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Are we able to detect hydrological impacts of beaver dams at the catchment scale?

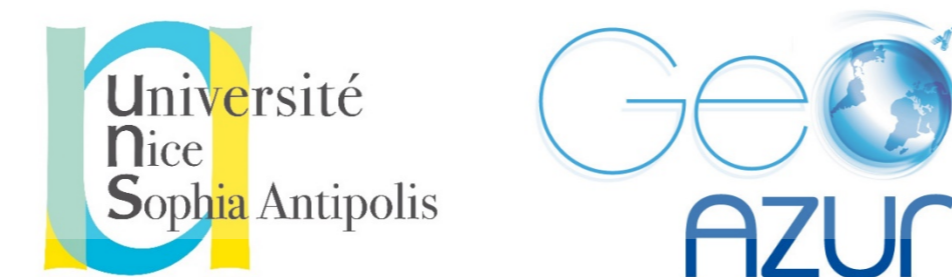
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UNIVERSITÉ CÔTE D'AZUR



Beaver dam on the Cheval river, Rensiwé, Belgium

1 INTRODUCTION

Modeling on changing watersheds is a particularly challenging topic for hydrologists, as land use change is not stationary and it has impacts on the rainfall-runoff relationship. It is necessary then to take into account these changes in the modeling, as well as climate change, in order to understand the hydrosystem and to improve the use of modeling tools. Several types of land use changes can influence the runoff, including beaver dams. Since the 20th century, beavers are recolonizing territories due to protective laws in Europe and reintroduction operations in several countries. On some rivers, series of beaver dams are observed, producing potential significant hydrological impacts at the catchment scale. This work aims to develop a methodology able to detect hydrological impacts due to land use changes, using a rainfall-runoff model and to quantify these hydrological changes.

2 METHODOLOGY AND DATASETS

The model used here is a daily rainfall-runoff model named GR4J^{1,2} (with 4 parameters to calibrate), used in combination with a snow accounting routine, CemaNeige³ (2 parameters to calibrate). The Nash and Sutcliffe efficiency coefficient (NSE)⁴ was used as an objective function to calibrate the model.

The methodology is based on two subperiods : “before change” and “after change”. The model is calibrated on the period “before change”, and then simulates discharges on the “after change” period (Fig.1).

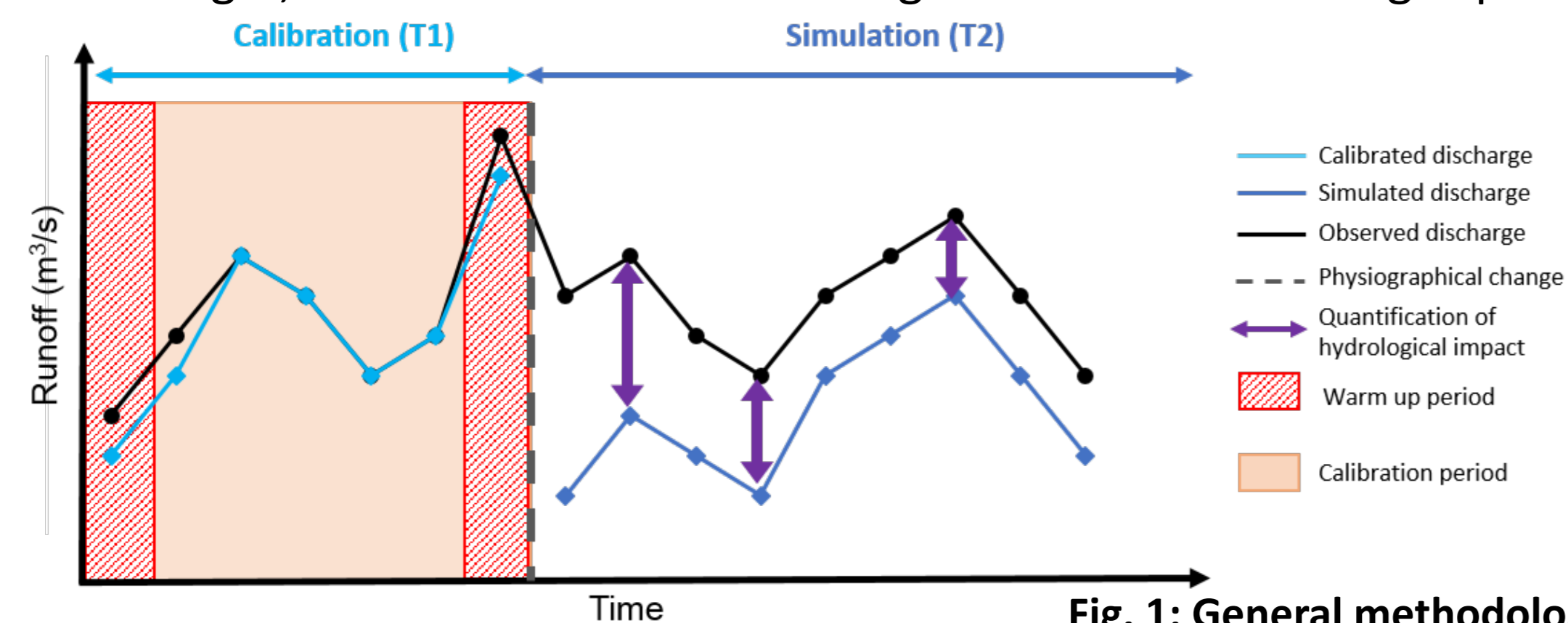


Fig. 1: General methodology

This methodology was used on 7 catchments impacted by different land use changes :

