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

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Urban catchments are characterized by a high degree of imperviousness, as well as a highly modified landscape and interconnectedness. The hydrological response of such catchments is usually complex and fast and sensitive to precipitation variability at small scales. To properly model and understand urban hydrological responses, high-resolution precipitation measurements to capture spatiotemporal variability is crucial input.

In urban areas floods are among the most recurrent and costly disasters, as these areas are often densely populated and contain vital infrastructure. Runoff from impervious surfaces as a result of extreme rainfall leads to pluvial flooding if the system's drainage capacity is exceeded. Due to the fast onset and localised nature of pluvial flooding, high-resolution models are needed to produce fast simulations of flood forecasts for early warning system development. Data-driven models for predictive modelling have been gaining popularity, due to the fact they require minimal inputs and have shorter processing time compared to other types of models.

Data-driven models to forecast peak flows in drainage channels of Brussels, Belgium are being developed at sub-catchment scale, as a proxy for pluvial flooding within the FloodCitiSense project. FloodCitiSense aims to develop an urban pluvial flood early warning service. The effectiveness of these models relies on the input data resolution among others. High-temporal resolution rainfall and runoff data from 13 rainfall and 13 flow gauging stations in Brussels for several years is collected (Open data from Flowbru.be) and the data-driven models for forecasting peak flows in drainage channels are build using the Random Forest classification model.

Optimal model inputs are determined to increase model performance, including rainfall and runoff information from the current time step, as well as additional information derived from previous time steps.

The additional inputs are determined by progressively including rainfall data from neighboring stations and runoff from previous time steps equivalent to the lag time equal to the forecasting horizon, in our case two hours. The data-driven model we develop has the form as shown in the following equation.

$\boldsymbol{Q_t = f(Q_{t\text{-}lag}, \sum RF_{i,j})}$ *for* ***i*** *is the number of rainfall stations considered and* ***j*** *is the time from* ***t-lag*** *to* ***t***

Where Q_t is the flow at a flow station at time t, $Q_{t\text{-}lag}$ is the lagged flow at the station and $RF_{i,j}$ is the rainfall values for station i and time j.

For Brussels nine relevant sub-catchments were identified based on historical flood frequency for which we are building data-driven flood forecasting models. For each sub-catchment, RF models are being trained and tested. More than 200,000 data point were available for training and testing the models. For most of the flow stations the data-driven models perform well with R-squared values up to 0.84 for training and 0.6 for testing for a 2-hour forecast horizon.

To improve the reliability of the data-driven models, as next step, we are including radar rainfall data input, which has the ability to capture temporal and spatial variability of rainfall from localized convective storms to large scale moving storms.

KEYWORDS

Data driven models, FloodCitiSense, Flood Early Warning System, Urban pluvial flooding