10th iEMSs Conference 2020
International Environmental Modelling and Software Society

Sensitivity analysis to evaluate a new spatialized process-oriented model of water and pesticide transfers at the catchment scale

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[5]INRAE, UR MIAT, Toulouse, France

Introduction

Context

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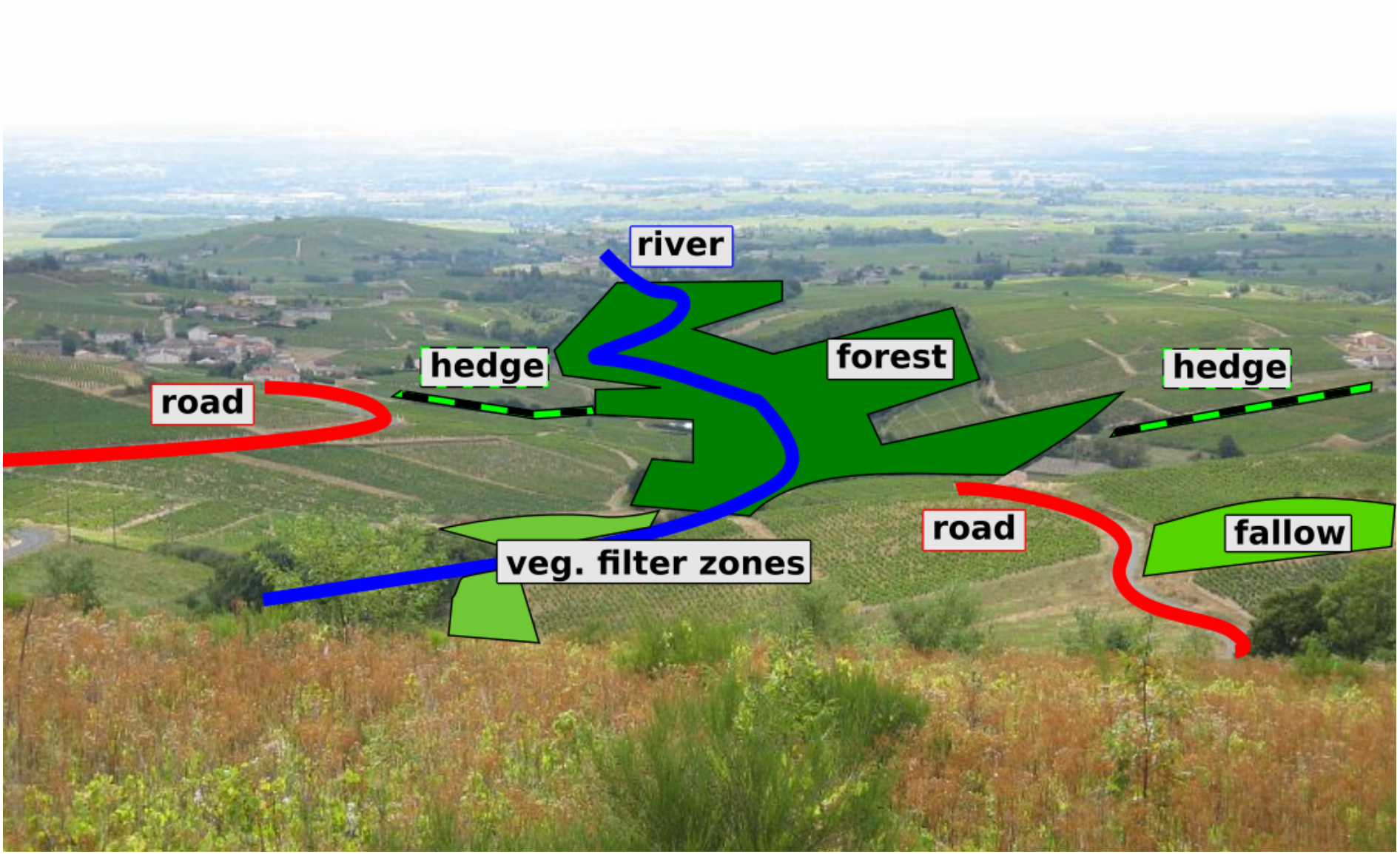
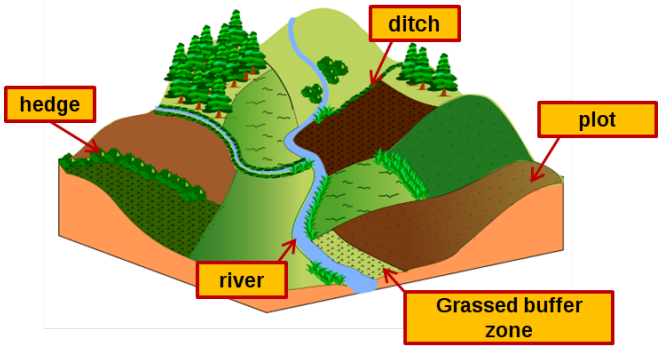


How to tackle pesticide transfers and fate on small agricultural catchments with modelling tools ?

✓ Integrating landscape elements diversity



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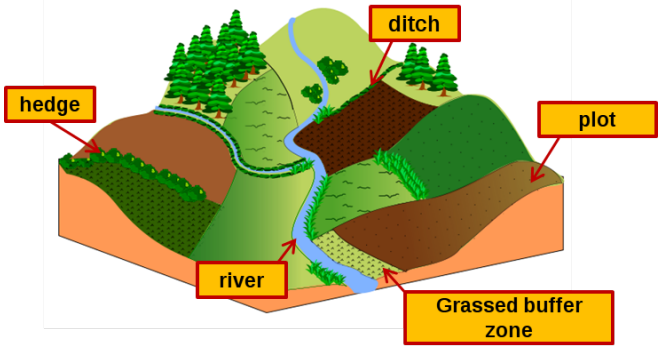
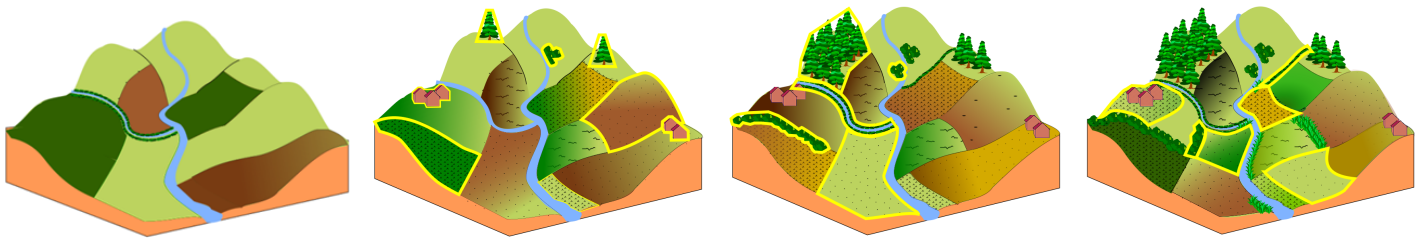


