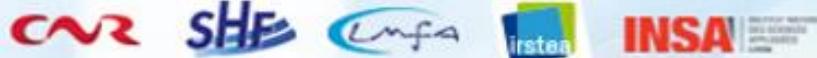


# River Flow 2018

NINTH INTERNATIONAL  
CONFERENCE ON FLUVIAL  
HYDRAULICS



LYON-VILLEURBANNE, FRANCE  
SEPTEMBER 5-8, 2018

## Experimental bed active-layer survey with active RFID scour chains:

Example of two braided rivers (the Drac  
and the Vénéon) in the French Alps

PARIS  
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AGENCE FRANÇAISE  
POUR LA BIODIVERSITÉ  
ÉTABLISSEMENT PUBLIC DE L'ÉTAT



Guillaume Brousse, Frédéric Liébault, Gilles Arnaud-Fassetta, Daniel Vazquez-Tarrio

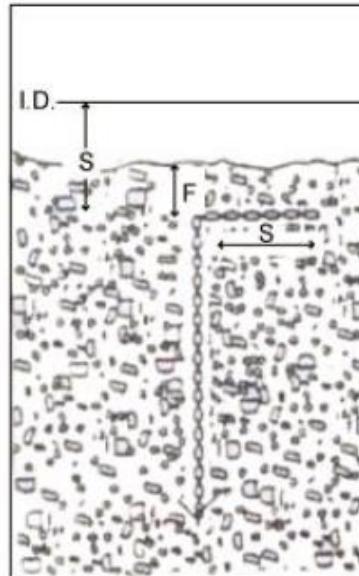
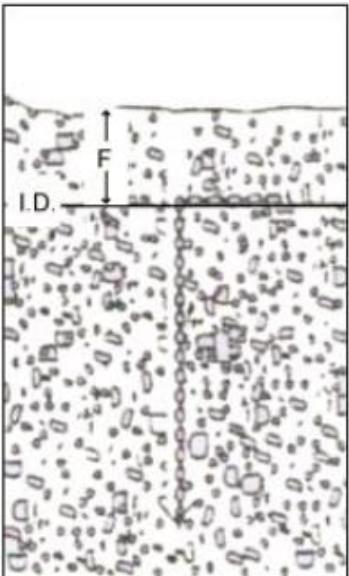
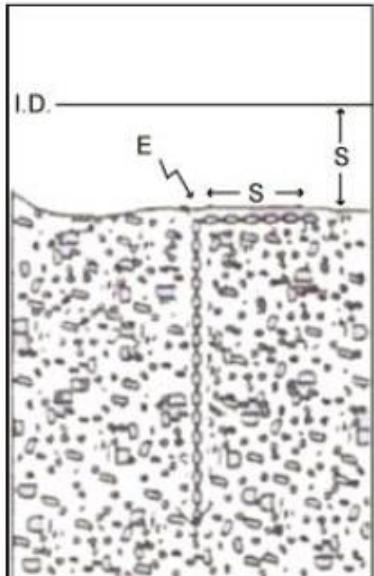
# Outline

- Research context
- Material and methods
- Results
- Feedback and prospects

# Research context



Luna Bergere Leopold  
(1915-2006)

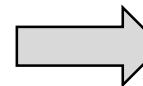


Laronne et al. 1994

## Traditional scour chains

**(Leopold et al., 1966)**

- Very cheap
- Do not require presence on the field during flow events
- Lifetime could be very long



- Laborious field efforts are required for the recovery and relocation
- Efforts are higher for torrential river

