Ditch maintenance as a lever to limit water contamination by pesticides

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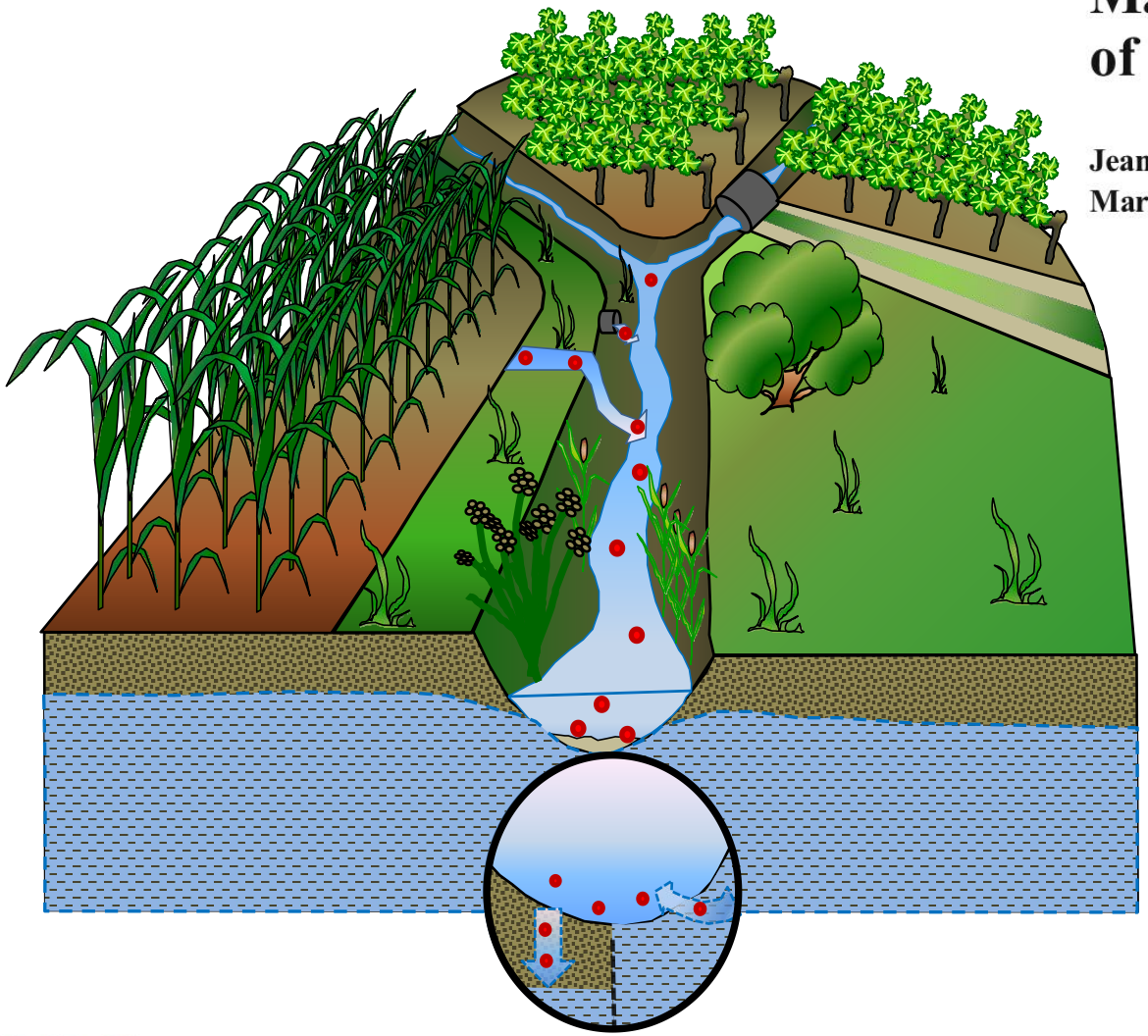
UMR LISAH, Laboratoire d'Etude des Interactions entre Sol-Agrosystème-Hydrosystème
2 Place Pierre Viala, 34060 Montpellier

Ditches as buffer zones



REVIEW ARTICLE ASD, 2015

Managing ditches for agroecological engineering of landscape. A review

Jeanne Dollinger[1] · Cécile Dagès[1] · Jean-Stéphane Bailly[2] · Philippe Lagacherie[1] · Marc Voltz[1]

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)

