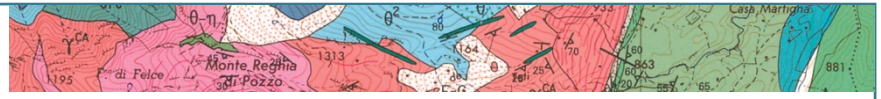
Estimating nitrate and pesticide transfer mode within the unsaturated zone of a fluvioglacial aquifer and its implication on spatial and temporal concentration variability

Laurence Gourcy, Nicolas Surdyk, Laurent Cadilhac, Nicole Baran, Marie Rousseau, Jean-Jacques Seguin



Estimating nitrate and pesticides transfer mode within the unsaturated zone of a fluvioglacial 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

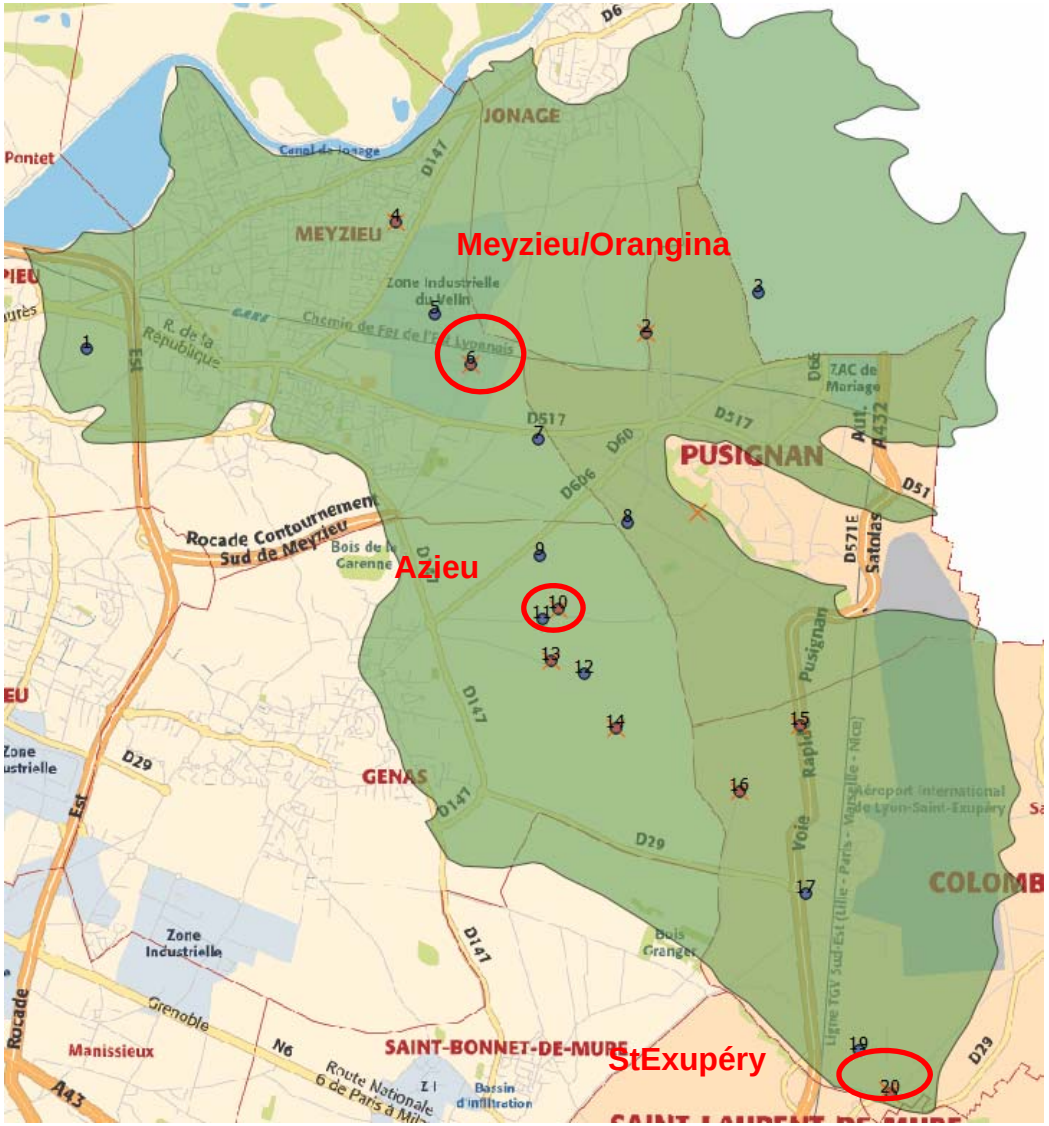
agence de l'eau RHÔNE MÉDITERRANÉE CORSE
établissement public de l'État

