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► To cite this version:

Cécile Dagès, Jean-Stéphane Bailly, Jeanne Dollinger, Marc Voltz. Ditch maintenance as a lever to limit water contamination by pesticides. XVI Symposium in Pesticide Chemistry, Sep 2019, Piacenza, Italy. hal-02962199

HAL Id: hal-02962199

<https://hal.inrae.fr/hal-02962199>

Submitted on 9 Oct 2020

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Ditch maintenance as a lever to limit water contamination by pesticides

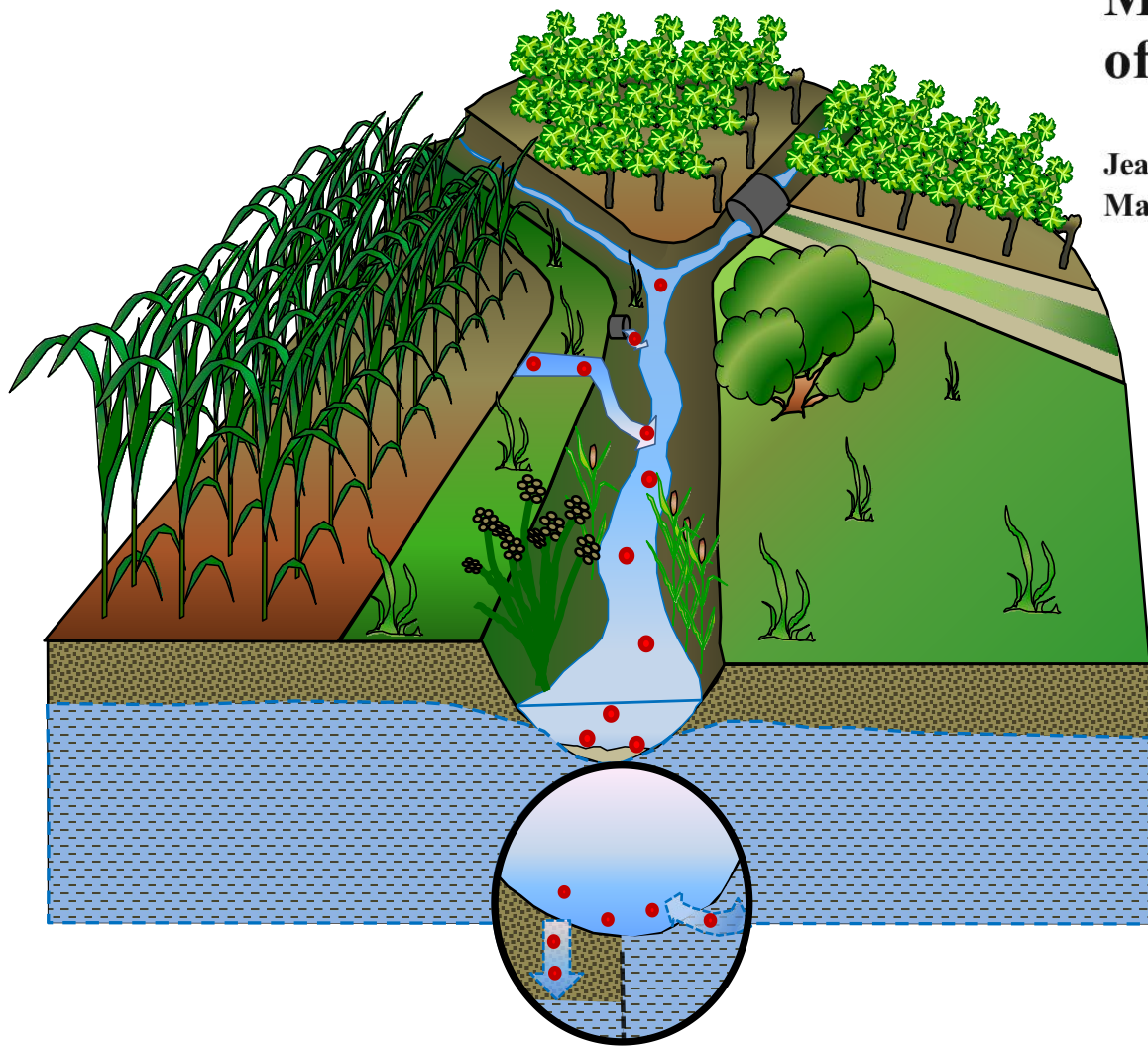


Cécile Dagès, Jean-Stéphane Bailly, Jeanne Dollinger,
and Marc Voltz

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Managing ditches for agroecological engineering of landscape. A review