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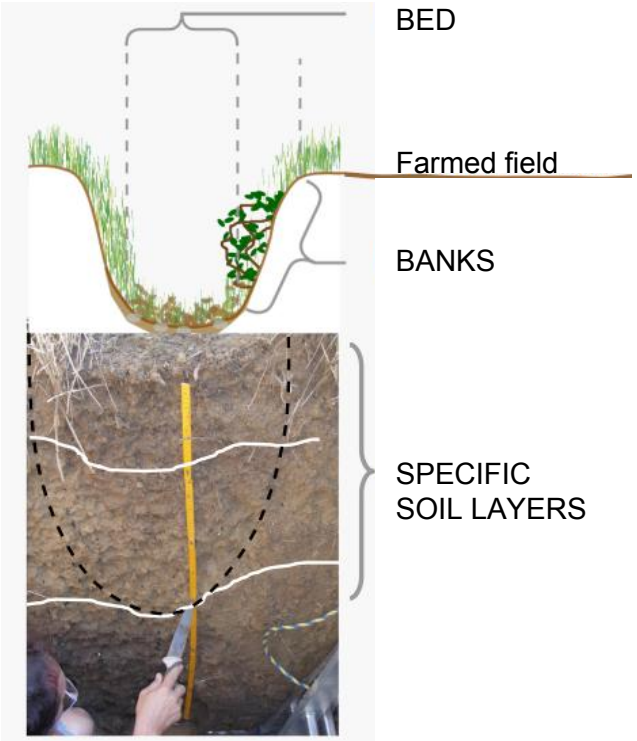
Large variability of ditches types



Morphology

slope, lenght, width…

Topology

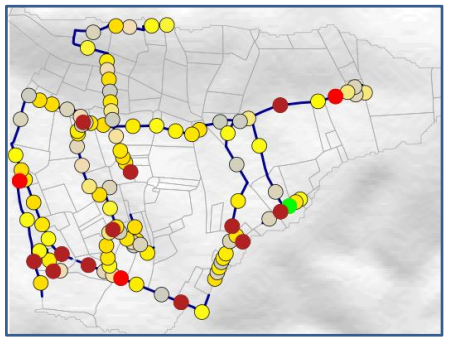
location within the network

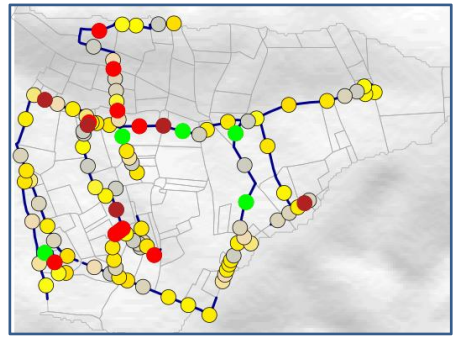
Type and abundance of substrates

soil, litter, plants, ashes…

Nature et vegetation density

Number and types of soil layers





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Ditch maintenance : operations, effect and calendar

