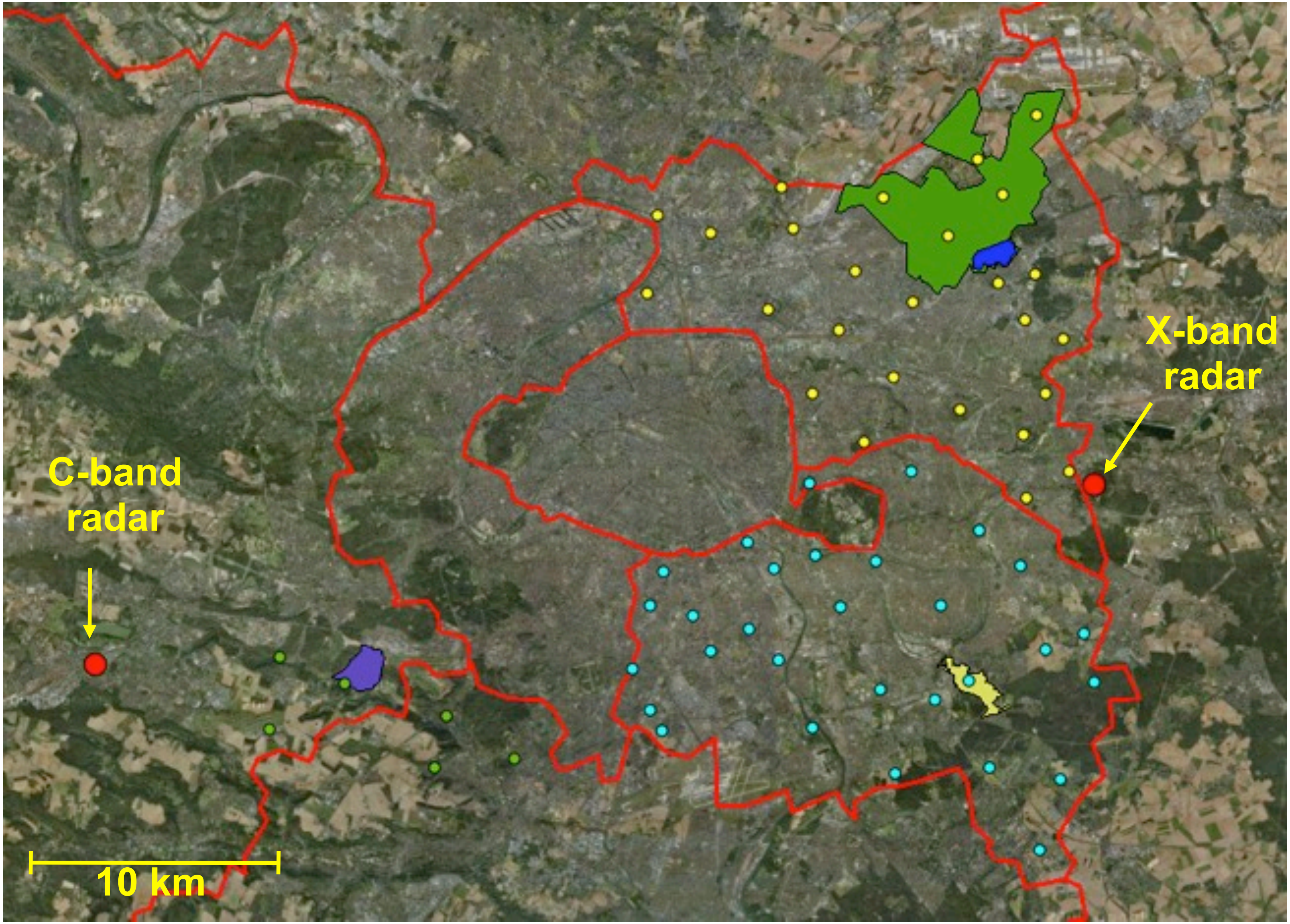
Report activities of French pilot site

RainGain Project Meeting, London, 15-17 April 2013

ENPC : A. Gires, I. Tchiguirinskaia, D. Schertzer, A. Giangola-Murzyn, J. Richard
Val-de-Marne : A. Ichiba, P. Bompard
Seine-Saint-Denis : N. Stantic, F. Chaumeau, V. Lanier


X-band
radar
C-band
radar
10 km

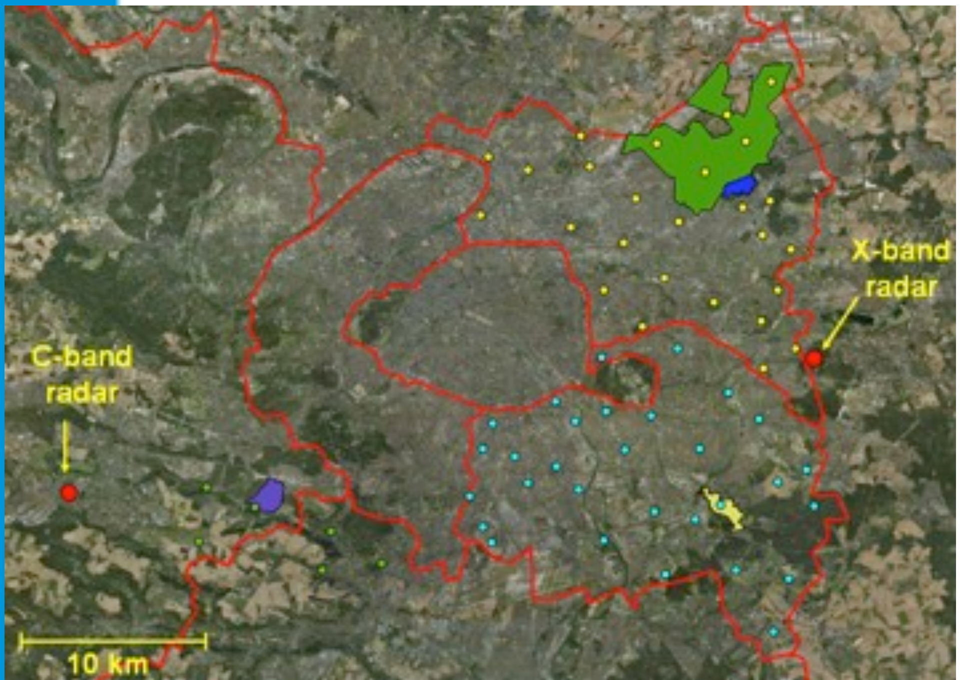
Activities within WP1

X-band radar acquisition

Other rainfall data

Radar acquisition

Implementation



Interest of having two radars (X of RainGain, C of Météo-France at Trappes) rather far apart

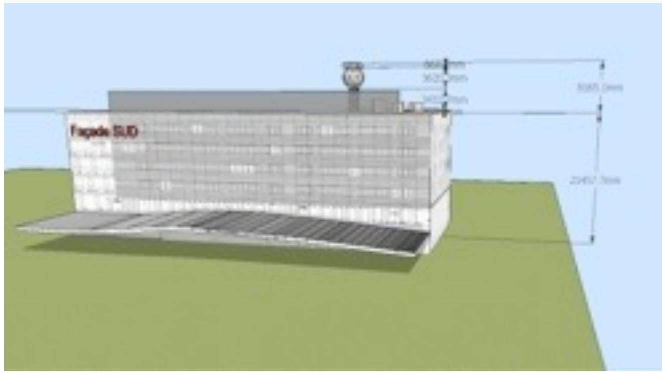
- Storms generally from West, discharges from East
- East of Paris:
  - low visibility from Trappes
  - Important test field for urban research (Marne-la-Vallée),
  - in particular within the programme « Numerical City »
  - PST Paris-Est on urban systems
  - Several gauge networks (>2 x 30) + C-band radar

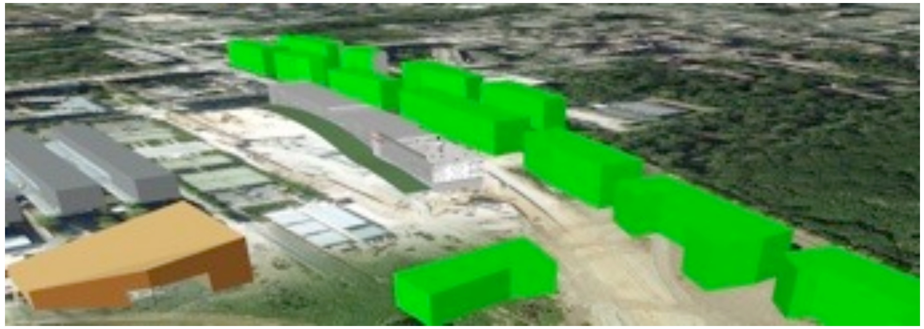
Radar acquisition

Implementation

A rather systematic study of the potential sites with GIS tools (ENPC) and in-situ visits with the help of Veolia and CG94

→ Back to Paris-Est Campus





Radar acquisition

Tender procedure

Preparation of the tender

→ Published 3rd Aug. 2012 with a deadline 19 Sept 2012

(Prepared and analysed by ENPC with Meteo-France, some consultancy with TU Delft)

Evaluation of the two bidders

→ Rather similar and high performance
- more originality with Ineo-Novimet
- Less operational experience
- Large budget difference (≈30%)

→ Presentations, radar experts reports

→ Selection of Selex-Gematronik Meteor 50 DX

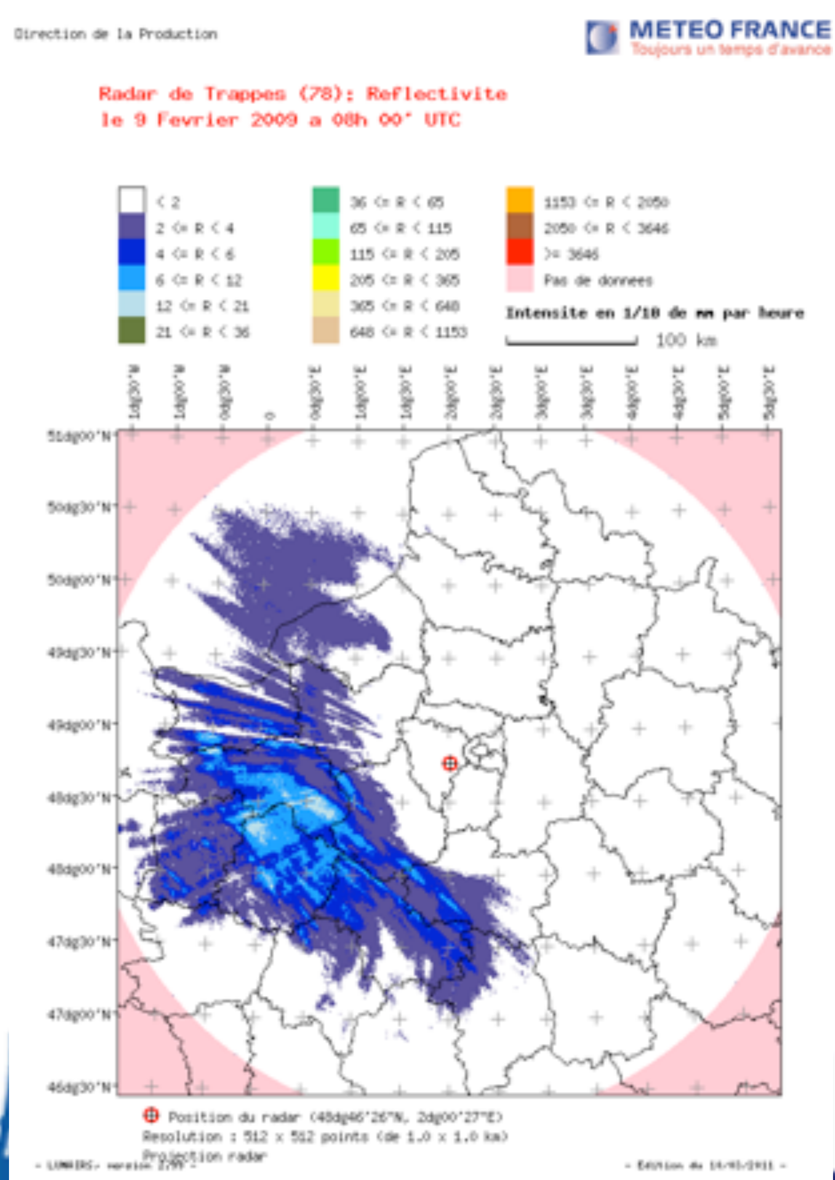
Purchase of the radar

→ Effective purchase 25 March 2013

→ Time to delivery (8.5 and 12.7 month)

Other rainfall data

Météo-France C-band radar of Trappes

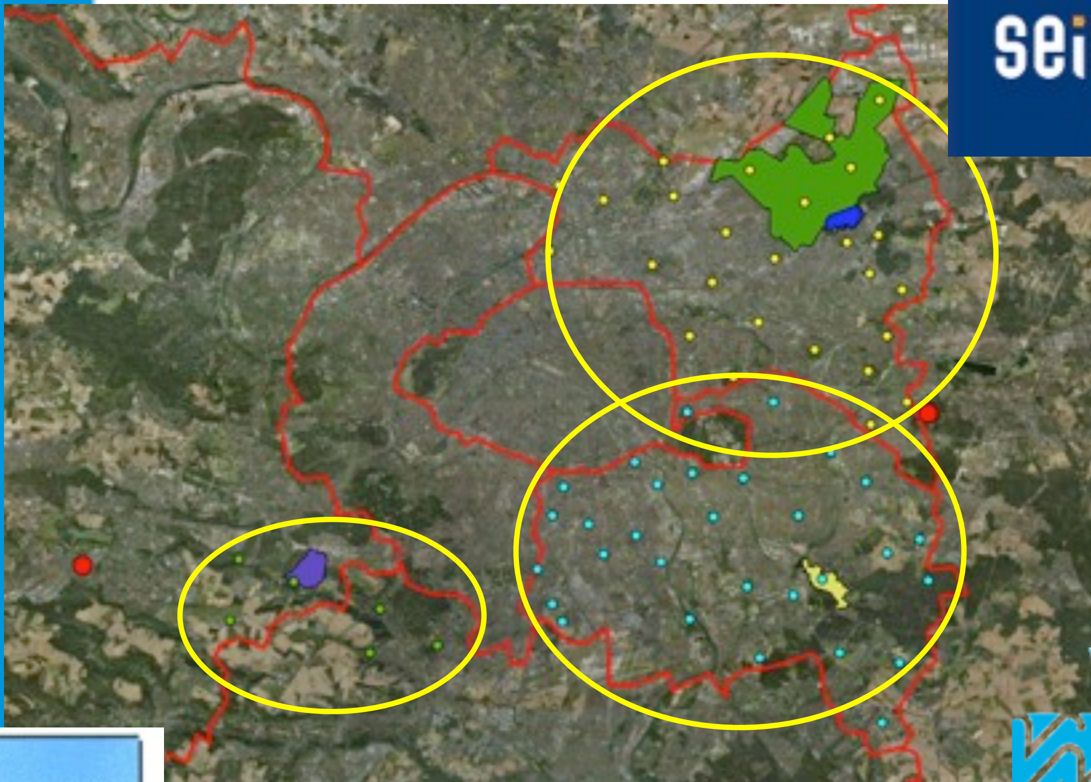


Doppler, Dual Pol.

