Comparison of various X and C-band radar products over the Paris area

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Outline :

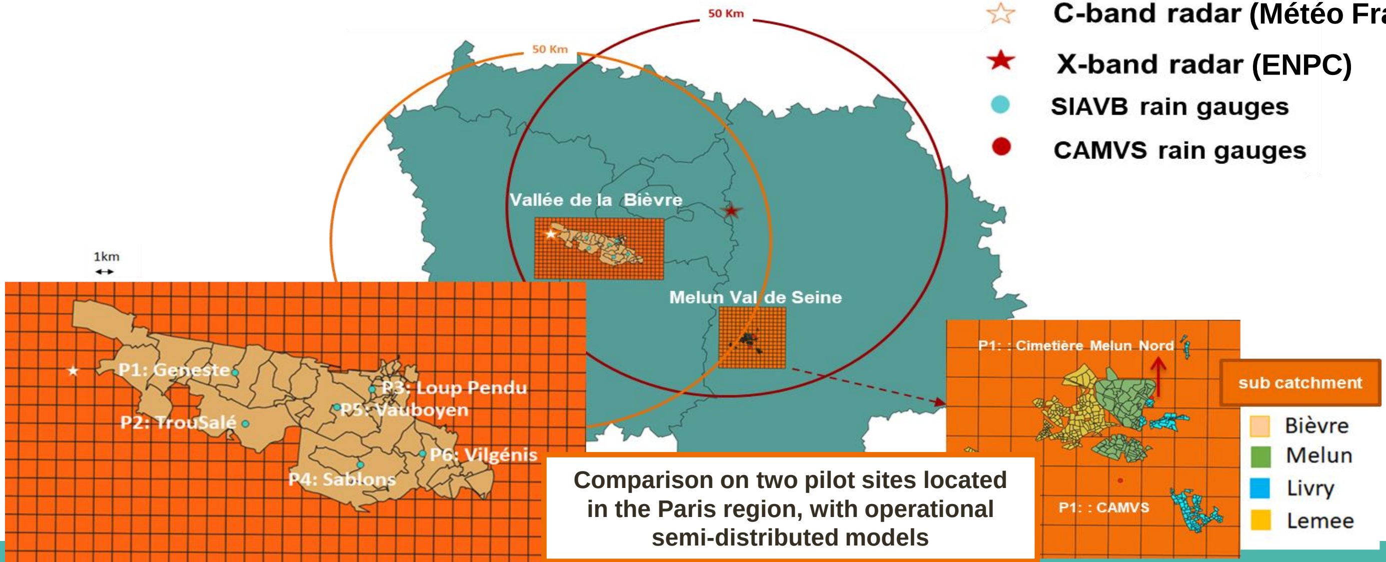
Introduction

Preventing urban flooding and maximizing water depollution → High resolution precipitation data is required → Meteorological radars are the only device providing space-time data

The problematic of this work then revolves around the evaluation of the performance of meteorological radars

Objective

Hydrological comparison various rainfall products from two radars in the Paris region



Comparison on two pilot sites located in the Paris region, with operational semi-distributed models

Introduction

This hydrological comparison is carried out on seven rainfall events

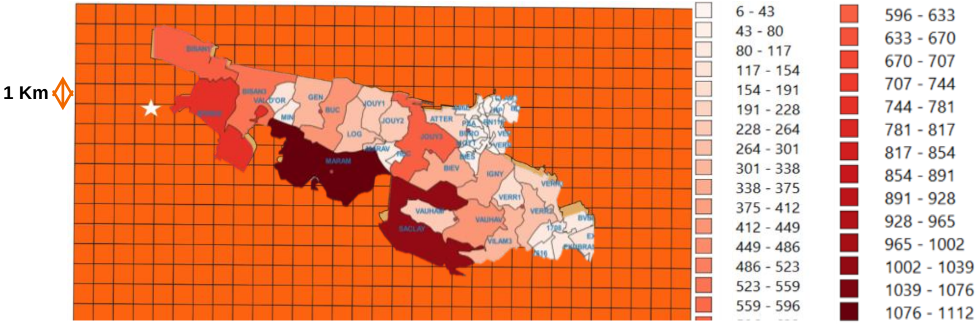
Event	Start	End	Pilot sites
1	04/07/2018 00H00	05/07/2018 22H55	Melun Val de Seine
2	09/08/2018 00H00	09/08/2018 22H55	Melun Val de Seine
3	23/09/2018 00H00	23/09/2018 22H55	Melun Val de Seine
4	22/05/2018 12H45	22/05/2018 22H55	Vallée de la Bièvre
5	11/06/2018 04H40	12/06/2018 12H40	Vallée de la Bièvre
6	28/08/2018 22H50	29/08/2018 16H55	Vallée de la Bièvre
7	14/01/2018 22H10	22/01/2018 23H55	Melun Val de Seine

