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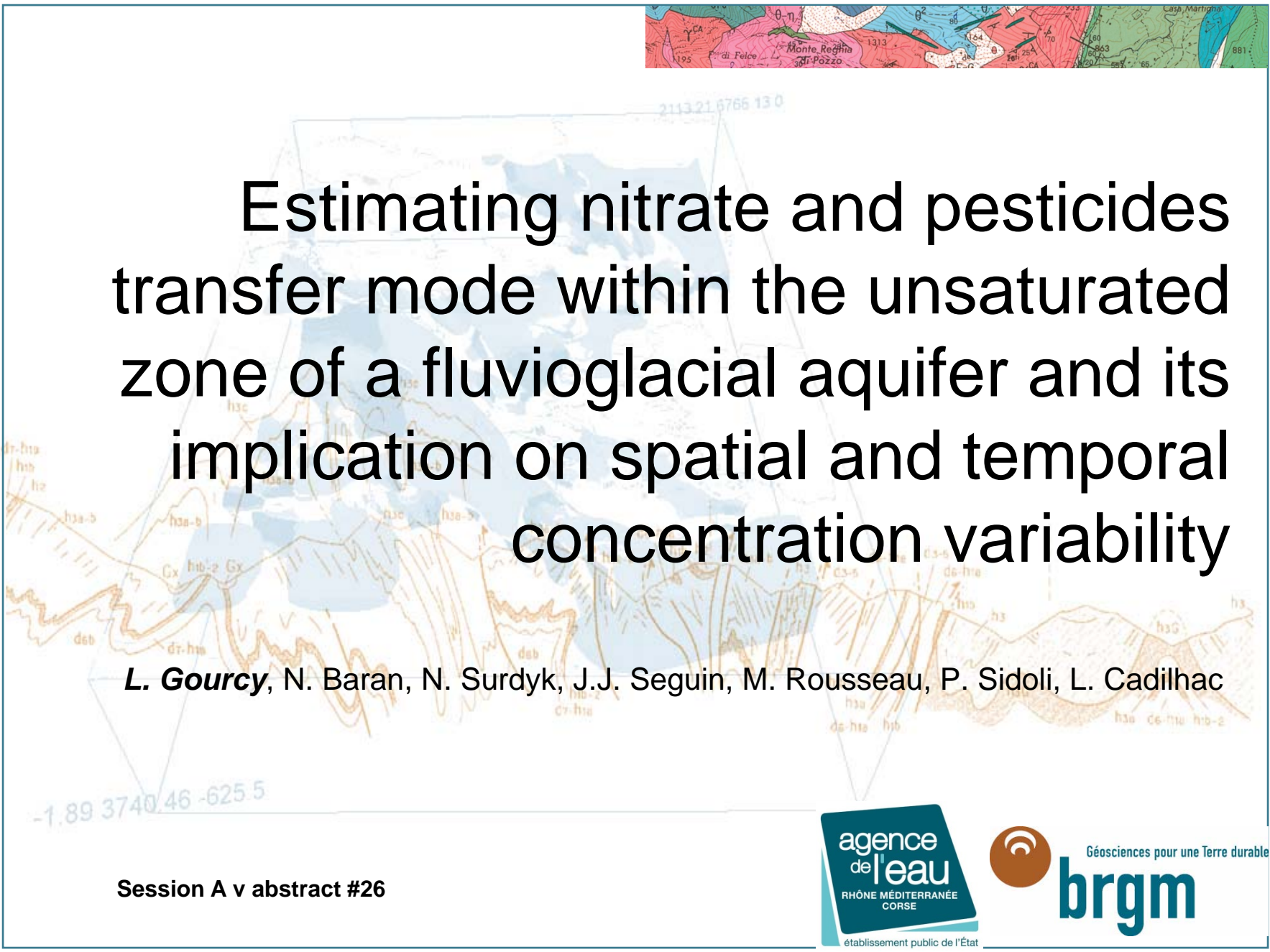
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# Estimating nitrate and pesticides transfer mode within the unsaturated zone of a fluvio-glacial aquifer and its implication on spatial and temporal concentration variability