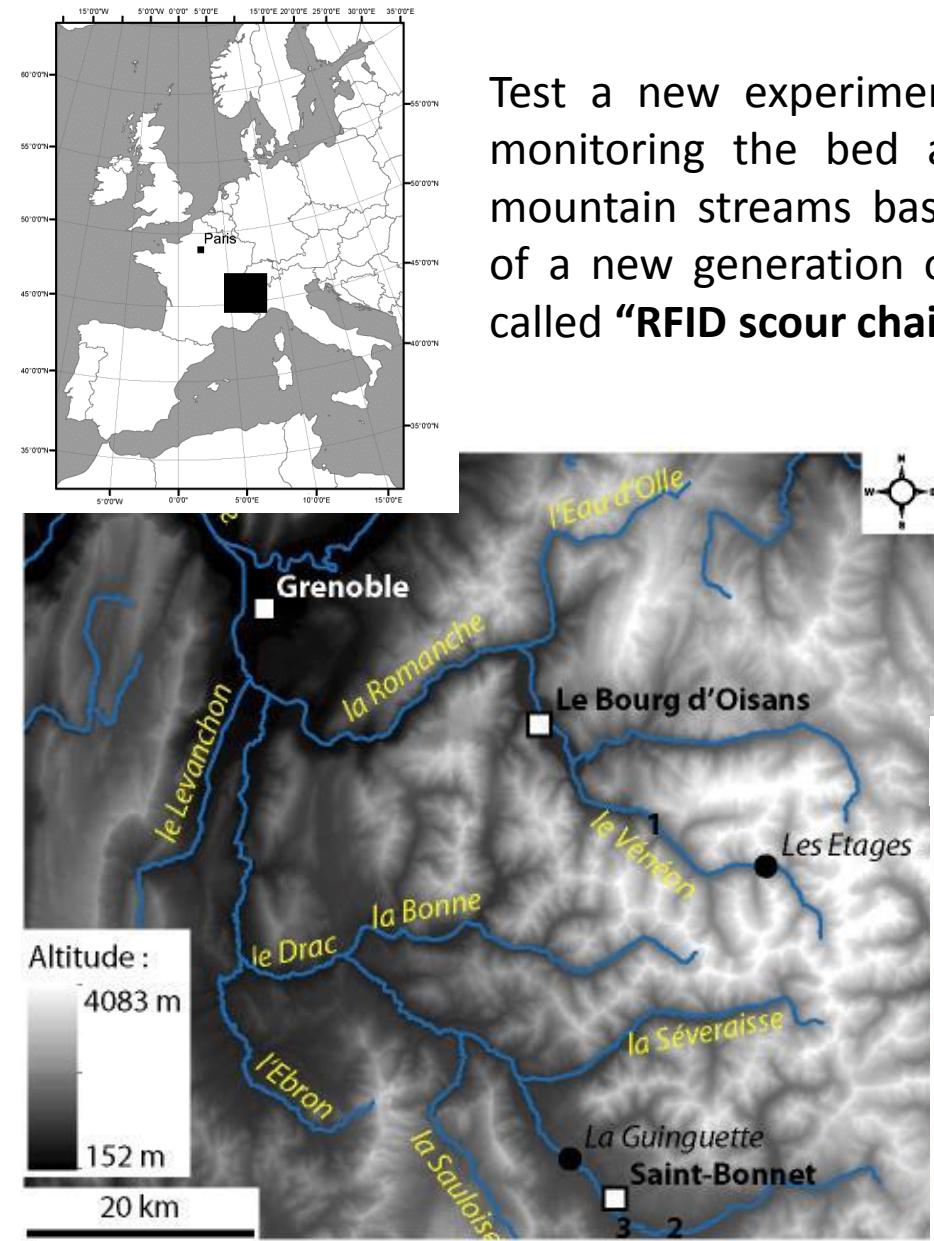


## Multiple evolutions of metallic chain:

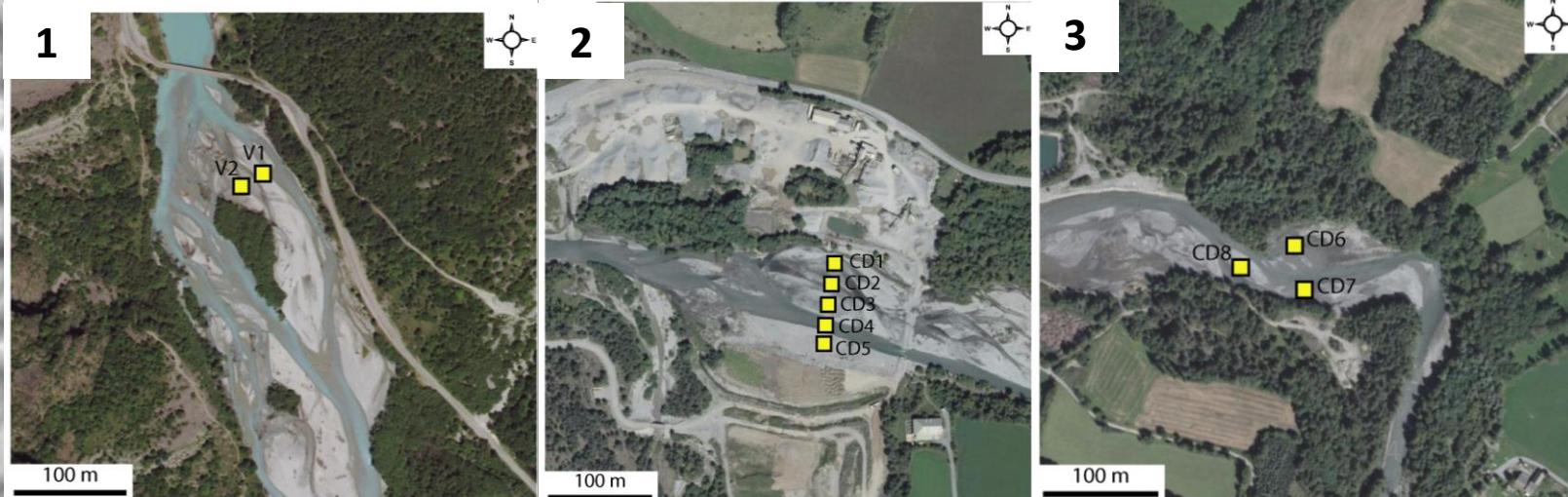
- Deployment method
- Anchor design
- Accelerometers Scour Monitors » (ASMs) with or without passive RFID tags
- Vertical passive RFID antenna with continuous power
- Resistance chain with GSM modem and solar panel
- **Use of UHF RFID tags**

# Research context

Test a new experimental device for monitoring the bed active layer of mountain streams based on the use of a new generation of scour chains called “**RFID scour chains**”



