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## Ditch maintenance as a lever to limit water contamination by pesticides

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# Ditch maintenance as a lever to limit water contamination by pesticides

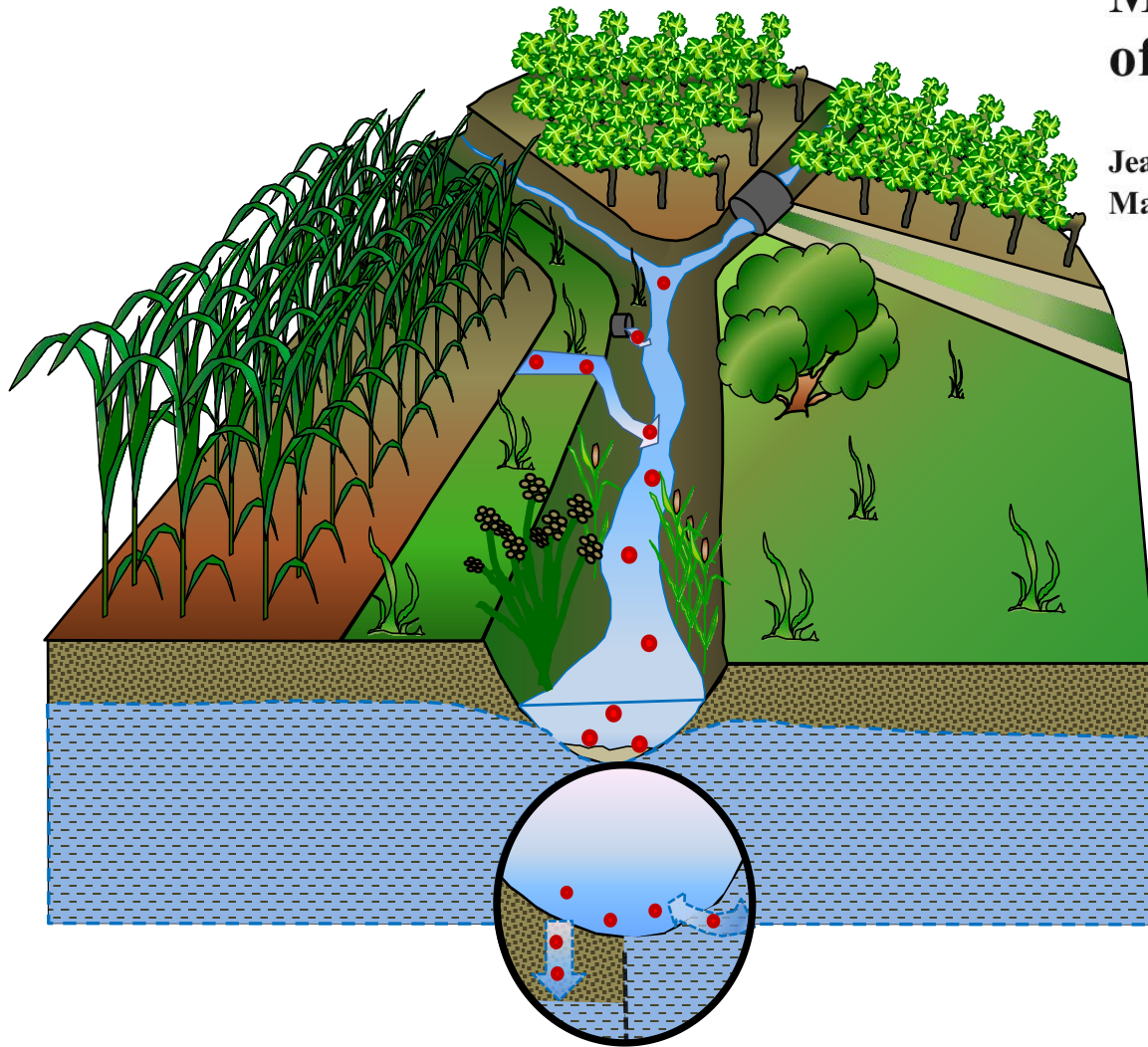


Cécile Dagès, Jean-Stéphane Bailly, Jeanne Dollinger,  
and Marc Voltz

UMR LISAH, Laboratoire d'Etude des Interactions entre Sol-Agrosystème-Hydrosystème  
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## Managing ditches for agroecological engineering of landscape. A review

Jeanne Dollinger<sup>1</sup> · Cécile Dagès<sup>1</sup> · Jean-Stéphane Bailly<sup>2</sup> · Philippe Lagacherie<sup>1</sup> · Marc Voltz<sup>1</sup>