Product resolution : 1 km x 1 km x 5 min

Other rainfall data

Real time rain gauge networks



Seine-Saint-Denis
LE DÉPARTEMENT

26 rain gauges

Gérard Philippe

VAL de MARNE
Conseil général

30 rain gauges

SIAVB

6 rain gauges

Other rainfall data

ENPC disdrometers

1 PWS100 (Campbell Scientific)

2 Parsivel (OTT)

- Class of size and velocity
- Ground validation of radar
- DSD very helpful to check/calibrate Z-R or Z-K_{dp} relationship

Internship starting end April 2013

Activities within WP2

Current

- Validation of a downscaling process for rainfall with the help of dense networks of point measurement devices (in coll. with Ecole Polytechnique Fédérale de Lausanne, Switzerland; and Bradford Univ., UK)
- Revisiting the issue of comparison between radar and rain gauges taking into the differences of observation scale.
- Input for the WP2 Review document
- Comparison of Météo-France radar product, Calamar radar product, and Val-de-Marne rain gauge network

Planned

- Validation of the X-band rainfall estimates (in coll. with Météo-France)
- Dvp of merging techniques for rainfall data with different observation scale (C-band, X-band, rain gauge, disdrometer) (in coll. with Météo-France)
- Dvp of nowcasting techniques (PhD position available)

Validation of a Universal Multifractal downscaling process with the help a dense network of disdrometers or rain gauges

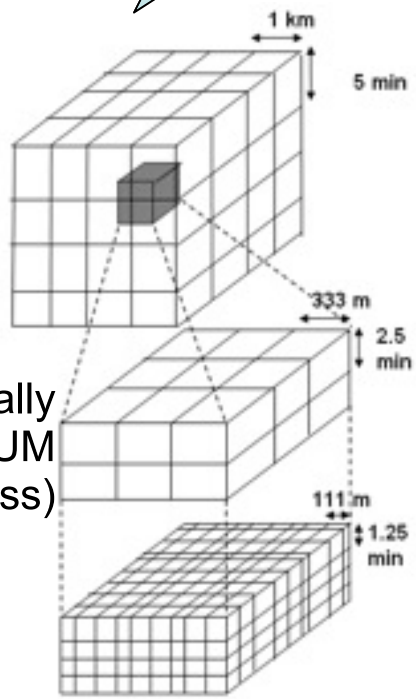
8 x 2 rain gauges, 0.2 mm

Coll. with A. Schellart, Bradford U. Campus (UK)

16 PARSIVEL® disdrometres, 1 min

Coll. with Alexis Berne EPFL Campus (Switzerland)

Aggregation to 1km x 5 min



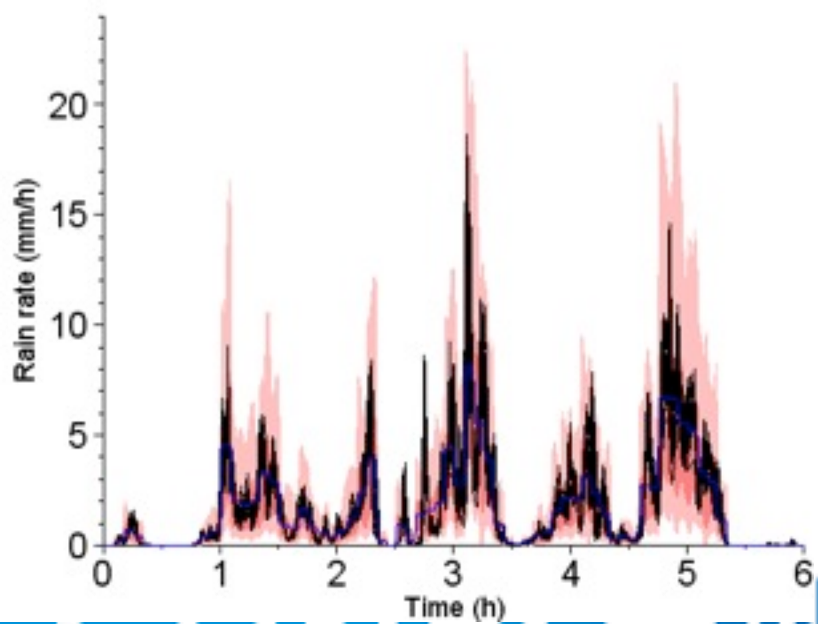
Downscaling (stochastically continuing the underlying UM cascade process)

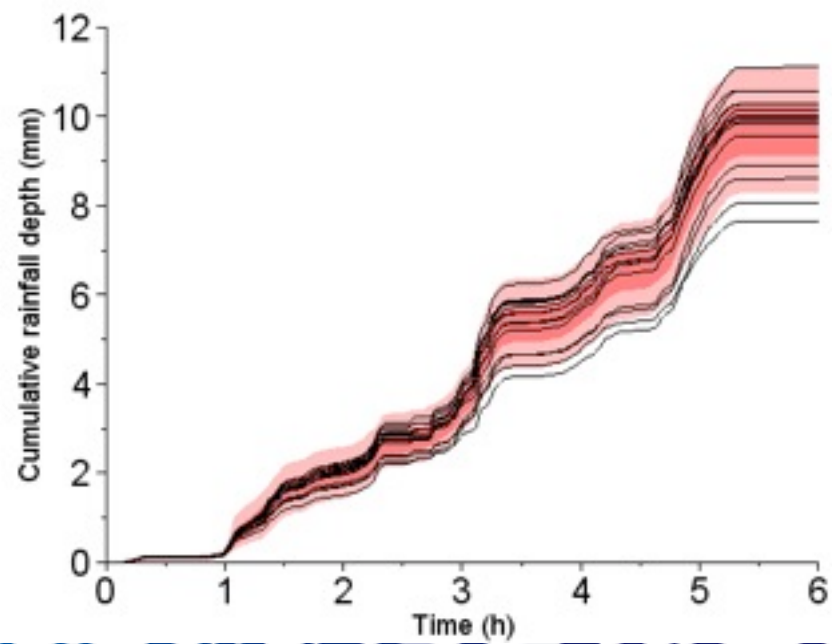
Generation of the output of 2187 x 2187 virtual point measurements with observation scale of 46 cm x 1 min

Validation of a Universal Multifractal downscaling process with the help a dense network of disdrometers or rain gauges.

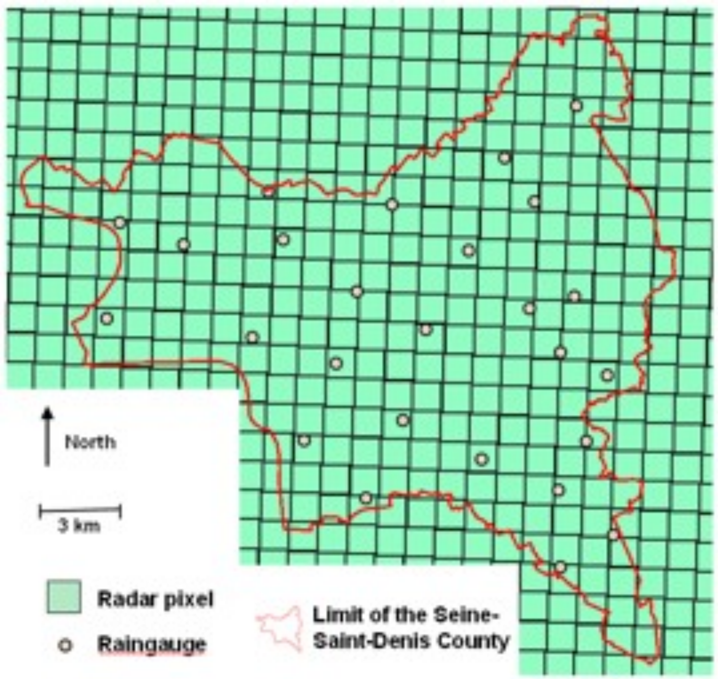
Results for 6 June 2009 in Lausane

16 disdrometers measurements + uncertainty range (75% and 95% quantile)





Revisiting the issue of comparison between radar and rain gauges



Methodology

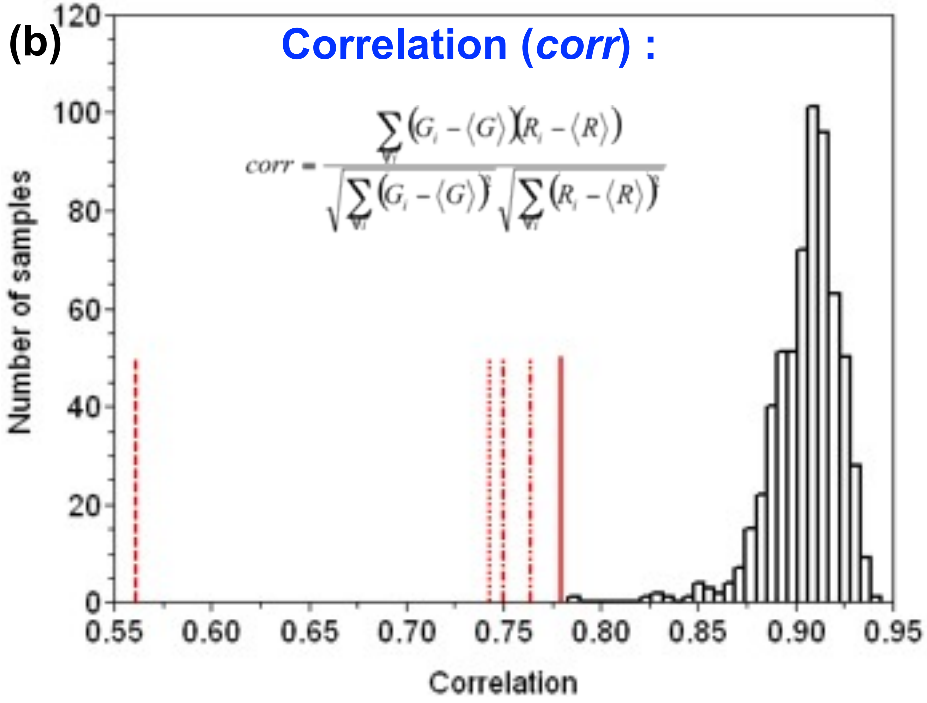
4 rainfall events over Seine-Saint-Denis :
- **9/2/2009**
- **14/07/2010**
- **15/08/2010**
- **15/12/2011**

(i) Downscaling the radar data for each radar pixels to a resolution of 46 cm in space and 5 min in time → outputs of "virtual rain gauges" for each of the 26 radar pixels.

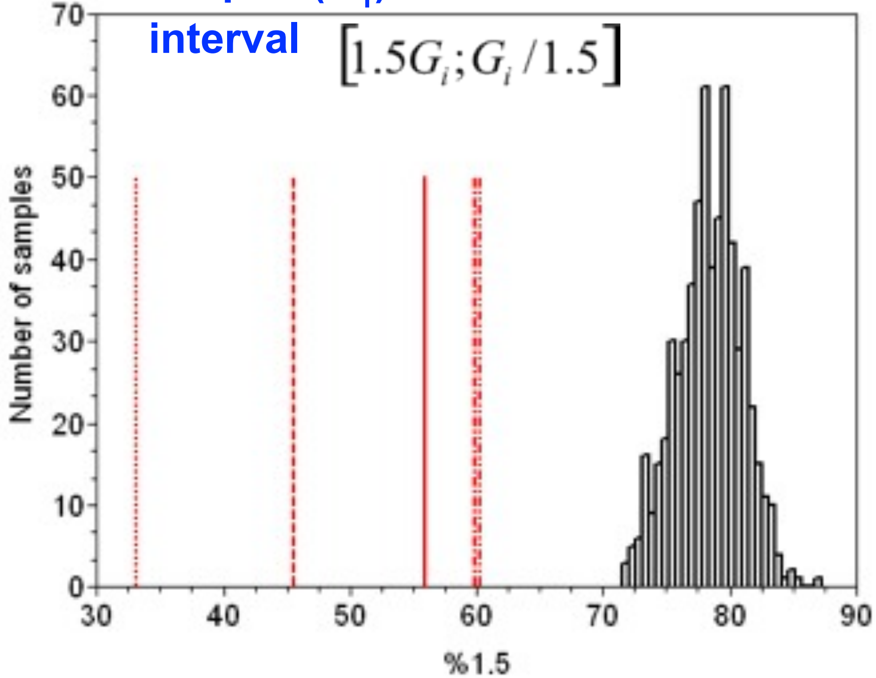
- **Randomly selecting a "virtual rain gauge" for each radar pixel and computing the corresponding scores. In order to generate a distribution of possible values for each score, 1000 sets of 26 virtual rain gauges locations (one per radar pixel) are tested**

