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

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Session A v abstract #26
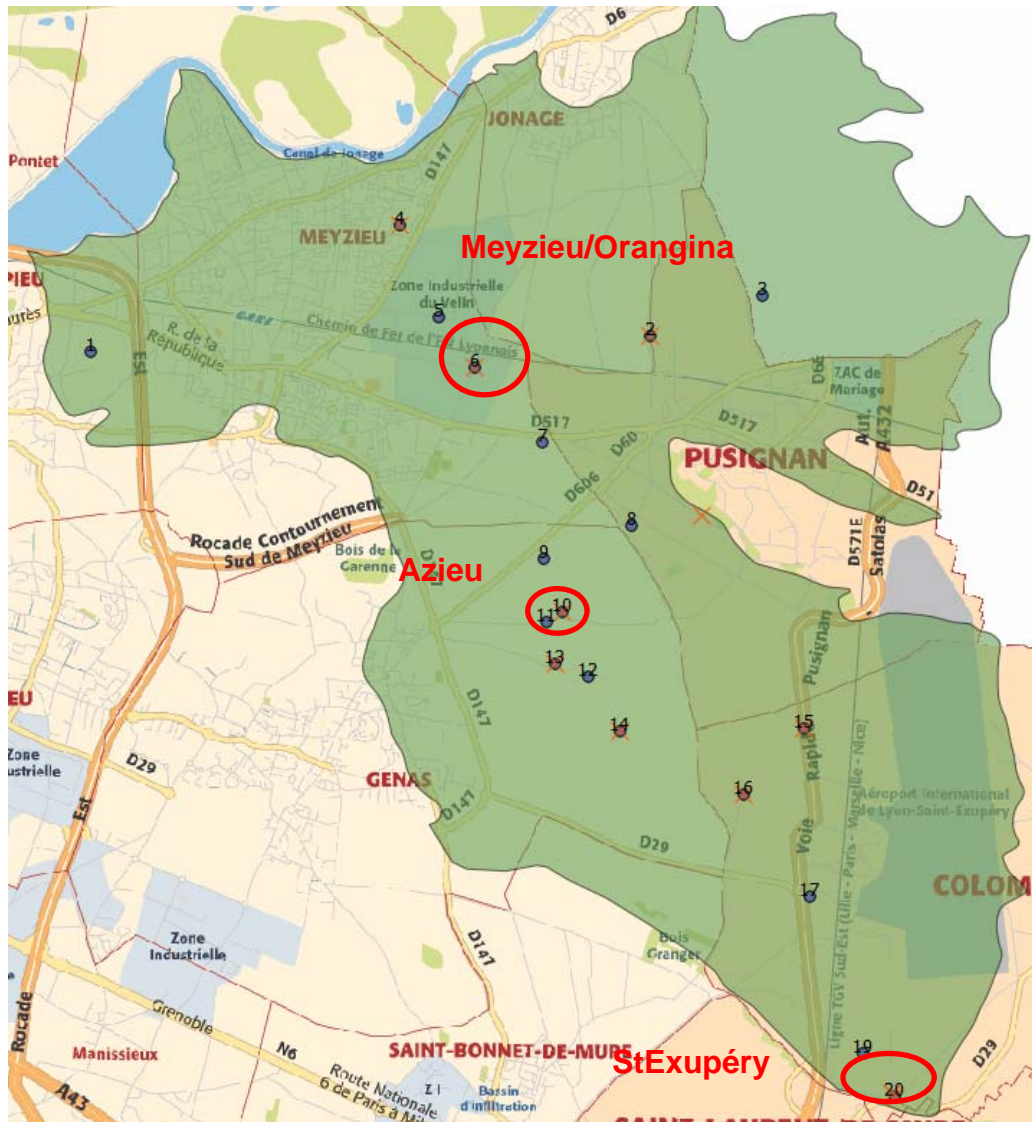
mercredi 28 juin 2017

