Using a fully distributed rainfall-runoff model Multi-Hydro to evaluating Low Impact Development (LID) and Nature-Based Solutions (NBS) for storm water management in small urban catchments

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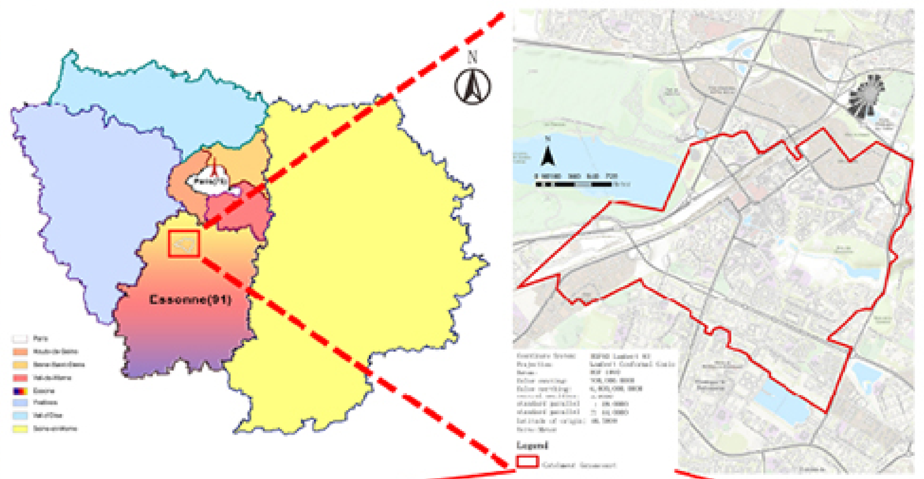
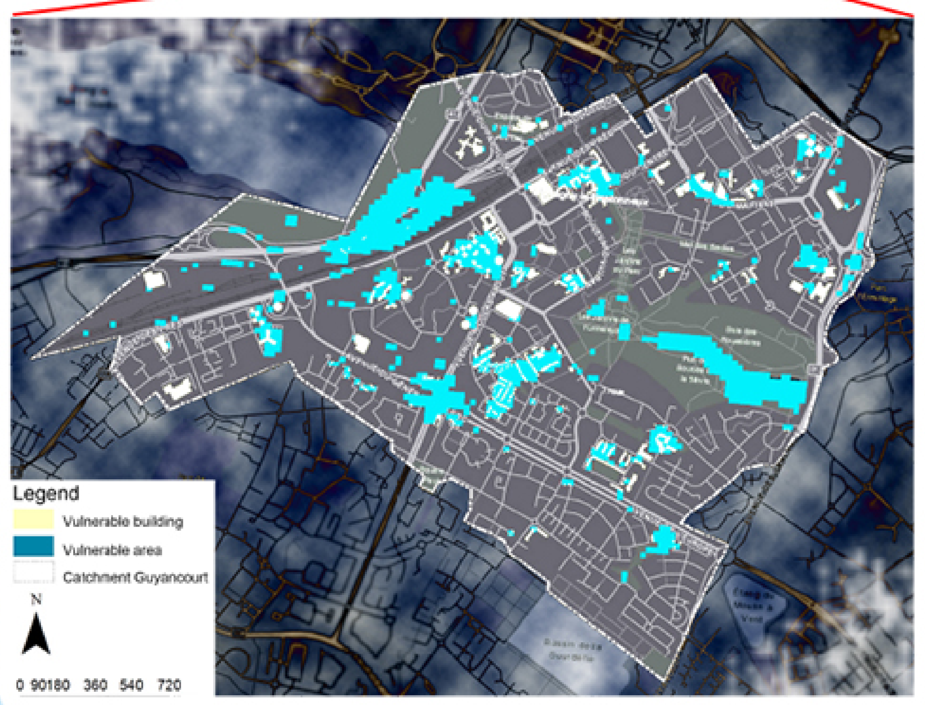
Introduction