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

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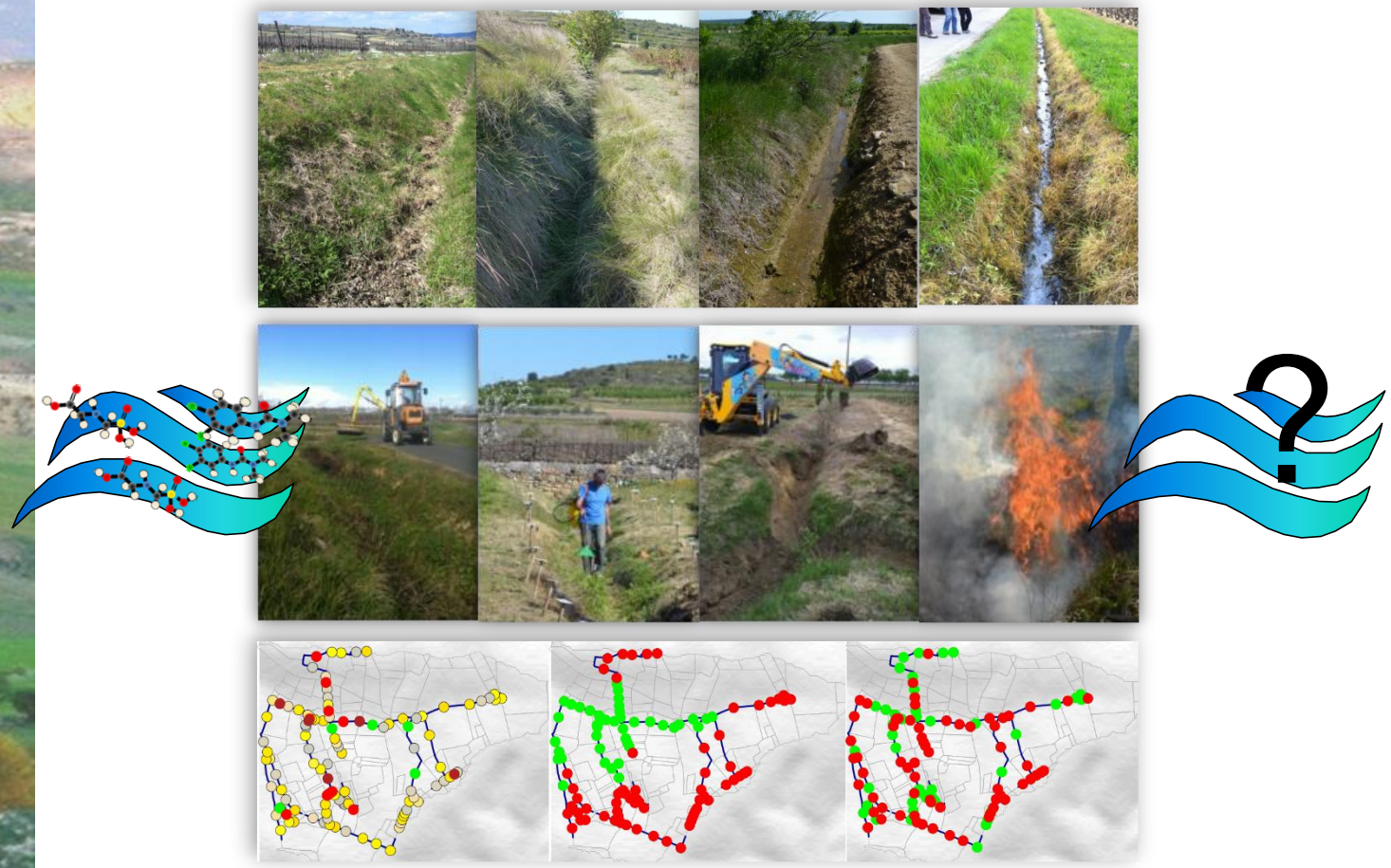
Goals

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 ?**

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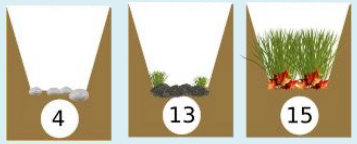
Method

DITCH CARACTERISATION

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




Agron. Sustain. Dev.
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REVIEW ARTICLE
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Marc Voltz[1]

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Observatoire Méditerranéen de l'Environnement Rural et de l'Eau

studied catchments

Observation


Surveys


Infiltrability


Roughness


Sorption


Percolation

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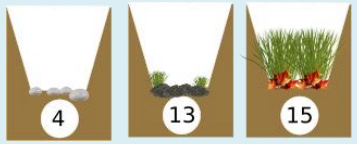

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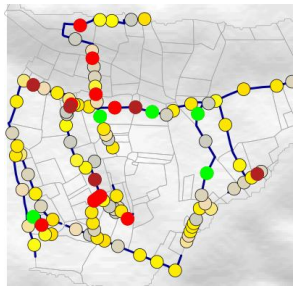
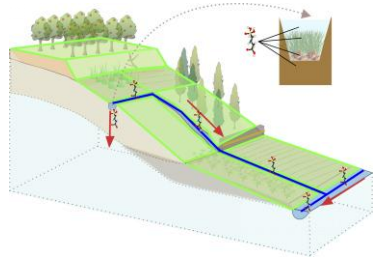
MODELLING

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





OpenFLUID
Software Environment for Spatial Modelling in Landscapes

Fabre et al., 2010
https://www.openfluid-project.org/

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Method

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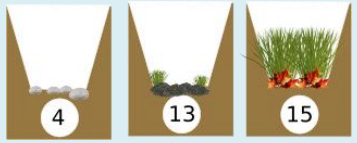