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
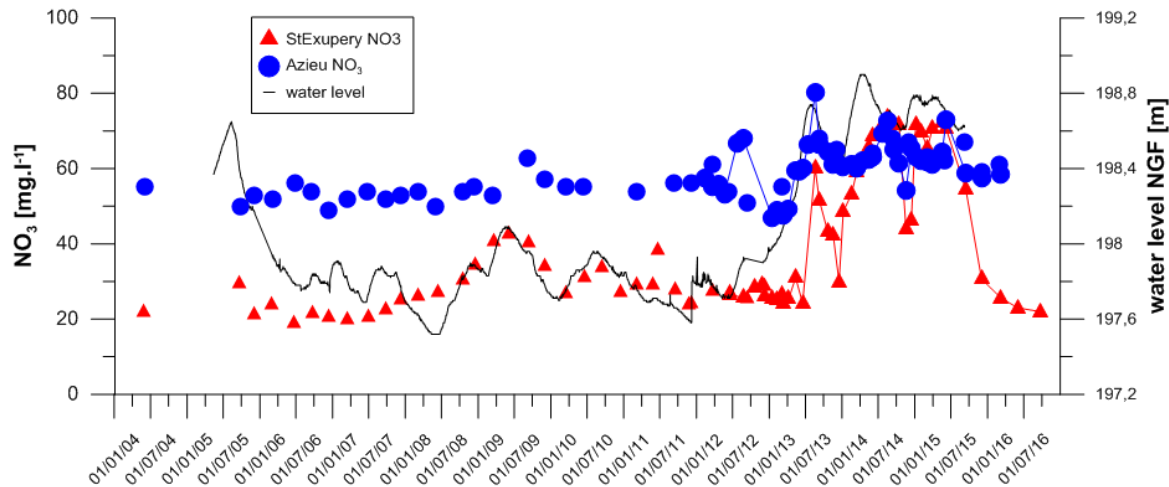
> **Data interpretation**

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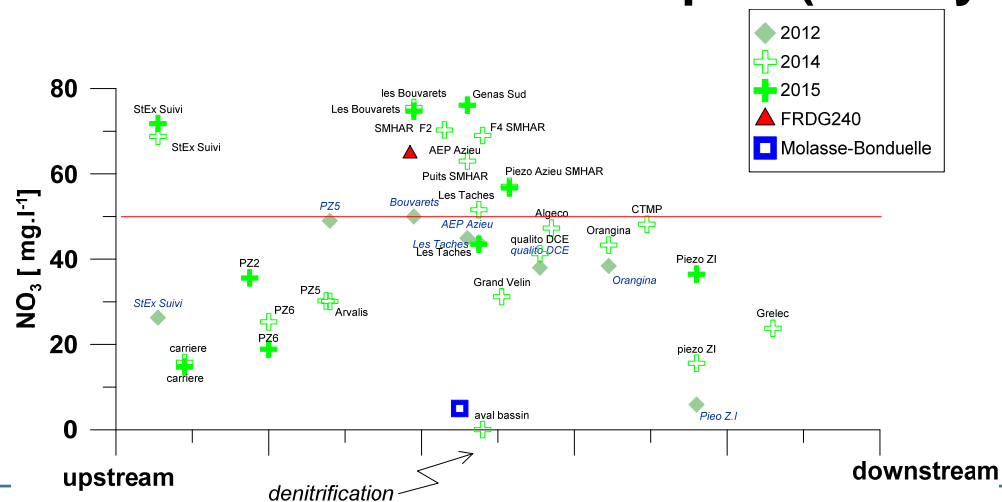
> **Modeling**

