# Urban Drainage Systems modelling for Early Warning Service Using Data-Driven Modelling

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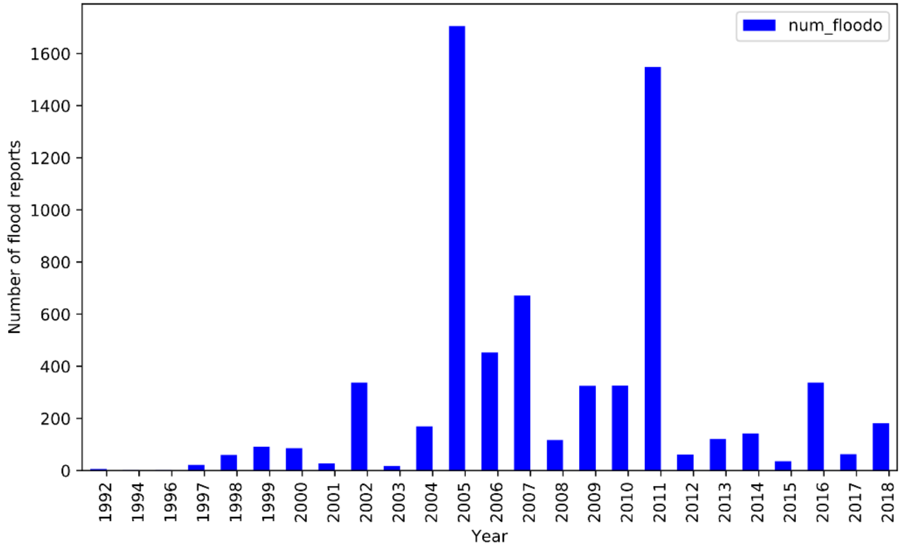
FloodCitiSense

# Problem statement

## Pluvial flooding occurs frequently in Brussels capital region

6912 reports of flooding in total from 1992 to mid-2018 recorded (Brussels Environment)