- With the acceleration of urbanization and climate changes, many cities have been forced to face more inundation risks (Lovejoy and Schertzer, 2013, Tchiguirinskaia, Bonnel and Hubert, 2004).
- Low Impact Development (LID) and Nature-based Solutions (NBS), referred in *http://bgd.org.uk/*, are universally considered as the sustainable approaches for urban storm water management (Versini et al., 2016).
- To evaluate the efficiency of LID and NBS techniques, especially their capability of runoff volume reduction and peak discharge attenuation.
- Using the fully-distributed and physically based model Multi-Hydro (Ichiba A. et al., 2017), which allows the consideration of the whole catchment variability at different scale.

Study area

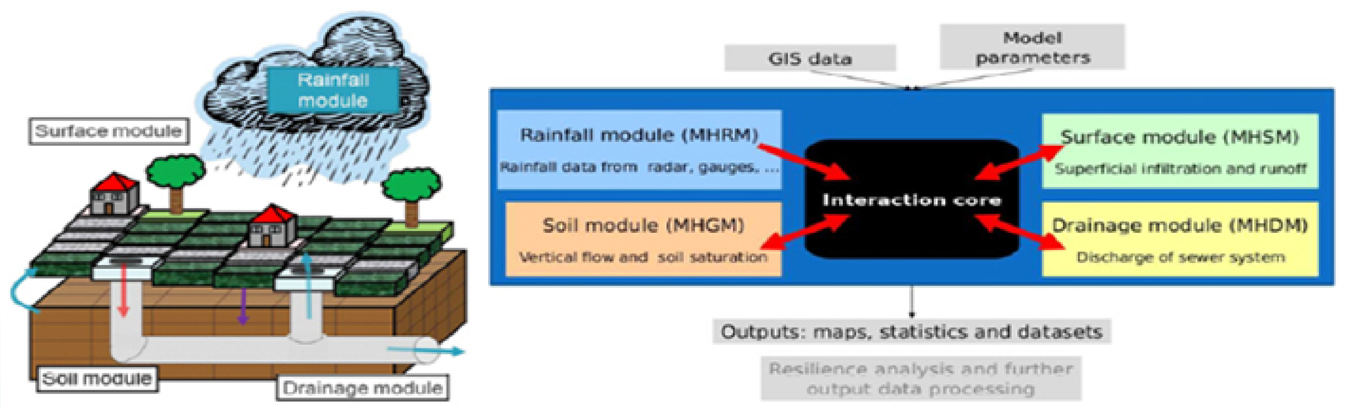


- Guyancourt (France), a semi-urban catchment of about 520 ha in the southwest of Paris, at the Saclay Plateau that should soon become the "French Silicon Valley".



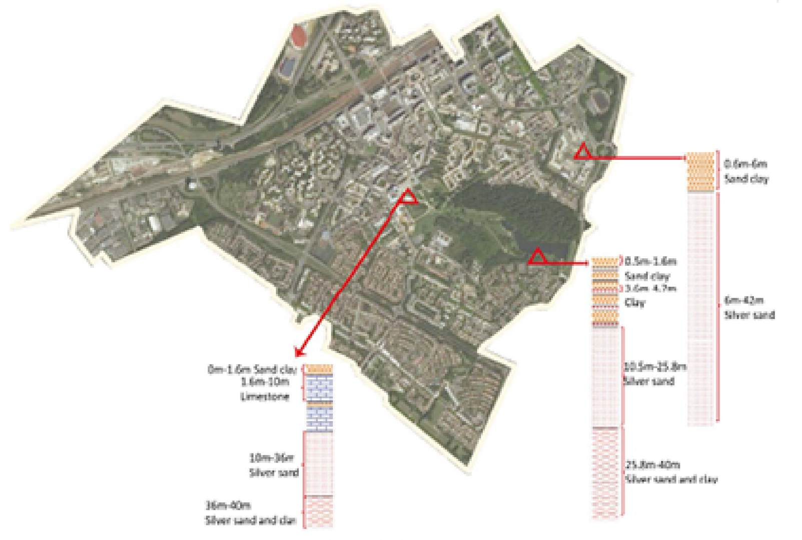
- With a 10-m resolution DEM data to find areas at risk of flooding, in a stormwater, the map show blue spots which are the vulnerable area (about 0.6 km2) that easily be flooded and the vulnerable building that lie within and adjacent to them.