Number	River	Country	Hydrometric station	Catchment area (km ²)	Change type
1	Fernow	USA	Watershed 6 (W6)	0,2	Cut and forest plantation
2	Obyån Creek	Suède	Lissbro	97	Deforestation
3	Rimbaud	France	Collobrières	1,4	Forest fire
4	Blackberry Creek	USA	Yorkville	182	Urbanisation
5	Ferson Creek	USA	Saint Charles	134	Urbanisation
6	Allier	France	Vieille Brioude	2267	Dam construction
7	Ourthe orientale	Belgium	Mabompré	317	Beaver dams

Datasets :

Daily temporal series are needed to run the model:

- Precipitations (mm),
- Air temperature (°C),
- Potential evapotranspiration, calculated with Oudin *et al.*'s formula (2005)⁵,
- Eventually, catchment hypsometric distribution to calculate the snow precipitation.

3 RESULTS

- Observed runoff seems to show some tendencies before and after change (runoff decrease due to the dam in low flow for example Fig. 2, catchment n°6).
- Good efficiency of the NSE overall, but model has difficulties to calibrate on low flow.
- Some tendencies shown by a few river catchments :
 - deforestation increases low flow and median flow, then a return to normal runoff values occurs,
 - diminution of low and median flow due to urbanisation, and increase on high flow,
 - increase of low flow as a result of dam construction and reduction of median and low flow,
- No visible impacts due to beaver dams, but this could be due to their location in the catchment.