**L. Gourcy**, N. Baran, N. Surdyk, J.J. Seguin, M. Rousseau, P. Sidoli, L. Cadilhac

Session A v abstract #26

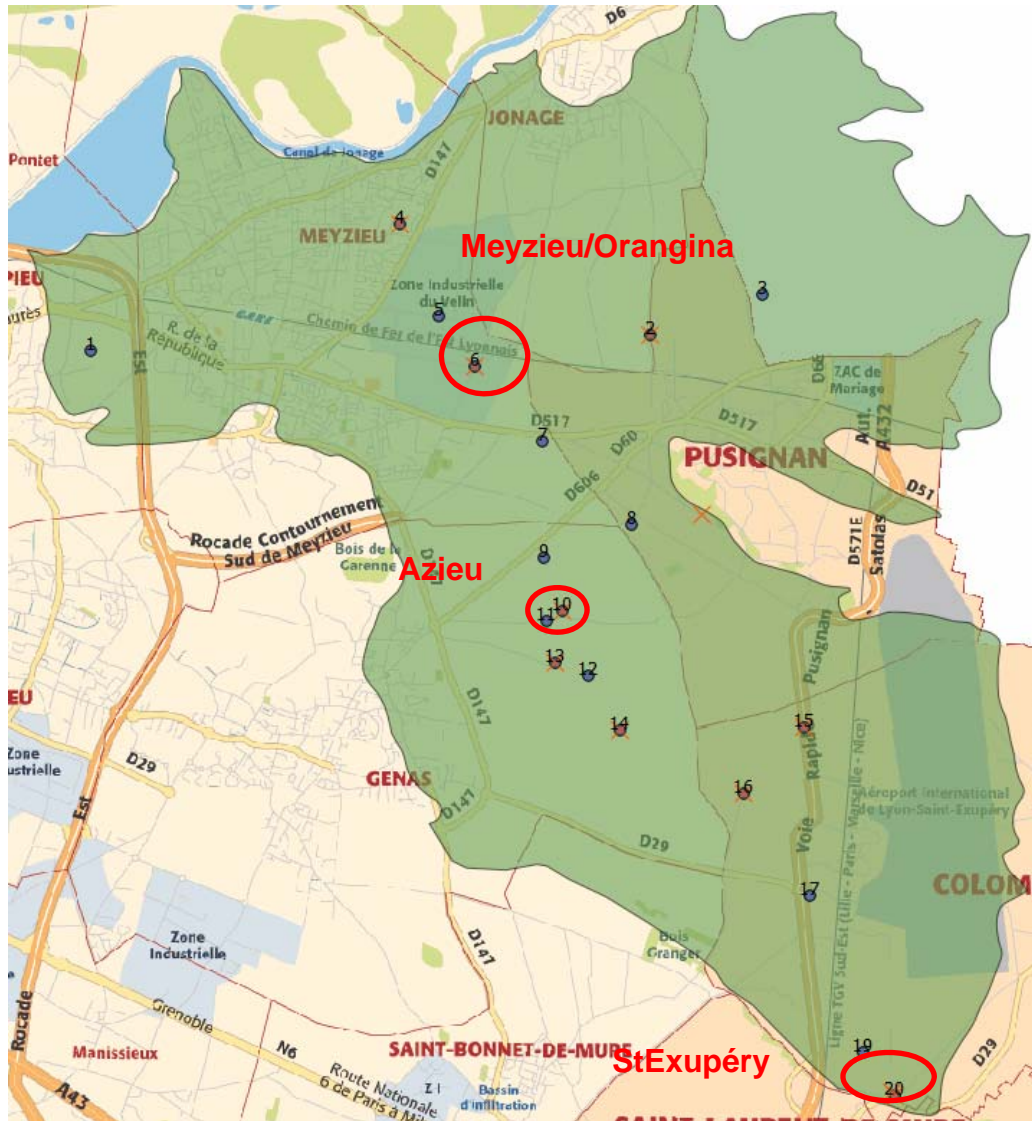
# Objective and context of the study

- 2012-2017 research project funded by the Water Agency and BRGM (including a pH-D work)
- To improve knowledge on contaminant transfer from soil to groundwater
- Fluvio-glacial aquifer with important unsaturated zone (up to 40m height)





## Location and sampling points



- > **3 water sampling points** – monthly
- > **23 water points** – 2 sampling campaigns
- > **43 soil samples**
- > **4 points** – daily water level



# Approach for nitrate transfer understanding

## > **Monitoring**

- Spatial variability (existing and new acquired data from 2 sampling campaigns)
- Temporal trend (at 3 points from 2012 to 2016) and historical data
- Combined with water level, all major chemicals, GW age dating

