# Study of the impact of the rainfall resolution on the discharge simulations in urban areas

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# Introduction

**Basic features of hydrological processes at stake during urban flooding (rainfall, surface runoff, sewer flow, and sub-surface flow):**

- **Non linear**
- **Different characteristic spatial and temporal scales**

**Fully distributed hydrological models are a useful tool to better understand these complex interactions between natural processes and man built environment.**
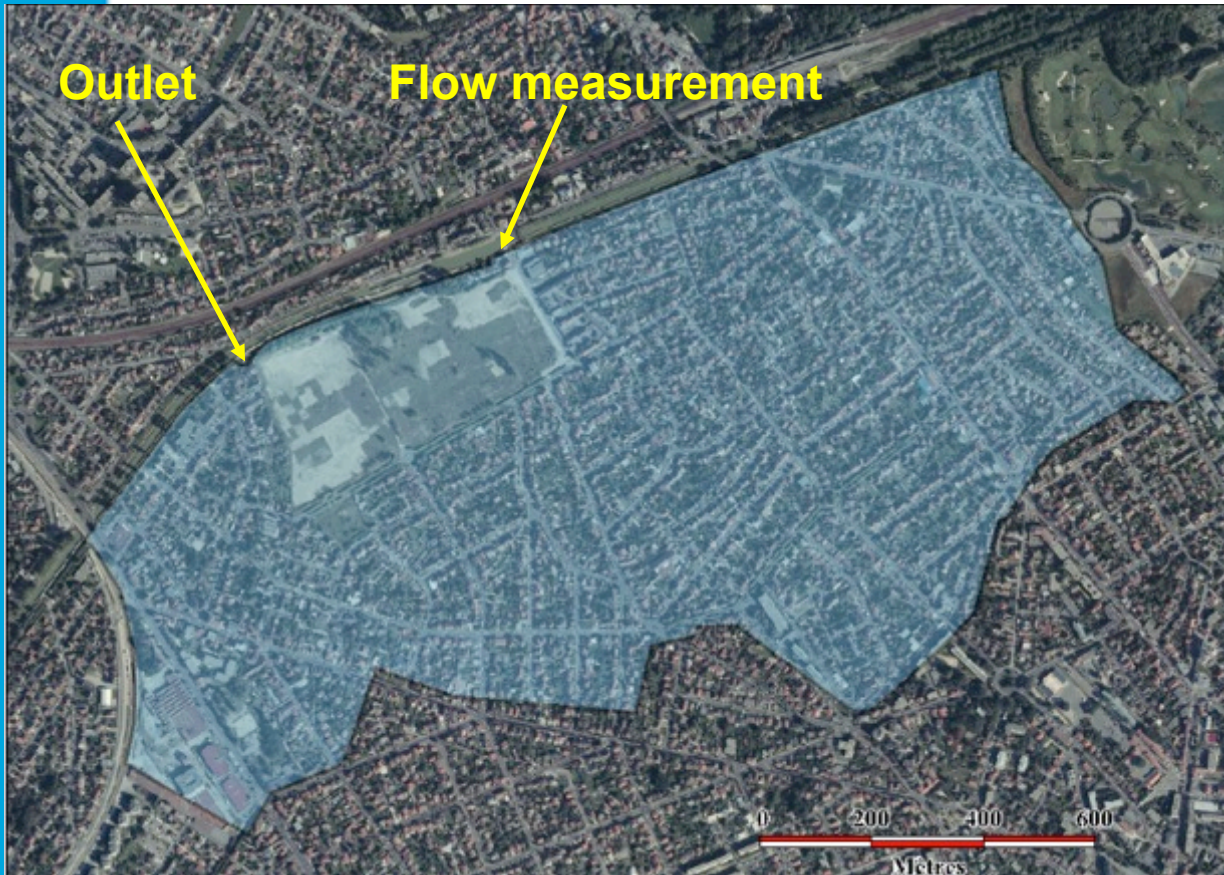
→   **What should be the spatial resolution ?**