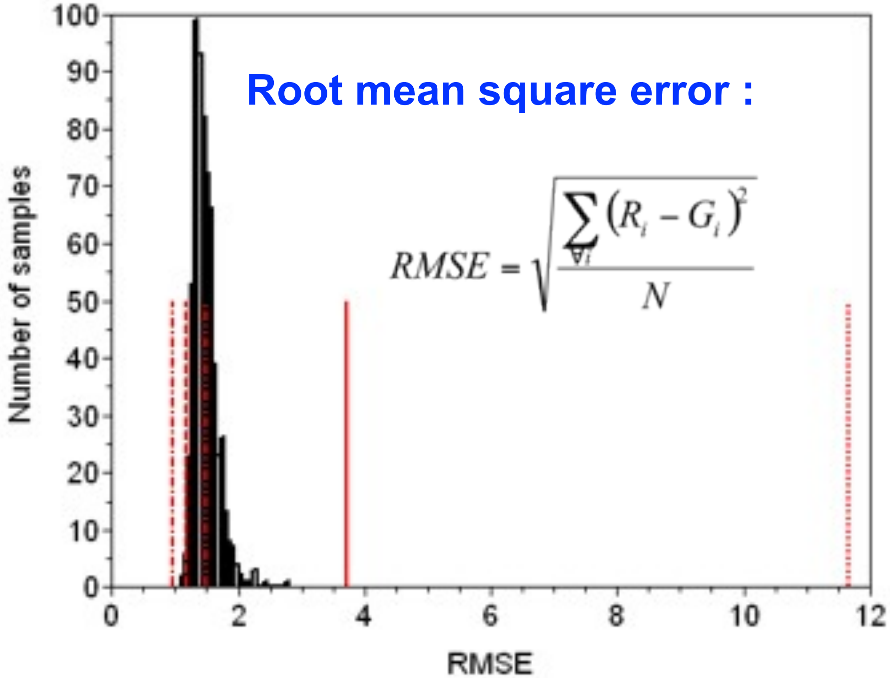
Revisiting the issue of comparison between radar and rain gauges

Time steps of 15 min are considered

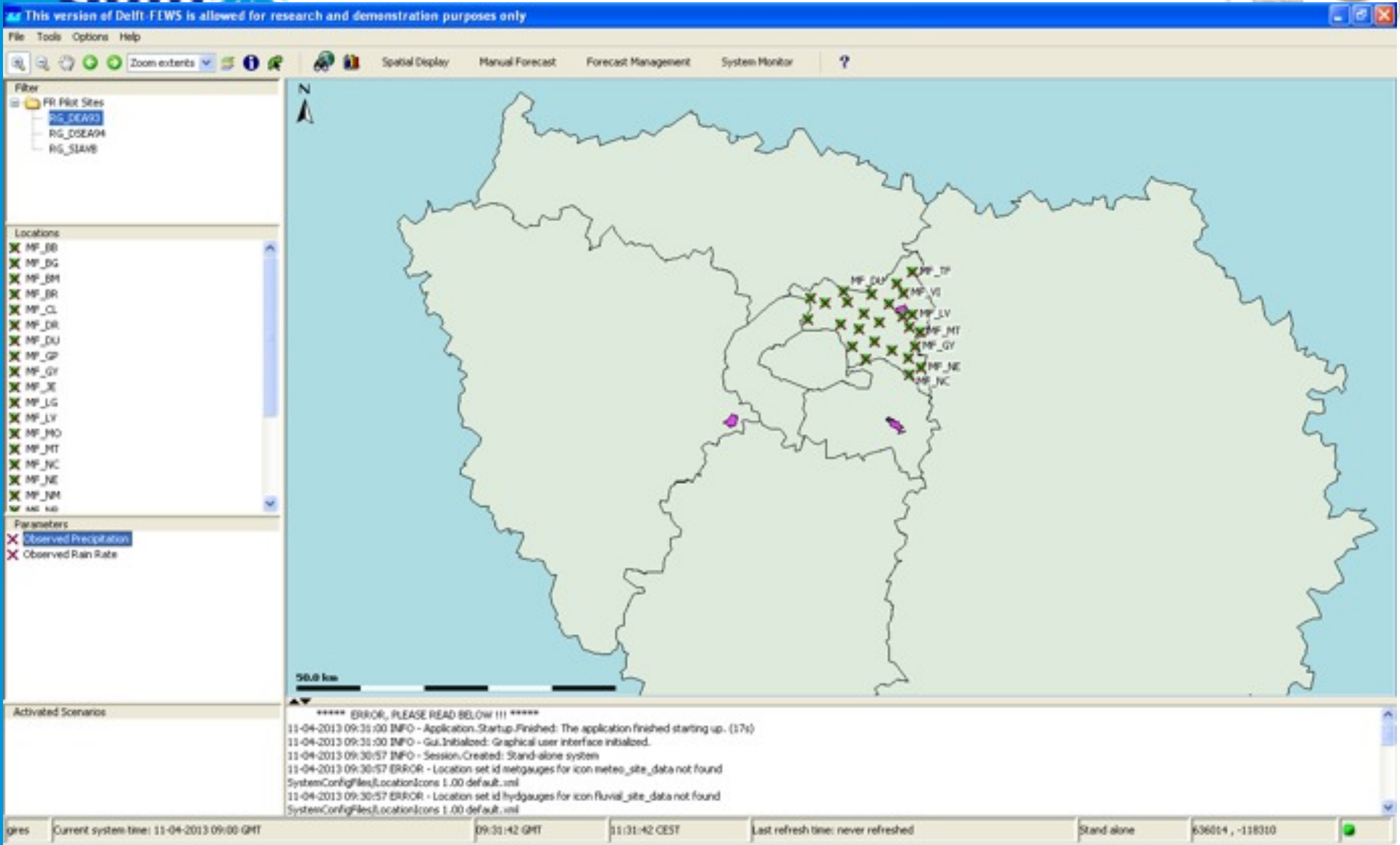


Percentage ($\%_{1.5}$) of radar time steps (R_i) contained in the interval $[1.5G_i; G_i/1.5]$





Implementation of the FEWS platform



Activities within WP3 and WP4

Urban hydrological / hydraulic models

- Canoe
- MH : in house fully distributed model

Three case study with various aims

- Morée-Sausset and Kodak (with Conseil Général Seine-Saint-Denis)
- Sucy-en-Brie (with Conseil Général Val-de-Marne)
- Jouy-en-Josas (with SIAVB)

Urban hydrological models

Canoe

Modelling

- Semi-distributed (lumped model to represent rainfall / runoff relation for each sub-catchment)
- Saint-Venant equations in the links

Main features

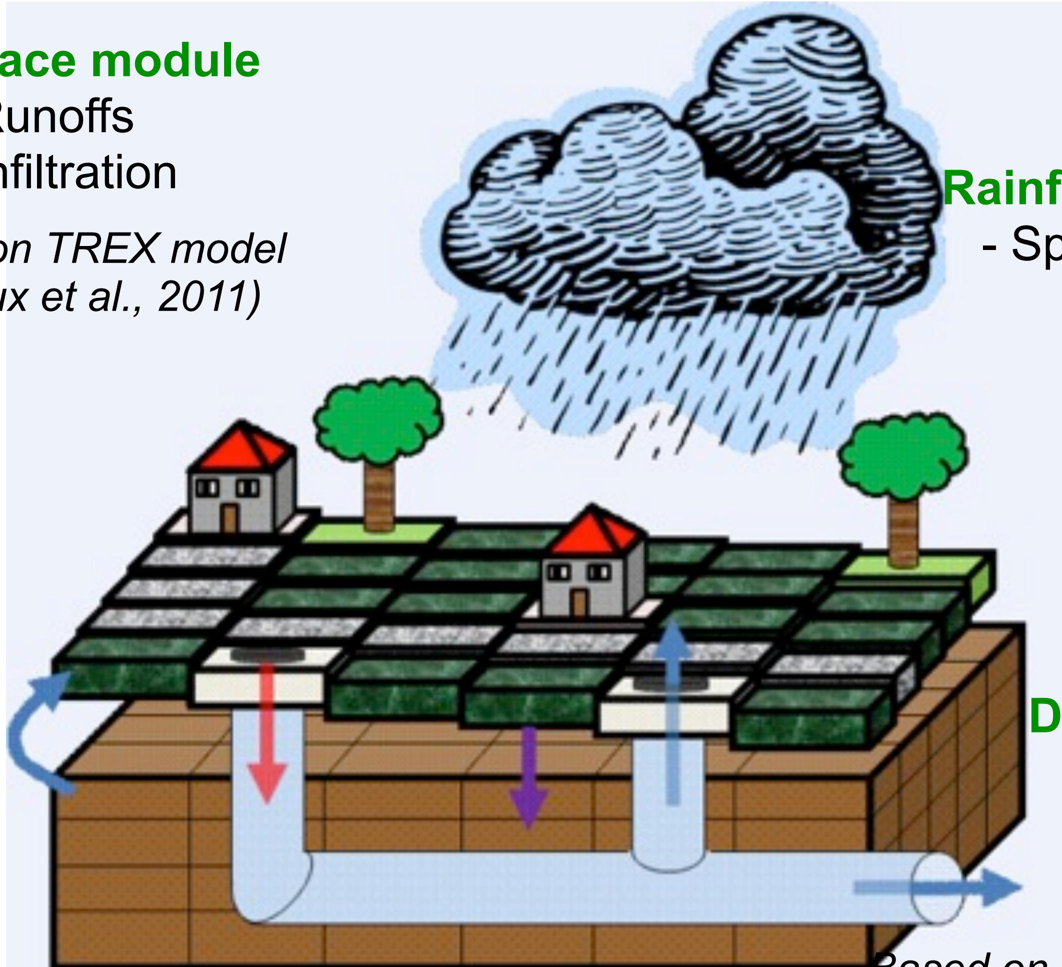
- Quick computation time
- Commercial software / widely used in France

Urban hydrological models

Multi-Hydro : an interacting core between existing modules

Surface module
- Runoffs
- Infiltration

Based on TREX model (Velleux et al., 2011)



Rainfall module
- Spatio-temporal rainfall

Based on Multifractal cascades (Schertzer and Lovejoy, 1987)

Drainage module
- Sewer flow
  (free surface, and loaded)
- Overflow

Based on SWMM model (Rossman, 2005)

Soil module
- Vertical flow in the non-saturated area
- Saturation during a rainfall event

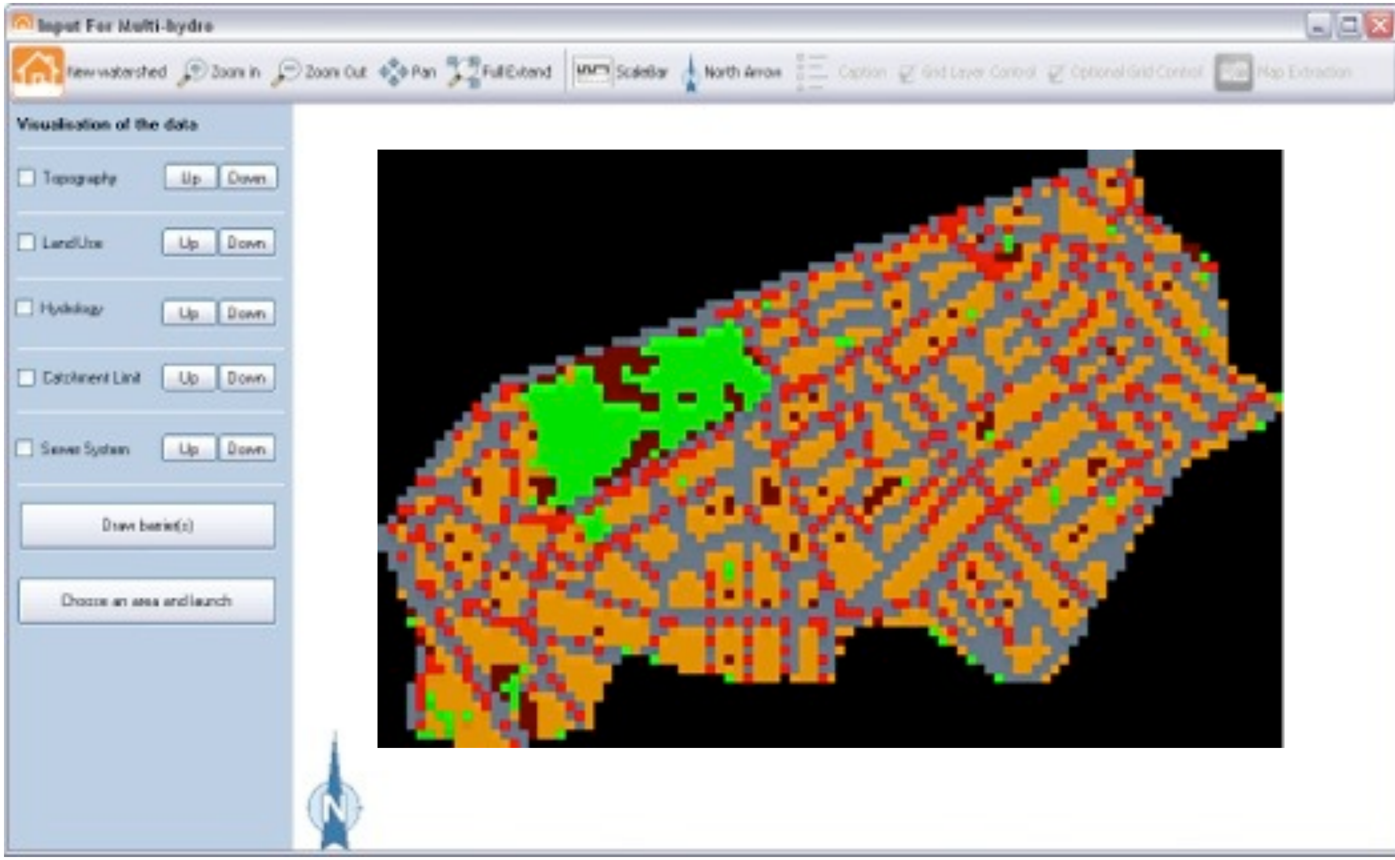
Based on VS2DT model (Lapalla et al., 1987)

PhD Project Agathe Giangola-Murzyn

Urban hydrological models

Multi-Hydro AssimTool

→ A user friendly interface to generate the input from available GIS data



PhD Project Julien Richard

Urban hydrological models

Overview of Multi-Hydro

Main features

- Fully distributed
- Physically based
  - easy assimilation of GIS data
  - multi-scale generation of missing data; downscaling
- Transportable
  - GIS based
  - no calibration
- Modular structure (each module widely used and validated)
- Easy change of the resolution (ex: cell size from 50 m to 1 m)