Jeanne Dollinger¹ · Cécile Dagès¹ · Jean-Stéphane Bailly² · Philippe Lagacherie¹ · Marc Voltz¹

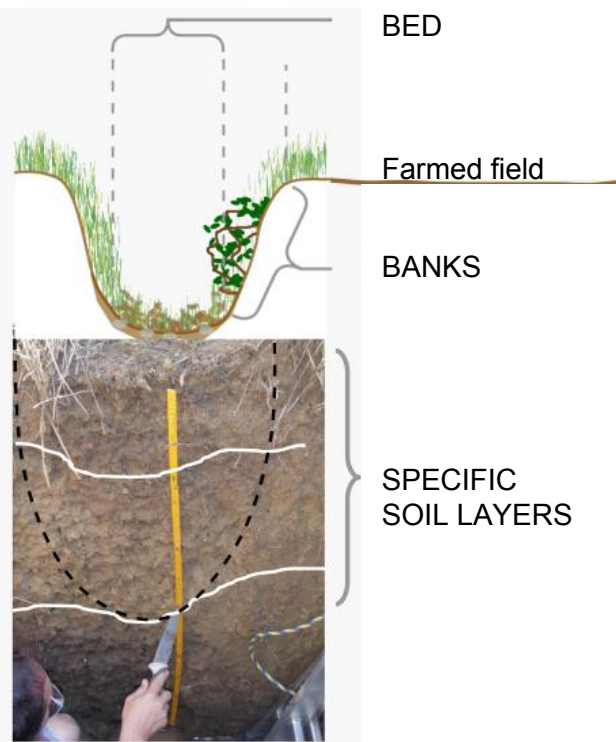


Collecting pesticides from :
Overland flow, soil drainage,
drift deposition, direct
application

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

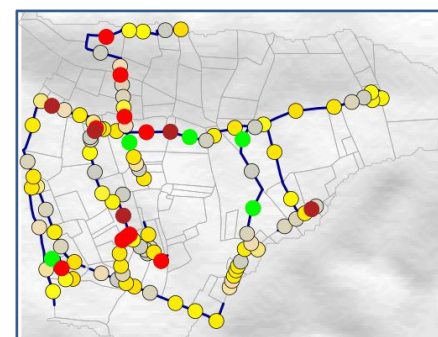
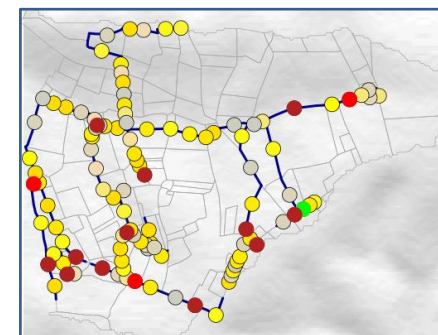
location within the network

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

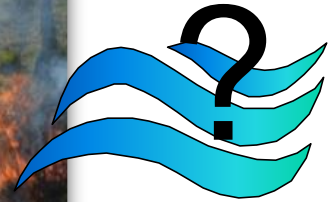
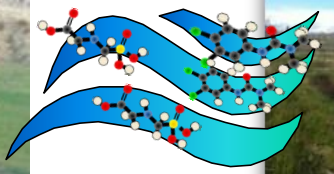
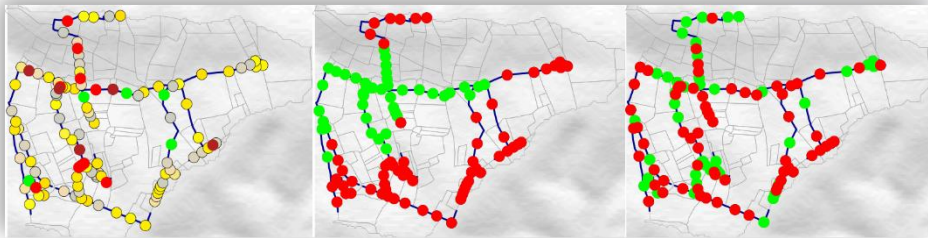
Chemical weeding