We will present the results of event 5

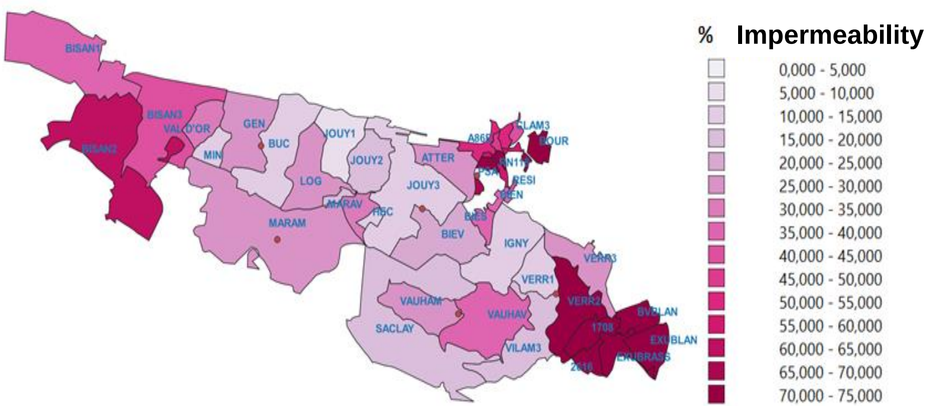
Data presentation:

A. Catchment basin:

Vallée de la Bièvre:

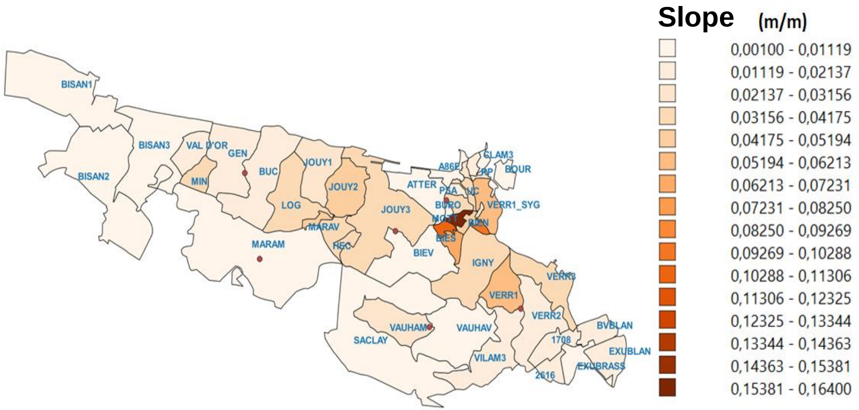


The areas in ha of the sub-catchments of the Bievre valley



Percentage of impervious areas of the sub-catchments in the Bièvre Valley.

The imperviousness is quite heterogeneous with highly urbanized areas (imperviousness> 40%) downstream (East of the basin) **hence the importance of the regulation provided by the gates to prevent flooding.**



The slopes in (m / m) of the sub-catchments of the Bièvre valley.

The distribution of average slopes is more homogeneous, with a concentration of steep slopes (between 5 and 15%) in the northeast of the basin, where the smallest sub-basins are found.

