THE RHONE SEDIMENT OBSERVATORY: **EVALUATION AND COMMUNICATION ON THE FLUXES OF PARTICULATE CONTAMINANTS AT THE BASIN SCALE**

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IRSTEA, Lyon, France

ALLIANCE-NERIS workshop, Munich, March 2018

The Rhone river

One of the largest european rivers

First freshwater input to the western Mediterranean basin

560 km in France
(800 km in total)

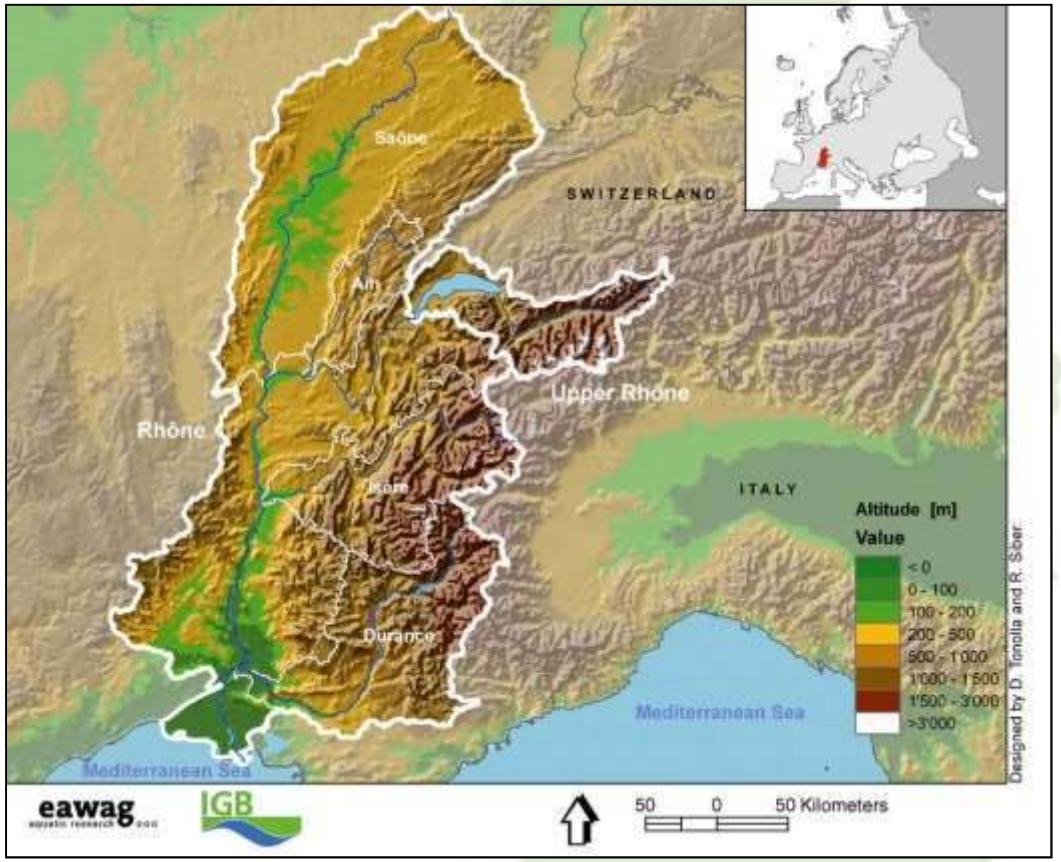
Watershed: 98 000 km^2

Mean discharge at the mouth:

1700 m^3/s

Annual flood :

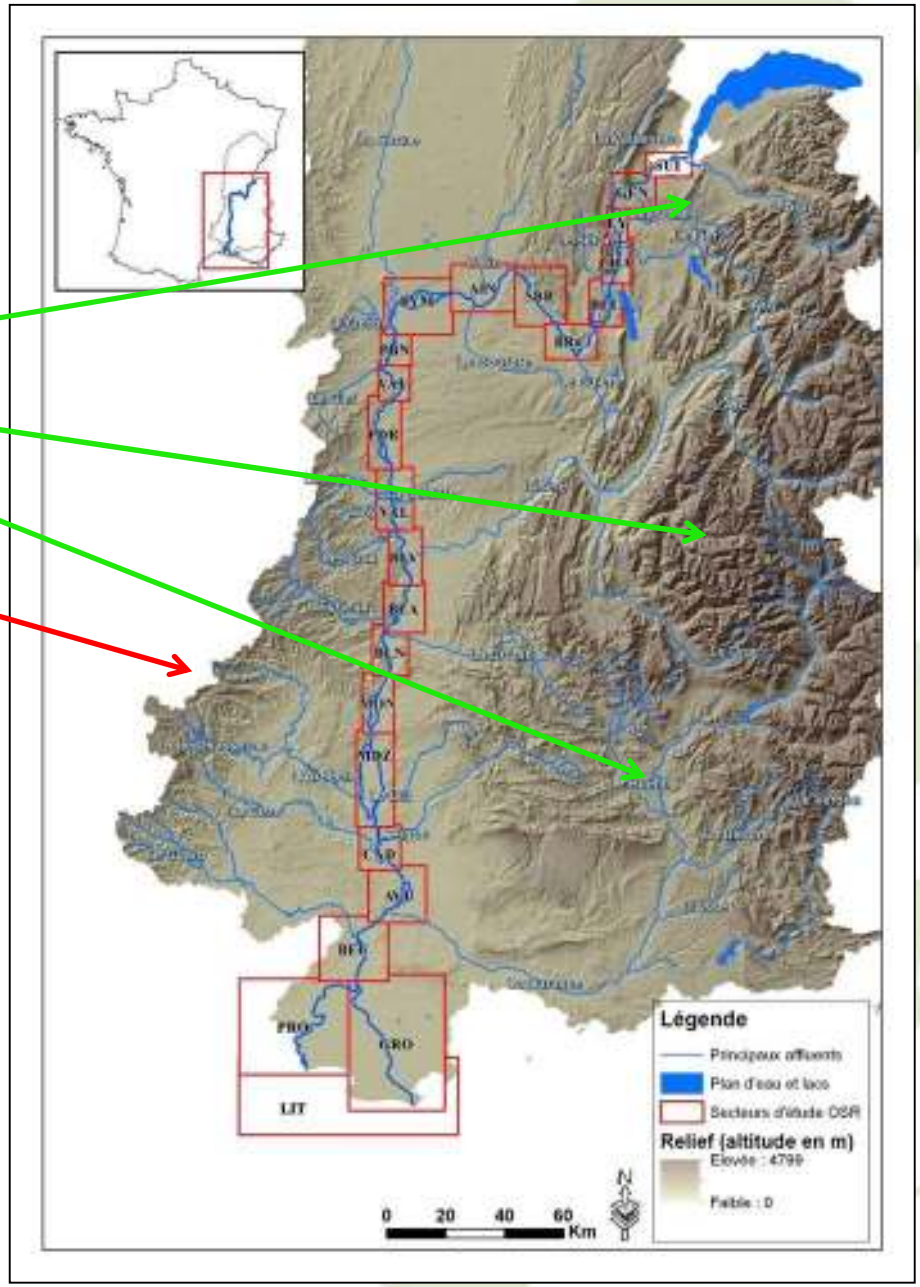
4000 m^3/s



J.M. Olivier et al., 2009

The Rhone river

Flash-flood events (few hours to days) occur regularly on the Alps
and
Massif Central Mountains
(≈ 50-90% of the annual solid discharge in 10% of time)



Poor knowledge of the time and spatial scales and fluxes of sediment transported or stored within the river !

Regulated between 1850 and 1930
for navigation purposes...
(embankments, groynes, walls)

… then dammed for producing electricity
(1948-1986: 19 hydroelectric dams)

Embanked reach

Hydroelectric power plant

« Old Rhone » or by-passed reach

Why an observatory on sediments ?

Succession of damaging floods 1993-1994-2003 + PCB Crisis (2005)

Stakes and questions related to the sediment transfer, morphology and contamination.

- *What is the impact of the river geometry and existing infrastructures on the flooding risk or the ecological potential of the river ?*
- *How has the geometry of the channel evolved over the last two centuries?*
- *What is the annual bedload transport ?*
- *What is the impact of development and management activities such as dredging, channel maintenance or sediment flushing ?*
- **What suspended sediment and contaminant fluxes are transferred to the Mediterranean Sea ? Where do they come from and what are their temporal patterns ?**
- **Can we predict the sediment transfer and deposition ?**
- **How can we share data and information for stakeholders and public ?**

Europe

Water agency and stakeholders

Regional councils

Observatoire des Sédiments du Rhone

2009 OSR 1 → 2019 OSR 5

WP A
Alluvial margin restauration: feasibility, risks and opportunities

WP B
Flux monitoring

WP C
Knowledges to establish the diagnosis of the functional state of the river

WP D
Modelling, data banking and valorization

Some objectives related to fluxes of SPM and contaminants

- Choose the methodologies in order to collect Suspended Particulate Matter (SPM) in the river, its tributaries and in all conditions (especially during flood events).

