Is the hydrological response of Nature-Based Solutions related to the spatial rainfall variability?

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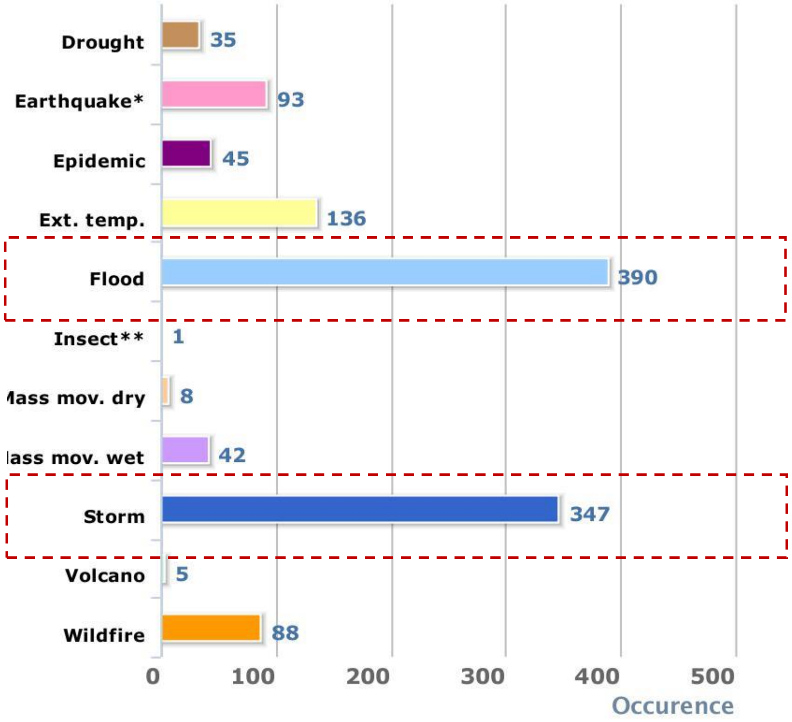
Introduction

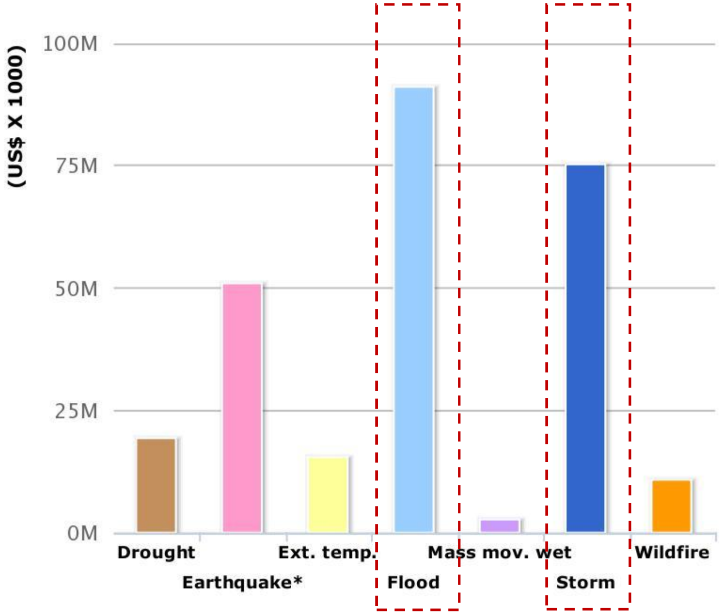
- With the acceleration of urbanization and climate change, many cities are facing more inundation risks.