**Pluvial floods** are typical the result of intense rainfall, triggering a fast hydrological response in cities.

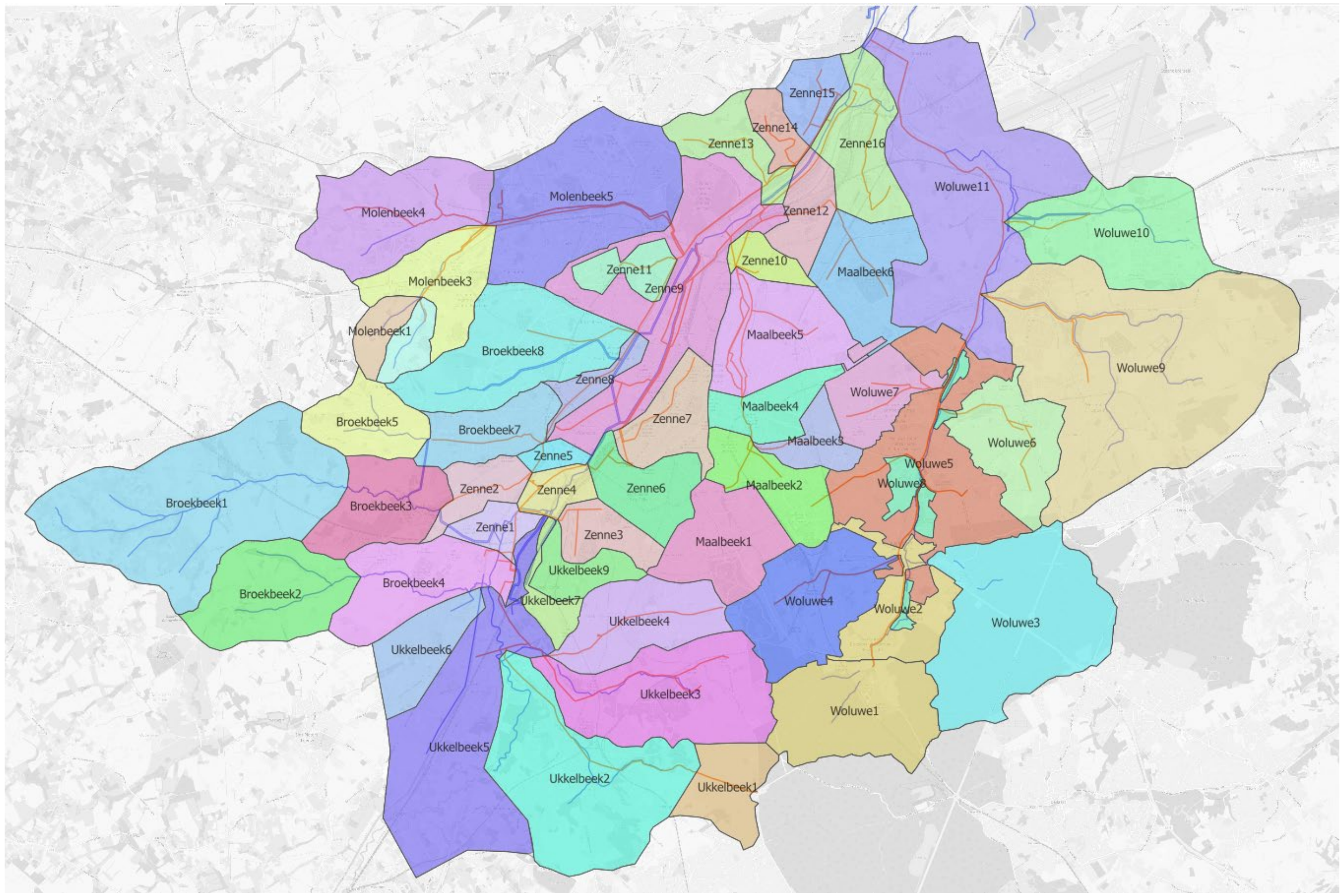



No hydraulic model available to use for flood forecasting