- Define the collection systems, in order to get samples representative of the section, of the temporal variation and that can be analysed for both organic and inorganic contaminants (→ quality and quantity).

- Propose the best way to determine the SPM fluxes and those of associated contaminants, at the watershed scale.

- Define the best way to easily provide these values to stakeholders and public, with a high degree of confidence.

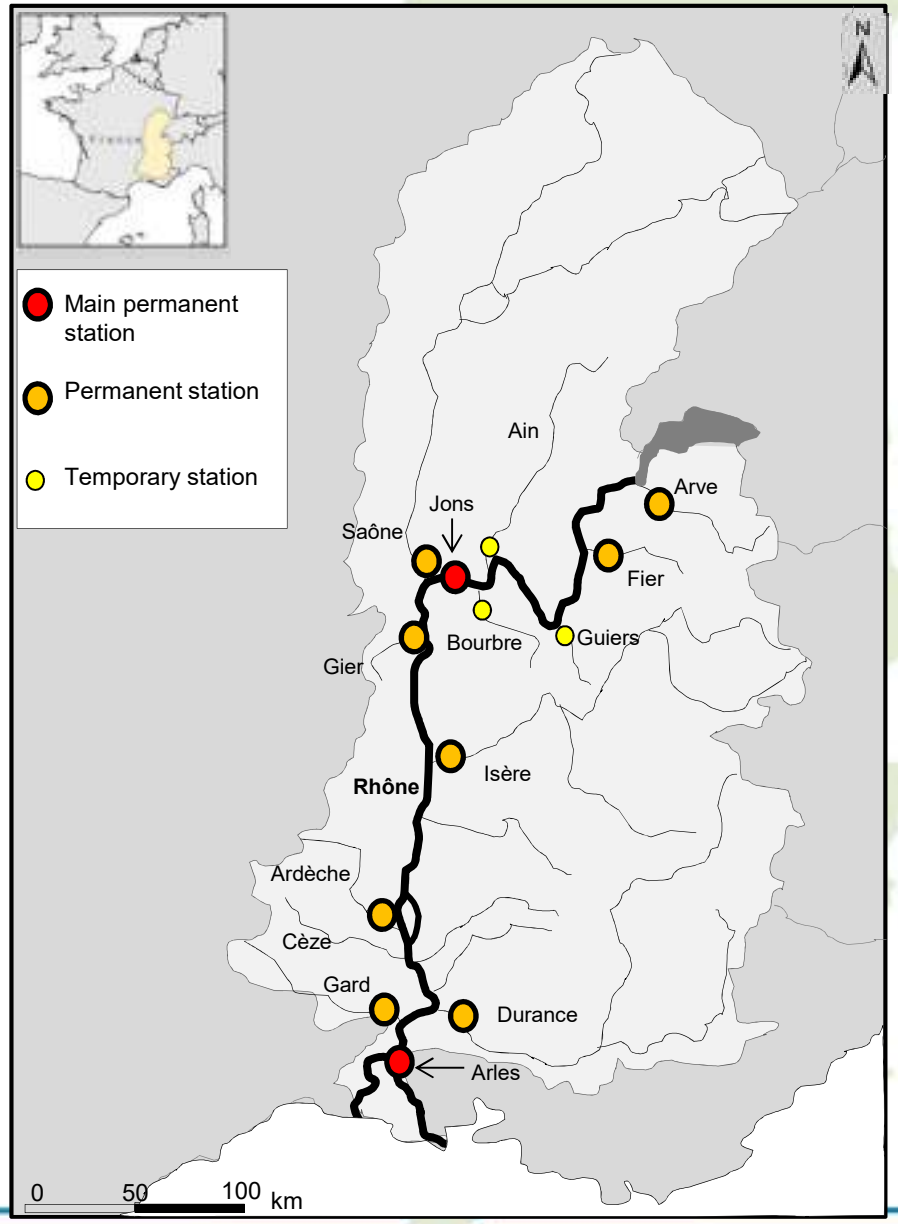
A network of permanent and temporary stations has been developed to measure SPM transfer and to collect samples for the analyses of contaminants and geochemical tracers

13 stations were instrumented on the Rhone and its main tributaries to measure SPM and collect samples for the analyses of contaminants and geochemical tracers :

- 2 main permanent stations on the Rhone, upstream and before the outlet
- 8 permanent stations on the tributaries
- 3 temporary stations (one year)

Monitored from 2011 → 2016
Network in evolution

Liquid discharges obtained from CNR or « HydroFrance »



Sampling systems defined to obtain representative samples for geochemical analyses

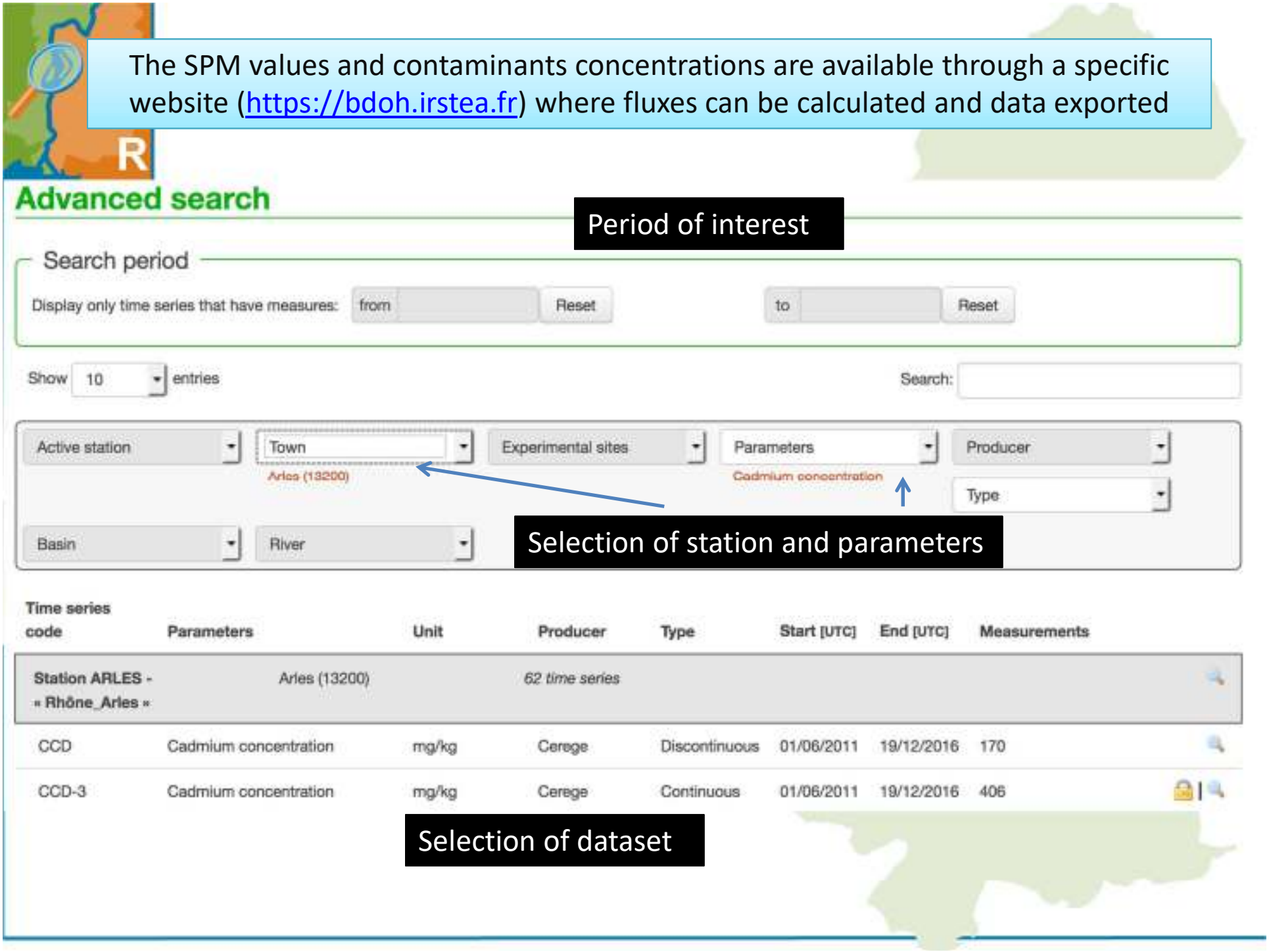
Particles trap
Sampling over 15-30 days

Fixed or portable centrifugation system
« Instantaneous » sampling (2-4h)

Enough material can be distributed to all laboratories and stored for analyses

Calibrated Turbidity gauges are used for the estimation of SPM concentrations at fine temporal scale → precise evaluation

