



Booklet-Guide of the Montoussé Experimental Agricultural Catchment in Auradé (Auradé Catchment, Gascony)

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Booklet-Guide

of the Montoussé Experimental Agricultural Catchment in Auradé (Auradé Catchment, Gascony)

Probst J.L and Probst A.



*View of the upper part of the Auradé catchment
with the stream lined with grass strips and poplars.*

Web site : <https://bvea.sedoo.fr/>



Preamble

The experimental agricultural catchment of Montoussé in Auradé, called Auradé Catchment (AC), is today integrated into various labeled systems at the regional, national and international levels:

1- Regional scale: AC is today a Regional Research and Innovation Platform initially recognized in 2013 by the Midi-Pyrénées region, which has become the Occitanie Region.

2- National scale:

- AC (<https://bvea.sedoo.fr/>) has been part of the Research Infrastructure (IR) OZCAR (Observatory of the Critical Zone: Applications and Research) since 2016: <https://www.ozcarri.org/fr/ozcar-observatoires-de-la-zone-critique-applications-and-research/>
- AC is part of the National Equipex CRITEX (National park of innovative equipment for the spatial and temporal study of the critical zone of watersheds) which started in 2011: <https://www.critex.fr/quest-what-critex/?lang=en>
- AC is also integrated into the regional territory of the Zone Atelier "Pyrénées-Garonne (ZA PYGAR)" (<https://pygar.omp.eu>) which is part of the IR RZA (Réseau des Zones Ateliers: <http://www.za-inee.org/en/network>).

3- International scale :

- since 2018, the IR OZCAR has entered with the IR RZA (Réseau des Zones Ateliers) in a European Research Infrastructure (ESFRI) on European Long-Term Ecosystems Research (eLTER): <https://www.lter-europe.net/>
- AC is also part of the international iLTER network: <https://www.lter.network/> (DEIMS-SDR database: Dynamic Ecological Information Management System- Site and dataset registry: <https://deims.org/>)
- since 2013, AC has also been part of the "Critical Zone Exploration Network" (CZEN) which brings together all the Critical Zone observation sites around the world: <https://www.czen.org/>.

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Booklet-Guide realized with the contributions of Marion Tetegan (LEFE), Vincent Bustillo (CESBIO), Francis Macary (INRAE) et Jeanne Laffont (GAGT)

Contents of the Booklet

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Presentation of Auradé Catchment



Figure 1- Views of Auradé Catchment in Spring (left) and in Winter (right)

General Characteristics

<https://bvea.sedoo.fr/>

The Montoussé stream which drains the Auradé Catchment (320 ha) is a tributary of the Boulouze river (tributary of the Save river which joins the Garonne river at Larra). Auradé is a small village in the Gers and it is located 40 km west of Toulouse, in the hillsides of Gascony (Fig. 1).

The cultivated area of the catchment covers 298 hectares (93% of the total area of the catchment). Crops in rotation (wheat and sunflower) occupy 90% of the surface of the watershed. The soils - called "Terreforts" - are clayey and belong to the sequence of brown calcareous-brown calcic-leached brown soils and have developed on a clayey and carbonated molassic substrate of Miocene age.

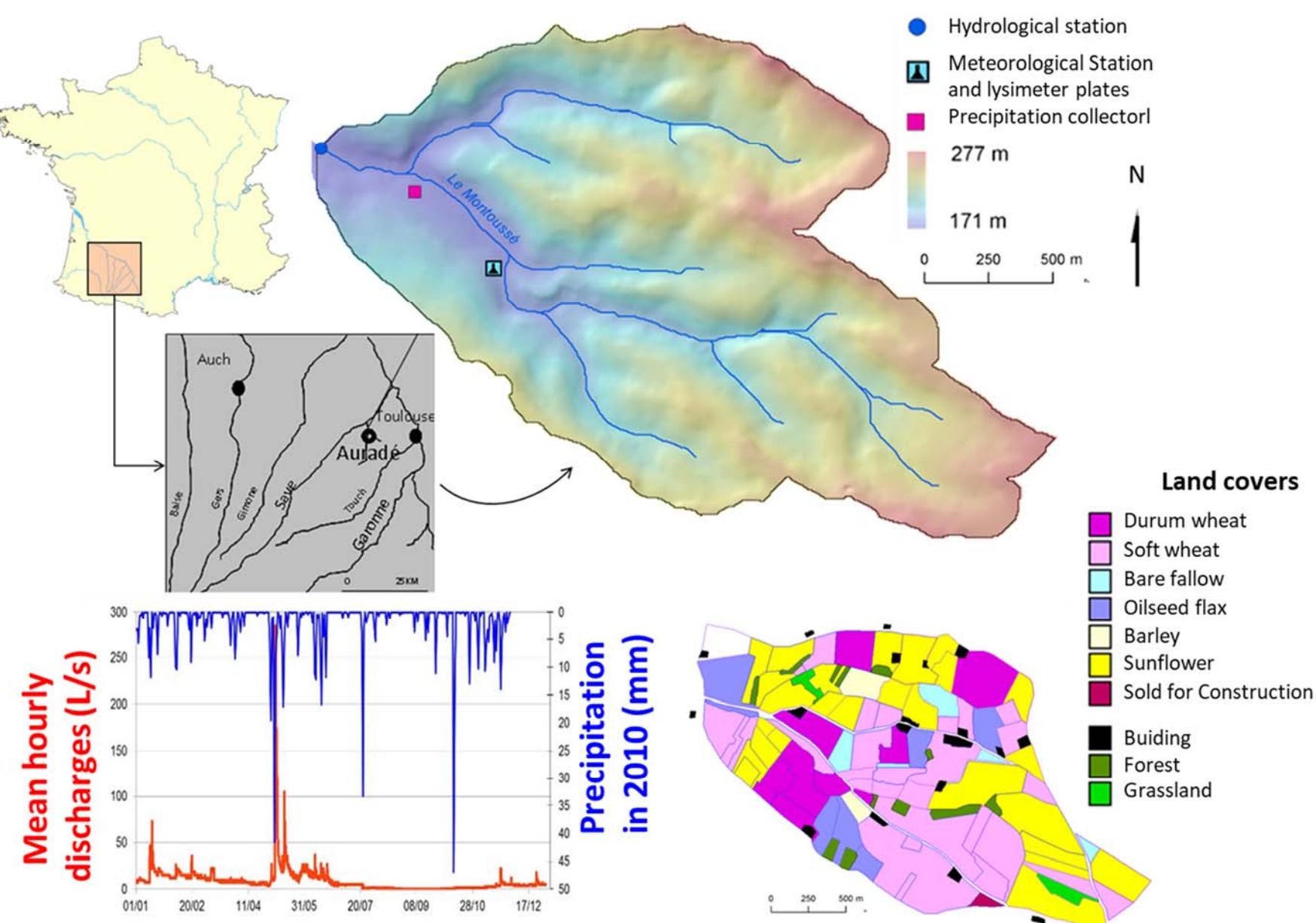


Figure 2- General location of Auradé Catchment (top left), relief map with the location of the different stations in Spring (top right), land cover map and rotation (bottomright) and annual variations of precipitation and discharges (bottom left).

Climate and Hydrology

The climate is of oceanic type according to Köppen Climate Classification. The nearby Atlantic Ocean plays an important role in regulating the temperature. The mean annual regional air temperature is 13.9°C. Since 1985, a significant increasing trend can be observed, even if interannual variations occur (Ponnou-Delaffon et al. 2020).

Moreover, since 1994 the occurrence of positive anomalous annual temperatures was observed, and in a continuous way since 2014 (Ponnou-Delaffon et al. 2020). Average annual rainfall calculated for the last 32 years is 621 mm, with a maximum value in spring. Most of the annual precipitation comes from thunderstorms from November to December and from April to May. Snowfall is rare and does not generate persistent cover.

Despite the temperature increase over the period, no significant trend was observed on annual stream discharge variations for the same period (Ponnou-Delaffon et al. 2020). Whereas, these variations point out a humid period between 1992 and 1996; since 1997, the occurrence of dry years tends to increase. The annual discharge over 34 years (1985–2018) ranges from 44 to 336mm (1985 and 1994, respectively), with a mean of 164 mm. The highest discharge period occurs in February and the major flood events generally occur in May, while the low water flow period is from June/July to September/October. Because the molassic substratum is impermeable and the slopes are steep, the stream discharge is mostly supplied by surface and sub-surface runoff during flash flood events (Roussiez et al., 2013). The underground water reserves are very limited to a few perched layers (sandy lenses) in the molasse and to alluvial and colluvial aquifers. During the summer dry period, the stream discharge is very low and sometimes the stream dries up (Brunet et al., 2011).

Mean evapotranspiration is high (500–600 mm), which refers to this catchment's semi-arid hydroclimatic characteristics (Perrin et al., 2008). Evapotranspiration mainly occurs during high temperature period in summer (86%, Ferrant et al., 2013).

History

This experimental site has been instrumented since 1982 by the AZF Research Center in Toulouse (Grande Paroisse Company) to monitor the evolution of nitrogen transfers. In 1995, GRAMIP (Regional Action Group for the reduction of water pollution by phytosanitary products in Midi-Pyrénées) started monitoring pesticide concentrations in water. In 2004, the Laboratory of Functional Ecology and Environment (LEFE) set up biogeochemical and ecological monitoring in partnership with the Grande Paroisse Azote Company (GPN-TOTAL, agreement signed in 2006) and the Association of Farmers of Auradé (AAA), interface between farmers, local authorities and research laboratories. Currently, climatological, hydrological, geochemical, soil and ecological monitoring is carried out by LEFE and research is carried out in partnership with other laboratories in Toulouse (CESBIO, GODE, GET, DYNAFOR, EDB) and Bordeaux (ETTIS and EABX of INRAE in Cestas), with the Group of Farmers of Gascony Toulousaine (GAGT) and the company GPN Agriculture (2006-2011). This research is also being developed with all the teams involved in IRs OZCAR and RZA (including ZA PYGAR), and in the Equipex CRITEX and TERRA FORMA.

Scientific Objectives

The main scientific objectives are to determine the impacts of agricultural activities (land use, agricultural practices, inputs of fertilizers and phytosanitary products) and climate change on mechanical and chemical soil erosion, water and carbon fluxes, pollutant transfers (nitrates, pesticides and heavy metals), quality of environments and living organisms (biodiversity, critical loads, ecotoxicology, bioaccumulation and biomarking).

It is therefore a question of establishing the mass-balances and matter fluxes (sediments, pollutants, nutrients) in response to climatic fluctuations and anthropogenic pressures, of understanding the mechanisms that regulate their transfers, of modeling these balances and these transfer mechanisms, of determining the impact of pollutants on living organisms from the organism to the community (diatoms, macro-invertebrates, fish).

From an R & D and management point of view, the main objectives are:

- To diagnose the quality of water, soils, sediments and aquatic ecosystems in these highly anthropized environments,
- To determine the impact of the devices (grass strips, riparian forests, etc.) and agri-environmental measures (rational fertilization) on the quality of water and aquatic environments,
- To establish water and aquatic environment quality scenarios in response to climate change, changes in land use and agricultural practices and the implementation of agri-environmental systems,
- To determine relevant biological indicators of the state of health of aquatic ecosystems and the response of ecosystems to pressures.

Geology

The Auradé Catchment belongs to the geomorphological unit of the Gascony Hillsides. It is cut in Oligo-Miocene molasses, formed from lacustrine and fluvial deposits of Pyrenean origin. The irregularity of their sedimentation induces significant textural variations: sandy lenses mingle with clay-limestone deposits and are sometimes interstratified with limestone or sandstone beds. Three geological units stand out in the catchment area:

- The upper Burgalian which outcrops at the tops of the plateaus and ridges of the hills in the form of an eluvial sandy-clayey mantle 3 to 4 m thick;
- The lower or middle Burgalian: the lower slopes are cut in formations of marl, clay and molasses;
- The formations of the slopes resulting from the molasses: colluvial in nature, they correspond to clayey-loamy deposits, sometimes sandy and decalcified which cover the molasses over 1 to 8 m from the top to the bottom of the slope.

The substratum being impermeable, the water tables are rare and poorly supplied. Springs are fed from sandy lenses included in the molasses.

Soils

The soils come from molasses or molassic colluvium; they are clay-limestone soils, called "terrefort". The thickness of the soils is very variable according to their position in the toposequence and to the slope. At the top of the rounded hilltops and on the steep slopes, the molasse is close to the surface, which keeps rendzinas in place. The steep slopes are lined with brown limestone soils or even rendzinas when the very steep slope conditions higher than normal erosion. The long, moderately sloping slopes are covered with colluvial deposits on which develop brown calcic soils (on the lower part of the slopes) and brown calcareous soils (on the upper part of the slopes).

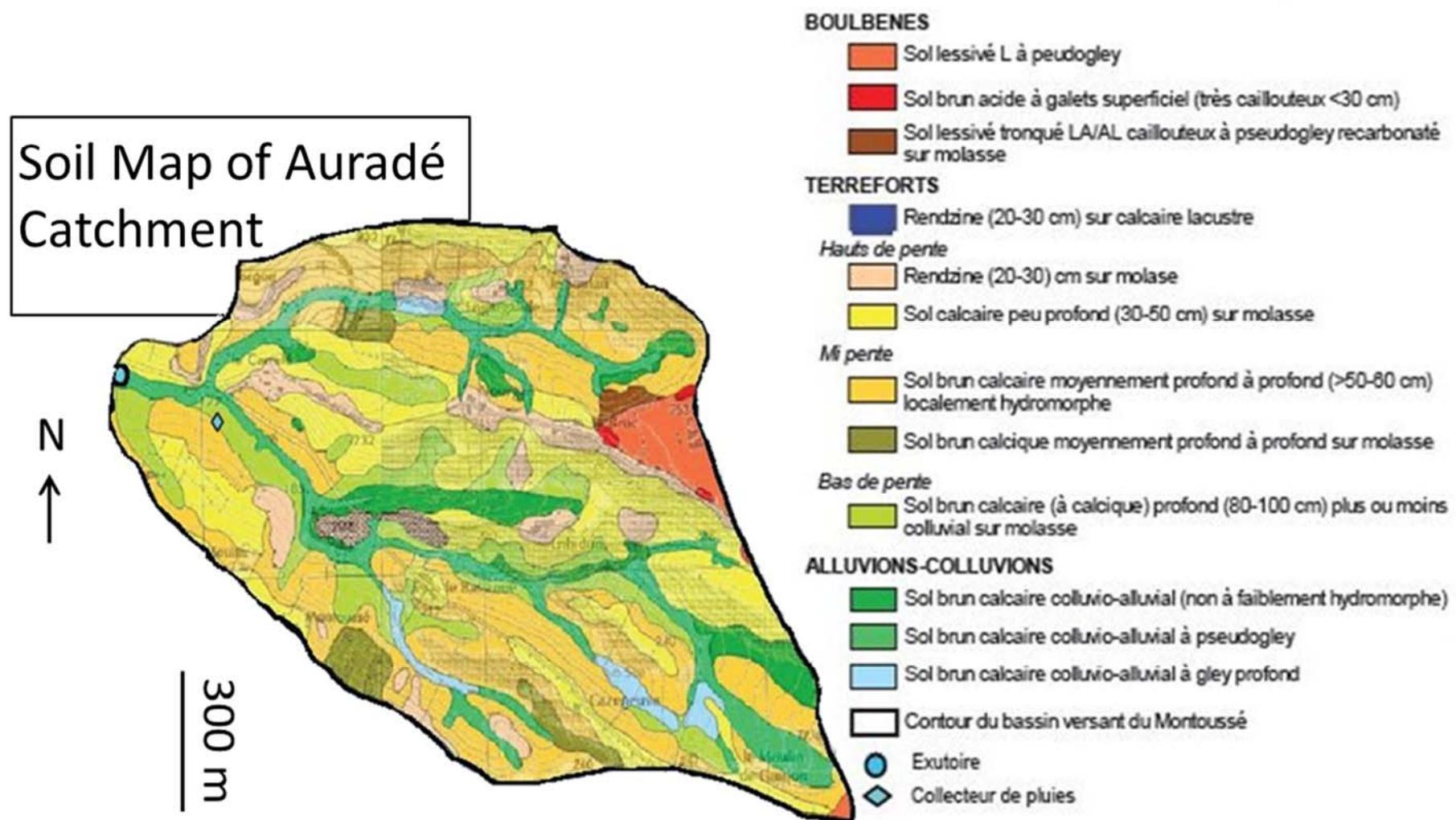


Figure 3- Soil map of Auradé Catchment (after Party and Probst, 2005)



Figure 4- Soil profiles of Auradé Catchment : brown calcareous soil (left), molassic substratum with sand lenses (middle), calcareous soil with carbonated encrustations (right).



Figure 5- Views of soils in the landscape of Auradé Catchment with white spots showing the carbonate soil horizons and even by place, the outcropping molassic substratum.

Topo séquence des types de sols du bassin versant du Montoussé à Auradé

- A- Sol brun calcaire colluvio-alluvial hydromorphe à pseudogley-gley de vallon. Type profil de sol n°1.
- B- Sol brun calcique à calcaire moyennement profond sur molasse à galets résiduels. Type profil de sol n°2.
- C- Rendzine à sol brun calcaire peu profond (érodé) sur molasse. Type profil de sol n°3.
- D- Rendzine sur calcaire lacustre. Type profil de sol n°5.
- E- Sol brun calcique à calcaire profond sur molasse. Type profil de sol n°4.
- F- Sol brun calcique profond plus ou moins colluvial sur molasse. Type profil de sol n°6.
- G- Sol brun calcique profond sur molasse (Calcaire en profondeur). Parcelle agricole cultivée depuis environ 20 ans (bois auparavant). Type profil de sol n°7.
- H- Sol brun à brun calcique profond sur molasse (en voie de lessivage - IIL=1,2). Bois. Type profil de sol n°8.

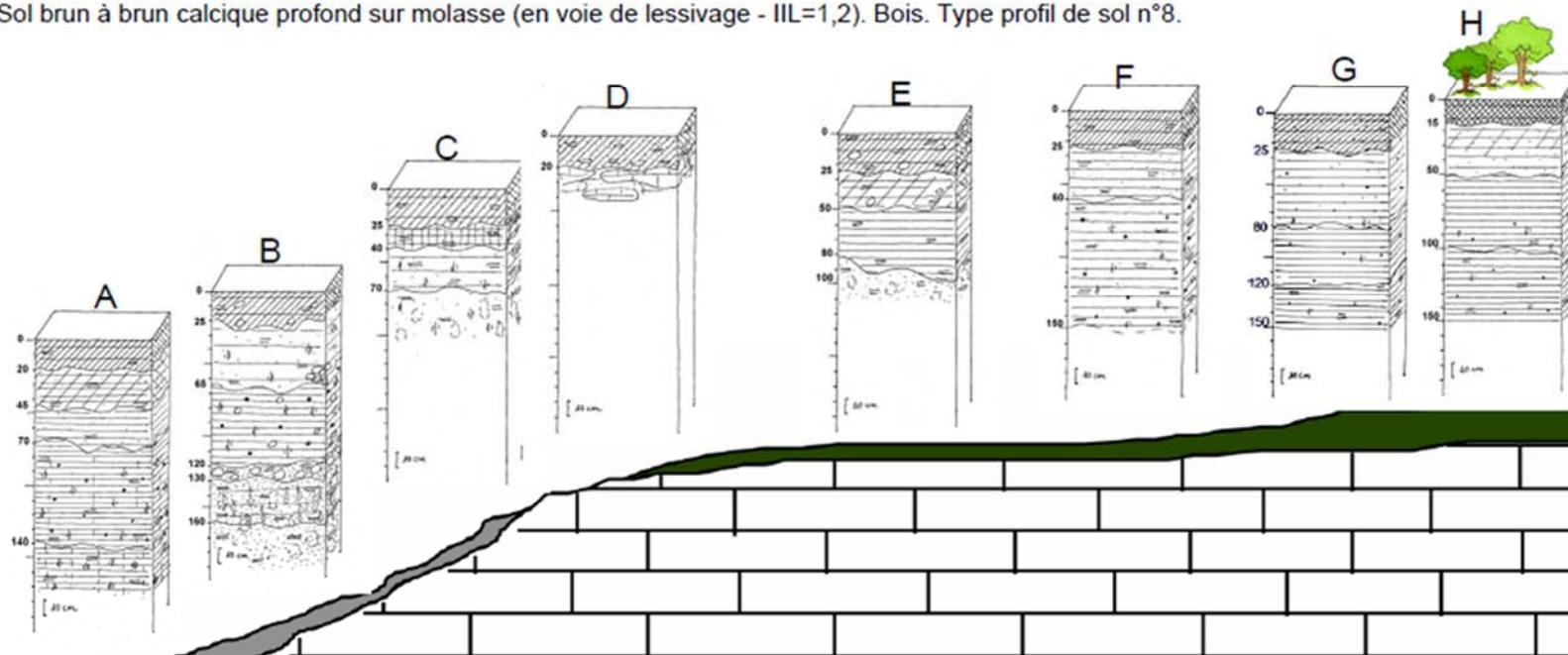


Figure 6- Soil toposequence with the different soil types in the Auradé Cartchment, going (left to right) from brown calacareous soils (A and B) to rendzinias (C and D), to brown calcic soils (E, F and G) and to brown soil (H).

The intermediate flats are covered with leached brown soils. The flats at the bottom of the thalweg are covered with colluvium on which brown hydromorphic soils or pseudo-gleys form.

Data available for Auradé Catchment

Stream water : hydrological and geochemical monitoring of the Montoussé stream began in 1983. The following Table presents the details of the data acquired at the level of the watercourse (at the outlet)

Table 1- Available data for stream water in Auradé Catchment.

| Start date | End date | Frequency | Parameters |
|---------------|---------------|--|--|
| 1983 | Until today | weekly | Water height and stream discharge |
| 1983 | Until today | weekly | nitrates |
| 1995 | 2008 | randomly | pesticides |
| 2004 | Until today | Weekly | anions, cations, alkalinity, pH, DOC, silica, Total Suspended Solids (TSS) |
| 2004 | Until today | Flood monitoring | anions, cations, alkalinity pH, DOC, silica, TSS |
| 2006 | Until today | Continuous monitoring | temperature, pH, conductivity, dissolved oxygen, turbidity, nitrates, dissolved organic carbon (DOC) |
| 2006 | 2007 | weekly | Trace elements (dissolved and particulate) |
| 2007 | Until today | weekly | ammonium |
| 2010 | Until today | monthly | Particulate Organic Carbon (POC) |
| 2008 and 2020 | 2008 and 2020 | Weekly and flood events | Pesticides, dissolved and particulate |
| 2010 | Until today | weekly | ^{13}C of Dissolved Inorganic Carbone (DIC) |
| 2010 | Until today | weekly | ^{18}O , ^2H of water and ^{13}C of DIC |
| 2013 and 2018 | 2013 and 2018 | Weekly, flood events and spatial campaigns | ^{15}N of nitrates |

- **Rain water** : anions, cations, alkalinity, pH, conductivity, DOC, silica (since 2004), ^{18}O , ^2H (since 2016).
- **Soil solutions** : anions, cations, alkalinity, pH, conductivity, DOC, silica (since 2006), ^{18}O , ^2H (since 2012)
- **Soil profiles** : soil depth, soil dry bulk density, soil mineralogy, pH, carbon content, cation exchange capacity, nitrogen, particle size distribution, texture (once in 2006), the compositions of major elements and metallic traces (by profiles, by typology), the ^{13}C and ^{15}N contents on a type of soil, the mineralogy (DRX, SEM, μ probe, laser-ICPMS), the DEM, Electric resistivity (once in 2012), Seismometry data (once in 2019),
- **Soil map** : for the whole catchment and DEM.
- **Climatological data** : precipitation amount (since 2004), air temperature (since 2007), wind direction and speed, sunshine duration (since 2007),
- **The biological data and agricultural practices**: yearly data on cultivation practices, land use, yield data, fertilizer inputs (quantity and chemical composition by type of fertilizer) and phytosanitary products by plot; by type of crop, the flows of quantifiable inputs in the balance sheets and the chemical composition data (major cations, C, N) of wheat, sunflower, rapeseed (stem, head, grain).

The instrumentation installed on the Auradé Catchment

The site is equipped at the outlet with a flow measurement station (limnigraph, ultrasonic sensor), 2 automatic samplers, 1 of which is controlled by water levels, 1 multi-parameter probe for continuous measurements ($\text{T}^\circ\text{water}$, Heau, pH/Redox, conductivity, dissolved O₂, turbidity, nitrates, DOC) and inside the catchment, a climatological station, 1 rain collector for physico-chemistry, 1 precipitation collector for isotopy and 1 station for measuring soil solutions at 3 depths. A station for measuring water and carbon fluxes at the crop-atmosphere interface (managed by CESBIO) is also located in the immediate vicinity of the site.