Géosciences pour une Terre durable
brgm

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

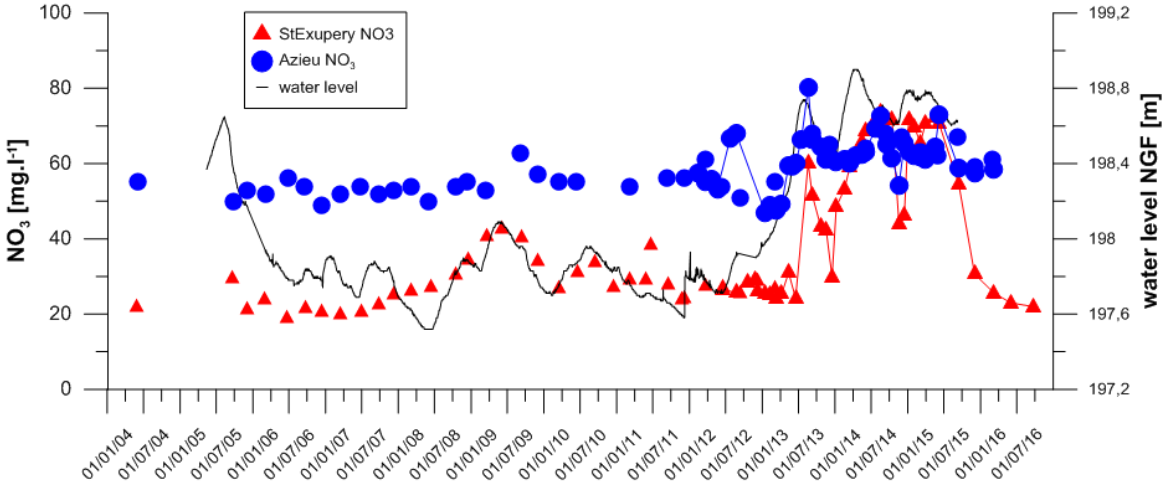
- Pressure estimation (NO_3 leaching)
- Geochemical analyses
- Statistical data treatment

> Modeling

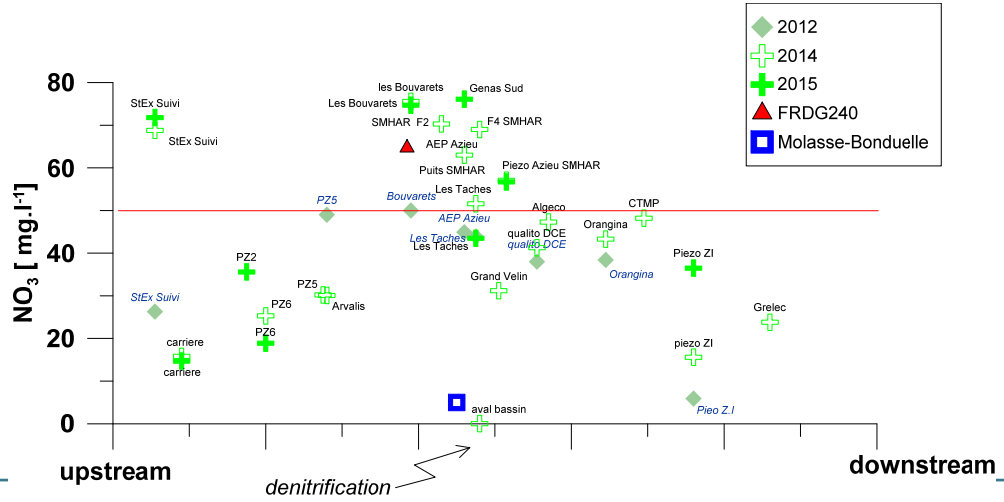
- Global modeling (@BICHE)
- Physically-based modeling (2D @MARTHE)