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

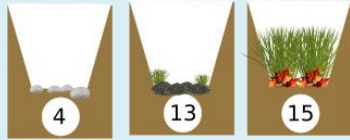


Percolation

Method

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MODELLING

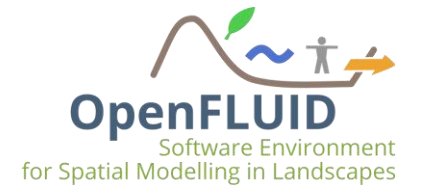
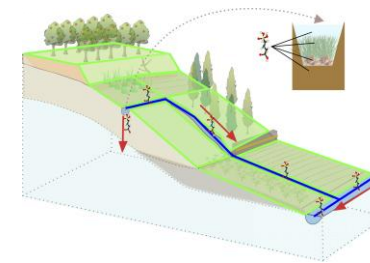
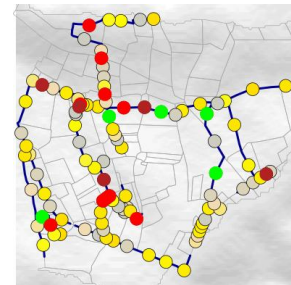
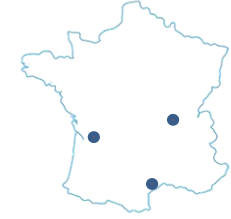
- Network model = $f(t,x,y)$
- Reactive transfer model - ditch and network

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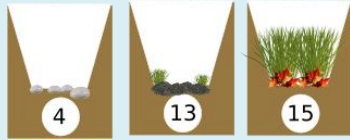
Fabre et al., 2010

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

Method

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MODELLING

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NUMERICAL SIMULATIONS

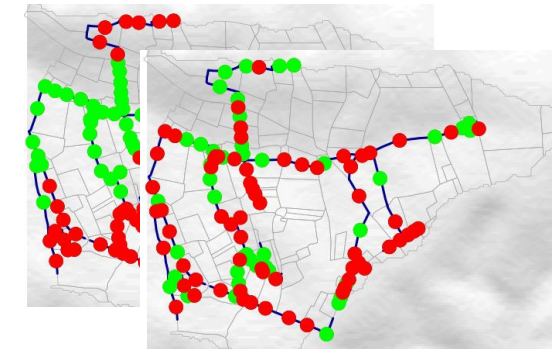
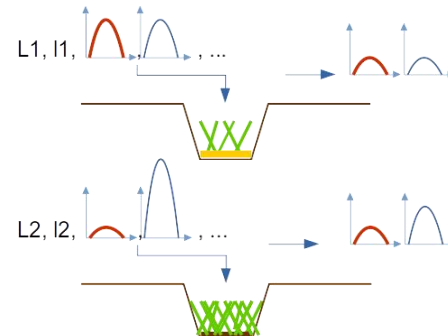
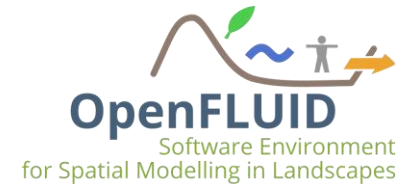
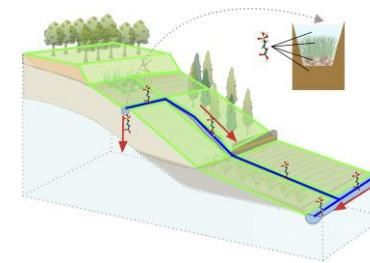
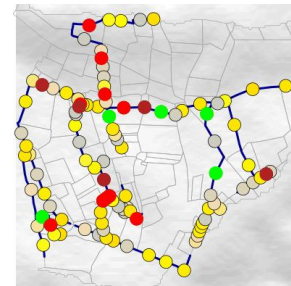
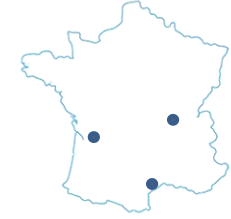
- Retentions variability / ditch
- Maintenance effect on retention
- Spatial distribution effect

