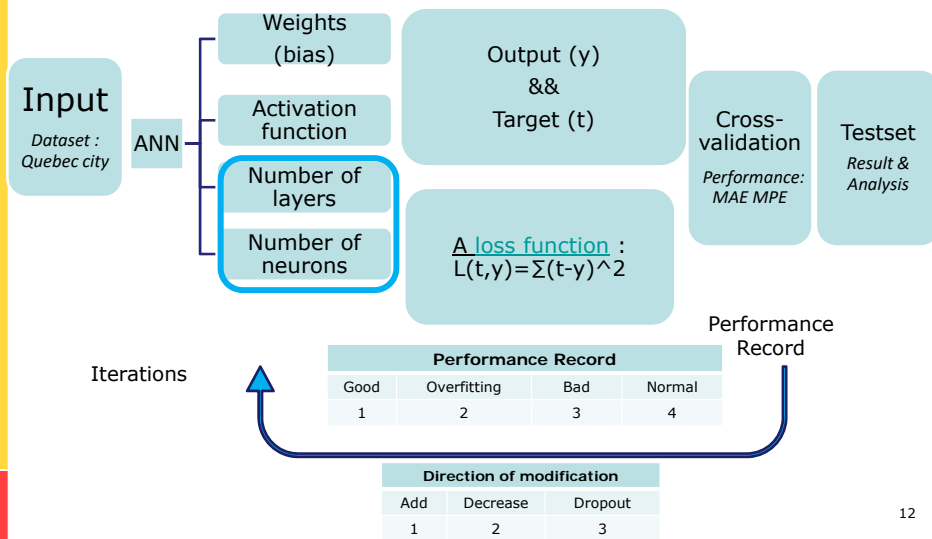
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## Methodology ANN training procedure



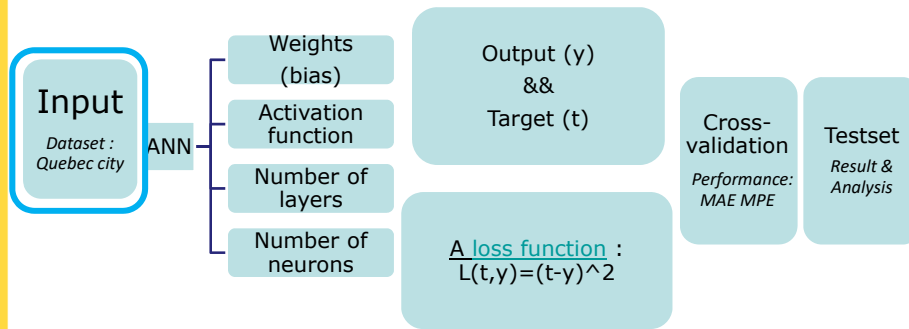
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## Methodology ANN training procedure



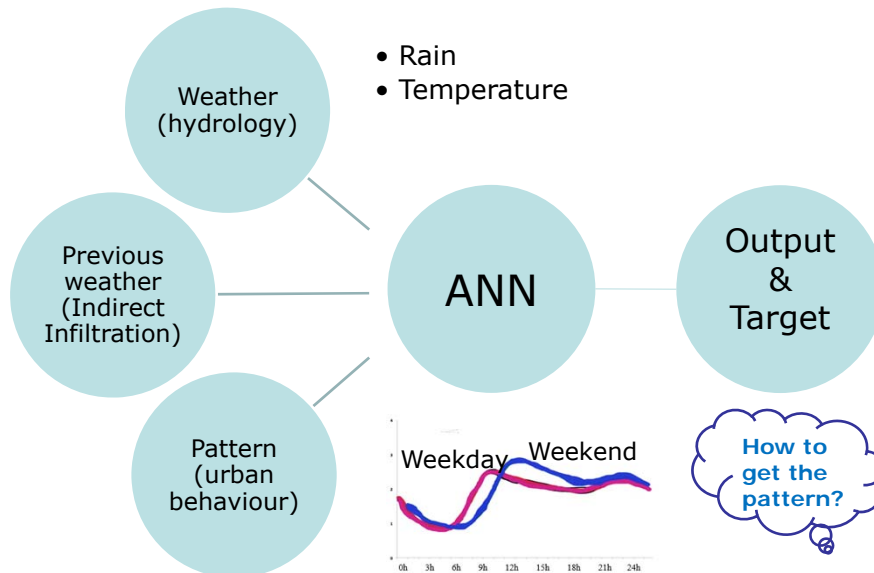
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## Methodology ANN training procedure



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## Methodology Input data preselection