✓ Exploring landscape management scenarios



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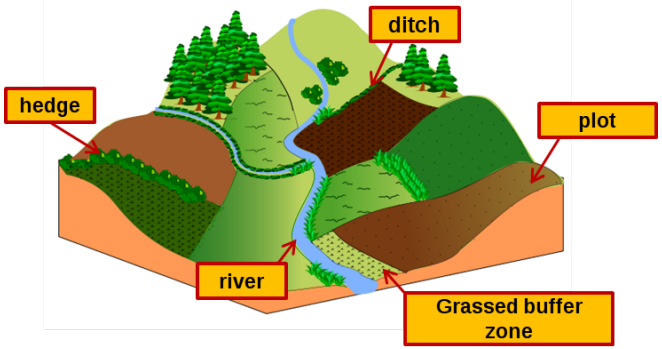

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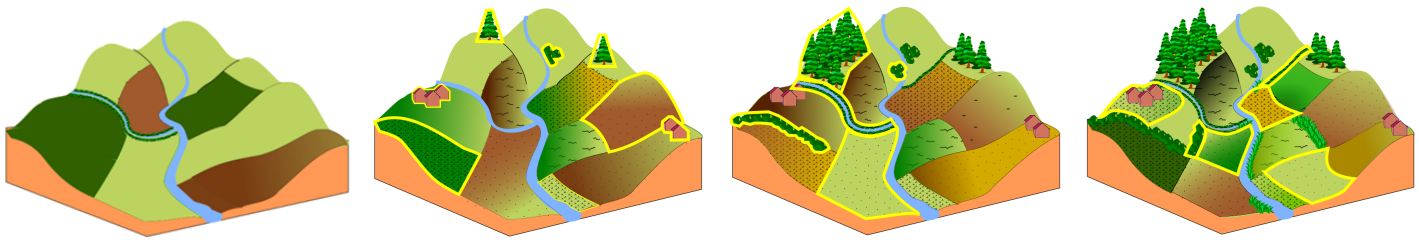
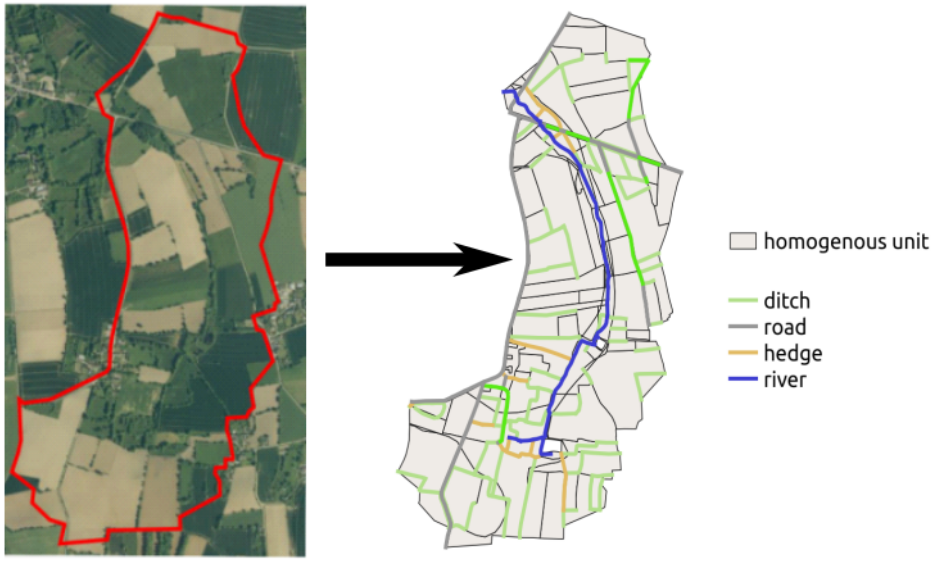


⇒ Development of the **PESHMELBA** model (Rouzies et al. 2019)

Introduction

The PESHMELBA model

- ✓ Simulation of heterogenous landscapes composed of plots, vegetative filter zones, hedges, ditches and rivers



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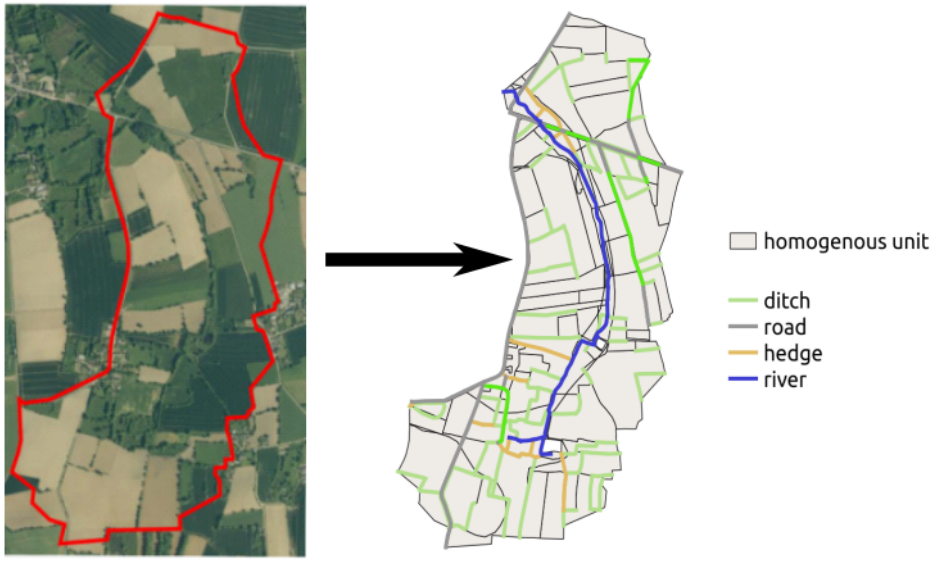
- ✓ Simulation of heterogenous landscapes composed of plots, vegetative filter zones, hedges, ditches and rivers
- ✓ Water transfers on surface and subsurface



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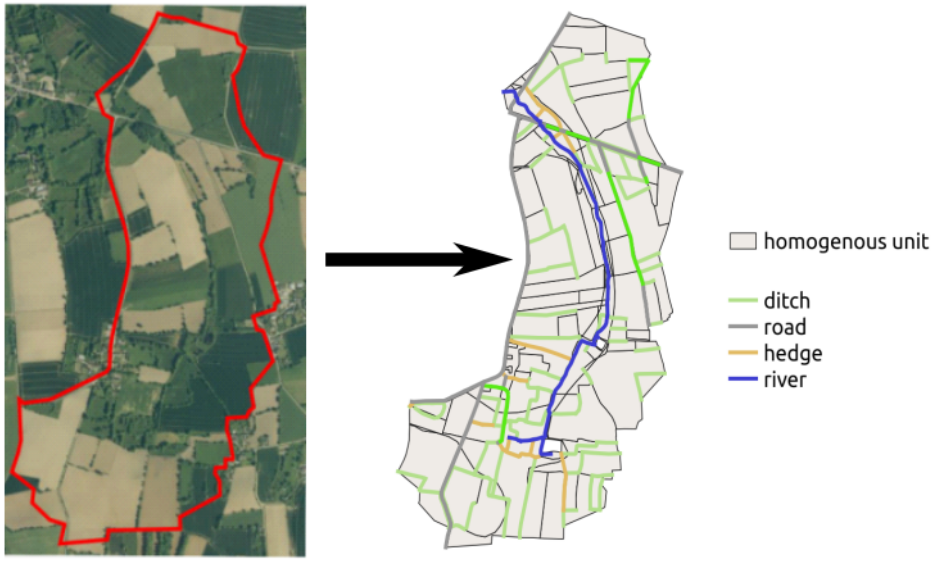