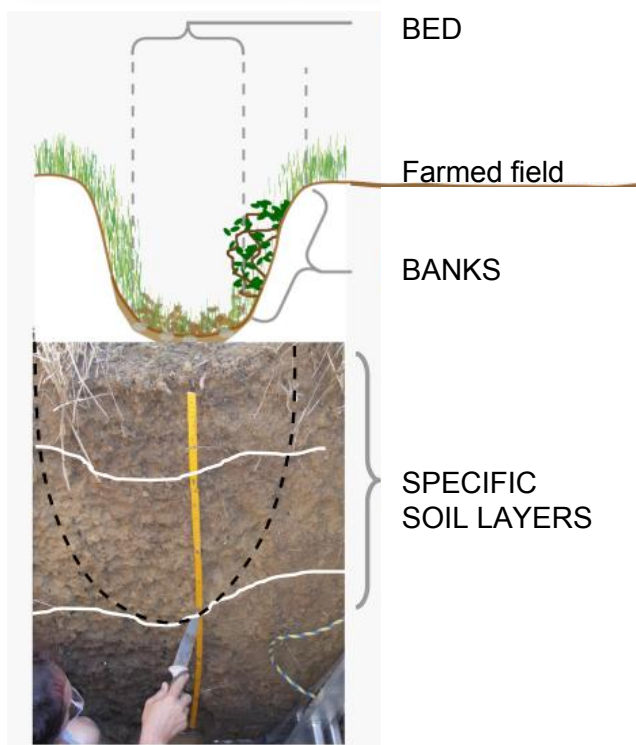
**Collecting pesticides from :**  
Overland flow, soil drainage,  
drift deposition, direct  
application

**Routing pesticides towards :**  
river, groundwaters

**Retaining pesticides : 3 à  
99%**  
sorption, biotic/abiotic  
degradation, sedimentation,  
dilution, (infiltration)



# Large variability of ditches types



## Morphology

*slope, lenght, width...*

## Topology

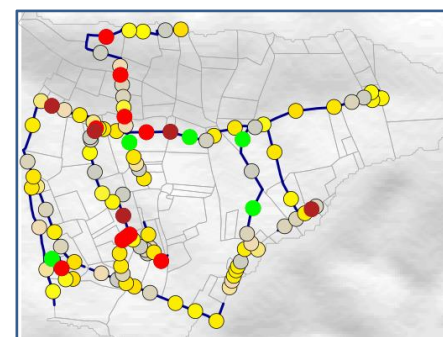
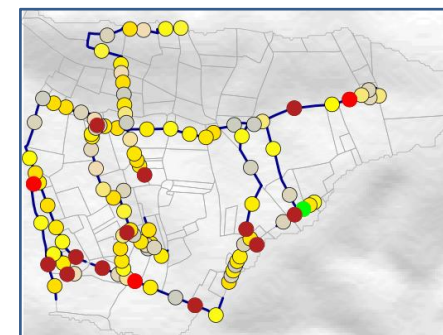
*location within the network*

## Type and abundance of substrates

*soil, litter, plants, ashes...*

## Nature et vegetation density

## Number and types of soil layers



## Usual maintenance operations to maintain ditch hydraulic capacity

### Mowing



April -  
September  
Litter formation

### Dredging



June - October  
Litter and soil  
extraction (15-30 cm)

### Burning



October – Mars  
Litter extraction,  
ashes formation

### Chemical weeding

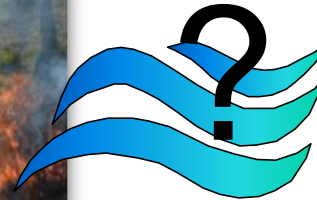
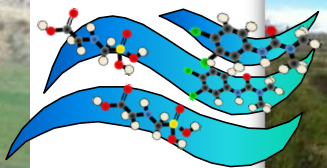
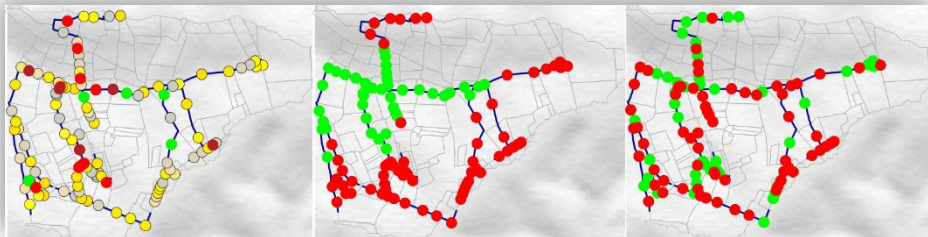


Mars – June  
Litter formation



# Goals

Can the contamination of water bodies be limited by managing ditches?