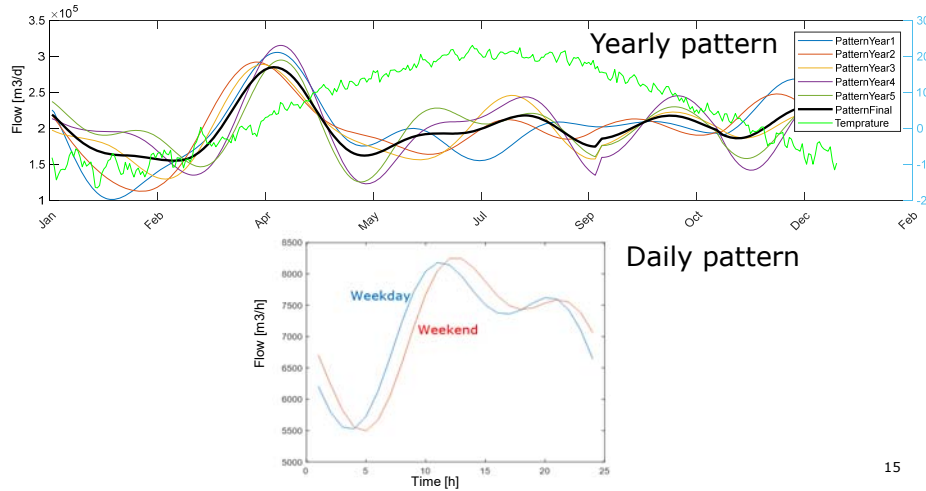


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## Methodology

### Input data preselection

- Fourier Transform: time domain  $\rightarrow$  frequency domain
- Chebyshev band pass filter

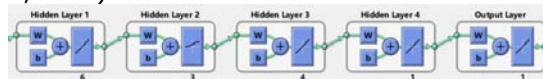


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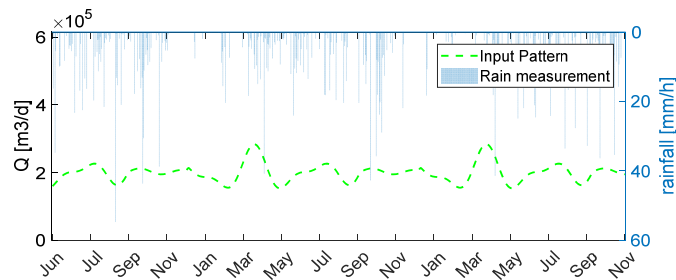
## Result analysis and discussion

### Influent generator for flowrate

- Input
  - Pattern derived by band pass filter ( $P_t, P_{t-1}, P_{t-2}, \dots, P_{t-5}$ )
  - Rain ( $R_t, R_{t-1}, \dots, R_{t-5}$ ) & sum ( $\text{Rain}(R_t \dots R_{t-5})$ )
  - Temperature ( $T_t, T_{t-1}, \dots, T_{t-5}$ )
- Neural network:



- Result: Daily flowrate

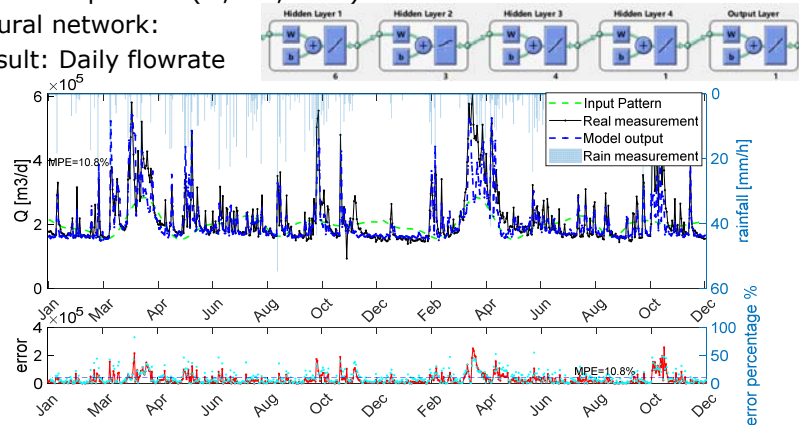


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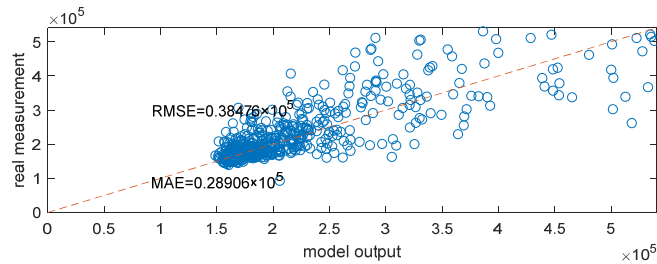
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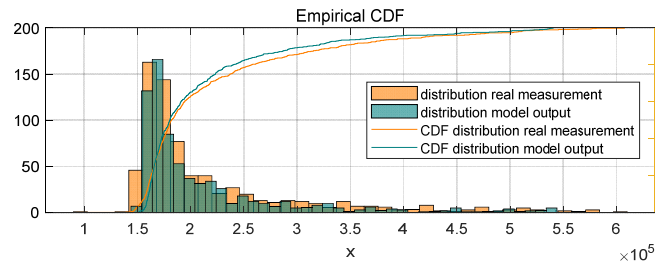


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## Result analysis and discussion Influent generator for flowrate



Symmetrically distributed

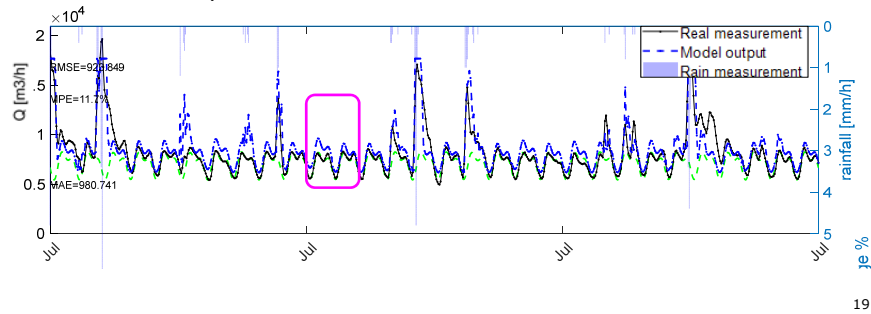


Similar statistical characterization

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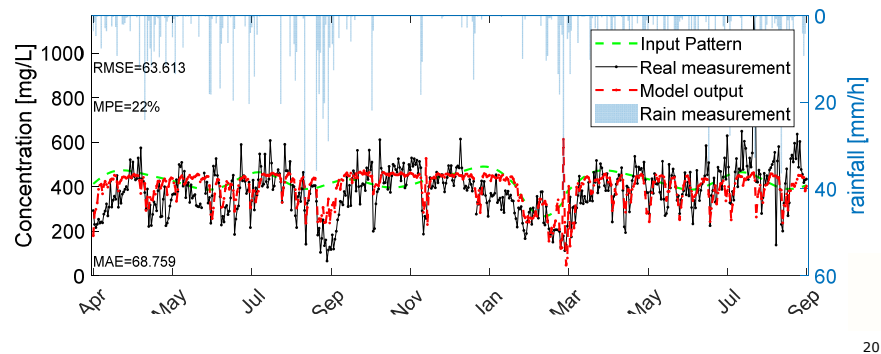
## Result analysis and discussion Influent generator for flowrate

- Input
  - Daily pattern derived by band pass filter ( $P_{t-1}, P_{t-2}, \dots, P_{t-6}$ )
  - $\text{Rain}(R_t, R_{t-1}, \dots, R_{t-6})$  & sum ( $\text{Rain}(R_t \dots R_{t-12})$ )
  - Temperature ( $T_t, T_{t-1}, \dots, T_{t-6}$ )
- Result: Hourly flowrate
  - Rain event (direct & indirect infiltration)
  - Weekend phenomenon



## Result analysis and discussion Influent generator for quality

- Input
  - Pattern derived by band pass filter ( $P_{t-1}, P_{t-2}, \dots, P_{t-5}$ )
  - $\text{Rain}(R_t, R_{t-1}, \dots, R_{t-5})$  & sum ( $\text{Rain}(R_t \dots R_{t-5})$ )
  - Temperature ( $T_t, T_{t-1}, \dots, T_{t-5}$ )
- Neural network:
- Result: Daily COD concentration



## Conclusions

- Generate flowrate and water quality (COD) profiles for a WRRF according to different time resolutions (hourly, daily).
- High performance
  - ✓ Accuracy: MPE of Quantity < 15%, Quality ~ 20%
  - ✓ Realistic: Dynamic
    - Phenomena included
  - ✓ Wet weather: Infiltration, Dilution
- Based on routine data, no additional investment needed
- Perspectives
  - ✓ Applied to gap filling, completing database and online water quality forecasting
  - ✓ Further studies for performance improvement: snow melt, confidence interval analysis

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**Thank you for your attention**  
**Merci à votre attention**