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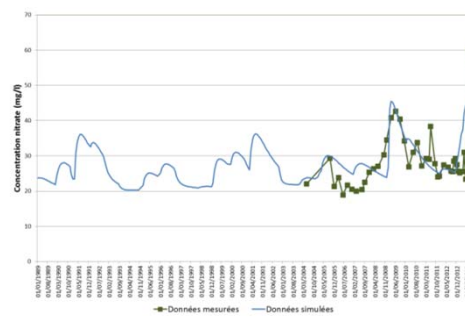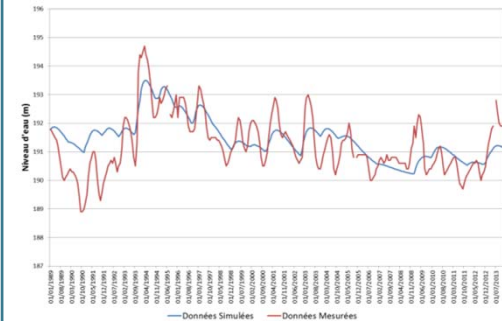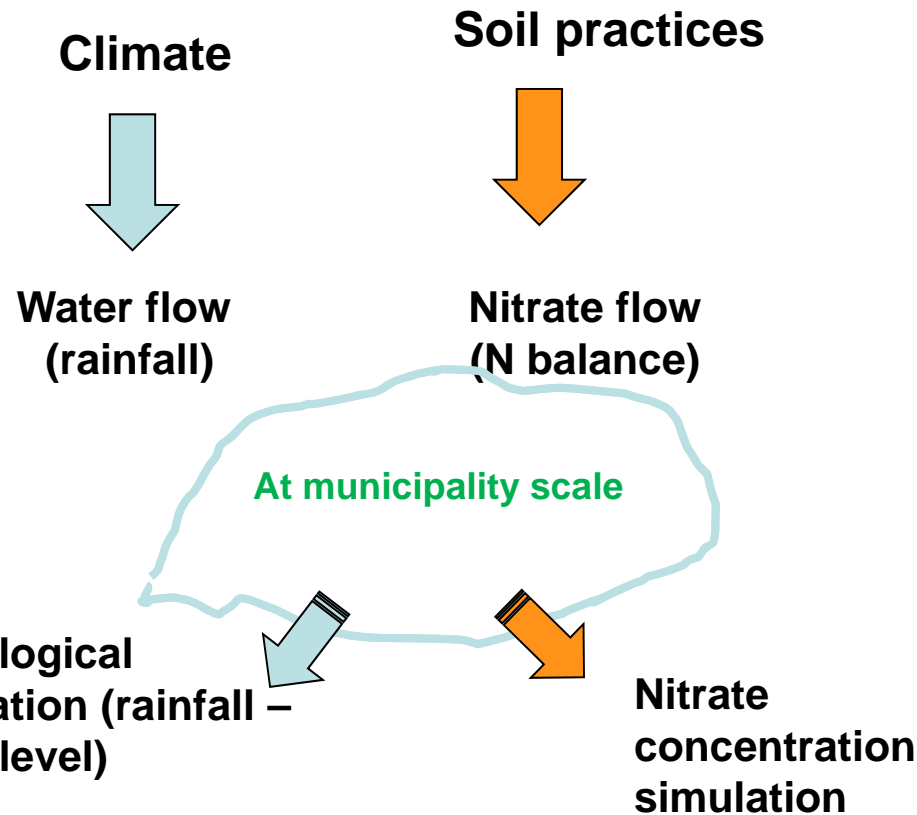- Physically-based modeling (2D @MARTHE)

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)