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

Climate

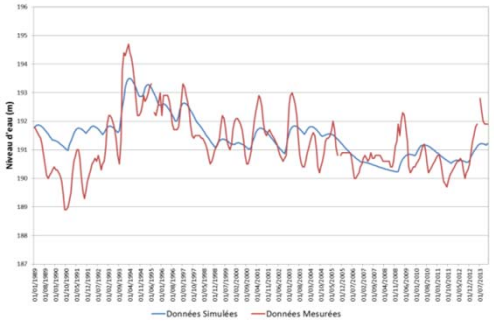
Soil practices

Water flow (rainfall)

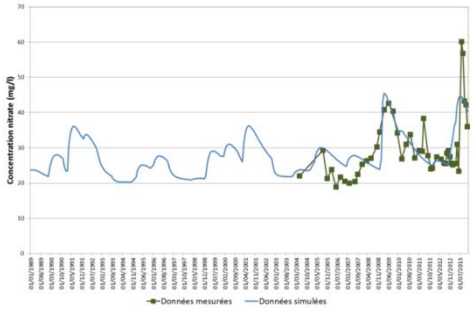
Nitrate flow (N balance)

At municipality scale

Hydrological simulation (rainfall – water level)



Nitrate concentration simulation



> Initial conditions

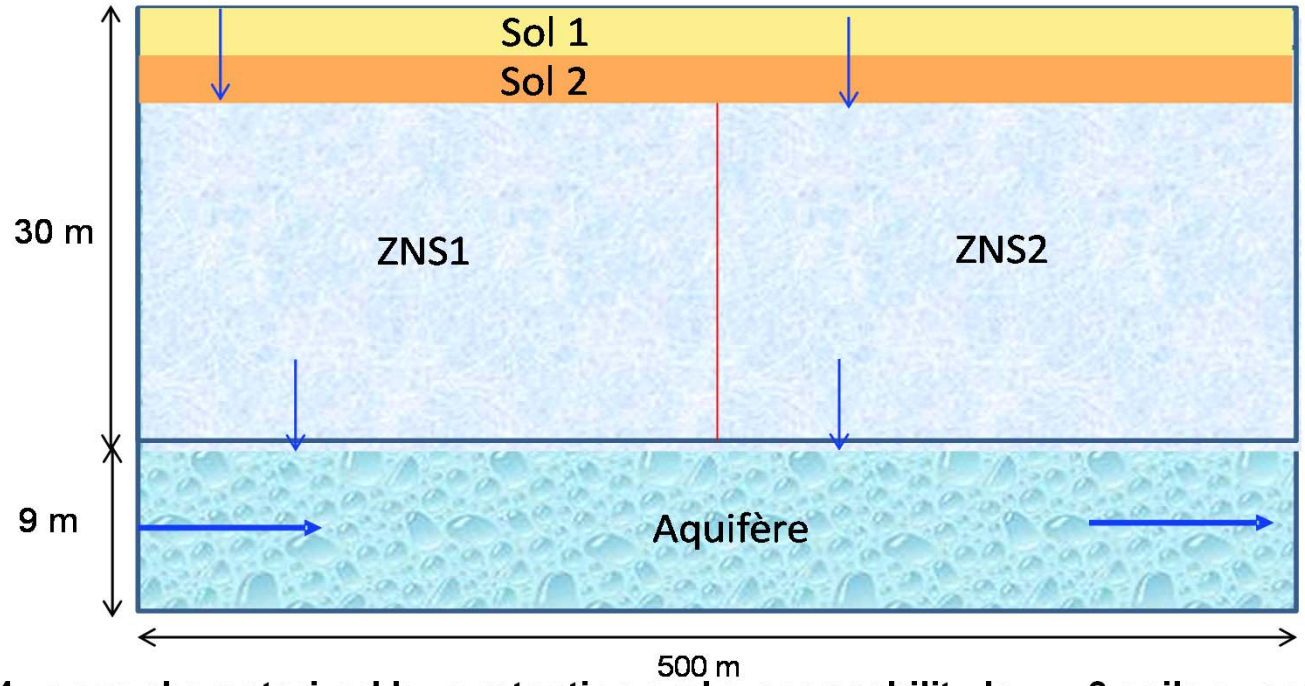
- H and NO_3 from 1987 to 2015
- Historical information on agricultural practices at municipality scale

