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# High resolution modeling of a small urban catchment

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**Introduction:** Flooding is the result of meteorological extremes which are aggravated by the hydrological behavior of urban catchments and human factors. It is one of the most complex issues that urban hydrologists have to deal with. The complexity of the urban catchments lies in their extreme heterogeneity, the interference between human activities and natural hydrological processes, and finally the continuing urbanization process. In order to simulate these processes at their specific temporal and spatial scales, high-resolution data and computational capacities are needed. In our case study, high spatio-temporal resolution modeling, using Multi-Hydro, developed at Ecole des Ponts ParisTech, is performed for a small peri-urban catchment of the Greater Paris region, Le Perreux-sur-Marne. The aim of this work, in the framework of the ANR Trafipollu project, was to launch and validate Multi-Hydro in that area. The main objective of the Trafipollu project is the development of modeling tools for the location and transport of pollutant generated by traffic at different spatio-temporal resolutions.

## Multi-Hydro

The Multi-Hydro model, developed at HM&Co at Ecole des Ponts, uses free and open software modules to simulate different parts of the urban water cycle and to compute the hydrological response of the catchment for every studied case.

It is:

- Modular
- Fully distributed
- Physical-based
- Event based

It uses GIS data and the interface MH-AssimTool

Multi-Hydro provides detailed description about the surface runoff, the subsurface flow and the sewer discharge. <sup>[1],[2]</sup>