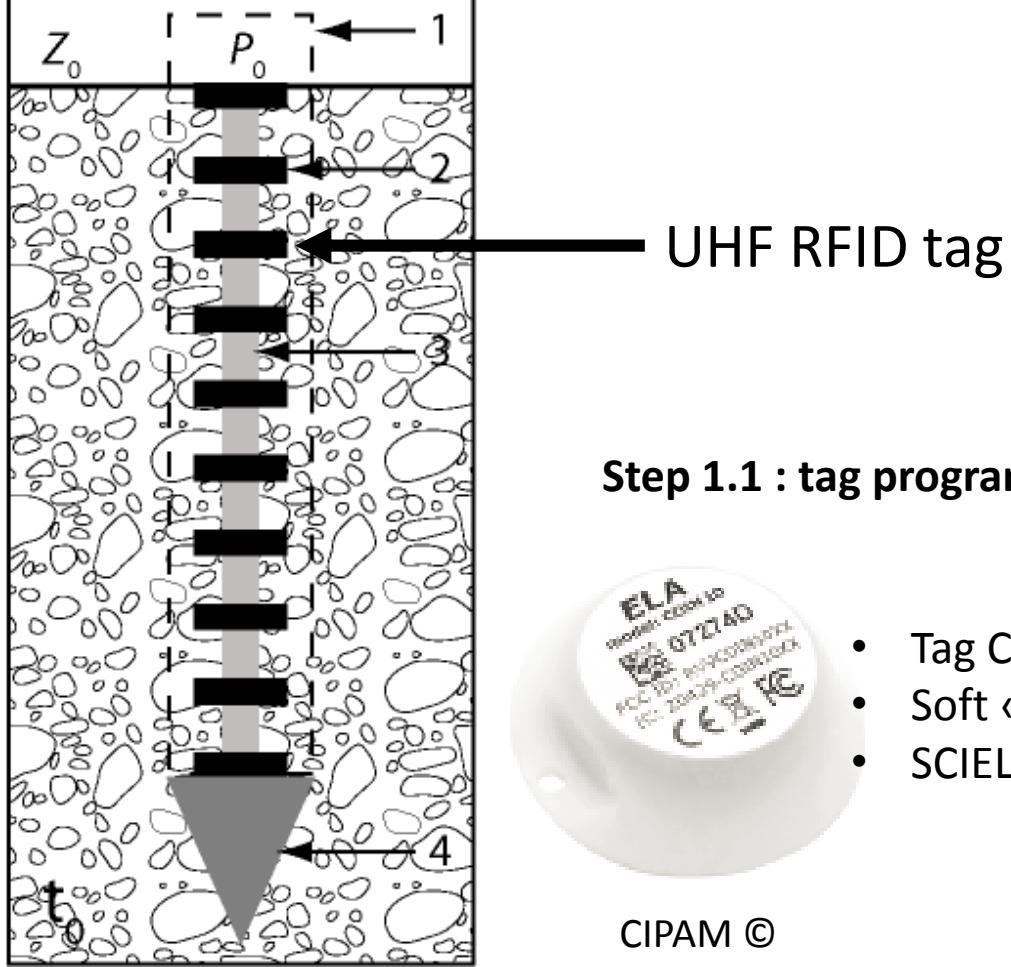
River	Vénéon	Drac	
Site	PL [22]	CHAB [23]	ZR [23]
<b>Drainage area (in km<sup>2</sup>)</b>	235	308	336
<b>Channel slope (in %)</b>	1.60	0.97	0.81
<b>D<sub>50</sub> (in mm)</b>	38.2	65.0	60.5
<b>D<sub>84</sub> (in mm)</b>	69.2	99.0	97.2
<b>Width (in m)</b>	141.5	109.4	81.4
$\tau_{c84}^*$	0.0300	0.0264	0.0255
<b>Number of RFID scour chains</b>	2	5	3





# Material and methods – general principle

## RFID scour chain principle



### 3 main steps:

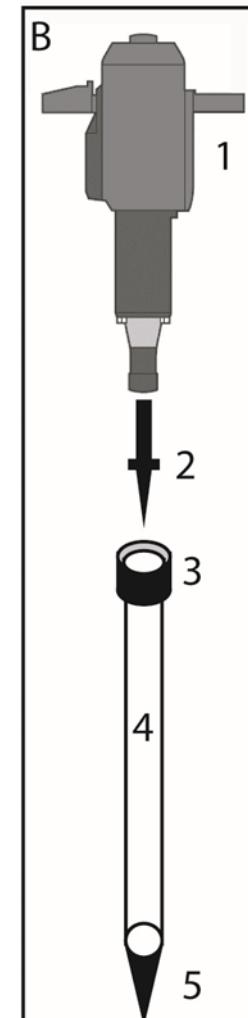
1. equipment preparation (tag programming and design of the drilling system)
2. onsite deployment (drilling with a jack-hammer, tags insertion and topographic survey)
3. RFID scour chain survey (tag detection and topographic survey)

### Step 1.1 : tag programming

- Tag COIN ID 433.92 MHz
- Soft « ELA Read and Write v4.4.8 »
- SCIEL PROG IR

### Step 1.2 : drilling system

1. jack-hammer
2. modified chisel
3. striking ring
4. steel tube
5. lost spike



# Material and methods – the specific device

## Step 2 : onsite deployment



Drilling device



Tube extraction

# Material and methods – the specific device

## Step 3 : RFID scour chain survey

$P$  (depth of the shallowest recovered PIT tag)