Multi-Hydro model

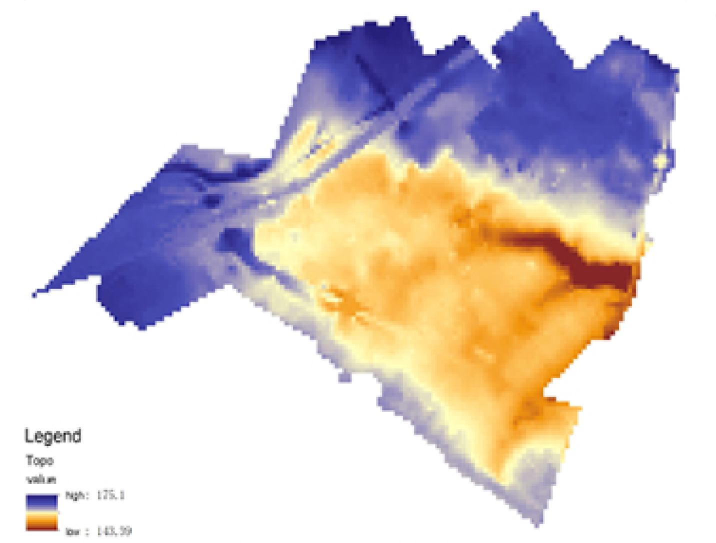


- The Couyancourt catchment was modelled with the fully distributed model Multi-Hydro (Giangola-Murzyn(2013)) developed at Ecole des Ponts ParisTech.
- This model is an interacting core between four modules (TREX, Rainfall module, Drainage module(MHDC), infiltration module (VS2DT)), each of them representing a portion of the cater in urban environments.

Data preparation



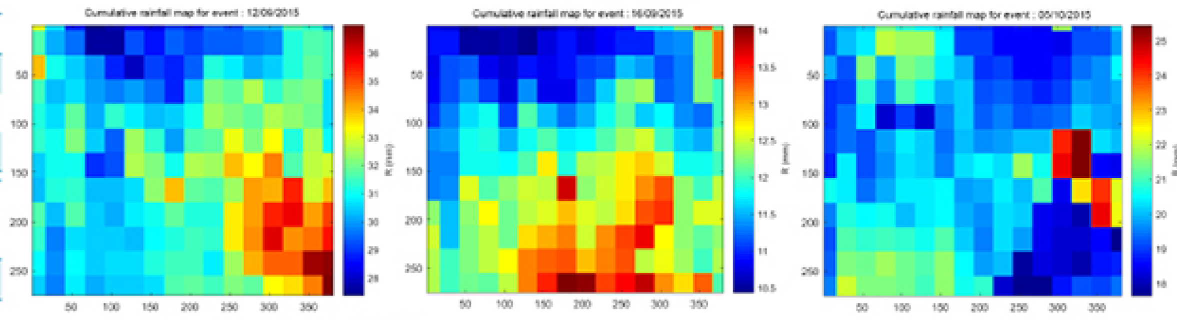
Soil data



Topography 10m resolution DEM

Events	Duration
12-13 September 2015	44h: 04:05-00:00
16 September 2015	16.8h: 00:05-16:50
5-6 October 2015	31h: 09:10-16:05