B. Radar Products :

X band radar (250 m & 3 min 25 seconds)

Single polarization

Z (mm6.m3)= aR^{b}

X-SRI M

a= 150 b= 1.3

X-DPSRI M

(R< 6mm/h)

Marshall Palmer

a= 200 b= 1.6

X-SRI

X-DPSRI

(R< 6mm/h)

Non-stationary variation of parameters a and b

X-DPSRI MP

(R< 6mm/h)

X-SRI MP

Depending on the precipitation intensity, the radar calculator switches between these two equations

Double polarization

R= c KDP^{d} (mm/h)

(R> 6mm/h)

X-DPSRI

X-DPSRI M

X-DPSRI MP

C band radar (1 Km & 5 min)

- Single polarization
  - **C-MG**
    - **Marshall Palmer**
      a= 200 b= 1.6
  - **C-Calamar**
    - **Stratiform rain** → Marshall Palmer
    - **Convective rainfall**
      a= 486 b= 1.37
- Double polarization
  - **C-Zphi**
    use of the whole information along a beam

Data processing :

This figure is the result of this weighting, it shows the cumulative precipitation per pixel and per SBV of a C-band radar product (Calamar) for event 6

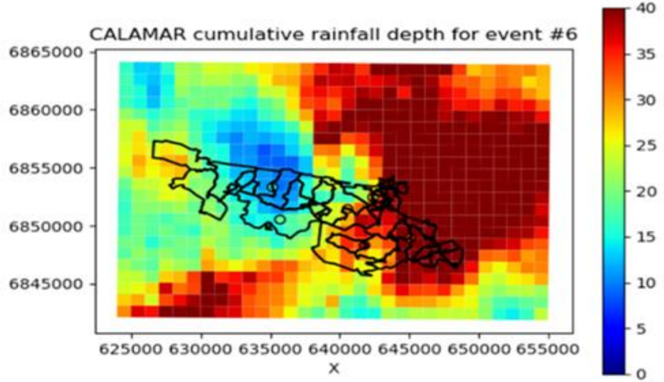
A. Preparation of rain data for each sub-catchment :

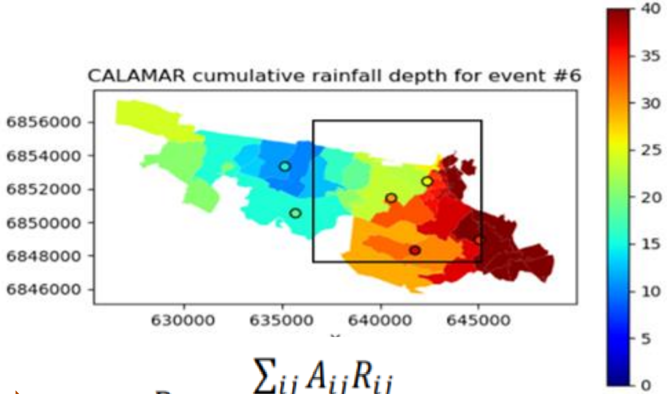
Precipitation data was provided per 250 m pixels for X-band radar and per 1 km pixels for C-band radar

The hydrological model (Info Works ICM) requires the introduction of the precipitation as time series for each sub-catchment

It is necessary to project the radar rain field on the sub-catchments

By calculating the weighted average of each sub-catchment (R_{BV}) from the precipitation of each pixel (R_{ij}) and the intersection Area (A_{ij}) which are obtained from QGIS





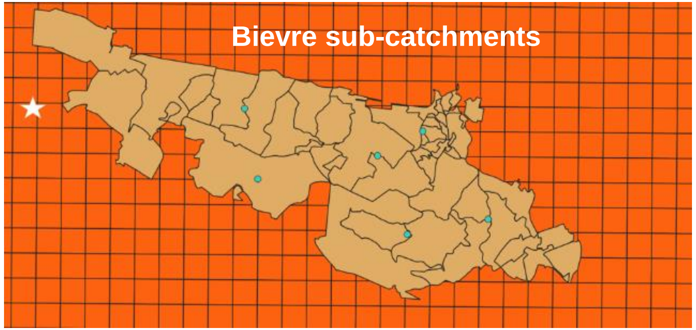
$$R_{BV} = \frac{\sum_{ij} A_{ij} R_{ij}}{\sum_{ij} A_{ij}}$$