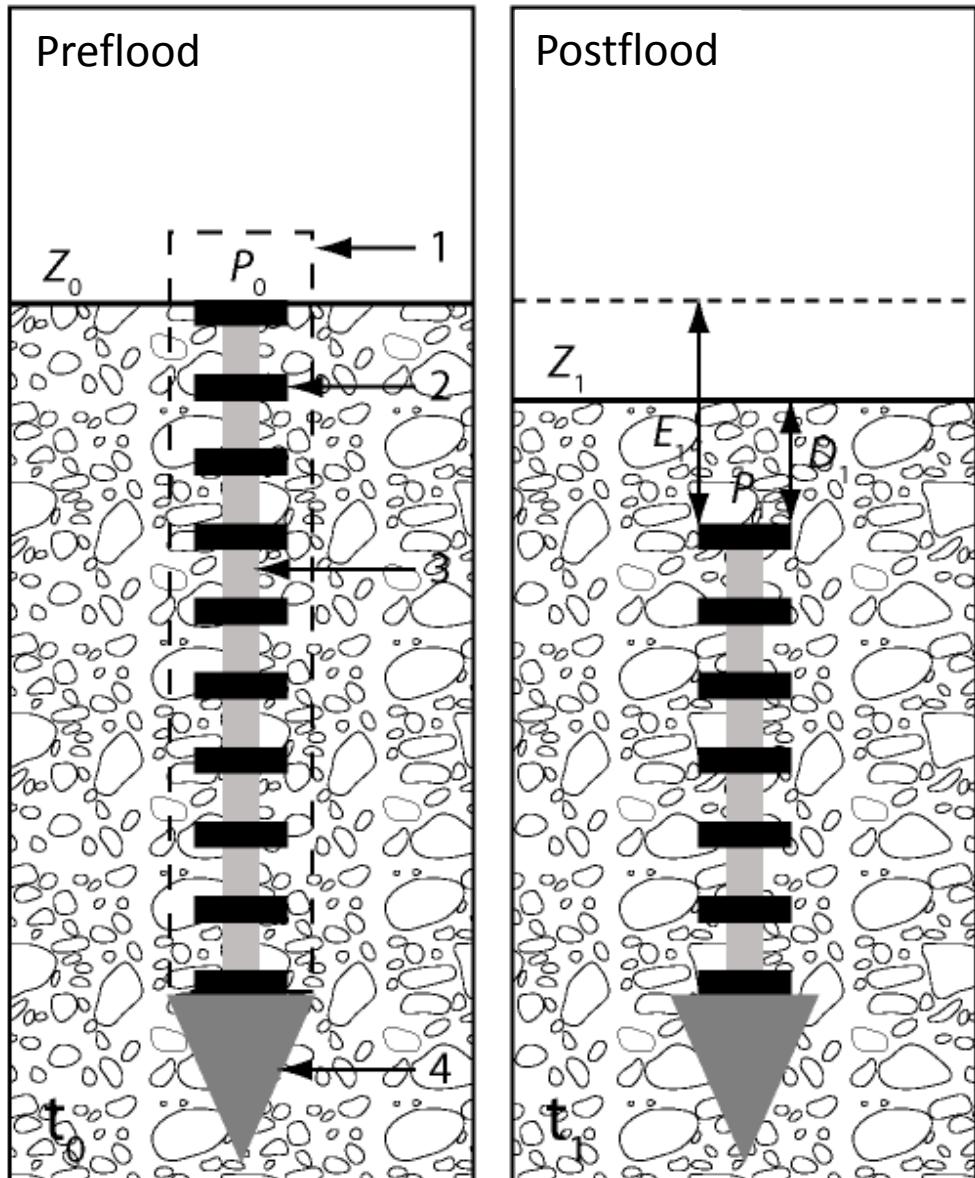
UHF RFID detection device

$Z$  = Elevation of the bed surface (RTK GPS)



Cross section with RTK GPS

# Material and methods – general principle



**Only scour information**  
**Repetitive cross section survey for fill information**

$Z$  = Altitude of the bed surface

$E$  (maximum scour depth) =  $P$  (depth of the shallowest recovered PIT tag)

$D$  (fill depth) =  $E - (Z_0 - Z_1)$

$\Delta_H$  (vertical evolution) =  $-E + D$

$d_b$  (bed active layer) =  $E + D$

# Material and methods – the specific device

## Device characteristics

River	Vénéon		Drac							
Site	PL		CHAB				ZR			
<b>Number of RFID scour Chain</b>	2		5				3			
<b>Scour chain name</b>	CV1	CV2	D1	D2	D3	D4	D5	D6	D7	D8
<b>Number of UHF RFID tag</b>	13	12	10	10	10	10	10	5	3	3
<b>Buried depth (m)</b>	1,1	1	1				0,5	0,3	0,3	
<b>Link lenght (m)</b>	0,083		0,1							
<b><math>D_{50}</math> link lenght ratio</b>	$2,17D_{50}$		$1,54D_{50}$				$1,65D_{50}$			
<b><math>D_{90}</math> link lenght ratio</b>	$D_{90}$		$0,91D_{90}$				$0,9D_{90}$			