## > **Data interpretation**

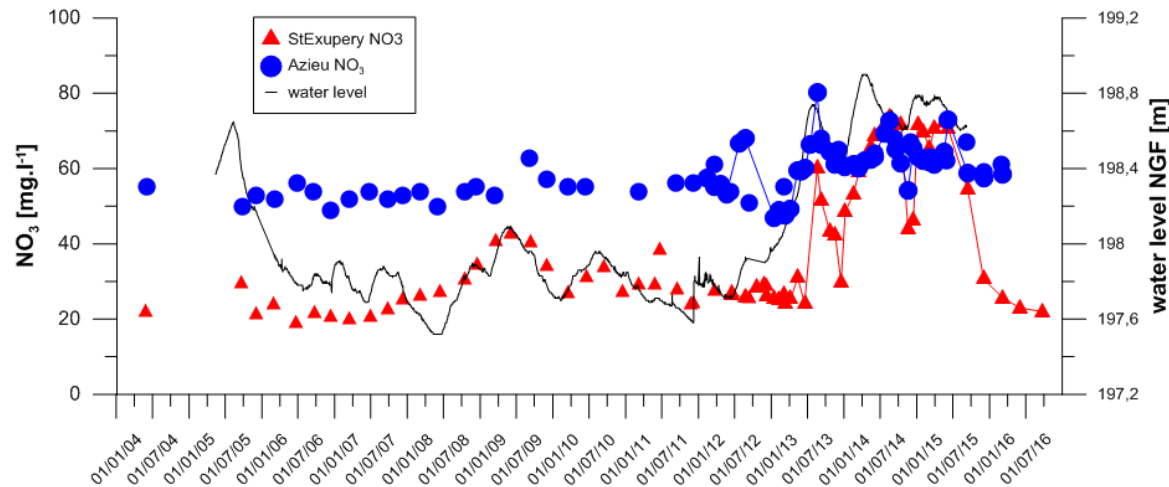
- Pressure estimation ( $\text{NO}_3$  leaching)
- Geochemical analyses
- Statistical data treatment

## > **Modeling**

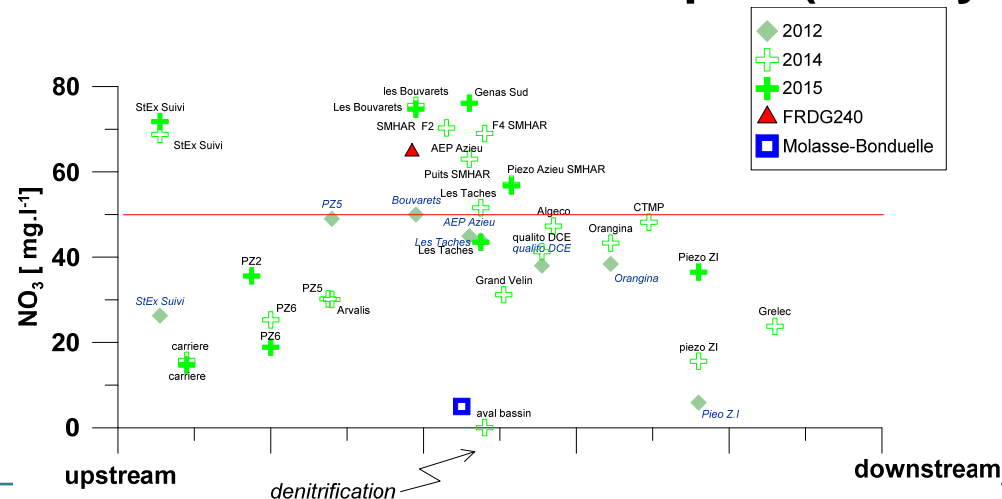
- Global modeling (@BICHE)
- Physically-based modeling (2D @MARTHE)