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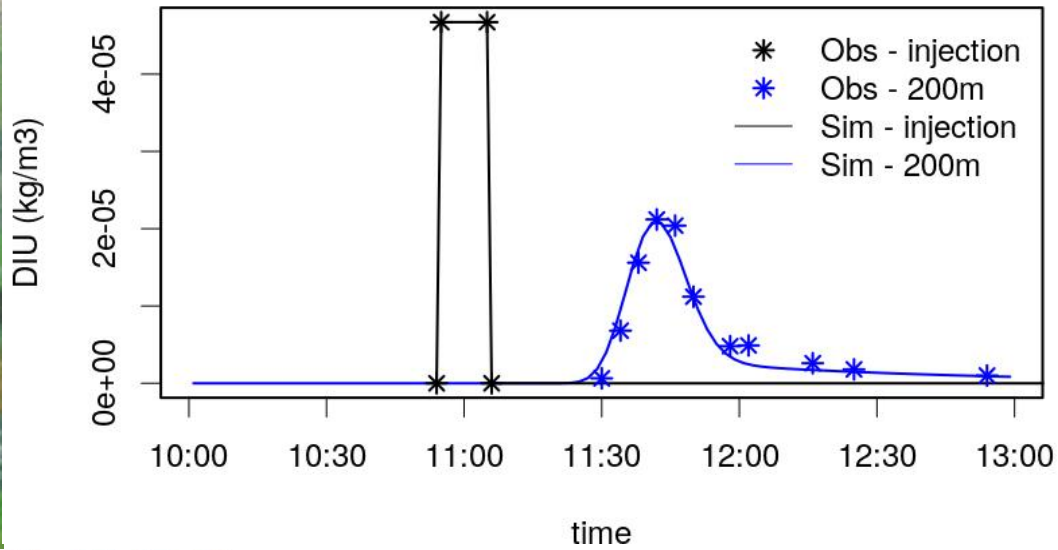
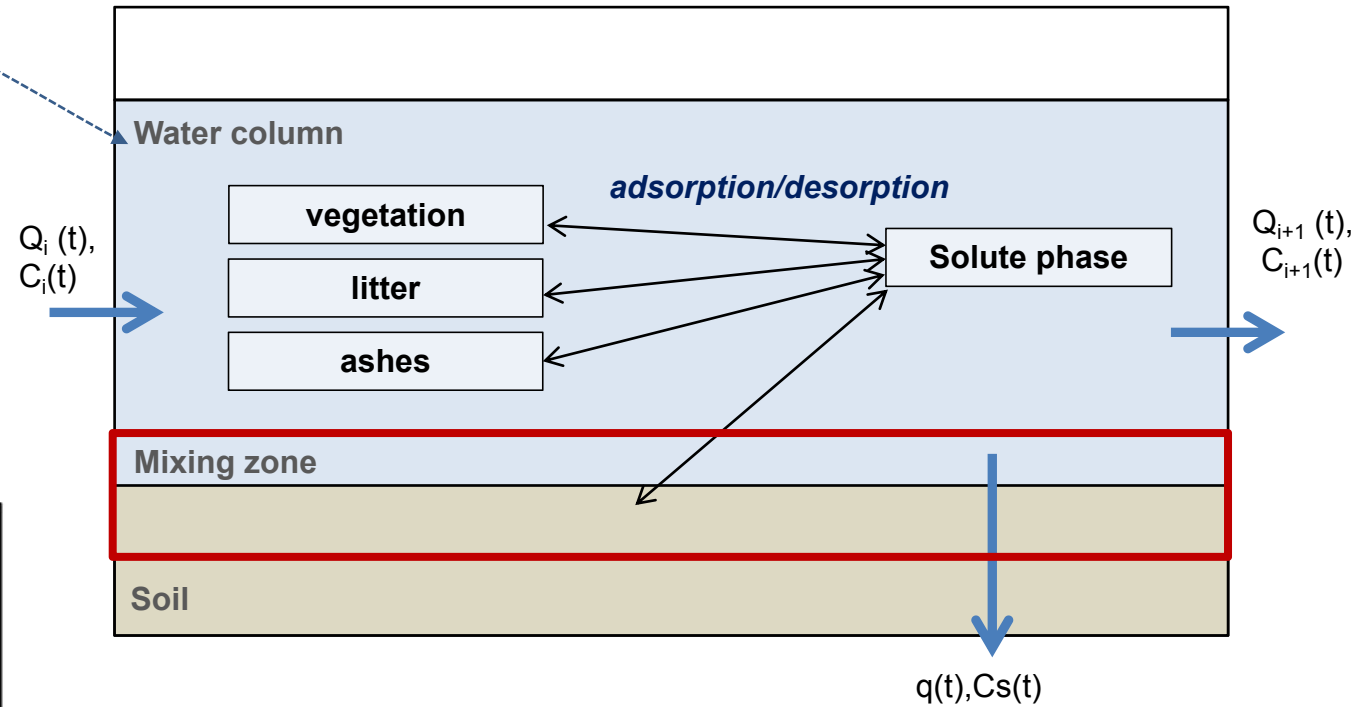