**Financial budget:**

UHF RFID tag = 37 € HT /unit  
Lost spike = 20 € HT / unit

**Cost per scour chain ≈ 400 € HT**

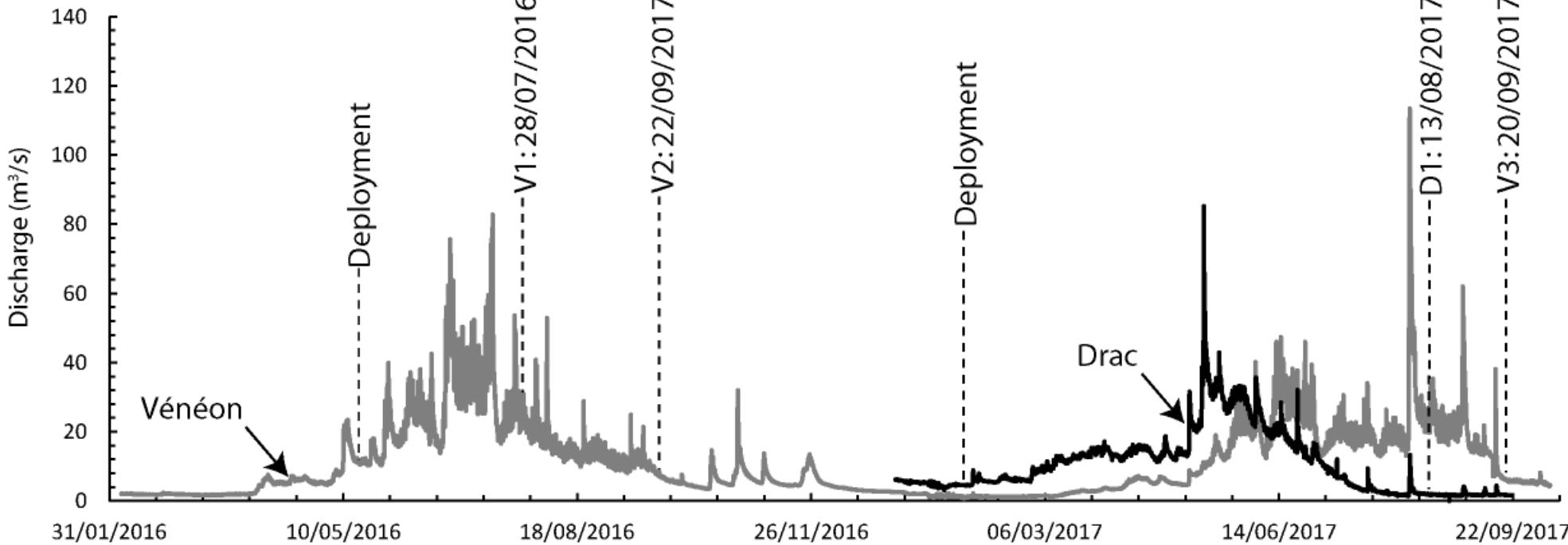
**2 operators**

**Onsite deployment ≈ 15 – 20 min**

**RFID survey < 5 min**

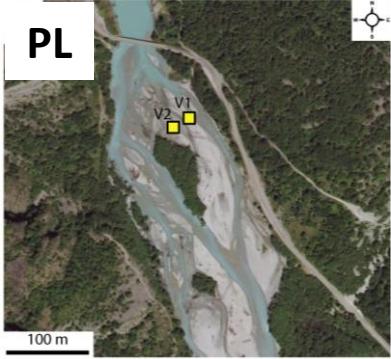
**Topographic survey < 20 min for a 110 m width braided river**