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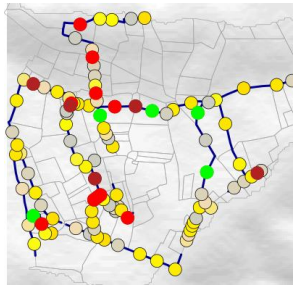

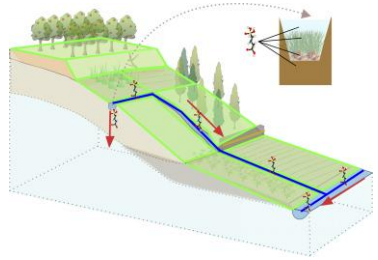

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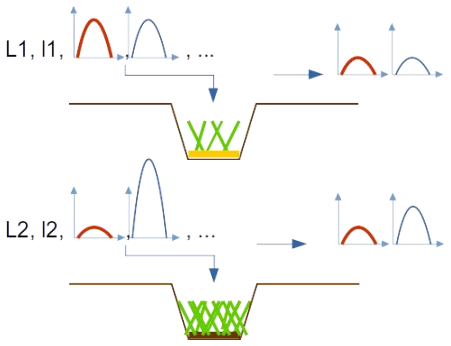
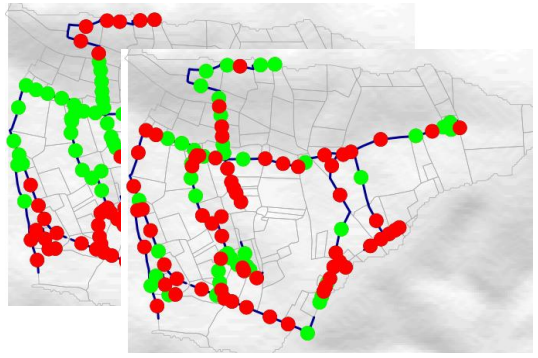
NUMERICAL SIMULATIONS