# Monitoring

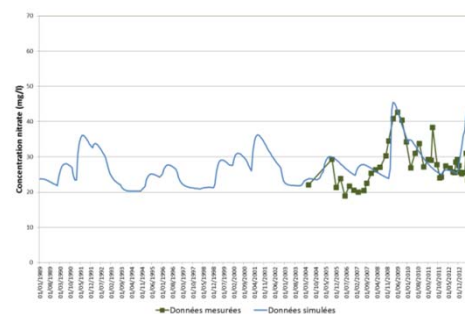
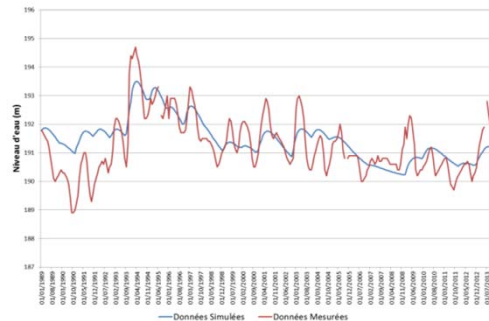
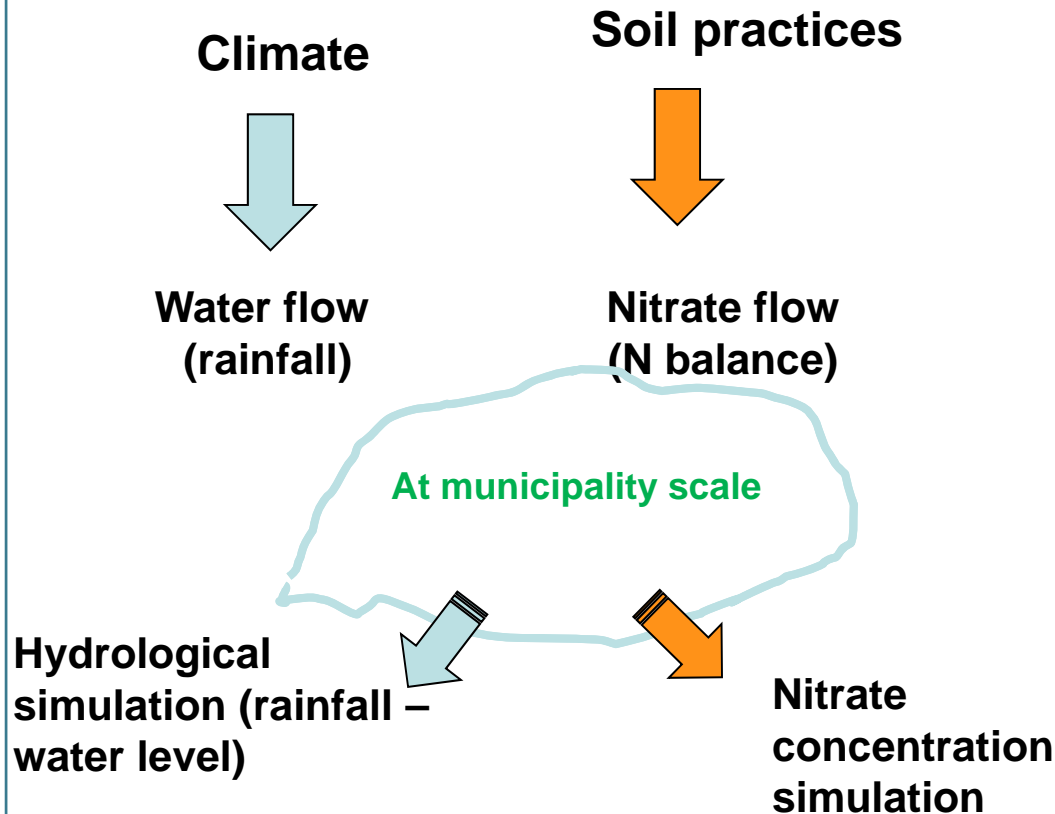
- Quite stable in the central part - high variation linked to water level changes in the upstream part



- Higher concentrations in the central part (mainly agriculture)