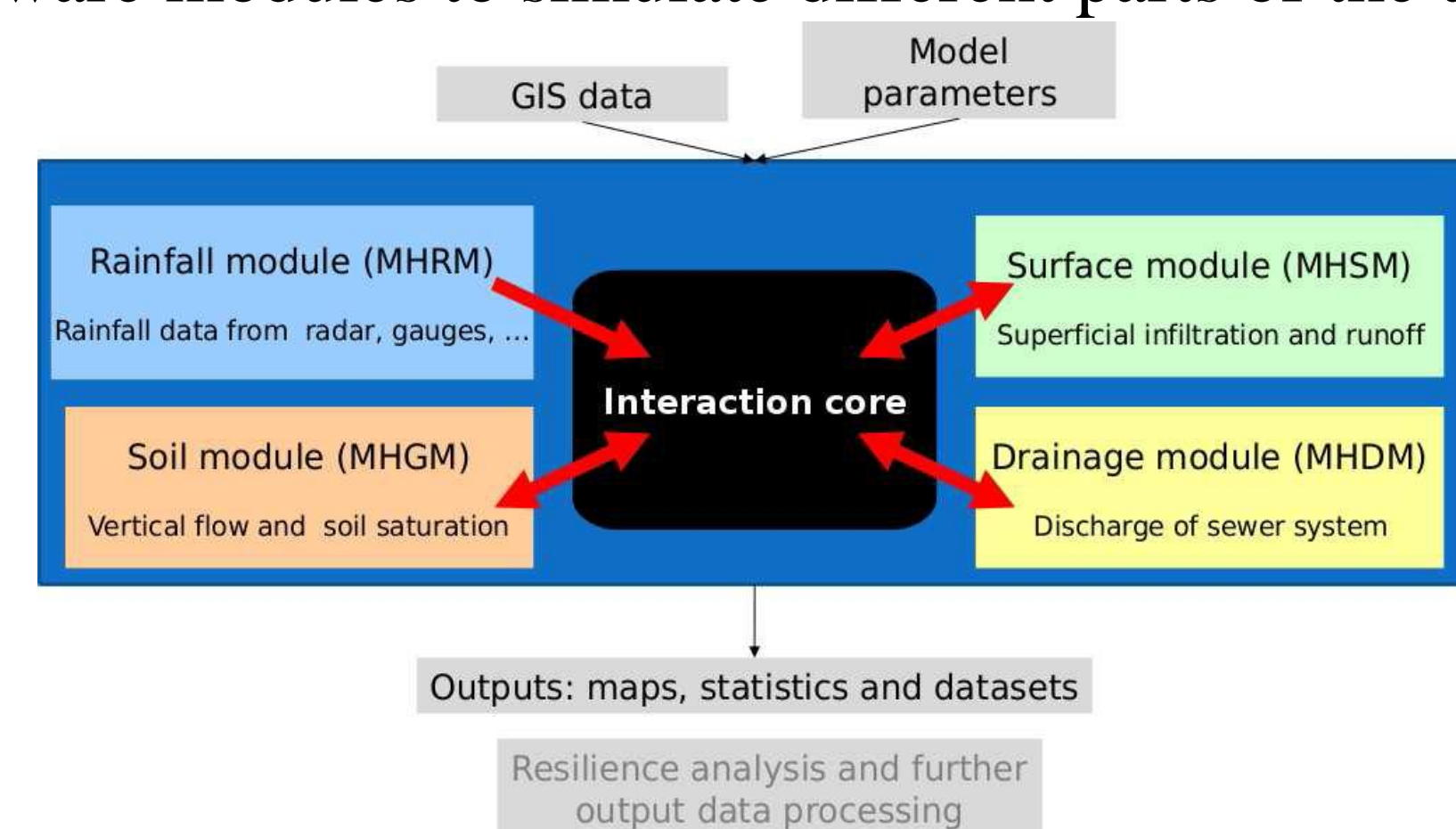


Fig. 1: The interaction of the four modules in Multi-Hydro

## Le Perreux-sur-Marne

Le Perreux-sur-Marne is located in the Val-de-Marne department south-east of Paris area. In the ANR Trafipollu project, this urban catchment is examined at neighborhood scale. The delimitation of the urban catchment was based both on the elevation data and on the sewer system because of its complexity.