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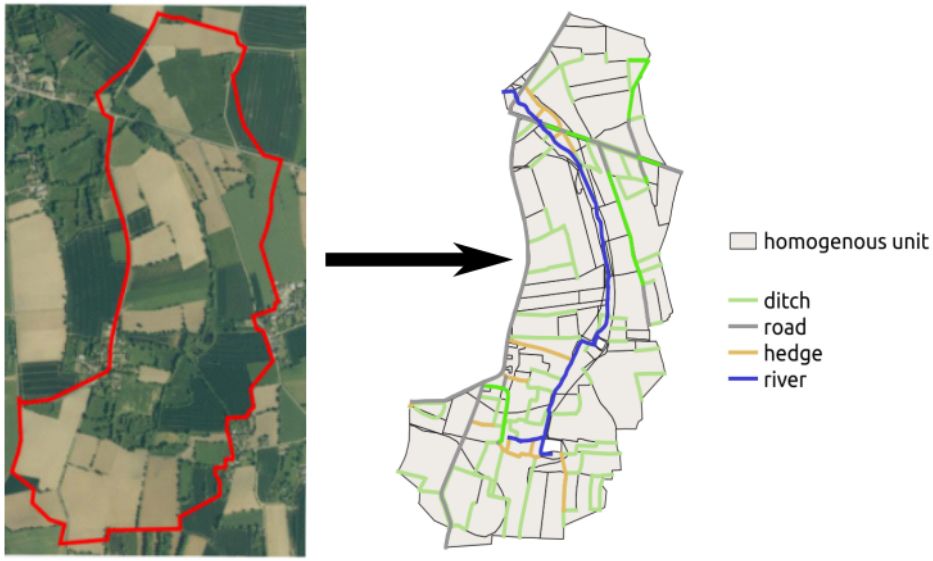
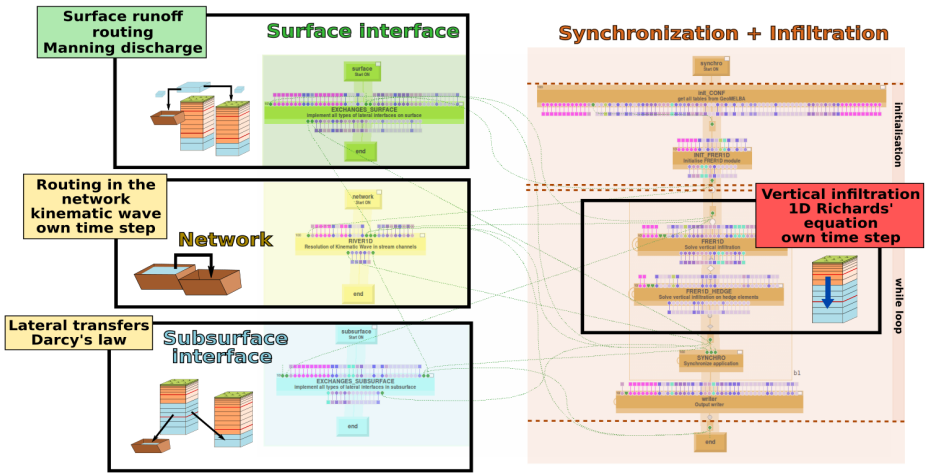
The PESHMELBA model

- ✓ Simulation of heterogenous landscapes composed of plots, vegetative filter zones, hedges, ditches and rivers
- ✓ Water transfers on surface and subsurface
- ✓ Solute advection, adsorption and degradation
- ✓ One module ≡ one process or ensemble of processes on a landscape element
- ✓ Coupling of modules within the OpenPALM coupler (Fouilloux and Piacentini 1999) turning the structure flexible





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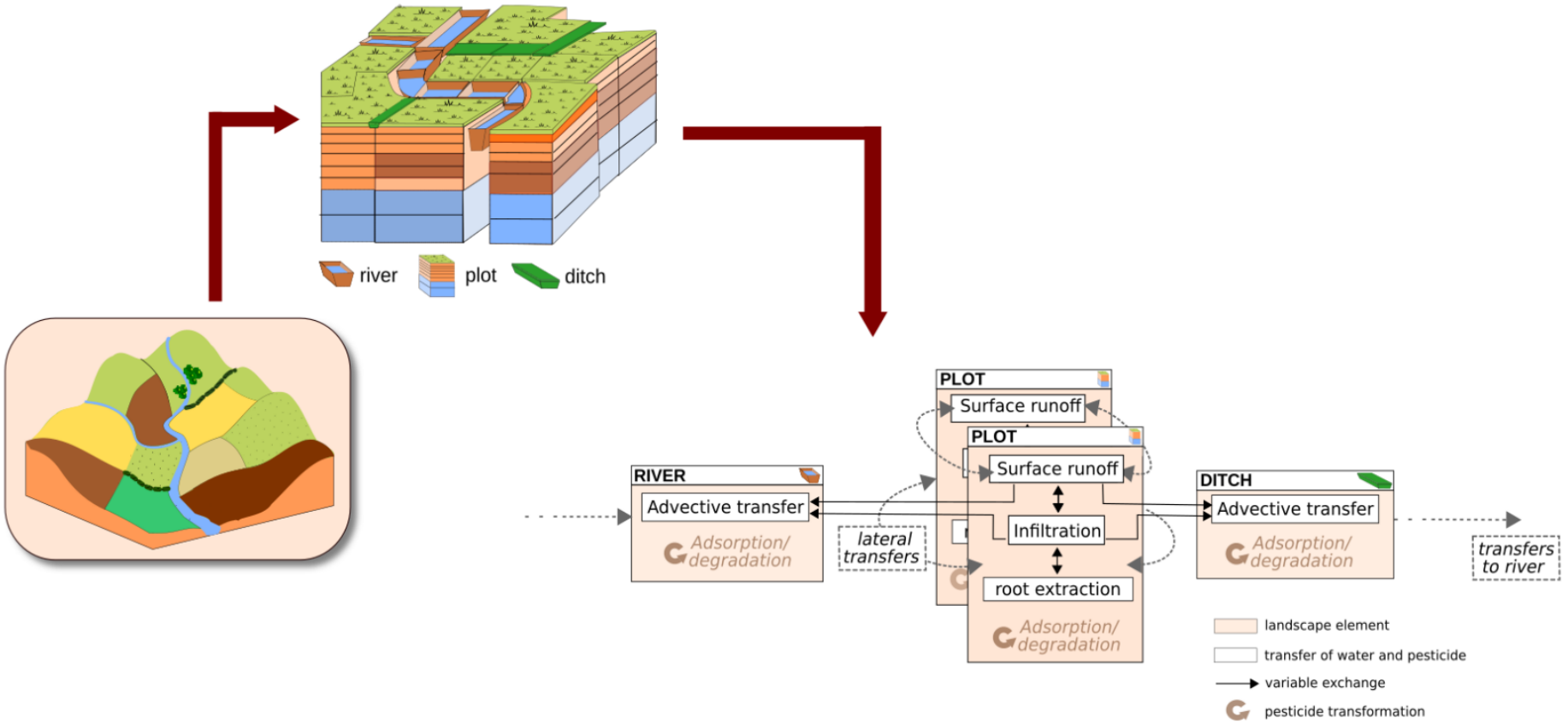