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





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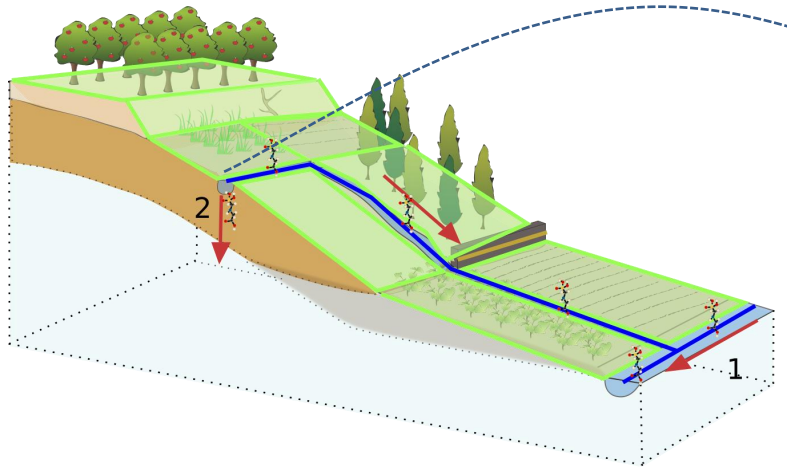
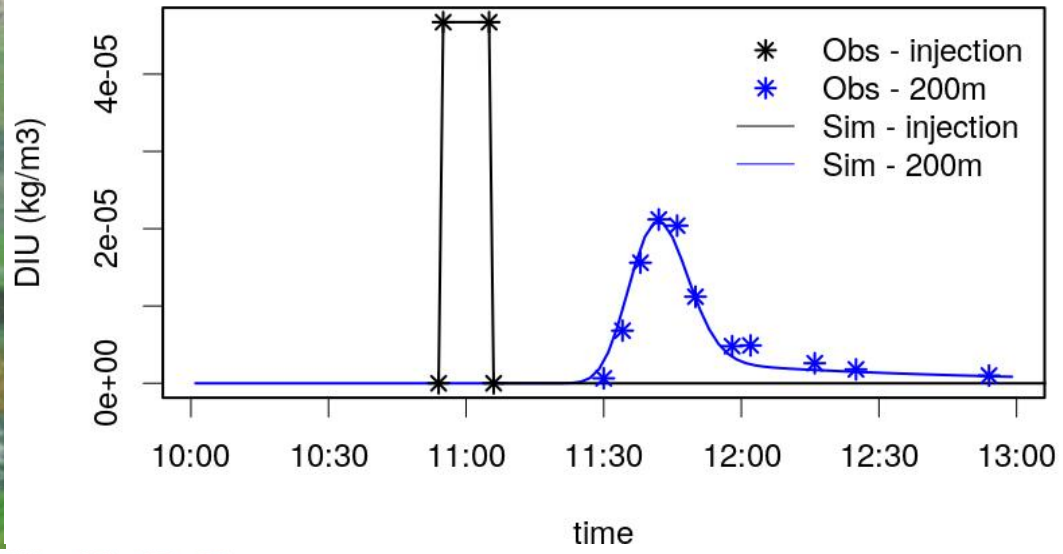
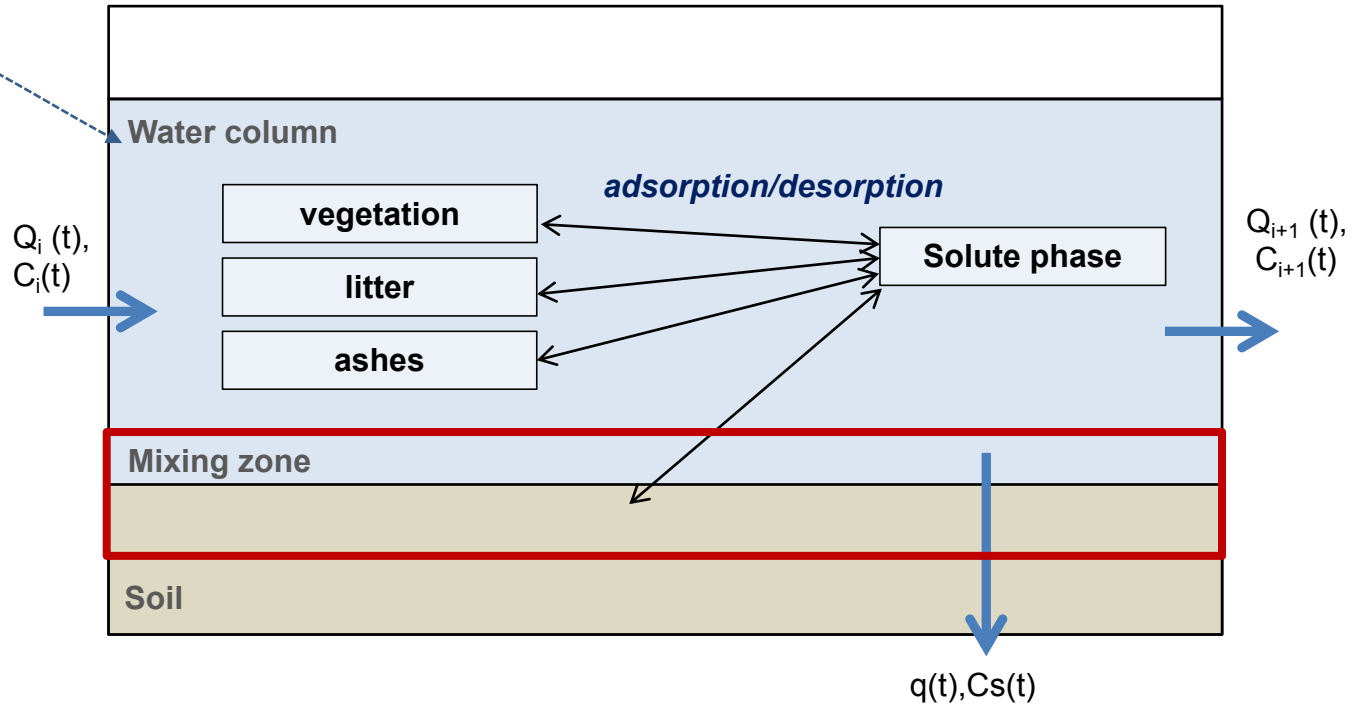
PITCH : A simplified pesticide transfer model for ditches network