**In this paper : issue investigated with the help of the rainfall input**

**A case study :**

- **Kodak Catchment (1.47 km$^2$ urban near Paris)**
- **Two models : a fully distributed one and a semi distributed one**
- **Three rainfall events : 9$^{th}$ February, 2009**

# Case study : Kodak catchment



- 1.44 km²
- Known for regular overflow
- Project to build a storm water storage basin
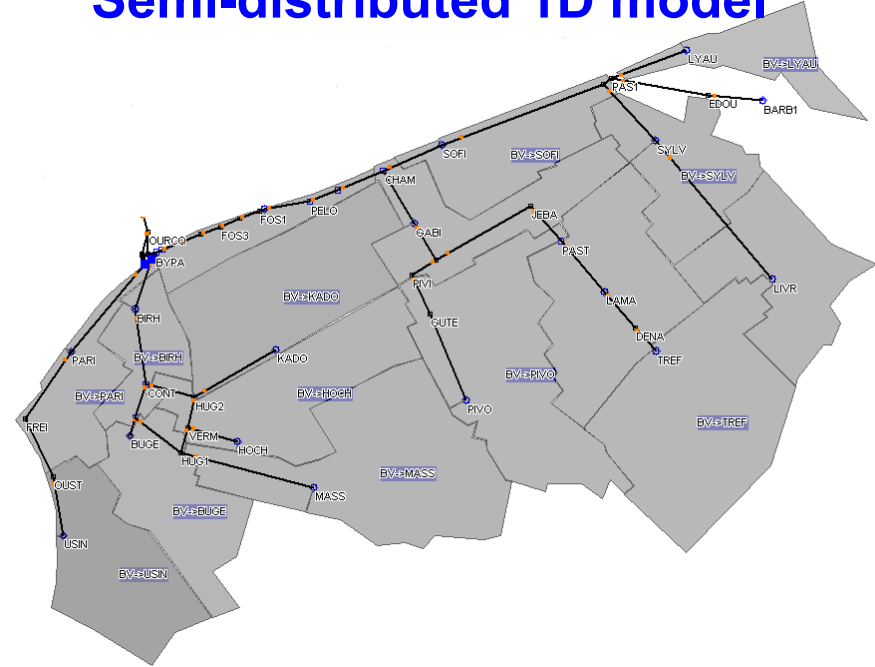
# Case study : Kodak catchment

## Multi-Hydro : 10 m resolution



- Fully distributed model (interactions between surface, sub-surface and sewer flow)
- Currently under dvp at Ecole des Ponts ParisTech
- MH Assim Tool to generate the input from available GIS data
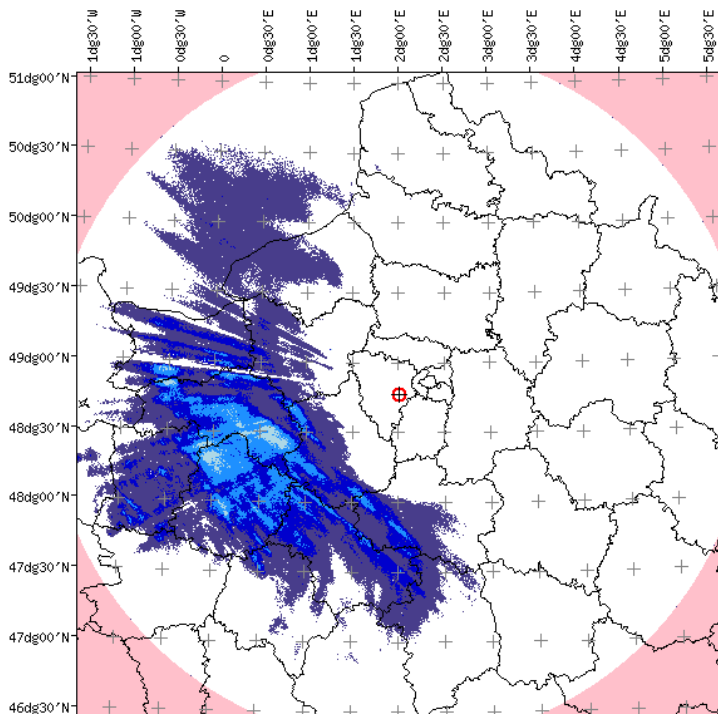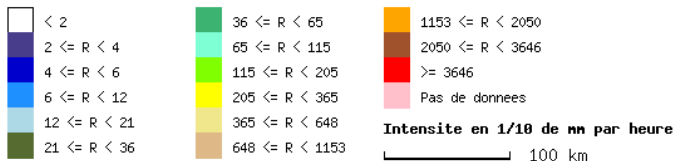
## Semi-distributed 1D model