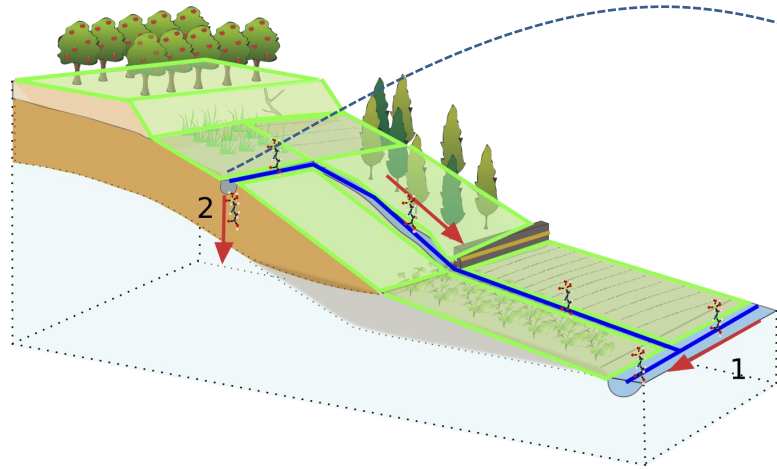
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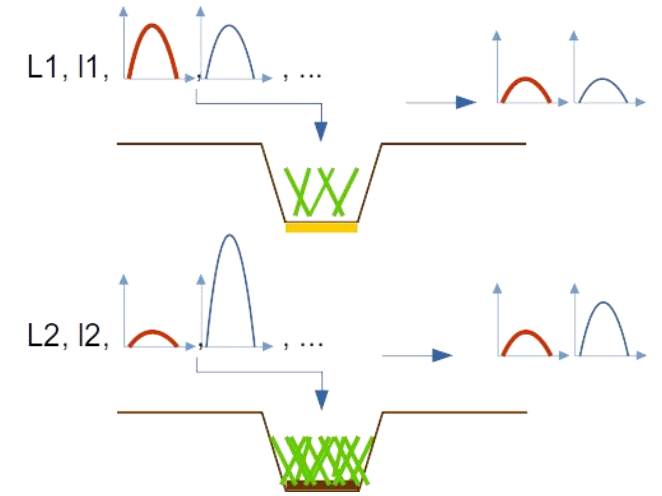