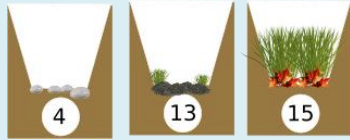


- What are the main factors of ditch retention properties ?
- Which maintenance operations favor (long term?) retention ?
- Can the design of ditch networks increase buffer effect ?

# Method

## DITCH CHARACTERISATION

- Object =  $f(t,x,y)$
- Processus : hierarchy and model
- Typology : “structure-function”



Agron. Sustain. Dev.  
DOI 10.1007/s12593-015-0301-6

REVIEW ARTICLE

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studied  
catchments



Observation



Surveys



Infiltrability



Roughness



Sorption

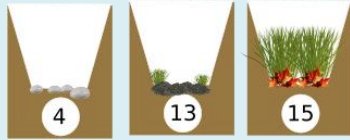


Percolation

# Method

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## MODELLING

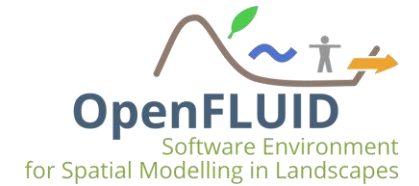
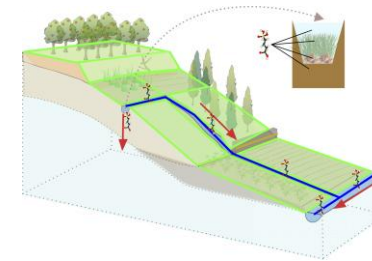
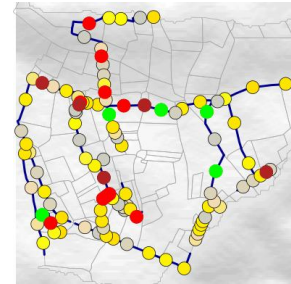
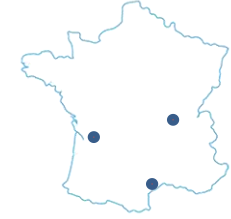
- Network model =  $f(t,x,y)$
- Reactive transfer model - ditch and network

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Fabre et al., 2010

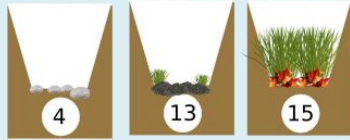
<https://www.openfluid-project.org/>



# Method

## DITCH CHARACTERISATION

- Object =  $f(t,x,y)$
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## MODELLING

- Network model =  $f(t,x,y)$
- Reactive transfer model - ditch and network

## NUMERICAL SIMULATIONS

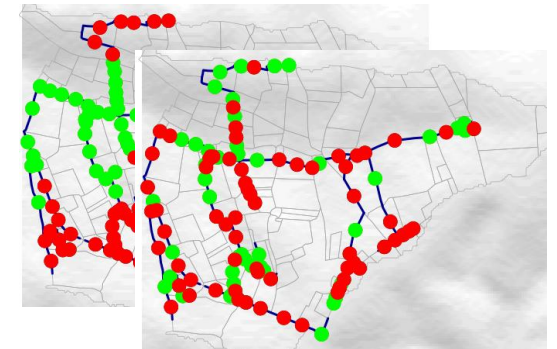
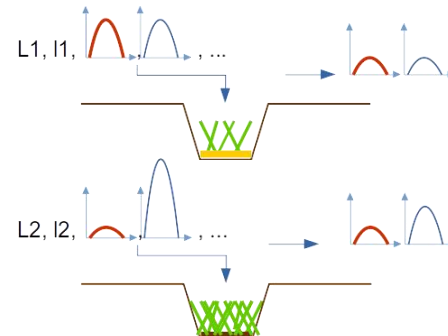
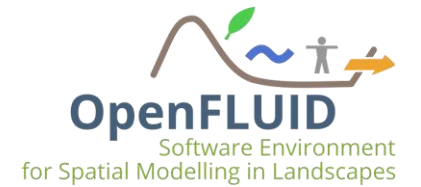
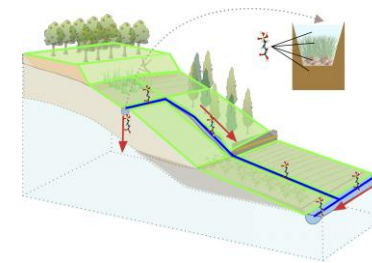
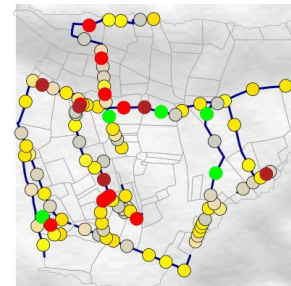
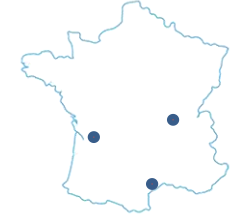
- Retentions variability / ditch
- Maintenance effect on retention
- Spatial distribution effect