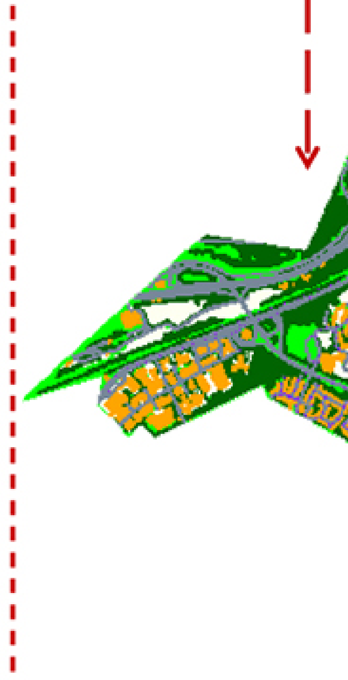
Data type	Spatial resolution	Temporal resolution
X-band	250m×250m	3.4min



Rainfall data

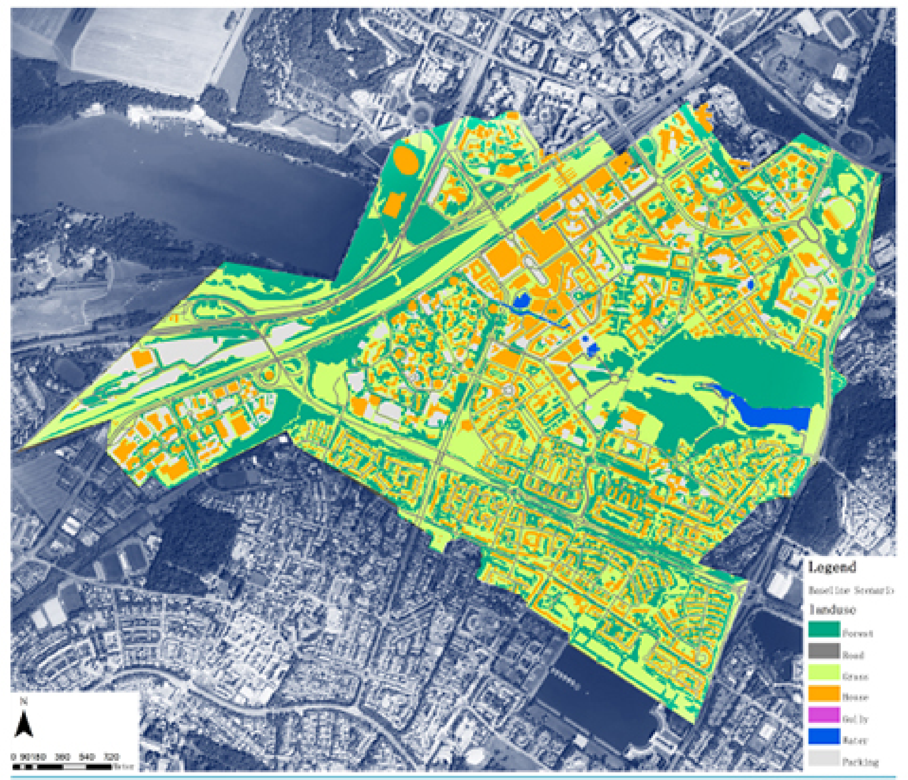
MULTI-HYDRO ASSIMTOOL

Input data generator for Multi-Hydro



10m space resolution

LID and NBS simulation scenarios



	Forest	Road	Grass	House	Gully	Water	Parking	Total	pervious surface	impervious surface
Area(km^2)	1.5	0.5	1.7	0.8	0.1	0.05	0.55	5.2	3.25	1.95
Percentage	28.80%	9.60%	32.70%	15.50%	1.90%	0.90%	10.60%	100%	62.40%	37.60%

Baseline scenario land use types and proportions in the study area

Porous pavement scenario

Green roof scenario

Rain garden scenario

Combined scenario

- Porous pavement scenario changed the road width ≤ 2.5m and all parking space
- Rain garden scenario changed the space surrouding the house
- Green roof scenario changed all flat roofs into green roofs
- Combined scenario is porous pavement scenario with rain garden scenario and green roof scenario