Within the FloodCitiSense project we are exploring the use of data-driven models to forecast pluvial flooding for Brussels

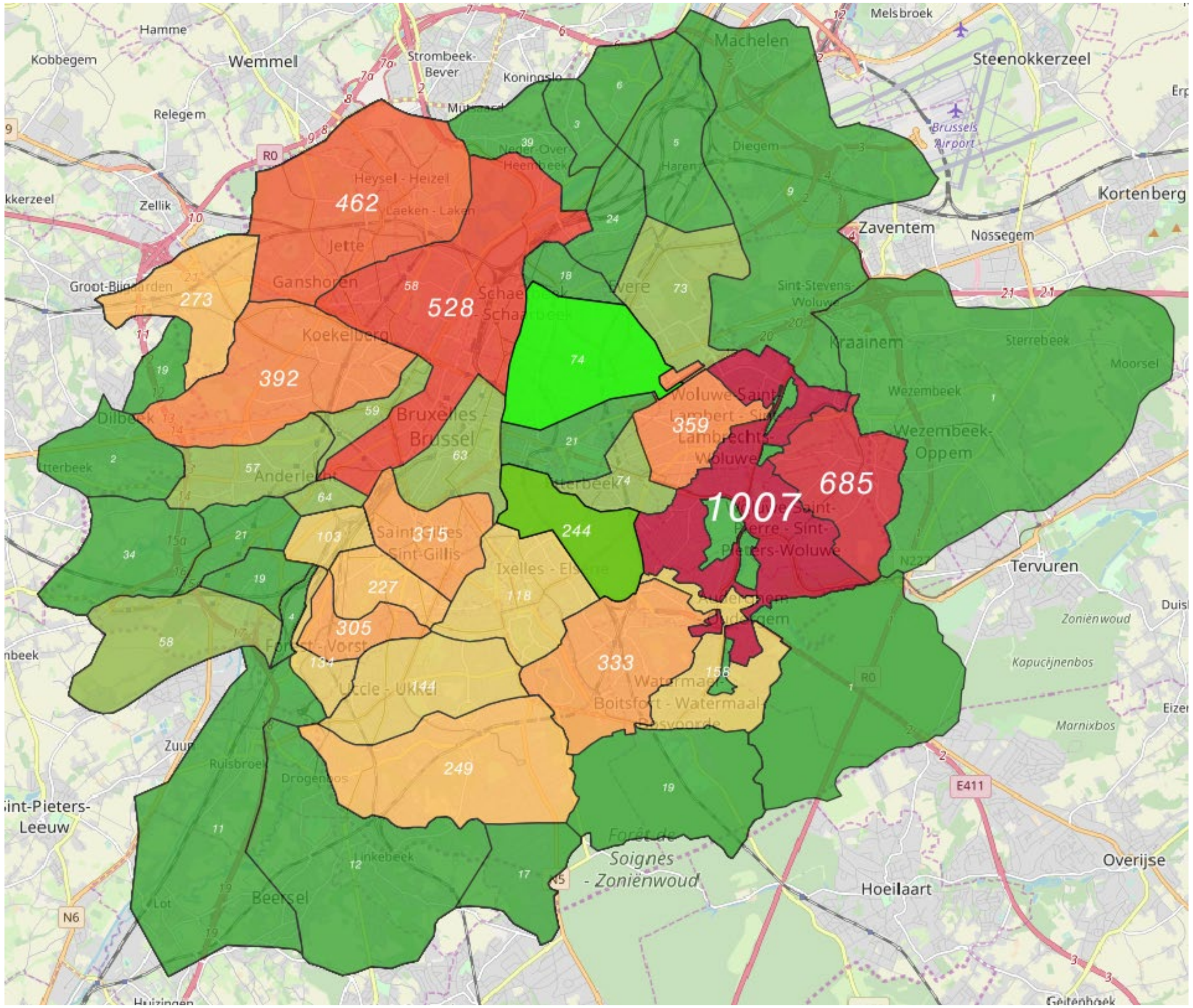
# Brussels Capital region subcatchment Delineation