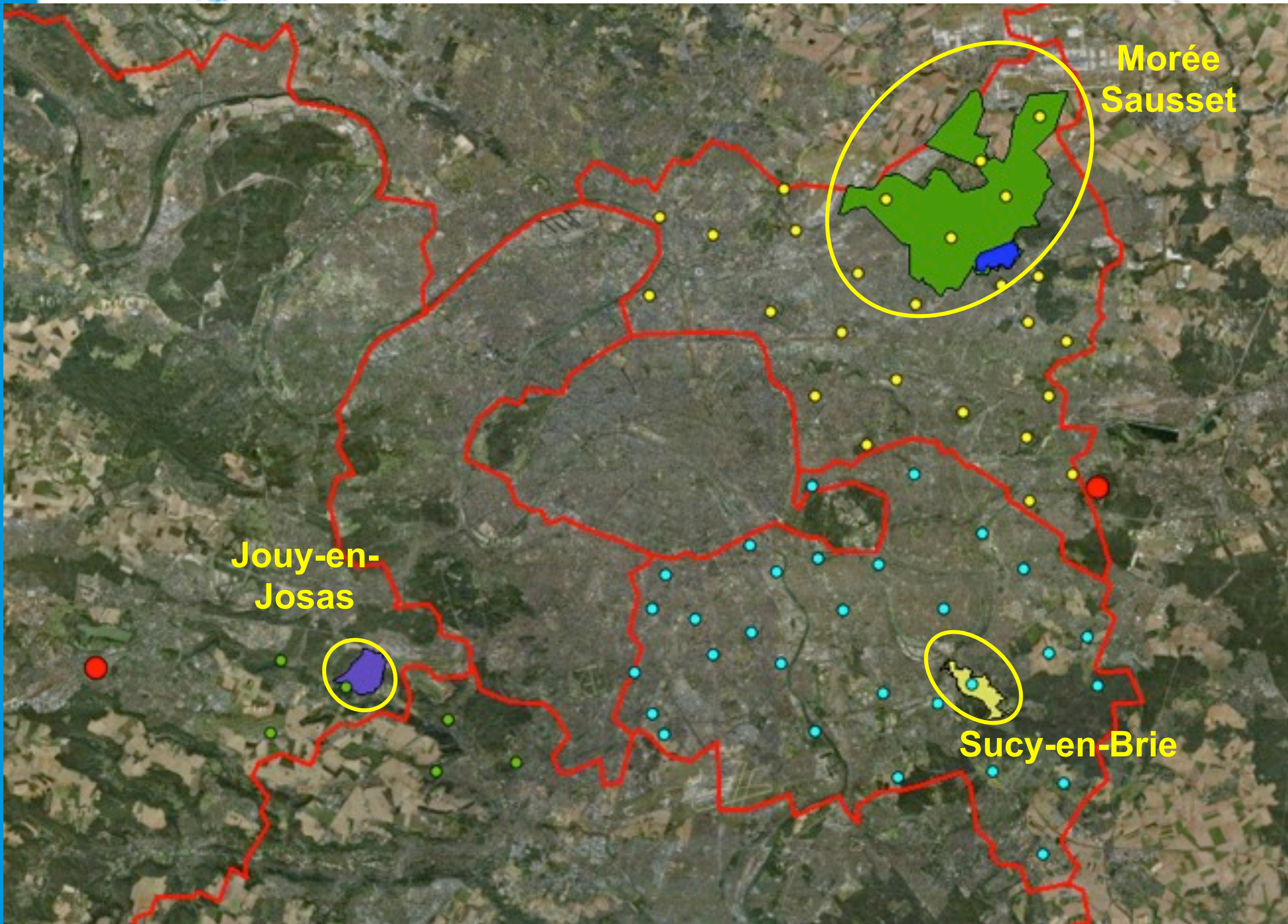
An open access European Tool

- EU projects : ERANET CRUE, SMARTeST, RainGain
- Climate KIC Network

Future works

- Statistical analysis in post-processing
- Visualization

Pilot locations



Morée-Sausset
Outline

Location and environmental settings

Pluvial flooding and weak points

Current solutions

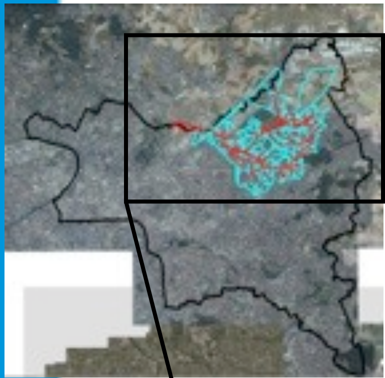
Monitoring

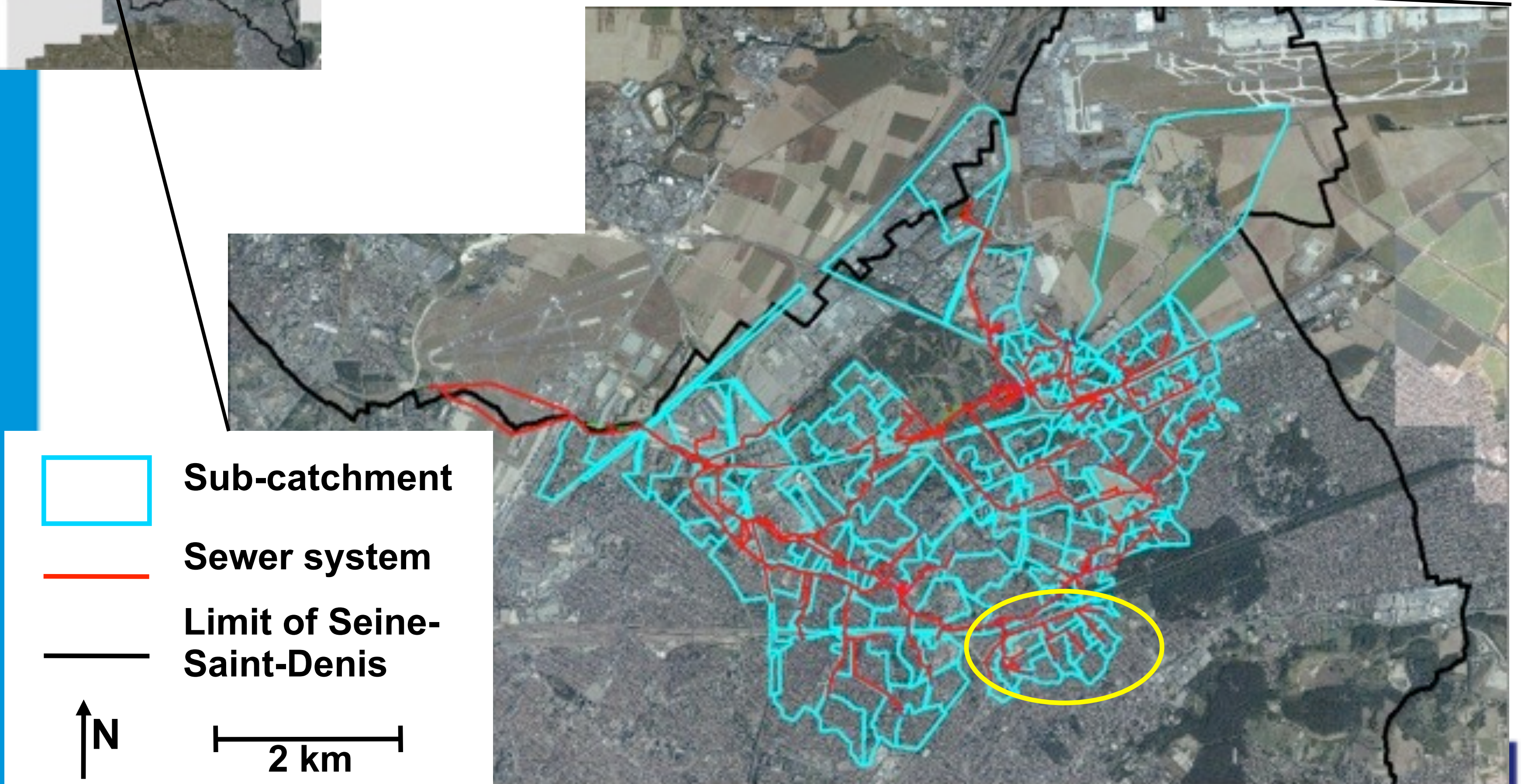
Current activities

- Implementation with Canoe and Multi-Hydro (various resolutions)
- Comparison for a rainfall event
- Quantification of the uncertainty associated with small scale rainfall variability

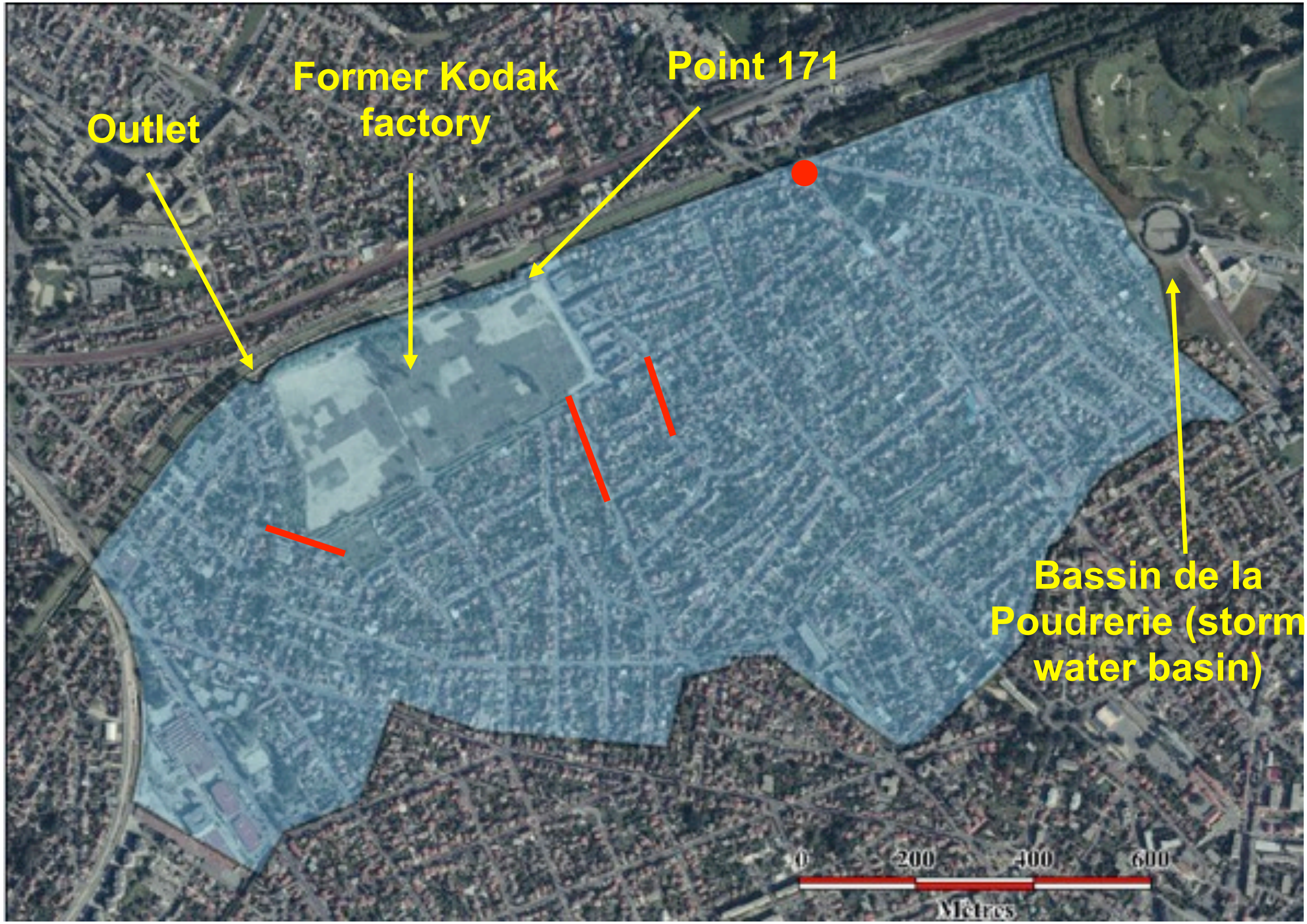
Morée-Sausset catchment

- 3 400 ha predominantly urban area
- Rather flat
- Average coefficient of imperviousness ~50% (rapid increase over the last decades
- Rivers channelled and culverted