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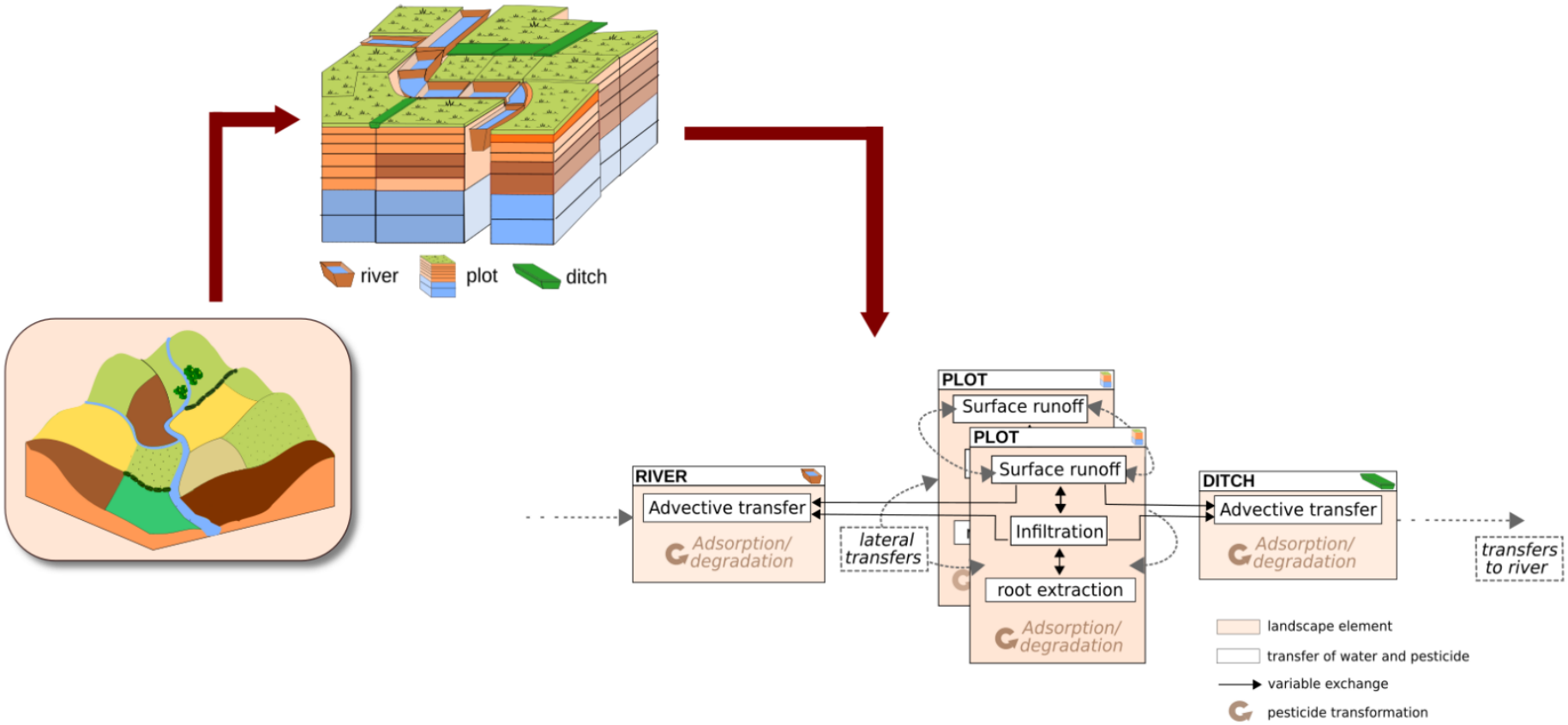

⇒Complex structure may lead to additionnal difficulties to diagnose model behavior!

Introduction

Objectives

Necessary to quantify and reduce the uncertainty associated to the model output variables, particularly for decision-making.
Global Sensitivity Analysis (GSA) is a necessary step.

? Which tools to address the question of GSA in a **modular**, **spatialized** model of **pesticide transfers**?

? How can GSA be a tool to assess physical processes representation in PESHMELBA model ?

Material and methods

Study case

La Morcille catchment (France)

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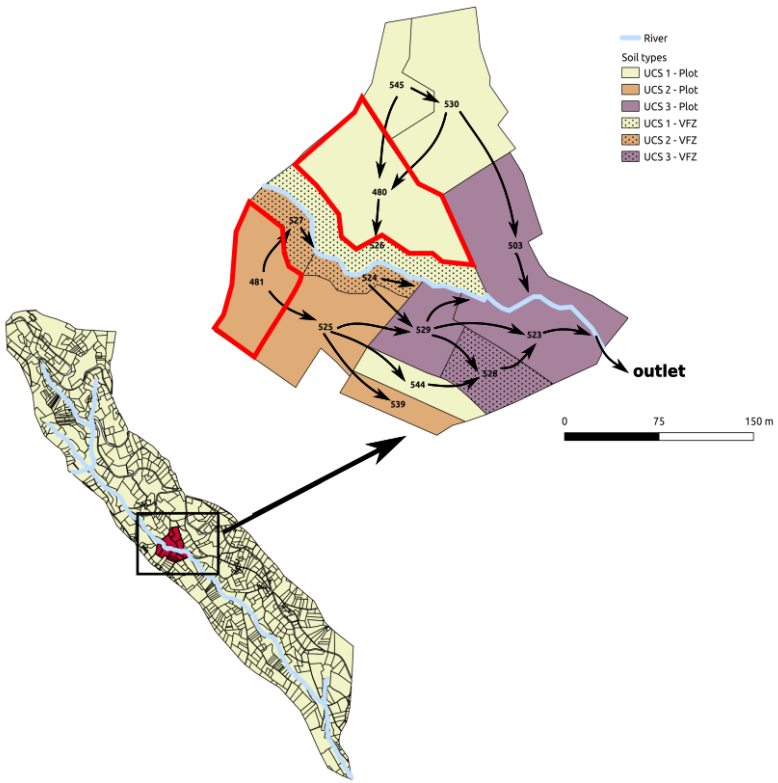