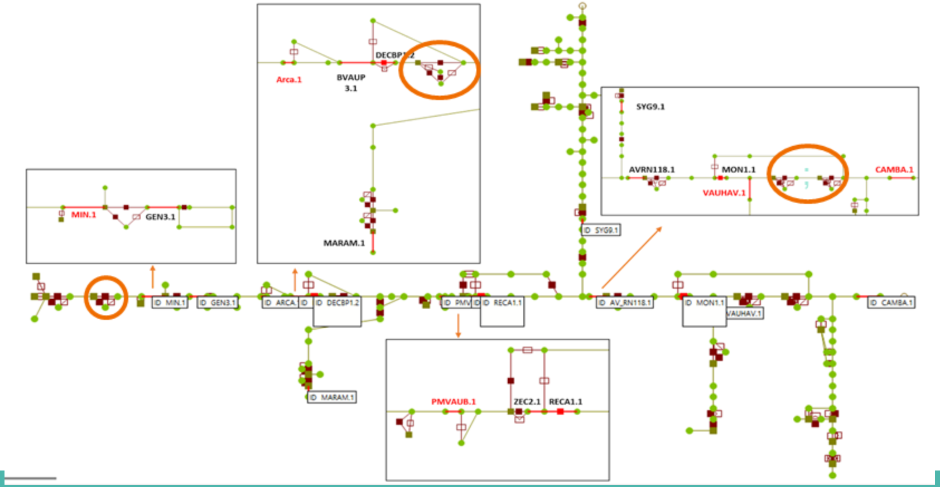
B. Simulation of flows :

1. Importing the model.
2. Assignment of rain profiles to the sub-watershed.
3. Preparation of a .rtc file for the Bièvre valley.
4. Import of precipitation.
5. Launch of the simulation.
6. Recovery of simulated flows.

The Bièvre catchment network is regulated and contains numerous gates whose height varies over time. To introduce these variations into the model, a computer script was written. It allows to automatically generate, for each event, a .rtc file (real time control) to import into Infoworks ICM

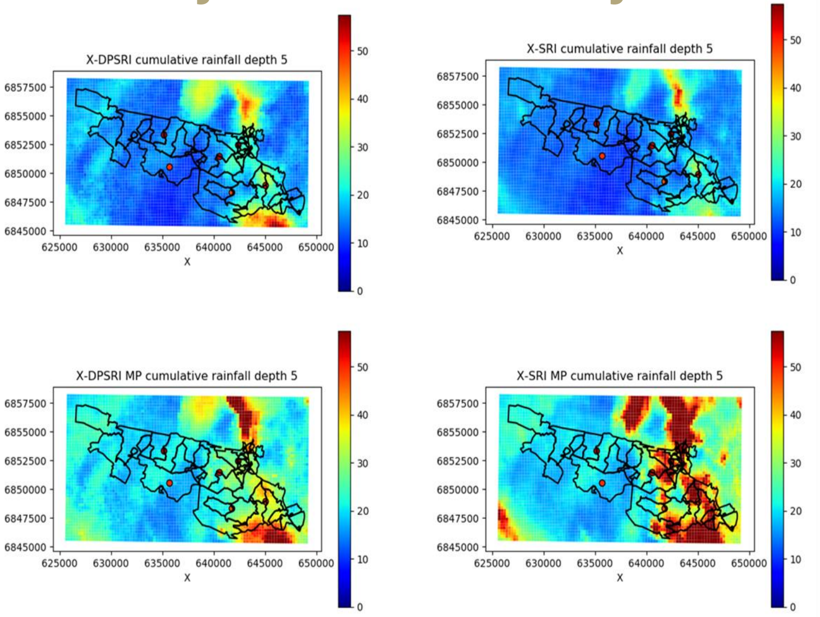
Schematic representation in Info Works ICM of the Bièvre catchment
The four zooms correspond to the pipes studied in more detail (red).



