Test and application of the surface-subsurface physically based reactive transport model CATHY on a vineyard hillslope

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Evaluation of the surface-subsurface physically based reactive transport model CATHY at several scales

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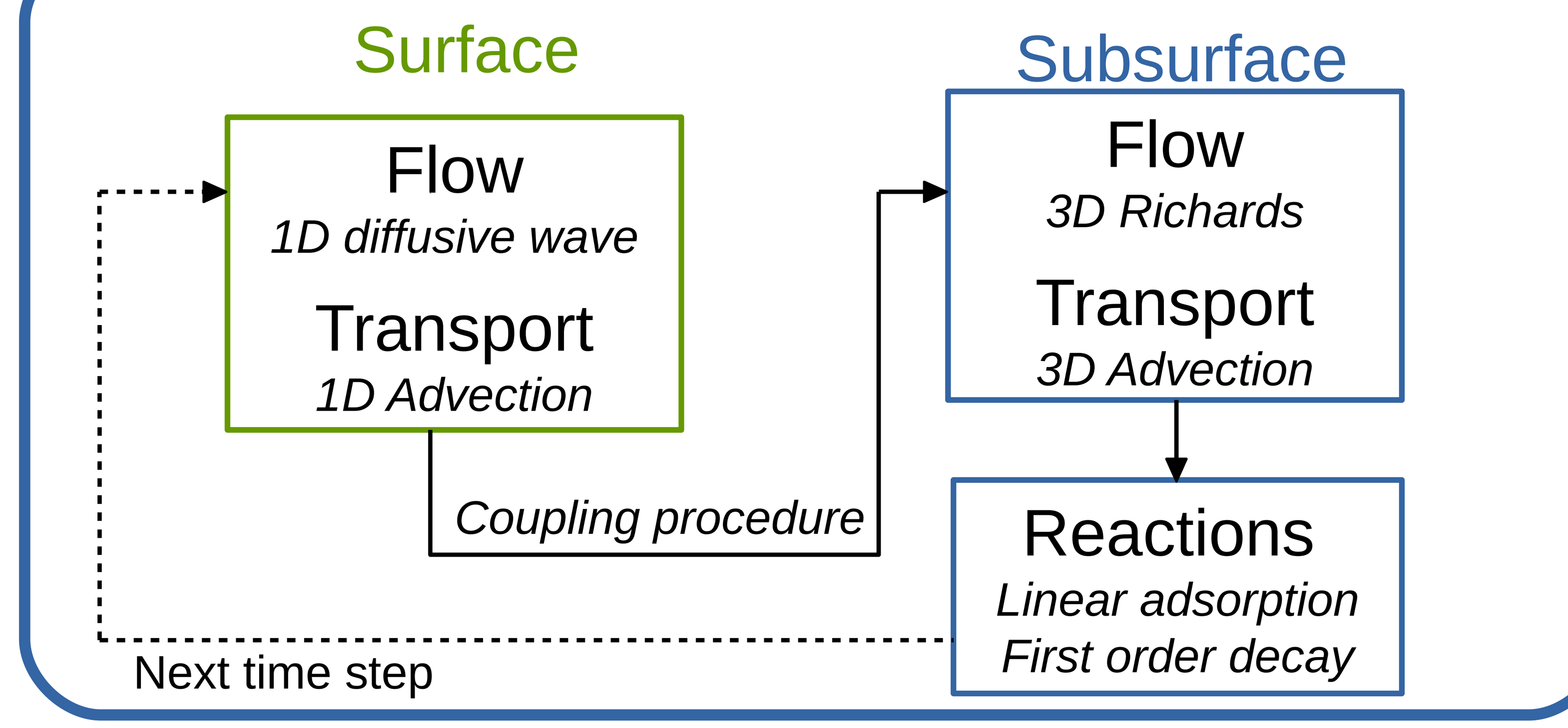
Context

Tools to help to understand and to quantify pesticide transfers in agricultural watersheds are necessary. Physically based and spatially distributed models can be particularly useful in representing precisely processes and interactions between the soil surface and subsurface and thus in evaluating landscape mitigation elements management.