# Global modeling



## > Initial conditions

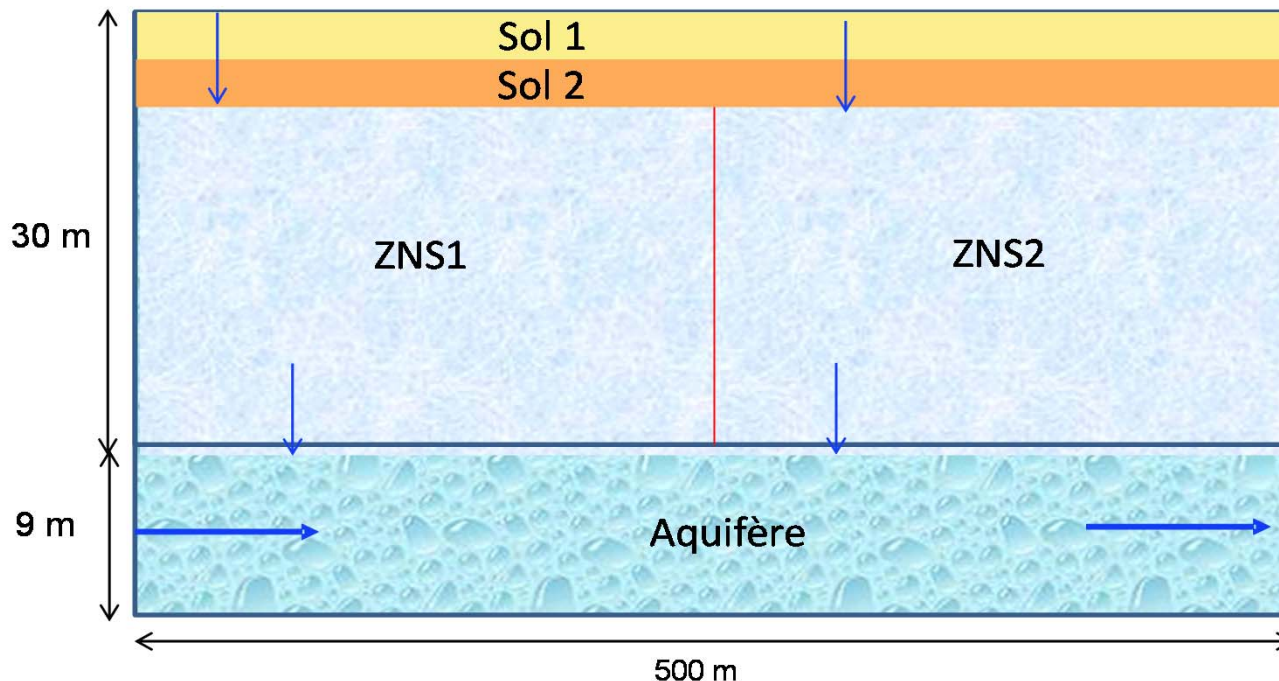
- H and NO<sub>3</sub> from 1987 to 2015
- Historical information on agricultural practices at municipality scale

## > Outputs

- N balance established
- Tool available for simulation of important/large scale changes

# Physically-based modeling

- 2 D vertical plan – theoretically representing the center of the studied area

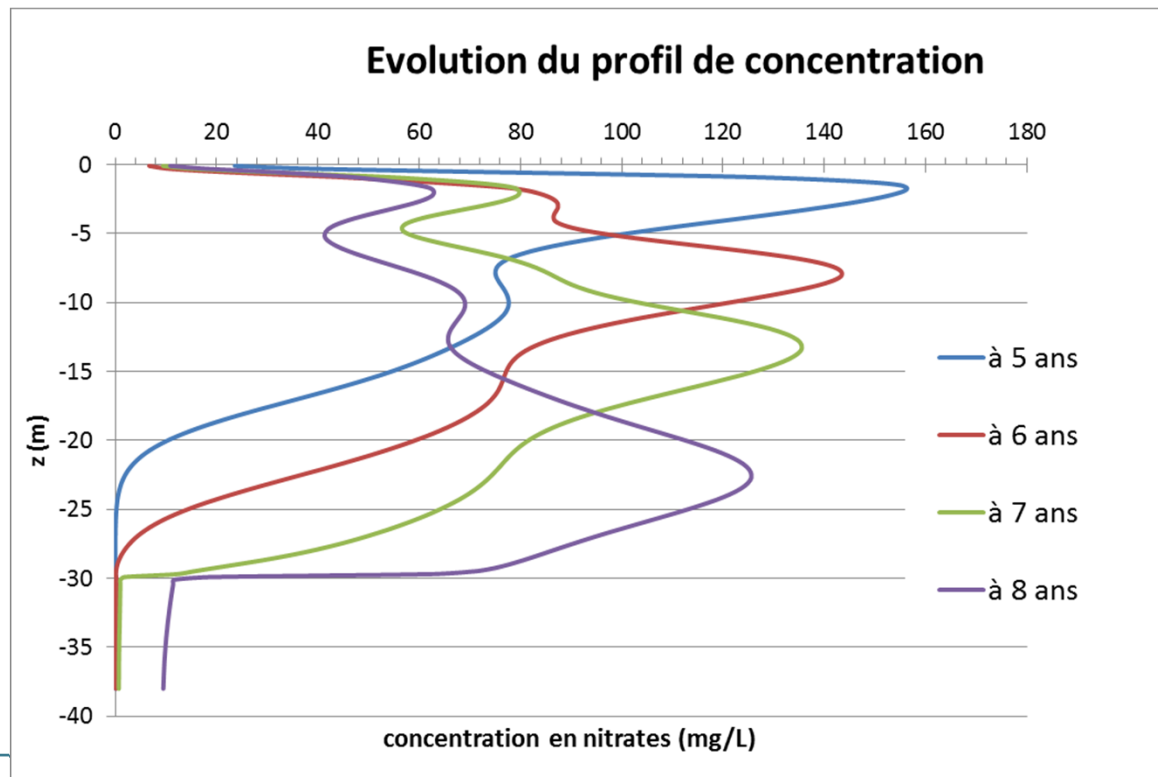


- 4 zones characterized by a retention and a permeability law : 2 soils superposed and 2 unsaturated zone with different characteristics
- ZNS1: Fluvio-glacial formation representing well the studied sector
- ZNS2: gravels dominating – extreme flow condition