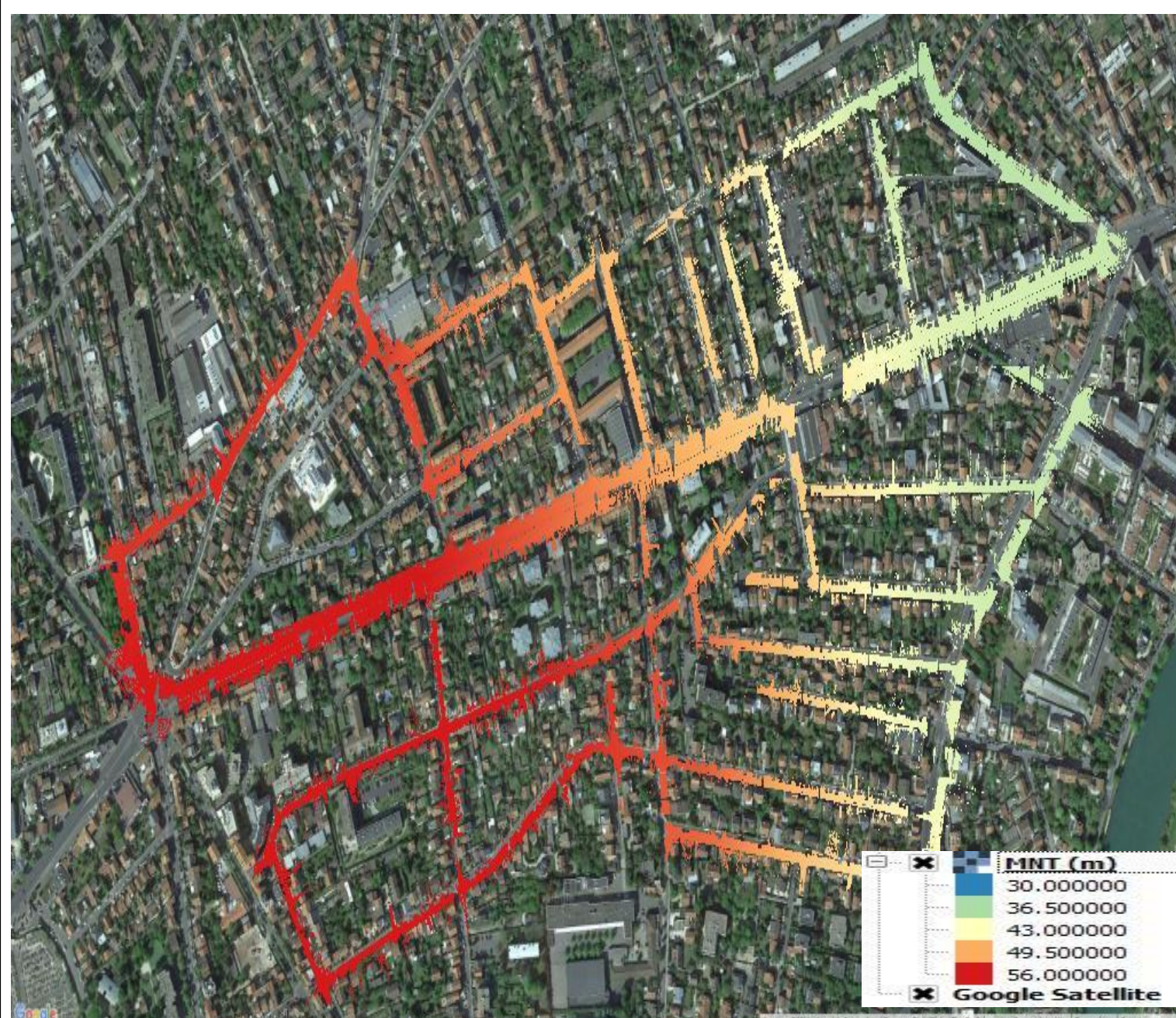


Fig. 2: The elevation data (resolution 0.2m) provided by the National Institute of Geographic and Forest Information .