Objectives :

- To better understand reactive solute transfers at the hillslope scale, in particular surface / subsurface interactions
- To deepen the expertise on the CATHY model

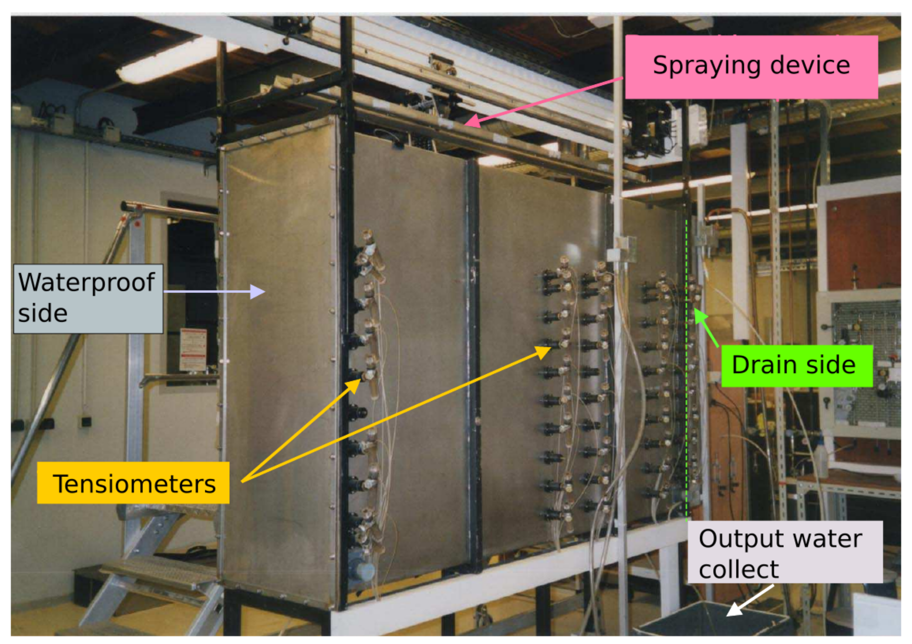
1- Implementation of reaction in the CATHY model

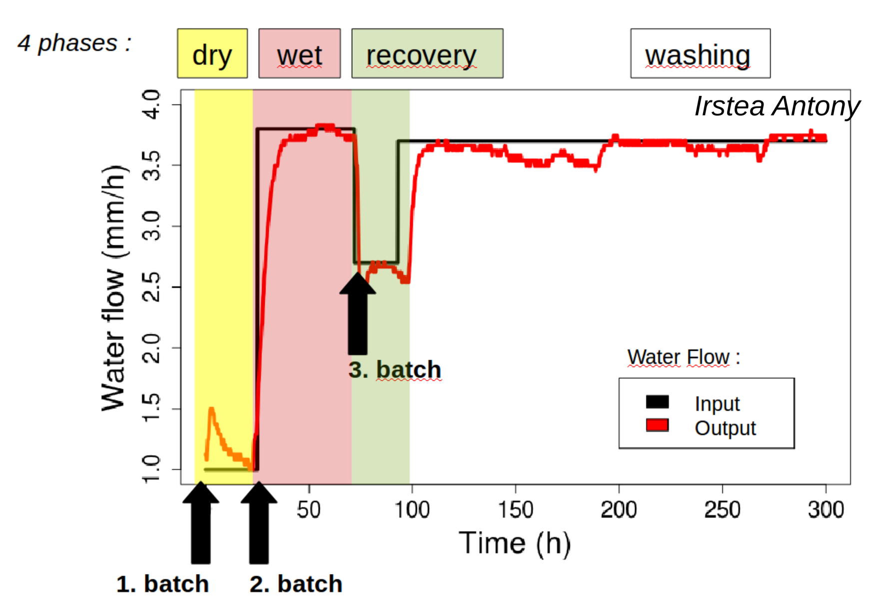


2 – Evaluation of surbsurface part of the new CATHY model on laboratory data

The laboratory MASHYNS tool :