# Outputs of the physical modeling

- Delay of first arrival of  $\text{NO}_3$  in the saturated zone is 6/7 years (3/4 in ZNS2)
- Arrival of the central part of a  $\text{NO}_3$  peak in about 8 years (6 for ZNS2)
- Increase of the  $\text{NO}_3$  concentration in the aquifer when a  $\text{NO}_3$  peak arrives from the unsaturated zone depend on the peak intensity but can be up to 40 mg/L



# Approach for pesticide transfer understanding

## > **Monitoring**

- Spatial variability (existing and new acquired data from 2 sampling campaigns)
- Temporal trend (at 3 points from 2012 to 2016)
- Combined with water level, all major chemicals, GW age dating
- At one experimental site using a lysimeter of 1,4 m depth

## > **Data interpretation**

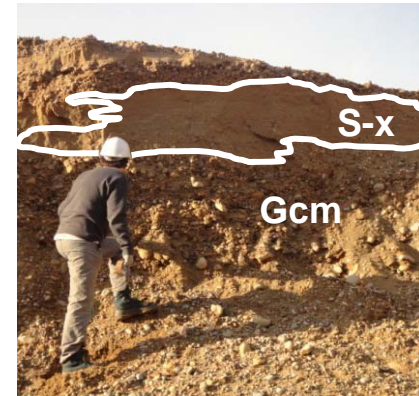
- Pressure estimation (pesticide used)
- Geochemical analyses

## > **Laboratory experimental work**

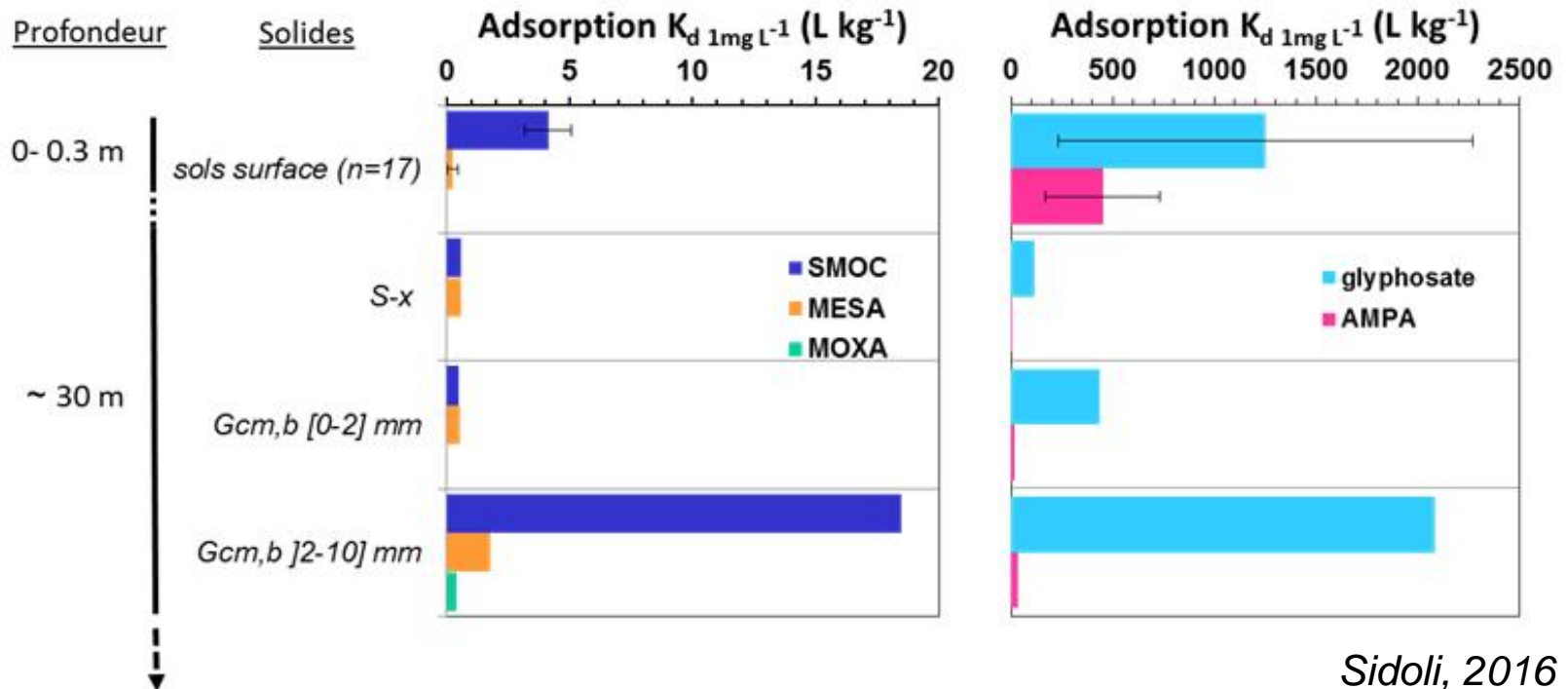
- Sorption experiments
- Column experiments