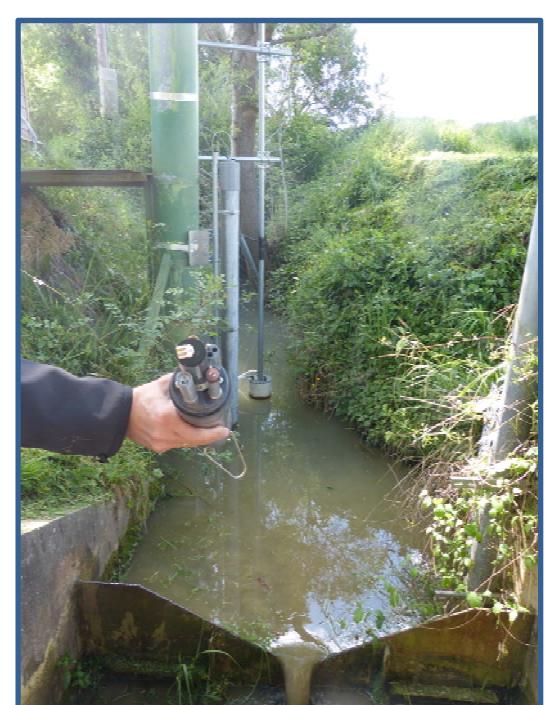
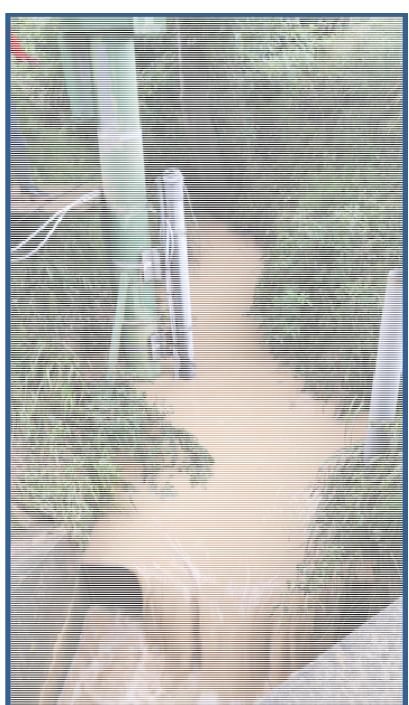


Figure 7- Views of the station at the outlet of Auradé Catchment. The Montoussé stream during a flood event (left), the wooden hut which houses all the equipements (middle), the Montoussé stream during a low water period (right)



Figure 8- The instrumentation installed on the Auradé Catchment for monitoring of the different compartments : soil solution (top left), rain water and climatological station (top right), soil experiments (middle right), stream water (bottom) with water height and discharge, automatic sampler, multi parameter probe with different sensors, DGT and POCIS passive samplers (from left to right).

A catchment at the heart of national and international research

National



- Research Infrastructure (IR) OZCAR (Observatory of the Critical Zone: Applications and Research) : The Auradé Catchment is one of the Observatory site of this French research infrastructure.



- Equipex CRITEX (national):

National Park of innovative equipment for the spatial and temporal study of the Critical Zone.
The Auradé Catchment is one of the CRITEX instrumented sites.



PIA3 EQUIPEX+

- PIA3 Equipex+ : TERRA FORMA :

Designing and testing the intelligent observatory of territories in the era of the Anthropocene

- LTSER Zone Atelier Pyrénées Garonne (ZA PYGAR) et IR RZA :



The Auradé Catchment is integrated into one of the workshop site (Valleys and Hills of Gascony) of the ZA PYGAR which is part of the IR RZA (Zone Atelier Network) with 14 other ZA in France.



- ANR ESCAPADES (2013-2016) : Evaluation of scenarios on the nitrogen cascade

in agricultural landscapes and territorial modelling. The Auradé Catchment was one of the experimental sites of this ANR project

- Project IRRIS (2012-2016) : Programme Eco industries(IRRigation Ingénierie Services):

Project Eco-Insdustries (financed by DGCIS) in collaboration with LAAS-CNRS and industrial partners.



- ANR PESTIPOND (2019-2023) : Role of ponds in the transfer and impact of pesticides

in surface waters of the critical zone in agricultural environments ». The Auradé Catchment is one of the 3 experimental sites of this ANR Project with the Bassioué pond.



- Project Région Occitanie PACSE (2018-2021): Landscapes and Compromise between

Ecosystem Services. Collaboration with 2 other research laboratories, DYNAFOR and LEREPS on the Auradé Catchment.

International:

- ESFRI eLTER : the Auradé Catchment is one of the long term experimental and observation sites of the european research infrastructure (ESFRI) eLTER, European Long-Term Ecosystem Research 
- iLTER : the Auradé Catchment is one of the sites of the international network LTER 
- CZEN : the Auradé Catchment is one of the sites of the Critical Zone Exploration Network 



Figure 9- World map of ILTER sites with the location of Auradé Catchment.

Research carried out in the Auradé Catchment

The issues and questions concerning this catchment relate to the impact of **agricultural activities** (land use, agricultural practices, inputs of fertilizers and phytosanitary products) and **climate change** on:

- mechanical and chemical soil erosion
- water and carbon fluxes
- transfers of pollutants (nitrates, pesticides and heavy metals)
- the quality of environments and living organisms (biodiversity, critical loads, ecotoxicology, bioaccumulation and biomarking)

Research objectives for the acquisition of knowledge

- Establish material flow balances (pollutants, nutrients) in response to climatic fluctuations and anthropogenic pressures
- Understand the mechanisms that regulate the transfer of materials from the atmosphere, crops and soils to the watercourse
- Model these balance sheets and these transfer mechanisms.
- Determine the impact of pollutants on living compartment of the critical zone: from the organism to the population and communities (diatoms, biofilms, macro-invertebrates):

- ▶ enrichment effect
- ▶ effect of toxins
- ▶ critère d'exposition
- ▶ “exposure-effects” relationship
- ▶ biodiversity



Research objectives: for management

- Diagnose the quality of water, soil, sediment and aquatic ecosystems.
- Determine the impact of agri-environmental devices and measures on the quality of water and aquatic environments.
- Establish (by modelling) scenarios for the quality of water and aquatic environments in response to:
 - climate change
 - changes in land use and agricultural practices
 - the implementation of agri-environmental systems
- Determine relevant biological indicators of the state of health of aquatic ecosystems and the response of ecosystems to pressures.

In the stream waters: The “electrocardiogram” of nitrates” & Demonstration of the impact of floods on the transfer of pesticides

ECOLAB & AZF-GPN

A positive effect of the establishment of grassy strips along the Montoussé stream in Auradé Catchment has been highlighted thanks to the monitoring of hydrogeochemical measurements. These measurements also showed that the concentrations and fluxes of pesticide molecules increase during periods of flooding, particularly in spring.

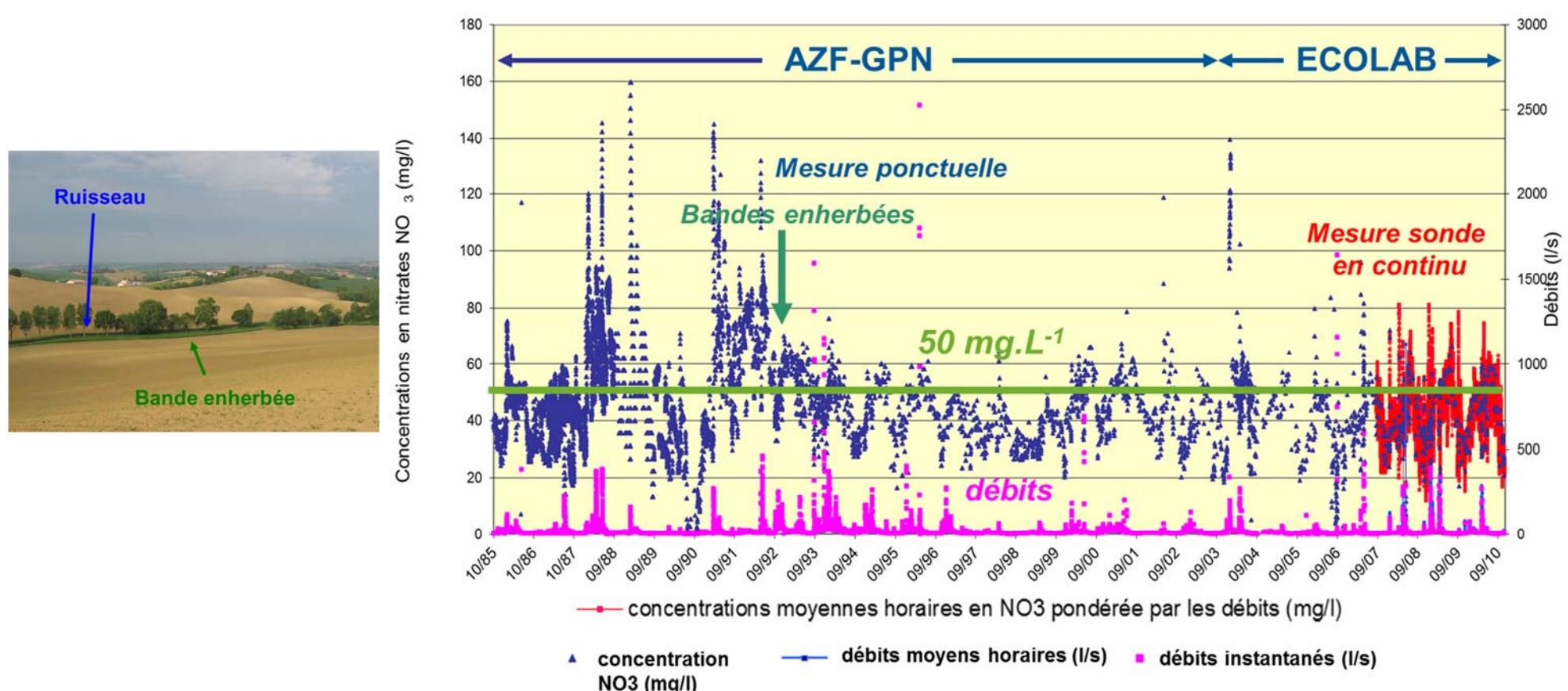


Figure 10. Evolution of nitrate concentrations (NO₃, weekly samples in blue and continuous measurements with the probe in red) and Montoussé stream discharge (in pink) from 01/10/1985 until 30/11/2010

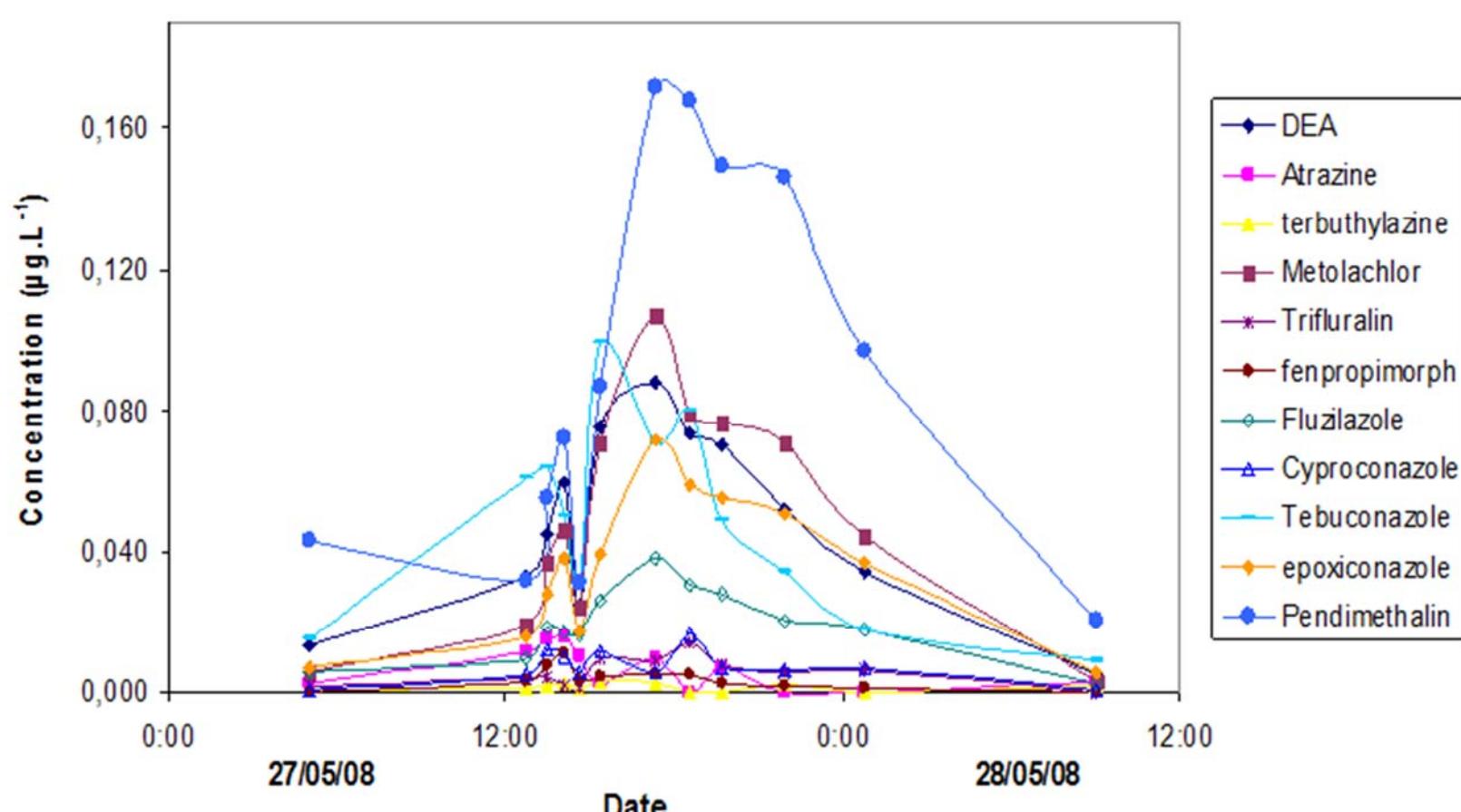


Figure 11. Evolutions of pesticide concentrations for different molecules in the Montoussé stream water during a spring storm event in 2008 (Taghavi et al., 2008).

An Observatory for long-term and high-frequency hydro-biogeochemical monitoring.

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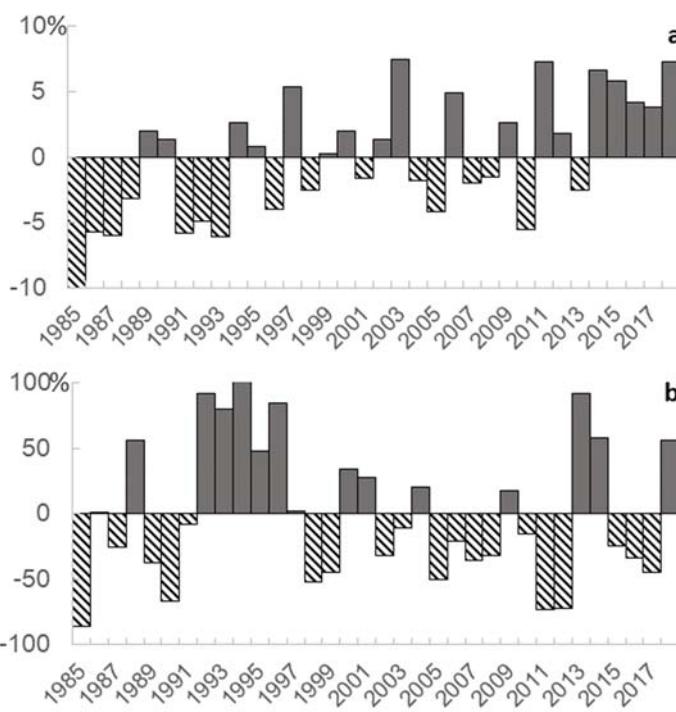


Figure 12- Interannual variations of mean annual air temperature (a) and mean annual stream discharge (b) : deviations (%) from the interannual mean.

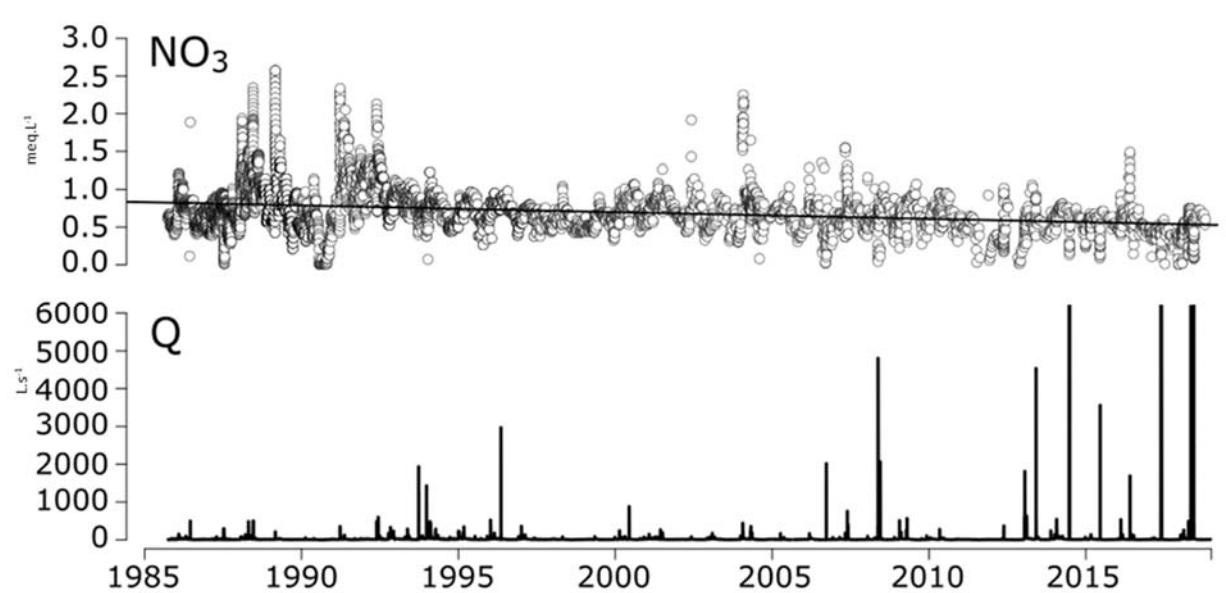


Figure 13- Fluctuations of nitrate concentrations and discharges of the Montoussé stream during the period 1985-2018.

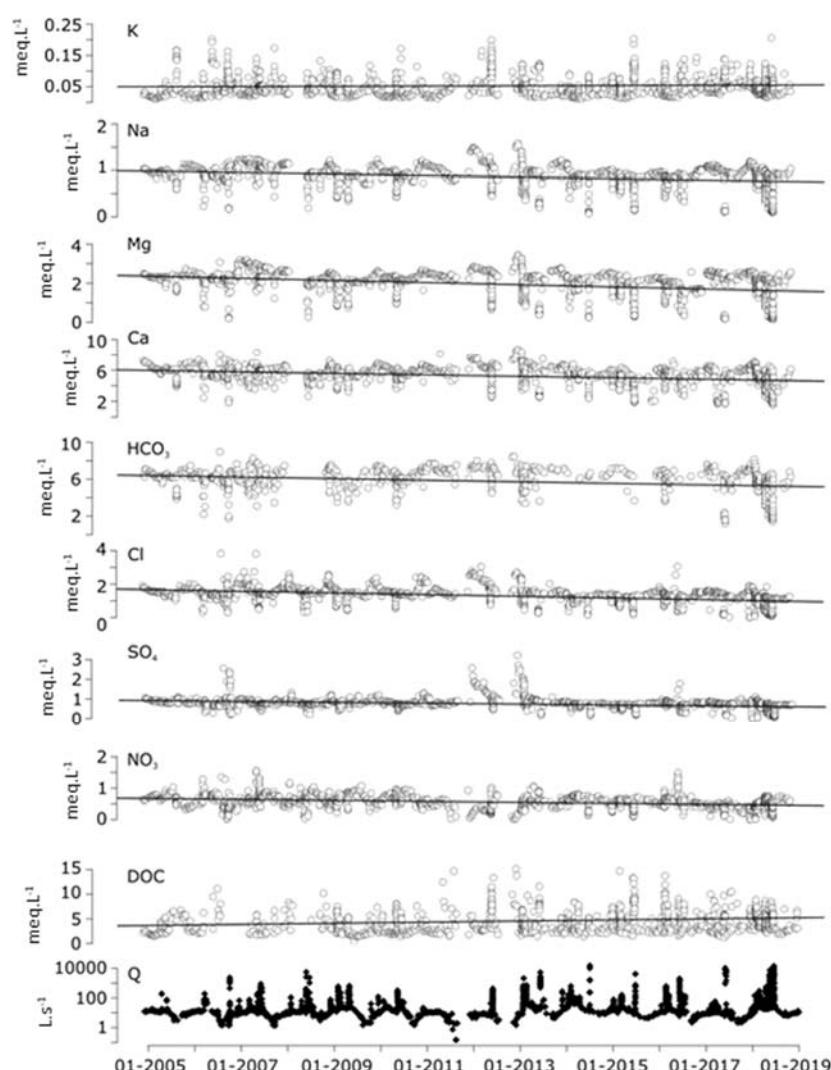


Figure 14- Interannual variations of major element (anions and cations) concentrations, dissolved organic carbon (DOC) contents and Montoussé stream discharges (Q) during the period 2005-2019. Straight lines represent long-term trends (linear regressions)

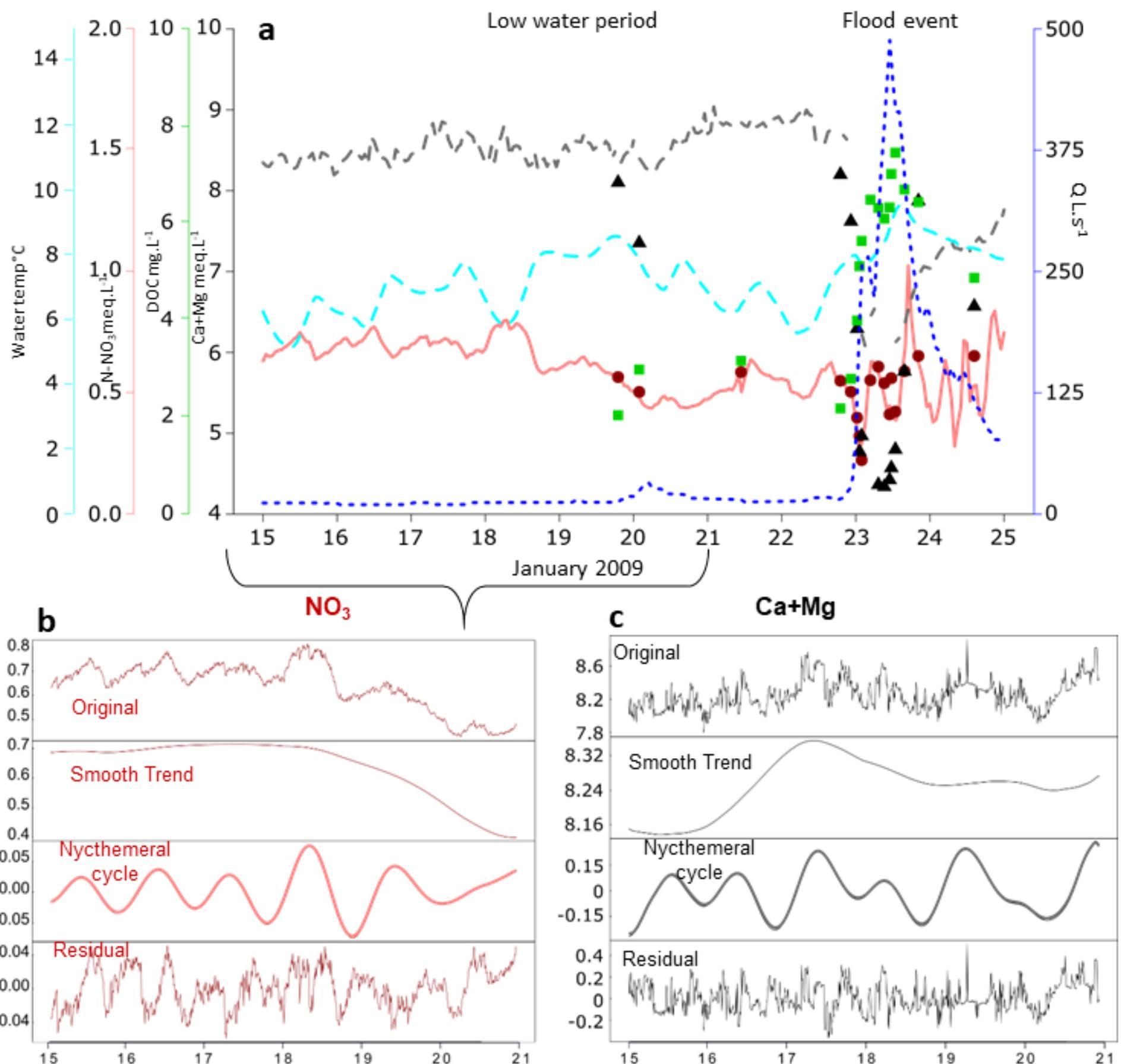


Figure 15- Short-term fluctuations (January 15 to 25, 2009) of nitrate concentrations, dissolved organic carbon, calcium+magnesium and Montoussé flows :

(a) continuous measurements of nitrate contents (with the multiparameter probe (red line), instantaneous nitrate measurements (red circles), Ca+Mg contents reconstituted from the conductivity measured continuously with the probe (dotted lines gray) and measured (gray triangles), measured dissolved organic carbon (green squares), water temperature (turquoise dotted line) and water discharge (blue dotted lines))
 (b) and (c) decomposition of the original signals for the nitrate (b) and Ca+Mg (c) contents into 3 components: signal smoothed over the period, nycthemeral cycle (day/night alternation) and residual.

These results are taken from an article published in 2020 in Ecological Indicators (Ponnou-Delaffon et al., 2020).

An Environmental Observatory to monitor pesticide transfers in the various compartments of the critical zone.