Europe - Disaster Statistics (1980 -2008) https://www.emdat.be/

Natural Disaster Occurence Reported



Estimated economic damages reported by disaster type (US$ X 1,000)



Introduction

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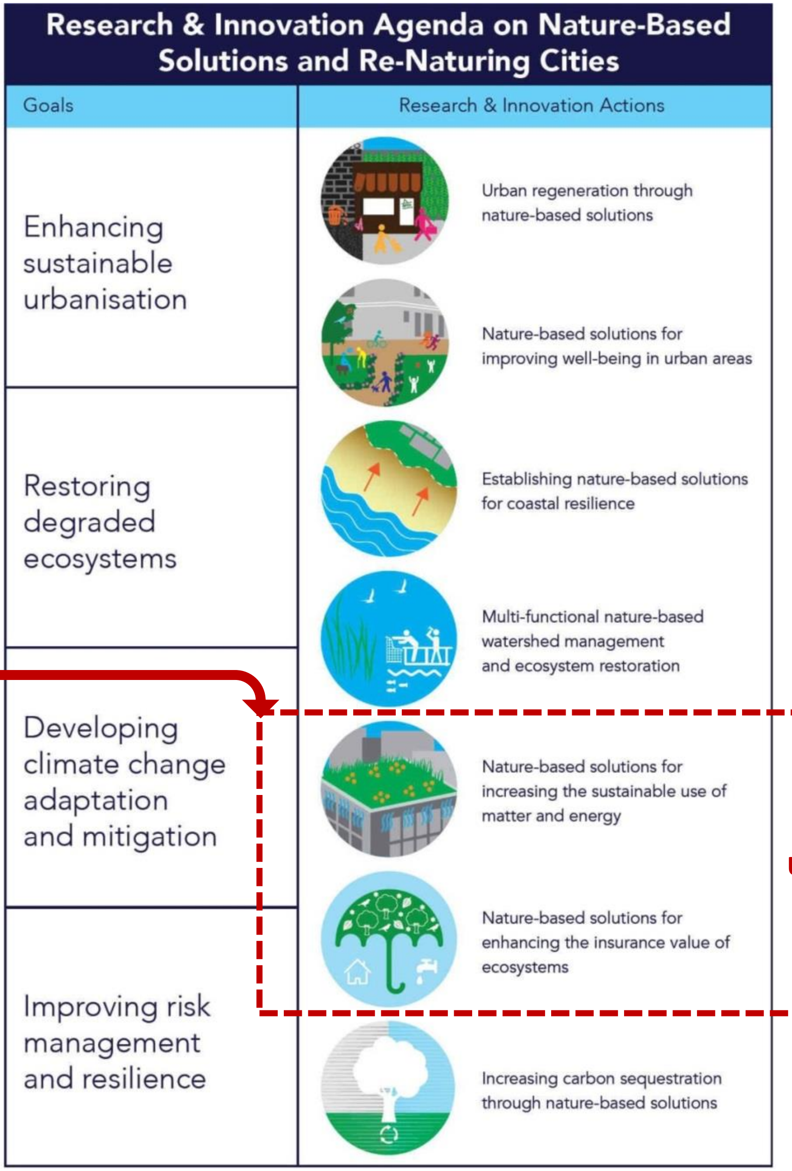
Nature-Based Solutions (NBS)

- They are actions which are inspired by, supported by or copied from nature.
- To help societies address a variety of nature and social challenges in a sustainable way.
- Based on the local conditions, to be resilient and resource efficient.

> - **Integrating grey with green and blue infrastructure**
> - **Low cost, low maintenance and low carbon emissions solutions**

- To contribute to ecosystem, social system and create more opportunities in business.

(European Commission 2015)



Actions for urban areas

Methodology

➢ **Objective: investigating the impacts of spatial rainfall variability on the hydrological responses of NBS.**

- Three rainfall events: high resolution **X-band** rainfall data/**Uniform** rainfall data.
- Modelling **different scenarios (baseline, and NBS)** by Multi-Hydro model under two different types of rainfall.
- **Two indicators** (Percentage error on peak flow and total runoff volume).