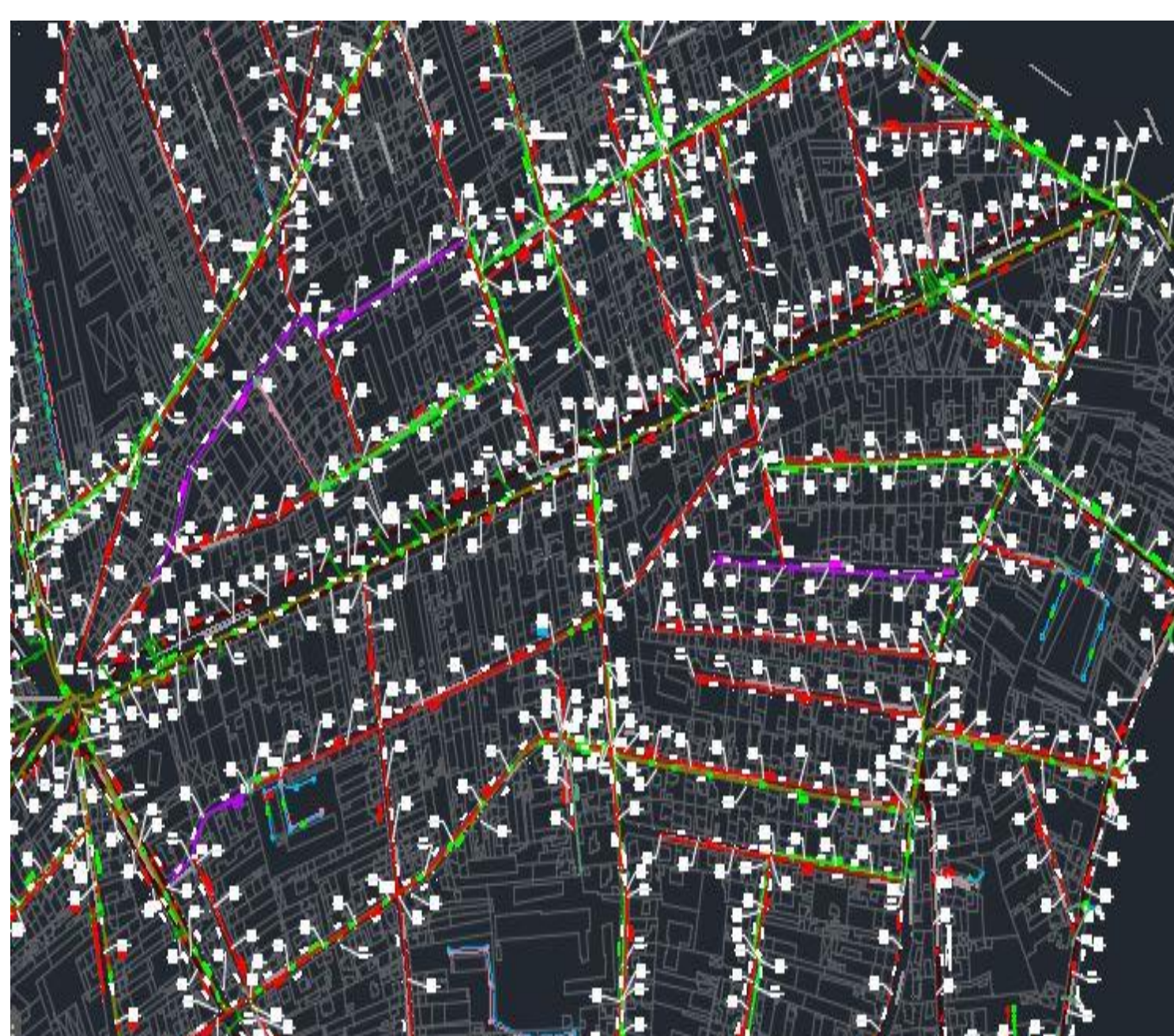


Fig. 3: Wastewater (in red) and the rain water (in green) sewer system. The unitary system is represented in violet.