- Lumped model for each sub-catchment and Saint-Venant equations in the links)
- 16 sub-catchments (considered homogeneous) with size ranging from 4 to 14.5 ha
- Calibrated by DEA 93

# Rainfall data


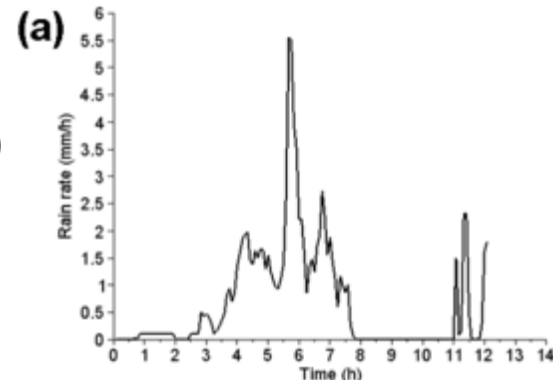
Radar de Trappes (78): Reflectivite
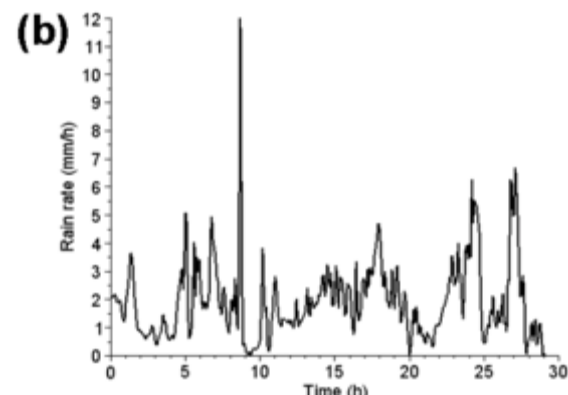le 9 Fevrier 2009 a 08h 00' UTC

**C-band radar of Trappes
(Météo-France)
1 km x 1 km x 5 min**

**09 / 02 / 2009
8.3 mm**

**15 / 08 / 2010
56.5 mm**

**15 / 12 / 2011
23.8 mm**

# Virtual X-band radar

## Methodology : stochastic ensemble approach

**(i) Generation of an ensemble of realistic downscaled rainfall fields :**
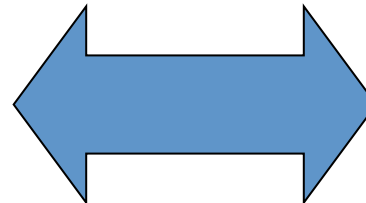- **Multifractal analysis of rainfall data**
- **Downscaling with the help of discrete universal multifractal cascades**

**(ii) Simulation of the corresponding ensembles of hydrographs :**
- **Use of operational hydrological/hydraulic urban models**