The SPM values and contaminants concentrations are available through a specific website (https://bdoh.irstea.fr) where fluxes can be calculated and data exported

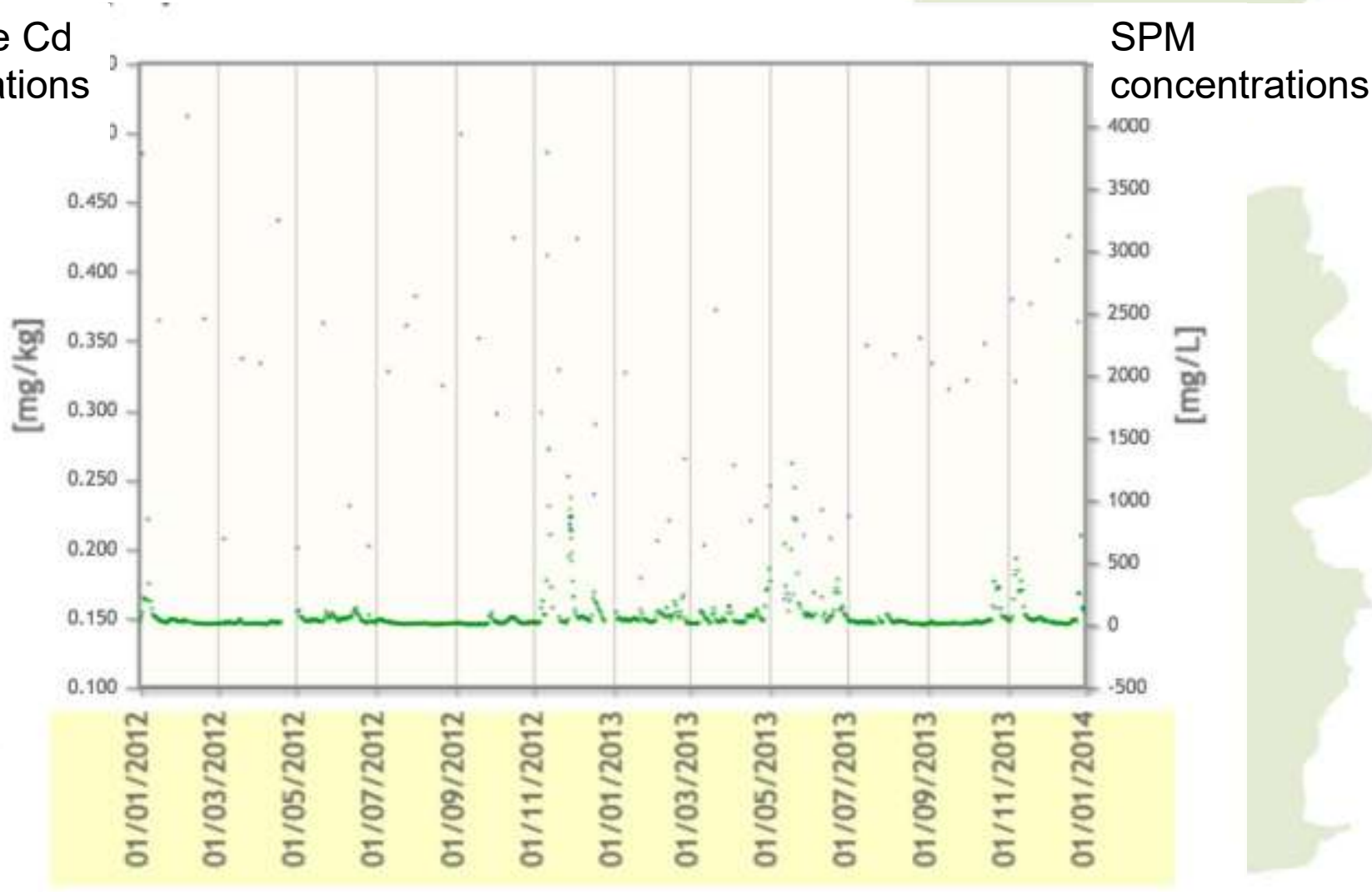


11 data producers, 22 stations, 43 parameters, 720 time series

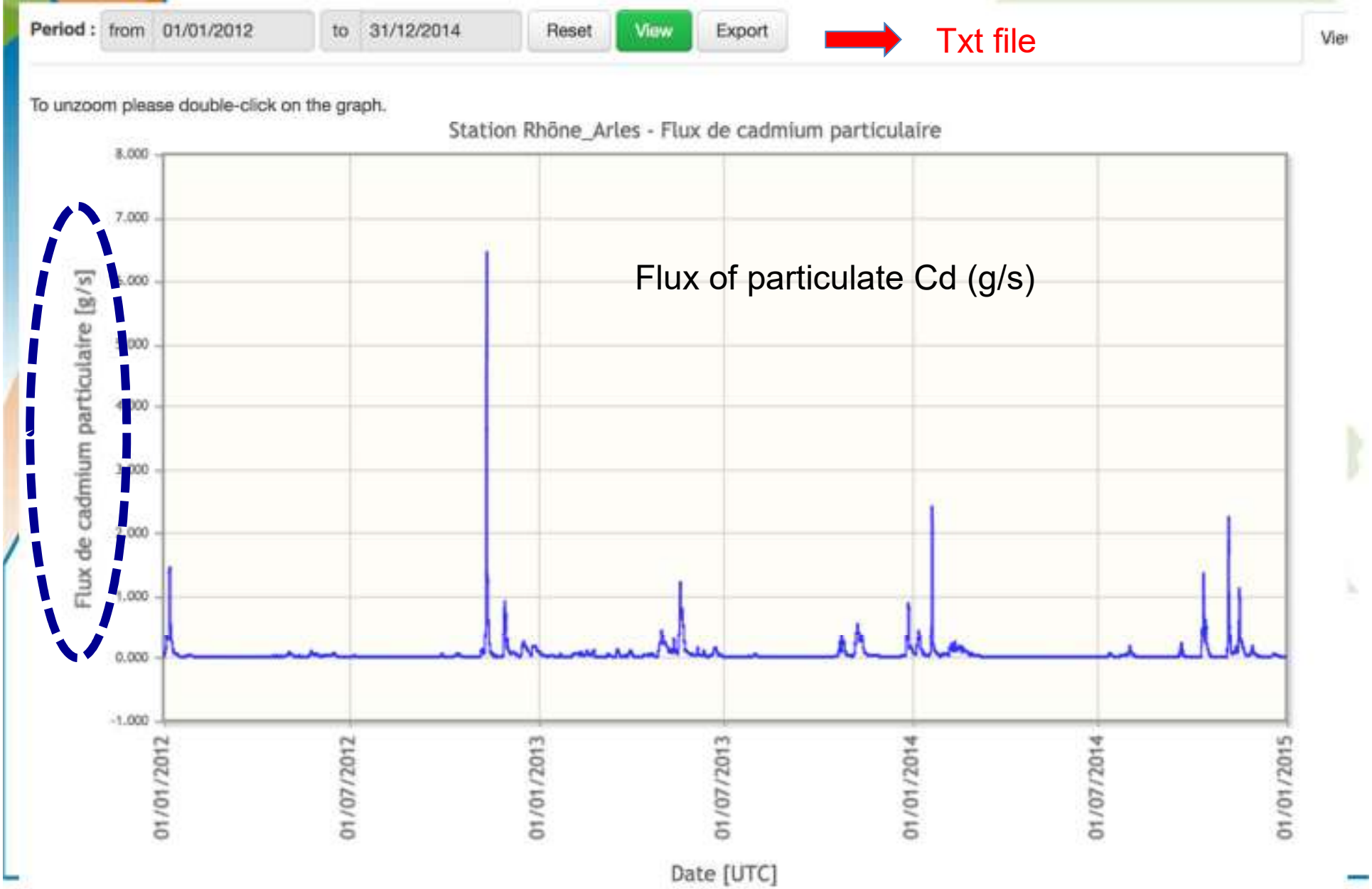
Time series can be combined for vizualisation and calculation

Particulate Cd Concentrations in Arles

SPM concentrations



Contaminant concentrations are combined with SPM data for the calculation of fluxes.
Anyone (including partners and public) may now use the same values .