# Determining physico-chemical properties of molecules and reactivity in soils and USZ material

- > Works using soils and material from the studied area and using local conditions
- > Soil and molecules in batch samples
- > Selected molecules S-metolachlor, MESA and MOXA and glyphosate, AMPA
- > Determination of the mobility of molecules by estimating adsorption coefficient ( $K_d$ )
- > pH-D work from P. Sidoli



# Determining physicochemical properties of molecules and reactivity in soils and USZ material



Data from P. Sidoli (2015)

Sx : sand

Gcm,B : mixture of gravel and sand

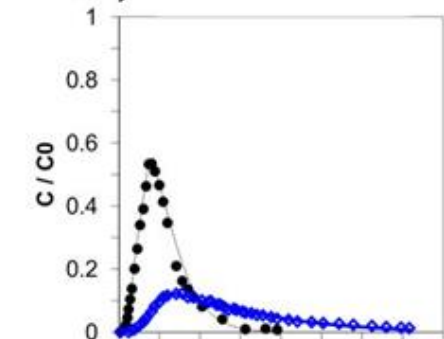
- Important reactivity in the fluvio-glacial material and mainly Gcm,b
- Glyphosate > AMPA >> SMOC > MESA > MOXA



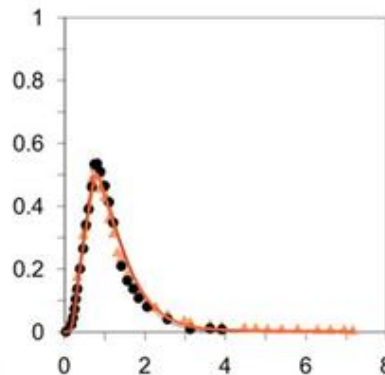
# P dynamics in the unsaturated zone

- Unsaturated zone column experiment
- Water + bromide + SMOC, MOXA, MESA

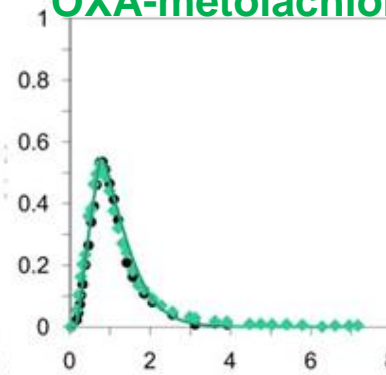
**Gcm,b** S-metolachlor



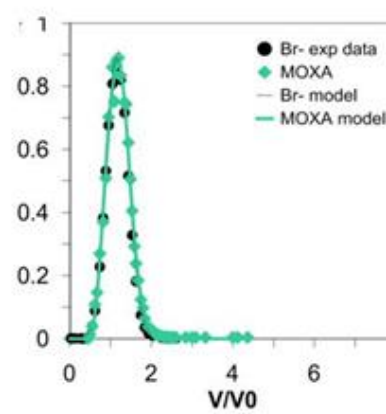
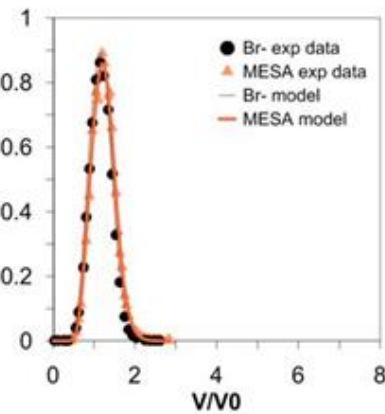
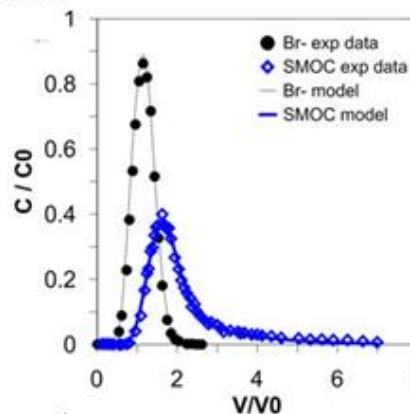
**ESA**-metolachlor