- 1m³ homogeneous soil 50 % loam + 50 % sand
- Drained system
- Measured parameters, Controlled conditions
- No macropores, Low dispersion



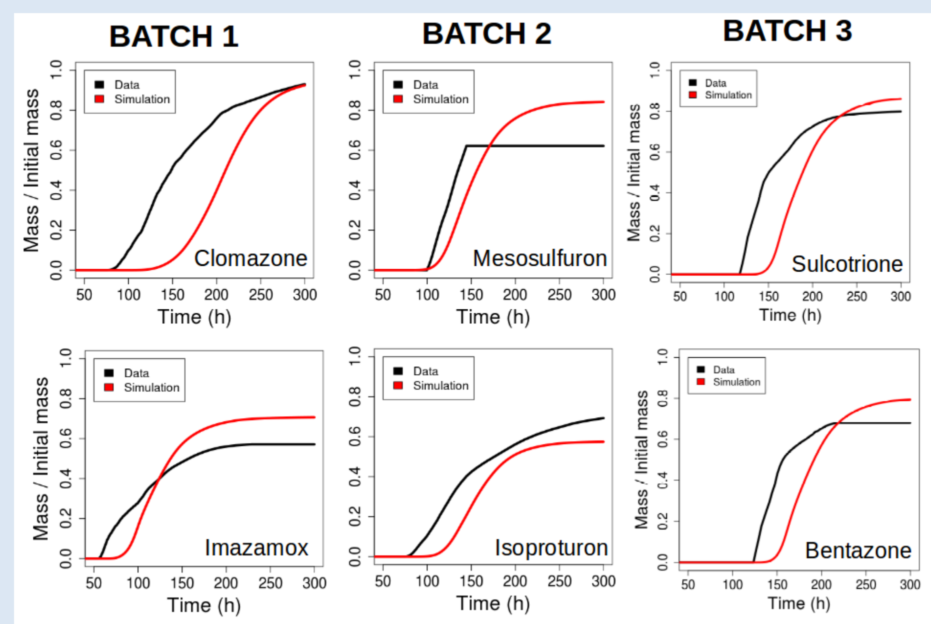


Experimentations on MASHYNS : four rain periods with three 2-hours solute inflow (batch 1, 2 and 3). For each batch, specific solutes and one tracer are used.

		Kd	DT50 (j)
BATCH 1	Clomazone	5.7	89
	Imazamox	0.3	70
BATCH 2	Isoproturon	2.32	12
	Mesosulfuron	1.77	45
BATCH 3	Bentazone	0.72	45
	Sulcotrione	0.68	25

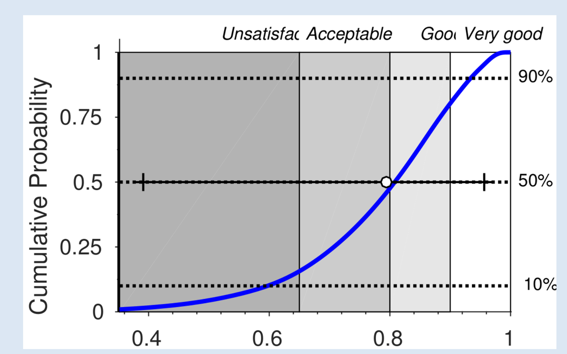
Reaction parameters for the 6 studied solutes

Comparison of observations and CATHY simulations without calibration



Simulation results and observations on cumulative output mass for each batch

Model evaluation, example for sulcotrione :