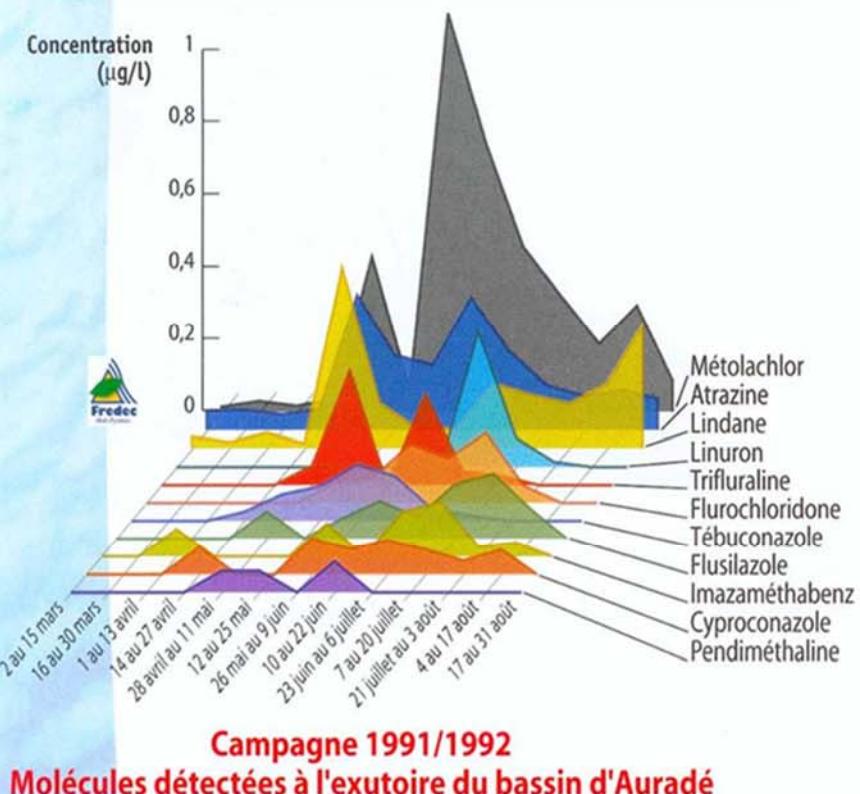
J.L. Probst, L. Taghavi, G. Merlina, A. Probst
LEFE, GRAMIP, FREDEC, GAGT



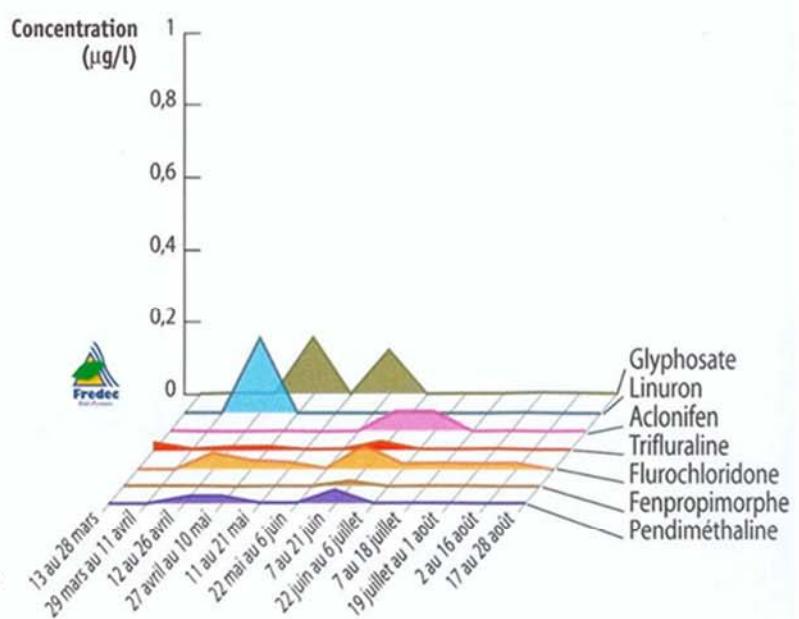
Figure 16- The Auradé Catchment (center) with hydrological sation (left) and the automatic samplers (right).

Grass strips and reasoned practices on pesticide levels in the Montoussé stream

Before the establishment of the grass strips and before the application of the protocol.



After the establishment of the grass strips and after the application of the protocol.



*Research carried out within the framework of GRAMIP
by the farmers' group (GAGT) and FREDEC*

Figure 17- Seasonal variations of pesticide concentrations in the Montoussé stream water during the water years 1991-1992 (before the grass strips, left) and 1999-2000 (after the grass strips, right).

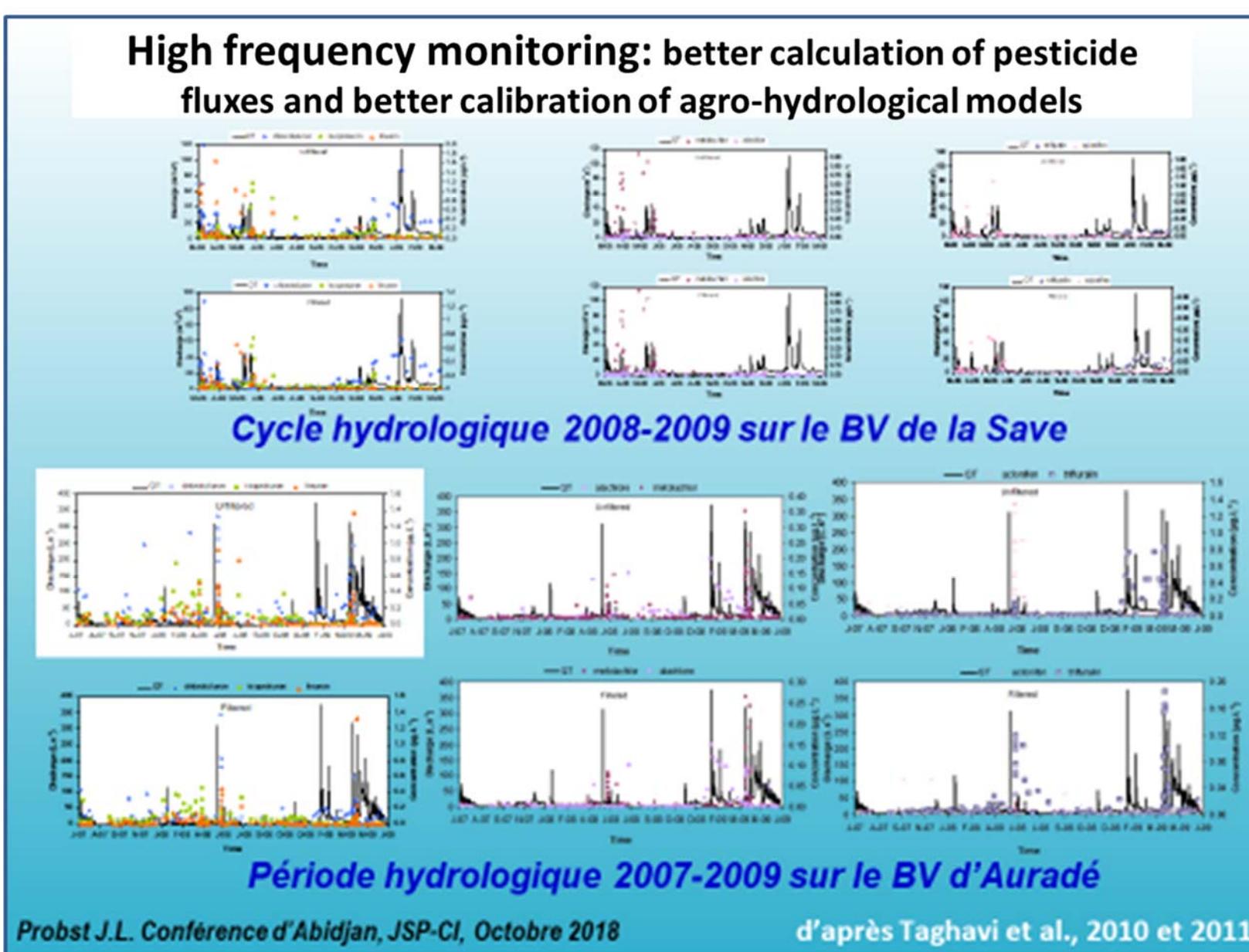


Figure 18- High frequency fluctuations of pesticide concentrations and stream discharges in the Save river basin (top) during the period 2008-2009 and Auradé Catchment (bottom) for 2007-2009.

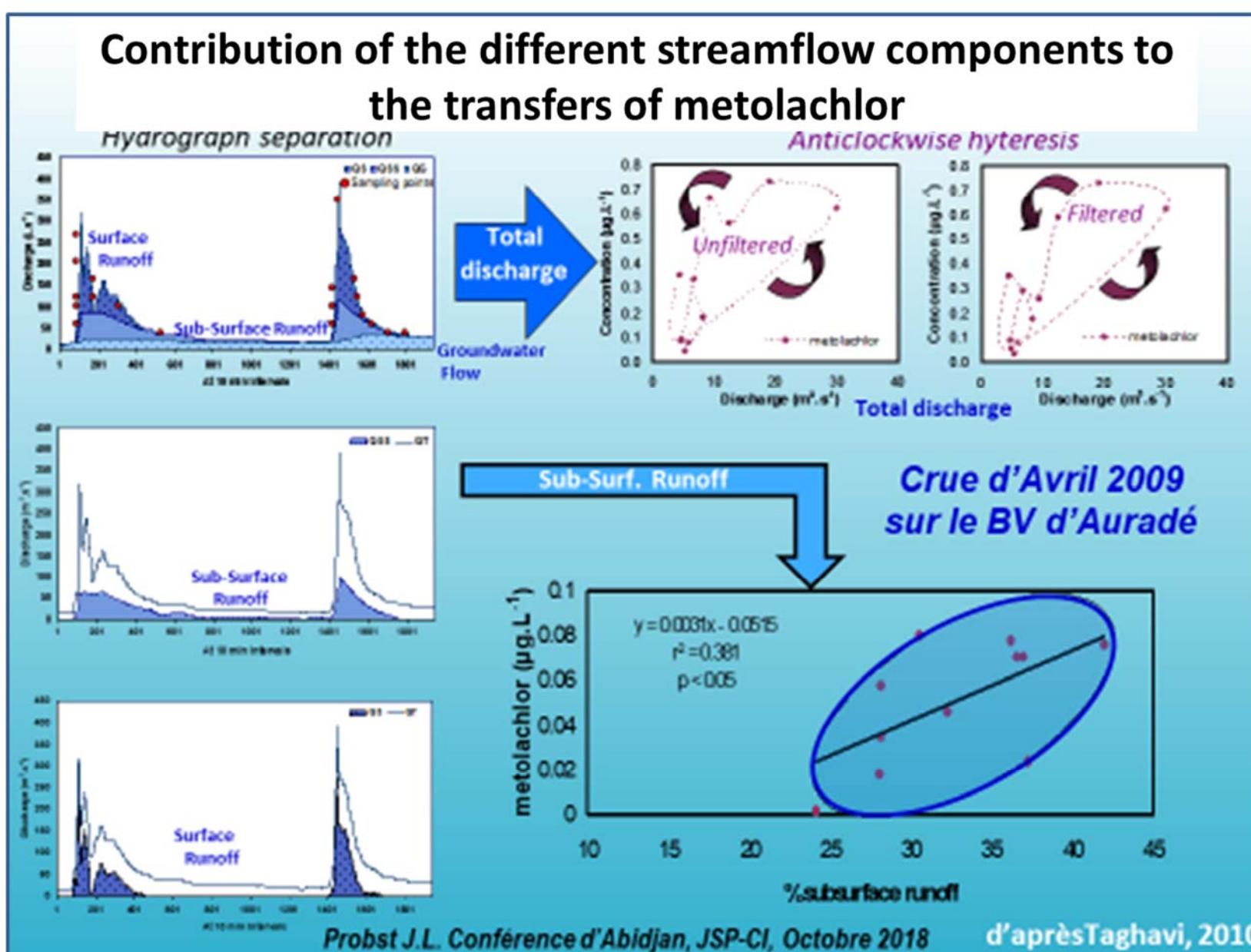
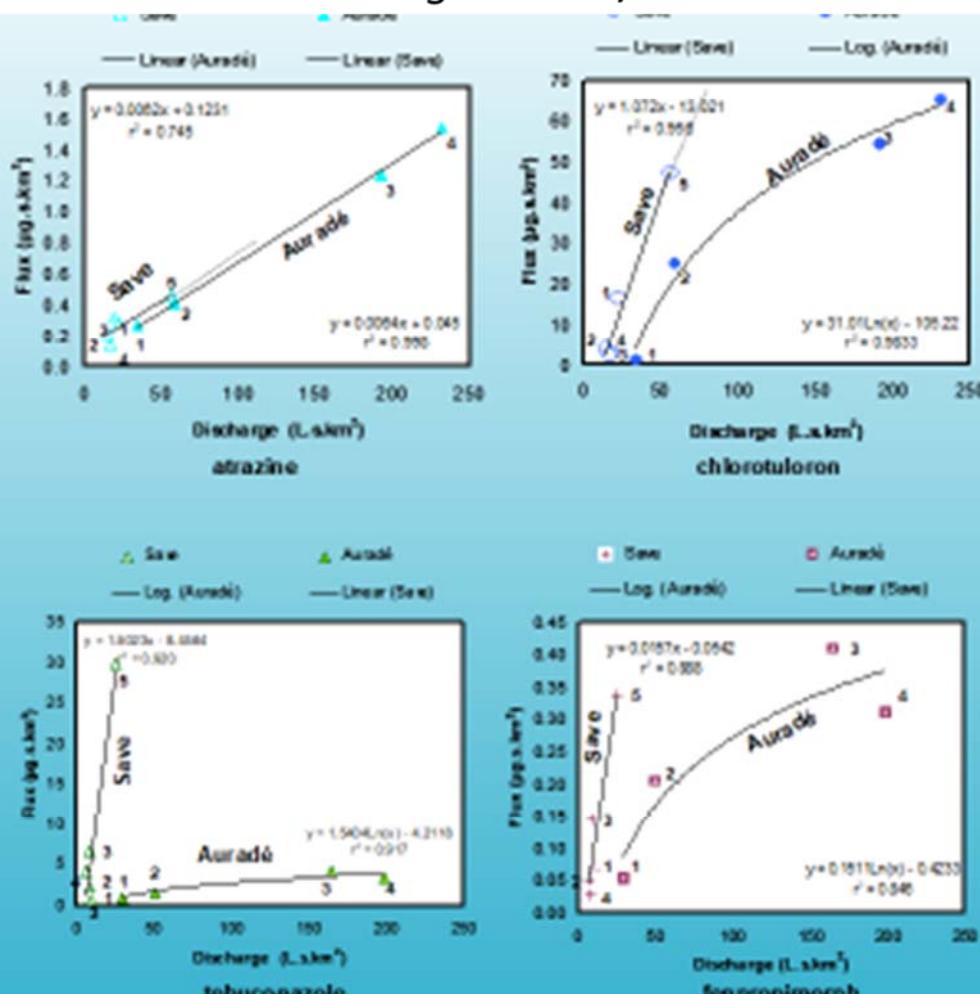


Figure 19- Contribution of the different streamflow components to the transfers of metolachlor : hydrograph separation (left), C-Q relationships (total Q (top right), % subsurface runoff (bottom right)).

Comparison between Auradé and Save Catchments: flux-discharge relationships. Auradé: reasoned agriculture/ Save: intensive agriculture



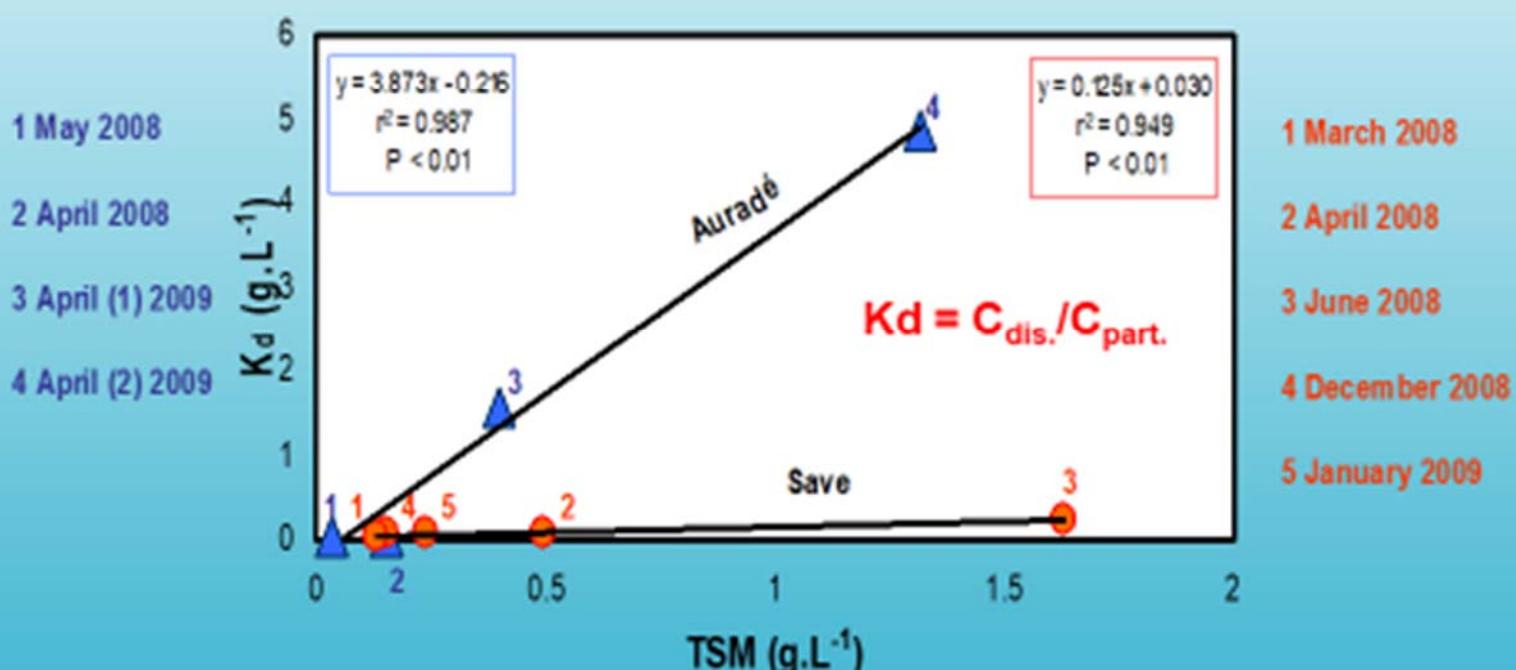
Probst J.L. Conférence d'Abidjan, JSP-CI, Octobre 2018

d'après Taghavi, 2010

Figure 20- Pesticide flux-Discharge relationships : comparison between Save and Auradé.

Relationships between Aclonifen K_d and TSM concentrations for different flood events on the Auradé and Save Catchments

$$K_d = C_{\text{dissous}} / C_{\text{particulaire}}$$

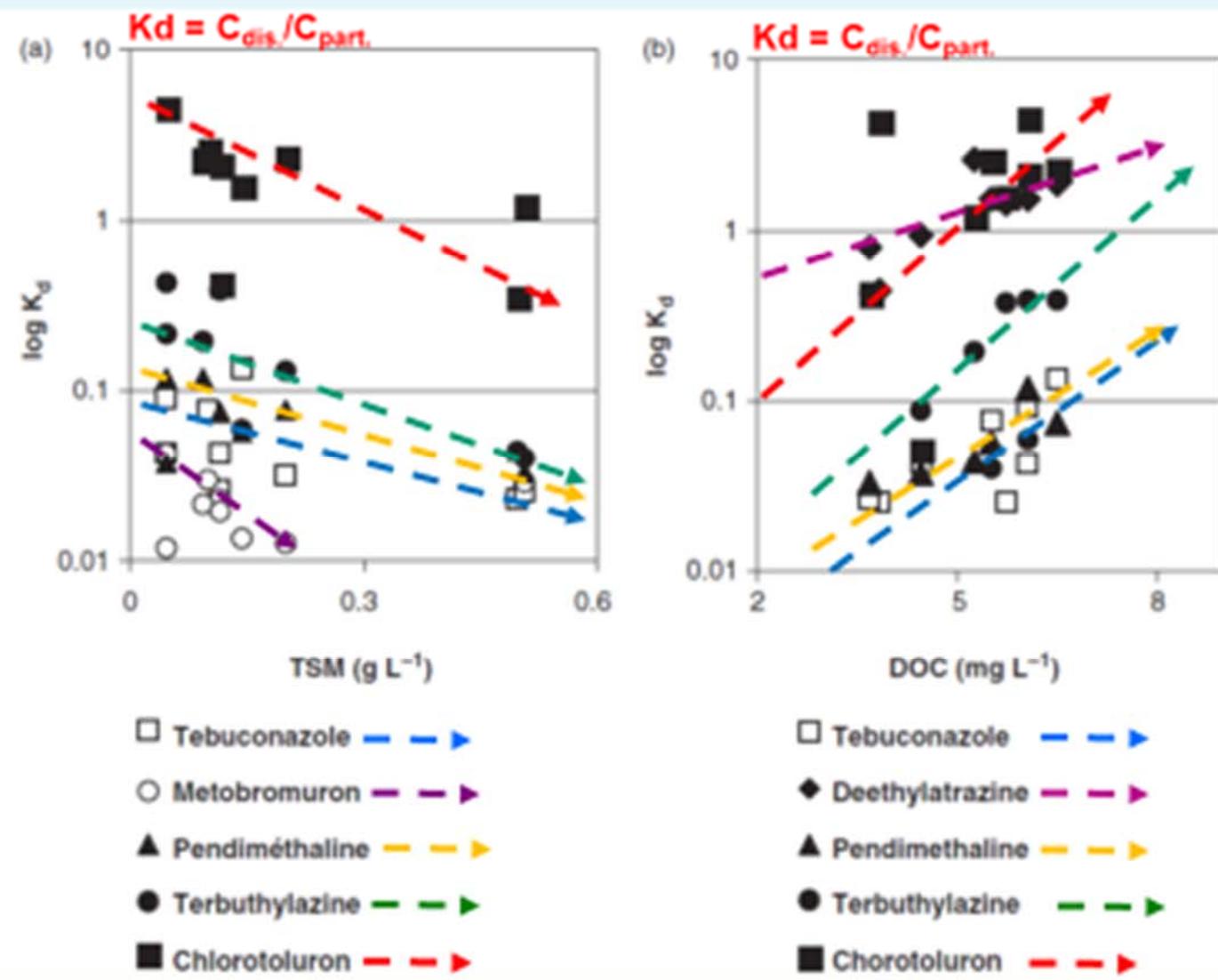


Probst J.L. Conférence d'Abidjan, JSP-CI, Octobre 2018

d'après Taghavi 2010

Figure 21- Relationships between Kd and TSM for Auradé and Save river basins.

Relationships between pesticide K_d and controlling factors
Flood event of March 2006 on Auradé Catchment



Probst J.L. Conférence d'Abidjan, JSP-CI, Octobre 2018

D'après Taghavi et al. 2010 IJEAC

Figure 22- Relationships between pesticide K_d and two controlling factors (TSM (left) and DOC (right)).

Flood events: Effects on soil erosion and fluxes of metallic trace elements

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As shown in the graphs below, the suspended solids (SPM) in the waters of the stream are all the more important as the precipitation is high. This is more particularly what we observe in the catchment in May and June 2007; where 95% of the annual SPM flows are exported. These results are taken from an article published in 2013 in the Journal of Hydrology (Roussiez et al., 2013).

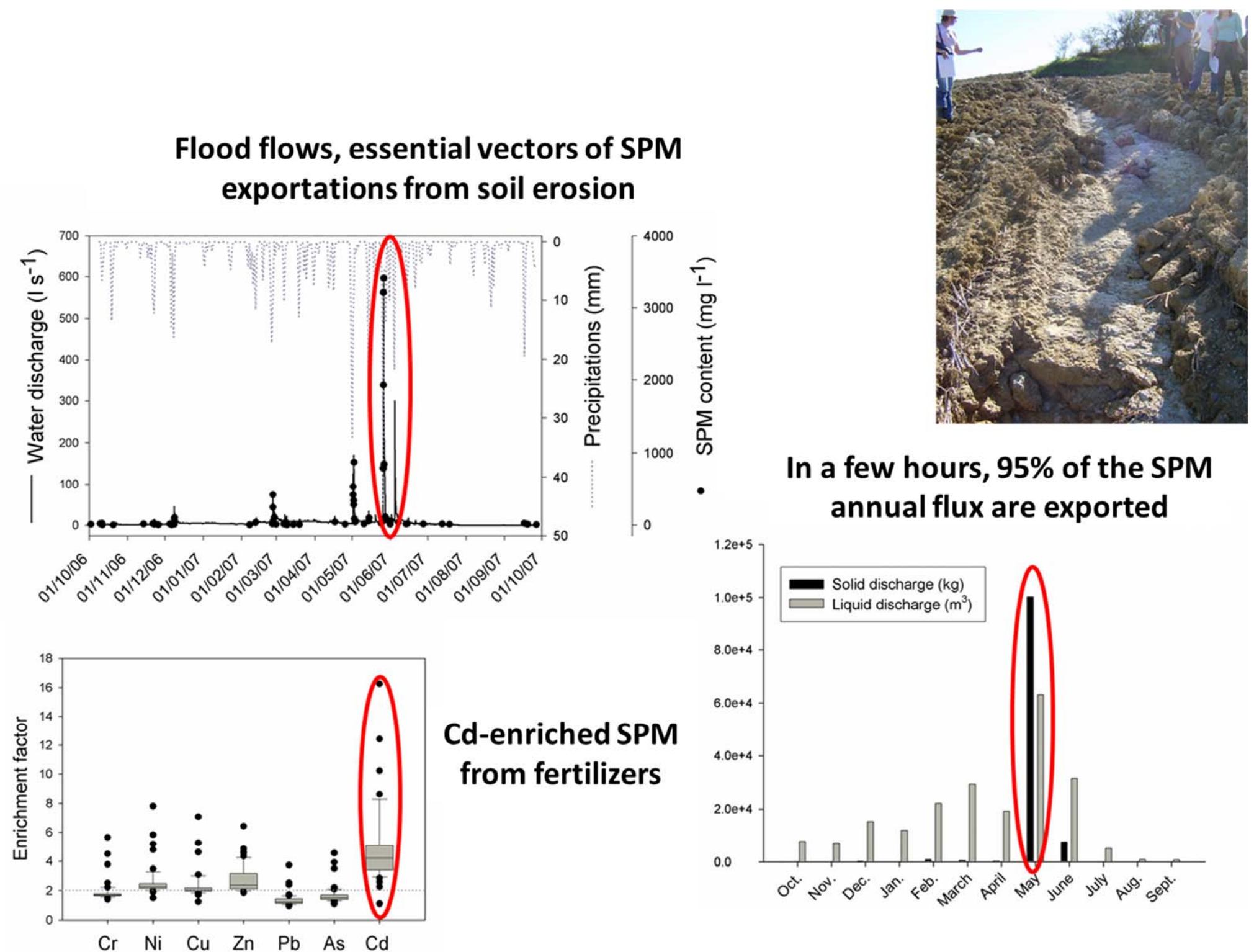


Figure 23. Significance of flooding in the export of metal from small-scale agricultural watersheds: the case study of the Montoussé River. (Roussiez et al., 2013)

During floods, there is a rapid enrichment of water in the dissolved phase of metals. This is linked to surface runoff; as well as the desorption mechanisms of the particulate phase of the soil. These graphs highlight a potential threat to ecosystems.