Kodak catchment



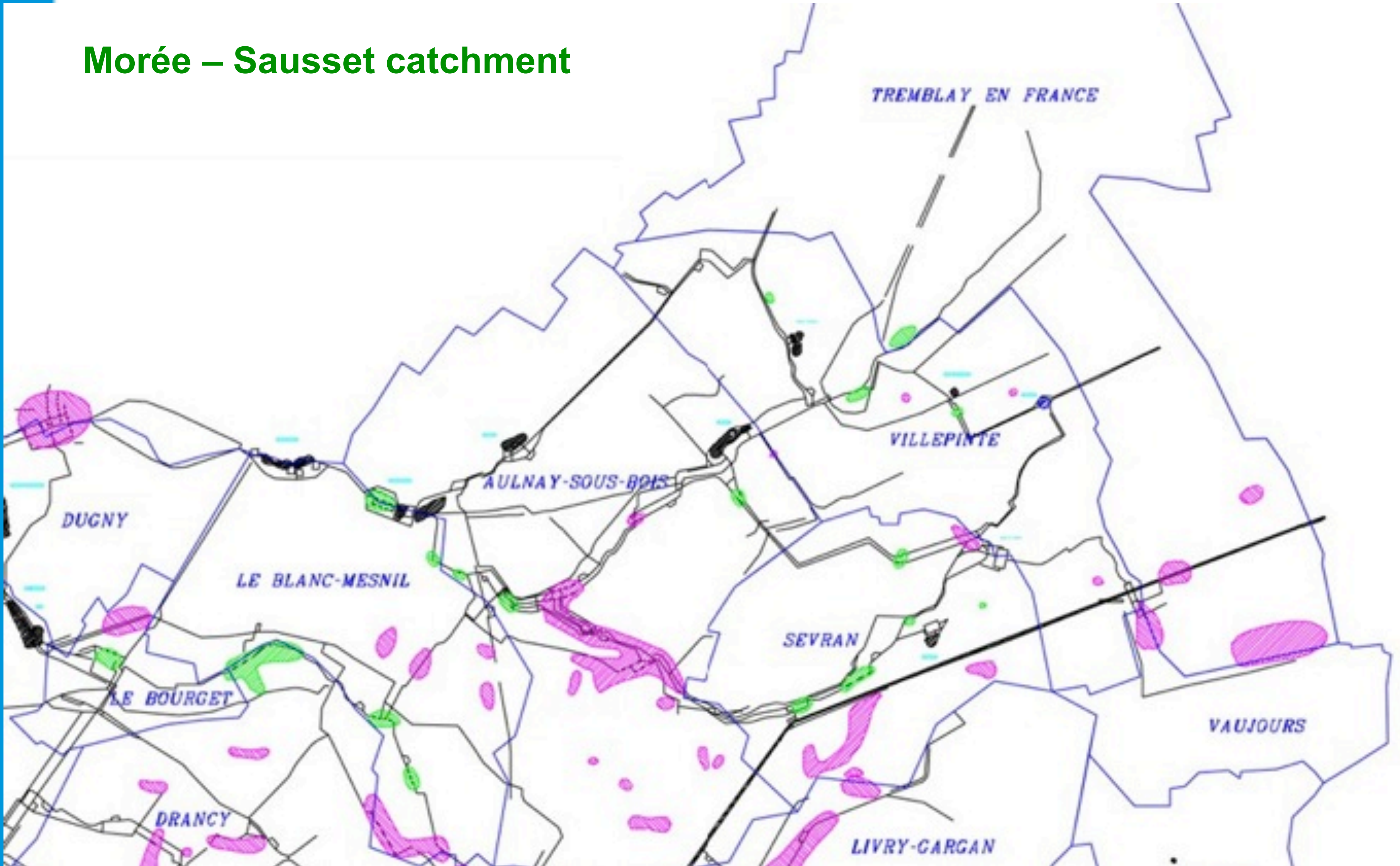
- 1.44 km^2
- Project to build a storm water storage basin

More details on the Fact Sheets: http://www.raingain.eu/en/paris

Pluvial flooding and weak points

Areas that have suffered regular pluvial flooding

Morée – Sausset catchment



Pluvial flooding and weak points

Example of flooded street in flat area

Livry-Gargan - rue Danton 23-08-2007

The water coming from this area is routed to the “Bassin de Poudrerie”.

Current solutions

Optimal use of storm water storm water storage basins.

- 18 such basins over the Morée-Sausset catchment (see below) of total size 577 000m^3. Some of them are underground and other open air.

- The real time control relies on the implementation of one out of 27 pre-defined scenarios. A scenario is selected according to the observed water level at strategic point in the network and rainfall radar estimates and nowcasts (mainly expected intensity and direction of next storm). Hydrological models are not currently used in real time.

Gérard Philippe

Bassin de la Poudrerie

Event of 27 June 2001

Monitoring

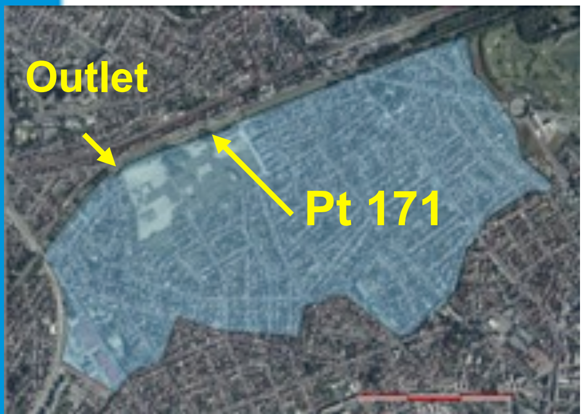
Sewer flow monitoring

Morée-Sausset catchment

At least one water level and velocity sensor before each storage basin

Kodak catchment

Level and velocity sensor measurement at Pt 171 (it needs to be re-installed)



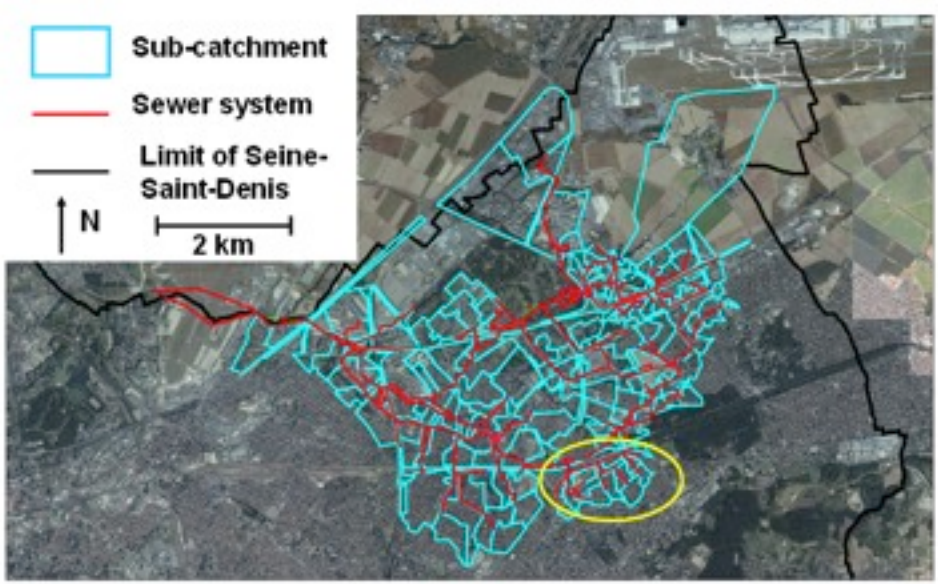
Pt 171 is located in this pipe

Current activities

Model implementation

Multi-Hydro

Semi-distributed 1D model



- 198 sub-catchments (avg 17 ha)
- 69 km of links (avg slope 0.009 m/m)

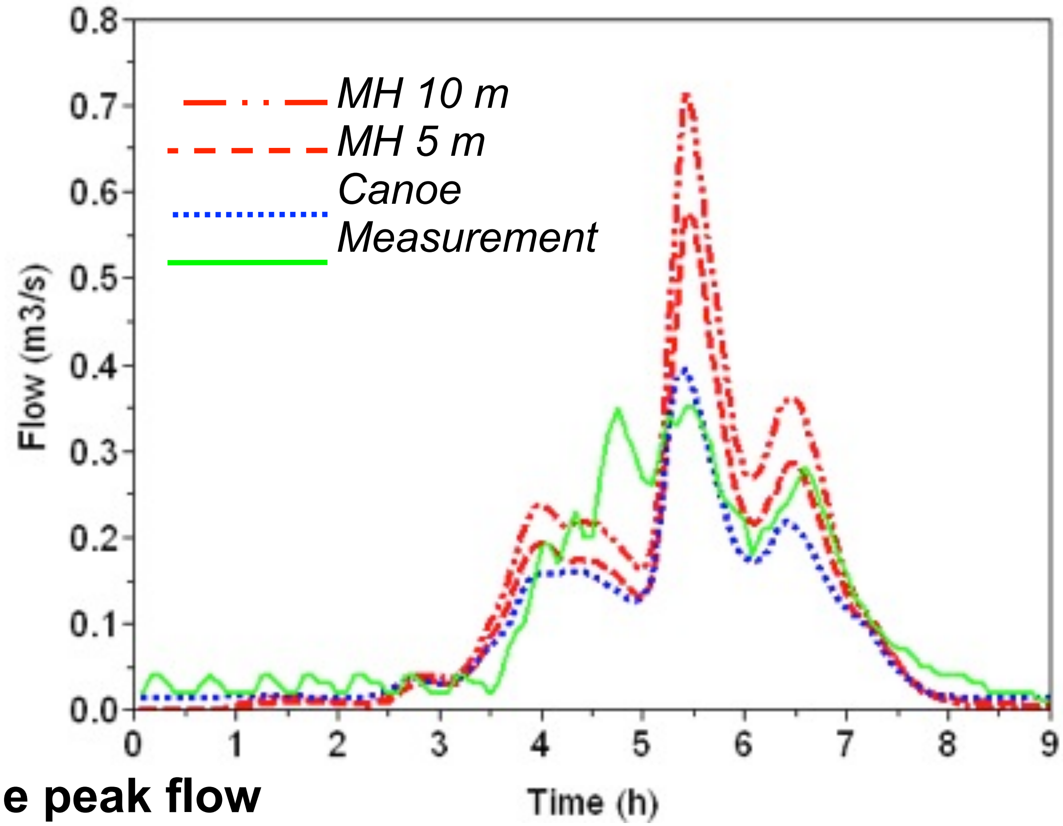
Current activities

Comparison of the simulated flow with raw radar data

9 February 2009

For the measurement point of Kodak :

Nash-Sutcliffe
- *MH 10 m : 0.40*
- *MH 5m : 0.68*
- *Canoe : 0.78*



- Rather similar patterns

- Significant differences in the peak flow

- Data quality ?

Current activities

Uncertainty associated with small scale rainfall variability

Methodology

(i) Generation of an ensemble of realistic downscaled rainfall fields (virtual X-band) :
- 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 :

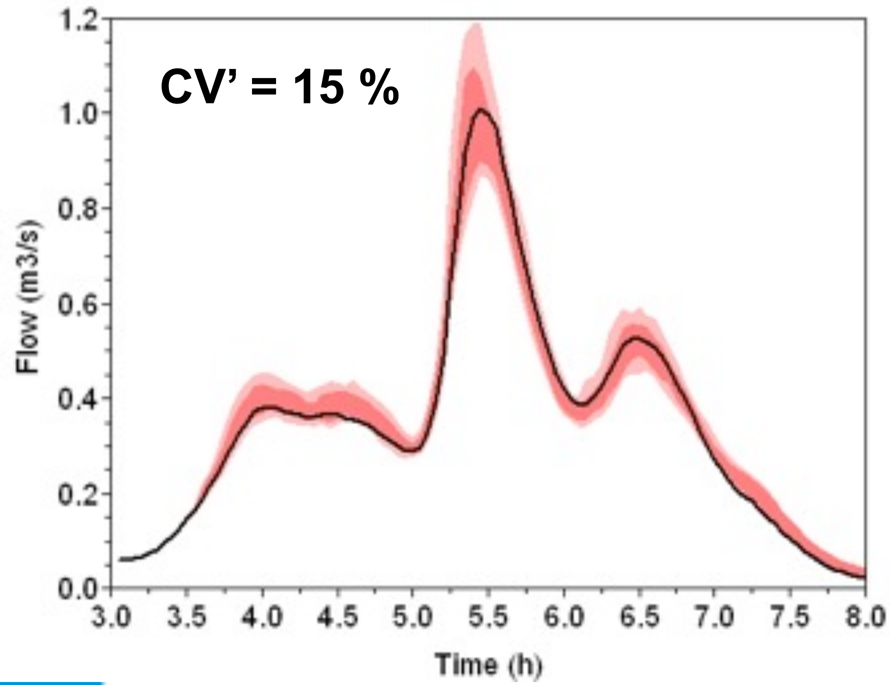
Variability among the 100 samples ⟷ Uncertainty due to the unknown high resolution rainfall variability

Current activities

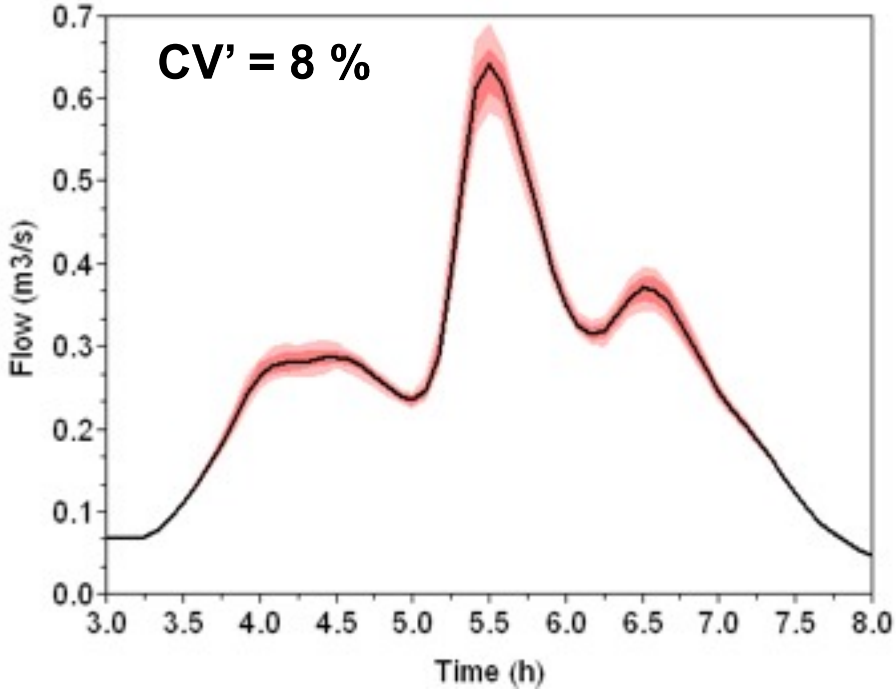
Uncertainty associated with small scale rainfall variability