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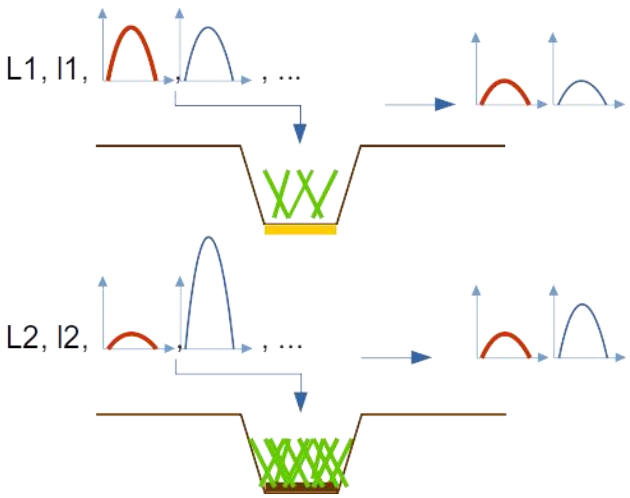
Sensitiviy analysis - ditch scale

- **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

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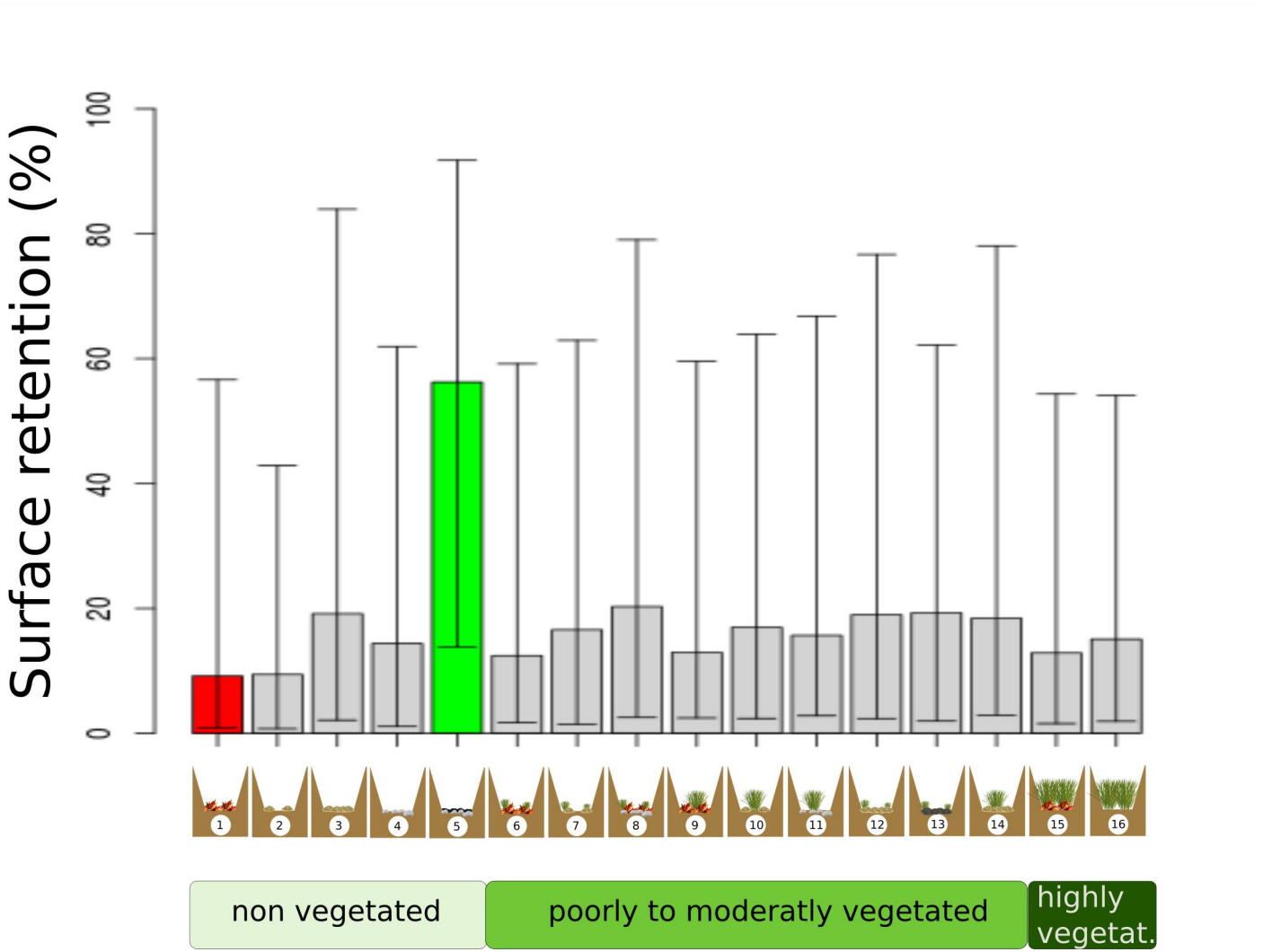
Results - Retention variation between the types of ditches