A large set of contaminants can be studied with the same samples

Contaminants provided into BDOH :

- Co, Cr, Ni, Cu, Zn, Pb, Cd, Hg
- PCB
- ^{137}Cs

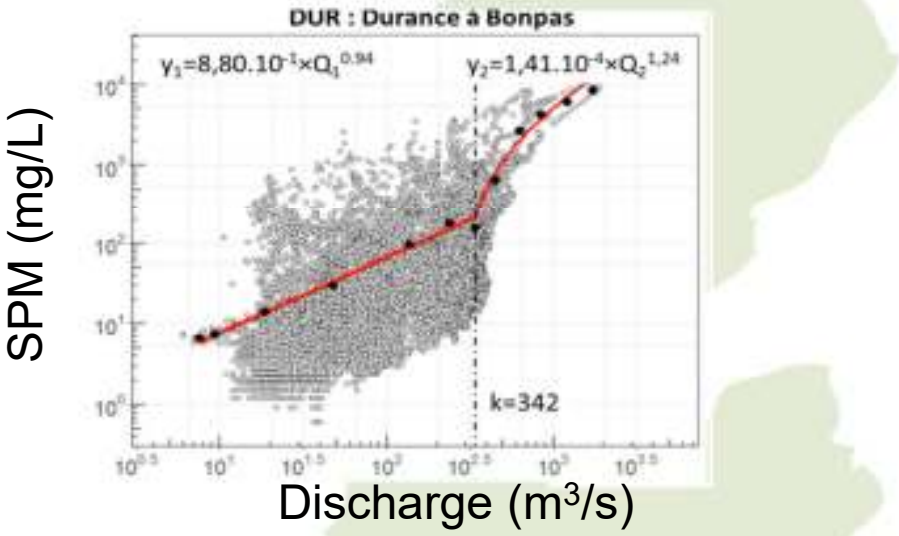
Other contaminants or tracers measured :

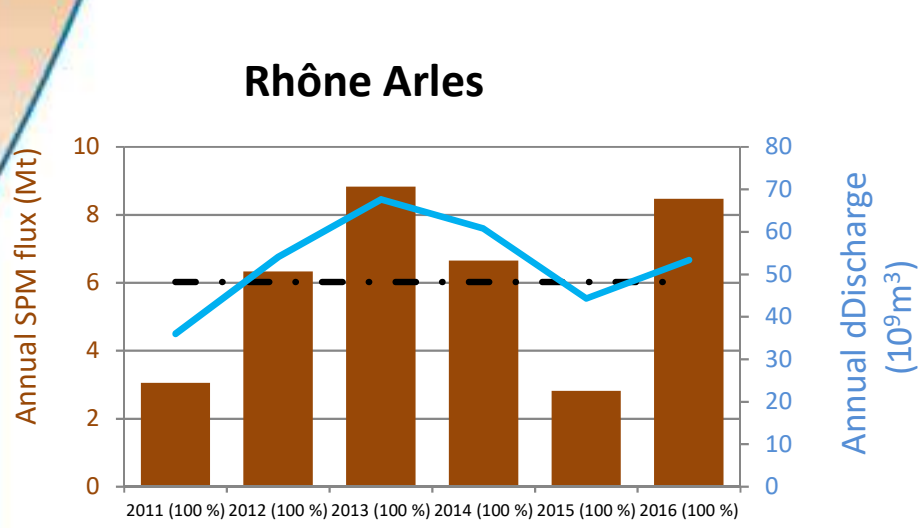
- Numerous TME, rare earth elements, methylHg
- PAH
- PBDE
- Pesticides
- « Urban tracers » : pharmaceutics + pesticides
- Radionuclides associated to power plants releases (HTO, ^{14}C)

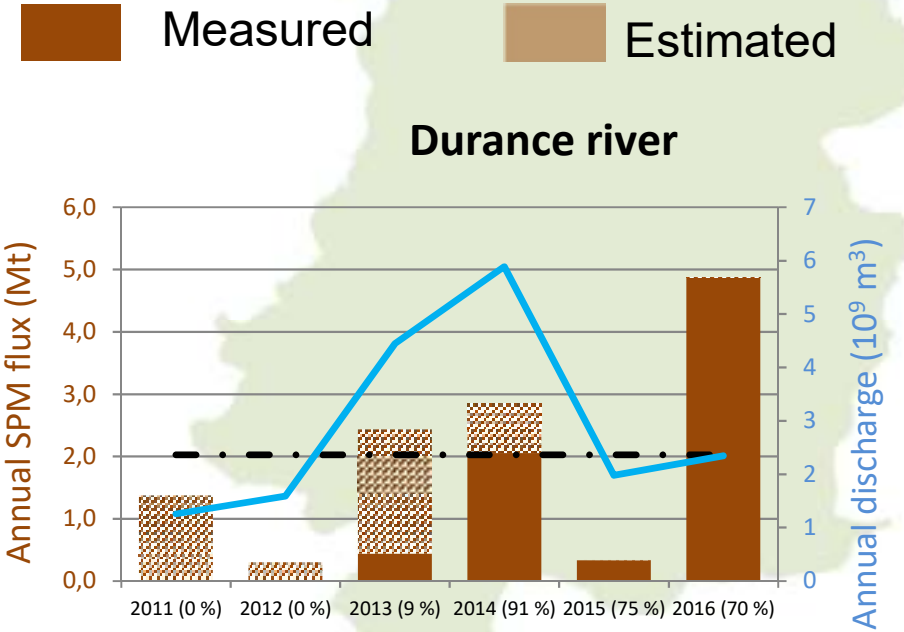
This dataset helps to construct a good expertise on the transfer of SPM and contaminants

Exemple 1: Providing validated SPM fluxes

SPM Data measured or reconstructed when missing through SPM-discharge relationship → <u>precise estimation of present and past fluxes</u>

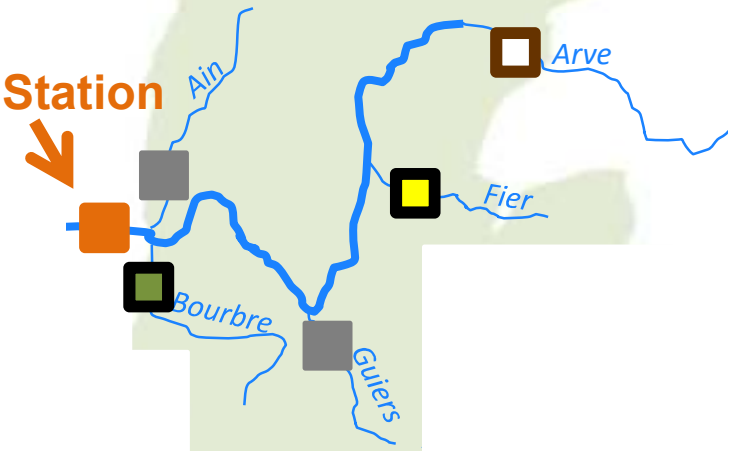




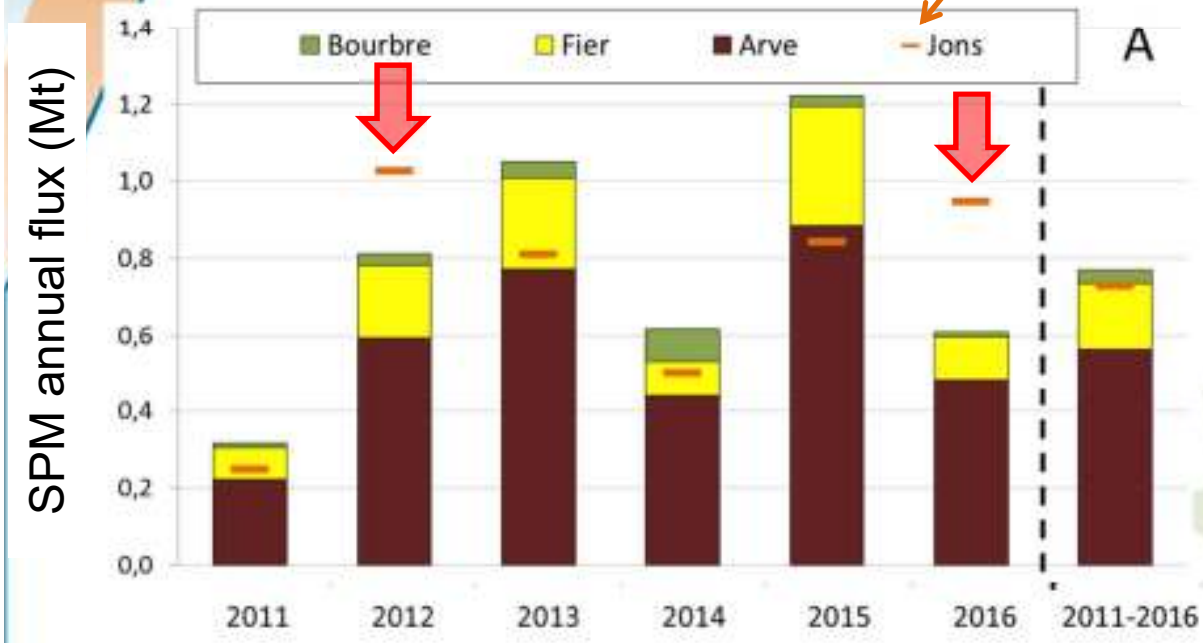


Exemple 2: Defining the contribution from tributaries and the role of temporal storages

The role of dam flushing on SPM and contaminant transfers at the basin scale is still unknown by both stakeholders and public



Dam flushing (2012, 2016)