# Hydromorphological monitoring conditions

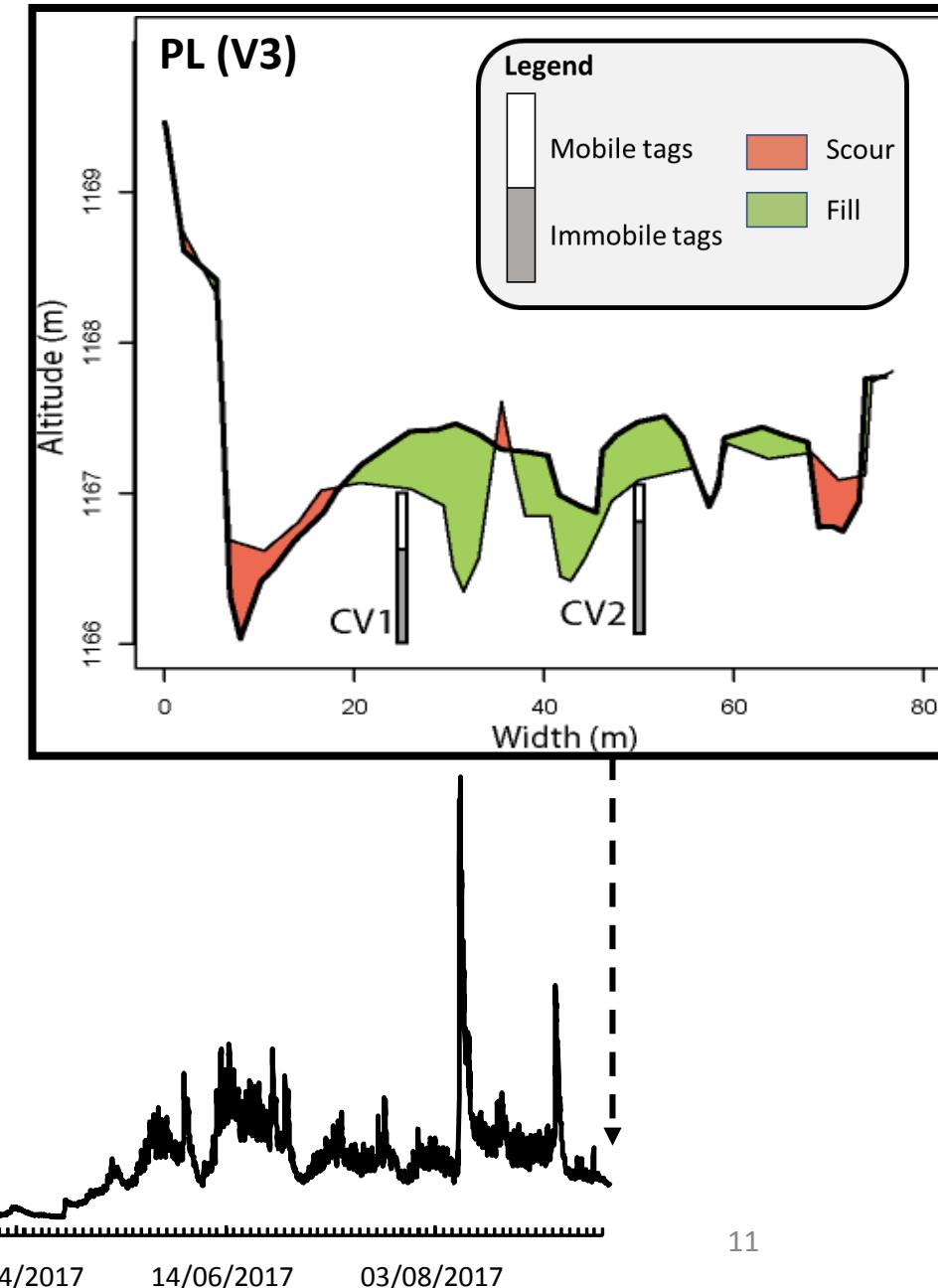
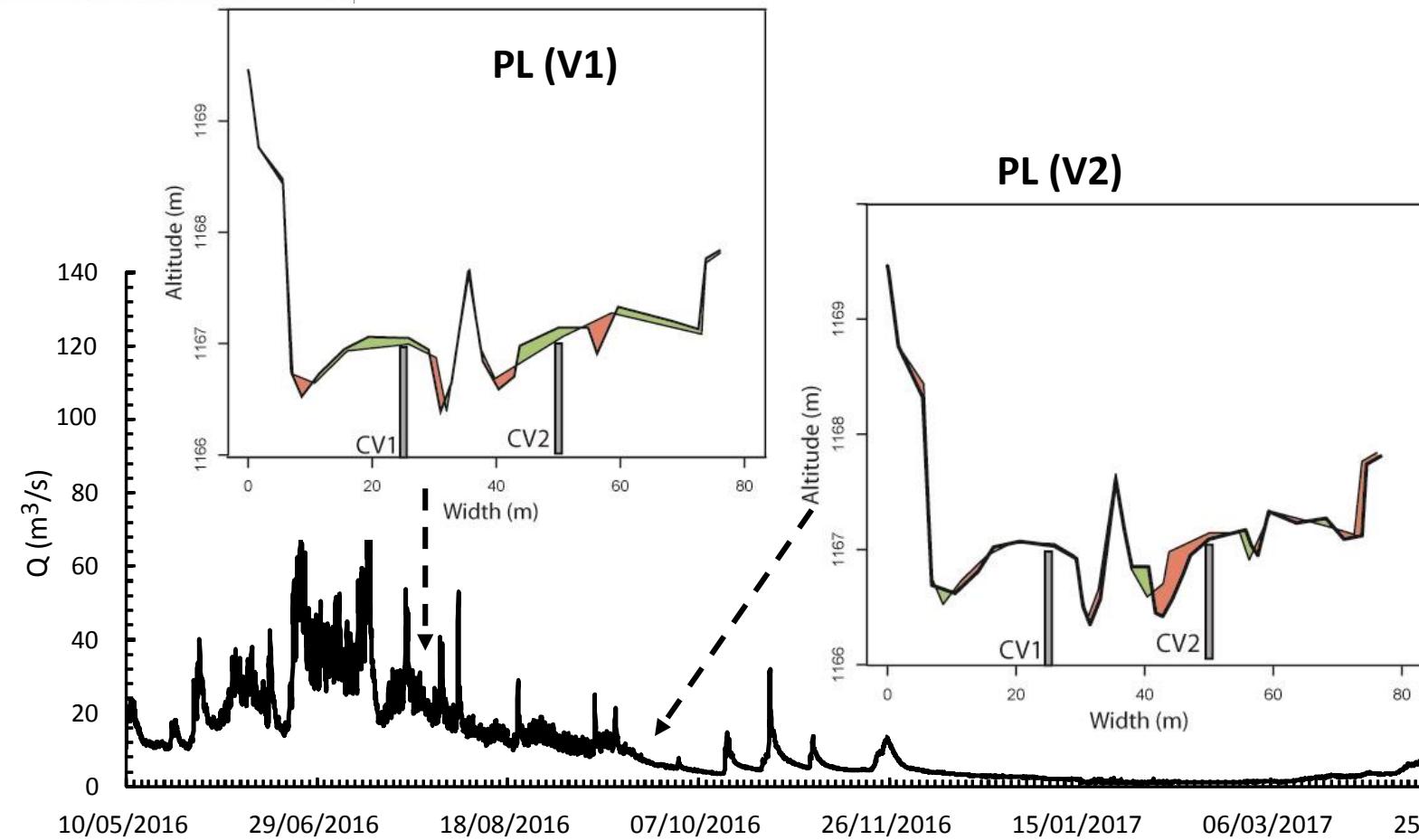


River	Vénéon			Drac	
Site	PL			CHAB	ZR
Survey period	V1	V2	V3	D1	D1
Maximum peak flow (in $\text{m}^3/\text{s}$ )	82.8	53.0	113.5	85.1	85.1
Maximum $\tau_{84}^*$	0.055	0.053	0.058	0.030	0.031
Maximum $\tau_{84}^*/\tau_{c84}^*$	1.83	1.76	1.93	1.14	1.18
% of time with active bedload transport ( $\tau_{84}^*>\tau_{c84}^*$ )	100	96	39	3	1017