Simulated flow for the outlet of the Kodak Catchment

Multi-Hydro 10m

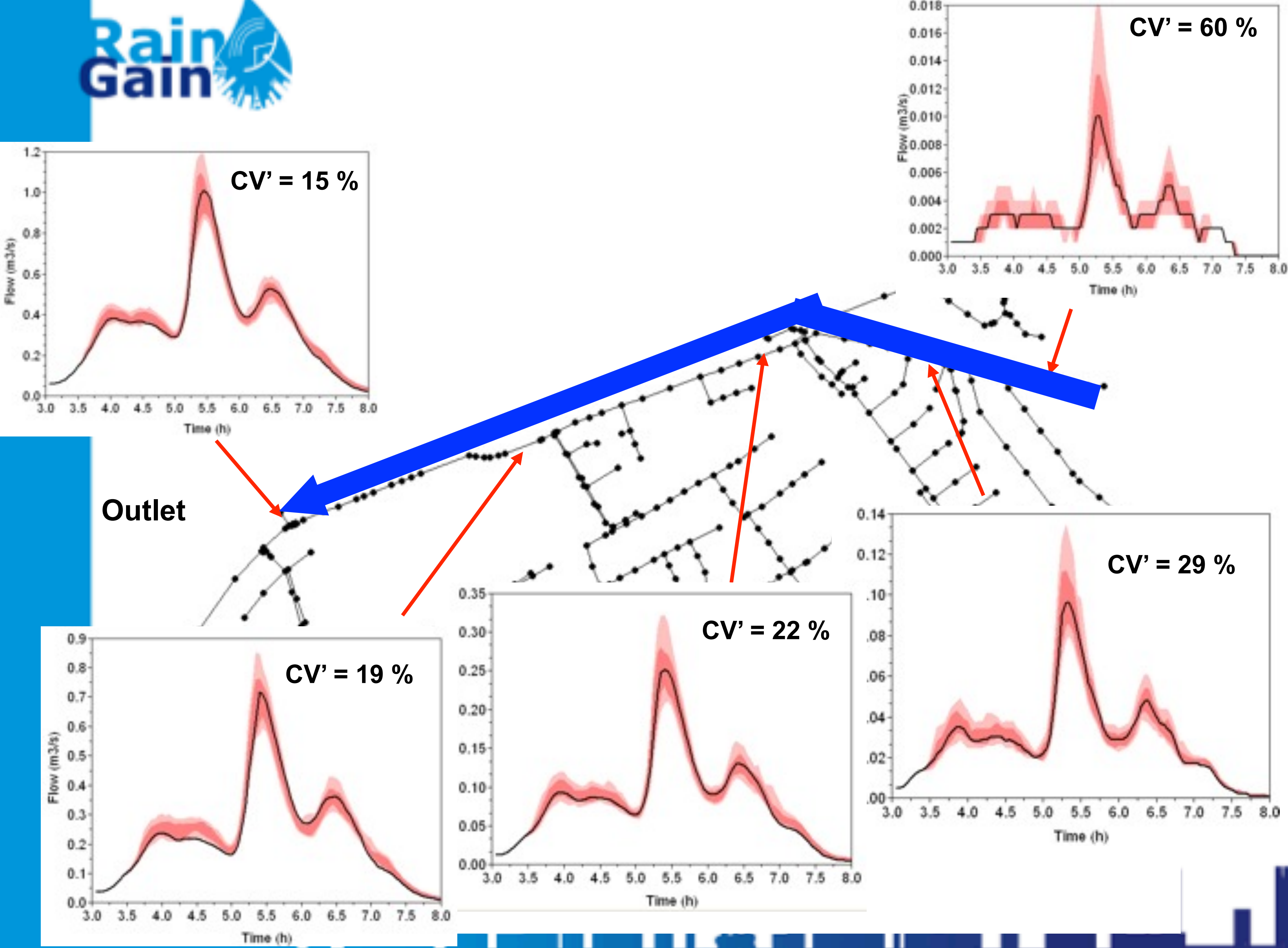


Semi-distributed 1D model



Note : in the downscaling process α=1.8 and C_1=0.1 to take into account the improvements of the model on zero rainfall

MH unveils much more uncertainty


CV' = 15 %
CV' = 60 %
Outlet
CV' = 19 %
CV' = 22 %
CV' = 29 %
Flow (m3/s)
Time (h)

Jouy-en-Josas
Outline

SIAVB

Location and environmental settings

Pluvial flooding and weak points

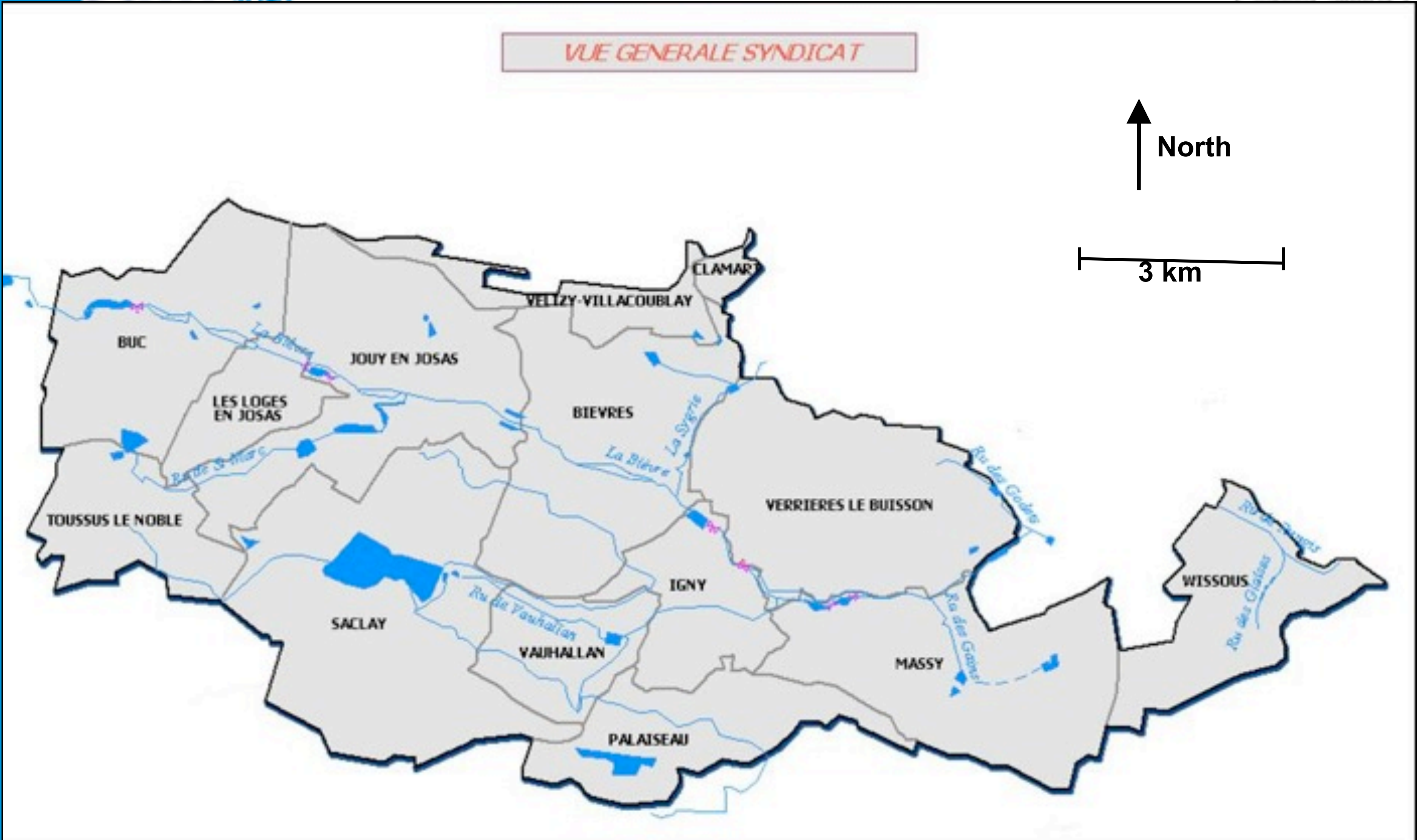
Current solutions

Monitoring

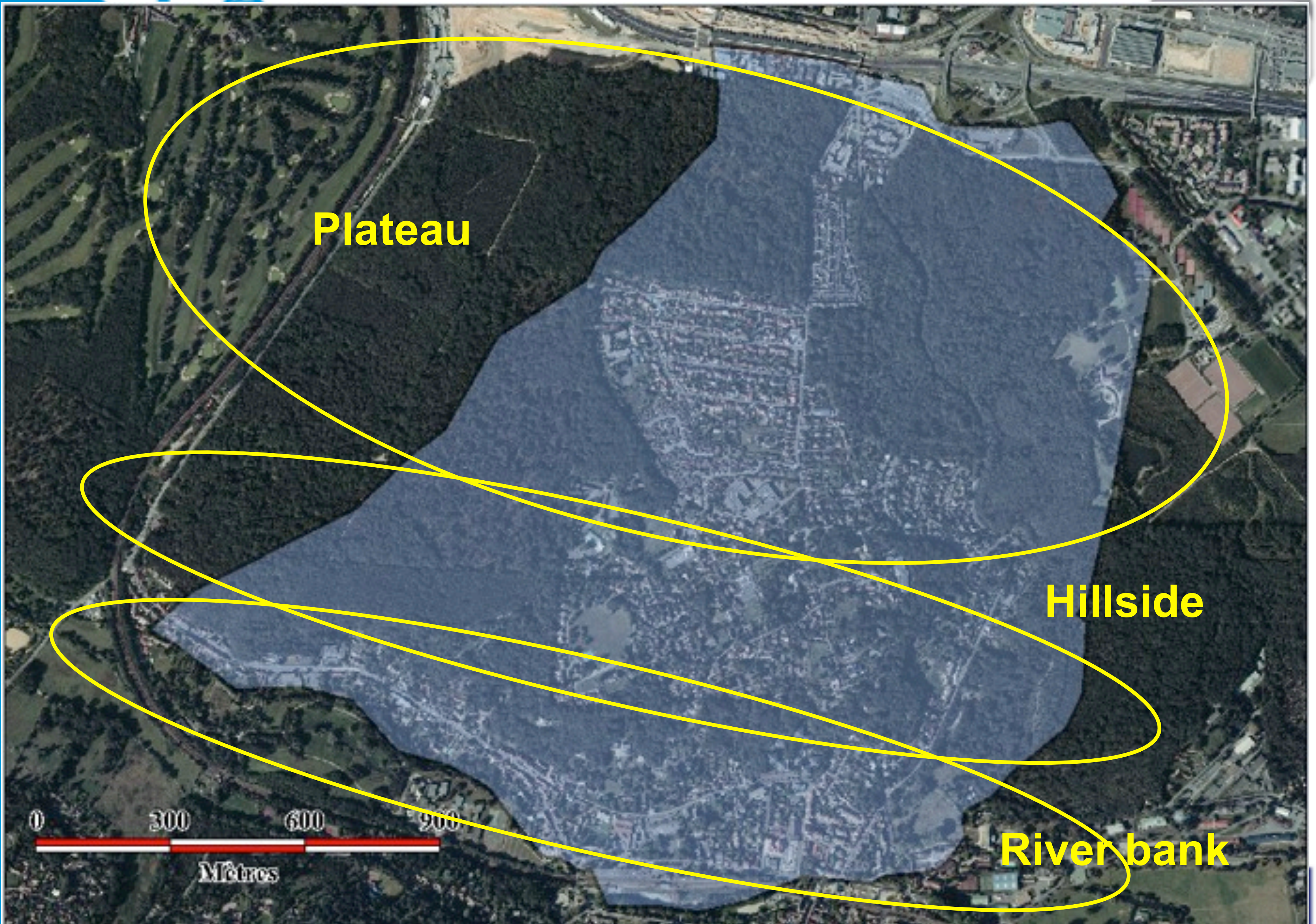
Current activities

Implementation and initial testing with Multi-Hydro

Jouy-en-Josas catchment

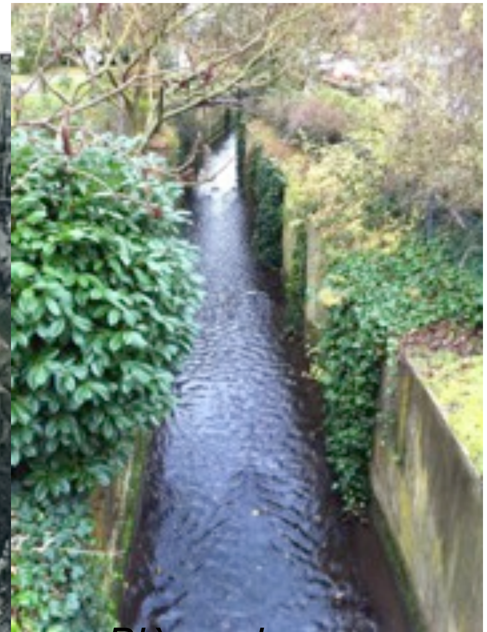


Catchment managed by the SIAVB


Plateau
Hillside
River bank
0
300
600
900
Mètres

Jouy-en-Josas catchment

Sharp slope



Bièvre river

RER C Station

Kinder garden

Hillside from the valley

- 2.5 km^2 area / Great slopes (~100m of elevation difference) / various land use

Pluvial flooding and weak points

Hydrological processes at stake

During a heavy rainfall event:

The water fallen on the plateau rapidly runoffs through the hillside to reach the flooded Bièvre river

(response time ~10-20 min)

Bièvre River undersized → flooding

21st to the 22nd of July 1982

- 96.2 mm during one hour and 115.5 during the 7 hours of this event (nearby rain gauge).
- a 20 cm deep flow of rapid water along the street Jean Bauvinon.

Current solutions

Optimal use of storm water storm water storage basins and river bed

- 15 such basins over the catchment managed by the SIAVB with a total storage capacity of 642 000 m^3.
- Real time control relying on observed water level at strategic point in the network, rainfall radar estimates and nowcasts (mainly expected intensity and direction of next storm), and a hydraulic representation of the river behaviour.