- We delineated the Brussels Capital Region into 54 subcatchments using
  - Digital Terrain Model
  - Subcatchments from Brussels Environment
  - looking at the existing drainage network
  - Considering the flow gauging stations and reservoirs in the city
  - local expert knowledge



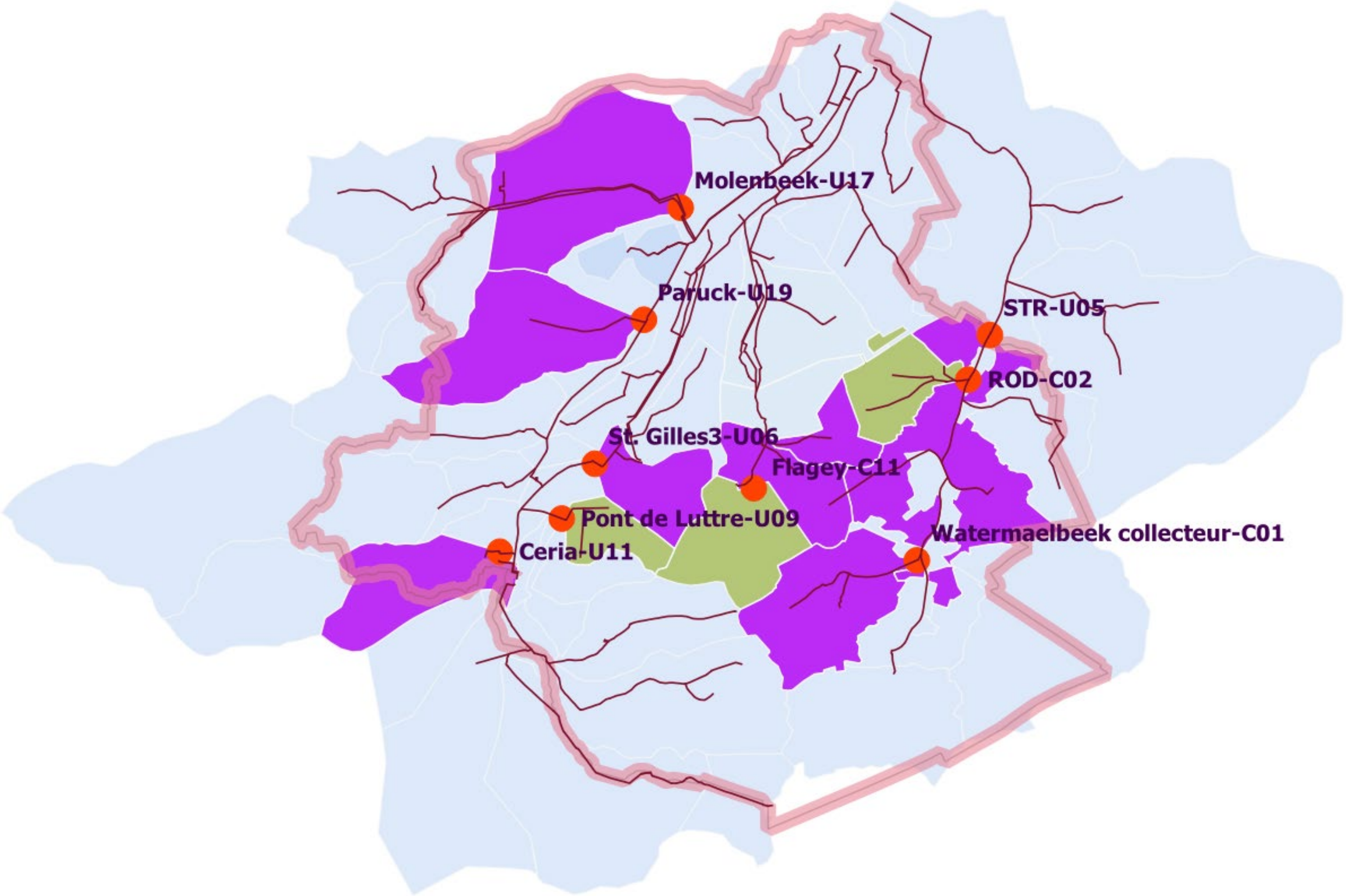
# Flood reports per subcatchment

- Flood reports from Brussels Environment for each sub catchment by date
- Flood reports total per subcatchment



# Focus subcatchments

- 9 sub-catchments were selected based on flooding history
- 9 Random Forest models were developed