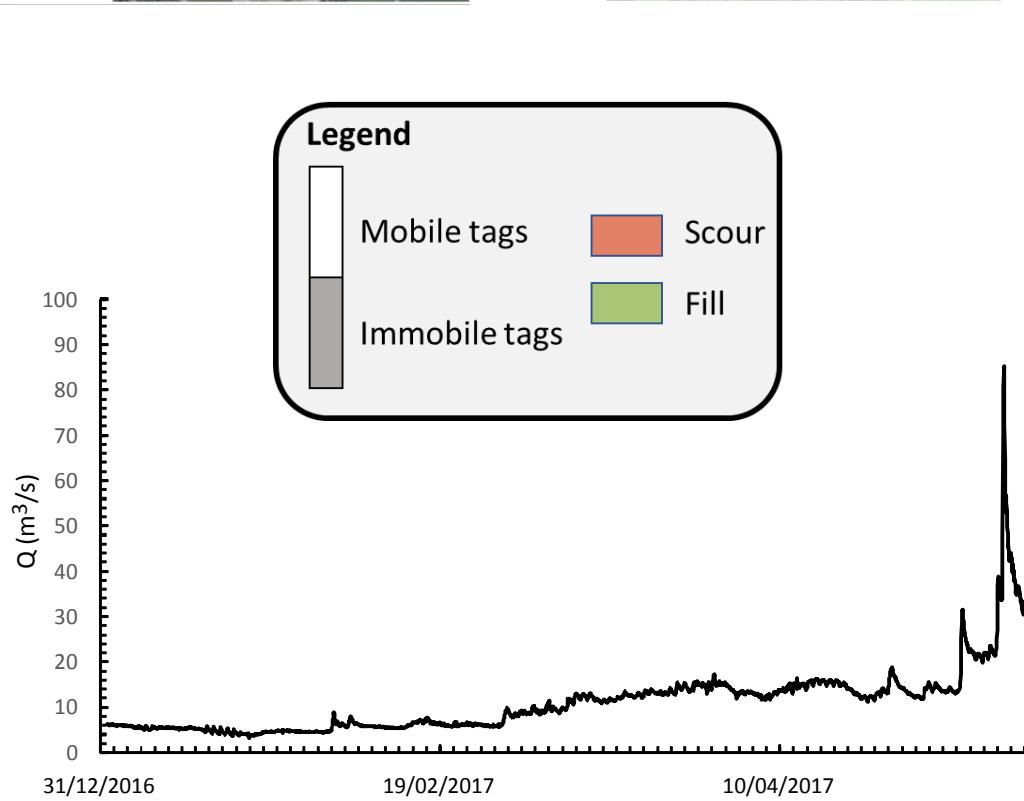
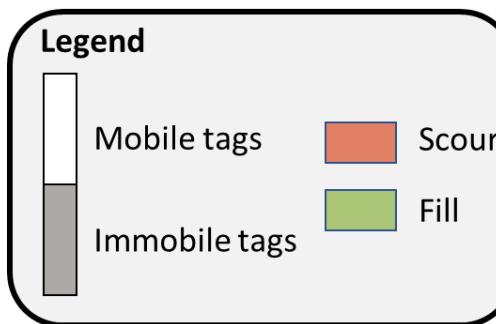
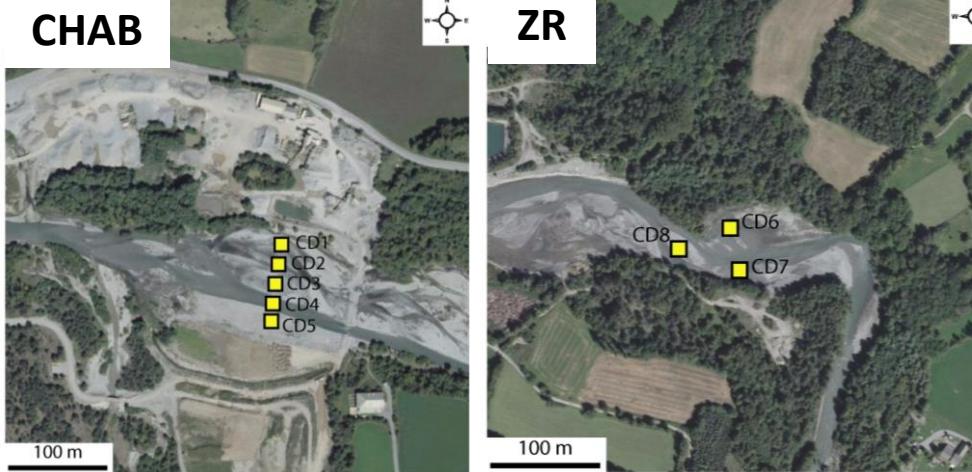
# Spatio-temporal variability of the bed active layer