> Outputs

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

Physically-based modeling

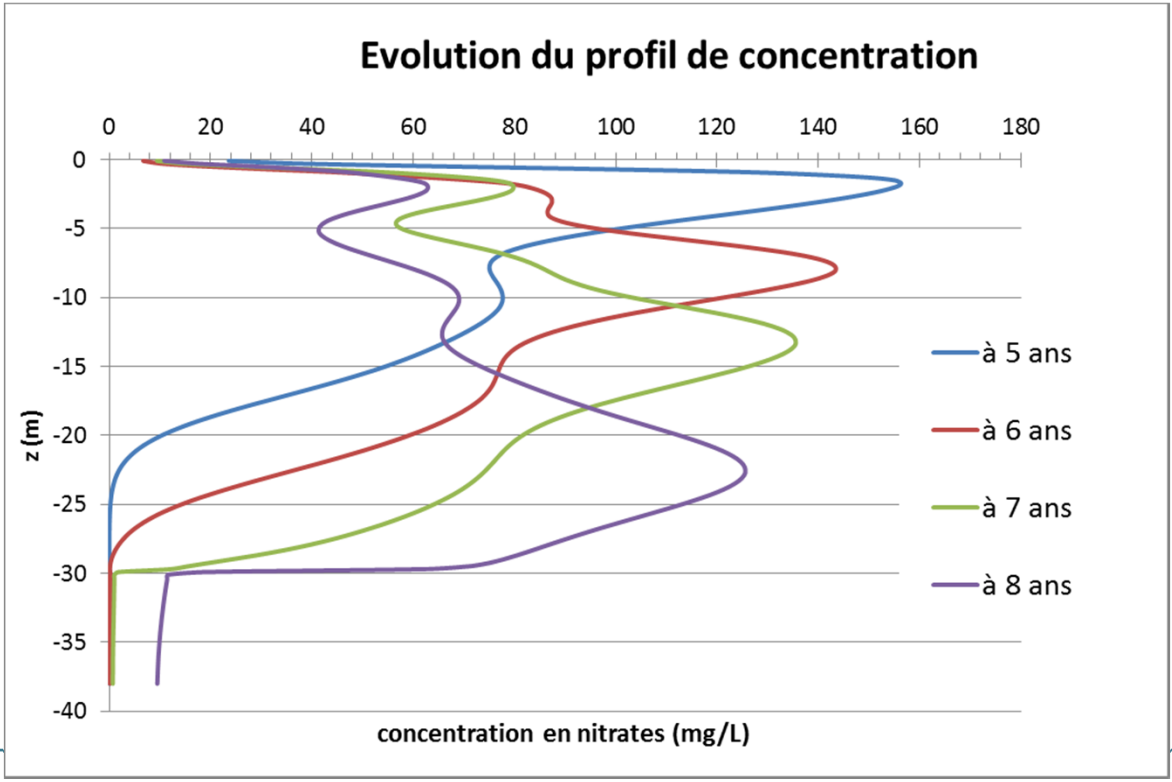
> 2 D vertical plan – theoretically representing the center of the studied area