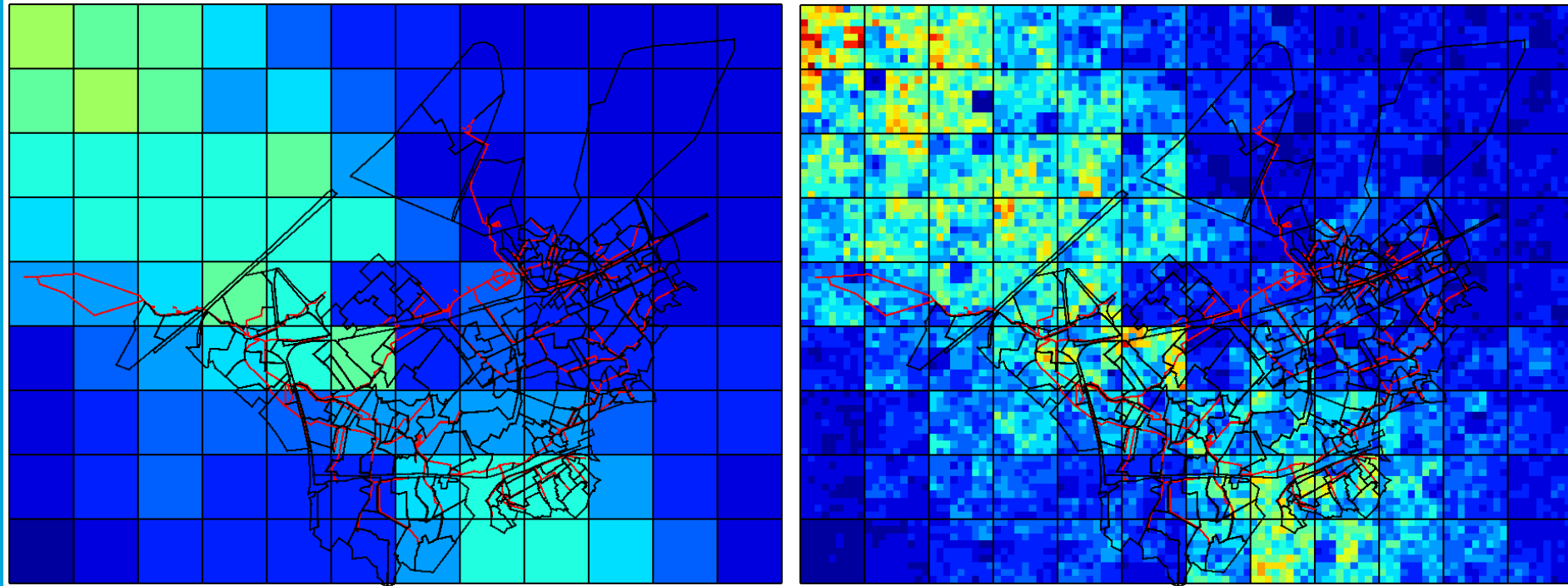**(iii) Analysis of the ensembles :**

**Variability among the 100 samples** ⬌ **Uncertainty due to the unknown high resolution rainfall variability**

# Virtual X-band radar

## Illustration of the downscaling for an arbitrary time step

### 1 km x 1 Km x 5 min → 111 m x 111 m x 5 min



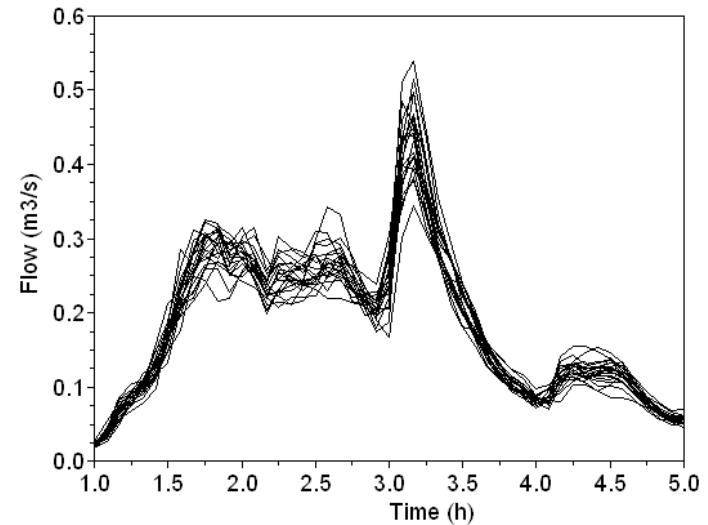Rainfall intensity (mm/h)

1    48

North

1 km

Radar pixel

Sub-catchment

Sewer system

Investing in Opportunities

This project has received European Regional Development Funding through INTERREG IV B.