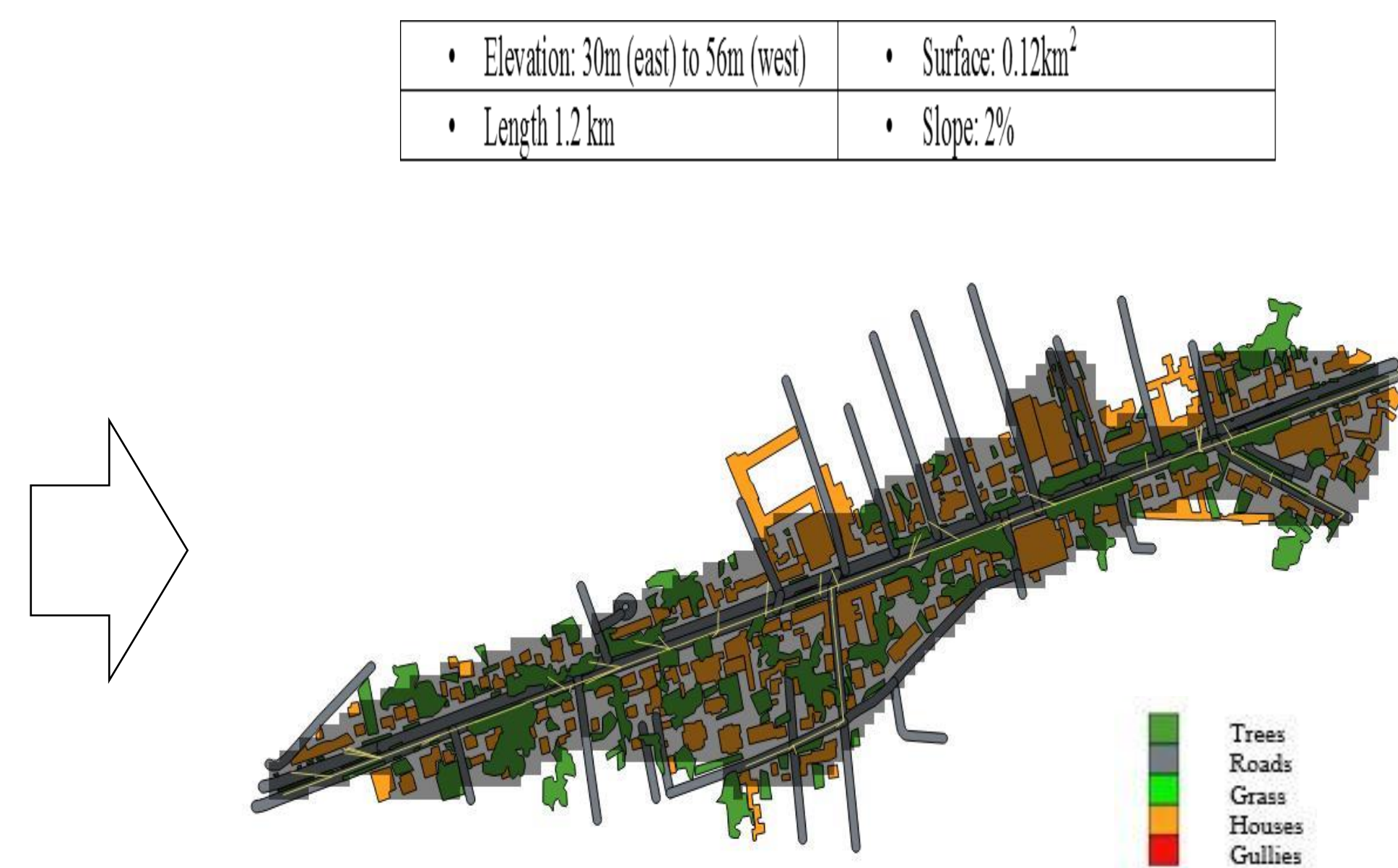


Fig. 4: Delimitation of the studied urban catchment

## Methodology and data

### Catchment representation

- Due to the fact that finer resolutions are more sensible, a technique has been developed for reducing that scaling sensibility <sup>[3]</sup>. The coefficient of the impermeability (C.I.) is calculated and is 55.4% for the resolution at 10m and 53.8% at 5m.