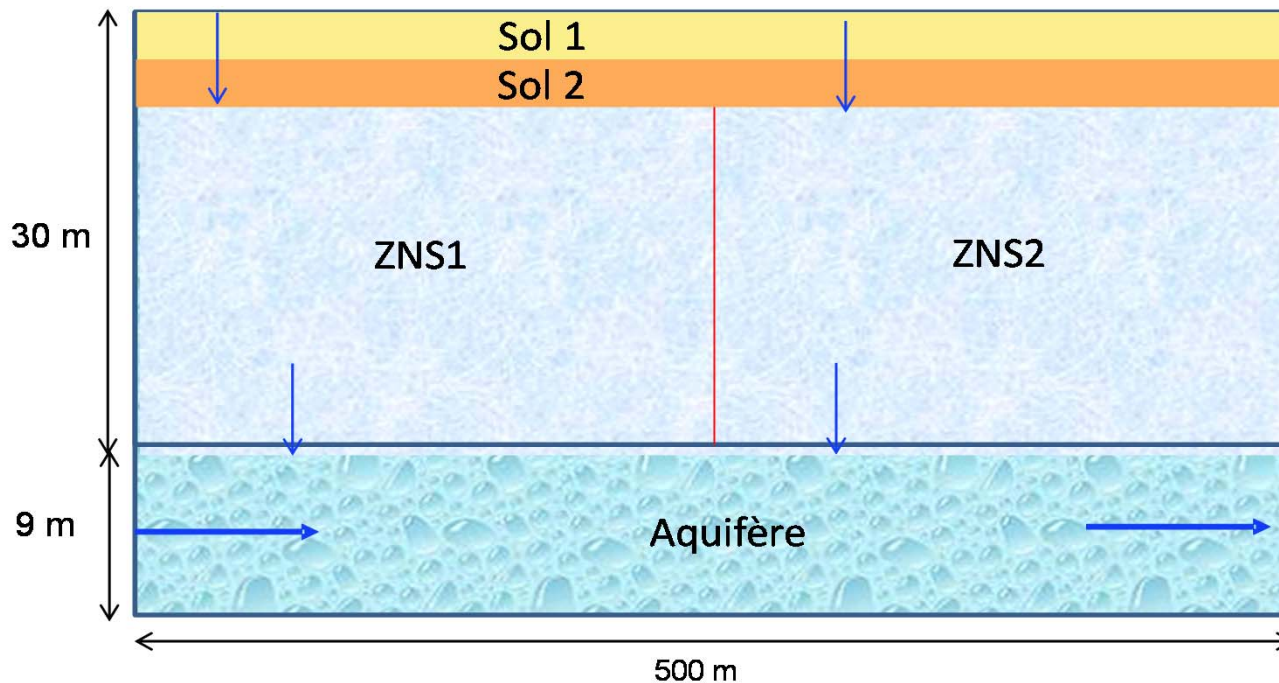**Nitrate concentration simulation**

> ## 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

Evolution du profil de concentration
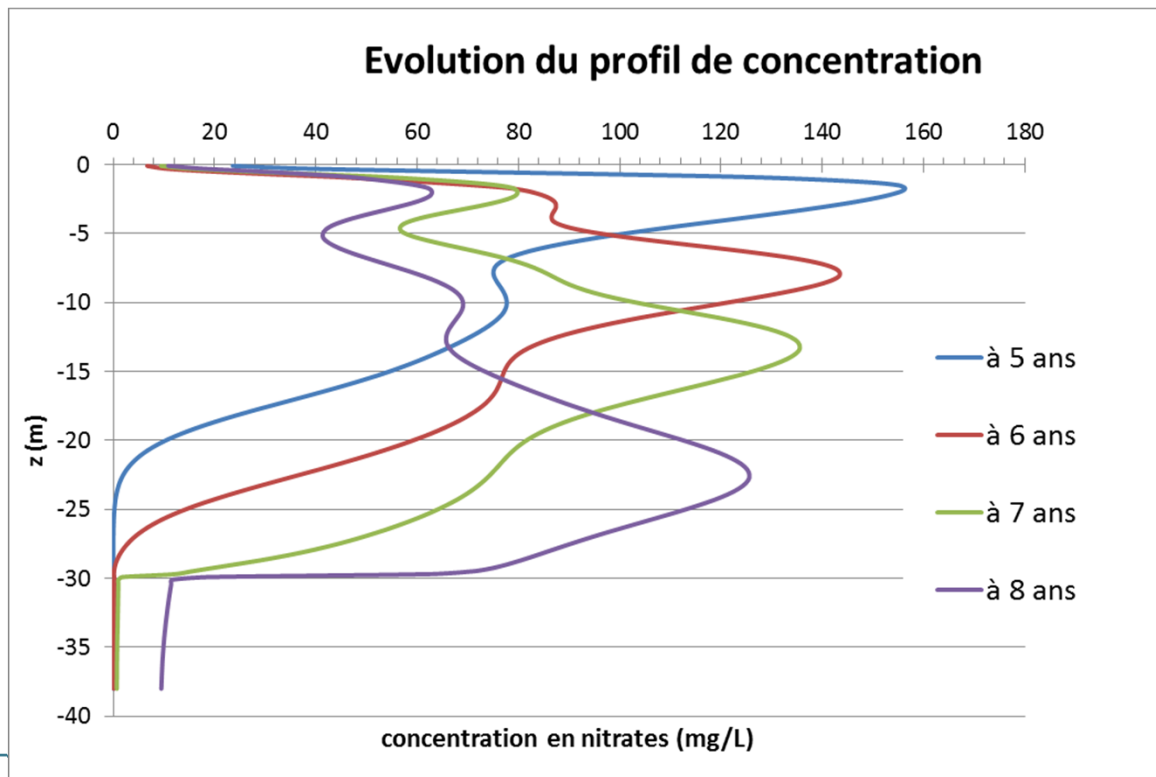
Approach for pesticide transfer understanding