INTERREG IVB

# Virtual X-band radar : hydrological consequences
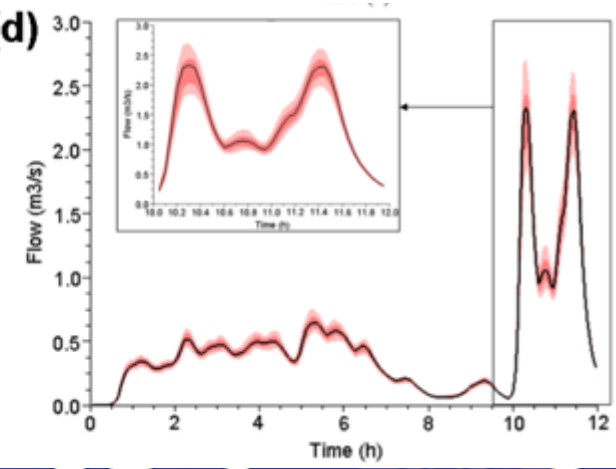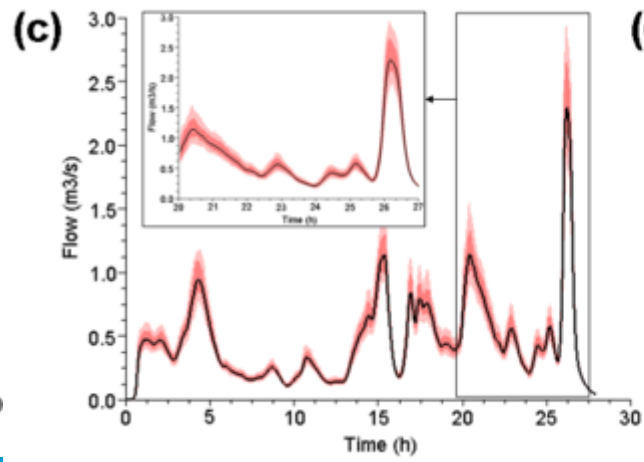
**Uncertainty associated with small scale rainfall variability**