- Main contributors are evidenced.
- Dam flushing conducted each 4 years within the Rhone allow to « equilibrate » the SPM transfer

Exemple 3 : Highlighting the environmental risk

Method proposed to map the environmental risk associated to organic contaminants:

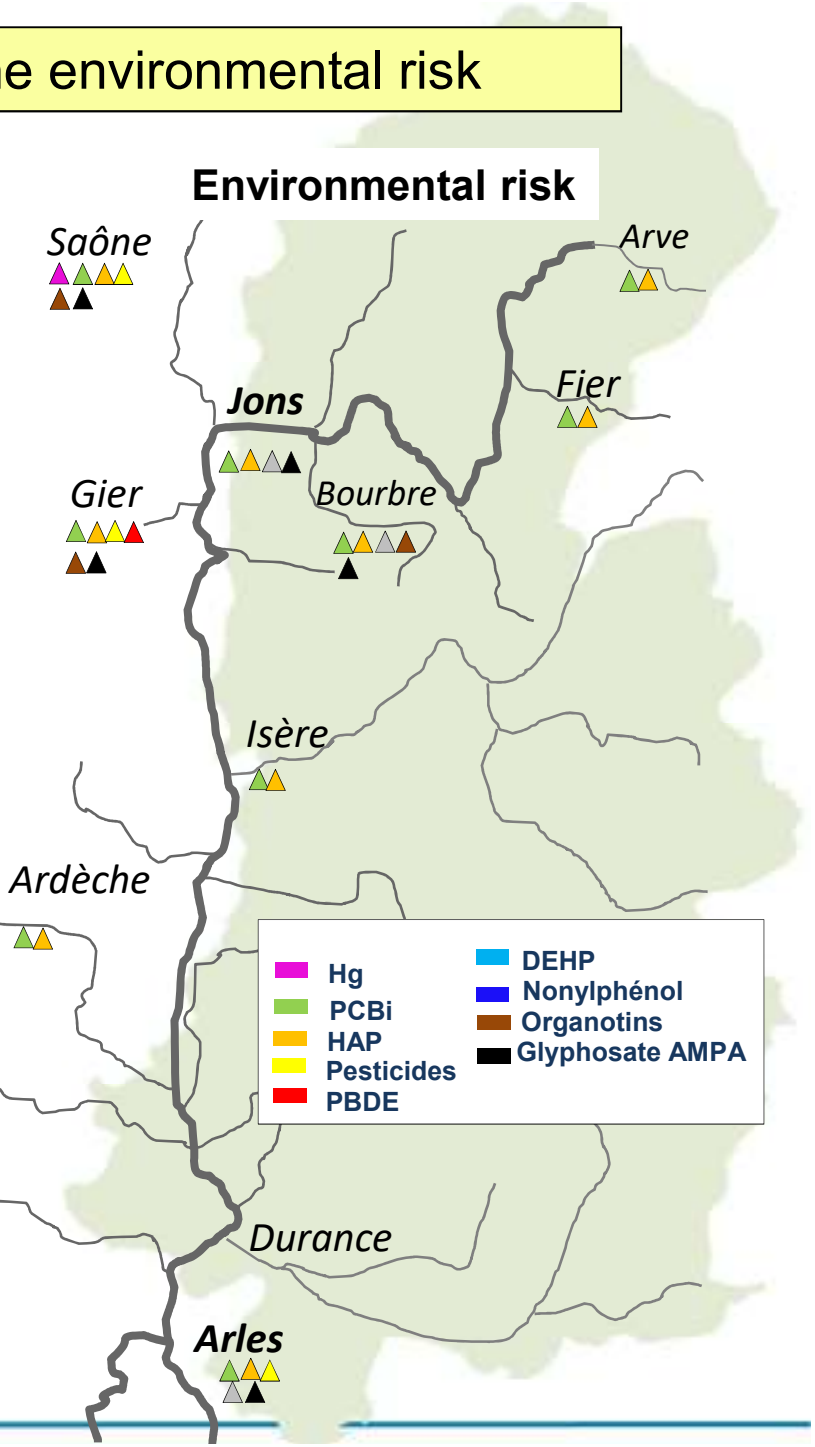
Comparison of concentrations with sediment quality guidelines *(PNEC: predicted non effect concentration),* taking into account their temporal trends

↓

Calculation of the frequency of measures exceeding the threshold

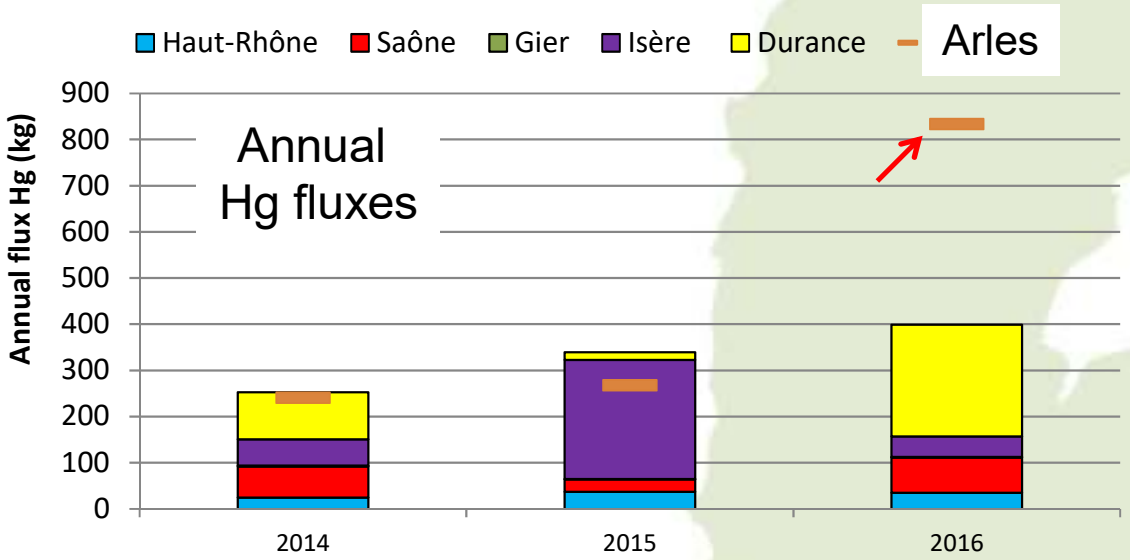
↓

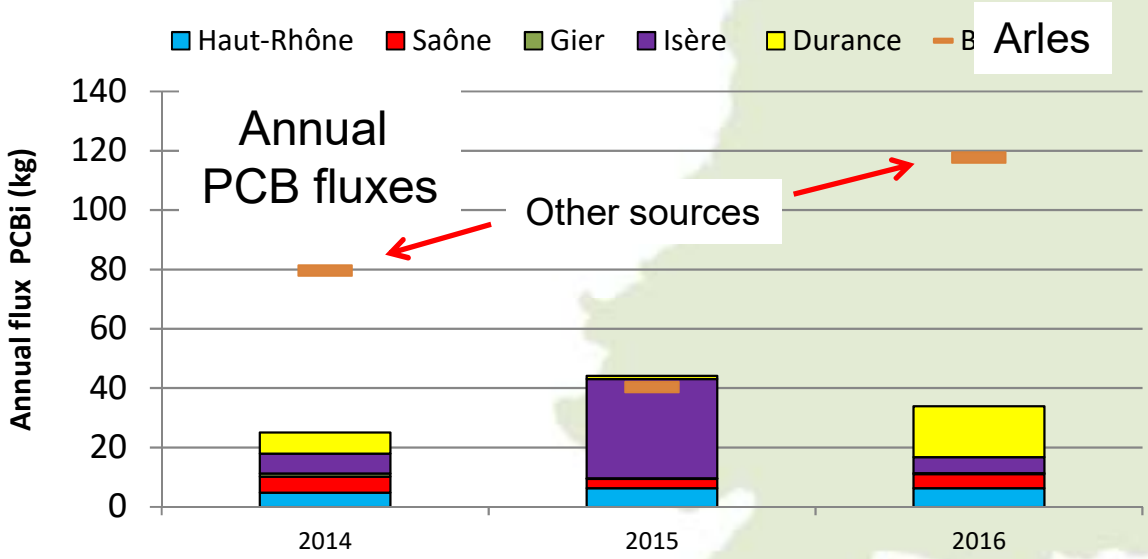
Simple map illustrating where the risk may occur (→ support to Water Agency).