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

Differences in pesticide retention between ditches vary largely

- **with differences in physical properties**
- **according to the compound**

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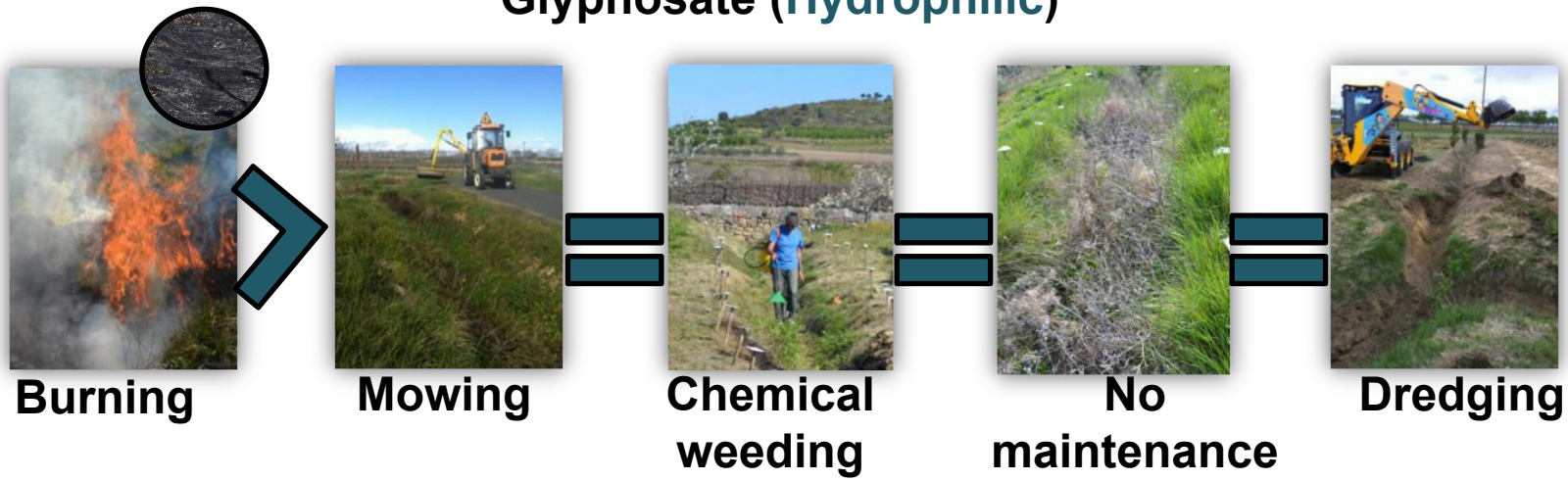
Results - Ditch maintenance can be a lever to limit contamination

Diuron & Isoproturon (Hydrophobic)

Glyphosate (Hydrophilic)