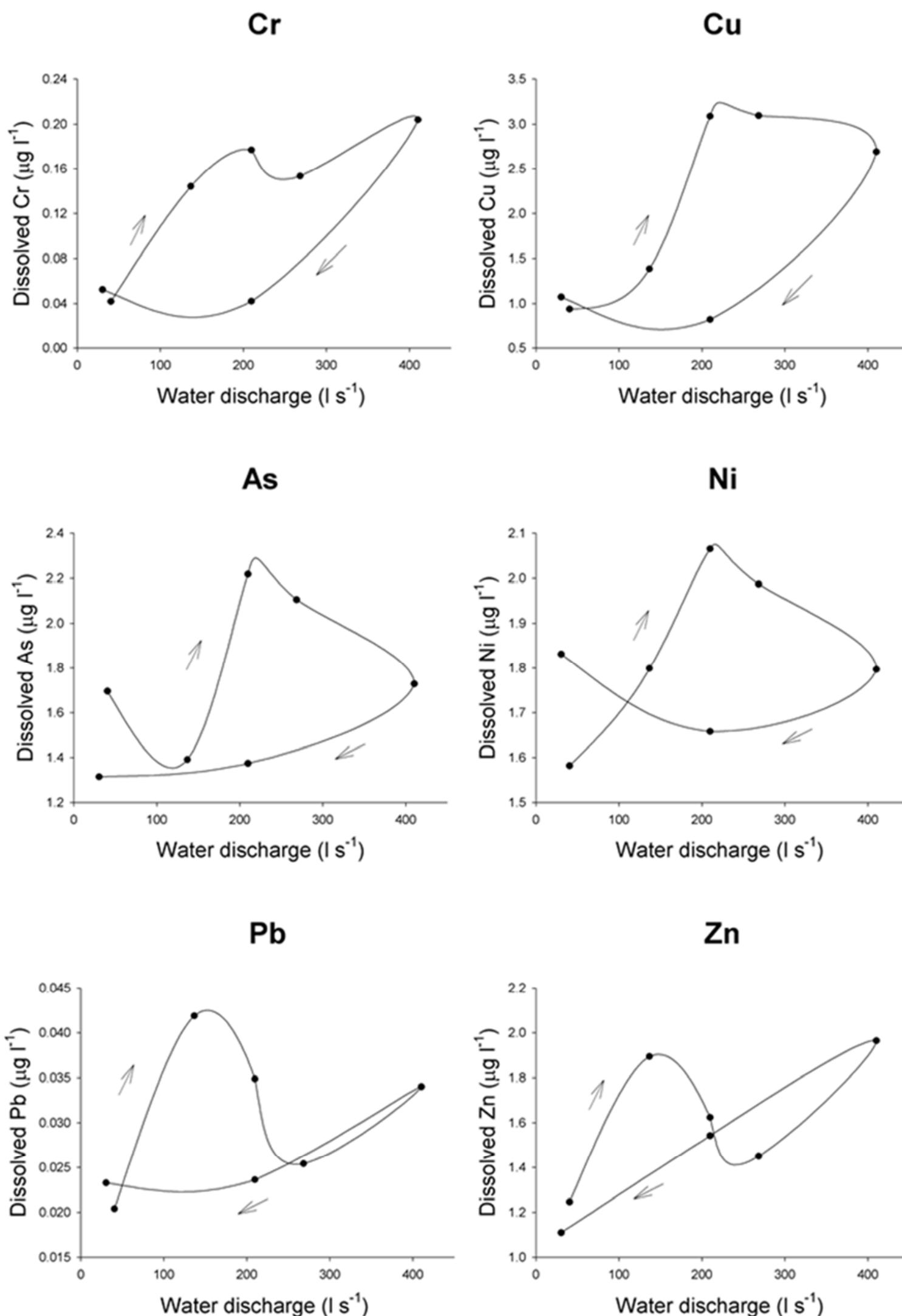


Figure 24. Dextral hysteresis showing the evolution of the dissolved phase of metals in the streamwaters of the Montoussé watershed. (Roussiez et al., 2013)

Fate of metals and enrichment factors in soils

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On certain calcosols of the catchment area, an accumulation of TME in the form of shotgun pellets has been observed: at the surface for profile 2 and at mid-depth for profile 4. These accumulations are strongly linked to variations in groundwater which thus cause hydromorphy.

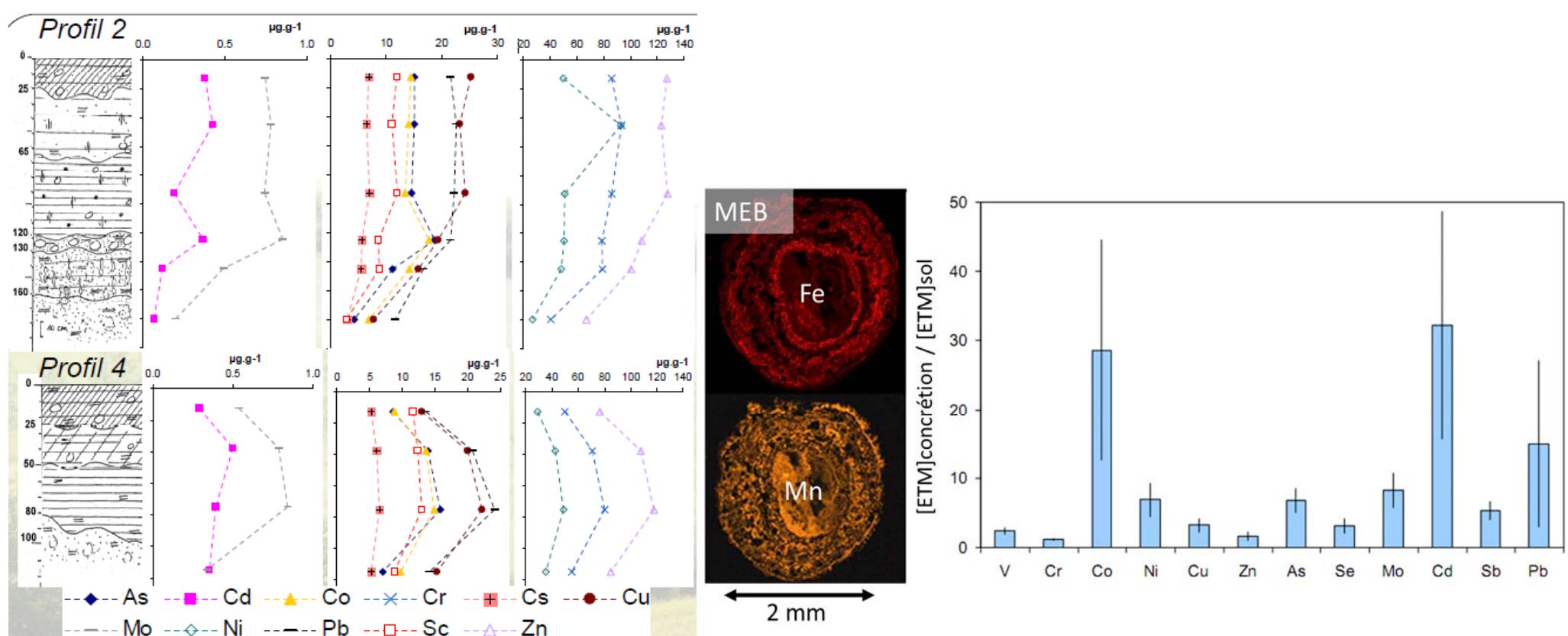
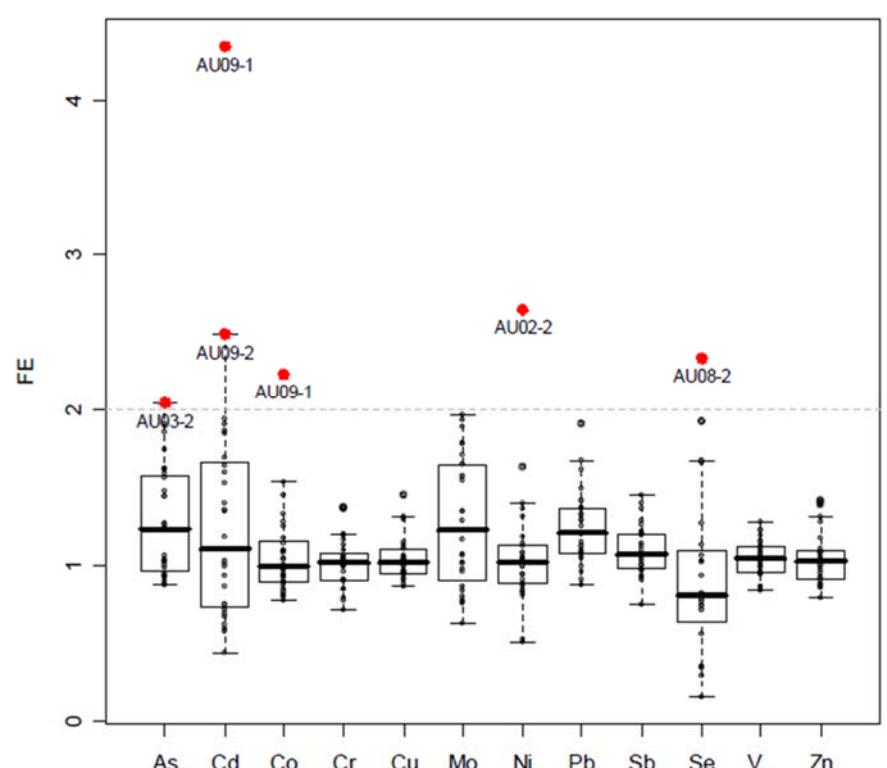


Figure 25. From left to right: Concentrations of various metals within calcosol profiles; Ratio between the concentration of ferro-manganic concretions and that of the soil (Bur et al., 2009, 2010, 2012).

Ferro-manganic concretions are therefore sequestration agents formed by alternating saturation/desaturation. The concentrations of major elements and TME have a mass of less than 1% but it is possible to quantify a stock of up to 10% Cd.

The enrichment factors, all soils included, vary between 0.5 and 2. The environments are very little contaminated. With few exceptions, enrichment factors are highest for Cd, Mo and As

Figure 26. Metal enrichment factors in the soil (Bur et al., 2009, 2010, 2012).



Toxicity of TME for springtails

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An experiment carried out on natural soils in Midi-Pyrénées has made it possible to observe various relationships between the bioaccumulation factor of metals in springtails and the fractions of metallic trace elements available in the soil. The biogenic elements (Zn, Cu for example) are the most bioaccumulated. The bioaccumulation of cadmium is all the higher as the availability of the metal in the soil is important.

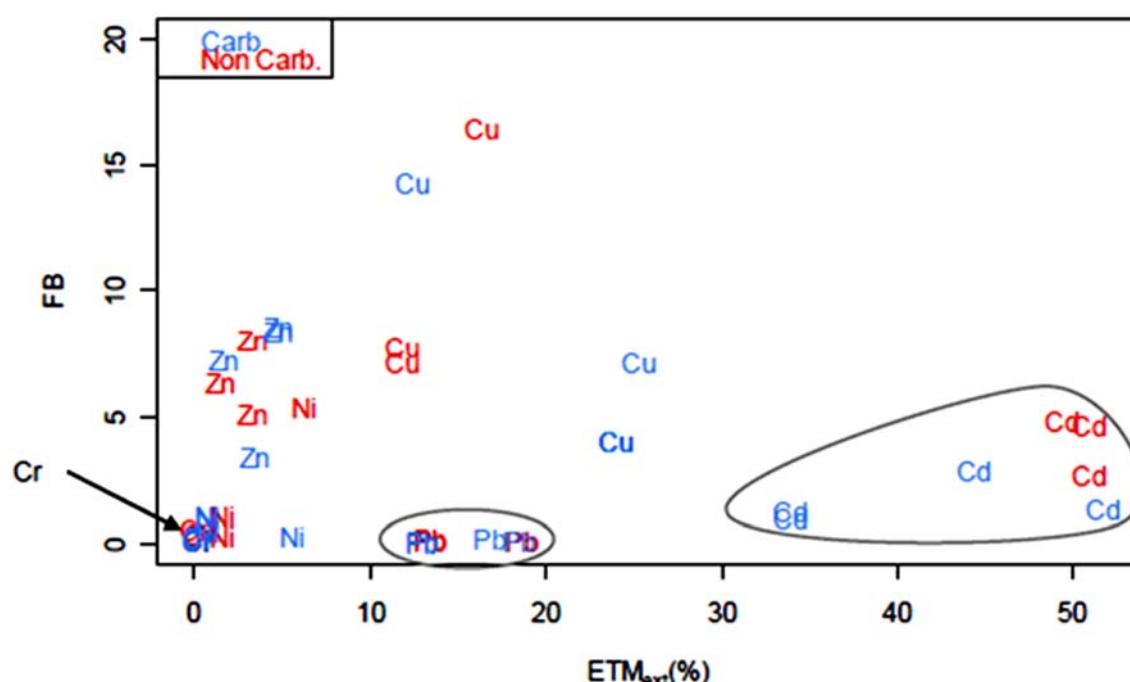
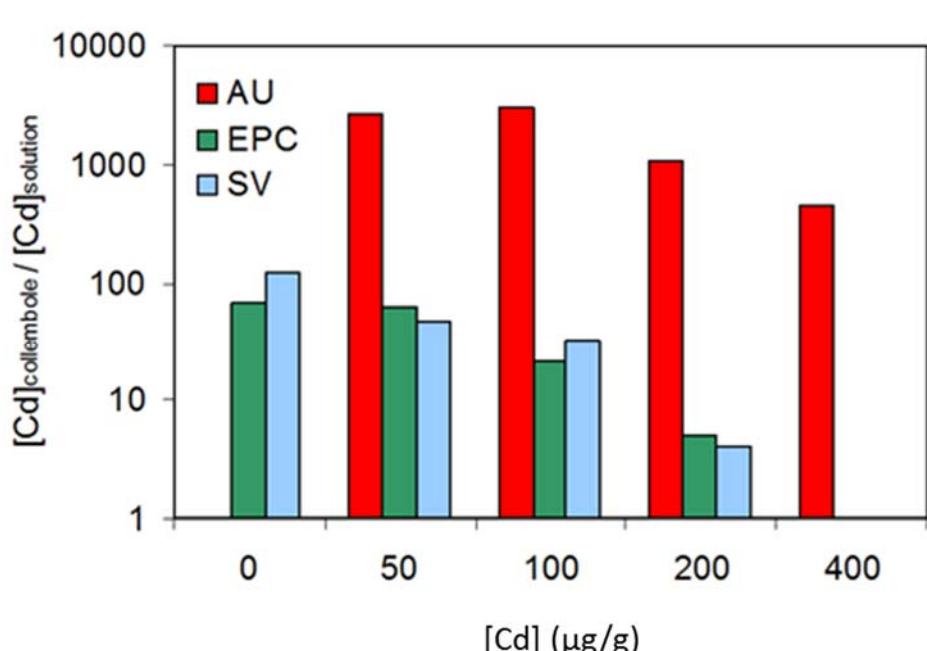


Figure 27. Metal bioaccumulation factors according to metals extractable from the soil (Austruy 2007 and Bur, 2009).



Observation of bioaccumulation:
 $[\text{TME}]_{\text{springtail}} / [\text{TME}]_{\text{soil solution}}$

- Decrease → Maximum bioaccumulation reached.
- Strong bioaccumulation for carbonated soils.

Two hypotheses: effect of pH

- Facilitates Cd penetration (weak competition with H⁺)
- Adsorption on non-dosed ingested particles (filtration).

Figure 28 Comparison between soils with different pH of the relationship [Cd] springtail / [Cd] solution. AU = Auradé (pH8, 2% MO). EPC = forest floor (pH4.5, 16% MO). SV = agricultural soil (pH6, 2%Mo). (Bur et al., 2009, 2010, 2012).

Annual hydro-chemical mass balances

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Annual hydro-chemical mass balances for the period 2004-2004.

Chemical weathering of the molassic substratum : $20 \text{ t} \cdot \text{km}^{-2} \cdot \text{y}^{-1} \text{ CaCO}_3$ et $8,4 \text{ t} \cdot \text{km}^{-2} \cdot \text{y}^{-1} \text{ MgCO}_3$, i.e. $28,4 \text{ t} \cdot \text{km}^{-2} \cdot \text{y}^{-1} \text{ Ca}(1-x)\text{MgxCO}_3$

→ Chemical denudation rate : 14,2 mm per 1000 years.

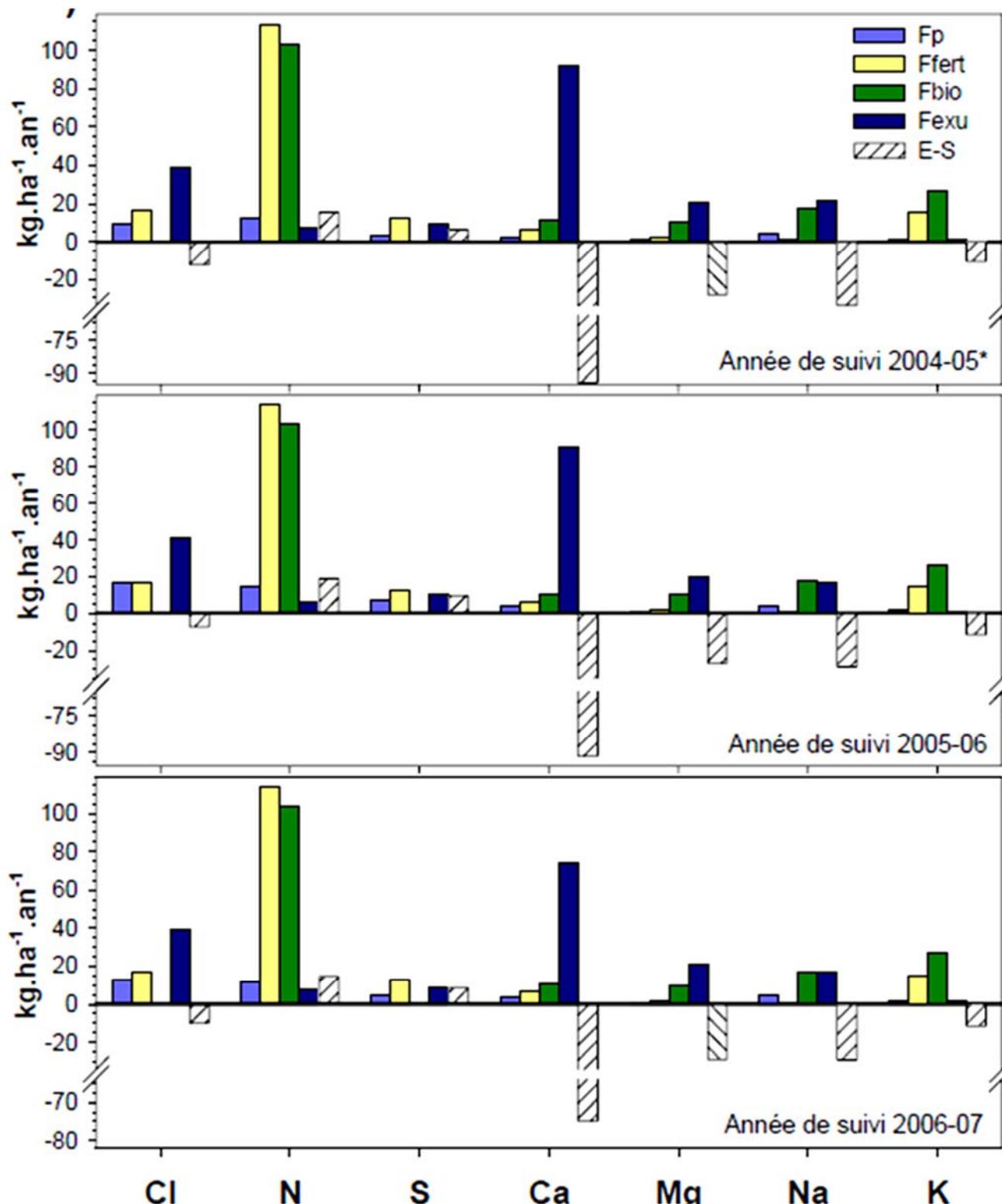


Figure 29. Annual hydro-chemical mass balances for the period 2004-2007 (Perrin et al., 2008).

Impacts of nitrogen fertilizers on weathering, constrained by carbon isotopes in the Auradé Catchment

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Tracing of carbon sources was carried out on the Montoussé watershed in Auradé with a view to analyzing the effect of fertilizers on chemical weathering. For this study, the relationships between atmospheric CO₂ and soil alteration were taken into account.

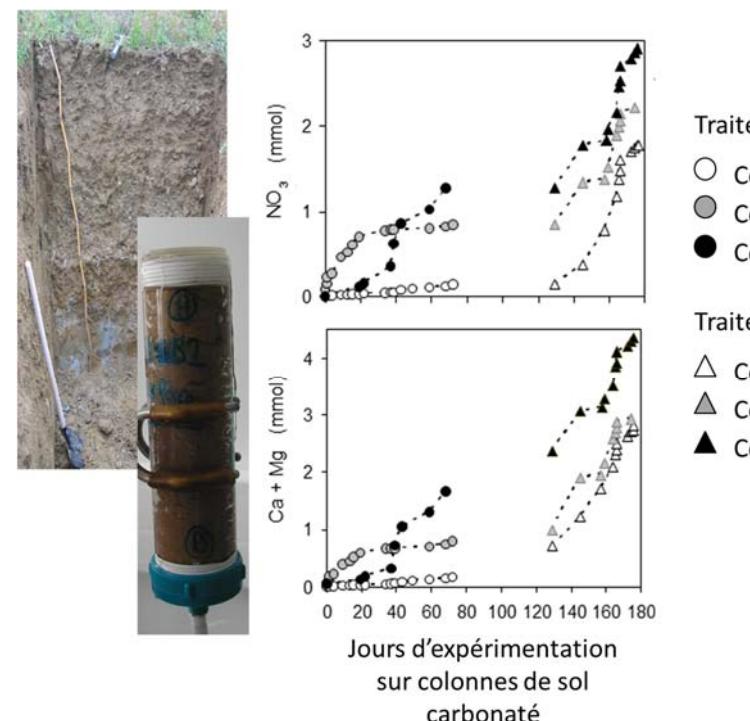
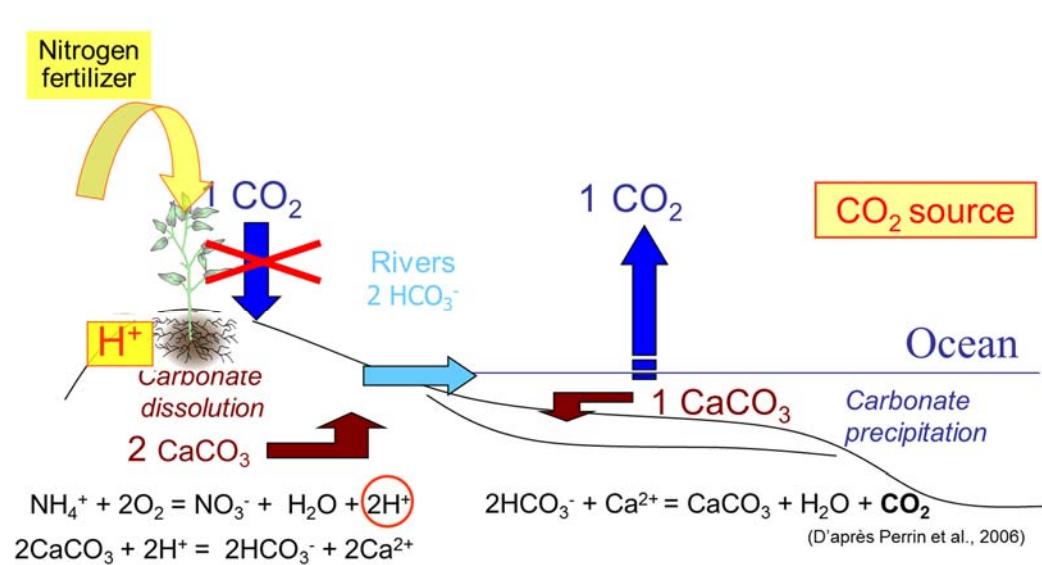


Figure 30. Impact of nitrogen fertilizers on carbonate dissolution and atmospheric CO₂ consumed (left) and the release of fertilizer protons induced on cultivated soils with contrasting carbonate contents (right), (Gandois et al., 2011).

An impact of nitrogen fertilizers on the chemical alteration of carbonated soils has been demonstrated. On a global scale, there is an increase in Ca Mg stream fluxes of $2.5 \cdot 10^{12} \text{ mol.ha}^{-1}$.