PITCH : A simplified pesticide transfer model for ditches network



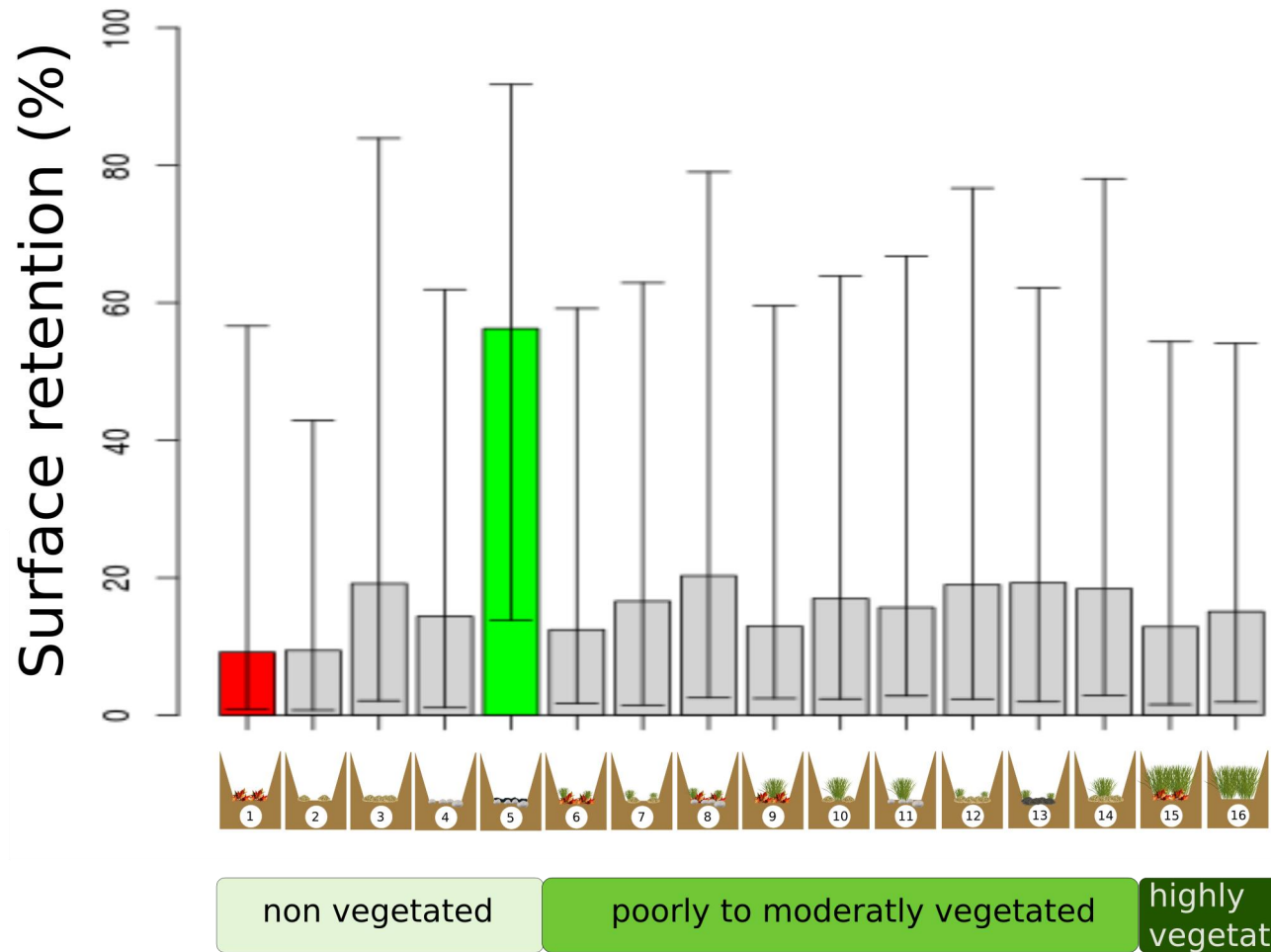
Sensitivity analysis - ditch scale

- **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)
 - K_d 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

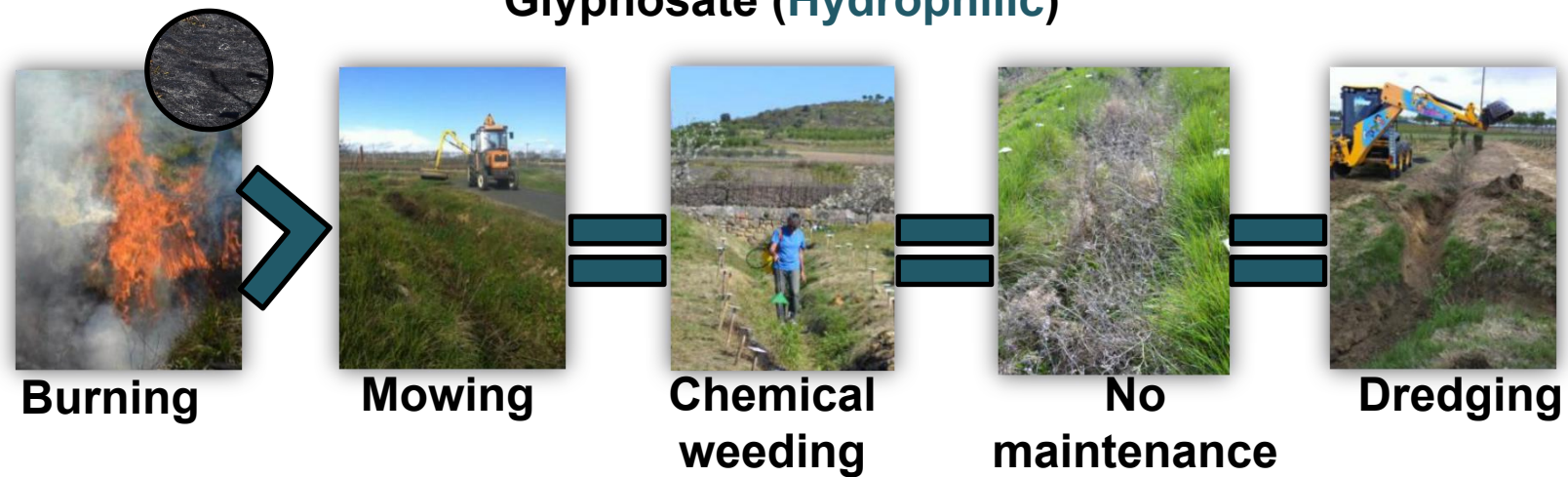
Histogram of simulated retentions (18,000 simulations) - Hydrophobic case molecule (diuron), contaminating flood