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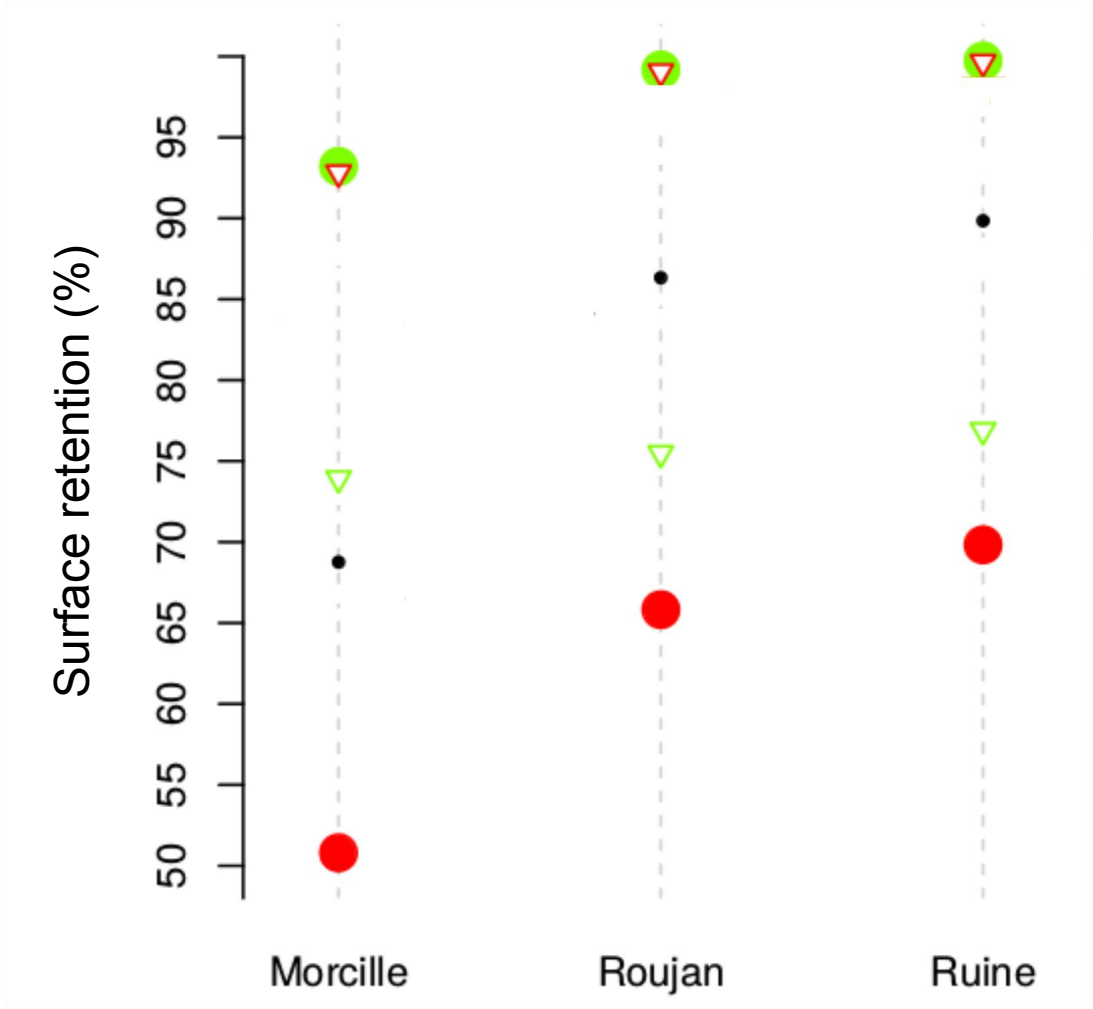
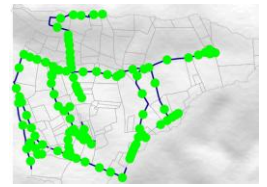
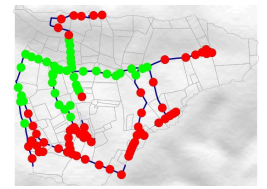
Results - The spatial distribution of ditch types influences overall retention

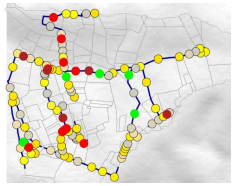




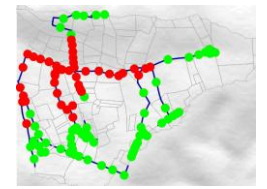
homogeneous distribution with high retention capacity ditch



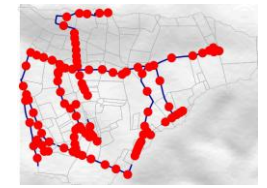
50 % of high retention capacity ditch located downstream



actual disttribution of ditch types along the network



50 % of high retention capacity ditch located upstream



homogeneous distribution with low retention capacity ditch

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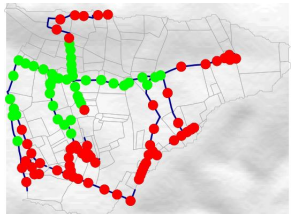
Ex - highly hydrophobic molecule (chlorpyrifos)

Conclusions and outlook



- **Ditches as a buffer zone**
  - Confirmation of potentials and limits of the buffer effect of dicth 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 considerd within their landscape....**
  - Plant protection pratices are heterogeneous within a catchment. Need to analyze succession of fields (properties, pratices) and ditch.
  - Ditches fullfill other landscape function (e.g. green corridor). What about the impact of maintenance operations on other ditch functions ?

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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.; Dagès, 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.; Dagès, 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.; Dagès, 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 Dagès, 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.

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