Case study: Guyancourt catchment

- A **5.2 km^2** catchment located at the southwest suburb of Paris.
- One of the **upstream sub-catchments** of Bièvre River**.**
- Being a part of the **“French Silicon Valley”.**

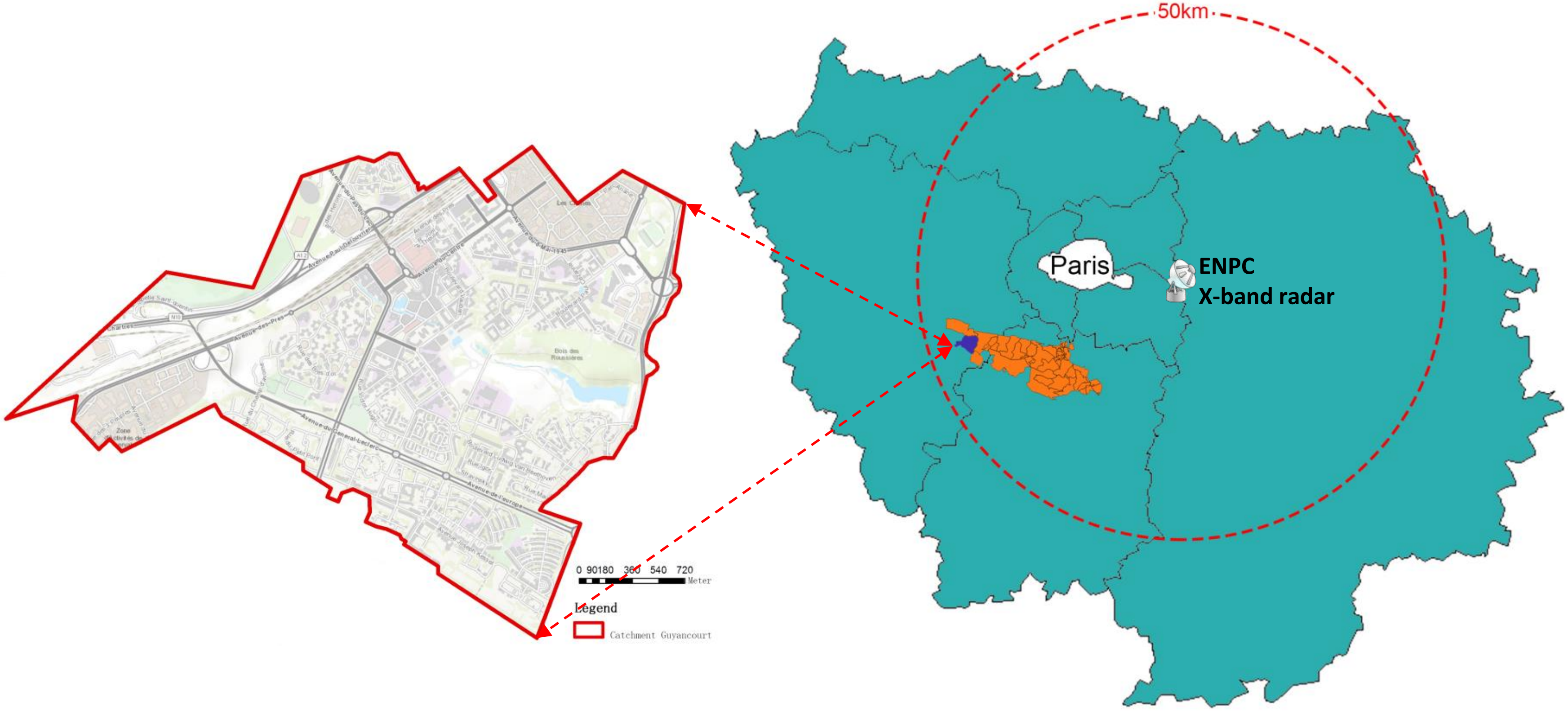


Figure.1 The study area of Guyancourt catchment.