Exemple 4 : Highlighting the potential origin of contaminants

Mass budgets allow to precise the origin of contaminants → inputs from tributaries vs output to the sea (Arles)

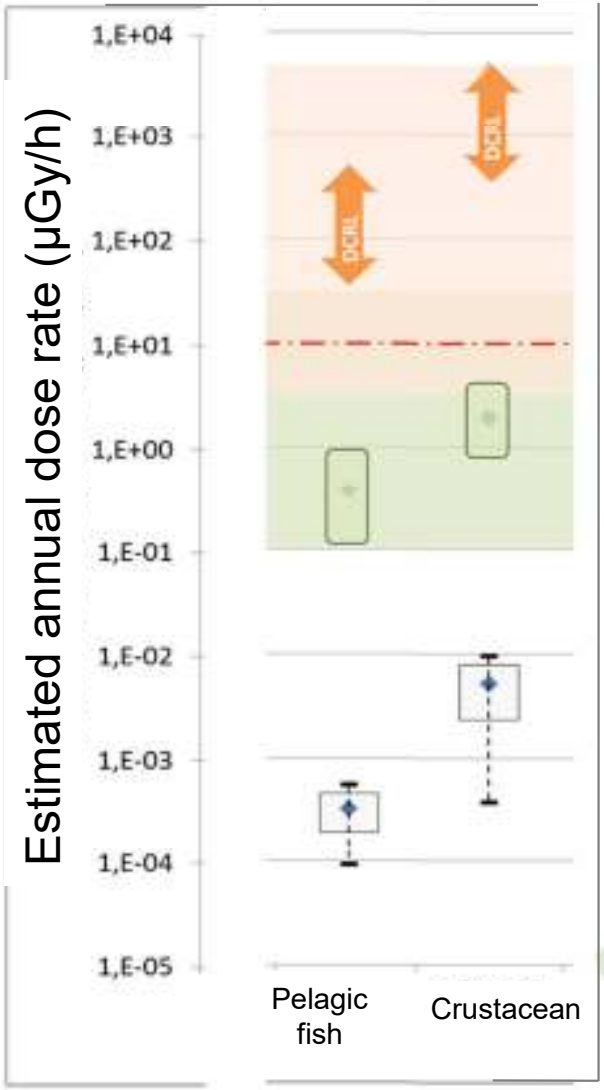




Exemple 5 : Estimation of the dose rate absorbed by reference organisms

IRSN
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

Evaluation of the **annual dose rate** absorbed by Reference Organisms according to the ERICA methodology



CIPR reference values (Derived Consideration Reference Levels)

Predicted No-Effect Dose Rate for the ecosystem

Dose rate due to natural background (U, Rn, Ra...)

Dose rate due to artificial RN (gamma: ^{110m}Ag, ^{241}Am, ^{57}Co, ^{58}Co, ^{60}Co, ^{134}Cs, ^{137}Cs, ^{54}Mn, ^{125}Sb)

Radionuclides dataset

Beaugelin-Sellier, Lepage, Gilbin

Modelling of SPM and contaminant transfer

The objective is to model water and SPM transfer and fluxes over the whole river:

545 km

21 hydroelectric dams

6 major and 26 minor tributaries

.

1D hydraulic model : MAGE

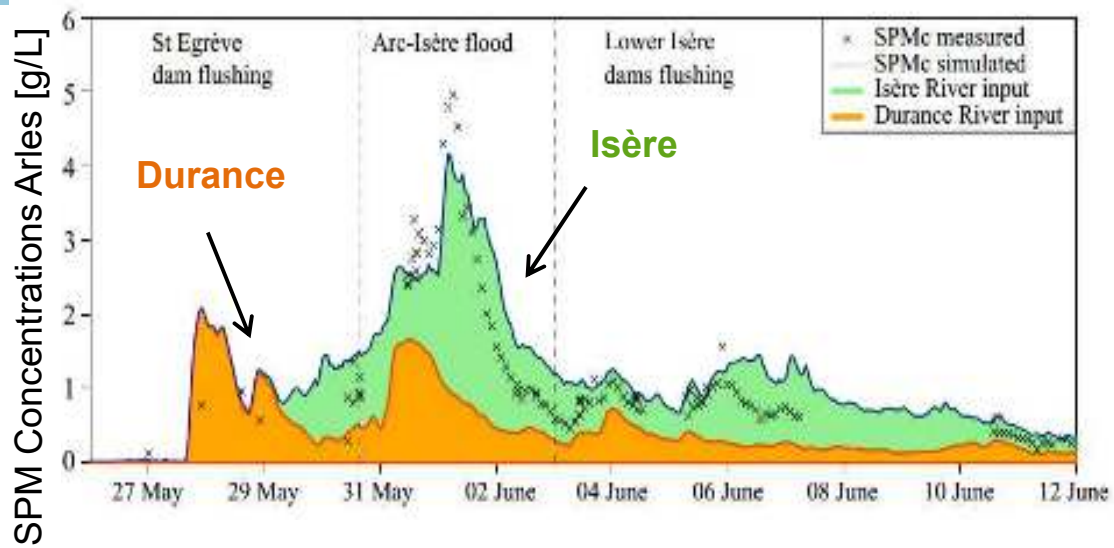
1D sediment model: ADIS-TS

Very fast calculation !

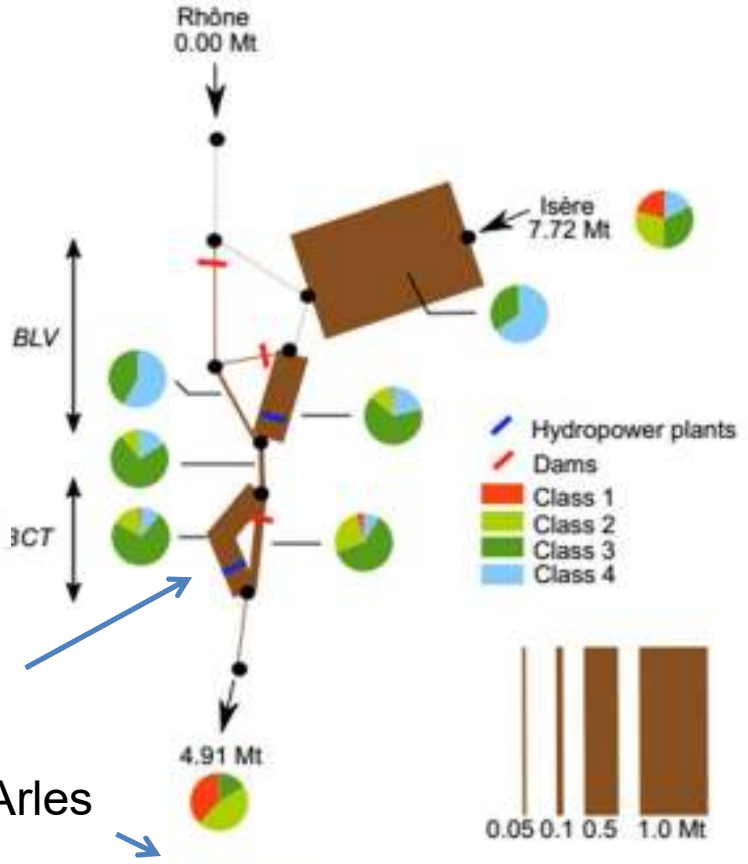
5mn running time for a 16 days simulation over 300 km (Lyon → sea)

An important goal is to reproduce the transfer and deposition during floods or flushing operations

Simulation of the SPM content in Arles compared to real measures during a flood in 2008 due to Isere and Durance tributaries



Simulation of mass deposited and grain size distribution



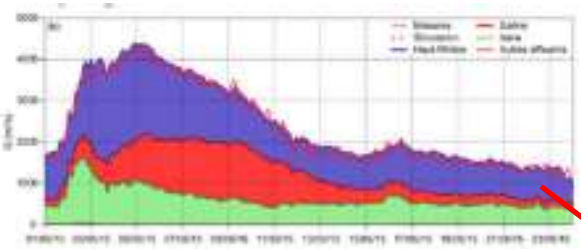
Storage of sediment in the dams

Arles

A final objective will be to combine three hydrosedimentary models to get a source-to-sink simulation : RIVER→ ESTUARY →CONTINENTAL MARGIN