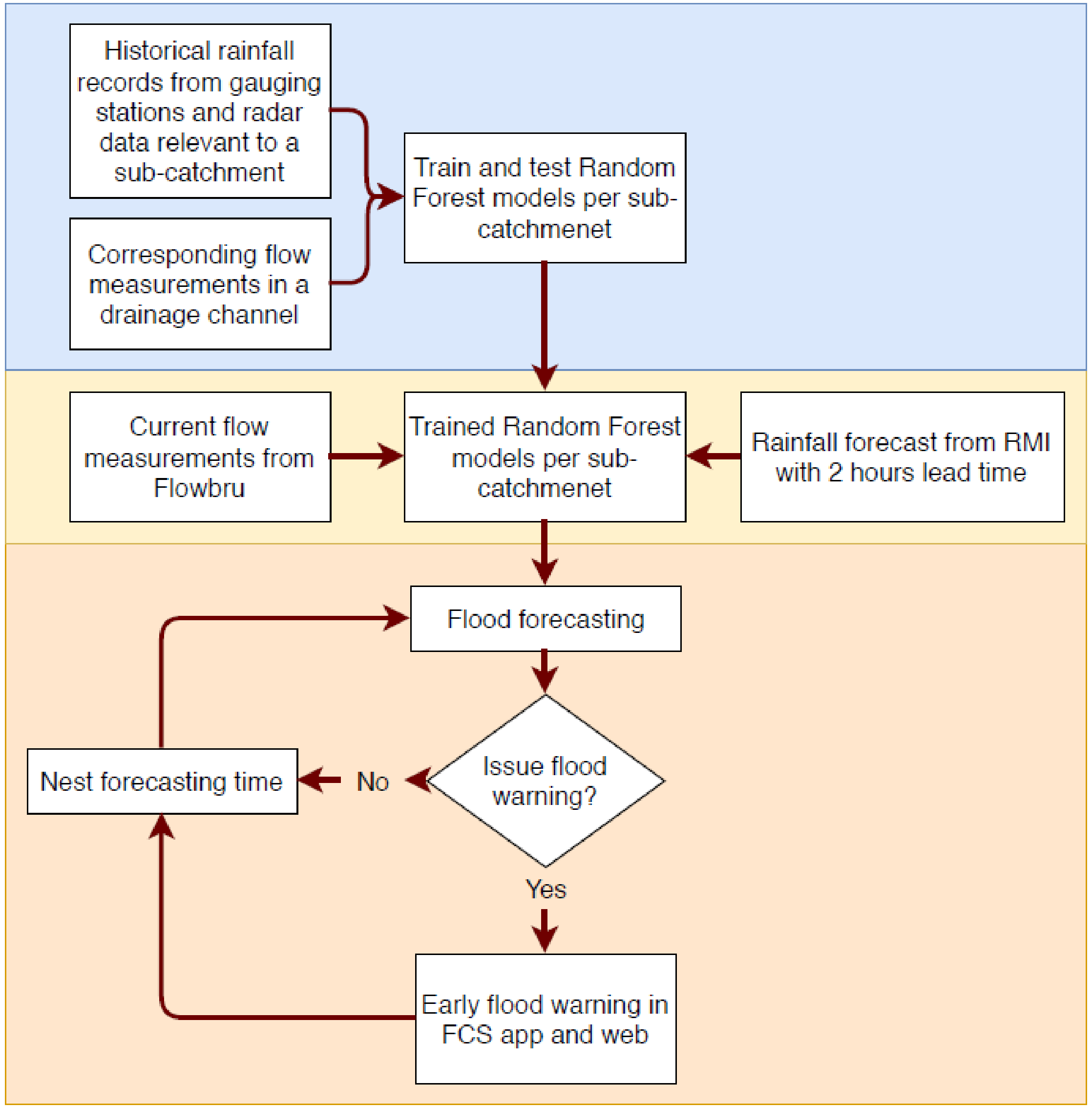


# Why DDM

- Data availability
- Absence of hydraulic model
  - Hydraulic models (1D or 2D) require detailed data about the system
    - DTM, dimension of each network element such as slope , size, depth,
    - Require much longer run time (unsuitable for early warning system)
- DDM – relationship between input and output without the need to understanding the mechanism underlying the system
  - Require large amount of data for training and testing
  - quick runtime, suitable for early warning

# Early flood warning system development

- On-going



# Random Forest models

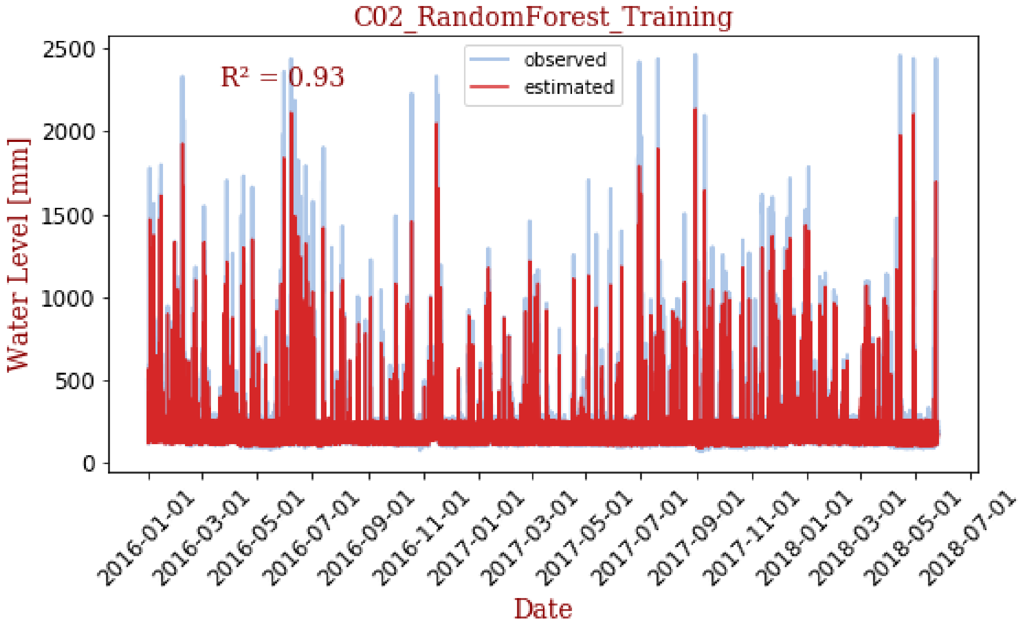
- For a model to perform adequately
  - determination of optimal model input and information in addition to the current time step is needed
  - Additional information can be derived from previous time step **rainfall** and **runoff**