- **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 NO_3 in the saturated zone is 6/7 years (3/4 in ZNS2)
- Arrival of the central part of a NO_3 peak in about 8 years (6 for ZNS2)
- Increase of the NO_3 concentration in the aquifer when a 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

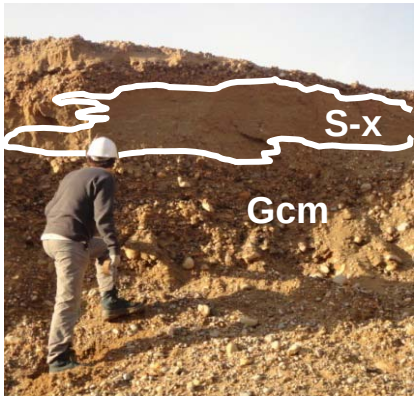
- Pressure estimation (pesticide used)
- Geochemical analyses

> Laboratory experimental work

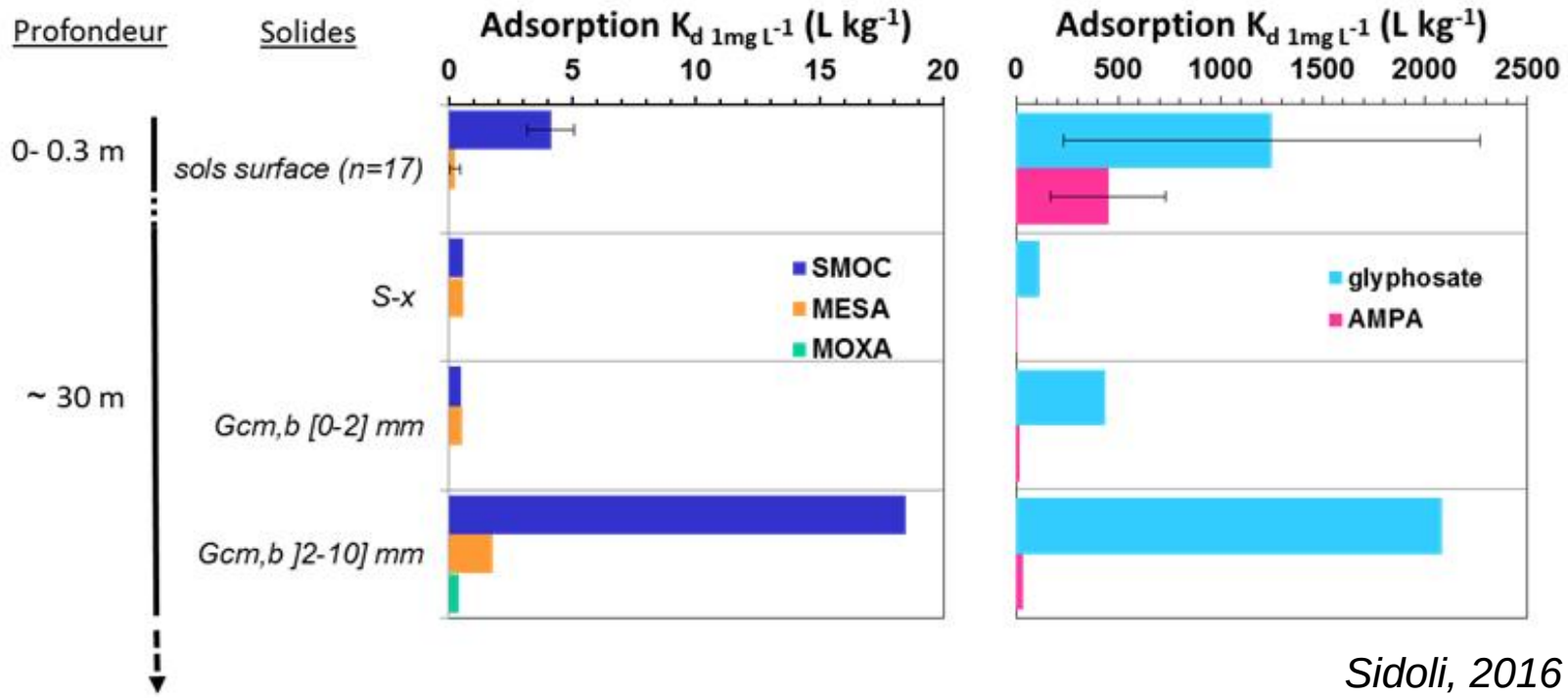
- Sorption experiments
- Column experiments