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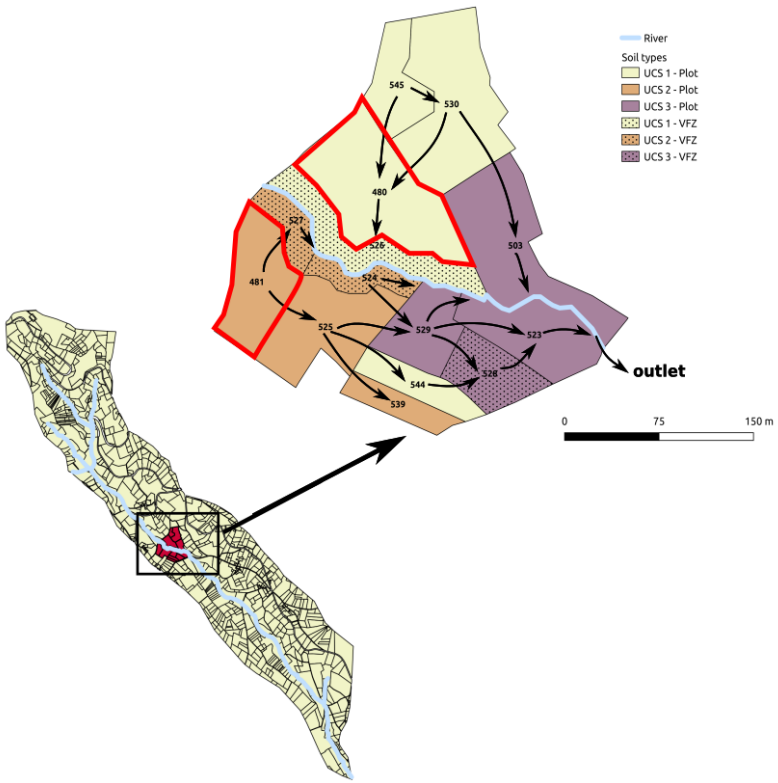
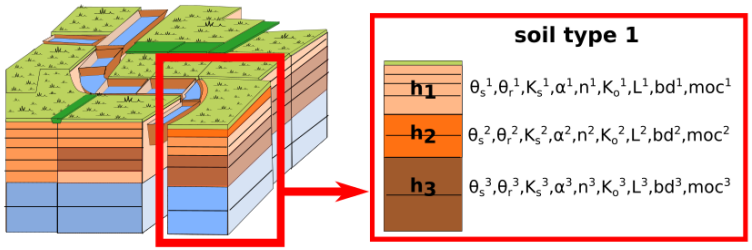


3 soil types : 15 horizons



Soil	Plots/VFZ	River	Vegetation	Pesticide
thetas	hpond	hpond	manning	Kf_{OC}
thetar	adsorpthick	di	Zr	DT50
K_S		Ks	F10	
alpha		manning	LAImax	
n				
Ko				
L				
bd				
moc				

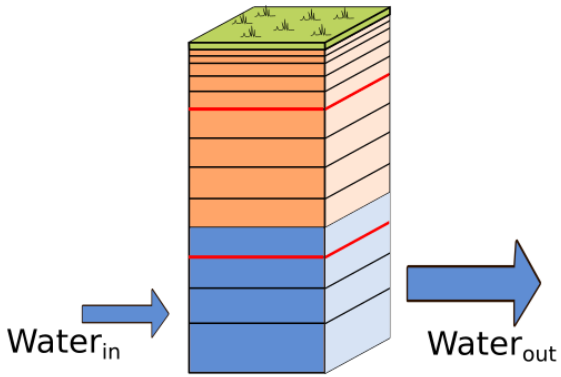
⇒ **145 parameters to be sampled**

but simulations computationally costly : limited to Latin Hypercube Sample of 4,000 points

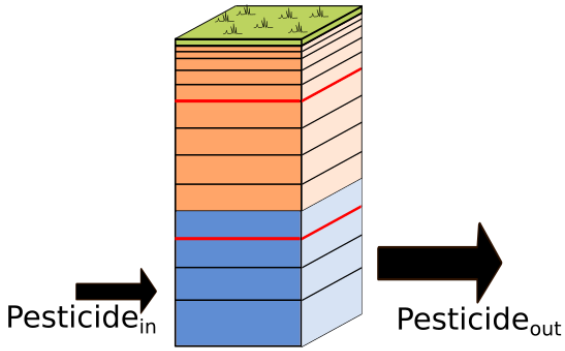
Material and methods

Target output

✓ Cumulated water lateral flow (saturated flow only)



✓ Cumulated pesticide lateral flow (advection/saturated flow only)



Material and methods

GSA methods

✓ **Variance-based Sobol method** (Sobol 1993)

Decomposition of the output variance in conditional variances.

⚠Sobol method requires a very large sample that cannot be computed

⇒ Use of **Polynomial Chaos Expansion** (PCE) : surrogate method that provides Sobol indices

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✓ **HSIC dependence measure** (Da Veiga 2015)

Describes similarity between P_Y and $P_{Y|X}$ using a dependence measure d:

$$S_i^d = \mathbb{E}_{X_i}(d(P_Y, P_{Y|X_i}))$$

⇒ dependence measure d : Hilbert-Schmidt independence criterion **(HSIC)** : generalizes notion of **covariance** between two random variables

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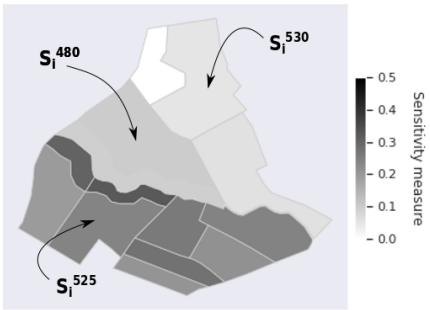
Strategy :

1. Screening using HSIC dependence measure
2. Ranking using Sobol method
3. Comparison with ranking from HSIC dependence measure

Spatial aspects

Block vs site indices (Saint-Geours 2012)

2 distinct ways to scrutinized spatialized output variables sensitivity :



1. Site sensitivity indices: as many analysis as spatial locations

2. Block sensitivity indices: Single analysis with respect to the whole spatial domain, aggregated indices

Results

Screening

Reminder : 145 parameters initially sampled

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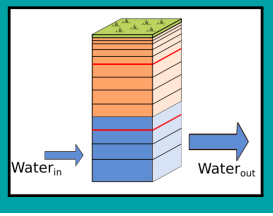
After screening (statistical hypothesis tests based on HSIC measure (De Lozzo and Marrel 2014)):

- ✓ Cumulated Water Lateral Flow : **84 remaining parameters**
- ✓ Cumulated Pesticide Lateral Flow : **80 remaining parameters**

Results

Sobol - Water lateral flow



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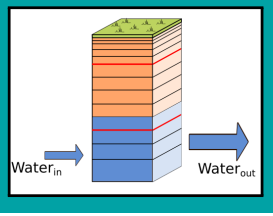
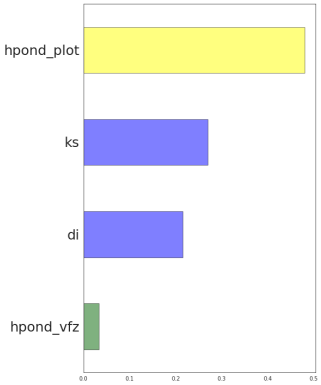
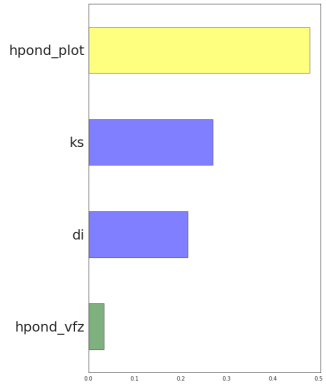