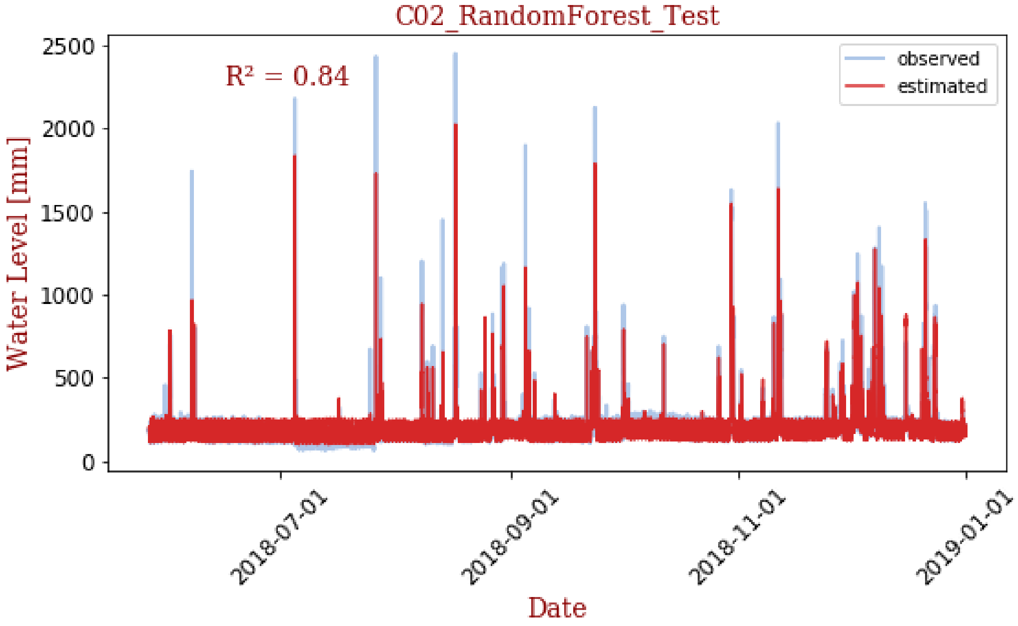
- The Data driven models (Random Forest) use rainfall data of 5 most correlated rainfall stations (sum of RF values for the past 2 hours) and the flow data of the station before 2 hours to forecaster the current flow

$$Q_t = f\left( Q_{t-lag}, \sum_{j=t-lag}^{j=t} RF_{i,j} \right) for\, i = 1\, to\, 5$$

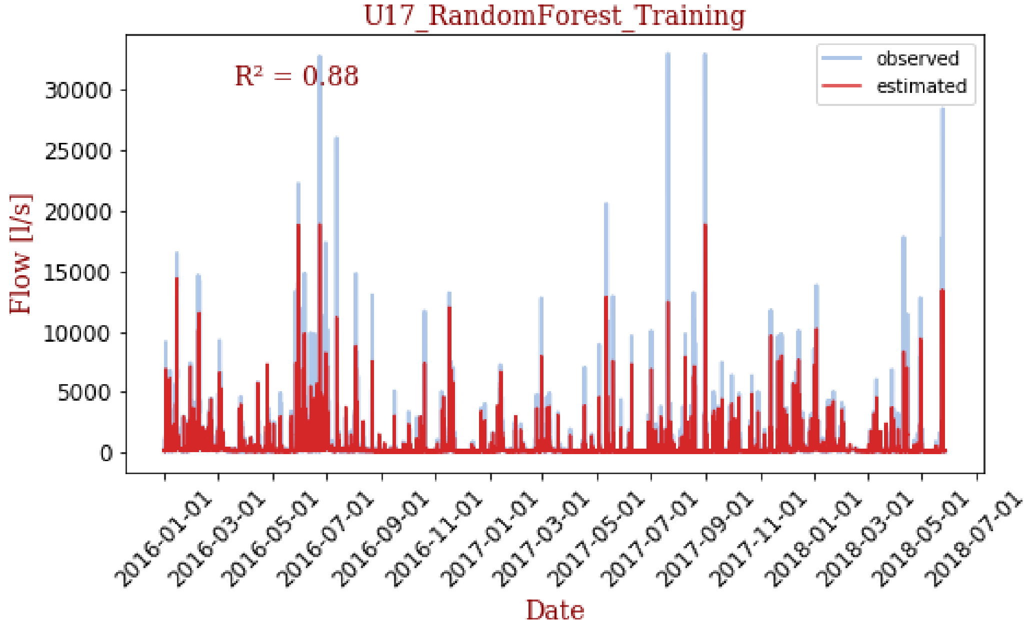
- After all the parameters of the DDM are tuned for each flow stations, the models can be used to forecast flows