Multi-Hydro model

➢ **A fully distributed hydrological model (HM&Co, École des Ponts ParisTech)**

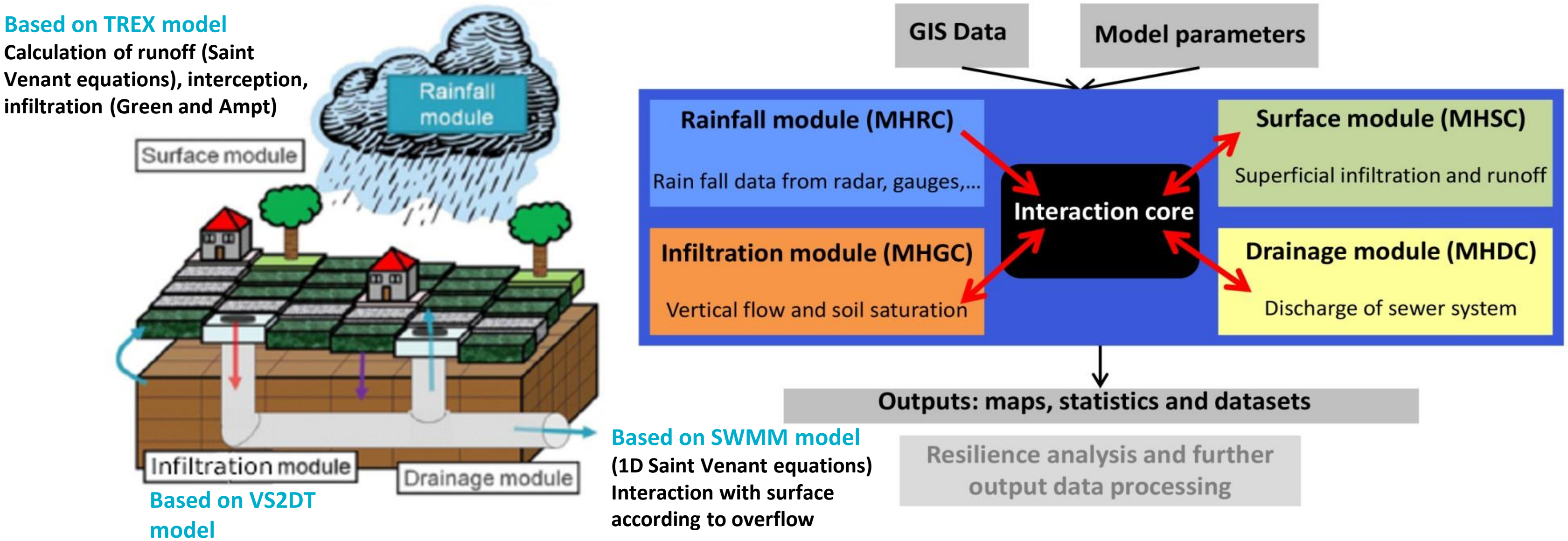


Figure.2 The framework of Multi-Hydro model.

- **Main features of Multi-Hydro :**

- **Fully distributed** – The solution of physical equations is computed at each pixel, and users can define the resolution.
- **Physically based** – It's easy to use GIS data, and rely on physically parameters, no need of calibration.
- **Modular structure** – Connection / disconnection / retroaction of each modules, according to needs of user.
- **Transportable** and **scalable** – Based on GIS. A special GIS tool (MH-AssimTool) can easily convert data for Multi-Hydro.
- **OpenSource** – User community.
- **Computation time** – Depends on space-time resolution, server performances (e.g few hours for one day precipitation).

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Data preparation

➢ Rainfall data (Distributed/Uniform)

Event ID	Data	Time start - end
EV1	12-13/09/2015	04:05 – 00:00 (+1)
EV2	16/09/2015	05:20 – 16:05
EV3	05-06/10/2015	09:10 – 16:05

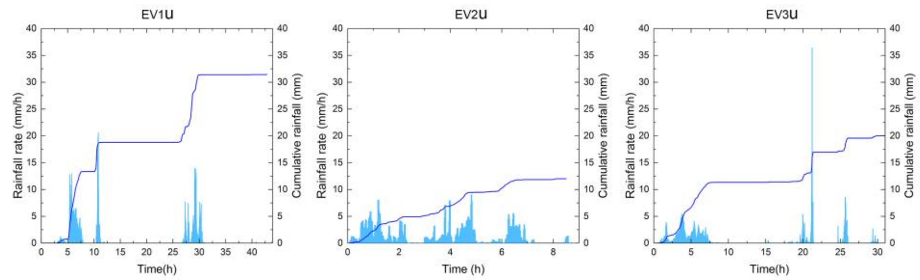


Figure.3 The rainfall rate and total rainfall depths of three uniform rainfall.