NSE = 0.795 RMSE= 0.142

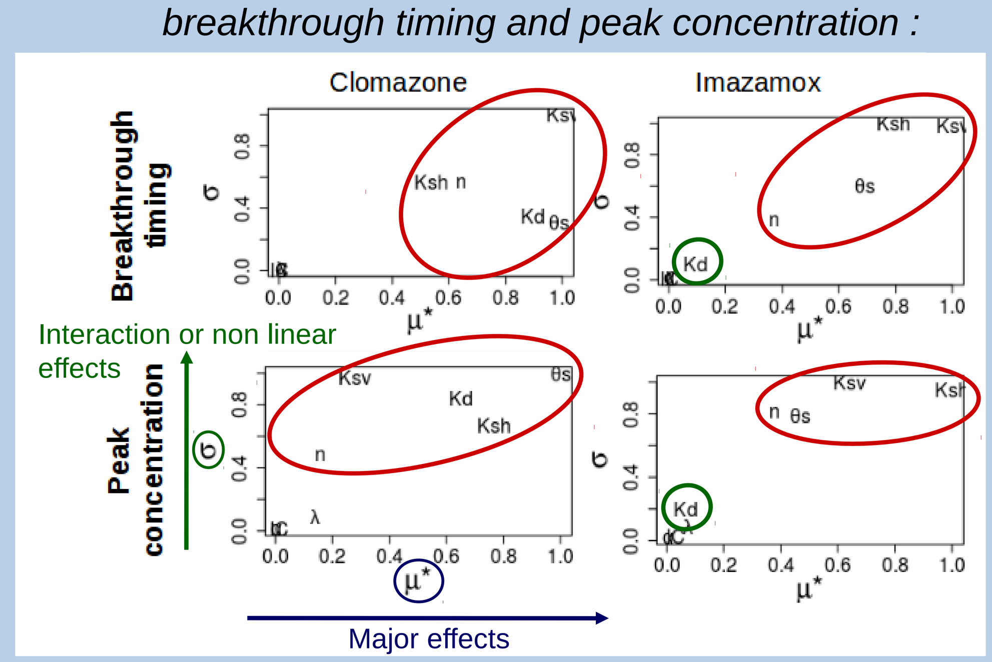
The evaluation was performed with the FITEVAL tool (Ritter 2003) which assesses several criteria and associated uncertainty.

→ Except for clomazone, all evaluations are between acceptable and good
→ Yet for all simulations, breakthrough delay is non negligible

A Morris sensitivity analysis for 4 solutes (batches 1 and 2)

Saturated conductivity	Ksh	m.s⁻¹	LN (9x10⁻⁵ ; 1)
	Ksv	m.s⁻¹	LN (5.62x10⁻⁵ ; 1)
Porosity	θs	-	N (0.47 ; 0.047)
VG parameter	n	-	N (1.8 ; 0.18)
	α	cm⁻¹	N (0.012 ; 0.0012)
Initial rain	IC	m.s⁻¹	U (2.5x10⁻⁷ ; 3x10⁻⁷)
Decay coef	λ	d	N (70 ; 21)
Sorption coef	Kd	-	N (0.3 ; 0.06)

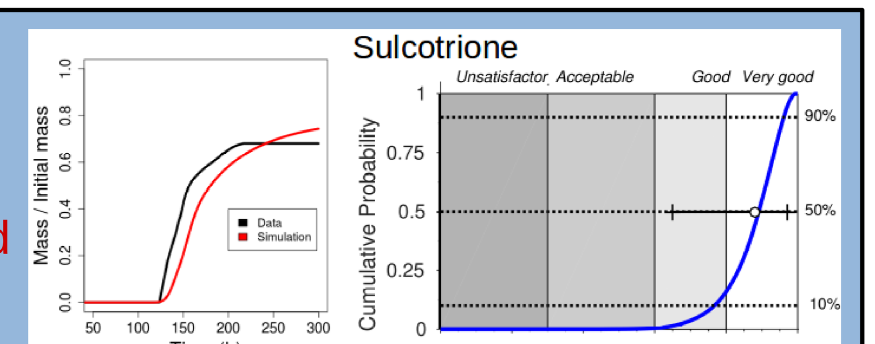
Examples of the sensitivity analysis results for breakthrough timing and peak concentration :