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 (Kd)
- pH-D work from P. Sidoli



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



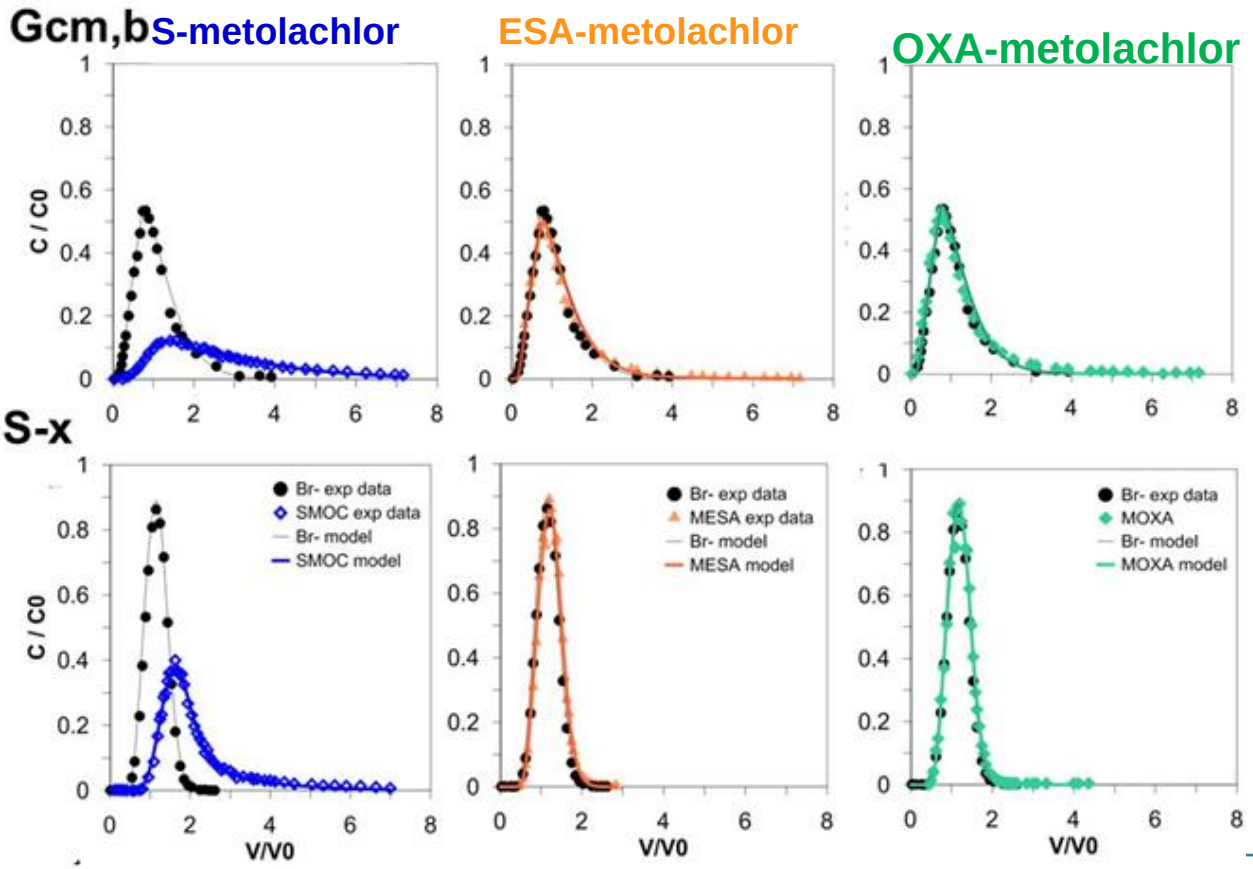
Sidoli, 2016

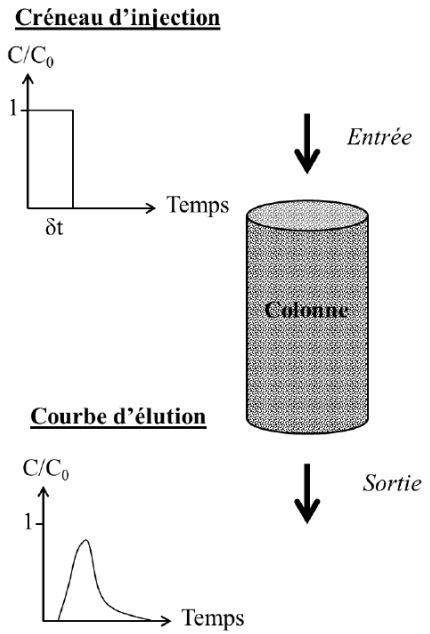
Data from P. Sidoli (2015)
Sx : sand
Gcm,B : mixture of gravel and sand

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

P dynamics in the unsaturated zone

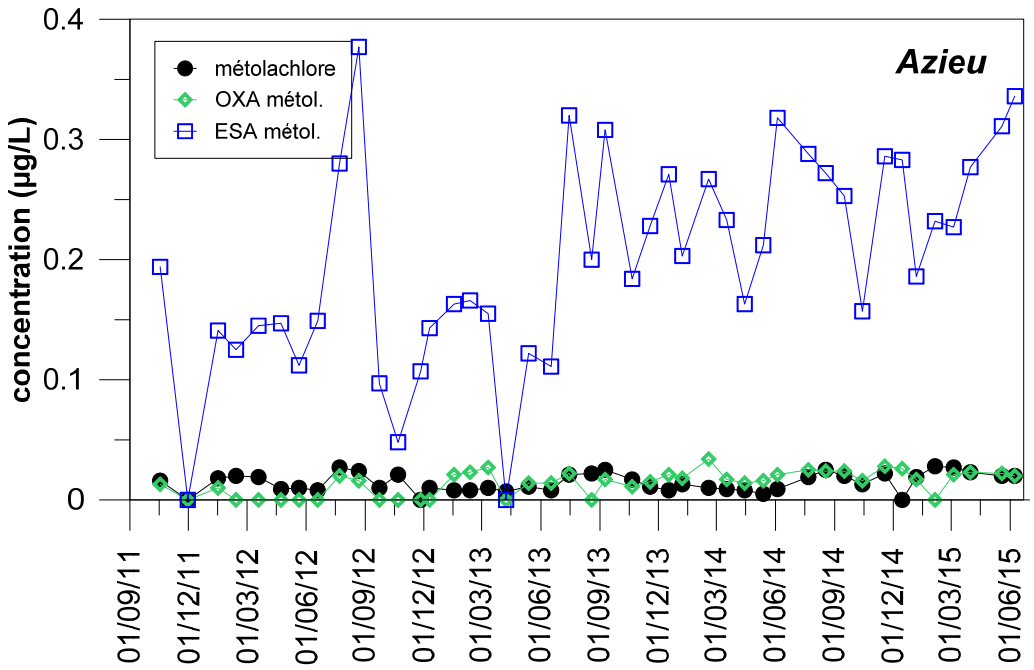
- Unsaturated zone column experiment
- Water + bromide + SMOC, MOXA, MESA





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 SMOC is usually not found (and is the most frequently analyzed up to now)



Operational conclusions

- NO_3 transfer in the unsaturated zone is dominating
- Changes in agricultural practices will be observed in the NO_3 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