X-band radar data

250 m / 3.41 min

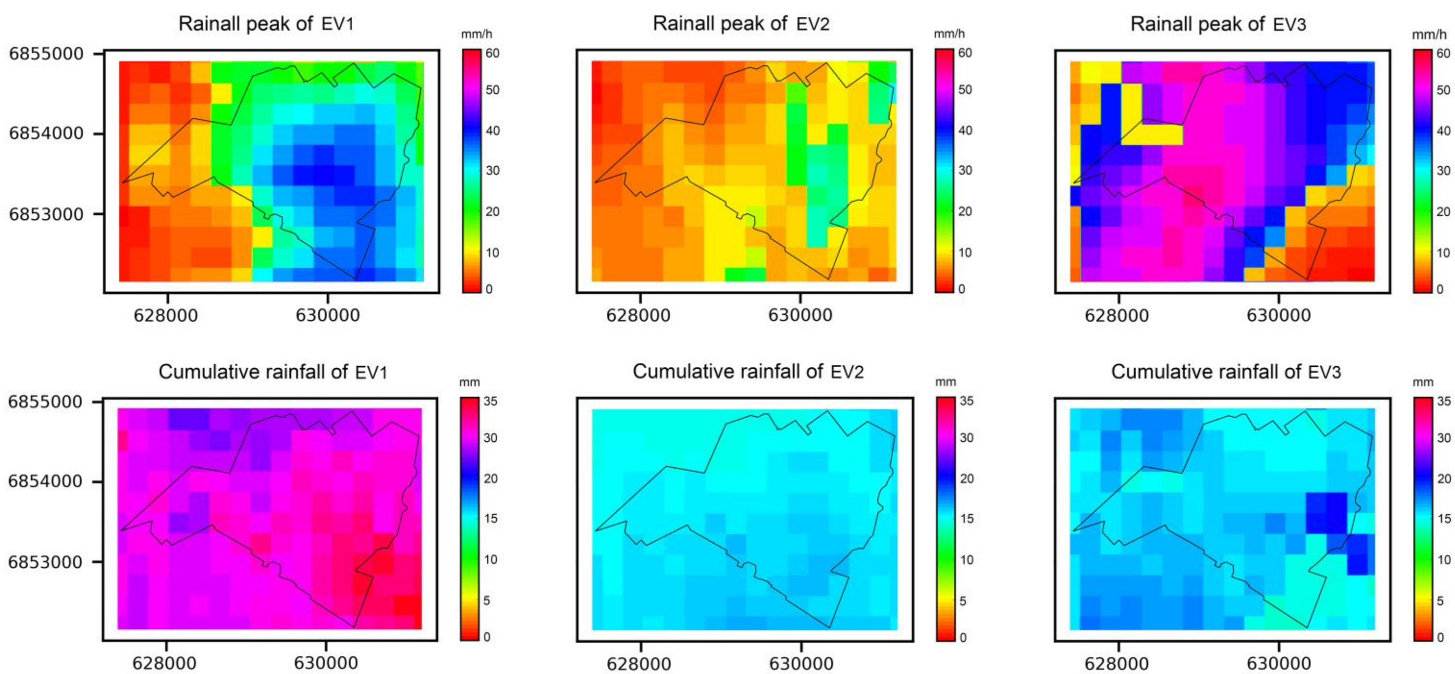
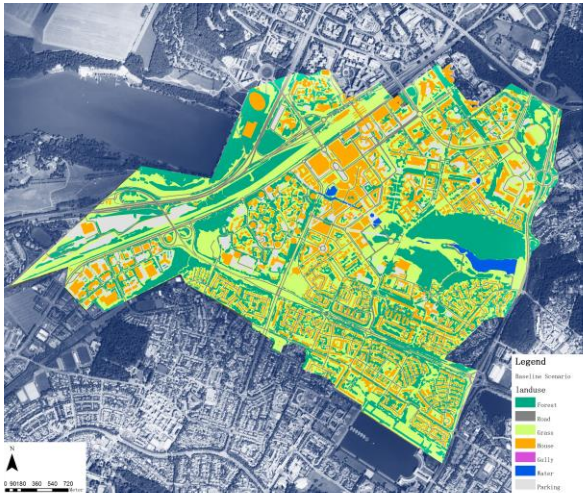