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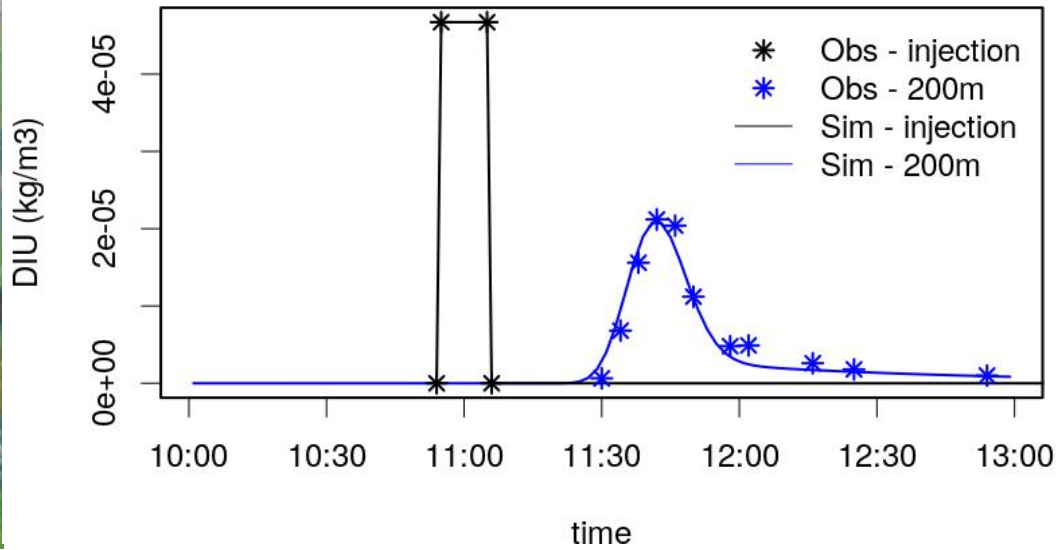
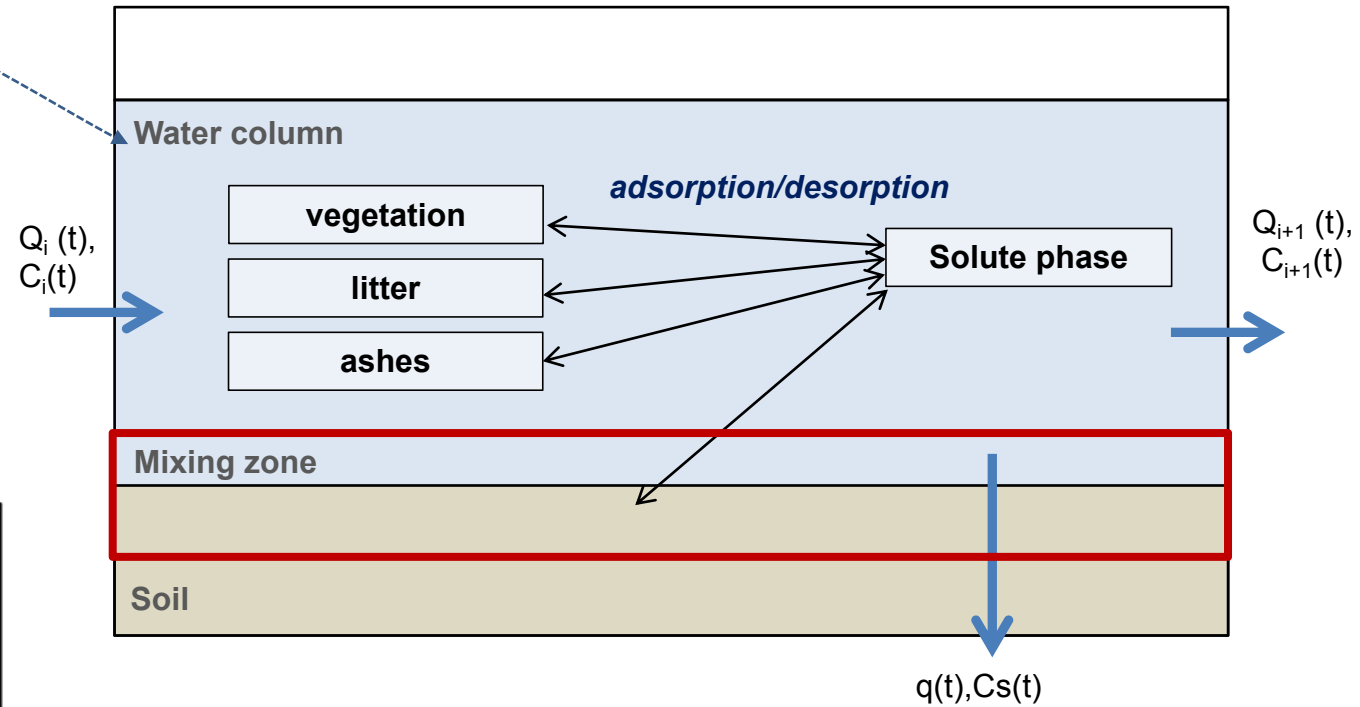
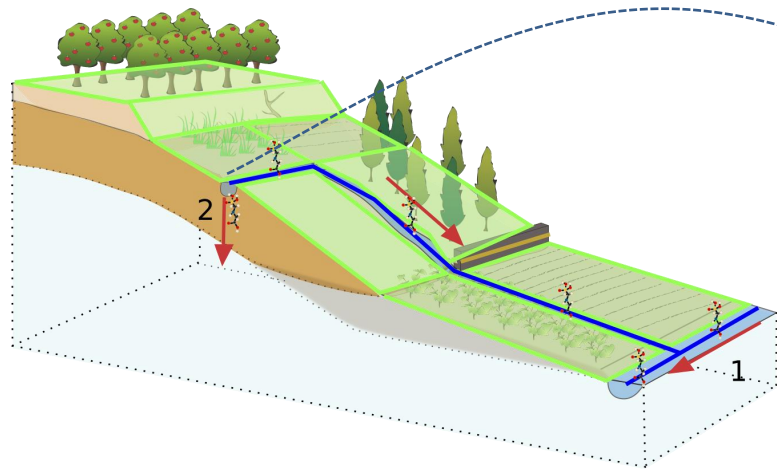
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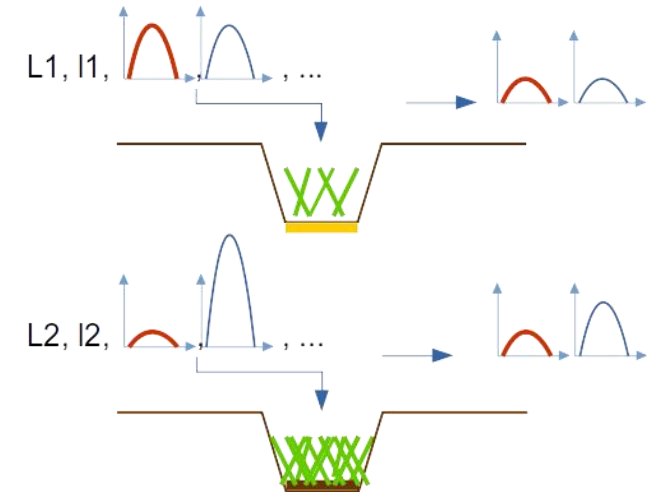
# PITCH : A simplified pesticide transfer model for ditches network