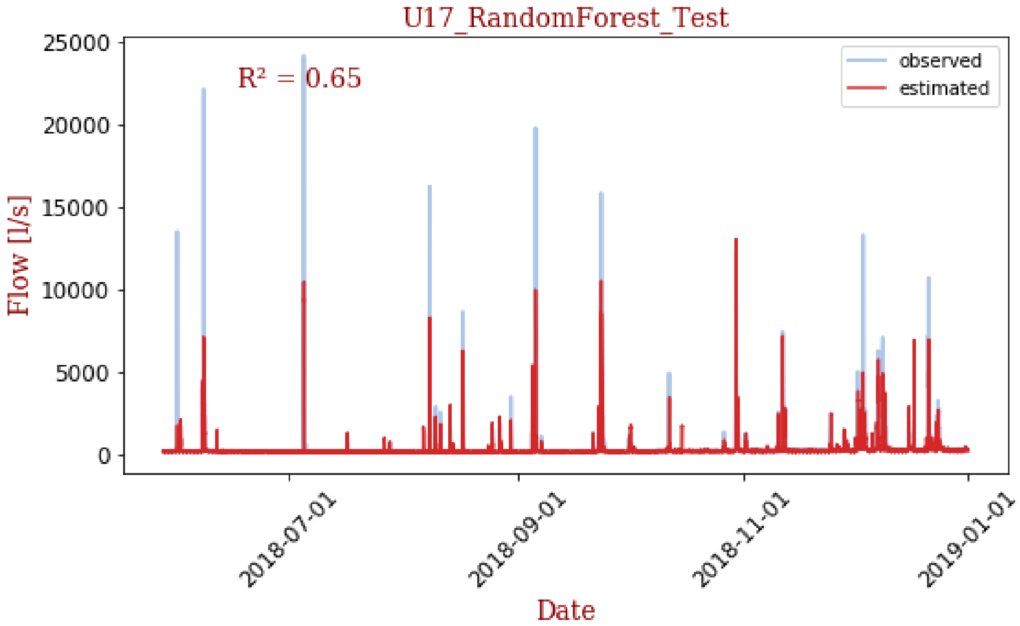
# Some results – station C02 – Good performance