1.Block sensitivity

1st order Sobol' indices



Total order Sobol' indices



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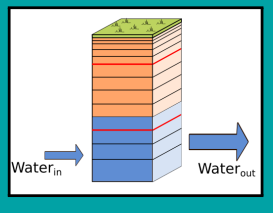

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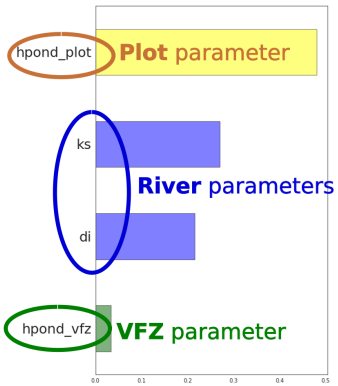

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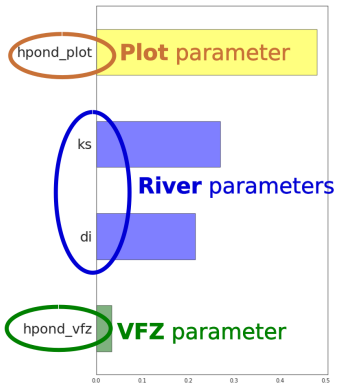

High influence of **river parameters** and **ponding height** on plots and VFZs but...no interactions captured by PCE ?!?

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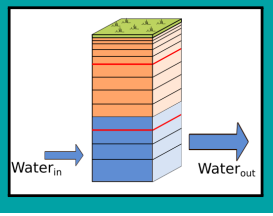

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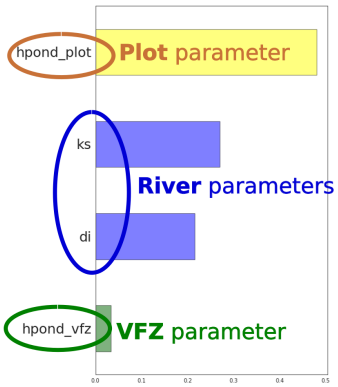

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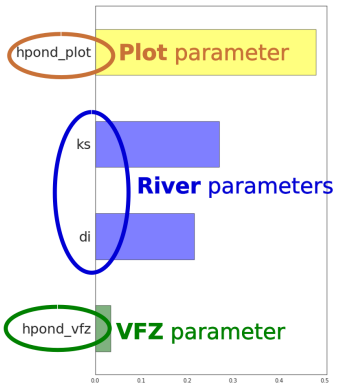

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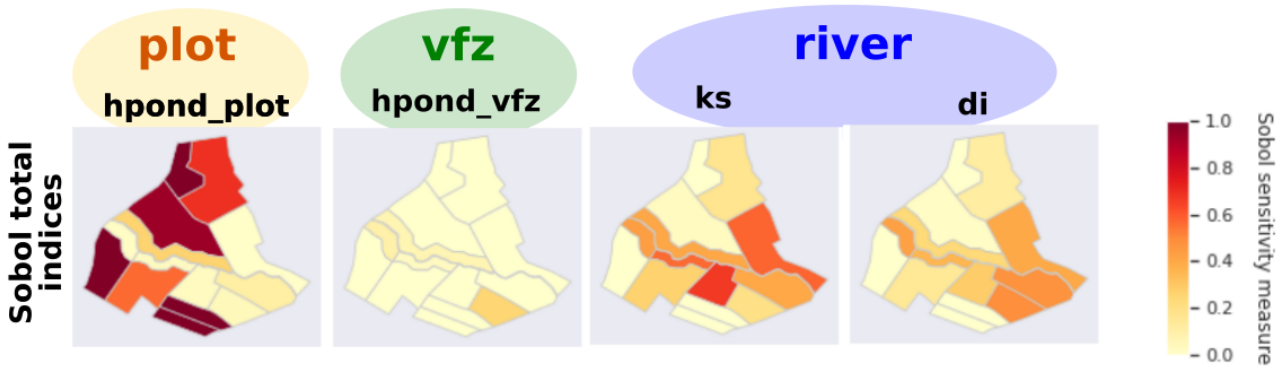
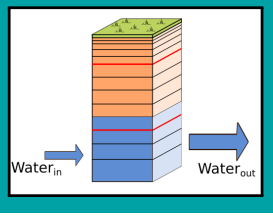


$\Longrightarrow$ Spatial heterogeneities in influential parameters

Results

HSIC - Water lateral flow



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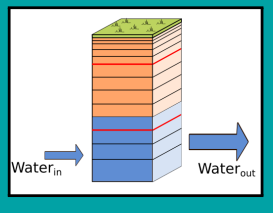

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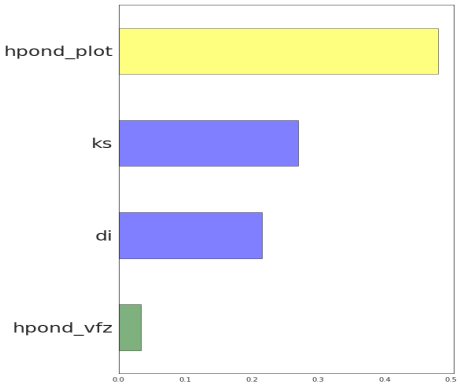
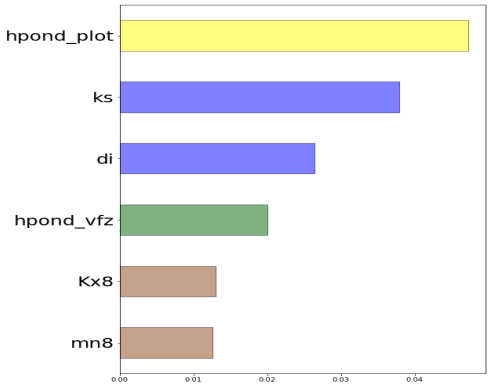


Ranking from HSIC



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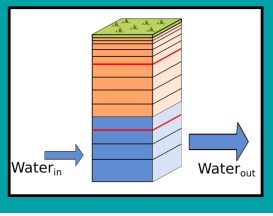

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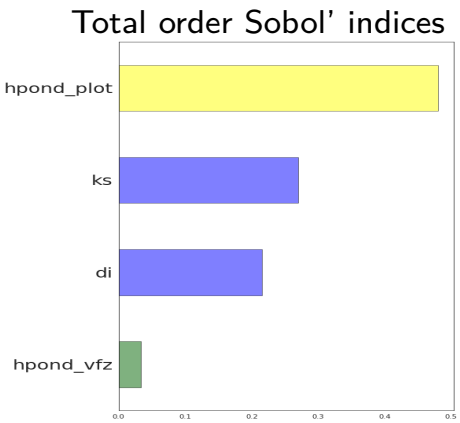