Results - Ditch maintenance can be a lever to limit contamination

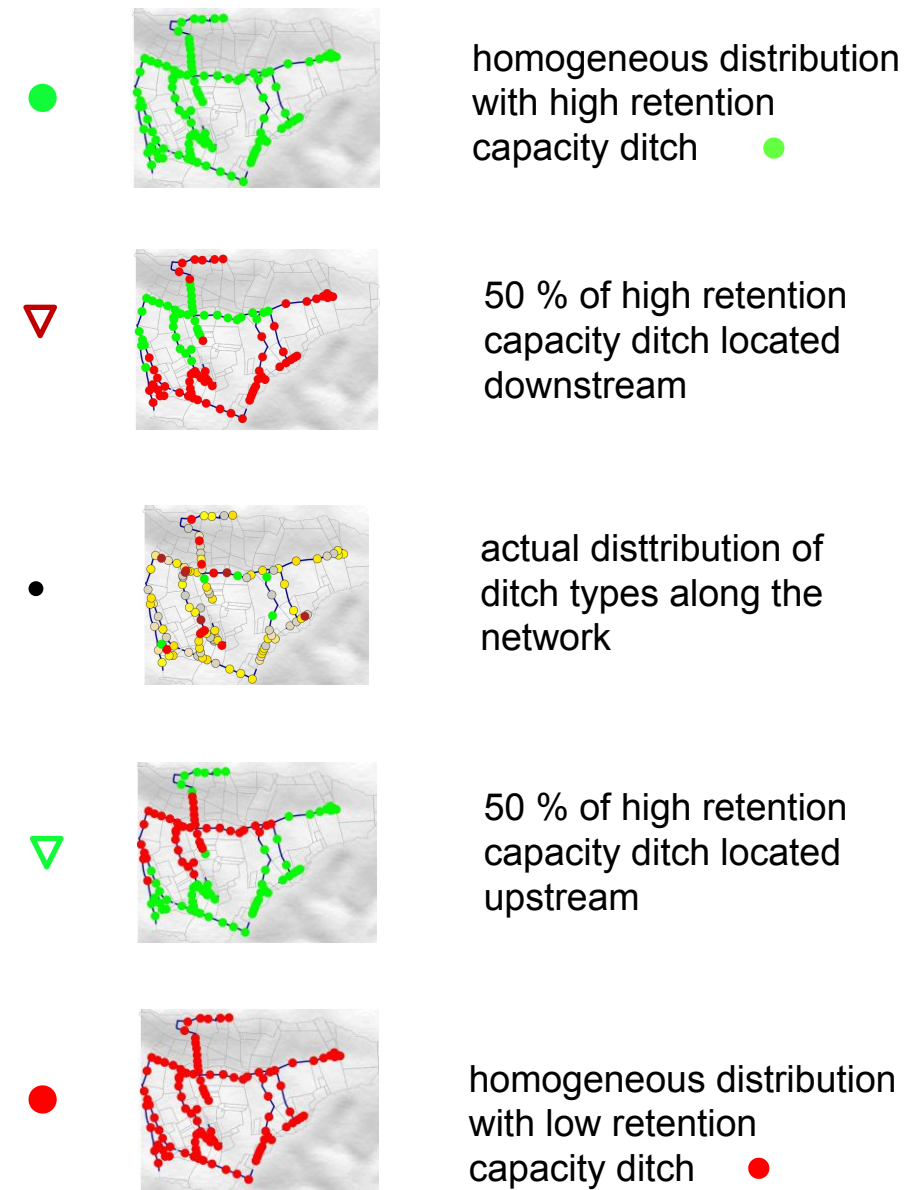
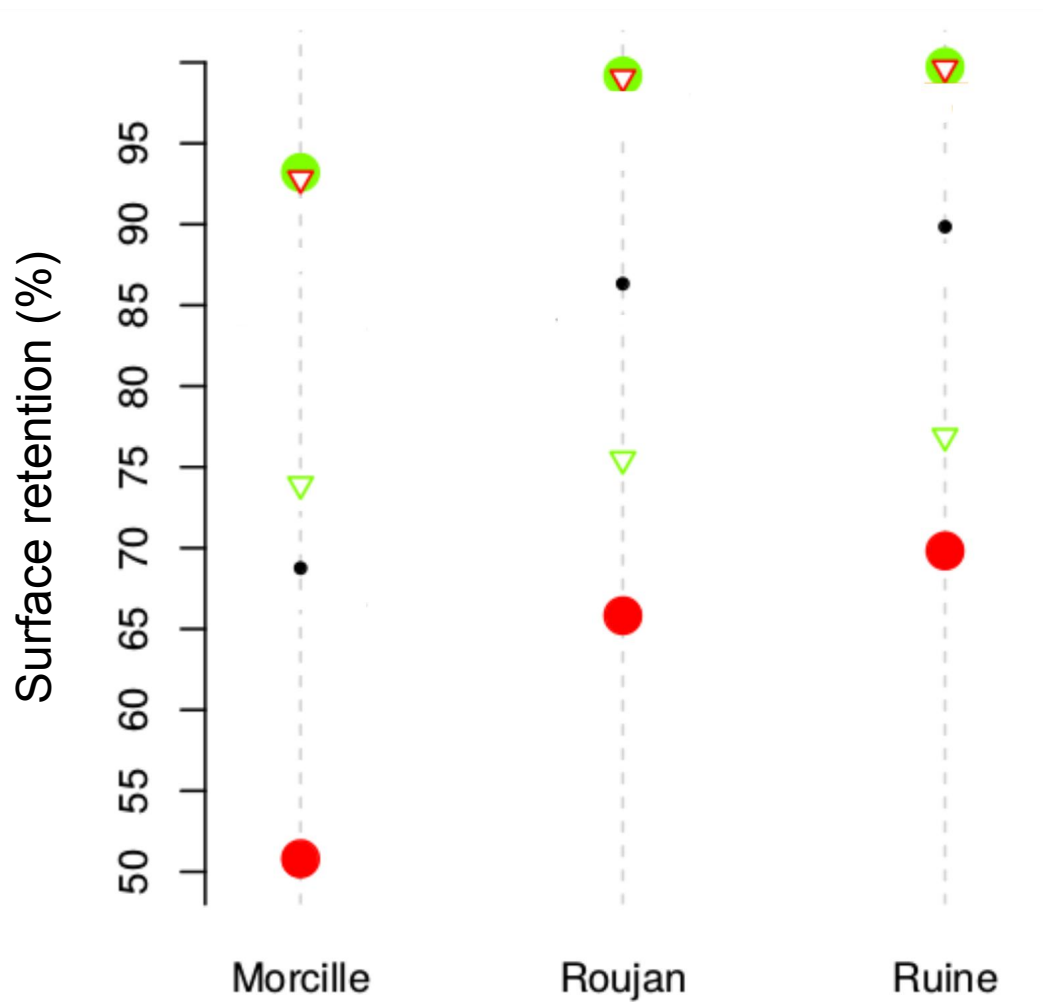
Diuron & Isoproturon (Hydrophobic)



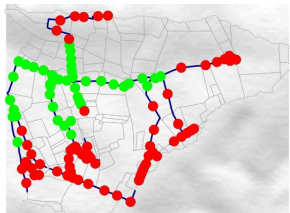
Glyphosate (Hydrophilic)



Results - The spatial distribution of ditch types influences overall retention



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.