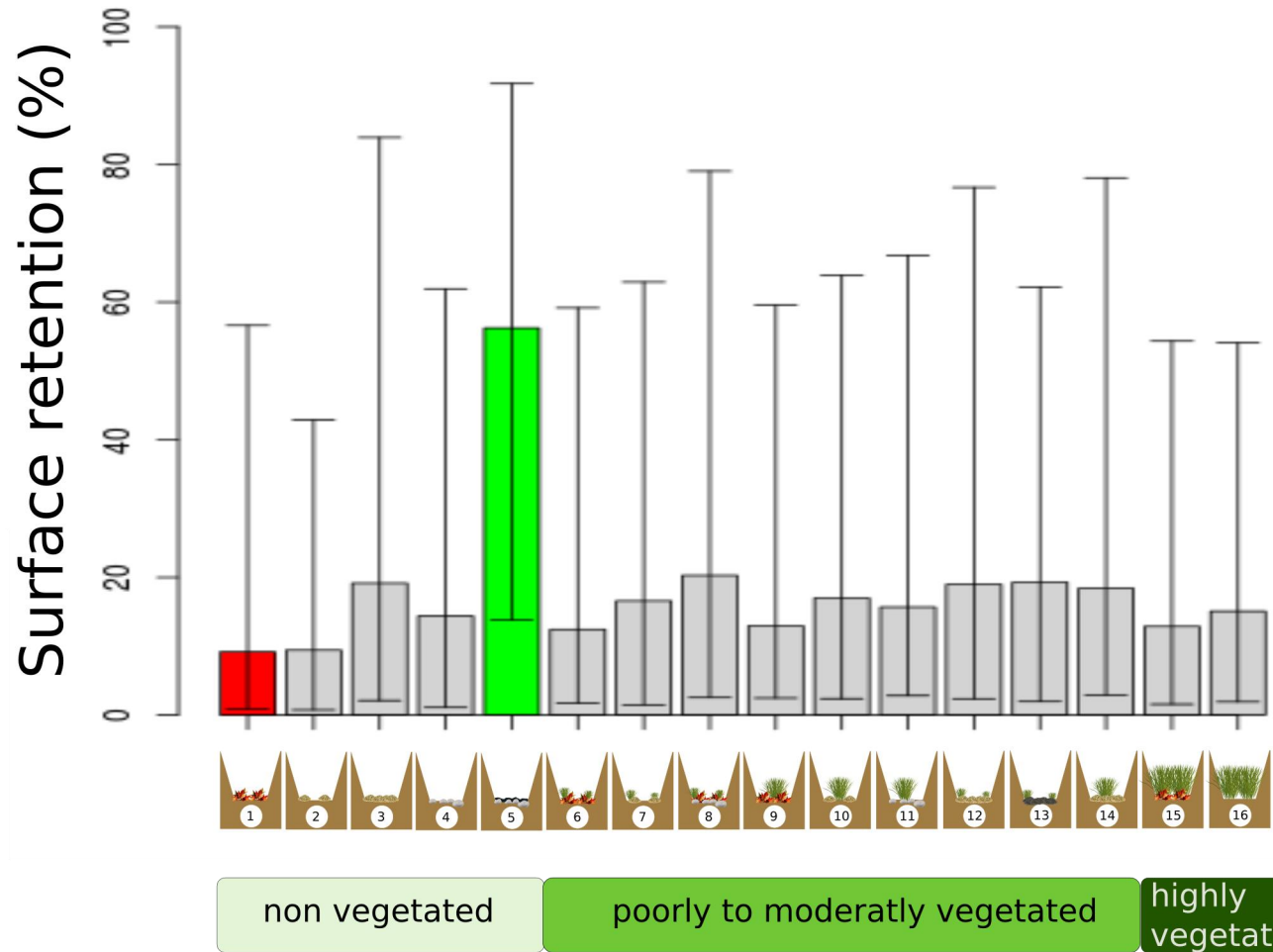
# Sensitivity analysis - ditch scale

- **Sensitivity analysis for 3 compounds with differing characteristics**
  - Hydrophile : Glyphosate
  - Hydrophobe : Diuron
  - Highly hydrophobe : Chlorpyrifos
- **Sensitivity analysis to 7 factors :**
  - Width
  - Slope
  - Soil type (sand, clay, loam)
  - Ditch type (with substrates types and abundance, ...)
  - Hydrogram (Inflow)
  - Kd soil
  - Contamination types :
    - **New contamination (input of concentrated water)**
    - Old contamination (Initial pesticide stock in soil)
    - New contamination and Remobilisation
- **Sensitivity criteria**
  - **Surface attenuation**
  - Groundwater risk
  - Storage



- Optimized randomized experiment design
- 18 000 simulations / molecules' type / contamination type

## Results - Retention variation between the types of ditches



**Differences in pesticide retention between ditches vary largely**

- with differences in physical properties
- according to the compound

Histogram of simulated retentions (18,000 simulations) - Hydrophobic case molecule (diuron), contaminating flood