Figure.4 The rainfall intensity at the largest rainfall peak by per radar pixel of three rainfall events (Top). The accumulative rainfall by per radar pixel of three rainfall events (Bottom).

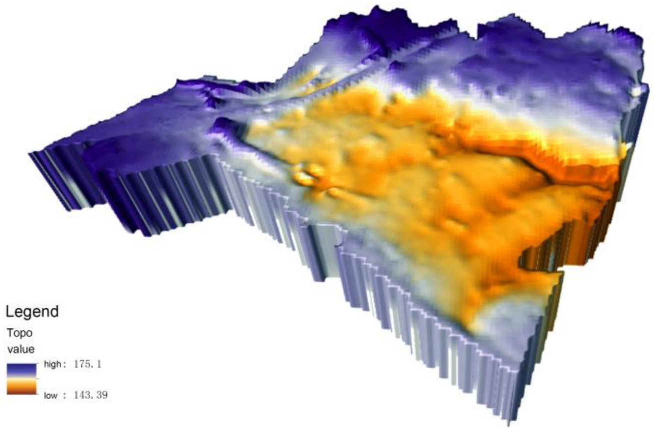
Data preparation

➢ **High resolution GIS data**

➢ **Land use**



➢ **Digital elevation model (DEM) 10 m**



➢ **Drainage system (76 km)**

➢ **Soil description available at some locations**

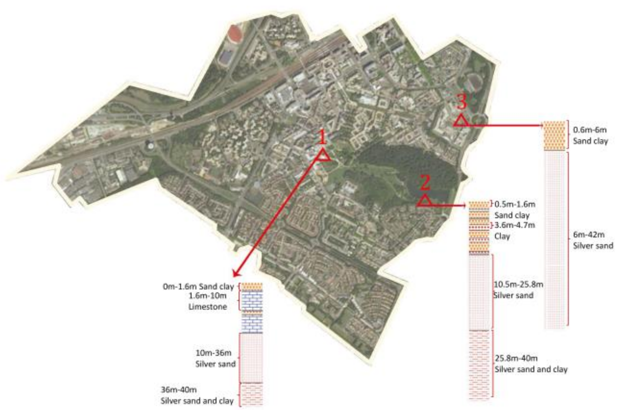


Figure.5 The high resolution GIS data.

Baseline scenario

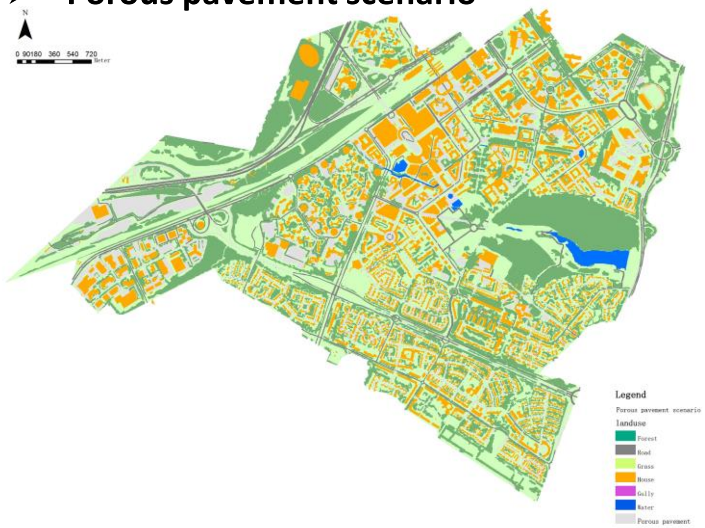
➢ **The baseline scenario is simulated under two types of rainfall.**

Figure.6 The land use of baseline scenario

NBS scenarios

- Porous pavement scenario changed the road width ≤ 2.5m and all parking space.
- Rain garden scenario changed the low-lying space around the house.
- Green roof scenario changed all flat roof as green roof.
- Combined scenario is porous pavement scenario with rain garden scenario and green roof scenario.