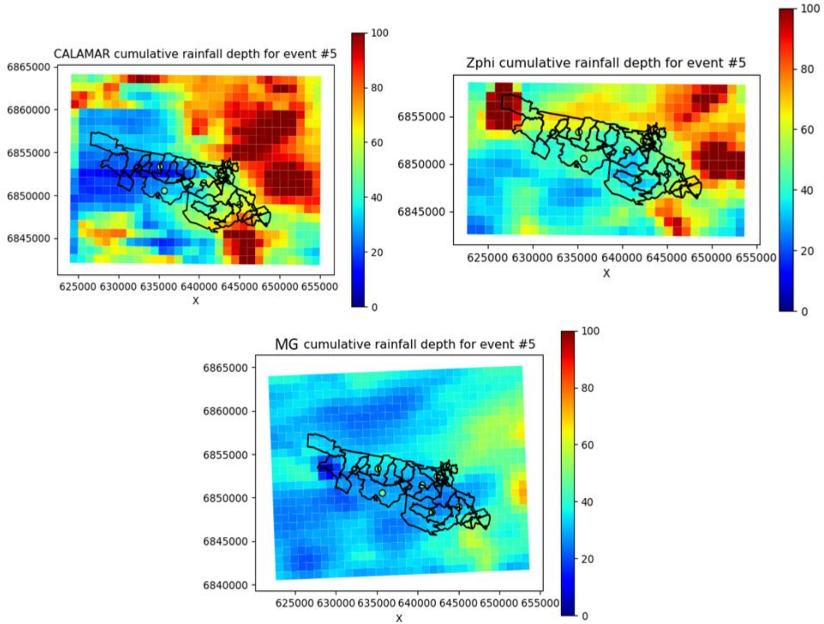


Results:

EV5 : 11 June at 04h40 to 12 June 2018 at 12h40



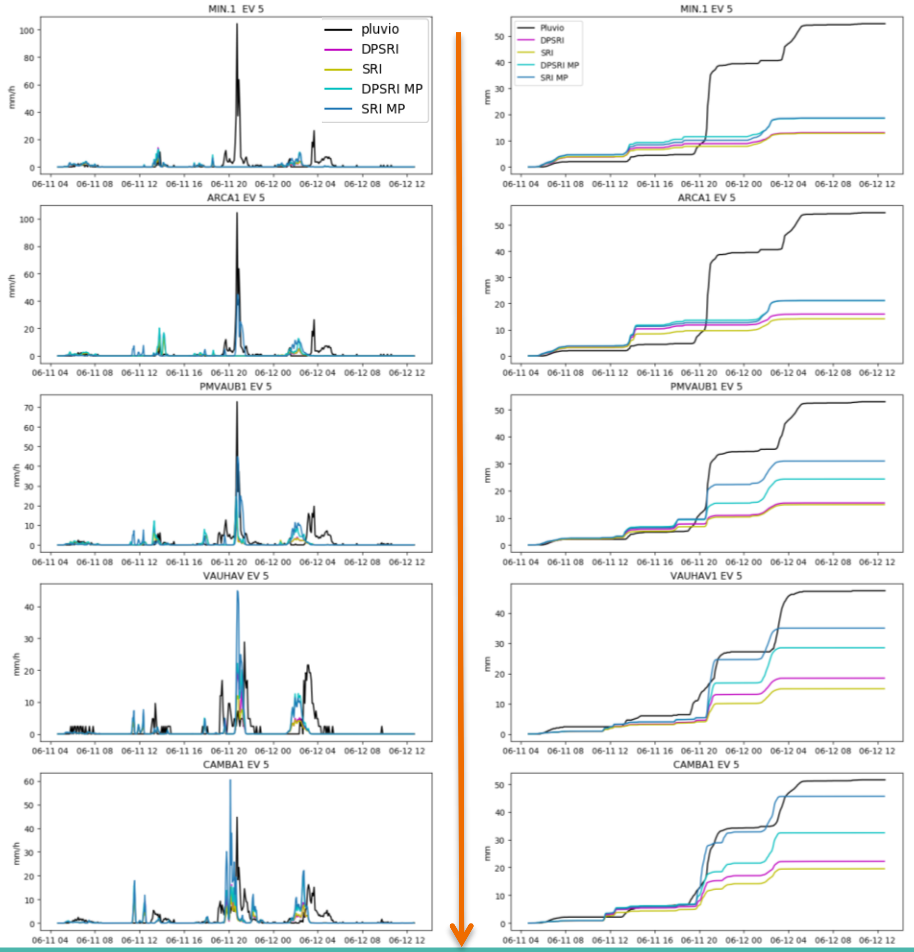
Cumulative precipitation maps per pixel of 250 m for X-band radar products for EV 5 in the Bièvre Valley