Bassin des Bas-Près (upstream Jouy-en-Josas)

Use of the river bed

Monitoring

Sewer flow monitoring

Height (and flow) measurement

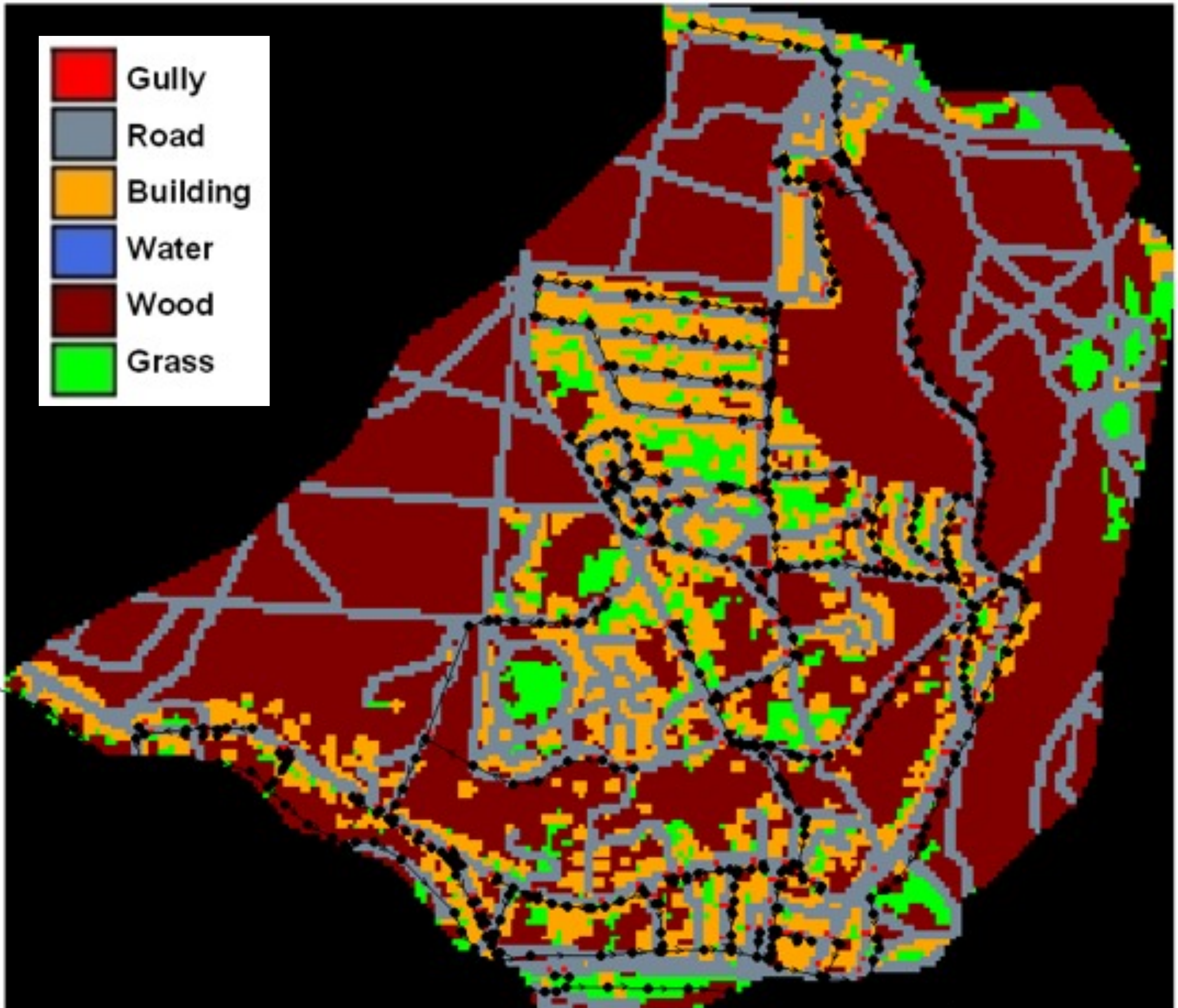
(Outlet Bas-Près basin)

Height measurement

(Pont de pierre)

Current activities

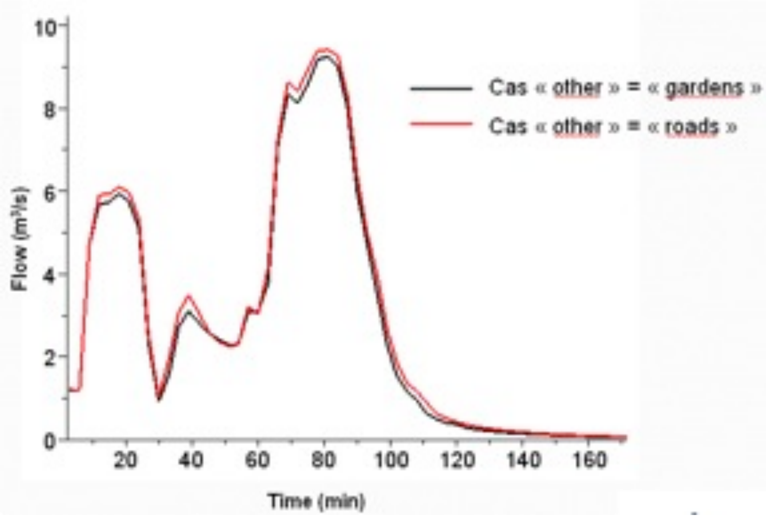
Multi-Hydro implementation



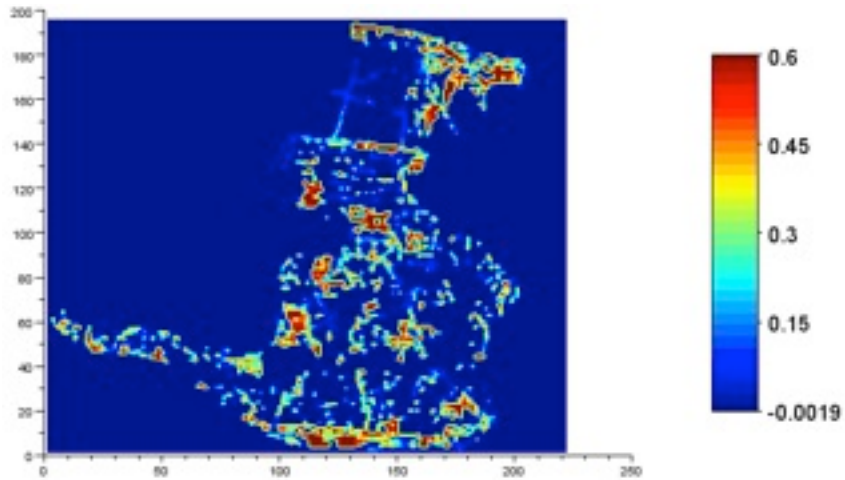
Current activities

Multi-Hydro implementation

Initial Implementation of MH on the catchment



Flow at the outlet (various land use for missing data)



Max water depth

Simulation output for a synthetic rainfall event

Validation still needs to done :

- aim is to be ready when X-band radar data is available

- recent meeting (3 April 2013 with SIAVB to define more precisely the catchment)

Future activities

Before the X-band radar rainfall data

- Validation of the models with more severe events (already selected 14/07/2010, 15/08/2010, 15/12/2011)

- Sensitivity to rainfall resolution

- Analysis of the spatial outputs

Once X-band radar rainfall data available

- Implementation of X-band rainfall data

- Hydrological validation of rainfall and models

- Reflexion on how can X-band data improve real time management of sewer system (CG93, CG94)

- Collaboration with Véolia

Sucy-en-Brie Outline

Location and environmental settings

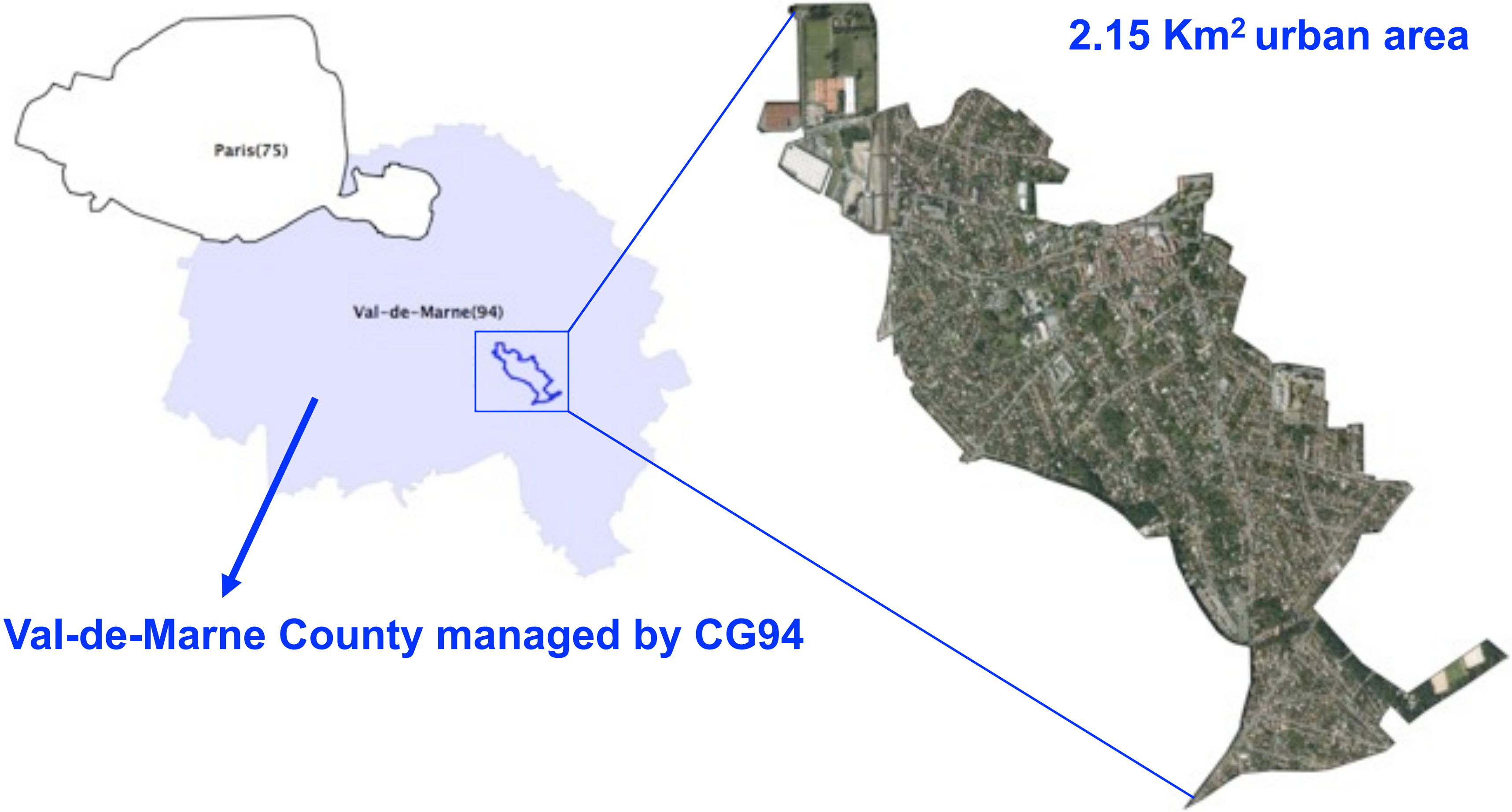
Pluvial flooding and weak points

Current solutions

Current and planned activities
- **Analysis of the current management procedure**
- **Implementation and initial testing of hydrological models**
- **Optimization of the storm water management basin**

Val-de-Marne County hired a PhD student (A. Ichiba). Scientific supervision by ENPC.