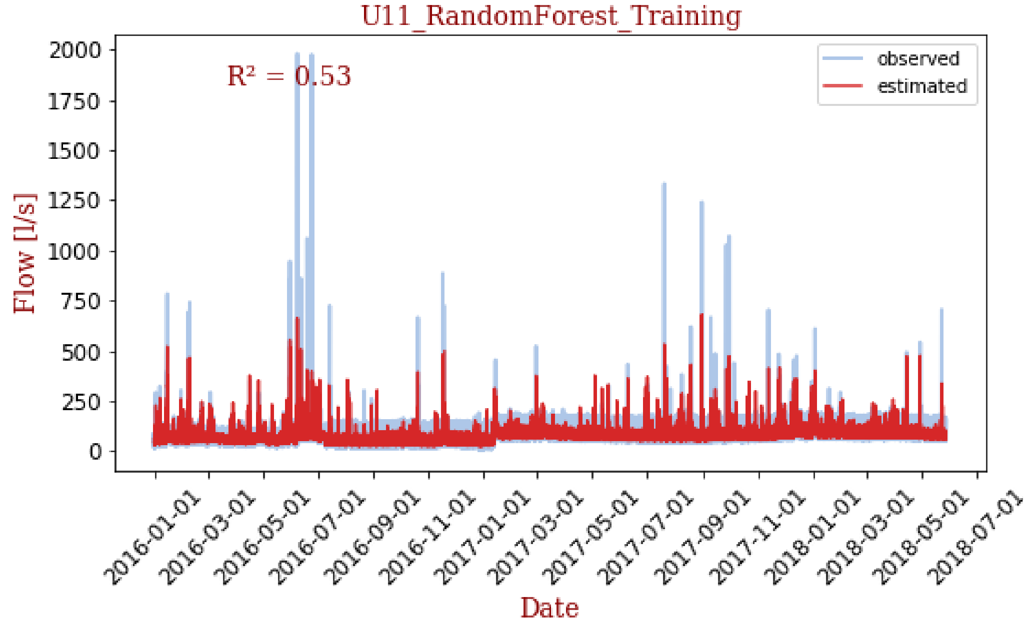



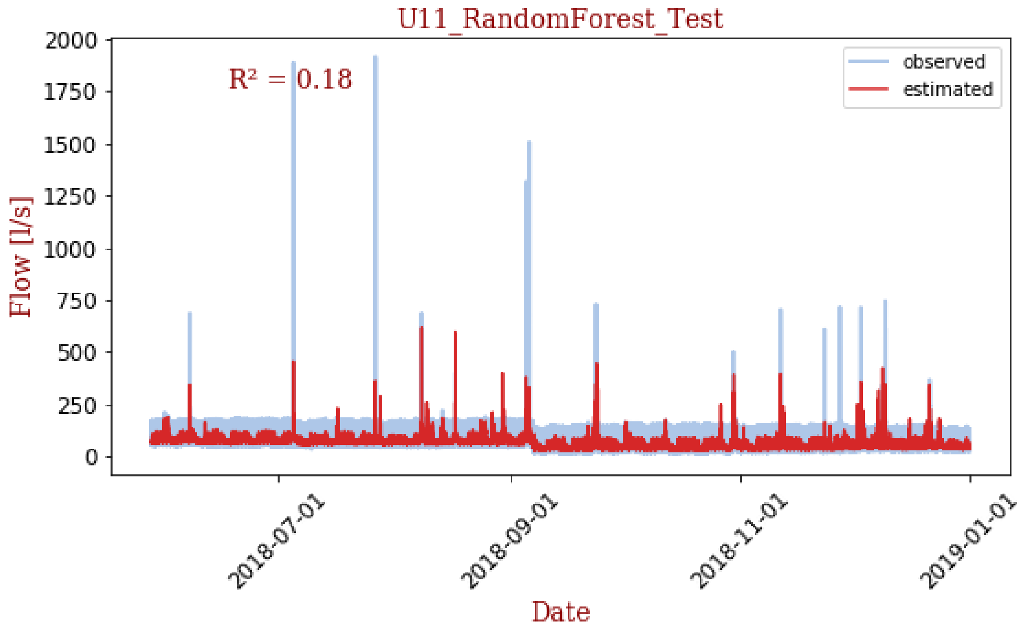
# Some results – station U17 – average performance



# Some results – station U11 – low performance



# Results and discussion

- For each flow station, RF models are being trained and tested
- In most cases the DDMs perform well with R-squared values ranging from 0.55 to 0.98 for a 2-hour forecast horizon
- Their performance increases 10 to 40% for a one-hour forecast horizon.
- Training the RF models are faster as they are classification models.
- The method can be used for other case studies if enough data is available 9 at least 2 to 3 years data with 5 minutes resolution) .
- Large amount of data is needed to train and test DDMs.
- Can only forecast flow at measuring stations .
- Cannot be used to forecast depth and spatial extent of flooding.

# Conclusion

- The use of DDM to forecast pluvial flooding was tested and shows promising results.
- DDM provide a means to forecast occurrence of pluvial flooding in absence of detailed hydraulic model for such a complex drainage system.
- Underestimation of peak flow is observed for RF models.
- Appropriate data transformation is said to improve the performance of such models (Sudheer, et al., 2003).

OUTLOOK:

- Include radar rainfall data as input for the training of the models
- Fine tune the DDM parameters