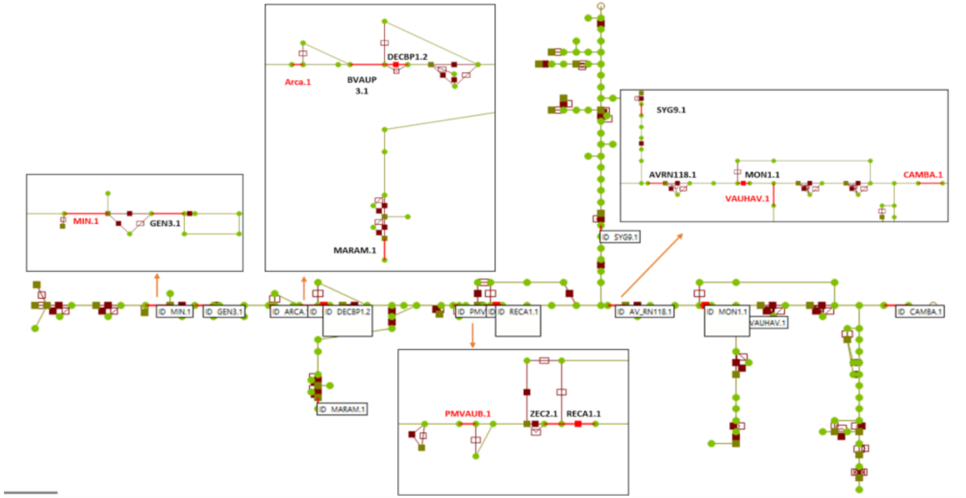


Cumulative precipitation maps per pixel of 1 Km for C-band radar products for EV 5 in the Bièvre Valley

We notice that there is a disparity in the estimated precipitation between the different radar products and this is due to the use of the different mathematical relations that we saw previously

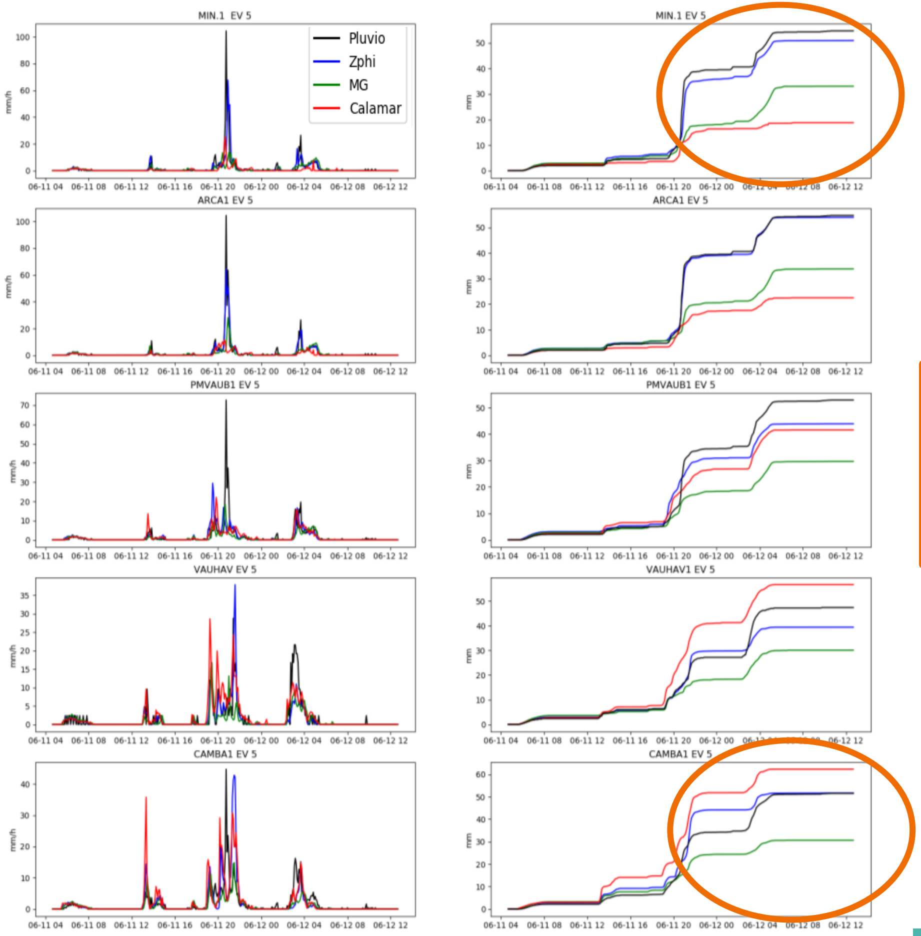
Temporal evolution of rates and cumulative rain (X-band radar) for the 5 studied conduits of the Bièvre catchment