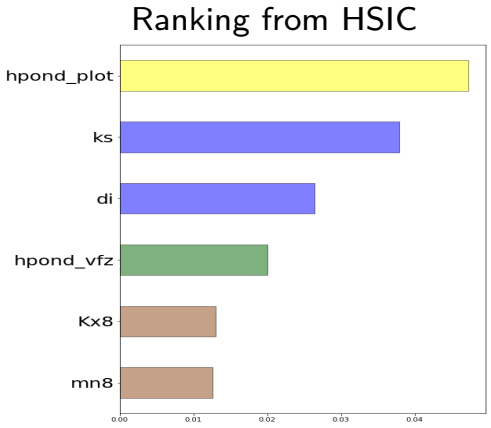

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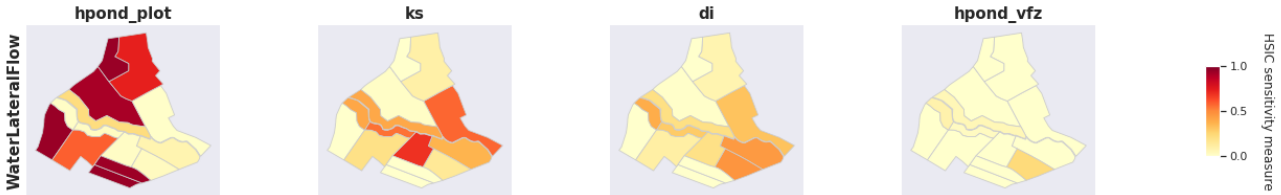
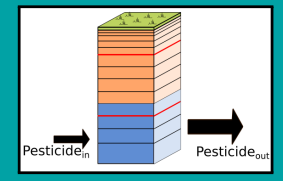


$\Longrightarrow$ Good match between HSIC and Sobol ranking

Results

HSIC - Pesticide lateral flow



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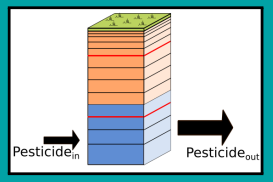

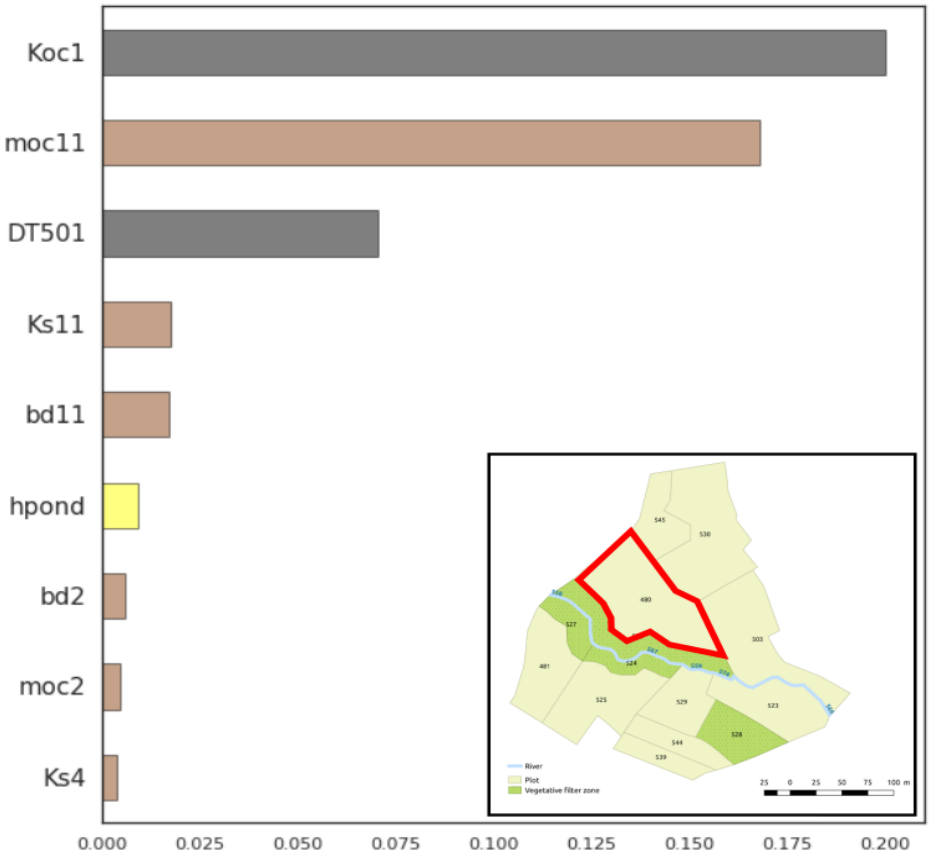

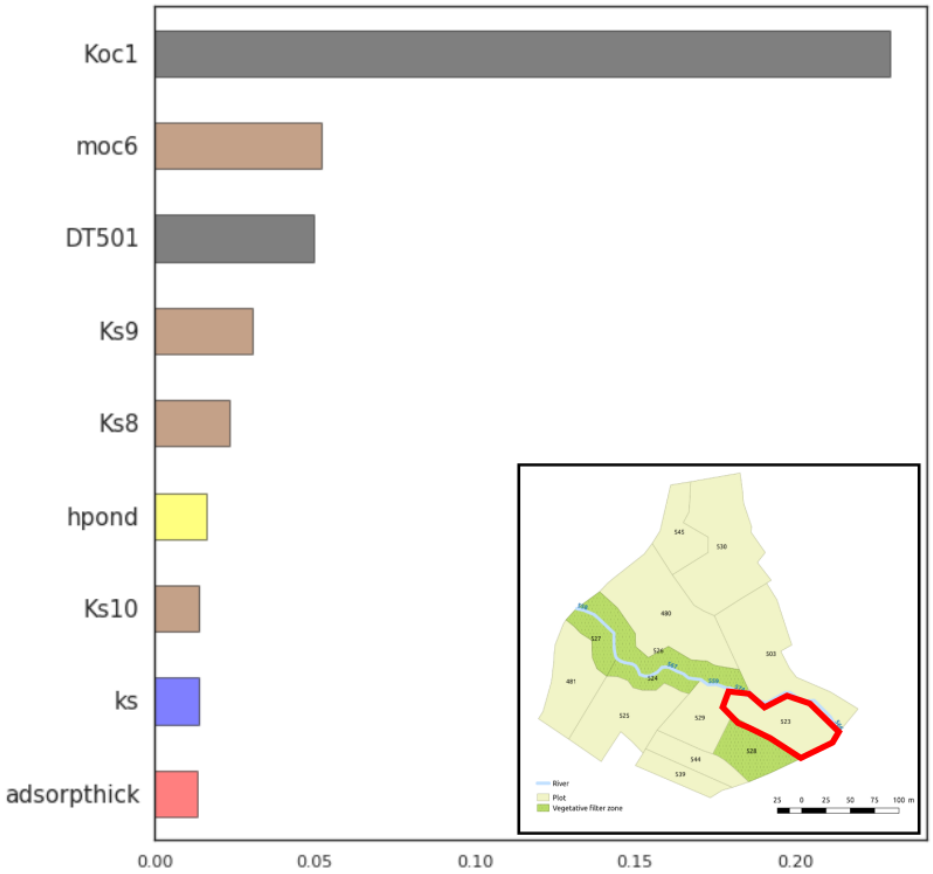

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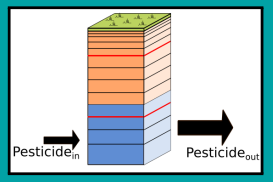