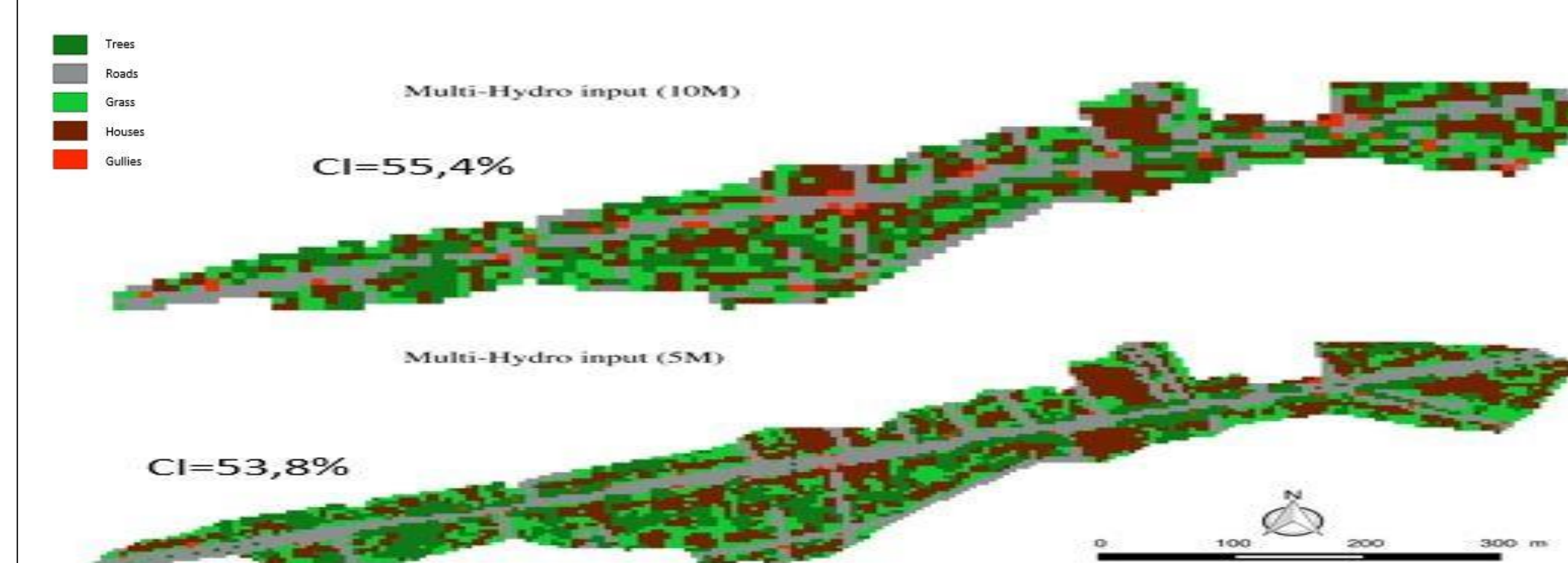


Fig. 5: Representation of the land use cover of the catchment

### Rainfall and instruments

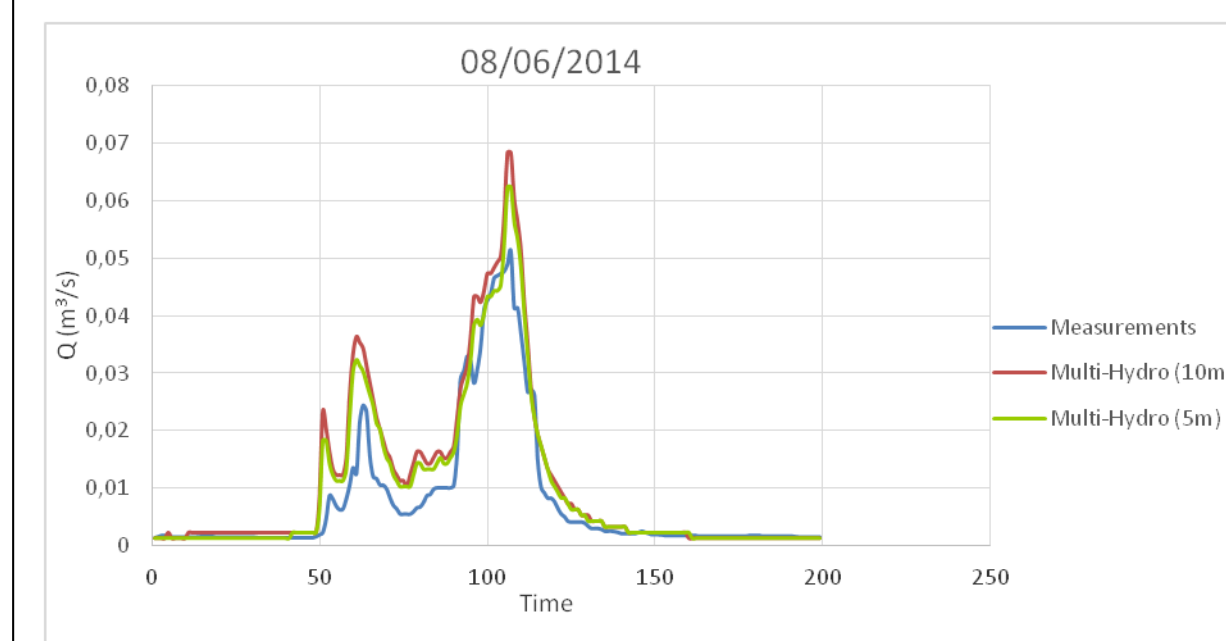
-Discharge flowmeter at the outlet presented many errors in the measurements  
-Rain gauge used for the period 05/06/214-24/08/2015 **but** a newly installed X-band data in ENPC can be used for having access to high resolution data  
-Two criteria were chosen for the validation of the model's behavior, the Nash-Sutcliffe and the relative volume error

Episodes	Date	Duration (min)	I <sub>max</sub> (mm/h)	Total rainfall (mm)	V <sub>rainfall</sub> (m <sup>3</sup> )	V <sub>Q</sub> (m <sup>3</sup> )	Quantite (m <sup>3</sup> /s)	Antecedent dry hours (h)
1	08/06/2014	1469	180.000015	8.1	626.465201	188.89548	0.051126	13.97
2	11/08/2014	352	72.0000013	4.4	536.405327	256.3758	0.140689	24.13
3	07/10/2014	167	51.4285684	4	496.05423	113.4084	0.126492	3.07
4	08/10/2014	1236	12.4137932	17.5	1931.94809	1025.9382	0.067562	9.9
5	09/11/2014	596	32.7272726	12.5	1553.44114	509.5116	0.088283	15.93
6	14/11/2014	332	8.57142862	7.5	922.655939	257.41548	0.043313	29.26
7	15/11/2014	385	6.20689658	12.8	1545.71143	501.25092	0.048917	11.43
8	12/12/2014	1479	39.9999999	29	3604.96975	1641.5419	0.121371	4.63
9	20/02/2015	616	2.18181818	3.5	452.240419	298.61424	0.034835	128.28
10	03/04/2015	610	4.55696201	7	882.750383	476.4132	0.028757	17.23
11	26/04/2015	342	16.3636363	6.8	840.045333	476.61372	0.112188	16.08
12	14/05/2015	186	27.6923066	3.4	411.654479	194.44512	0.127538	15.62