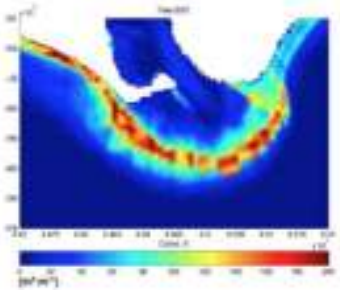
irstea

1D-MAGE +ADIS-TS



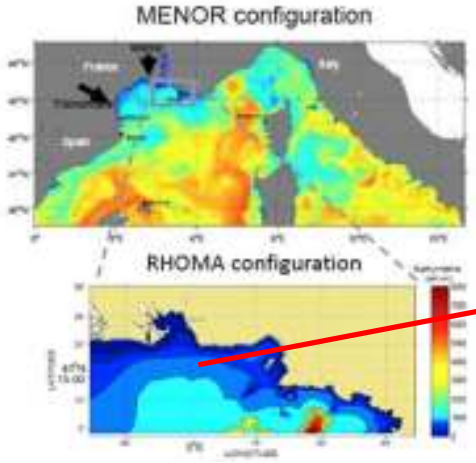
cerege

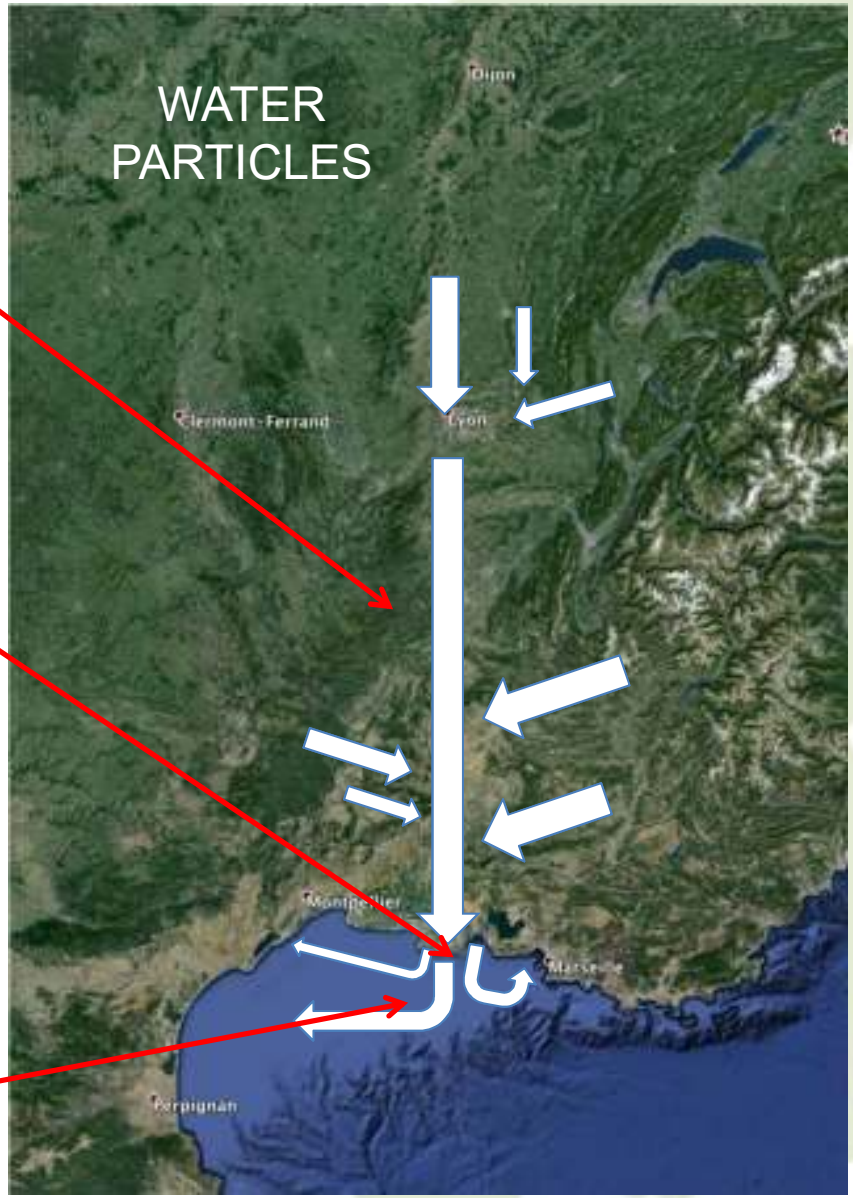
2D DELFT Deltares



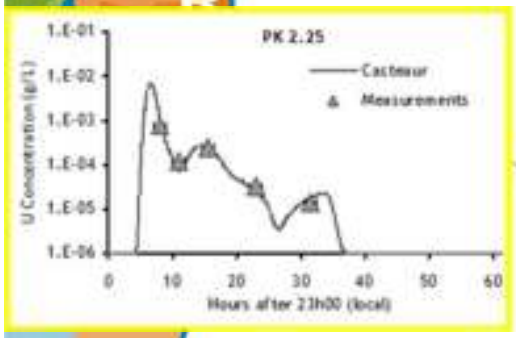
Ifremer

3D – RHOMA + MARS



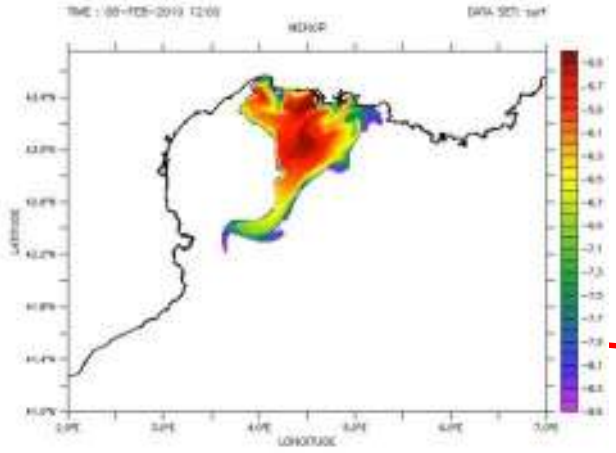


For IRSN, the objective is to combine his own models of hydrological and radionuclides transfer to get a source-to-sink simulation : RIVER→ ESTUARY →CONTINENTAL MARGIN