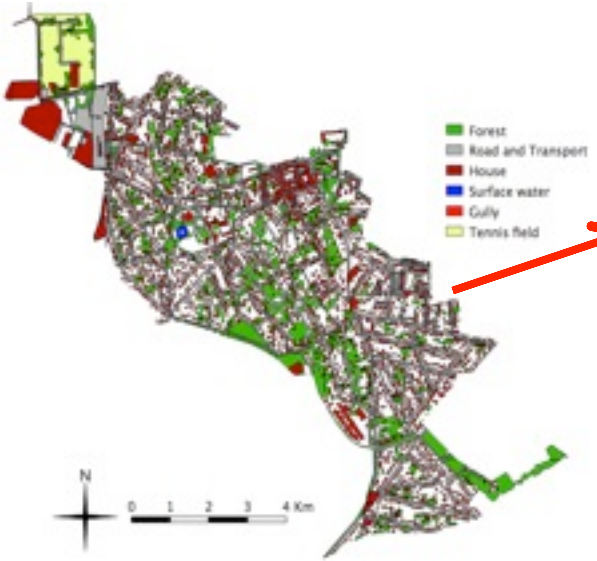
Sucy-en-Brie catchment



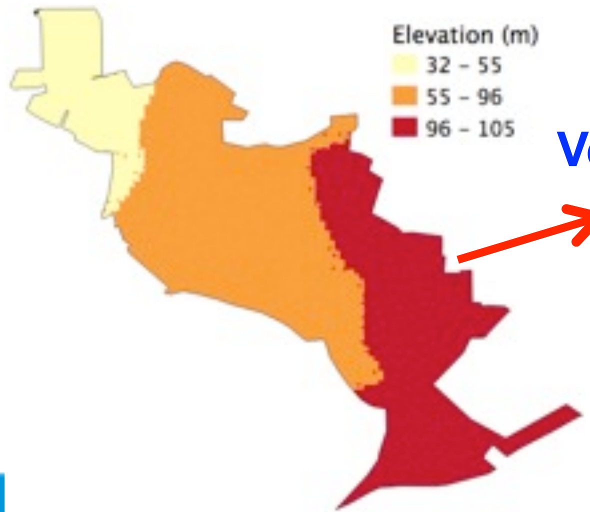
2.15 Km^2 urban area

Val-de-Marne County managed by CG94

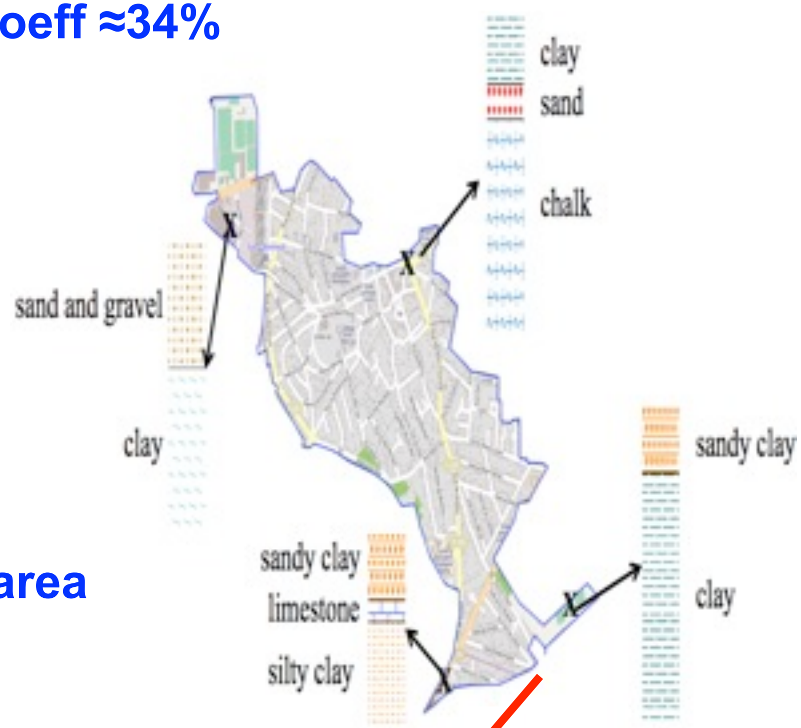
Location and Environment



Impervious coeff ≈34%



Very step area



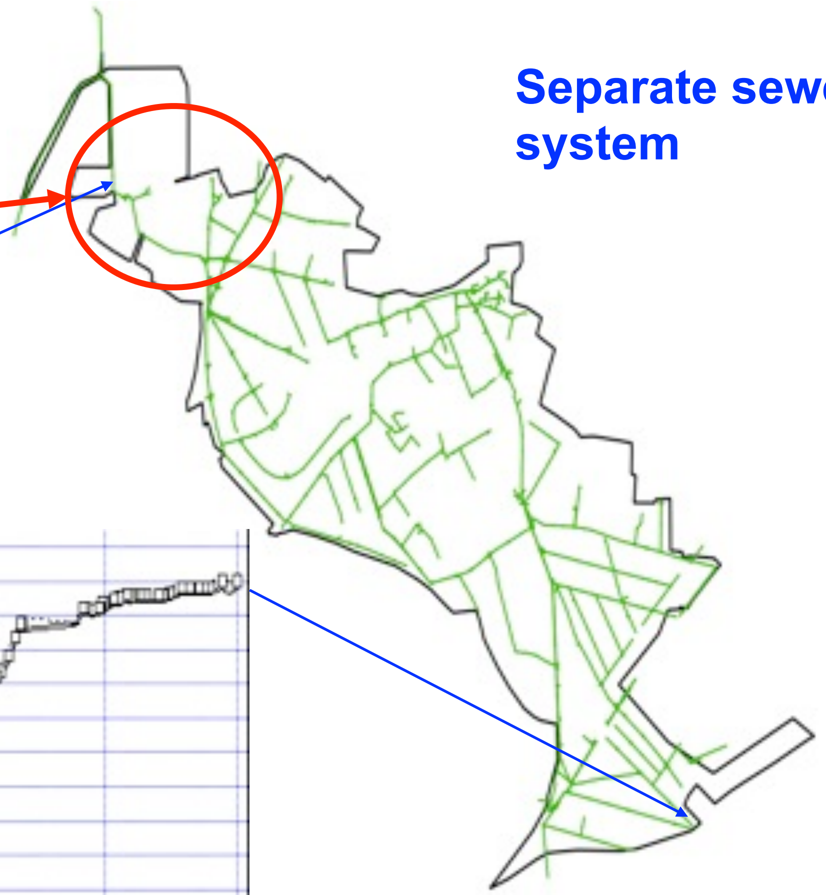
Infiltration limited by the soil structure

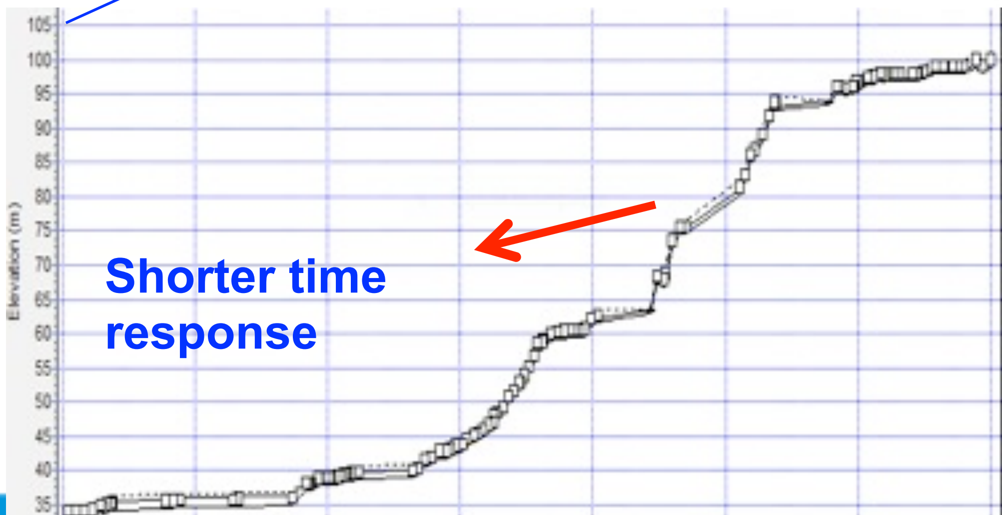
Pluvial flooding

x **Outlet**

Separate sewer system

Serious flooding issues in this area

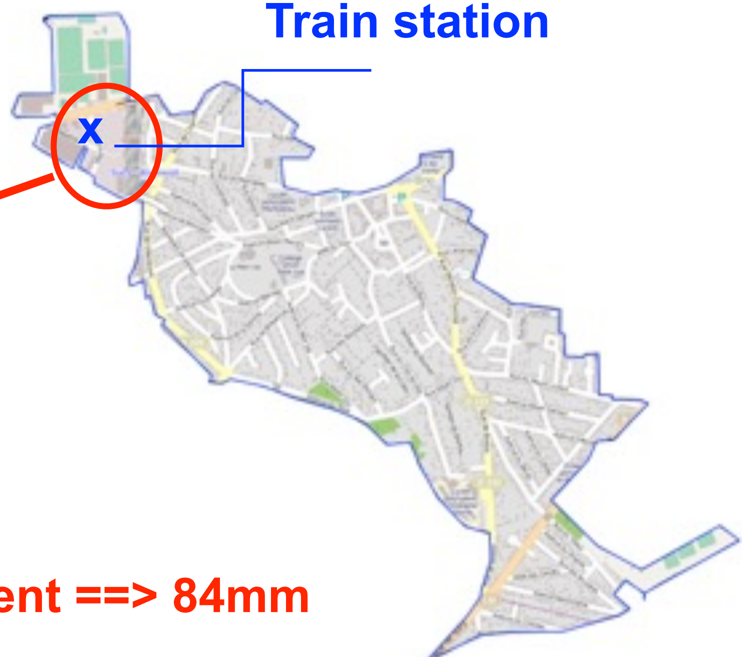




Shorter time response

Pluvial flooding

Train station

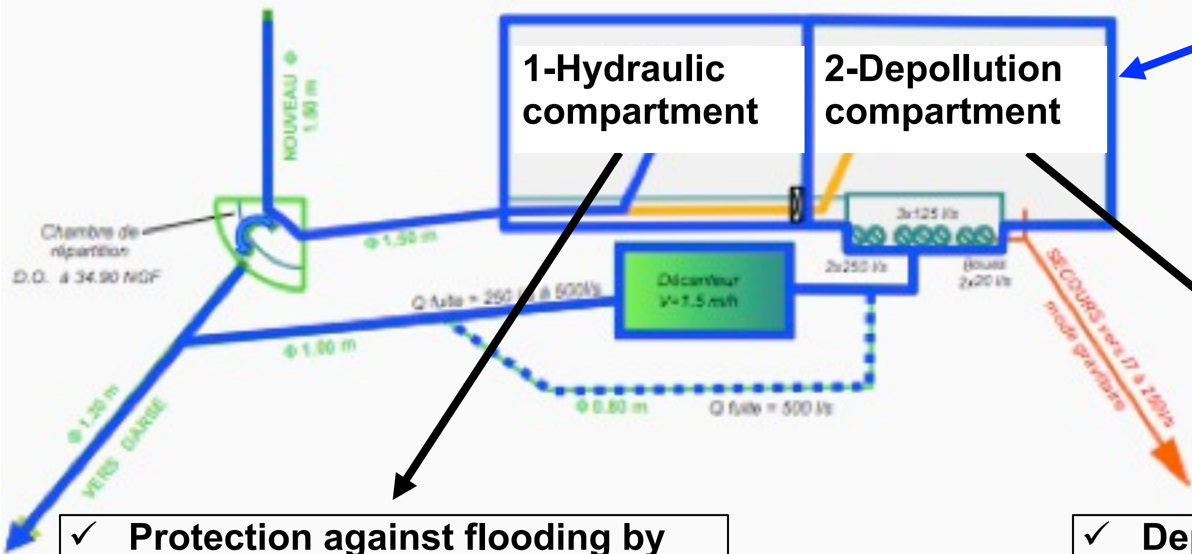


Houses and streets flooded
Train station blocked

07 July event ==> 84mm

Current solution

Building a retention basin (≈10000m3)



- ✓ Protection against flooding by storing water during the peak flow events
- ✓ Depollution of water before releasing it into the natural environment

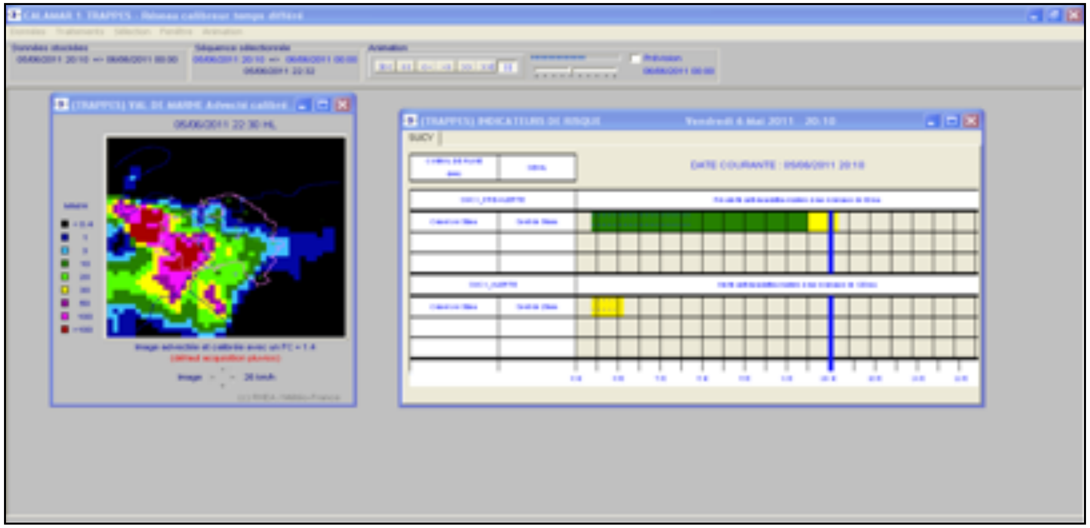
Having the basin empty in case of a flooding event

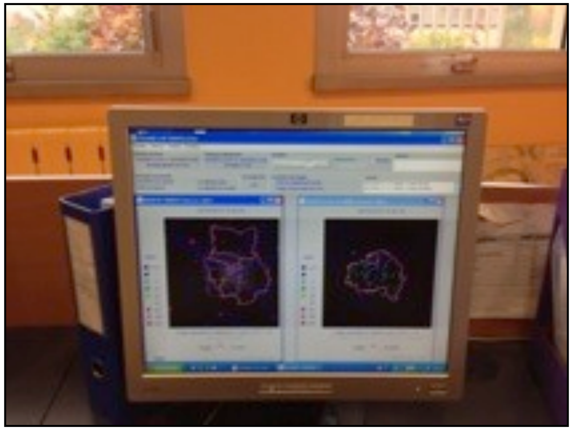
Increasing the volume of water depolluted

MANAGEMENT STRATEGY

Current solution

CALMAR forecasting system to manage the retention basin





- Uses C-band radar data (Trappes Météo-France)
- Generates warning indicators(based on forecasting)
- Need real time calibration with rain gauges
- Important risk of false warning

Current and future activities

1- Analyzing the feedback of CALAMAR system

Transmission of rain gauge data becomes impossible during some severe events
→ No calibrating with rain gauge data
≈ 50 early warnings per year and no actual warning (warning indicators are based on forecasting)
For the same events and using radar data (measurements)==>No early warnings
→ CALAMAR forecasting system overestimates rainfall

2- Implementation of hydrological models

CANOE model

MH model (10m resolution)

MH model (5m resolution)

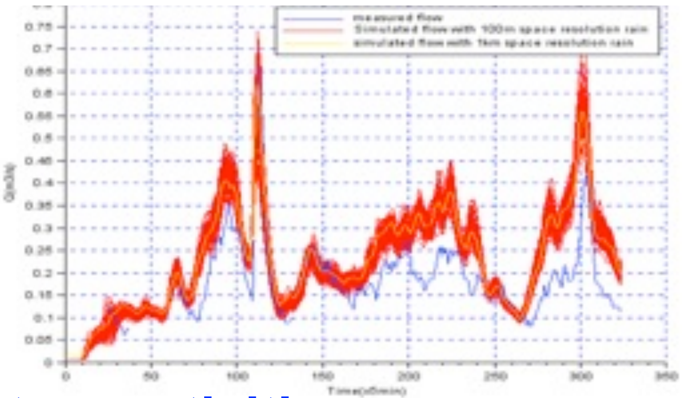
Current and future activities

3- Comparison of hydrological model

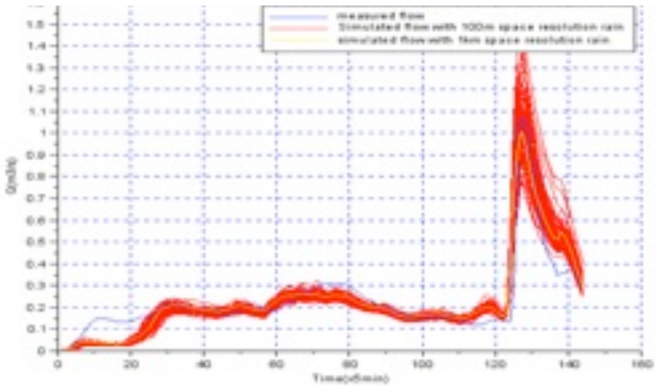
Testing models for three events (14/07/2010, 15/08/2010 and 15/12/2011) with:
a.Rain gauge data
b.Radar data at original resolution (1 km x 1 km x 5 min)
c.Downscaled radar data at high resolution (100 m x 100 m x1,25 min)

Some first with the CANOE

15/08/2010 event



15/12/2011 event



4- Future activities

Dvp of tools to use high resolution X-Band rainfall data to improve basin management.