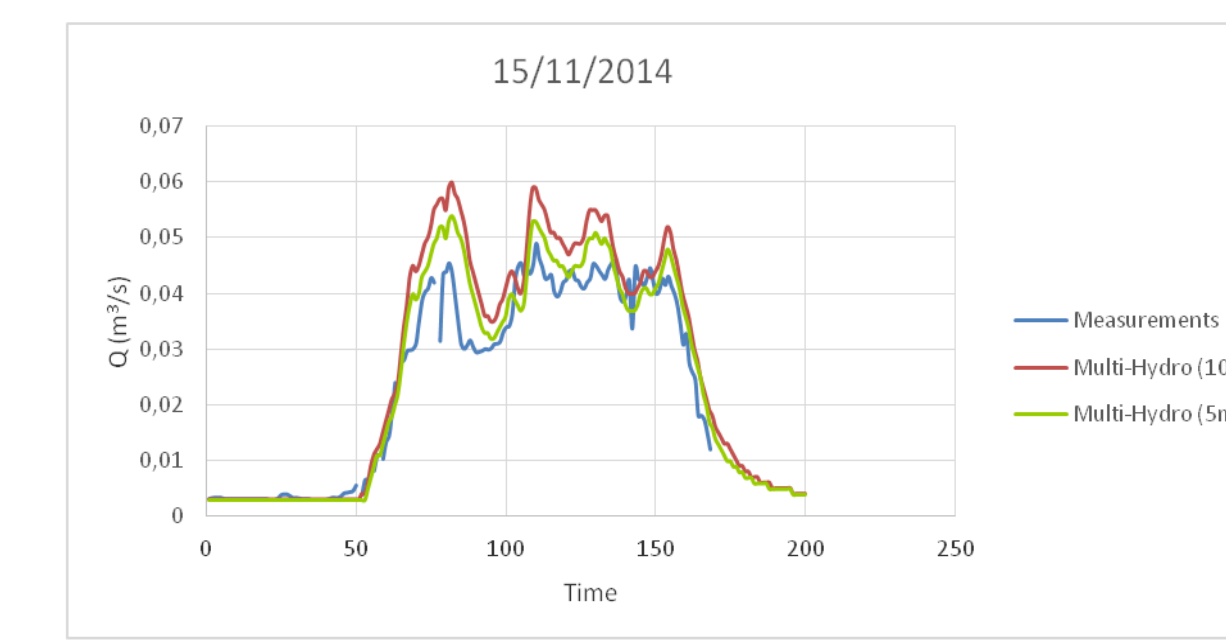
Table 1: The main characteristics of the selected rainfall events

## Results:

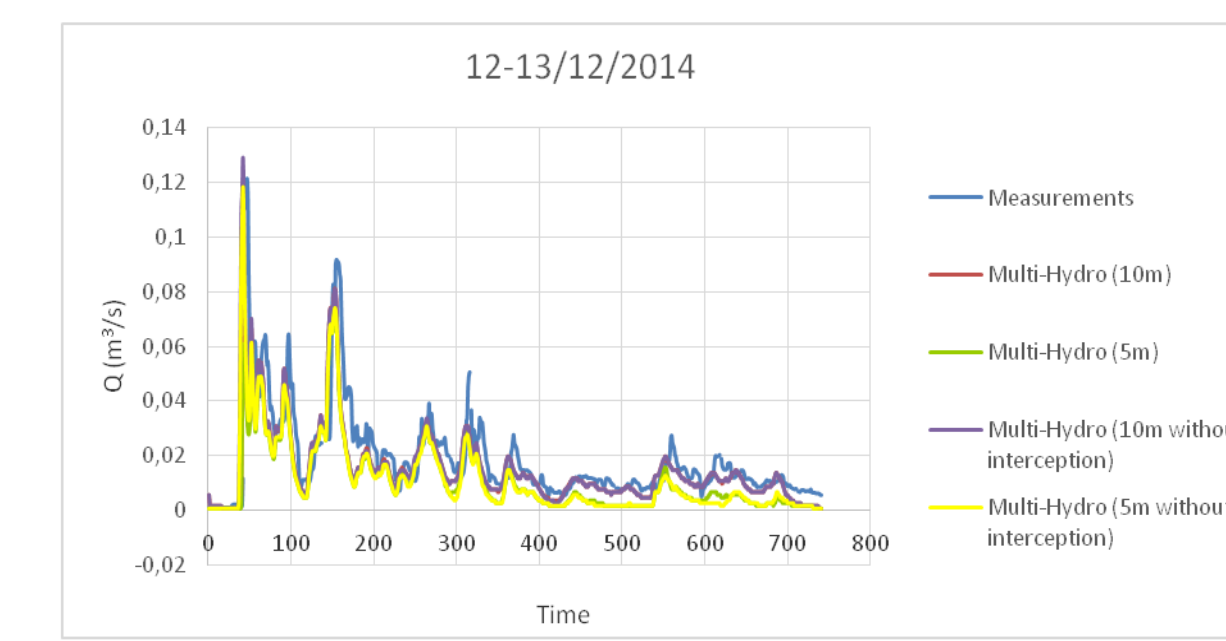
Generally, every simulation at 10m overestimates measured flow while at 5m output are closer to observations. Events with differentiated characteristics concerning the duration of the rainfall event, its mean intensity, the height of the rain and the volume of the discharge flow are displayed in the following graphs. As expected Multi-Hydro gives better results if the dry initial conditions are respected (event of 12-13/12/2014).