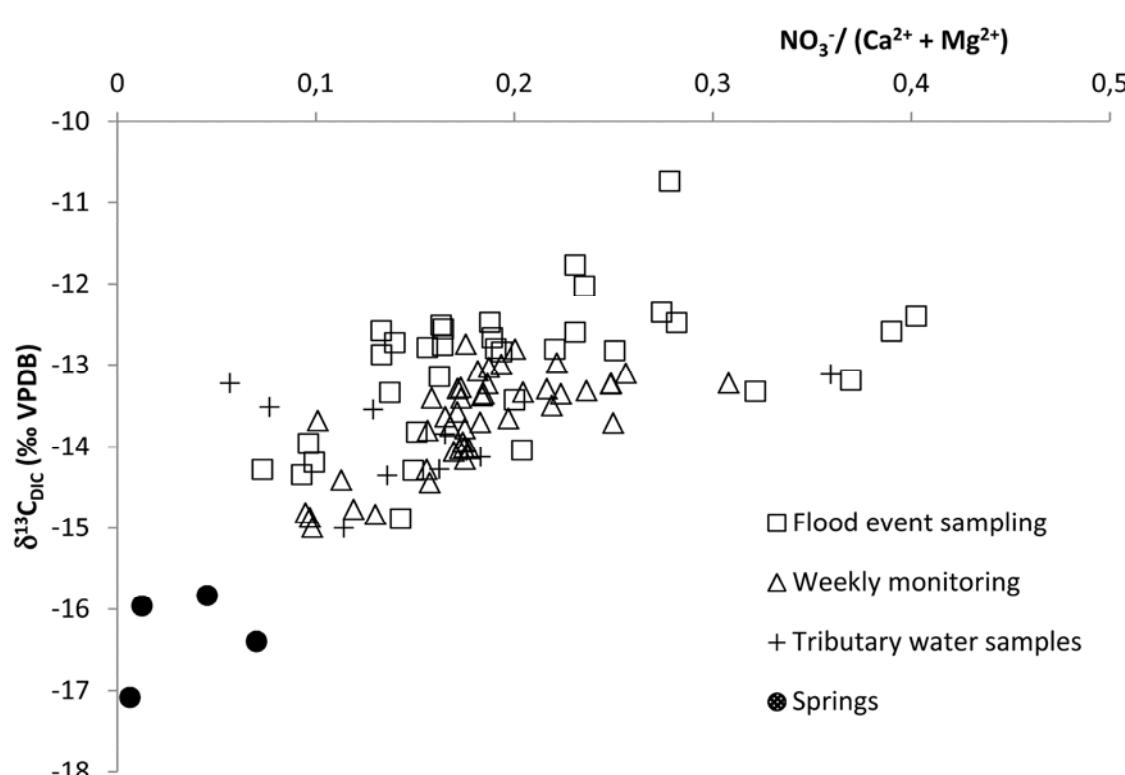


Figure 31. Relationship between $\delta^{13}\text{C}_{\text{DIC}}$ (‰) and the molar ratio $\text{NO}_3^- / (\text{Ca}^{2+} + \text{Mg}^{2+})$ for the surface waters (springs, tributaries and Montoussé main course) of the Auradé Catchment during the period March to December 2010. (Brunet et al., 2011).

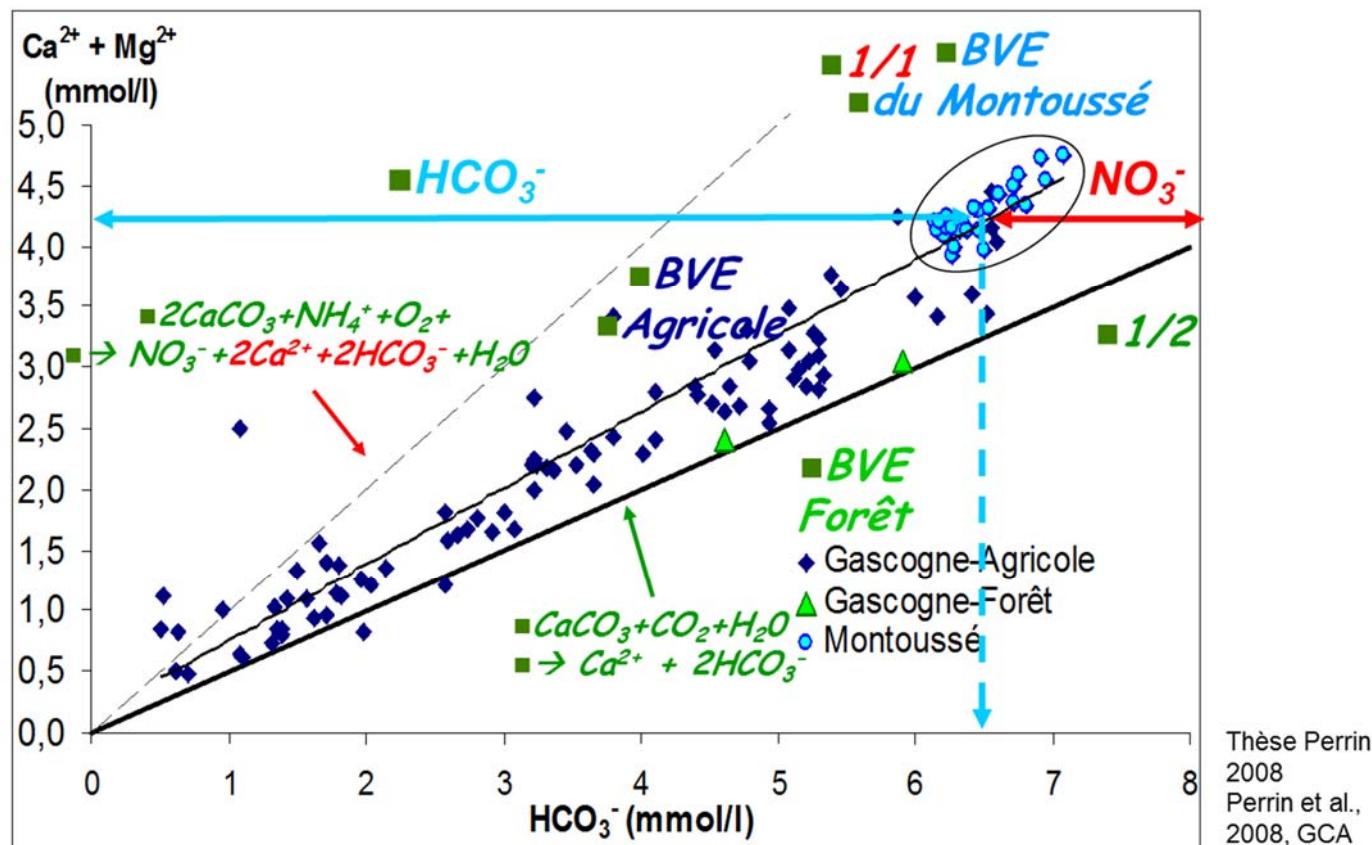


Figure 32. Relationships between $\text{Ca}+\text{Mg}$ and HCO_3^- in the stream waters of the Gascony region, including the Montoussé in Auradé Catchment. Line 1/2 corresponds to the natural weathering pathway of carbonate with carbonic acid. Line 1/1 : anthropogenic weathering of carbonate with nitric acid. (Perrin et al. 2008)

Thèse Perrin
2008
Perrin et al.,
2008, GCA

The Auradé Catchment : modeling support. Nitrate transfer modeling.

LEFE-AKKA technologies-INRAE

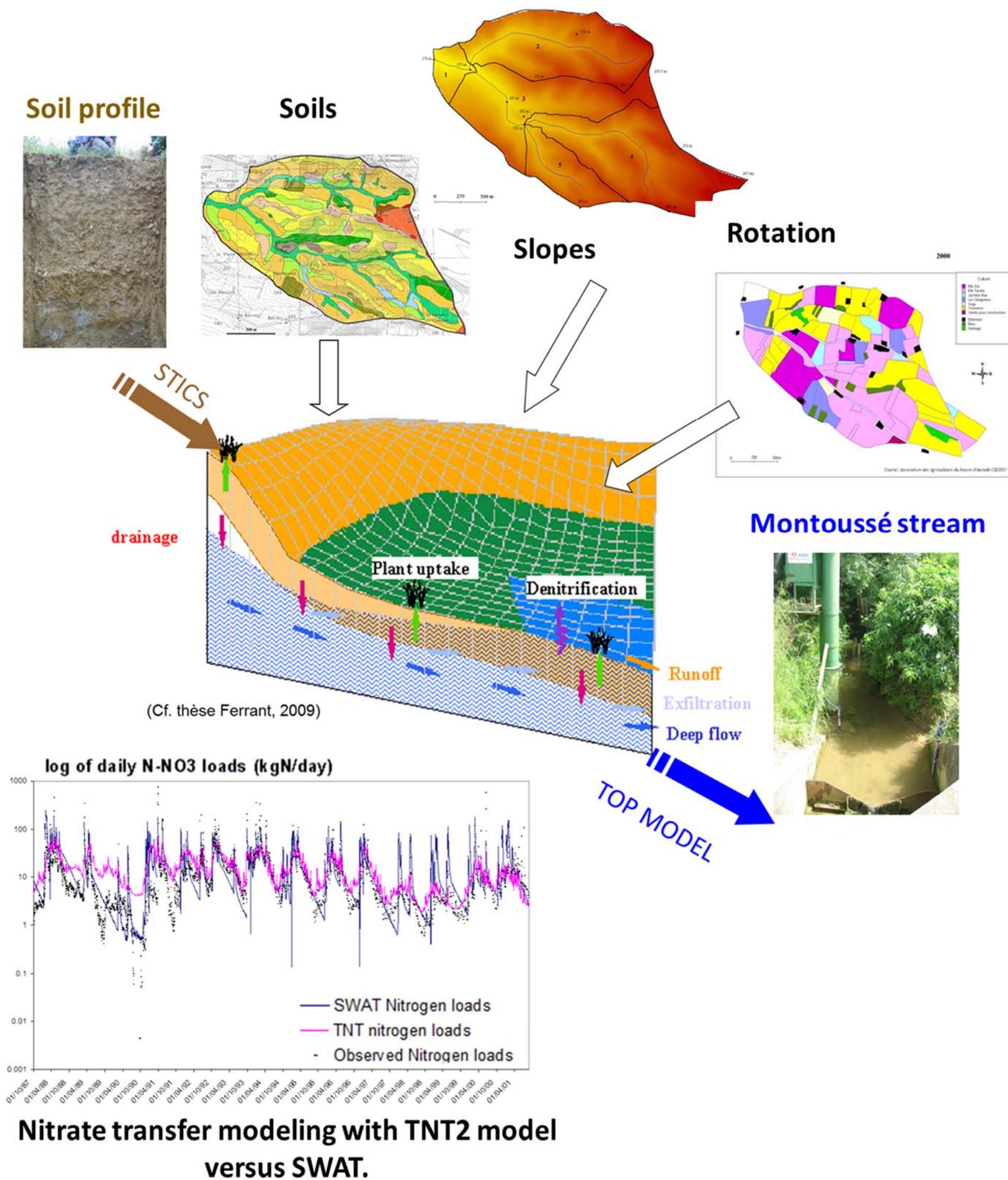


Figure 33- Modelling of nitrate transfers in Auradé Catchment using SWAT and TNT2 models (Farrant, 2008).

These results were obtained as part of Farrant's thesis (2008) for nitrates and in numerous scientific articles (Farrant et al., 2011, 2012, 2013).

The quality of surface water in the Auradé Catchment. Agri-environmental risk assessment and analytical measures.

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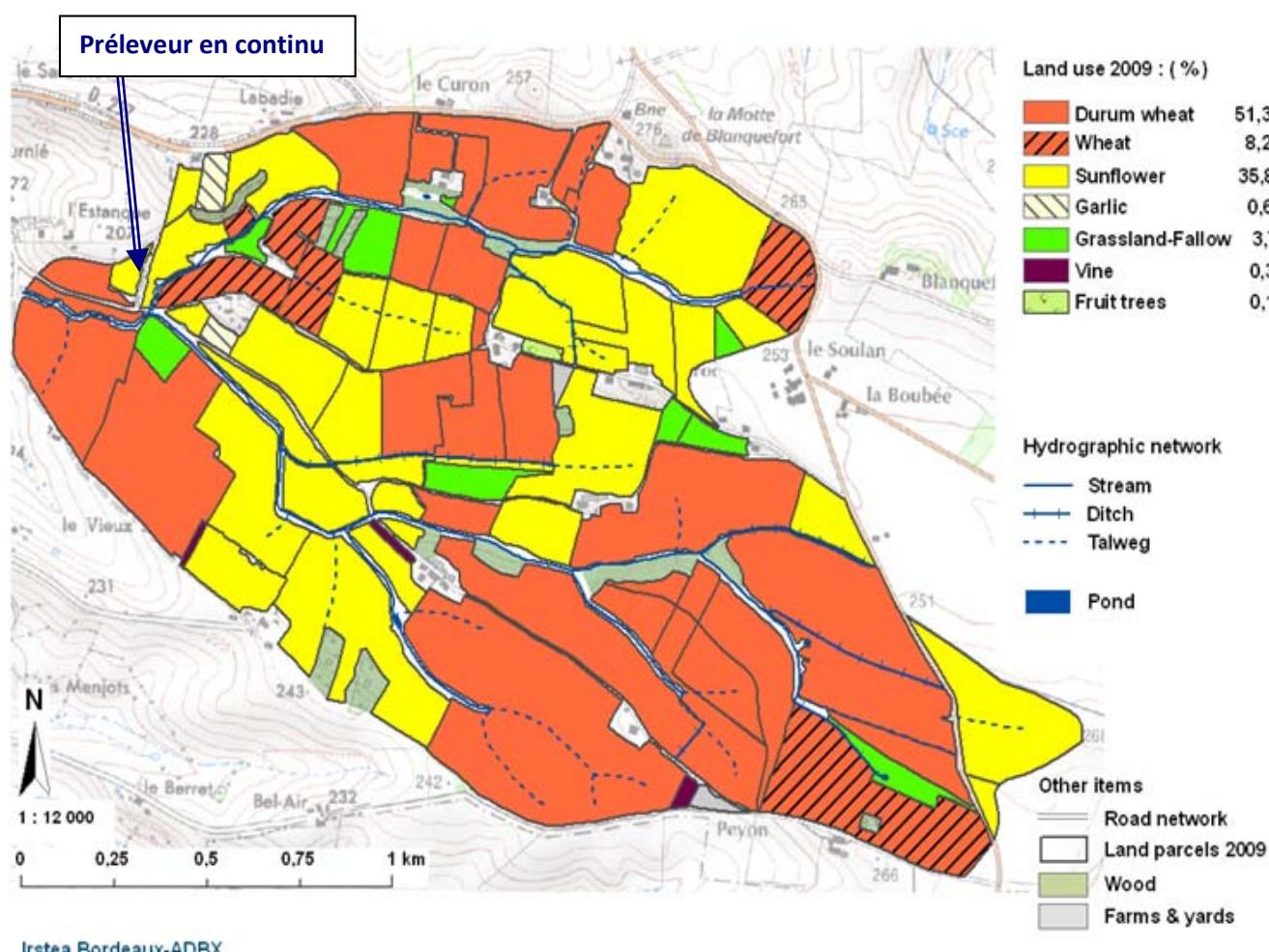
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⁴CNRS, EcoLab, 31326 Castanet-Tolosan, France

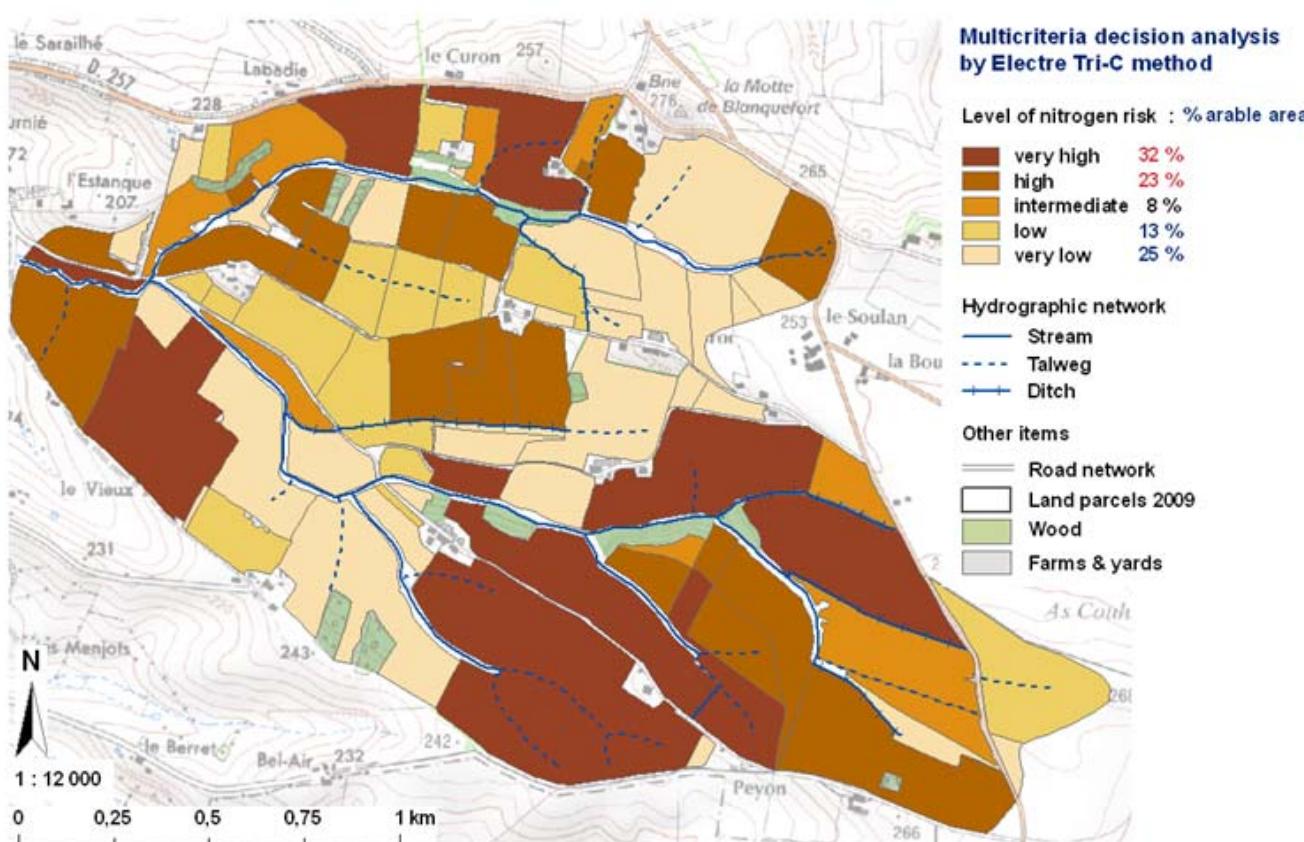
The experimental catchment of Auradé (320 ha), a few km from the pumping station and water treatment of the city of L'Isle Jourdain is located in an agricultural production area whose intensive practices have a strong impact on the quality of surface water (fertilizers, phytosanitary products, very simplified rotations). This catchment has been the subject of hydro-chemical monitoring of the quality of the surface waters of the Montoussé stream since the beginning of the 1980s (Grande Paroisse Company, ex AZF for NO₃ monitoring), then by LEFE since 2006 which also controls the concentration of phytosanitary products. Good environmental practices (GEPs) have been implemented along the watercourse since the creation of the farmer's association (Association des Agriculteurs d'Auradé, AAA) in 1992. A method for assessing the risks of contamination of the waters of the Montoussé was developed by INRAE (Bordeaux-Cestas) taking GEPs into account, with comparison with the nitrate concentrations.

Results



- An experimental catchment area of 320 ha: 90 agricultural plots.
- Steeply sloping plots; cambisols ("terreforts") on molasse.
- Circulation of water flows very largely by surface runoff.
- Short rotations: Wheat / Sunflower: 60% and 36% UAA.
- For 20 years: environmental measures (grass strips, poplars along the watercourse, riparian forest).

Figure 34. The rotation in Auradé Catchment during the year 2009



Irstea Bordeaux-ADBx

Sources : IGN, Auradé farmers association

Figure 35. Risks of contamination of surface water by agricultural activities on the Auradé Catchment in 2009

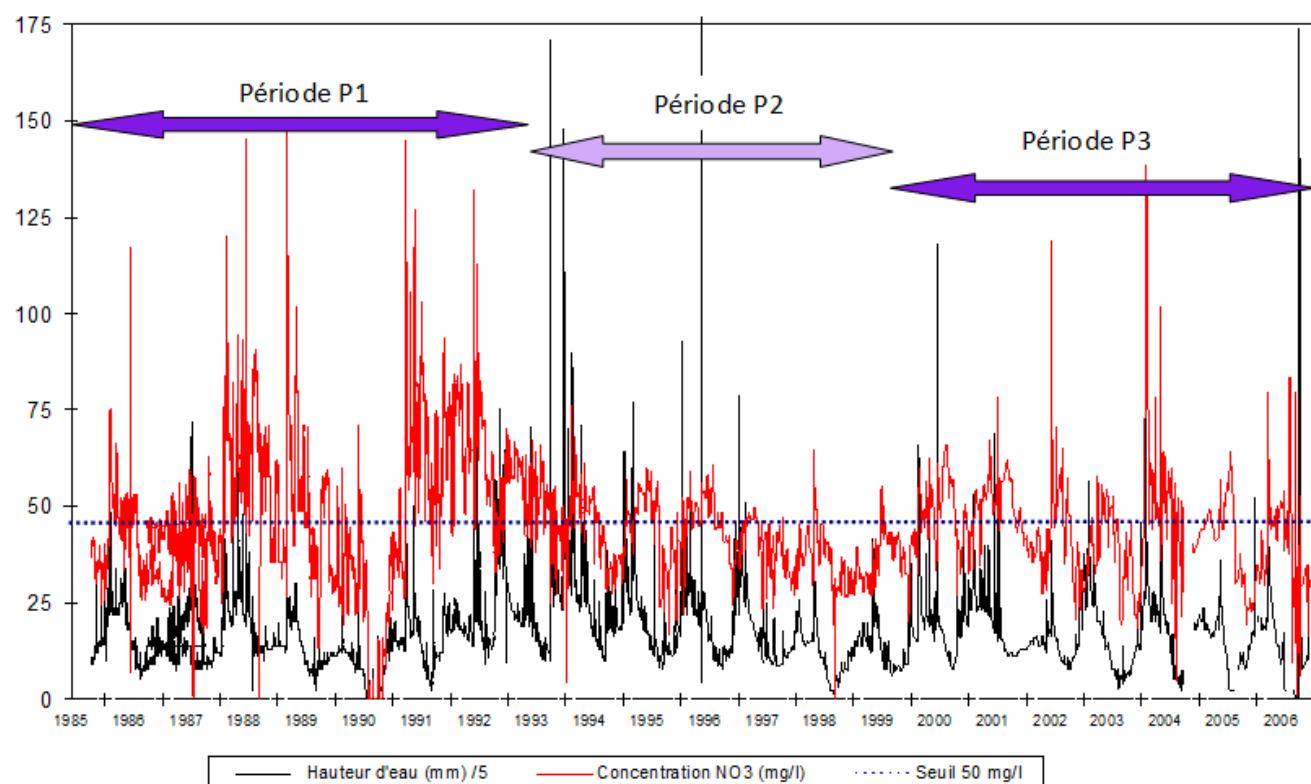


Figure 36. Fluctuations of nitrate concentrations in the Montoussé stream, Auradé Catchment, since 1985 (Sources : Ferrant, 2009, after the nitrate concentration monitoring by Grande Paroisse and LEFE)

- Evaluation of agro-environmental risks (NO₃) by analysis and spatialized multicriteria modeling for decision support.
- 55% UAA classified as high to very high risk of surface water contamination.
- The plots concerned are steeply sloping, well connected with the stream with a high level of inputs.
- Confrontation > 0 of the high level of risks with in situ measurements.

- P1 (1985-1992): higher [NO₃] values. Strong intensification, without regulation of GEPs.
- P2 (1993-2000): decreasing trend [NO₃]. Effects of GEPs and the 1992 CAP.
- P3 (Post 2000): stagnation, but...level > P2 and above all ~ 50 mg/l => very worrying

Synthesis

Despite the implementation of public policies aimed at the protection of natural resources and environmental devices in the field, the concentrations of inputs: nitrates, but also phytosanitary in a catchment such as that of Auradé remain a concern. Hydro-chemical monitoring is more necessary than ever, as well as the reinforcement of good agricultural and environmental practices.

These results are taken from the theses of Macary (2013) and Ferrant (2009) and the following publications: Ferrant et al., 2011 J. of Hydrol., Macary et al., 2013 Int. J.MCDM

Fusion of geophysical and spatial remote sensing data to estimate the useful reserve of soils: towards a 3D vision of catchments

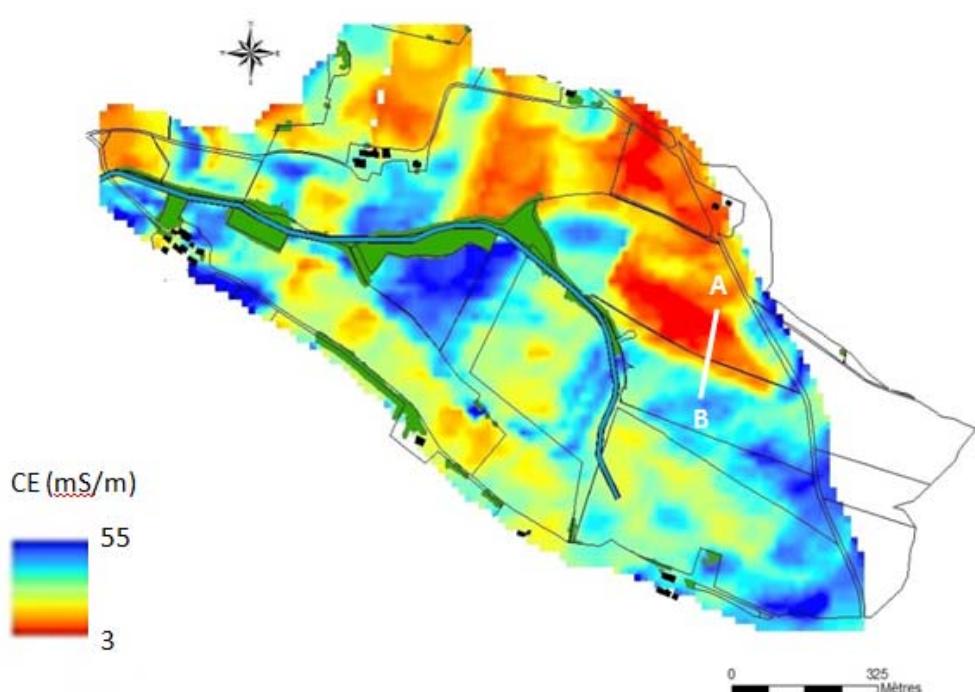
V. Bustillo^{1,2}, S. Ferrant¹

¹ UMR CESBIO 5126, Université Paul Sabatier - ² IUT 'A' 24 rue d'Embaques 32000 Auch

The useful soil reserve (UR) is an essential factor in the spatial variability of agricultural production, but also in the transfer of water and pollutants. Its estimation is a major knowledge issue to understand the vulnerability of crops to climate hazards, but also the resilience of agro-hydrosystems, i.e. the memory of water inlets/outlets and past pollution. We were able to establish a UR map of the soils of the Auradé catchment by taking advantage of geophysical acquisitions (electromagnetic and geoelectric methods) and an inverse modeling exercise based on Formosat satellite images at very high spatial and temporal resolution.