➢ **Porous pavement scenario**



➢ **Rain garden scenario**

➢ **Green roof scenario**

➢ **Combined scenario**

Preliminary results

- **The percentage error on peak flow and total runoff volume of the baseline scenario and NBS scenario, in terms of the sum of the flow in four conduits (4541,4542,4543, and 4544).**

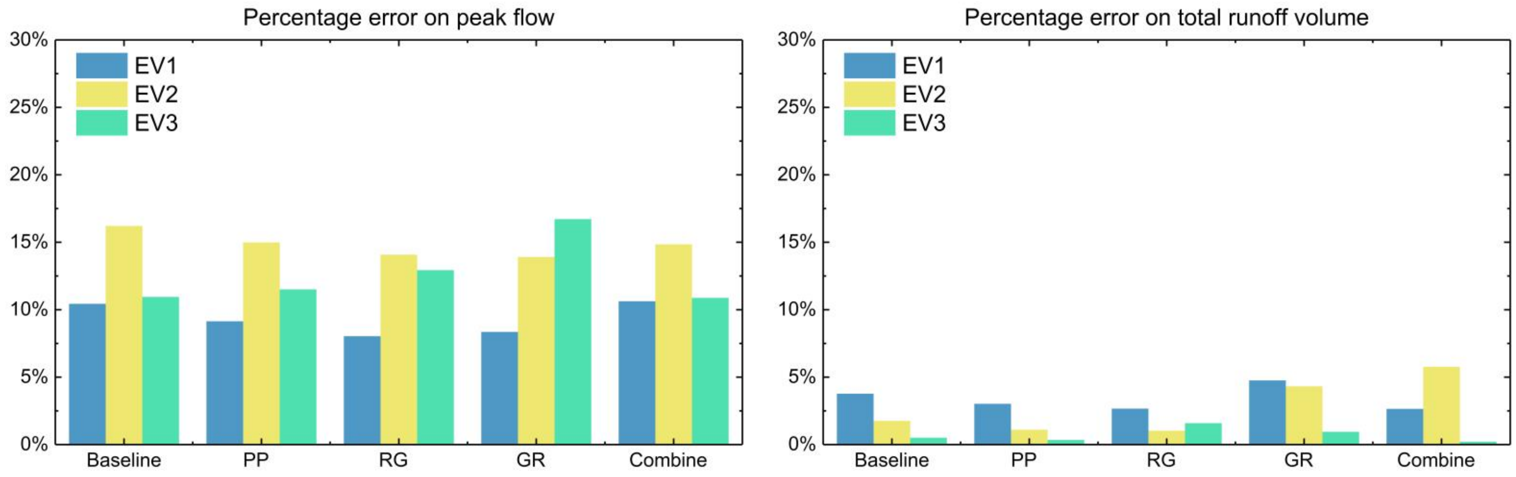


Figure.7 The percentage error on peak flow (left) and total runoff volume (right) of baseline and NBS scenarios.

Conclusion/Perspectives

- The spatial rainfall variability has certain impacts on the peak flow of NBS scenarios, which makes the percentage error on peak flow ranges from about 8% to 17%. For most of NBS scenarios, the higher the spatial rainfall variability, the higher the percentage error on peak flow (except GR scenario).

- Regarding the percentage error on total runoff volume of each scenario is range from about 1% to 7%. It is indicated that the spatial rainfall variability has fewer impacts on the total runoff volume of NBS.

Future:

✓ More results will be analyzed by Multifractal in the future.

✓ Other investigations will follow using larger samples of high resolution rainfall data to investigate the effect of space-time rainfall variability on the NBS performance.

Reference

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