References

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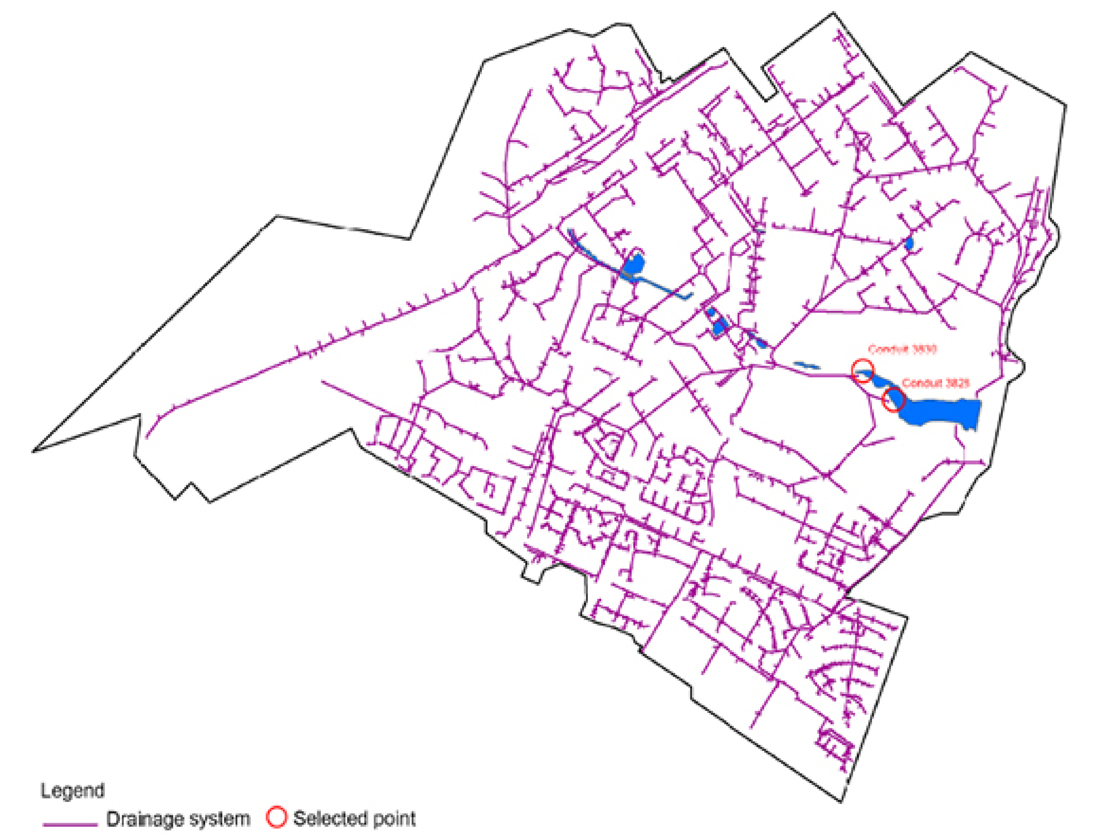
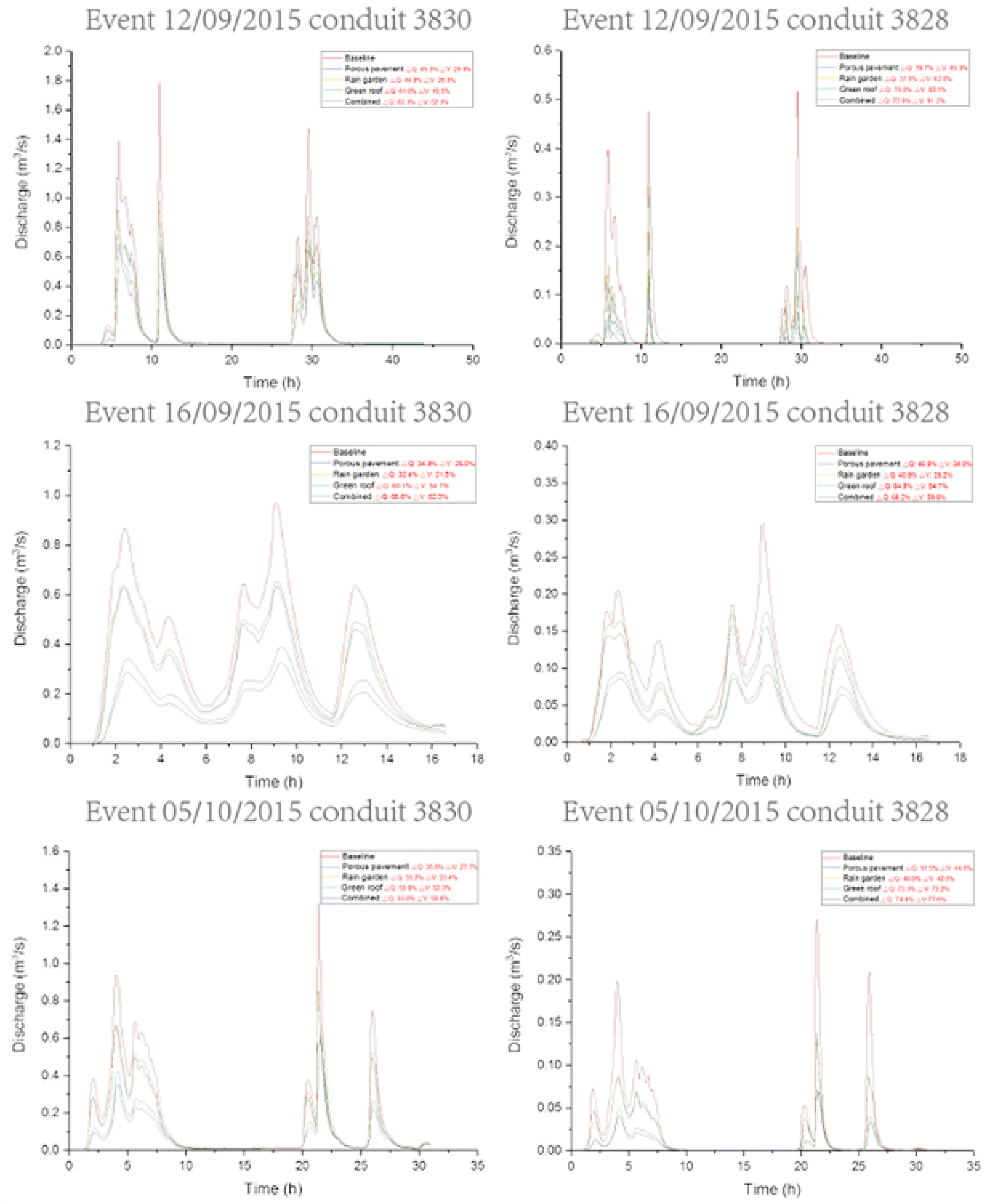
Conclusion

- The optimal scenario appears to be the combined scenario with ΔQ around 55.6% to 75.6%, and ΔV around 52.3% to 91.2%, and then green roof scenario.
- Porous pavement scenario and rain garden scenario present the less effect on the catchment hydrological response.
- The integration of LID and NBS scenarios in the fully distributed model Multi-Hydro is still under the development. In the future, more parameters will be taken into consideration and tested in order to better simulate the effect of these scenarios.

Results and discussion



Sewer system with the two selected ponits (conduit 3830 and conduit 3828) highlighted



- Peak discharge reduction (ΔQ)

$$\Delta Q(\%) = \frac{(QP_0 - QP_i)}{QP_0} \times 100\%$$

- Runoff volume reduction (ΔV)

$$\Delta V(\%) = \frac{(V_0 - V_i)}{(V_0)} \times 100\%$$

Qp0 and V0 : Peak discharge and volume computed for baseline scenario
Qpi and Vi : Peak discharge and volume computed for other LID and NBS scenarios

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