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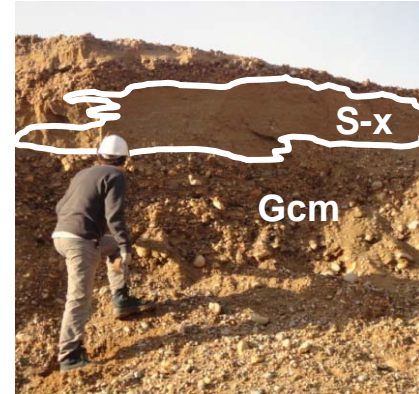
Determining physicochemical properties of molecules and reactivity in soils and USZ material
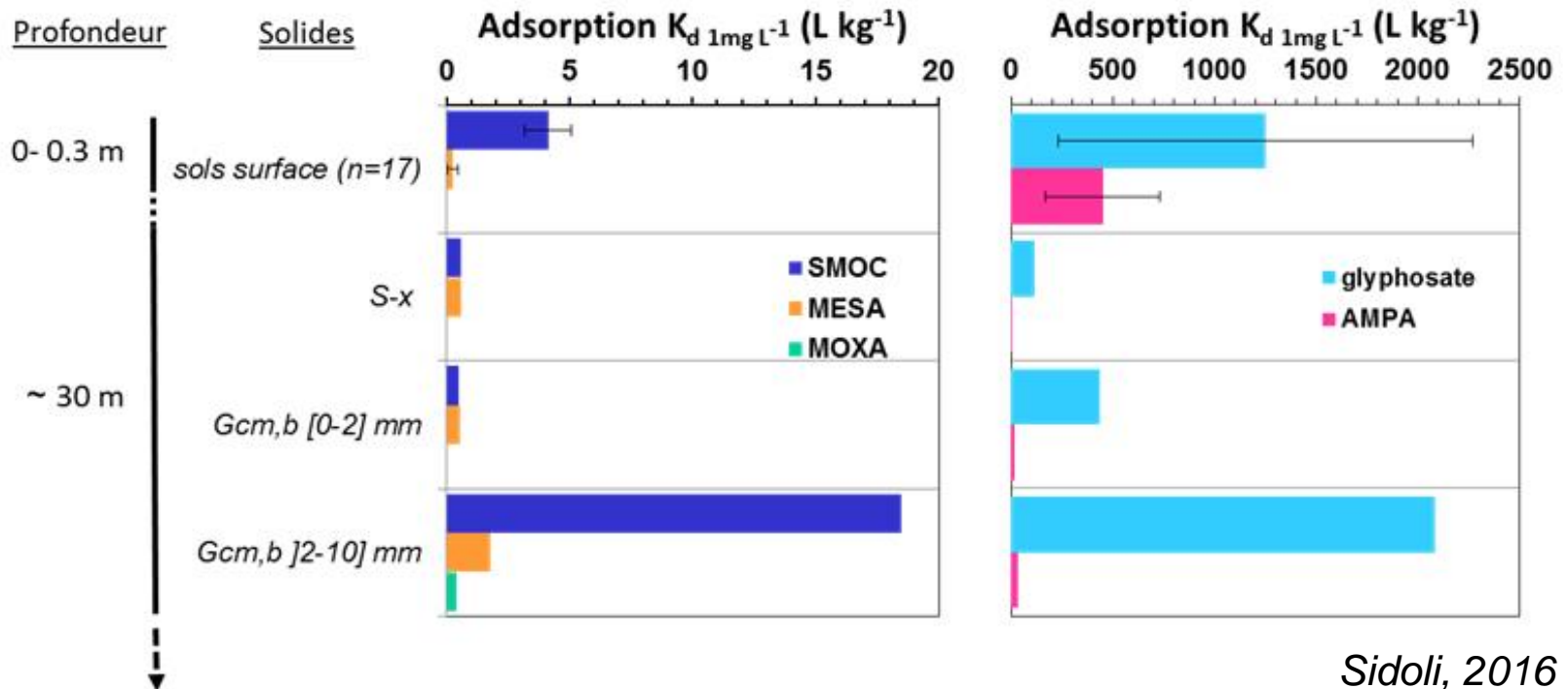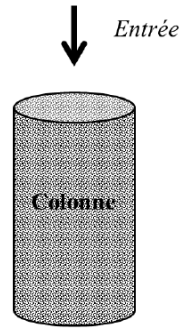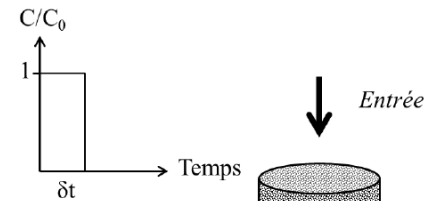