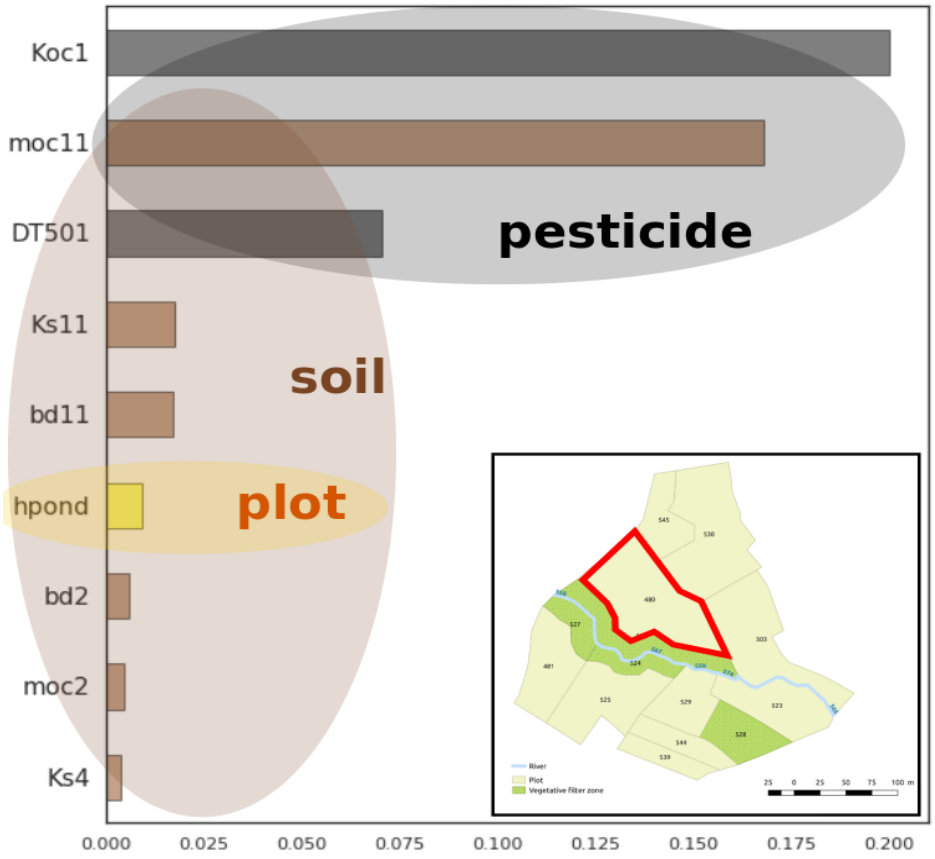

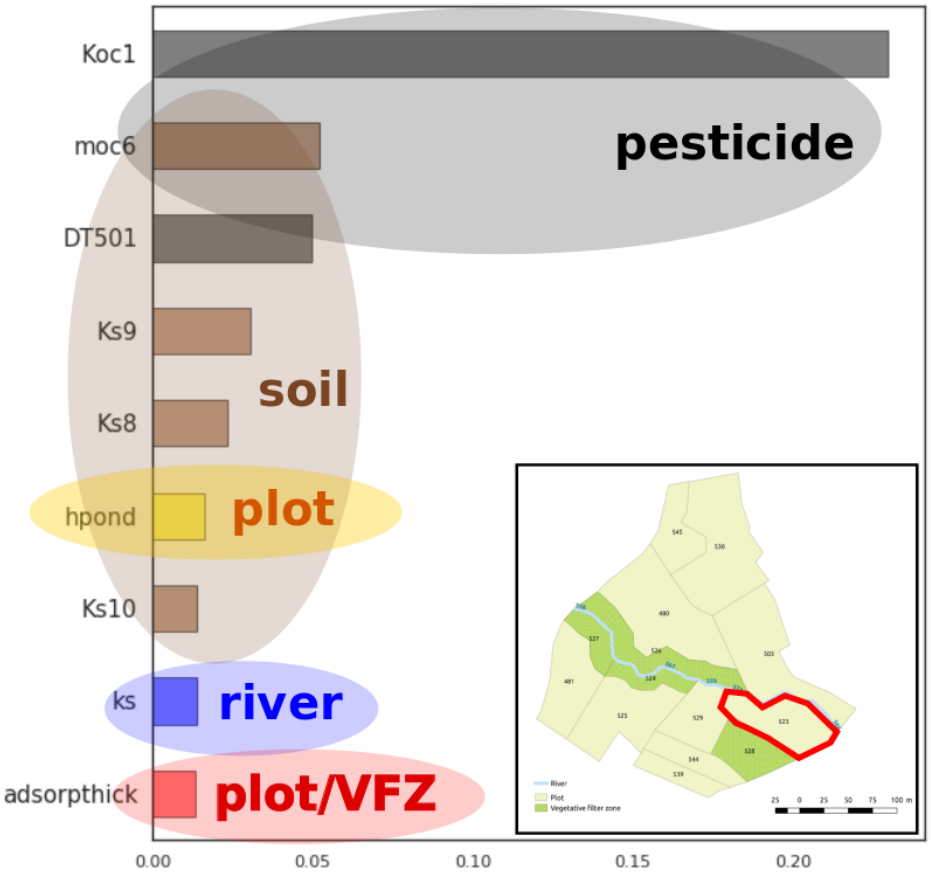

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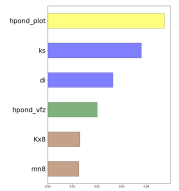
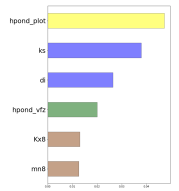
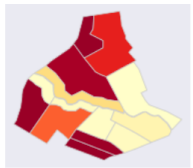
- ✓ Sobol' indices hard to estimate on PESHMELBA model
- ✓ HSIC measure as a consistent alternative for sensitivity measure



Conclusion

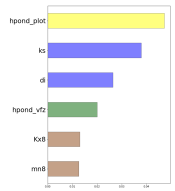
- ✓ GSA on a complex spatialized model with different methods
- ✓ Sobol' indices hard to estimate on PESHMELBA model
- ✓ HSIC measure as a consistent alternative for sensitivity measure
- ✓ A few parameters are identified as influential but spatially heterogeneous

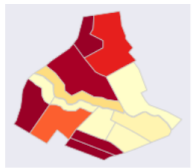


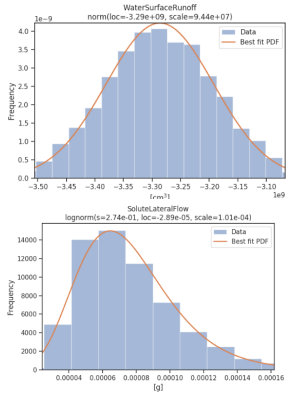


Conclusion

- ✓ GSA on a complex spatialized model with different methods
- ✓ Sobol' indices hard to estimate on PESHMELBA model
- ✓ HSIC measure as a consistent alternative for sensitivity measure
- ✓ A few parameters are identified as influential but spatially heterogeneous
- ✓ LHS also informs about output variables distribution : mainly gaussian or lognormal
  ⇒ Valuable information for next step : uncertainty reduction using **data assimilation**







Conclusion

Thanks for your attention !

Questions ?

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