Results

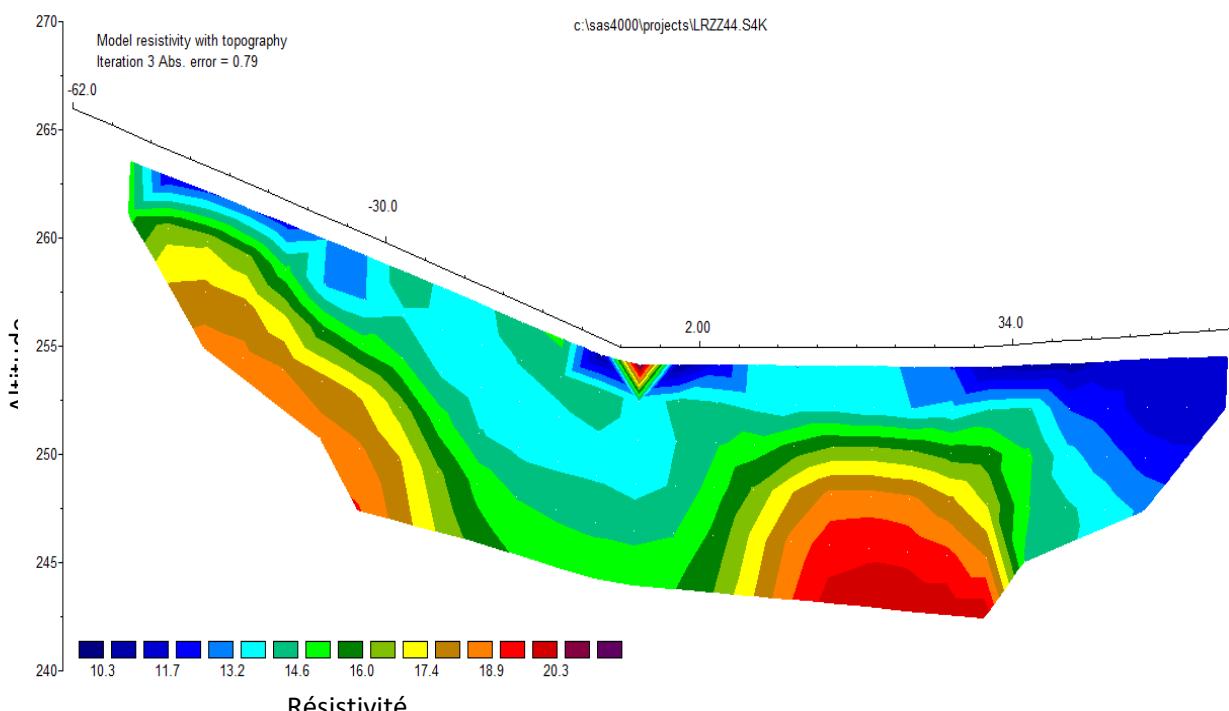
The itinerant acquisition of geophysical data by electromagnetic induction (EM38) makes it possible to map the electrical conductivity (EC) of soils, which accounts for the combined effect of dynamic variables (e.g. soil moisture) and static soil properties (i.e. texture, mineralogy and depth). Given its multifactorial nature, EC does not provide direct access to soil UR and must therefore be approached by diachronic monitoring and concomitant monitoring of soil moisture at different control points to isolate the static and dynamic components of the recorded signal.



At the scale of a 120 ha sub-catchment, we observe specific geophysical signatures at the level of slope breaks which are places of erosion (if convex) or of deposition (if concave). The microtopography therefore appears to be the main determinant of the intra-plot variability of UR. The exposure of the slopes also seems to closely control the variability of EC at the sub-catchment scale. The detailed knowledge of the topography (e.g. by Lidar) suggests a real ability to extrapolate off-site the results acquired on intensive monitoring sites.

Fig.37- Electric Conductivity (EM38 : 1 m) of soils in a sub-catchment of 120 ha. July 2012.

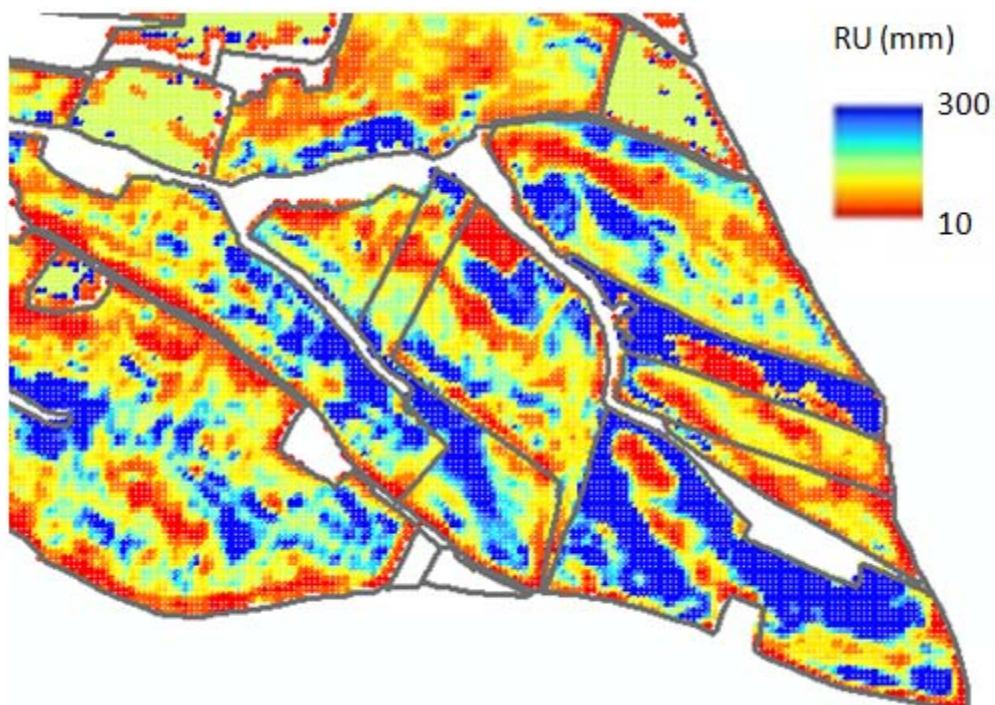
The EM38 method provides an integrated picture of the properties of the first meter of soil. However, a 3D view of the ground can be accessed by resistivimetric tomography methods (Fig. 2), which make it possible to deduce the depths of the ground and to document the main spatial patterns depending, in particular, on the DTM and the geomorphology.



This very characteristic profile illustrates the preponderant effect of topography on the redistribution of molassic materials along the slopes: the asymmetry of slope coincides with a pattern of asymmetrical soil thickness. The deepest soils (> 2m) are typically located downstream of molasse outcrops which are the site of intense physical erosion

Fig. 38- Electrical resistivity profile and overview of profile thicknesses along a typical toposequence of folded terrains.

A robust estimate of the useful soil reserve was obtained by inverting an ecophysiological model (SAFY) calibrated to the spatio-temporal variations of leaf indices on 8-meter-sided grids, from time series of Formosat images.



The inversion of SAFYE on a series of 78 images (2006 to 2010) made it possible to estimate the UR of the soils of the Auradé catchment at the pixel scale (grid cells of 8 m). Sunflower is a particularly appropriate plant model for this inverse modeling exercise, given the particularly explicit phenotypic expression of the effects of limiting access to water. The patterns identified by geophysics (i.e. UR gradients along the slopes related to slope failures and the geometry of the molasses outcrops) manifest themselves very clearly.

Fig.39- Estimate of the useful reserve of the Auradé catchment (zoom on sub-catchment 4 of 120 ha).

Synthesis

The challenge for the future will be to access a 3D vision of the soil from THRS satellite images, thanks to (1) a geophysical calibration on a representative selection of intensive monitoring sites, and (2) the use of crop models that deduce the causes (limited access to water) from the observed effects (vegetation dynamics). The geophysical/remote sensing fusion uses a Bayesian approach taking advantage of an a priori estimate obtained by interpreting information (e.g. DEM and soil maps) via geophysical acquisitions.

List of publications

Publications in JCR-indexed Journals

- BRUNET F., POTOT C., PROBST A. and PROBST J.L. (2011)– Stable carbon isotope evidence for nitrogenous fertilizer impact on carbonate weathering in a small agricultural watershed. *Rapid Commun. Mass Spectrom.*, 25, 2682–2690. DOI: 10.1002/rcm.5050
- BUR T., CROUAU Y., BIANCO A., GANDOIS L., PROBST A. 2012 - Toxicity of Pb and Pb/Cd combination on the springtail *Folsomia candida* in natural soils: reproduction, growth and bioaccumulation as indicators. *Science of the Total Environment*, 414, 187-197.
- BUR T., PROBST A., BIANCO A., GANDOIS L., CROUAU Y. (2010)– Determining cadmium critical concentrations in natural soils by assessing Collembola mortality, reproduction and growth. *Ecotoxicology and Environment Safety*, 73, 415–422. doi:10.1016/j.ecoenv.2009.10.010
- BUR T., PROBST J.L., N'GUESSAN M. and PROBST A. 2009 – Distribution and origin of lead in stream sediments from small agricultural catchments draining Miocene molassic deposits (SW France). *Applied Geochemistry*, 24, 1324-1338.
- CASAL L., DURAND P., AKKAL-CORFINI N., BENHAMOU C., LAURENT F., SALMON-MONVIOLA J., FERRANT S., PROBST A., PROBST J.L., VERTES F. 2019- Reduction of stream nitrate concentrations by land management in contrasted landscapes. *Nutr. Cycl. Agroecosyst.* <https://doi.org/10.1007/s10705-019-09985-0>
- CAUSSADE B., PRAT, M. 1990- Transport modelling in watersheds. *Ecol. Modelling.* 52, 135-179
- CAUSSADE B., PIERRE D., PRAT M 1984- Study and management model of surface-water nitrogen concentration in a cultivated catchment. *Journal of Hydrology*, 73, 105-128.
- CHAUMET B., PROBST J.L., EON P., CAMBOULIVE T., RIBOUL D., PAYRE-SUC V., GRANOUILAC F., PROBST A., 2021- Role of Pond Sediments for Trapping Pesticides in an Agricultural Catchment (Auradé, SW France): Distribution and Controlling Factors. *Water* 2021, 13(13), 1734; <https://doi.org/10.3390/w13131734>
- DEBENEST T., SILVESTRE J., COSTE M. and PINELLI E. 2010. Effects of pesticides on freshwater diatoms. *Rev. Environ. Contam. Toxicol.* 203: 87-103.
- DJUKICI., KEPFER-ROJAS S., SCHMIDT K.I., LARSEN S.K.ow M.A., BEIER C., BERG B., VEHEYEN K., Tea Group Composition: ...PROBST J.L., CAMBOULIVE T., OUIN A., PROBST A., DELIRE C.,...2018- Early stage litter decomposition across biomes. *Science of the Total Environment*, 628-629: 1369-1394.
- EL AZZI D., LAURENT F., ROUSSIEZ V., CHOU L., GUIRESSE M., PROBST J.L. 2018- Adsorption of aclonifen, alachlor, cd and cu onto natural river suspended matter in the context of multi-pollutions: influence of contaminant co-presence and order of input into the aqueous solution. *Water*, 10, 9: 1222
- FAGGIANO L., DE ZWART D., GARCÍA-BERTHOU E., LEK S. AND GEVREY M. 2010. Patterning ecological risk for pesticide contamination at the basin scale. *Sc. Total Environment*, 408, 11, 2319-2326.
- FERRANT S., LAPLANCHE C., DURBE G., JUSTES E.; PROBST A., DUGAST P., DURAND P., SANCHEZ-PEREZ J.M. and PROBST J.L. 2012 – Continuous measurement of nitrate concentration in a highlyevent-responsive agricultural catchment in south-west of France: is the gain of information useful? *Hydrological Processes.*, DOI: 10.1002/hyp.9324
- FERRANT S., Oehler F., DURAND P., RUIZ L., SALMON-MONVIOLA J.; JUSTES E.; DUGAST P., PROBST A., PROBST J.L. and SANCHEZ-PEREZ J.M. 2011 - Understanding nitrogen transfer dynamics in a small agricultural catchment: comparison of adistributed (TNT2) and a semi distributed (SWAT) modelling approaches. *Journal of Hydrology*, 406, 1-15.
- FERRANT S., DURAND P., JUSTES E., PROBST J.L., SANCHEZ-PEREZ J.M. 2013- Simulating the long term impact of nitrate mitigation scenarios in a pilot study basin. *Agricultural Water Management* 124, 85-96
- FERRANT S.; GASCOIN S., VELOSO A., SALMON-MONVIOLA J., CLAVERIE M., RIVALLAND V., DEDIEU G., DEMAREZ V., CESCHIA E., PROBST J.L., DURAND P. and BUSTILLO V. 2014. Agro-hydrology and multi temporal high resolution remote sensing: toward an explicit spatial processes calibration. *Hydrol. Erath Syst. Sci. Discuss.*, 11, 7689-7732
- FERRANT S, BUSTILLO V, BUREL E, SALMON-MONVIOLA J, CLAVERIE M, JAROSZ N, YIN T, RIVALLAND V, DEDIEU G, DEMAREZ V, CESCHIA E, PROBST A, AL-BITAR A, KERR Y, PROBST JL, DURAND P, GASCOIN S 2016- Extracting Soil Water Holding Capacity Parameters of a Distributed Agro-Hydrological Model from High Resolution Optical Satellite Observations Series. *Remote Sens.* 2016, 8(2), 154; doi:10.3390/rs8020154

- GANDOIS L., PERRIN A.S., PROBST A. 2011- Impact of nitrogenous fertilizers-induced proton release on cultivated soils with contrasted carbonate contents: a column experiment. *Geochimica Cosmochimica Acta*, 75, 5, 1185-1198 doi: 10.1016/j.gca.2010.11.025 .
- IMFELD G., S. PAYRAUDEAU, J. TOURNEBIZE, S. SAUVAGE, F. MACARY, C. CHAUMONT, A. PROBST, J.M. SANCHEZ-PEREZ, A. BAHI, B. CHAUMET, T. GILEVSKA, H. ALEXANDRE, J.L. PROBST 2021- The Role of Ponds in Pesticide Dissipation at the Agricultural Catchment Scale: A Critical Review. *Water* 2021, 13(9), 1202; <https://doi.org/10.3390/w13091202>
- KWON T. et al. (Tea Composition Network)- 2021- Effects of climate and atmospheric nitrogen deposition on early to mid-term stage litter decomposition across biomes. *Front. For. Glob. Change*, 14 July 2021, <https://doi.org/10.3389/ffgc.2021.678480>
- MACARY F., ALMEIDA-DIAS J., UNY D., PROBST A., RUI-FIGUEIRA J., ROY B. (2013)- Assessment of the effects of best environmental practices on reducing pesticide pollution in surface water, using multi-criteria modelling coupled with a GIS. *Int. J. Multicriteria Decision Making*, 3, 2/3, 178-206 + appendix
- MACARY F, MORIN S, PROBST JL, SAUDUBRAY F 2014 A multi-scale method to assess pesticide contamination risks in agricultural watersheds. *Ecological Indicators*, 36, 624–639
- N'GUESSAN M., PROBST J.L., BUR T., and PROBST A. 2009 – Trace elements in stream bed sediments from agricultural catchments (Gascogne region, S-W France): where do they come from? *The Science of The Total Environment*, 407, 2939-2952.
- N'GUESSAN Y.M., WANGO T.E., ADOPO K.L., PROBST J.L., PROBST A. 2016- Geochemical characteristics of surface waters in an agricultural environment: case of Gascogne catchments (Midi Pyrenees region, SW France). *Int. J. Innovation and Applied Studies*, 17, 2 : 394-406.
- OUIN A., ANDRIEU E., VIALATTE A., BAVENT G., BARBARO L., BLANCO J., CESCHIA E., FAUVE M., GALLAI N., HEWISON M., DEJOUX J.F., KEPHALIACOS C., MACARY F., PROBST A., PROBST J.L., RYSCHAWY J., SHEEREN D., SIRAMI C. 2021- Chapter Two - Building a shared vision of the future for multifunctional agricultural landscapes. Lessons from a long term socio-ecological research site in south-western France. *Advances in Ecological Research*, 65, 57-106. <https://doi.org/10.1016/bs.aecr.2021.05.001>
- PAUL A., MOUSSA I., PAYRE V., PROBST A., PROBST J.L. 2015 - Flood survey of nitrate behaviour using nitrogen isotope tracing in the critical zone of a French agricultural catchment. *C.R. Geoscience*, 347, 328-337
- PAULE A., LYAUTHEY E., GARABETIAN F. & ROLS J.L. 2009. Autogenic versus environmental control during development of river biofilm. *Int. J. Limnol.* 45 : 1-10.
- PERRIN A.S., PROBST A. and PROBST J.L. 2008 – Impact of nitrogen fertilizers on carbonate dissolution in small agricultural catchments: Implications for weathering CO₂ uptake at regional and global scales. *Geochimica Cosmochimica Acta*, 72, 3105-3123.
- PINHEIRO A., CAUSSADE B. 1997- Simulation de la pollution diffuse dans des basins versants agricoles. *IAHS Publ.*, 243, 333-340.
- RONNOU-DELAFFON V, PROBST A, PAYRE-SUC V; GRANOUILLAG F; FERRANT S; PERRIN AS; PROBST JL 2020- Long and short-term trends of stream hydrochemistry and high frequency surveys as indicators of the influence of climate change, agricultural practices and inner processes (Aurade agricultural catchment, SW France). *Ecological Indicators*, 110, doi.org/10.1016/j.ecolind.2019.105894.
- REDON P.O., BUR T., GUIRESSE M., PROBST J.L., TOISER A., REVEL J.C., JOLIVET C., PROBST A. 2013- Modelling trace metal background to evaluate anthropogenic contamination in arable soils of south-western France. *Geoderma* 206, 112-122
- ROLLAND M.-N., GABRIELLE B., LAVILLE P., SERÇA D., CORTINOVIS J., LARMANOU E., LEHUGER S., CELLIER P. 2008- Modeling of nitric oxide emissions from temperate agricultural soils. *Nutr Cycl Agroecosyt.* (2008) 80:75–93
- ROUSSIEZ V, PROBST A, PROBST JL 2013- Significance of floods in metal export from small-scale agricultural watersheds: the case study of the Montoussé River (SW France). *Journal of Hydrology*, 499, 71-81
- SONG MY, LEPRIEUR F, THOMAS A, LEK-ANG S, CHON TS, LEK SOVAN, 2009 - Impact of agricultural land use on aquatic insect assemblages in the Garonne river catchment (SW France). *Aquatic Ecology* 43: 999-1009.
- TAGHAVI L., MERLINA G., MARCHAND A.L., DURBE G. and PROBST A. 2010- Flood event impact on pesticide transfer in a small agricultural catchment (Montousse at Aurade, South West of France). *International Journal of Environmental Analytical Chemistry*, 90, 388-403.

TAGHAVI L., MERLINA G. and PROBST J.L. (2011)- The role of storm flows in concentration of pesticides associated with particulate and dissolved fractions as a threat to aquatic ecosystems. *Knowledge and Management of Aquatic Ecosystems*, 400, 06 DOI: 10.1051/kmae/2011002

Other publications and communications

- ACKERER J., S. KUPPEL, S. ANQUETIN, I. BRAUD, L. RUIZ, A. PROBST, J.L. PROBST, O. FOVET, F. HABETS, M.C. PIERRET, J. GAILLARDET 2021- Ecohydrological modeling in three contrasted watersheds from OZCAR research infrastructure. *Proceedings 1st OZCAR-TERENO International Conference*, 5-7 October 2021, Strasbourg, France.
- BARCIET F. 1997- Dispositifs pratiques pour limiter l'entraînement par ruissellement des produits de protection des plantes vers les eaux de surface. *Proceedings Congress of the International Union of Game Biologists (IUGB) No23*, Lyon , FRANCE (1997) 1998, vol. 15, HS1 (170 p.) (7 ref.), pp. 109-115.
- BEAUCHARD O., CHOI K.H., LEE S.H., JI C.W., LEK S., CHON T.S. 2009- Quantitative characterization of response behaviors and individual variation in Chironomus riparius after treatments of diazinon. *Ecosystems and Sustainable Development VII Book Series: WIT Transactions on Ecology and the Environment* 122: 127-138.
- BOURGOIN B., KONCLEIN C. 1996- Pratiques, phytosanitaires, bandes enherbées et qualité des eaux : Cas du Bassin versant céréalier d'Auradé (Gers). *Phytoma, la défense des végétaux*, 482, 7-12.
- BRAUD I., O. KA, P.A. AYRAL, A. BLANCHOUIN, L. BOITHIAS, F. BRANGER, N. FOLTON, O. FOVET, B. HECTOR, I. HORNER, S. GALLE, D. JOSSELIN, S. KUPPEL, E. LAJEUNESSE, C. LE BOUTEILLER, C. LEGOUT, J. MOLENAT, G. NORD, C. PEUGEOT, M.C. PIERRET, A. PROBST, J.L. PROBST, D. RACLOT, G. TALLEC, M. WUBDA 2021- Use of hydrological signatures to characterize the hydrological functioning of catchments from the OZCAR French Critical Zone. *Proceedings 1st OZCAR-TERENO International Conference*, 5-7 October 2021, Strasbourg, France.
- BRUNET F., POTTOT C., PROBST A., PROBST J.L. (2010)- Impact des fertilisants azotés sur l'altération d'un bassin versant agricole : traçage avec le d13C du Carbone Inorganique Dissous (CID). 6ème congrès de la société française des isotopes stables, SFIS, Toulouse, 26-29 octobre 2010 (abstract).
- BUR T., BIANCO A., GANDOIS L., CROUAU Y., PROBST A. (2008)- Cadmium critical concentration in natural soils: collembolan reproduction as an indicator. XIVth International Conference on Heavy Metals in the Environment ICHMET, 16-23 Novembre 2008, Taipei, Taiwan, (extended abstract).
- BUR T., CREDOZ A., PROBST A., GUIRESSE M. et PROBST J.L. 2006 - Dynamique des éléments traces métalliques au sein des sols agricoles carbonatés en région Midi-Pyrénées. *Proceedings 21ème Réunion des Sciences de la Terre*, 4-9 décembre 2006, Dijon, p. 156.
- BUR T., CREDOZ A., PROBST A., GUIRESSE M., PROBST J.L. (2007)- Dynamique des Eléments Traces (Métaux, REE) au sein de sols agricoles - Cas du bassin versant expérimental d'Auradé (Gers). *Actes du 9èmes Journées Nationales d'Etude des Sols*, 3-5/4/2007, J.P. Rossignol (ed) Angers, Extended abstract, pp. 221-223.
- BUR T., PROBST J.L., PROBST A., N'GUESSAN M. et GUIRESSE M. 2006 – Origine du plomb dans les sédiments fluviaux de petits bassins versants sous cultures et sous forêts en gascogne : approche géochimique et isotopique. *Proceedings 21ème Réunion des Sciences de la Terre*, 4-9 décembre 2006, Dijon, p. 156.
- BUSCA D. 2003- Action publique, Agriculture et Environnement. La mise en oeuvre négociée des dispositifs agri-environnementaux. *Ruralia*, n°12/13.
- BUSCA D. 2004- La mise en oeuvre négociée des dispositifs publics agri-environnementaux : appropriation stratégique, effets d'organisation et enjeux de territoire. *Annuaire des Collectivités locales*, Editions du CNRS, Paris.
- BUSCA D. 2006- Agriculture et environnement. La mise en oeuvre négociée des dispositifs agrienvironmentaux. Collection Logique juridique, L'Harmattan, Paris.
- BUSCA D. et SALLES D. 2001- Agri-environnement : les territoires font la loi. *Environnement et Société*, numéro Normes et environnement, n°26, Fondation Universitaire Luxembourgeoise.
- CHAUMET B., J.L. PROBST, P. EON, V. PAYRE-SUC, F. GRANOUILAC, T. CAMBOULIVE, D. RIBOUL, C. PAUTOT, M.J. TAVELLA, B. TROCHON, A. PROBST 2020- Pesticide distribution in pond sediments from an agricultural catchment (Auradé, SW France). *Proceedings 5th International Conference On Water Sciences (ECWS5)*. <https://doi.org/10.3390/ECWS-5-08184>.