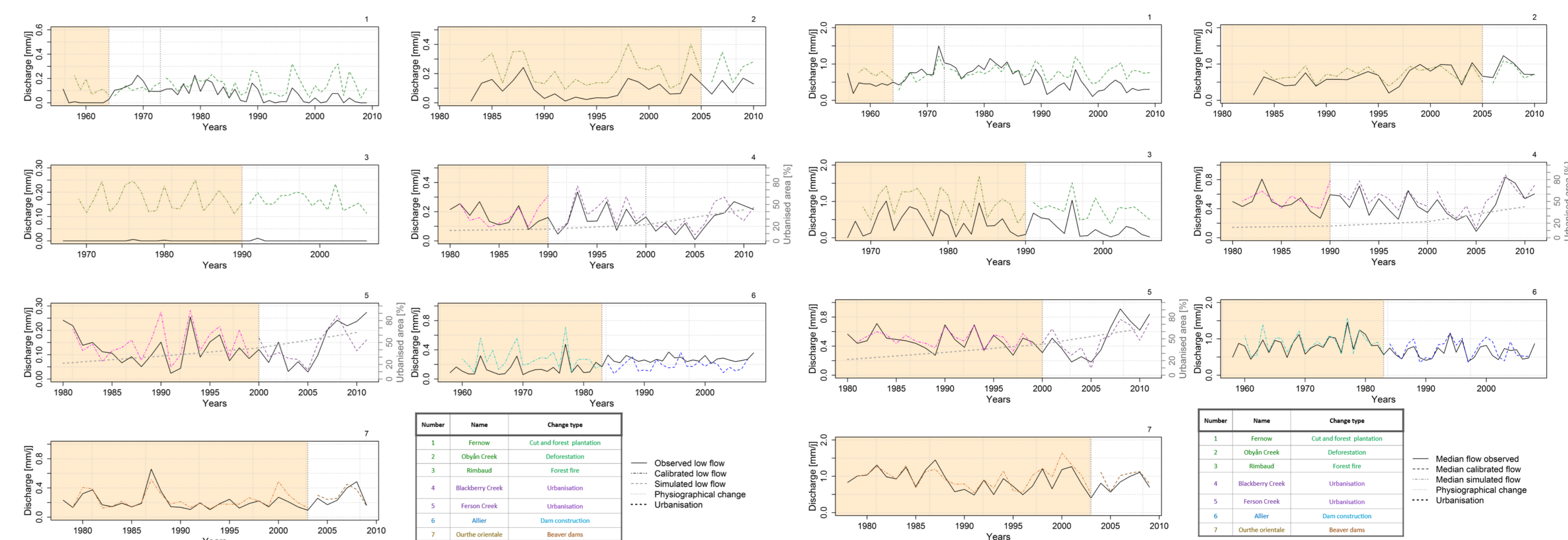


Fig 2: Low flow

Fig 3: Median flow

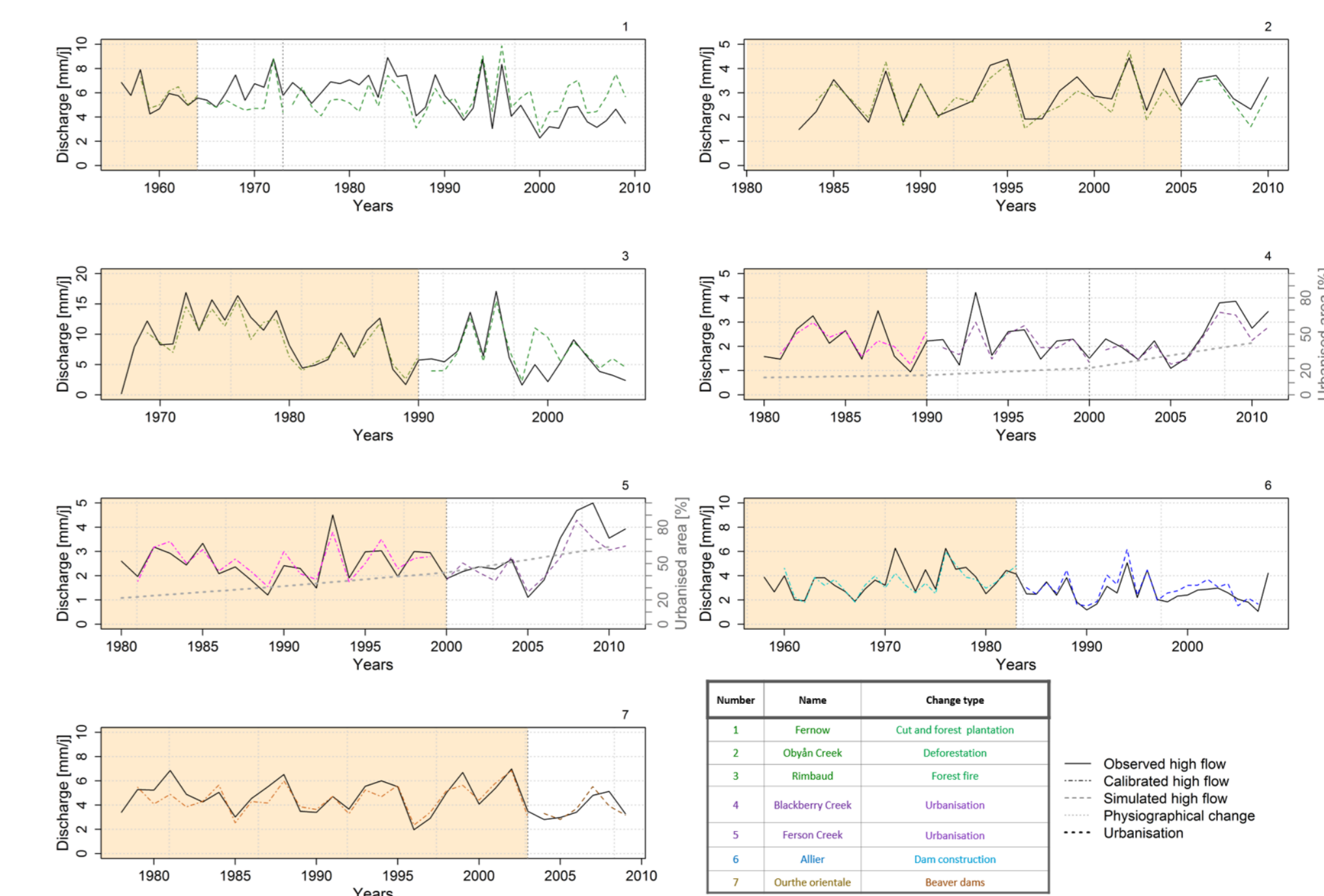


Fig 4: High flow

Table 1: GR4J and CemaNeige calibrated parameters and NSE performances

Number	River catchment	X1 [mm]	X2 [-]	X3 [mm]	X4 [day]	X5 [mm/°C/d]	X6 [-]	NSE
1	Fernow@W6	130.321	-2.250	36.966	1.242	0.079	6.565	0.761
2	Obyån Creek@Lissbro	206.438	-0.120	88.235	4.365	0.000	5.483	0.865
3	Rimbaud@Collobrières	148.413	1.992	62.803	1.369			0.850
4	Blackberry Creek@Yorkville	399.415	-1.055	66.023	1.583	0.069	8.861	0.774
5	Ferson Creek@St Charles	343.779	-0.970	38.861	1.037	0.007	12.829	0.780
6	Allier@Vieille Brioude	190.566	0.454	92.759	2.023	0.601	2.696	0.806
7	Ourthe Orientale@Mabompré	170.716	-0.400	131.631	2.023	0.003	12.082	0.856

5 CONCLUSION AND PERSPECTIVES

- Modeling allowed to detect the influence of land use changes, but these are not constant according to the catchment and the type of change.
- It is not possible yet to generalize a tendency on the impact of beaver dams after this study, but the method is validated and should be used on more catchments.

If you are studying a river catchment impacted by beaver dams and you have some hydrological data, we would be interested to include it in our catchment set!

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