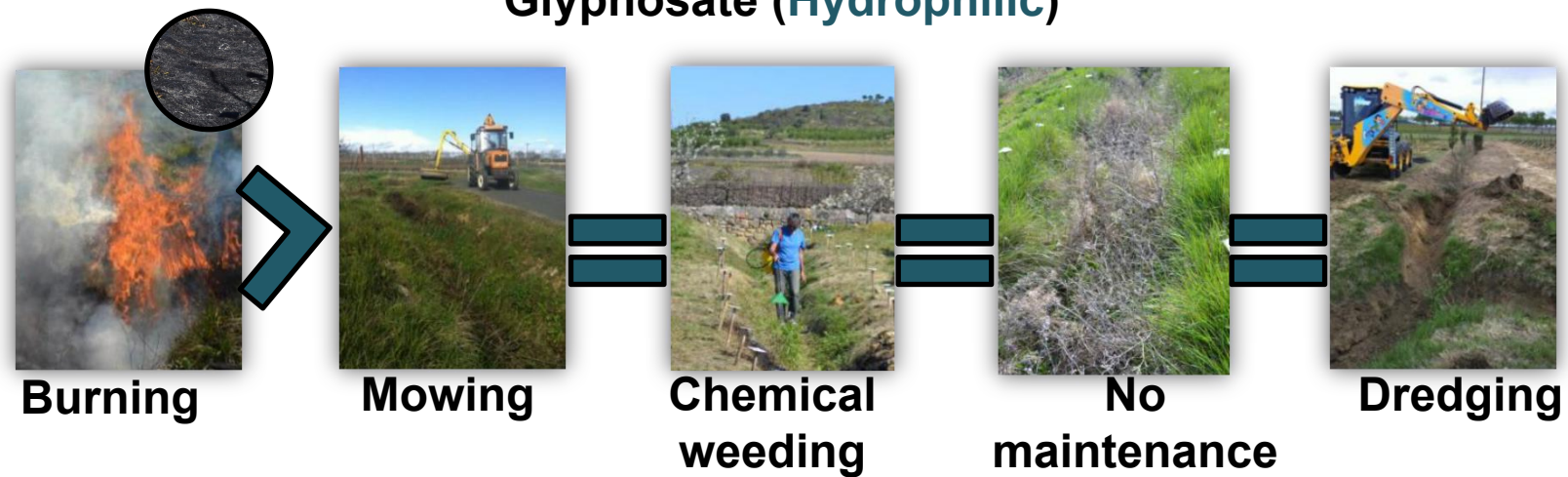


# Results - Ditch maintenance can be a lever to limit contamination

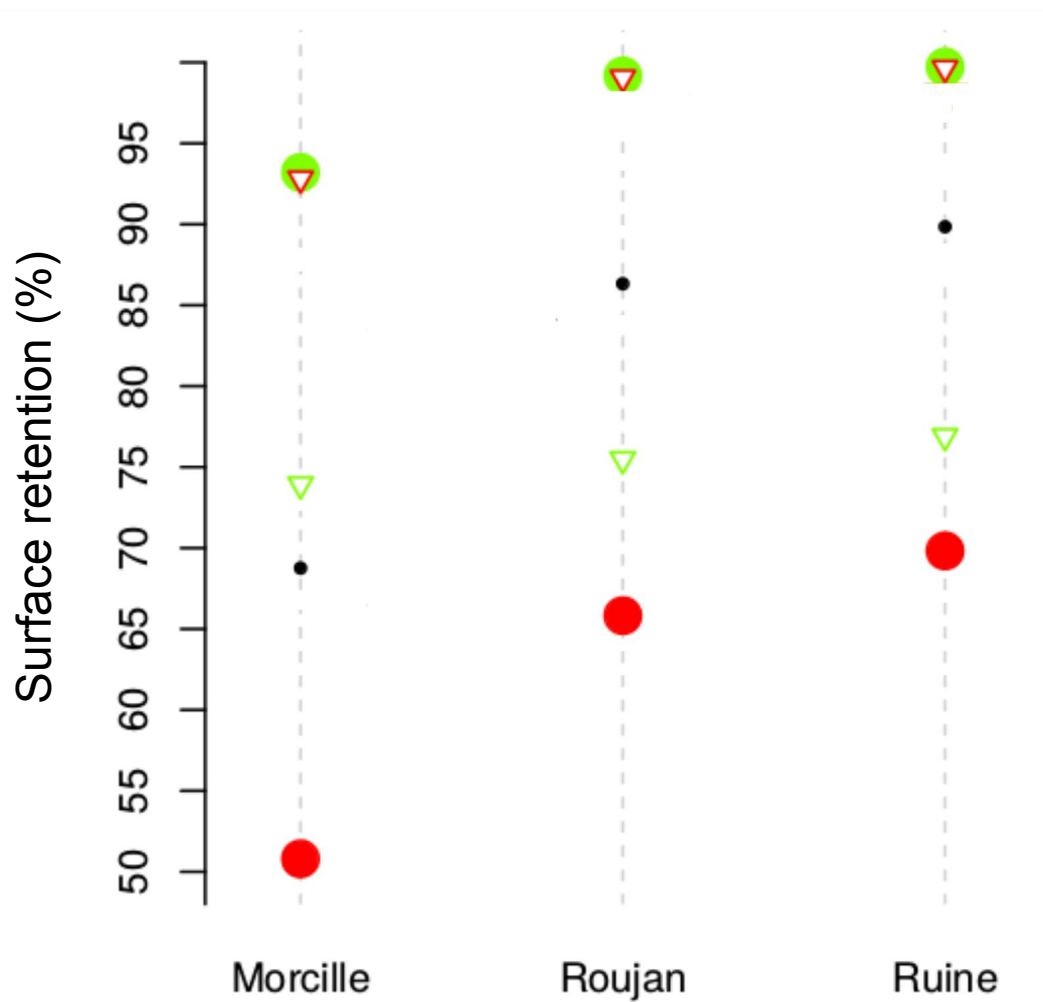
## Diuron & Isoproturon (Hydrophobic)






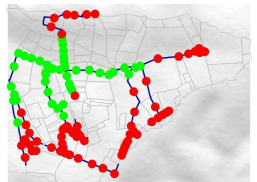
## Glyphosate (Hydrophilic)