- DEBENEST, T., DELMAS, F., CHARIER, A., COSTE, M., MAZZELLA, N., GRANGE, J. 2006. Impacts hydrobiologiques des pollutions agricoles sur les cours d'eau des Coteaux de Gascogne : Etude expérimentale en canaux artificiels de l'impact du diuron, de l'isoproturon, de l'acétochlore et de la terbutylazine sur les communautés de diatomées benthiques. Actes du 25ème Colloque de l'ADLAF, Caen, 25-28 Septembre 2006. In : L. Ector, F. Rimet & A. Georges (Eds) p 60.
- DEBENEST, T., COSTE, M., DELMAS, F., PINELLI, E. 2006. River pollution caused by agricultural herbicides and benthic diatom communities : study of relationships, setting-up of specific descriptors usable for bio-indication. In : Acs, E, Kiss, K.T., Padizak, J. et Szabo, K. E. (eds) Use of algae for monitoring rivers VI, Hungarian Algological Society, Göd, Hungary, p 40.
- DECROUX J. ET PUGINIER M, 1993 - Rôle du paysage agricole dans la dynamique de l'azote, intérêt de l'approche bassin versant agricole, exemple d'Auradé. Revue Purpan, ESAP, Toulouse, 166,93-104.
- DOS SANTOS V., S. SIMEONI-SAUVAGE, D. SHEEREN, J. DESAEGHER, T. CAMBOULIVE, V. PAYRE, F. ULLOA-CEDAMANOS, J. LAFFONT, A. PROBST, J.M. SANCHEZ-PEREZ, A. OUIN, J.L. PROBST 2020- Evolution de la qualité des eaux de surface en réponse à différents scénarios d'organisation des paysages agricoles en Gascogne: approche par modélisation agro-hydrologique. 5e colloque des Zones Atelier - CNRS : 2000-2020, 20 ans de recherche du réseau des Zones Ateliers, Nov 2020, En ligne, France. pp.51-52. (hal-03012496).
- DUGAST P. 1998- The Aurade watershed experiment: how to conciliate sustainable agriculture and reduction of nitrogen losses in surface water. Congrès Agriculture et environnement : les produits entraînés par l'eau , Paris, 18-19 novembre 1998 , Colloque d'hydrotechnique No159, Paris , FRANCE (18/11/1998) 1998 , 187-194.
- FAGGIANO L., DEZWART D., DYER S., MULDER C., LEK S., AND GEVREY M., 2010. Improving data priority pollutants: Bringing science into river management plans, Mars 2010.
- FAGGIANO L., LEK S., DE ZWART D. AND GEVREY M., 2009. Testing links between predicted risk of toxicant mixture and fish assemblages using predictive models. SEFS6: symposium for European Freshwater Sciences, Sinaia, Romania, August (Oral).
- FERRANT S., OEHLER F., DURAND P., JUSTES E., PROBST J.L. and SANCHEZ-PEREZ J.M. – 2009- Long term nitrogen budget modelling in a small agricultural watershed : hydrological control assessment of notrogen losses with semi-distributed (SWAT) and distributed (TNT2) models. Geophysical research Abstracts, vol. 11, EGU2009-5755-1, EGU General Assembly 2009.
- FERRANT S., OEURNNG C., SAUVAGE S., DURAND P., PROBST J.L. and SANCHEZ-PEREZ J.M. – 2009- Dynamic of nitrogen loads in surface water of an agricultural watershed by modeling approach, the Save, Southwest France. Geophysical research Abstracts, vol. 11, EGU2009-7203-3, EGU General Assembly 2009.
- GANDOIS L., PERRIN A.-S., PROBST A., POKROVSKY O., PROBST J.-L. (2007)- Rôle des fertilisants azotés dans l'altération des sols agricoles sur roche mère calcaire : approche expérimentale. Actes du 9èmes Journées Nationales d'Etude des Sols, 3-5/4/2007, J.P. Rossignol (ed) Angers, Extended abstract, pp. 391-393.
- GILLE A. 2001– Pratiques phytosanitaires locales et impact sur le suivi de la qualité des eaux sur le bassin versant céréalier d'Auradé dans le Gers. Ingénieries, Eau-Agriculture-Territoire, Hors Série « Phytosanitaires. Transferts, diagnostic et solutions correctives », 143-149.
- GUÉNARD G, PETER , VON DER OHE C, SOVAN LEK S, 2009. Spatial correspondence of chemical status and macro-invertebrates diversity. Proceedings SETAC North America 29th meeting, New-Orlean, USA, 18 24 November 2009.
- GUENARD G., DE ZWART D., VON DER OHE P., LEK S., 2009. Predicting sensitivity to pollutants using molecular characters. Proceedings 14th International Symposium on Toxicity Assessment, Université P Paul-Verlaine, Metz, France, 30 October - 3 September 2009.
- GUILLAUME GUÉNARD G., C. VON DER OHE P., AND LEK S., 2009 A spatially-explicit assessment of pollutants impact and macro-invertebrates diversity and community structure. Proceedings MODELKEY conference, Helmholtz Centre for Environmental Research UFZ, Leipzig, Germany, 30 November - 2 December 2009 (Poster).
- LEGOUT C. SEVE F., LE BOUTEILLER C., NORD G., BOITHIAS L., BRANGER F., CAMENEN B., EVIN G., FAUCHEUX M., FOVET O., GRIPPA M., HAMON Y., LAJUNESSE E., LE COZ J., MARTINEZ J.M., MOQUET J.S., NEMERY J., PROBST A., PROBST J.L., RACLOT D., RIBOLZI O., BLANES S., SIMONNEAU A., SANTINI W., STUBBE V., THOLLET F., VANHOYDONCK P. 2021 - Comparison of hydrosedimentary signatures of catchments from the French Critical Zone network. Proceedings 1st OZCAR-TERENO International Conference, 5-7 October 2021, Strasbourg, France.

- LEGUÉDOIS S., BUR, T., GANDOIS L., DURBE G., PROBST J.-L., PROBST A. (2008)-Assessing the risk caused by diffuse Cd and Pb pollution -Critical load modelling for forest and arable lands. XIVth International Conference on Heavy Metals in the Environment ICHMET, 16-23 Novembre 2008, Taipei, Taiwan, (abstract).
- MACARY F., VERNIER, F., 2007. Zonage de risque potentiel de transferts de pesticides à l'échelle de bassins versants : quelles méthodes pour un transfert d'échelles spatiales ? Pesticides : impacts environnementaux, gestion et traitements, in Presses de l'école nationale des Ponts et chaussées, 245 -259.
- MACARY F., ALMEIDA-DIAS J., PROBST A., GOBERT V., UNY D. (2011)- Risk of water pollution in a small agricultural watershed in Gascony: assessment of the effects of environmental practices by a specialised multicriteria modelling. 73th Meeting of the European Working Group MCDA, April 14&15, Corte (abstract).
- MACARY, F., BALESTRAT, M., CUINET, J., 2007. Estimation d'un risque potentiel spatialisé de la contamination des eaux de surface par les pesticides à différentes échelles sur les coteaux de Gascogne. Actes du Colloque FREDEC, Toulouse, 2-3 octobre, 14 p.
- MACARY, F., BALESTRAT, M., PUECH, C., SAUDUBRAY, F., 2007. Méthode d'estimation d'un risque potentiel spatialisé de la contamination des eaux de surface par les intrants agricoles à différentes échelles spatiales. Application sur les coteaux de Gascogne. Actes du Colloque international de Géomatique et Analyse Spatiale, Clermont Ferrand, 18-19-20 juin 2007.19 p.
- MACARY, F., BORDENAVE P., De VILLE D'AVRAY N., 2008. Estimation d'un risque agroenvironnemental : la contamination des eaux de surface par les intrants agricoles. Application sur les coteaux de Gascogne. Actes du Colloque interdisciplinaire : « vulnérabilités sociales, risques et environnement : comprendre et évaluer », Université Toulouse le Mirail, 14-15-16/06, 15p.
- MACARY, F., LAVIE, E., LUCAS, G., RIGLOS, O., 2006. Méthode de changement d'échelle pour l'estimation du potentiel de contamination des eaux de surface par l'azote. Ingénieries - E A T, n° 46, 35 – 49.
- MACARY F, LECCIA O, DARWICHE-CRIADO N, COMIN F, PEDROCCHI C, SORANDO R, SANCHEZ-PEREZ JM, LAPLANA R, UNY D, SAUVAGE S and PROBST JL- 2011- Agriculture et ressource en eau sur le territoire semi aride du Bassin de l'Ebre en Espagne. Actes du Colloque International des Sciences du Territoire – Université Paris Diderot, 23, 24, 25 novembre 2011, 1-7
- MATHIEU C. et LHOMME A. 2004 – Implantation et efficacité des bandes enherbées en région Midipyrénées (France). ESAP, Toulouse, 555-567.
- MAZZELLA, N., DUBERNET, J. F., DELMAS, F. - 2006. Analyse multirésidus du glyphosate, des tricétones et de plusieurs herbicides acides par HPLC-ESI-MS/MS. Actes des 23èmes Journées Françaises de Spectrométrie de Masse, Nantes, 11-14 Septembre 2006.
- MAZZELLA, N., DUBERNET, J-F., DELMAS, F. 2006. Comparison between pharmaceutical and pesticide POCIS for sampling different polar herbicide classes in aquatic environments. Proceedings 2nd International Passive Sampling Workshop and Symposium, Bratislava. Slovakia, 3-6 May 2006.
- N'GUESSAN M., PROBST J.L., PROBST A., BUR T. et DURBE G. 2006- Distribution des teneurs en éléments traces dans les sédiments fluviaux de petits bassins versants agricoles : cas de la Gascogne. Proceedings 21ème Réunion des Sciences de la Terre, 4-9 décembre 2006, Dijon, p. 170.
- OUIN A., J.L. PROBST, J.P. DEL CORSO, J. DESAEGHER, V. DOS SANTOS, G. KLEFTODIMOS, S. SIMEONI-SAUVAGE, D. SHEEREN, N. GALLAI 2020- Couplage de modèles agro-hydrologique, agro-écologique et économique pour déterminer les paysages agricoles assurant le meilleur compromis entre services écosystémiques. 2000-2020, 20 ans de Recherche du réseau des Zones Ateliers, Nov 2020, En ligne, France. pp.110-111. <hal-03016347>
- PAEGELOW, M. DECROUX J .; HUBSCHMAN J.; PUGINIER, M. 1990- Reducing nitrate pollution through simple measures of country planning. A case study: Aurade (Gers, France). Proceedings Congrès “Nitrates , Agriculture, Eau”, 7-8 novembre 1990, Paris.
- PERRIN A.S., PROBST A. et PROBST J.L. 2006 - Do nitrogen fertilizers change anything on natural weathering processes and CO₂ consumption ? Proceedings 21ème Réunion des Sciences de la Terre, 4-9 décembre 2006, Dijon, p. 172.
- PERRIN A.S., PROBST A. et PROBST J.L. 2006 - Impact of nitrogen fertilizers on natural weathering processes: evident role on CO₂ consumption. Proceedings 16th Annual Goldschmidt Conference, 27th August -1st September 2006, Melbourne.

- PERRIN A.S., PROBST A., DURBE G., PROBST J.L. (2007)- Quel Est L'impact Des Fertilisants Azotés Sur l'altération des sols carbonatés et sur la consommation de CO₂ atmosphérique? Actes du 9èmes Journées Nationales d'Etude des Sols, 3-5/4/2007, J.P. Rossignol (ed) Angers, Extended abstract, pp. 73-75.
- PEUGEOT C., V. WENDLING, M. GRIPPA, A. BA, S. BINET, L. BOITHIAS, I. BRAUD, C. CHAMPOLLION, P. CHOLER, A. DUCHARNE, J. FOUCHE, A. JOHANNET, D. JOSSELIN, S. KUPPEL, C. LEGOUT, M.C. PIERRET, A. PROBST, J.L. PROBST, S. SAUVAGE, P. SCHONEICH, V. SELLIER, A. SIMONNEAU, V. SIMONNEAUX, T. VISCHEL 2021- Looking for feedback loops in the critical zone. Proceedings 1st OZCAR-TERENO International Conference, 5-7 October 2021, Strasbourg, France.
- PIERRE D. 1985- Impact de l'agriculture du Sud-Ouest sur la teneur en azote des eaux de drainage. Aperçu de premiers résultats. Proposition d'une méthode d'étude. Actes du Congrès « Nitrates dans les eaux », Paris, 22-24 Octobre 1985, Partie « Nitrates and Agricultural Practices », 7 p.
- PINHEIRO, A., CERNESSON, F., TOURNOUD, M.G., KOSUTH, P. 2006- Evaluation of uncertainties on water quality management of in agricultural watershed to different scales of time. Geophysical Research Abstracts, (2006)
- RONNOU-DELAFFON, PROBST A., PAYRE-SUC V., FARRANT S., PROBST J.L. 2017 - Combined investigations on long-term hydrochemical monitoring and high frequency measurements in the Critical Zone (Auradé catchment, SW France). Conference « Functional Ecology and Environment », 10-year anniversary of EcoLab, July 11-12, 2017, Toulouse (Poster).
- RONNOU-DELAFFON, PROBST A., PAYRE-SUC V., PROBST J.L. 2017 - Long- vs. short-term trends of Ca, Mg, nitrates and alkalinity in a small agricultural catchment (Auradé, SW France): influence of N-fertilizer on carbonate dissolution. Goldschmidt Conference, August 13-18, Paris, France (Poster).
- RONNOU-DELAFFON V., PROBST A., ISSAM M., PAYRE-SUC V., GRANOUILAC F., PROBST J.L. 2017 - Isotopic constraints on water and carbon cycles in a small agricultural catchment (Auradé, SW France). SFIS 8th young scientist symposium, 8-11th October 2017, Nantes (abstract)
- RONNOU-DELAFFON V., PROBST A., FARRANT S., PAYRE-SUC V., GRANOUILAC F., CAMBOULIVE T., PROBST J.L. 2017 - Long-term and high frequency hydrochemical monitoring in a small cultivated experimental catchment (CZO Aurade, SW France): impacts of climate change and agricultural practices on streamwater quality. Joint Conference Zones Ateliers & Critical Zone Observatory Networks (LTER-France), Nantes, 2-4 October (Poster).
- RONNOU-DELAFFON V, PROBST A, PAYRE-SUC V, PROBST JL 2017- Long-vs short-term trends of Ca, Mg, nitrates and alkalinity in a small agricultural catchment (Auradé, SW France) : influence of N-fertilizer on carbonate dissolution. Goldschmidt Conference, August 13-18, Paris, France
- RONNOU-DELAFFON V, PROBST A, MOUSSA I, PAYRE-SUC V, GRANOUILAC F, PROBST JL 2017 - Isotopic constraints on water and carbon cycles in a small agricultural catchment (Auradé, SW France). Journée des Jeunes Chercheurs SFIS, 9-11 octobre 2017 à Nantes.
- PROBST J.L., PROBST A. 2020- Notice - Le Bassin Versant Expérimental Agricole du Montoussé à Auradé (Gascogne). Technical Report, Toulouse, 56 p. DOI: 10.13140/RG.2.2.35454.25927
- PROBST J.L., TETEGAN M. et PROBST A. 2014 – Livret-Guide: Bassin versant experimental agricole du Montousse a Aurade (Gascogne). Livret Guide, octobre 2014, Toulouse, 41 pp. DOI: 10.13140/RG.2.1.1695.4642
- PROBST J.L., PAUL A., MOUSSA I., PAYRE V. et PROBST A. (2016)- High resolution nitrogen isotope tracing during floods in a French agricultural catchment, Auradé: a way to better understand nitrate behaviour in the critical zone. Meeting CRITEX, Rennes, 21-22 janvier 2016 (abstract).
- PROBST J.L. Catchments as observatories of the hydrological and biogeochemical functioning of the Critical Zone. Conférence invitée à l'University of Mauritius, novembre 2017 (conférence invitée).
- PROBST J.L. Experimental Catchments as observatories of the hydrological and biogeochemical functioning of the Critical Zone. LIST WATER LECTURES Seminar Series, 13th June 2017, Belvaux, Luxembourg (conférence invitée).
- PROBST J.L., RONNOU-DELAFFON V., PAYRE-SUC V., GRANOUILAC F., CAMBOULIVE T., PROBST A. 2017 - Aurade experimental catchment: a Critical Zone Observatory of a cultivated area in South West of France. Joint Conference Zones Ateliers & Critical Zone Observatory Networks (LTER-France), Nantes, 2-4 October (Poster).
- PROBST J.L. Catchments as observatories of the hydrological and biogeochemical functioning of the Critical Zone. Conférence invitée à l'University of Mauritius, novembre 2017 (conférence invitée).

- PROBST J.L. Les bassins versants comme observatoires du fonctionnement hydrologique et biogéochimique de la Zone Critique. Conférences invitées à l'Université Ibn Tofail de Kénitra, Maroc (20 mars 2018) et au Centre National de l'Energie, des Sciences et des Techniques, CNESTEN à Rabat, Maroc (29 mars 2018). (conférences invitées).
- PROBST JL. 2018- Observatoire de l'environnement : suivi des transferts de pesticides dans les différents compartiments de la Zone Critique. Conférence internationale pour les premières journées scintifiques sur les pesticides en Côte d'Ivoire (JSP-CI). Thème 6- Conférence inaugurale à l'invitation du Ministère de l'Environnement et du Développement Durable, Abidjan, 28-31 octobre 2018.
- PROBST J.L. – 2019- Les bassins versants comme observatoires du fonctionnement hydro-biogéochimique de la zone critique. Conférence invitée à l'Université Ibn Tofail, Centre des Etudes Doctorales, Mardi 3 décembre 2019, Kénitra, Maroc.
- PROBST J.L. – 2019- Rapport d'Activité d'EcoLab dans le projet Région Occitanie PACSE « PAysages et Compromis entre Services Ecosystémiques », période sept. 2018-sept. 2019, 6 p.
- REDON P.O., BUR T., GUIRESSE M., PROBST J.L., TOISER A., JOLIVET C., REVEL J.C., PROBST A. (2012)- Modelling background concentrations of potentially harmful elements for evaluation of anthropogenic contamination: focus on calcareous soils in the South-West of France. 4th International Congress of ECSS, EUROSOLI, 2-6 July 2012, Bari, Italy (abstract).
- ROGER C., FOVET O., I. BRAUD, M. GRIPPA, B. HECTOR, J. MOLENAT, S. AUDRY, F. BRANGER, N. FOLTON, C. LE BOUTEILLER, G. NORD, A. PROBST, J.L. PROBST, D. RACLOT, J. RIOTTE, L. RUIZ, R. ZITOUNA, T. DATRYB 2021- Which hydrological signatures of intermittence of rivers and streams in order to identify causes and ecological impacts ?. Proceedings 1st OZCAR-TERENO International Conference, 5-7 October 2021, Strasbourg, France.
- SHINN C, GRENOUILLET G., LEK S. 2008. Impact of pesticides on stream fish life history traits. Proceedings Keybioeffects Workshop - Water Framework directive in relation to Priority and Emerging Pollutants. Koblenz, Germany .
- SHINN C, SLOOTWEG T, MOELLER A, AGBO, S. 2010. Aquatic organisms as bio-indicator on multiple levels. Keybioeffects workshop - Emerging and Priority Pollutants: bringing science into River Management Plans. Girona, Spain (oral).
- SHINN C., GRENOUILLET G., GUÉNARD G., FAGGIANO L., LEK S., 2009. Trends in fish traits and health along a pesticide gradient. MODELKEY final conference - How to assess the impact of key pollutants in aquatic ecosystems, Leipzig, Germnay (oral).
- SHINN C., GRENOUILLET G., LEK S. 2009. What can freshwater fish tell us about pesticide gradients in their environment? Proceedings 30th SETAC North-America, New Orleans, USA .
- SHINN C., GRENOUILLET G., LEK S. 2010. Pesticide gradients in rivers: fish-based investigative field monitoring. Keybioeffects workshop - Emerging and Priority Pollutants: bringing science into River Management Plans. Girona, Spain (poster).
- SHINN C., GRENOUILLET G., LEK S.. 2009. Variation of fish traits and health status along a gradient of pesticide pollution in a French river basin. Proceedings 14th ISTA, Metz, France .
- SHINN C., LEK S., DAUBA F., GRENOUILLET G. 2008. Temporal variation of heavy metal contamination in fish of a tributary in southern France. Proceedings 18th SETAC Europe, Warsaw, Poland .
- TAGHAVI L., MARCHAND A.L., MERLINA G., DURBE G., PROBST A. and PROBST J.L. 2008 - Pesticide transfers in a small agricultural catchment during flood flows: partitioning into dissolved and particulate fractions. Proceedings 5th European Conference on Pesticides and Related Organic Micropollutants in the Environment, 22-25 October, Marseille , France, 439-444.
- TAGHAVI L., MERLINA G., DURBE G., PROBST A. PINELLI E. and PROBST J.L. 2009 -Dynamique de transfert des pesticides en périodes de crue sur le bassin versant de la Save (Sud-Ouest de la France). Proceedings XXXIXème congrès du Groupe Français des Pesticides - 13-15 mai 2009, Toulouse.
- VOGRINCIC C. 2002- Plus de dix années de pratiques raisonnées à Auradé. Oléoscope, 68, 23-25.

PhD thesis

- BUR T. 2008 - Impacts des activités agricoles sur la dynamique des éléments traces métalliques dans les sols du piémont pyrénéen. Thèse de doctorat INP Toulouse, 372 p.

- BUSCA D. 2002- Agriculture et environnement : la mise en oeuvre négociée des dispositifs agrienvironmentaux. Thèse de doctorat Université de Toulouse Le Mirail.
- DARRADI Y. 2010 - Optimisation de la performance environnementale des activités agricoles à l'échelle d'un espace à enjeux: Le cas du bassin versant de la Bouloze. Thèse de doctorat Université Bordeaux I
- DEBENEST T. 2007- Caractérisation de l'impact des pollutions agricoles sur les diatomées benthiques. Thèse de Doctorat , Université de Bordeaux 1, 237 p.
- EL AZZI D. 2012- Interactions Matières en Suspension-Matières Organiques-Polluants inorganiques et organiques dans les Hydrosystèmes. Thèse de Doctorat Université de Toulouse, INPT, 308 p et annexes.
- FERRANT S. 2009 - Modélisation des transferts de nitrates à l'échelle des bassins versants gascons: impacts des changements d'occupation des sols et des changements climatiques. Thèse de doctorat Université de Toulouse, UPS, 188 p.
- MACARY F. 2013 - Evaluation des risques de contamination des eaux de surface sur des bassins versants agricoles. Approches multiscalaires par modélisation spatiale et analyse multicritère pour l'aide à la décision. Thèse de doctorat Université de Toulouse, INPT, 277 p. et annexes.
- MAISON P. 2000-, Un modèle Hydrologique de suivi de la pollution diffuse en bassin versant. Une approche mécaniste simplifiée de la zone non saturée. Thèse de doctorat, INP Toulouse, n°1653, 246 p
- N'GUESSAN M. 2008 – Dynamique des éléments traces métalliques dans les eaux de surface des bassins versants de Gascogne. Thèse de doctorat INP Toulouse, 213 p et annexes.
- PERRIN A.S. 2008- Rôle des fertilisants azotés dans l'érosion chimique des bassins versants carbonatés : implication dans la consommation de CO₂ et la composition chimique des eaux de surface. Thèse de Doctorat Université de Toulouse, UPS, 314 p.
- PINHEIRO A. 1995- Un outil d'aide à la gestion de la pollution agricole: le modèle POLA. Thèse de doctorat de l'Institut National Polytechnique de Toulouse, 344 p.
- PONNOU-DELAFFON V. 2020- Fonctionnement de la Zone Critique en milieu agricole: cas du Bassin versant d'Auradé. Variations hydrochimiques spatiotemporelles et bilans d'érosion. Thèse de doctorat de l'Université de Toulouse, INPT, soutenue le 3 juillet 2020.
- RIBEYREIX-CLARET C. 2001- Agriculture et environnement en Gascogne Gersoise. Erosion du sol et pollution diffuse par le phosphore. Le cas du bassin versant d'Auradé (Gers). Ph.D thesis, Université Toulouse II.
- TAGHAVI L. 2010 - Dynamique de transfert des pesticides en périodes de crues sur les bassins versants agricoles gascons. Thèse de doctorat INP Toulouse, 205 p. et annexes.