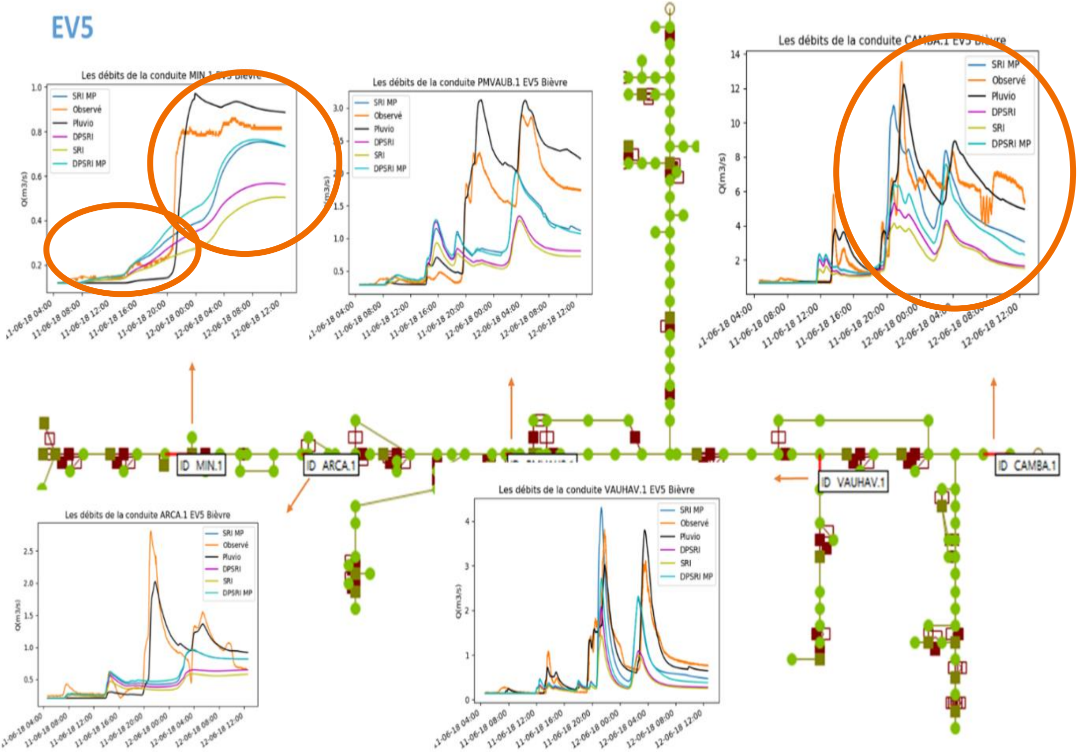
X-band radar shows a slight temporal shift with the rain gauges (Black) with a difference in intensity which decreases from upstream to downstream

Temporal evolution of rates and cumulative rain (C-band radar) for the 5 studied conduits of the Bièvre catchment



- Strong disparities between the C band products (cumulative depth and temporal evolution)
- Depending on the peak, it is not always the same products that perfoms best

Comparison of the observed and simulated flows (X-band radar) for the 5 studied conduits