→ Ksh, Ksv, n, θs and Kd are the most influent parameters
→ For Imazamox, Kd has a poor influence compared to the other solutes

Selection of an efficient parameter set and application on two solutes (batch 3)

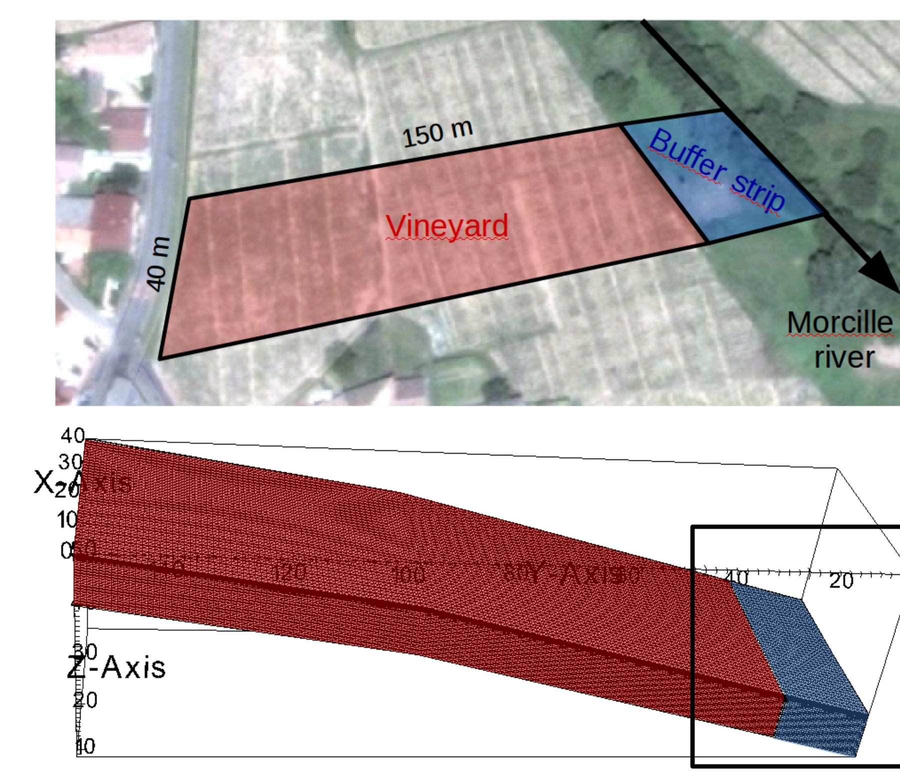
→ Delay and mass balance have been improved and the FITEVAL evaluation leads to « very good »