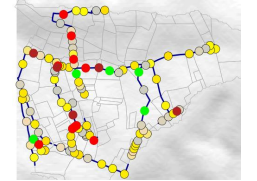



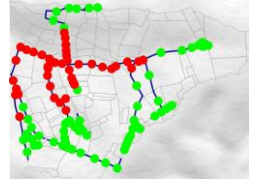
# Results - The spatial distribution of ditch types influences overall retention





- 


homogeneous distribution with high retention capacity ditch ●
- 


50 % of high retention capacity ditch located downstream ▼
- 


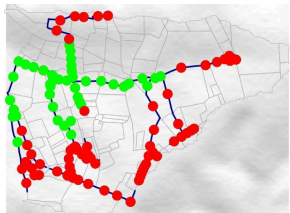
actual distribution of ditch types along the network ●
- 


50 % of high retention capacity ditch located upstream ▼
- 


homogeneous distribution with low retention capacity ditch ●



## Conclusions and outlook



- **Ditches as a buffer zone**
  - Confirmation of potentials and limits of the buffer effect of ditch and ditches network.
  - Elucidate the “pattern-process” link between ditch properties and ditch retention by identifying types of ditches with contrasting physical and retention properties.
  - Ditch classification is compound dependant.
- **Maintenance operation as a management lever**
  - Burning is the maintenance operation that favors the most retention according to the compound.
  - Management strategies must be reasoned in time and space
- **Ditches must be considered within their landscape....**
  - Plant protection practices are heterogeneous within a catchment. Need to analyze succession of fields (properties, practices) and ditch.
  - Ditches fulfill other landscape function (e.g. green corridor). What about the impact of maintenance operations on other ditch functions ?

## A few papers for a more detailed overview...

- Dages, C.; Samouëlian, a.; Negro, S.; Storck, V.; Huttel, O. & Voltz, M. (2015) Seepage patterns of Diuron in a ditch bed during a sequence of flood events. *Science of The Total Environment* 537 , 120--128
- Dollinger, J.; Dages, C.; Bailly, J. S.; Lagacherie, P. & Voltz, M. (2015) Managing ditches for agroecological engineering of landscape. *A review. Agronomy for Sustainable Development*
- Dollinger, J.; Dages, C.; Negro, S.; Bailly, J. S. & Voltz M. (2016) Variability of glyphosate and diuron sorption capacities of ditch beds determined using new indicator-based methods. In: *Science of The Total Environment* 573. 716-726
- Dollinger, J.; Dages, C.; Samouelian, A.; Coulouma, G.; Lanoix, M.; Blanca, Y. & Voltz, M. (2018) Contrasting soil property patterns between ditch bed and neighbouring field profiles evidence the need of specific approaches when assessing water and pesticide fate in farmed landscapes. *GEODERMA* 309, 50-59
- Dollinger, J.; Dages, C. & Voltz, M. (2017) Using fluorescent dyes as proxies to study herbicide removal by sorption in buffer zones. *Environmental Science and Pollution Research* . 1--12
- Dollinger, J.; Vinatier, F.; Voltz, M.; Dages, C. & Bailly, J.-S. (2017) Impact of maintenance operations on the seasonal evolution of ditch properties and functions. In: *Agricultural Water Management* 193, 191 – 204
- Fabre, J.C. and Louchart, X. and Moussa, R. and Dages, C. and Colin, F. and Rabotin, M. and Raclot, D. and Lagacherie, P. and Voltz M., 2010. *OpenFLUID: a software environment for modelling fluxes in landscapes. LANDMOD2010.*  
<https://www.openfluid-project.org/>

in french

- Dages, C.; Bailly, J. S.; Dollinger, J.; Lagacherie, P. & Voltz, M. (2016) Diagnostic et gestion des réseaux de fossés agricoles infiltrants pour la limitation de la contamination des masses d'eau par les pesticides, INRA-ONEMA
- Bailly, J. S.; Dages, C.; Dollinger, J.; Lagacherie, P. & Voltz, M. (2015) Protocole de spatialisation et d'évolution d'états de surface de fossés, ONEMA-INRA
- Dollinger, J.; Dages, C.; Bailly, J. S.; Lagacherie, P. & Voltz, M. (2014) Synthèse bibliographique des différentes fonctions des réseaux de fossés aux échelles du fossé élémentaire et du réseau. ONEMA-INRA.
- Dollinger, J. (2016) Analyse et modélisation des transferts et de la rétention de pesticides dans les fossés agricoles infiltrants en lien avec les stratégies d'entretien, Montpellier SupAgro, PhD Thesis (298 p. + Annexes), Montpellier SupAgro, Montpellier.