The brochure of the ANR project PESTIPOND

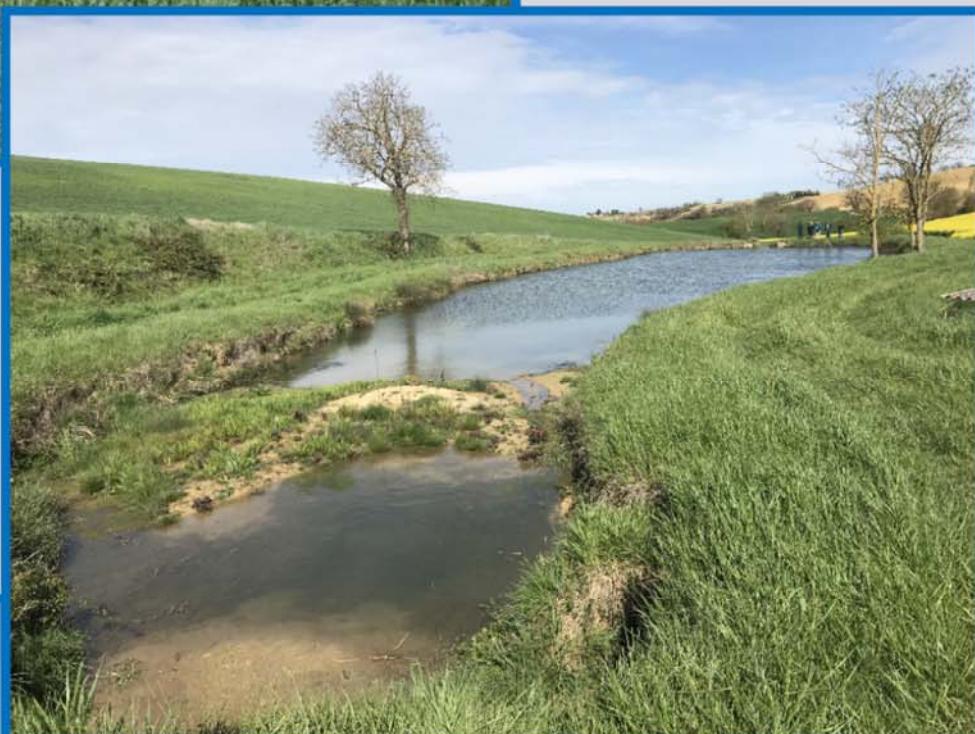
ANR PESTIPOND

Rôle des retenues d'eau artificielles et naturelles dans le transfert et l'impact des pesticides dans les eaux de surface de la zone critique en milieu agricole

Role of ponds in the transfer and impact of pesticides in surface waters of the critical zone in agricultural environment

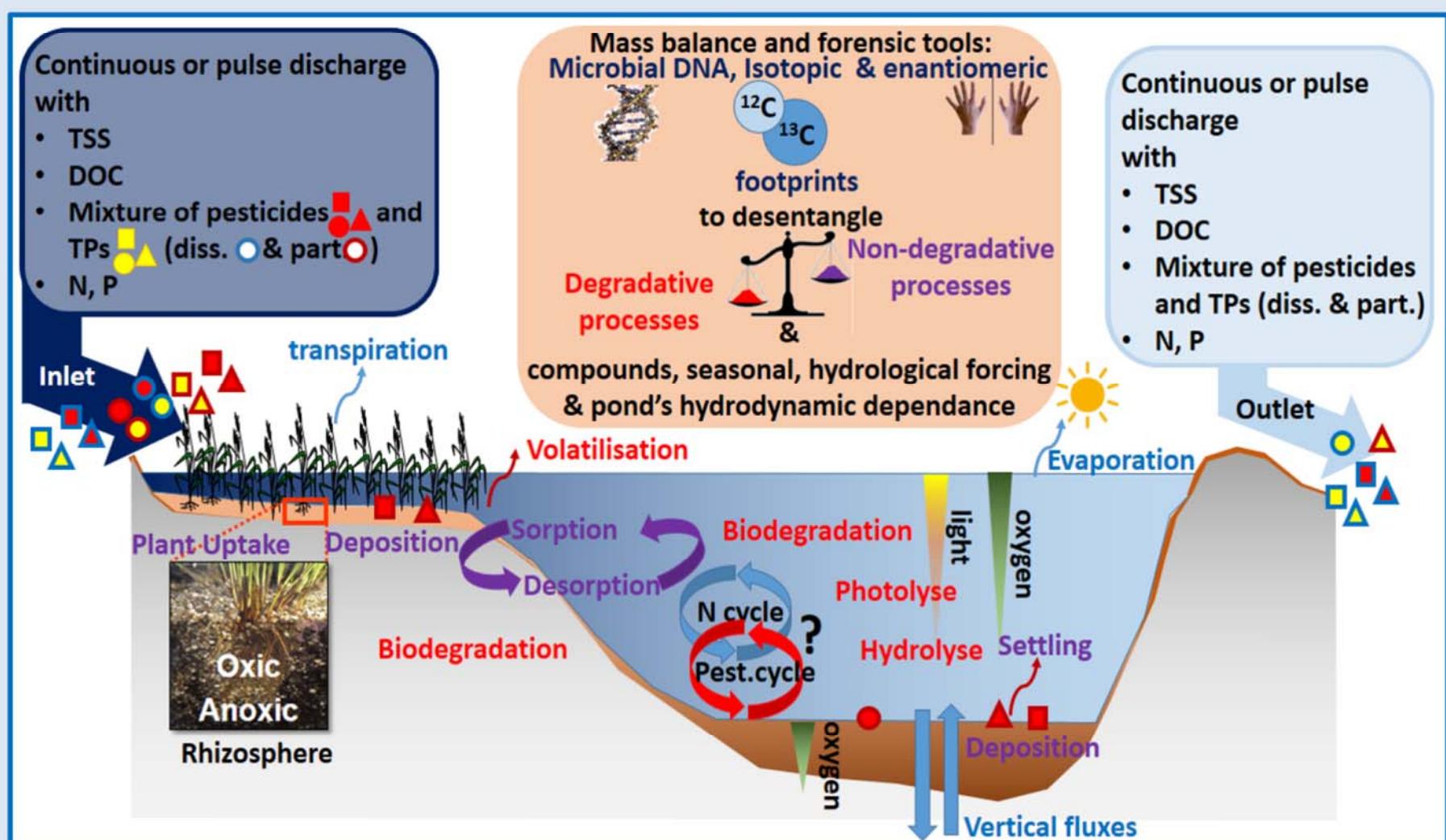


Site Web:
<http://pestipond.cnrs.fr/>





Biogeochemical and pesticide dissipation processes in artificial pond systems



AGENCE NATIONALE DE LA RECHERCHE
ANR



Project ANR PESTIPOND



**Role of ponds in the transfer and impact of pesticides in surface waters
of the critical zone in agricultural environment**

CONTEXT

In agricultural catchments, wetlands, and natural or artificial ponds are complex and dynamic ecosystems acting as biogeochemical reactors degrading pollutants. However, their role in pesticide transfer at the catchment scale remains largely unexplored. Most processes involved in pesticide dissipation or accumulation remain largely unknown.

OBJECTIVES OF PESTIPOND

The PESTIPOND project aims to provide answers to these issues. The project combines well-referenced field survey data and a hydrobiogeochemical approach, which, together with integrative modeling at different spatial scales, will allow to evaluate key processes of basin compartments involved in cycle, storage and dissipation of pesticides.

PESTIPOND is an innovative collaborative research project of 48 months involving partners from four research units in France and 15 social-economical partners. Our fields of expertise is complementary, and include hydrology, biogeochemistry, microbiology, isotopic analysis and chemistry of pesticides, soil and sediment sciences, agronomy, ecology, database management, multi-criteria modeling coupled with a GIS, agro-hydrological and biogeochemical modeling, landscape ecology as well as management of territories.

PESTIPOND focuses on water reservoir and natural and artificial wetlands in the agricultural landscape to provide innovative concept to evaluate pesticide storage and transformation in different compartments (water, sediments, vegetations, etc.). These processes are eventually included in a spatialized and integrative multi-criteria modeling framework to improve risk predictions of pesticide transfer to surface water at the catchment scale.

EXPERIMENTAL SITES

PESTIPOND relies on the pilot sites of 3 agricultural catchments in France: Aurade in Gascony (IR OZCAR and RZA, LTSER ZA PYGAR), Rampillon in Brie (LTSER ZA SEINE) and Hohrain in Alsace (Regional Platform, RECOTOX network, INTEREG projects , IDEX)



A pond within Aurade catchment (Gers)



A wetland within Rampillon catchment (Brie)



A pond within Hohrain catchment (Alsace)

Organisms, universities & laboratoires involved





Project ANR PESTIPOND



LINKS WITH PARTNERS

The project is conducted in close collaboration with social-economical partners participating with the PESTIPOND scientists to elaborate various structure and organization scenarios of buffer zones and ponds in the agricultural landscape. These scenarios will be incorporated into the modeling to define favorable configuration to reduce pesticide transfer.

The results of PESTIPOND will be useful to decision-making processes to protect water quality at the catchment scale: water and environmental agencies, water agencies, local cooperatives, engineering consulting firms, etc. Overall, the project targets factors and processes controlling the capacity of ponds to store and degrade pesticide mixtures, far beyond their primary role of delaying pesticide transfer or transforming parent molecules into degradation products.

PROJECT ORGANIZATION

The project is organized in three interconnected experimental tasks:

- ◆ Biogeochemistry of pesticide behavior in real conditions, in ponds and in response to hydroclimatic conditions in different agricultural contexts;
- ◆ Role and contribution of pesticide dissipation pathways in ponds: *in situ* and laboratory experiments;
- ◆ Modeling and evaluation of the impact of pesticide transfer to surface waters (simulation of pond-scale pesticide dissipation, and cumulative effects of successive ponds in the landscape to generate management scenarios for ponds at the catchment scale).

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LABORATORIES INVOLVED

- ◆ Laboratoire d'Hydrologie et de Géochimie de Strasbourg, LHyGeS, UMR 7517 CNRS-UNISTRA-ENGEES, Strasbourg - <https://www.lhyges.unistra.fr/>
- ◆ Laboratoire Ecologie fonctionnelle et environnement, ECOLAB, UMR 5245 CNRS-UPS-INPT, Toulouse <http://www.ecolab.omp.eu/>
- ◆ Environnement, Territoires et Infrastructures, ETBX, UR IRSTEA, Bordeaux-Cestas - <https://www.irstea.fr/fr/recherche/unites-de-recherche/etbx>
- ◆ Hydrosystèmes continentaux anthropisés-Ressources, Risques, Restauration, HYCAR, UR IRSTEA, Antony - <https://www.irstea.fr/fr/recherche/unites-de-recherche/hycar>

SOCIO-ECONOMIC PARTNERS

From a socio-economic viewpoint, PESTIPOND will facilitate the development of novel management scenarios, in particular through the involvement of 15 socio-economical partners for the conception and the evaluation of different agro-environmental and transition scenarios used for predictive modelling.

- ◆ French Water Agencies Adour-Garonne (AEAG), Seine-Normandie (AESN) and Rhin-Meuse (AERM)
- ◆ French Biodiversity Agency AFB
- ◆ Regional Directions of Agriculture and Forest (DRAF): Occitanie, Alsace-Champagne Ardenne-Lorraine
- ◆ Company Jean-Voisin-Beaumont La Rone (37)
- ◆ EPLEFPA Les Sillons de Haute Alsace-Rouffach (67)
- ◆ Association AQUI'Brie-Dammarie Les Lys (77)
- ◆ Company Aquatiris-Bréal-sous-Montfort (35)
- ◆ Coopérative UNICOQUE (KOKI)-Cancon (47)
- ◆ Coopérative Agricole de Stockage de Céréales et d'Approvisionnement (CASCAP)- L'Isle Jourdain (32)
- ◆ Groupement des Agriculteurs de la Gascogne Toulousaine (GAGT)-Auradé (32)
- ◆ Chambre d'Agriculture du Gers
- ◆ Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt

WEB SITE: <http://pestipond.cnrs.fr/>

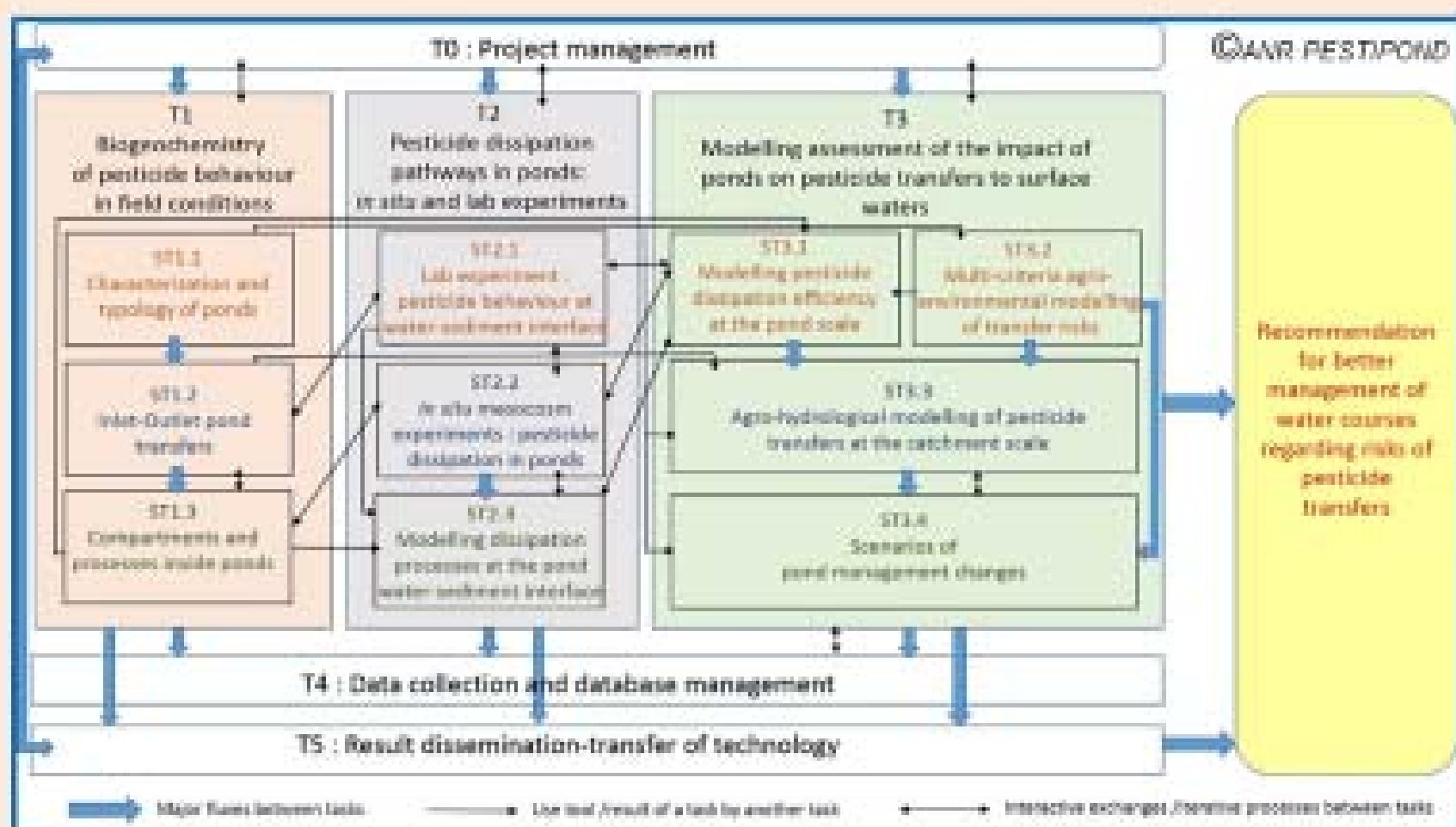
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Socio-economic partners involved





Structure & Organization of PESTIPOND



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ANR PESTIPOND

Projet collaboratif entre scientifiques



INP ENSAT

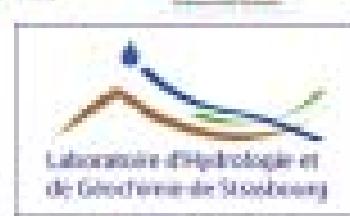
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Paul Sabatier



UNIVERSITÉ DE STRASBOURG



EcoLab
Laboratoire d'Analyse Environnementale et Agroécologique



Zones
Ateliers
Lyon France

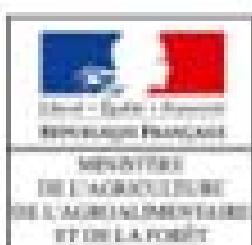


et partenaires socio-économiques

AGENCE FRANÇAISE
POUR LA BIO DIVERSITÉ
MINISTÈRE DE L'ENVIRONNEMENT



AQUIBrie
Institut de recherche
en sciences de la Terre



cascap



SITE WEB : <http://www.pestipond.cnrs.fr/>

The brochure of Auradé Farmer's Association (AAA), today Groupement des Agriculteurs de la Gascogne Toulousaine (GAGT)

<http://groupe mentdesagriculteursdelagascognetoulousaine.e-monsite.com/>



La qualité de l'eau,
notre préoccupation depuis plus de 30 ans

L'ASSOCIATION DES AGRICULTEURS D'AURADÉ



DÉVELOPPER UNE AGRICULTURE PERFORMANTE DANS UN ENVIRONNEMENT PROTÉGÉ

Depuis 1982 les agriculteurs d'Auradé innovent, expérimentent, agissent, se battent pour faire exister leur parole, conscients des effets sur l'eau de leur métier, à l'échelle d'un bassin versant.

Objectif, optimiser un maximum de moyens pour pénaliser le moins possible l'environnement.

Dès 1982 quelques agriculteurs exploitant dans les bassins versants d'Auradé travaillent avec des ingénieurs de Grande Paroisse sur les transferts des fertilisants azotés dans le sol et vers les cours d'eau. On ne parle pas encore de pollution.

Deux au départ, puis cinq, ils fédèreront progressivement jusqu'à 42 fermes. Ils sont encore aujourd'hui 35, exploitant 70 ha en moyenne en grande culture, souvent double actifs, producteurs d'ail, etc.

L'ASSOCIATION
DES AGRICULTEURS D'AURADÉ

PIONNIÈRE

C'est à Auradé que se construit le concept de bande enherbée. Ces précurseurs se constituent en association pour concourir au prix de la fondation Pierre Sarazin qu'ils remportent en 1992. La bourse leur permet d'embaucher leur premier animateur.

Le site accueille de nombreuses recherches et expérimentations, portées par des laboratoires comme Ecolab (CNRS-Toulouse III-INP), le Cesbio (CNRS-CNRS-IRD-Toulouse III), ou la recherche appliquée, à travers Arvalis, le Cetiom et les Chambres d'Agriculture, etc. Ecolab vient de faire labelliser le bassin versant du Montoussé dans le réseau d'expérimentation national et international du CNRS.



INDÉPENDANTE

L'association régie par la loi de 1901, sans but lucratif, gère également le Plan d'Action Territorial « Boulouze Save Lisloise Amont » sur 21 communes en limite des départements du Gers et de Haute-Garonne, financé en partie par l'Agence de l'eau Adour-Garonne.

Cas unique, c'est l'aboutissement de plans d'action conduits pendant 20 ans sur des sujets comme la qualité de l'eau dans les ruisseaux, les transferts des phosphates, nitrates et des molécules phytosanitaires dans le sol, l'érosion, l'impact des techniques culturales simplifiées, etc.

Avec de multiples partenaires, publics, privés ou associatifs (Protection des Végétaux, Fredec, Chambres d'Agriculture, Arvalis, Syngenta, GPN etc.)

OUVERTE

Situé à la limite du Gers et de la Haute-Garonne, le site se trouve en lisière de l'agglomération toulousaine. L'association est impliquée dans différentes missions des collectivités (préfiguration des trames verte et bleue en lien avec le Scot, surveillance de la qualité de l'eau, etc.).

Son expérience et la qualité de ses travaux lui permettent d'intervenir véritablement dans le concert des élus et techniciens. L'association a une politique de communication active, avec de nombreuses visites organisées pour les élus, les scolaires, les étudiants, les professionnels.

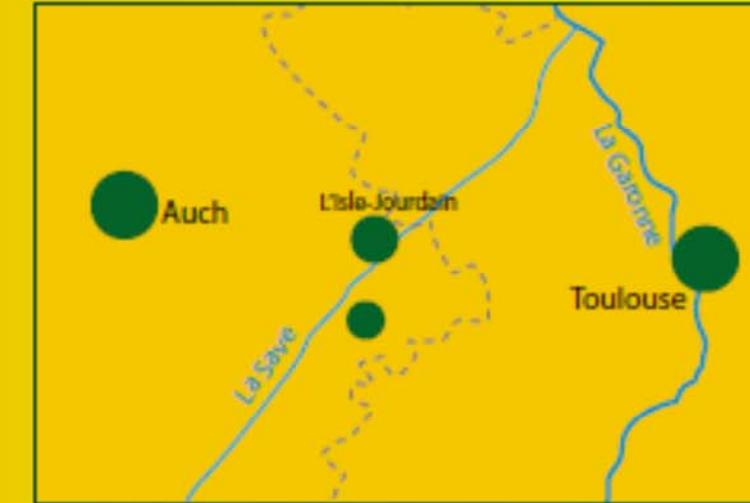
De nombreux étudiants, thésards français et étrangers ont travaillé sur le bassin versant d'où une bibliographie très riche, constituant peu à peu un réseau de référence sur les problématiques agro-environnementales.

Curieux, passionnés par l'expérimentation, les agriculteurs d'Auradé partent régulièrement à la découverte d'autres régions agricoles françaises voire européennes. « Notre vision, c'est le long terme ».



LES CONTACTS

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- Mail : agriculteurs.aurade@orange.fr
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www.agriculteurs-aurade.fr

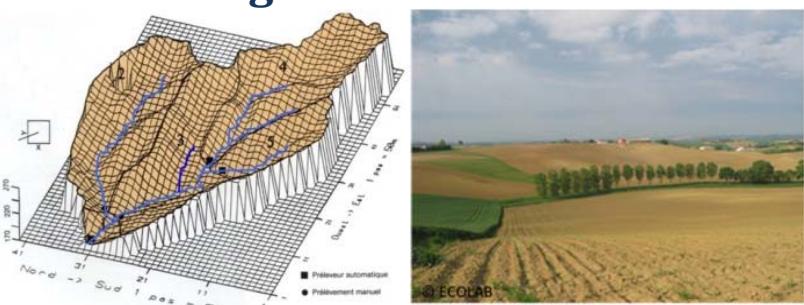


Third Days of the French Catchment Network (RBV)

17 and 18 october 2013
Toulouse - Auradé

Visit of the Montoussé catchment in Auradé (Gers) &

Thematic discussion on the question: "What are the minimum parameters required for monitoring common to all the observatories in the Critical Zone?"



Schedule of days

17 october : Visit of Auradé Catchment

- ▶ 9h – 11h : Arrivée à l'hôtel à l'Isle-Joudain (voir encadré ci-contre)
- ▶ 12h : Déjeuner à l'auberge du lac
- ▶ 14h – 17h30 : Visite du bassin versant
 - Présentation du bassin versant, des équipements installés et des résultats scientifiques acquis sur le site
 - Exercice d'inter-calibration géochimique
 - La tour à flux : présentation de la parcelle et des mesures de flux
- ▶ 18h : Rencontre à la mairie d'Auradé avec l'Association des Agriculteurs d'Auradé
- ▶ 19h30 : Dîner à l'auberge du lac
- ▶ 21h – 23h : Réunion du comité de pilotage du Réseau des Bassins Versants. Divers sujets seront abordés :
 - L'avenir du RBV
 - La base de métadonnées
 - Le CRITEX ...

Logis Hostellerie du Lac
Avenue Corps Franc Pommies
32600 L'Isle-Joudain
05 62 07 03 91

- 3 itinéraires depuis Montpellier
 - A9 puis A61
 - D999
 - D612

- 2 itinéraires depuis Bordeaux
 - A62
 - A62 puis D930

- 1 itinéraire depuis Toulouse
 - N124

18 october : Scientific and technical discussions

- ▶ 7h - 8h : Petit-déjeuner à l'auberge du lac
- ▶ 9h - 12h : Echanges scientifiques à la salle des fêtes de la mairie d'Auradé (1^{ère} partie)
- ▶ 12h30 : Déjeuner à l'auberge du lac
- ▶ 14h - 16h : Echanges scientifiques à la salle des fêtes de la mairie d'Auradé (2^e partie)



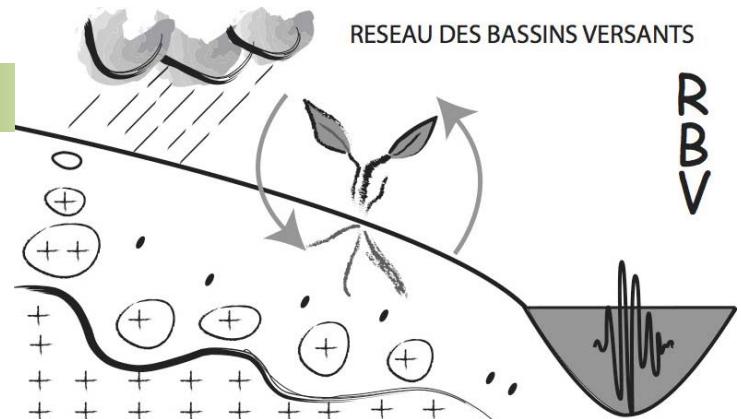
Items to be discussed during the scientific discussions on October 18

Discussions and reflections on the list of parameters allowing the monitoring of the critical zone:

→ Soil, water, rivers, soil water, hydrological parameters, edaphic parameters, soil parameters...:

Creation of an exhaustive list of measured parameters

- Présentation de tableaux synthétiques.
 - Tableaux d'instrumentation des sites présents sur le site internet du RBV.
- Regard sur les paramètres mesurés sur d'autres sites.
 - Nouvelles mesures qui devraient être faites sur les sites du RBV.
 - Exercice à faire pour :
 - Les CZO américains.
 - D'autres réseaux européens.



Which measurements for which scientific question?

- Questions scientifiques à définir pour l'ensemble du RBV.
 - Conservation des interrogations scientifiques propres à chaque observatoire.
 - Discussion focalisée sur les variables concernant uniquement le long terme.

Debate over measurement frequencies

- Quelles fréquences?
- Lien avec le CRITEX.
- La haute fréquence est-elle nécessaire toujours ?
- Dépendance de la fréquence de mesure par rapport au processus observé.

Link to operational systems

- **Lien avec l'opérationnel ?**
- Nos variables sont-elles d'intérêt public?
- Y a-t-il eu dans l'opérationnel une réflexion sur les paramètres qui doivent tous être mesurés ?

Representativeness and genericity

- Un site ne documente-t-il que des processus particuliers ?
- Sites : intérêt régional versus intérêt global ?
- Peut-on montrer que la mise en réseau des observatoires SIC actuels est un plus pour les organismes de recherche ?
- Particularité de certains sites :
 - Sites instrumentés auxquels s'ajoutent des actions expérimentales ponctuelles :
 - Majorité des ORE et observatoires du RBV.
 - Sites d'expérimentation mono variable :
 - Les observatoires atmosphériques.
 - Les observatoires océaniques.

Pour contribuer de manière active à cette journée, en fonction de ces quelques items (et d'autres qui vous paraîtront intéressants à aborder), vous êtes invités à préparer éventuellement une diapositive illustrant une de vos figures ou une figure tirée d'un papier emblématique de votre discipline. Que cette discussion interdisciplinaire nous permette d'aboutir à une liste de paramètres communs ainsi qu'à une construction plus claire de la base de métadonnées.

Merci pour votre participation.



List of participants

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Université de Toulouse

Montpellier
SupAgro



*The Bassioué pond, instrumented site of the Auradé Catchment
within the framework of the ANR PESTIPOND*