Exemple with sulcotrione

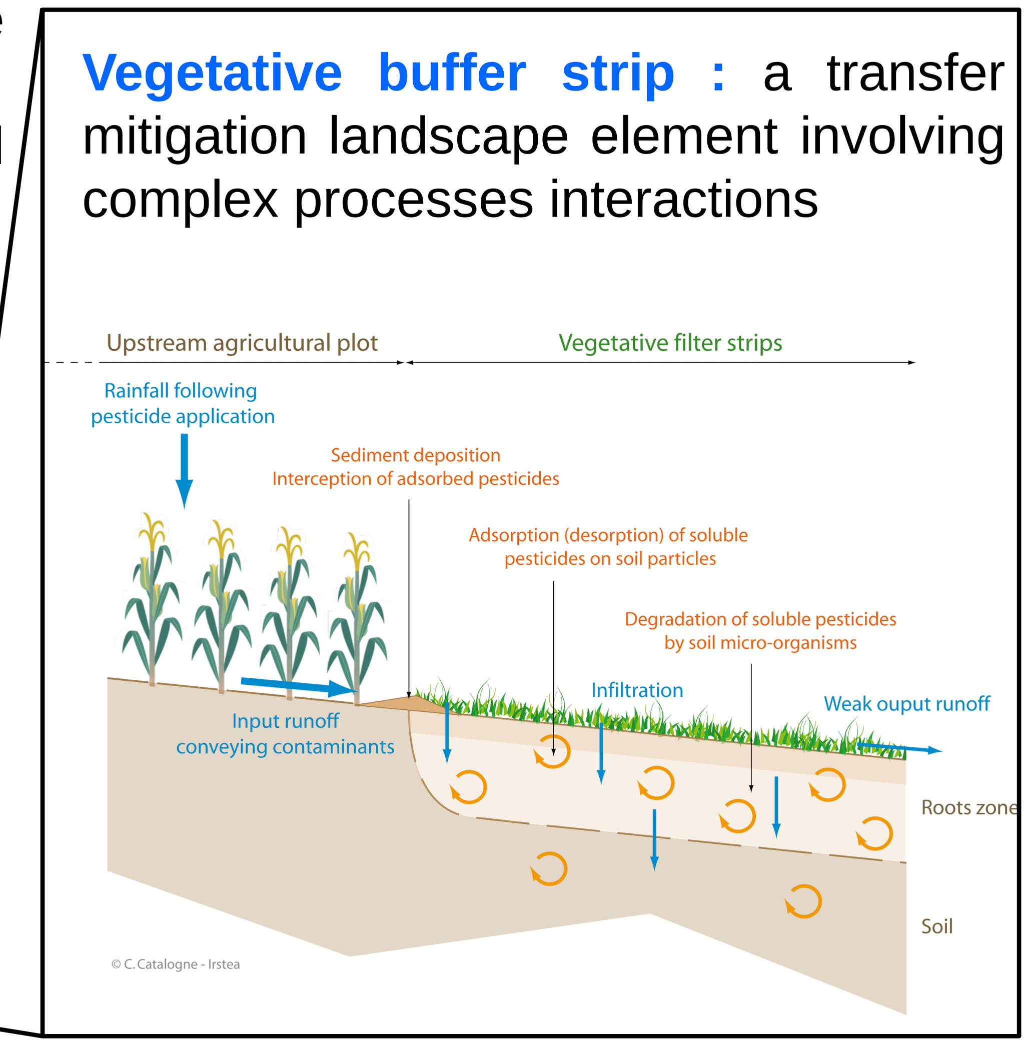
3 – Test of the new CATHY model on a vineyard hillslope

Study site : a 150-m long vineyard hillslope along the Morcille river (Beaujolais, France). The study will use data from a natural rain/runoff event.



Aerial view of the vineyard hillslope and corresponding domain as used in CATHY (1 m x 1 m mesh and 25 layers)

Vegetative buffer strip : a transfer mitigation landscape element involving complex processes interactions



Real field situation : not all parameters are well-known. + Solute exchange between surface and subsurface is complex. + The runoff repartition is complex ("rases" : small ditches which artificially gather surface runoff). + The upscaling (compared to MASHYNS) will increase computing costs. = **Challenging simulation !**

Conclusion & perspectives

On the CATHY model with reactive transfers :

The performed tests and the sensitivity analysis based on MASHYNS data validated the subsurface part of CATHY reactive transfers version : ability to reproduce observations, robustness regarding to parameters variation.

On the hillslope modeling :

The field is ideal to study complex processes and thus represents a major challenge for CATHY with reactive transfers. Additionally, some existing processes are not explicitly represented (macroporosity, diffusion and dispersion) and we will verify CATHY's ability to globally report major processes at the hillslope scale. The aim is not to reproduce exact observations, but more to analyse model's results on chosen synthetic cases.