Multi-hydro ; outlet

09 / 02 / 2009

15 / 08 / 2010

15 / 12 / 2011

# Virtual X-band radar : hydrological consequences
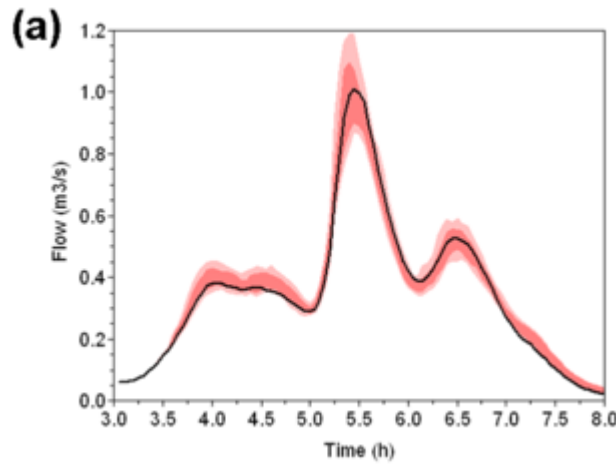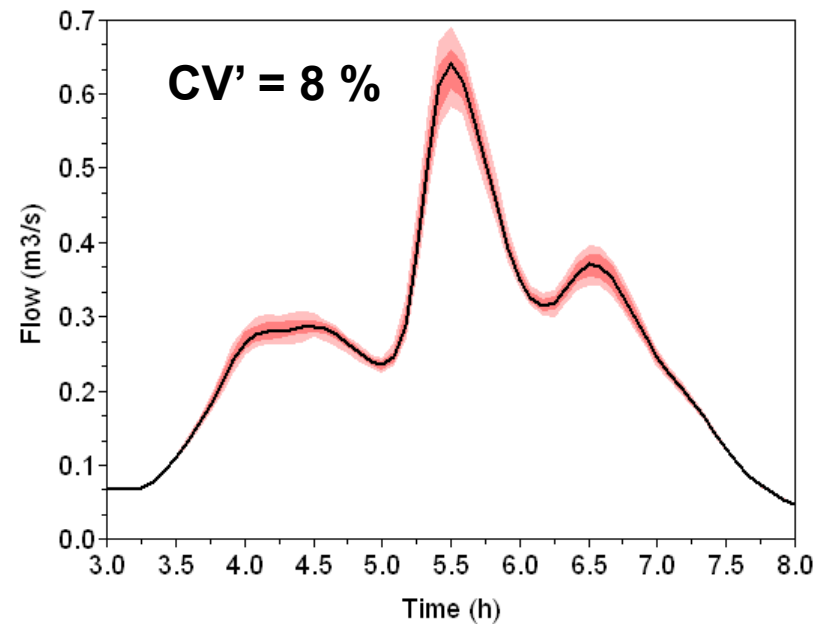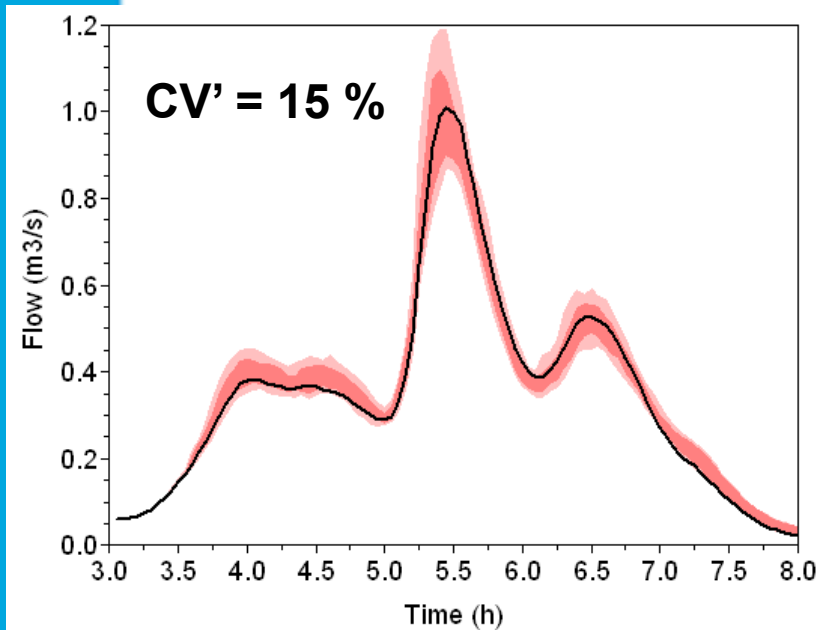
## Fully distributed vs. semi-distributed

### Uncertainty on the simulated flow for the outlet

**Multi-Hydro 10m**



CV' = 15 %

**Semi-distributed 1D model**



CV' = 8 %

**MH unveils much more uncertainty**

# Conclusion

**Quantifying the uncertainty associated with unmeasured small scale rainfall variability :**

    - It cannot be neglected ($CV$ reaches 30% for up-stream links and 7.5% for the outlet, and power law fall-off for probability distribution for both discharge and rainfall).

    - A need to implement actual X band-radars (which provide an hectometric resolution) in urban area

**Comparison of fully a distributed model (10 m resolution) with semi-distributed one (300 m resolution)**

    - Much more uncertainty is unveiled with the fully distributed / Even moderate rainfalls are affected

**→ Small scale phenomenon must be taken into account in urban hydrology**

**Limits / further investigations :**
- Perform similar study with other inputs
- Test this on other catchments