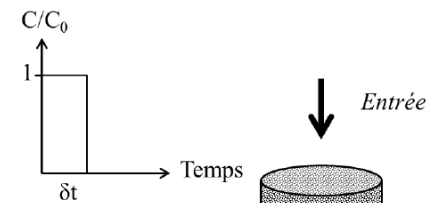
**OXA**-metolachlor



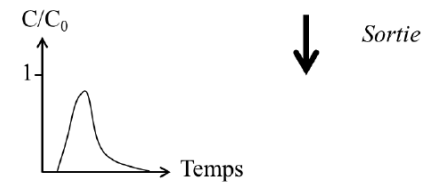
**S-x**



Créneau d'injection

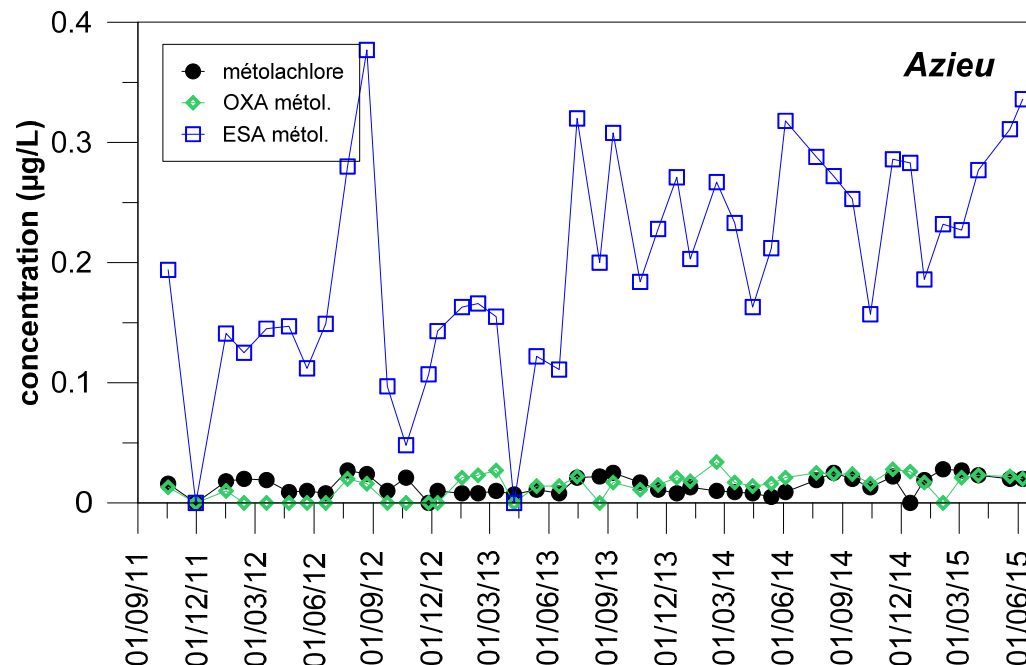


Courbe d'élution



# Outputs of pesticides experiments

- AMPA and glyphosate adsorption is strong in soil and unsaturated zone -> no molecules in groundwater – Degradation of these molecules is also possible in soils
- No delay effect in soils and USZ for metolachlor metabolites – these molecules are often quantified in the studied aquifer while SMOG is usually not found (and is the most frequently analyzed up to now)



# Operational conclusions

- > NO<sub>3</sub> transfer in the unsaturated zone is dominating
- > Changes in agricultural practices will be observed in the NO<sub>3</sub> groundwater concentration :
  - With delay, due to transfer time within the USZ
  - Without direct links due to a combination of various factors in N flow : N application, plants needs and rainfall
- > Short term trend is not a good indicator of efficiency of changes of practices – long term trend should be used
- > Metabolites of specific pesticides (acetochlor, alachlor, metolachlor) can be released to GW a few years after the last application