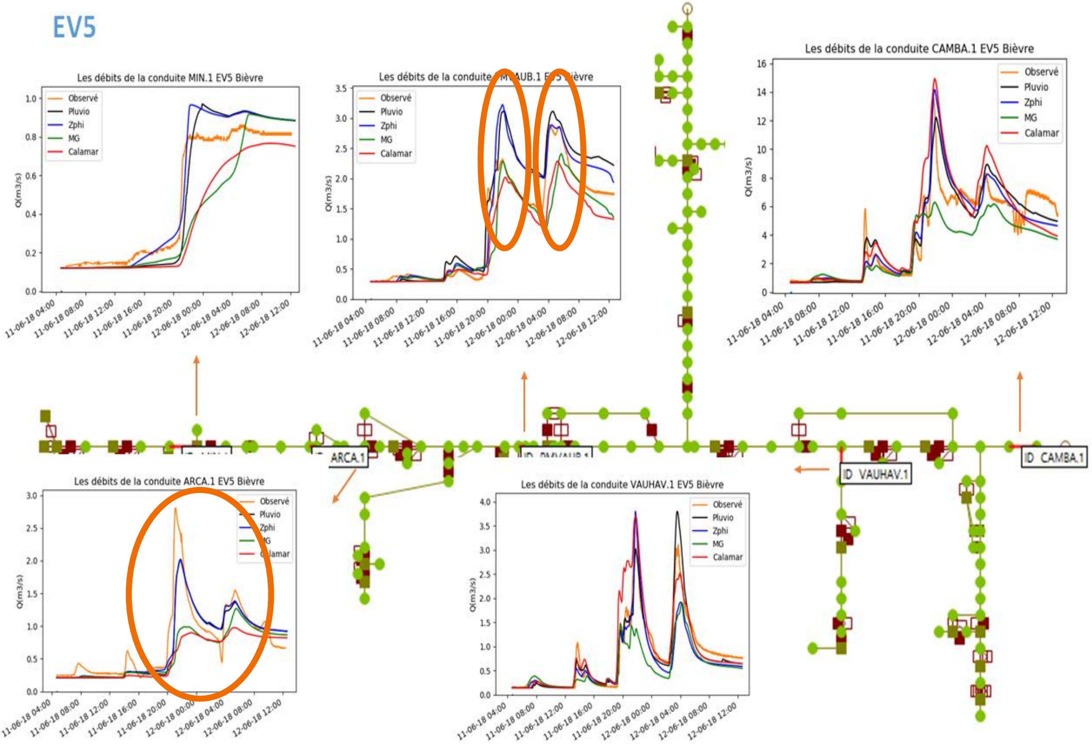


NSE EV 5	MIN.1	ARCA.1	PMVAUB.1	VAUHAV.1	CAMBA.1
Pluvio	0.81	0.67	0.76	0.88	0.84
DPSRI	-0.08	-0.67	-0.33	-0.17	0.05
SRI	-0.56	-0.84	-0.43	-0.35	-0.11
SRI MP	0.41	-0.40	0.25	0.23	0.62
DPSRI MP	0.58	-0.33	0.20	0.16	0.48

Corrélation EV5	MIN.1	ARCA.1	PMVAUB.1	VAUHAV.1	CAMBA.1
Pluvio	0.96	0.83	0.97	0.95	0.93
DPSRI	0.85	0.00	0.51	0.68	0.79
SRI	0.80	0.01	0.61	0.70	0.82
SRI MP	0.81	0.07	0.70	0.67	0.82
DPSRI MP	0.86	0.10	0.66	0.65	0.84

- **Confirmation of the increasing agreement from downstream to upstream**
- **X-MP products outperform X**

Comparison of the observed and simulated flows (C-band radar) for the 5 studied conduits



NSE EV 5	MIN.1	ARCA.1	PMVAUB.1	VAUHAV.1	CAMBA.1
MG	0.45	0.19	0.75	0.49	0.65
calamar	0.47	0.04	0.79	0.76	0.66
Zphi	0.88	0.69	0.79	0.79	0.82
Pluvio	0.81	0.67	0.76	0.88	0.84

Corrélation EV5	MIN.1	ARCA.1	PMVAUB.1	VAUHAV.1	CAMBA.1
MG	0.83	0.59	0.89	0.87	0.90
Calamar	0.88	0.57	0.95	0.91	0.89
Zphi	0.98	0.83	0.95	0.92	0.92
Pluvio	0.96	0.83	0.97	0.95	0.93

- **For this event, zphi and the rain gauges are closest to the observed flows**
- **Strong disparities between the flows of the C band products**

Analysis and conclusions :

- ❖ In most events there are no systematic trends between the radar products.
- ❖ Significant differences between the simulated flows with the products of the same radar are visible.
- ❖ C-band products are carefully calibrated with rain gauge observations while X-band radar products are not.
- ❖ Radar product responses are highly dependent on the type of hydrometeor, and advection between measurement height and ground should be accounted for.
- ❖ The strong regulation of the Bièvre catchments complicates the comparison of simulated flows.
- ❖ The model exhibited some difficulty to reproduce the observed base rates.

➔ The differences between the products of the same radar suggests that more work should be done to improve their determination by looking at the calibration of the radar.

➔ The intrinsic limits and biases of hydrological models underline the need to continue the methodological development of techniques for comparing precipitation.

Thank you for your attention