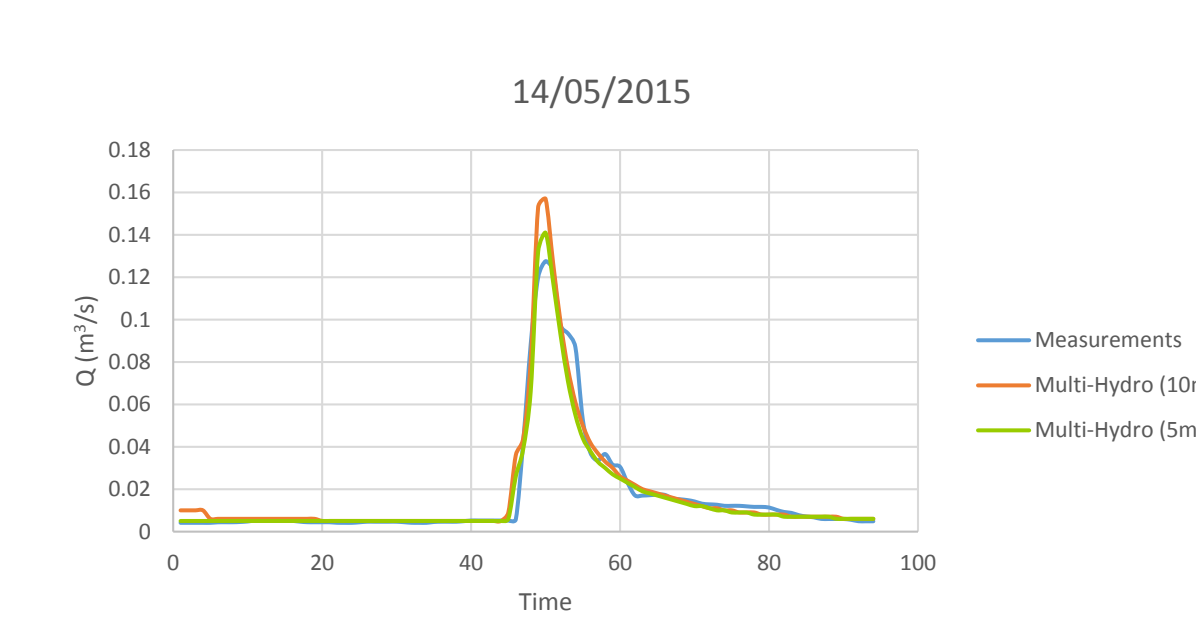
NSE (10m)=0.74 NSE(5m)=0.85  
δV(10m)=0.39 δV(5m)= 0.27



NSE (10m)=0.73 NSE(5m)=0.85  
δV(10m)=0.27 δV(5m)=0.17



NSE (10m)=0.47 NSE(5m)=0.39  
δV(10m)=-0.17 δV(5m)= -0.37



NSE (10m)=0.90 NSE(5m)= 0.90  
δV(10m)=0.06 δV(10m)= -0.05

## Conclusions:

Multi-Hydro is validated in Le Perreux-sur-Marne and is able to reproduce the effects of small changes in the land use. As it is expected, the results are more accurate at a higher resolution. Apart from the restriction of dry initial conditions, a more detailed land use would give better results but the problem concerning the scaling sensibility has to be overcome. Multi-Hydro can model the pollutants transport but that part is not activated so far. Consequently, Multi-Hydro can be integrated in Trafipollu project for modeling the pollutants transportation.

**References:** [1] <https://hmco.enpc.fr/Tools-Training/Tools/Multi-Hydro.php>

[2]Giangola - Murzyn, A. (2013). Modélisation et paramétrisation hydrologique de la ville, résilience aux inondations. *Earth Sciences. Université Paris-Est, 2013. French. <NNT :2013PEST1189>. <pastel-01060497>*

[3] Ichiba, A., Gires, A., Tchiguirinskaia, I., Bompard, P., Schertzer, D. (2015). High resolution modeling in urban hydrology: comparison between two modeling approaches and their sensitivity to high rainfall variability. *EGU General Assembly. 17*, pp. 14103-1. Vienna: Geophysical Research Abstracts.