Sidoli, 2016

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**
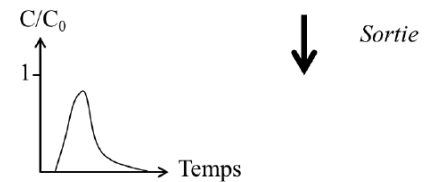- **Glyphosate > AMPA >> SMOC > MESA > MOXA**

P dynamics in the unsaturated zone

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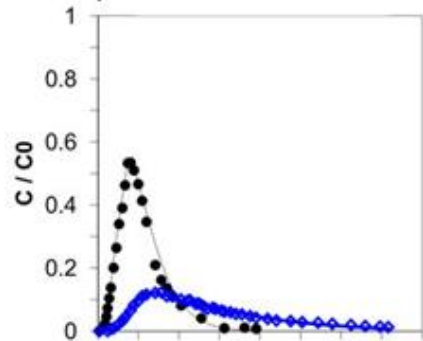> Water + bromide + SMOC, MOXA, MESA

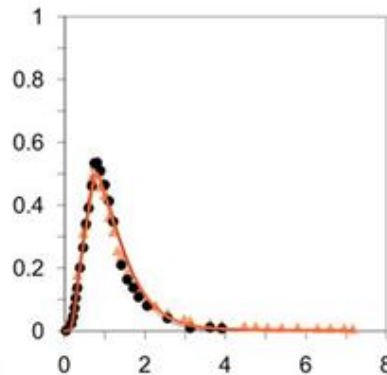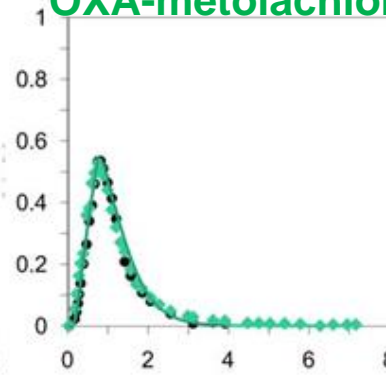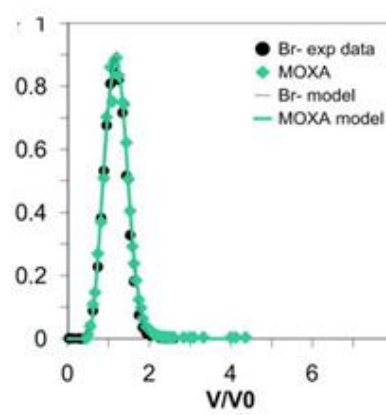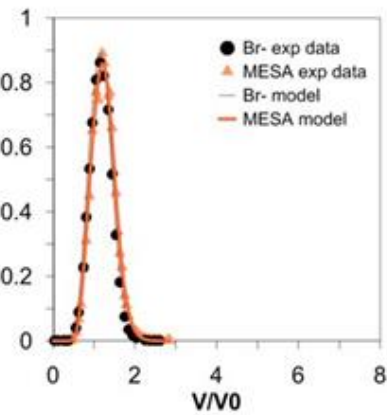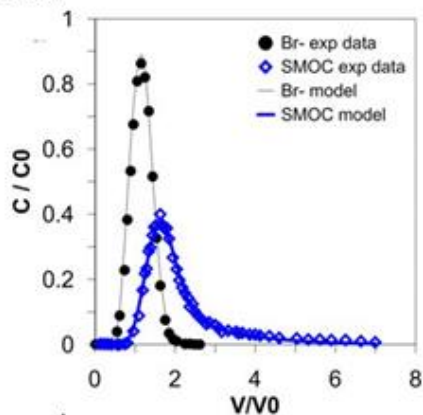# Outputs of pesticides experiments

> 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)
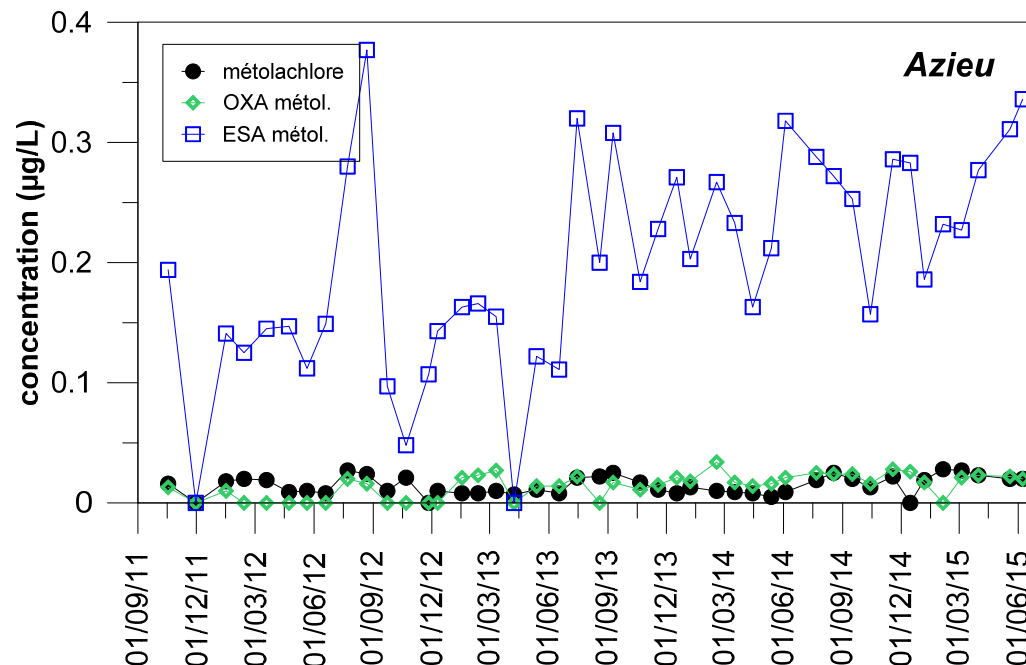
Operational conclusions

> 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