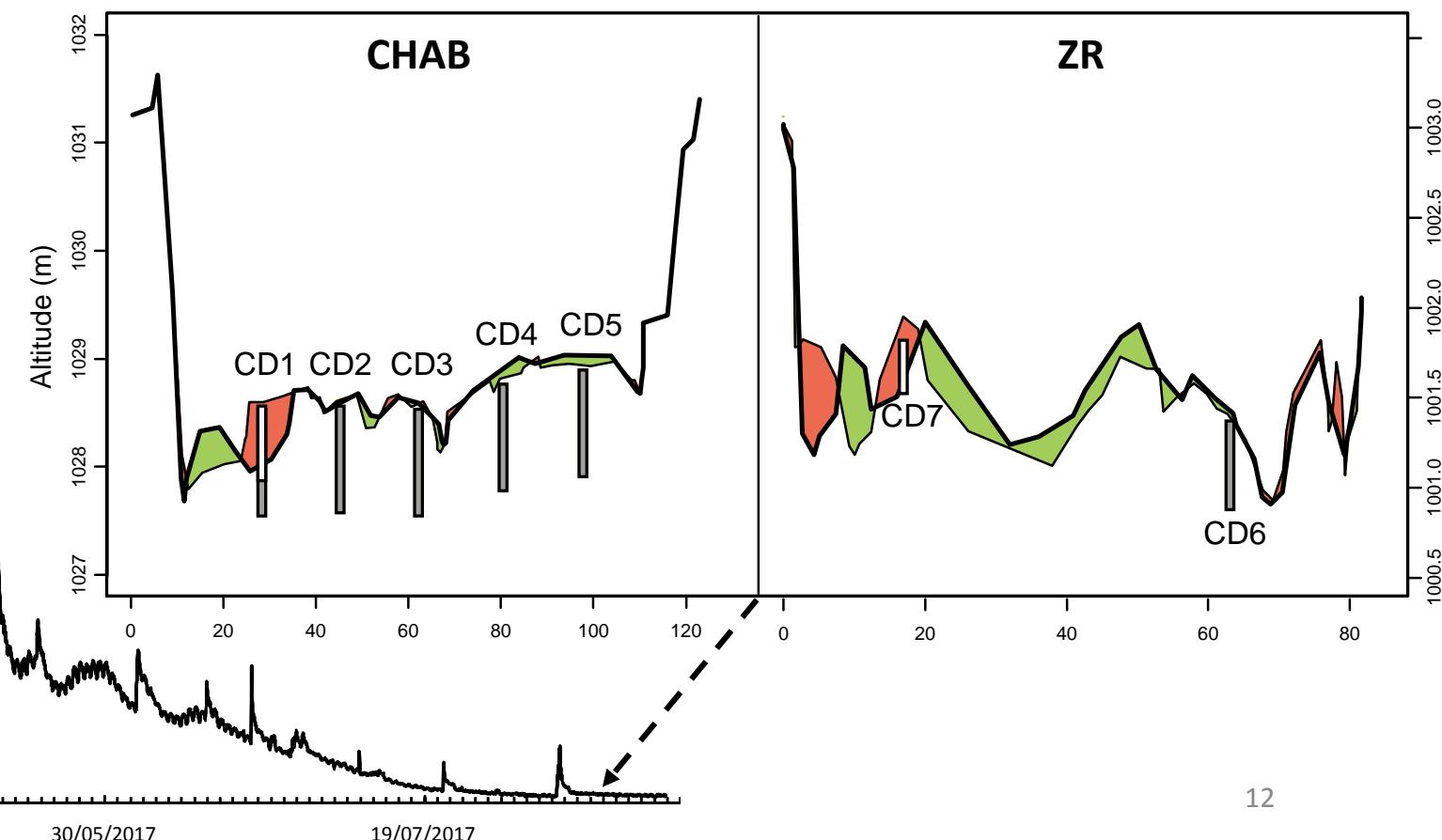
Survey	V1		V2		V3	
Column	CV1	CV2	CV1	CV2	CV1	CV2
<b>Scour (in m)</b>	0	0	0	0	0.53	0.32
<b>Fill (in m)</b>	0.06	0.08	0.08	0.03	0.90	0.69
<b><math>d_b</math> (in m)</b>	0.06	0.08	0.08	0.03	1.43	1.01



# Spatio-temporal variability of the bed active layer



Survey	D1							
Column	CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8
<b>Scour (in m)</b>	0.70	0	0	0	0	0	>0.30	>0.30
<b>Fill (in m)</b>	0.21	0.02	0.01	0.10	0.10	0.06	0.14	0.11
<b><math>d_b</math> (in m)</b>	0.91	0.02	0.01	0.10	0.10	0.06	0.44	0.41



# Feedback and prospects

## Feedback from field experiment:

- Time saving for deployment
- Time saving for monitoring (bypass excavation step)
- Succesfull monitoring under very high flow conditions with strong morphological channel change in active, braided rivers
- No artefact in the column due to efficiency of active RFID technology
- Tag lifetime maximize survey potential
- Extra cost
- Resolution is lower than traditional scour chains

## Device prospects:

- Using mobile tags for sediment tracking
- Artificial pebbles in the column
- Make it possible to constrain spatio-temporal variability of the bed active layer and the mobility of subsurface coarse sediment



# Thank you for your attention



UFR GEOGRAPHIE HISTOIRE  
ECONOMIE ET SOCIETES (GHES)

UMR 8586 PRODIG



UMR 8586

Guillaume Brousse  
Doctorant en Géographie

Bâtiment Olympe de Gouges – Case courrier 7001  
5 rue Thomas Mann – F – 75205 Paris Cedex 13  
+33 (0)6 77 18 97 98  
[www.univ-paris-diderot.fr](http://www.univ-paris-diderot.fr) | [www.prodig.cnrs.fr](http://www.prodig.cnrs.fr)  
[guillaume.brousse@univ-paris-diderot.fr](mailto:guillaume.brousse@univ-paris-diderot.fr)  
[guillaume.brousse@gmail.com](mailto:guillaume.brousse@gmail.com)