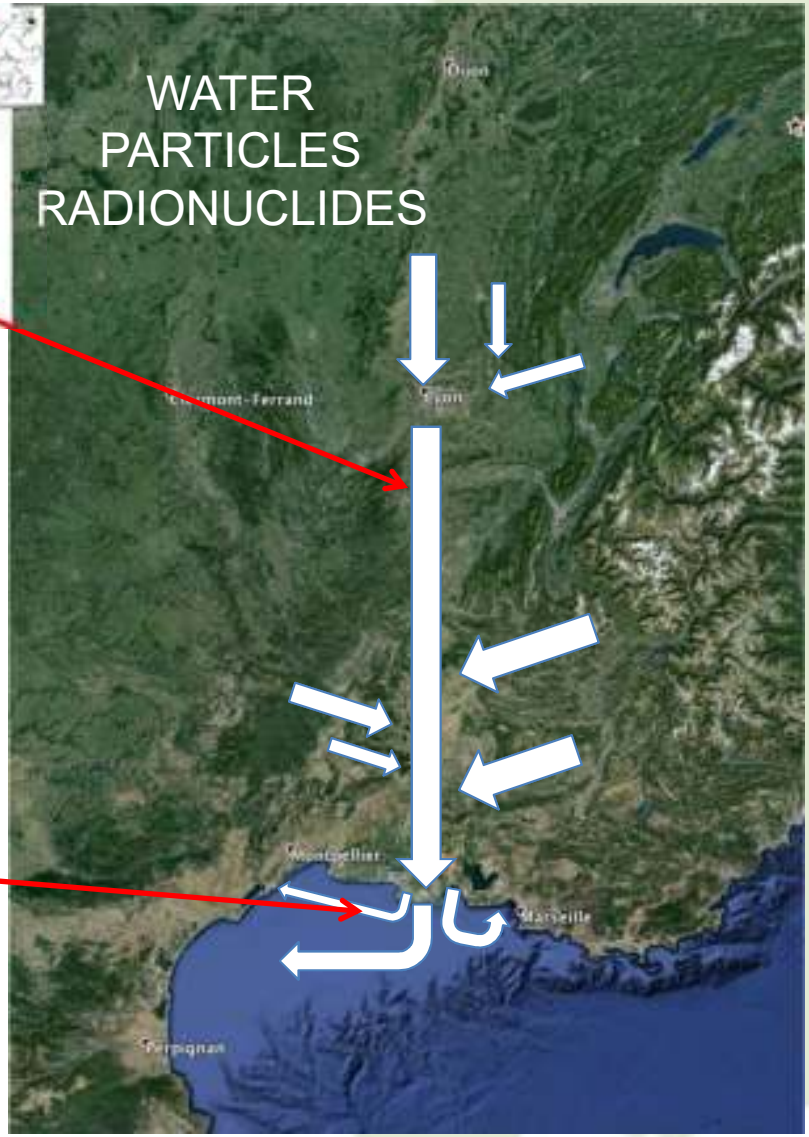


CASTEAUR
Radionuclides transfers in rivers

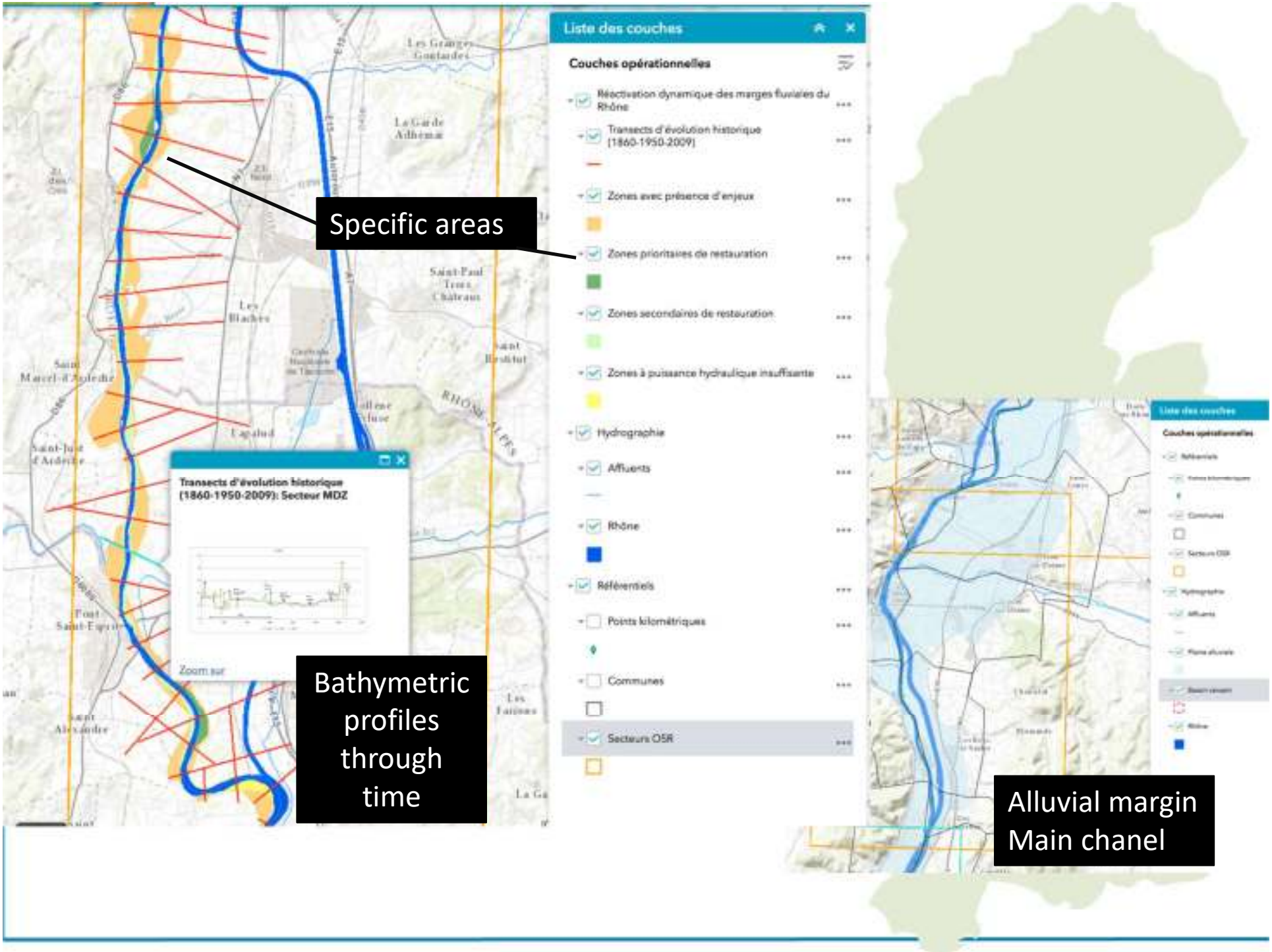
STERNE
Simulation de crise du Transport et des transferts d'Éléments Radioactifs en Environnement marin

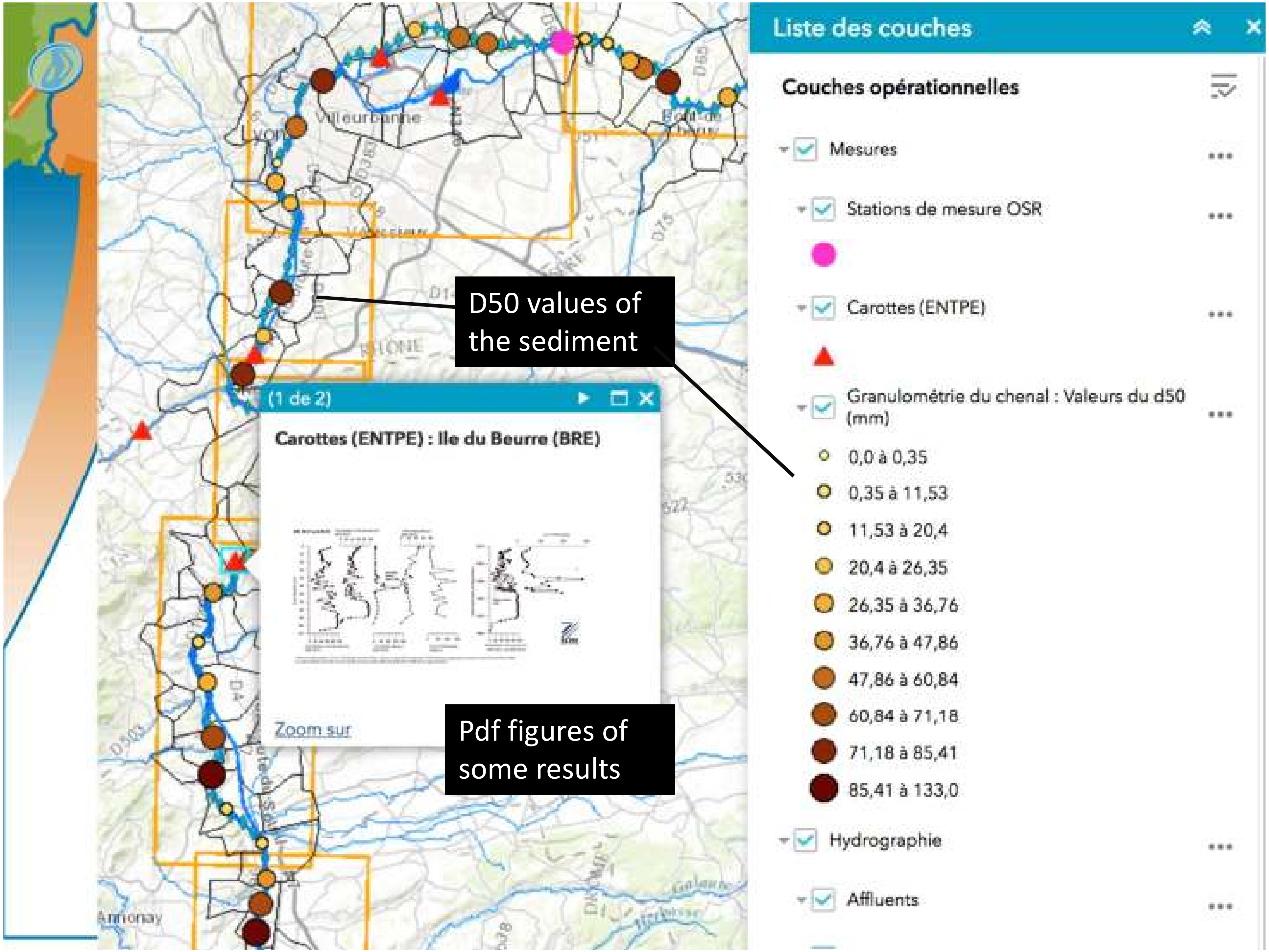


PhD starting in October 2018



A webmapping system provides an access to some geographical informations:
maps and figures
https://websig.ens-lyon.fr:3344/webappbuilder/apps/39/


Liste des couches
Couches opérationnelles
Réactivation dynamique des marges fluviales du Rhône
Transects d'évolution historique (1860-1950-2009)
Zones avec présence d'enjeux
Zones prioritaires de restauration
Zones secondaires de restauration
Zones à puissance hydraulique insuffisante
Hydrographie
Affluents
Rhône
Référentiels
Points kilométriques
Communes
Secteurs OSR
Transects d'évolution historique (1860-1950-2009): Secteur MDZ
Zoom sur
Specific areas
Bathymetric profiles through time
Alluvial margin
Main chanel



Liste des couches
Couches opérationnelles
Mesures
Stations de mesure OSR
Carottes (ENTPE)
Granulométrie du chenal : Valeurs du d50 (mm)
0,0 à 0,35
0,35 à 11,53
11,53 à 20,4
20,4 à 26,35
26,35 à 36,76
36,76 à 47,86
47,86 à 60,84
60,84 à 71,18
71,18 à 85,41
85,41 à 133,0
Hydrographie
Affluents
(1 de 2)
Carottes (ENTPE) : Ile du Beurre (BRE)
Zoom sur
D50 values of the sediment
Pdf figures of some results
Villeurbanne
Lyon
Annonay

http://www.graie.org/osr/

Special issue
« Science of the Total Environment »
2018

Collaborators : J. Gattacceca, S. Gairoard, M. Launay, H Angot, R. Gilbin, K. Beaugelin-Sellier, M. Masson., J.B. Faure, V. Dugué