Application of a reactive transport processes module for a coupled (groundwater/surface water) physically based model on a vineyard hillslope (Beaujolais, France).

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Context

The European Water Framework Directive → to achieve a good ecological and chemical status for all natural aquatic environments.

Physically based and spatially distributed models are useful to :

- 3D surbsurface processes (lateral transfers)
- spatial surface runoff → representation of specific surface runoff patterns (for exemple concentratred fluxes)
- interactions between the soil surface and subsurface

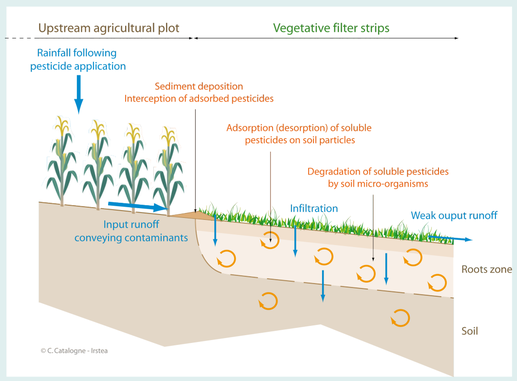
Objectives :

- Better understanding of solute transfers at the hillslope scale, in particular the surface / subsurface interactions
- Deeper expertise on the CATHY model

2- Study site : A hillslope with complex surface / subsurface interactions

Study site (Beaujolais, France) **:**

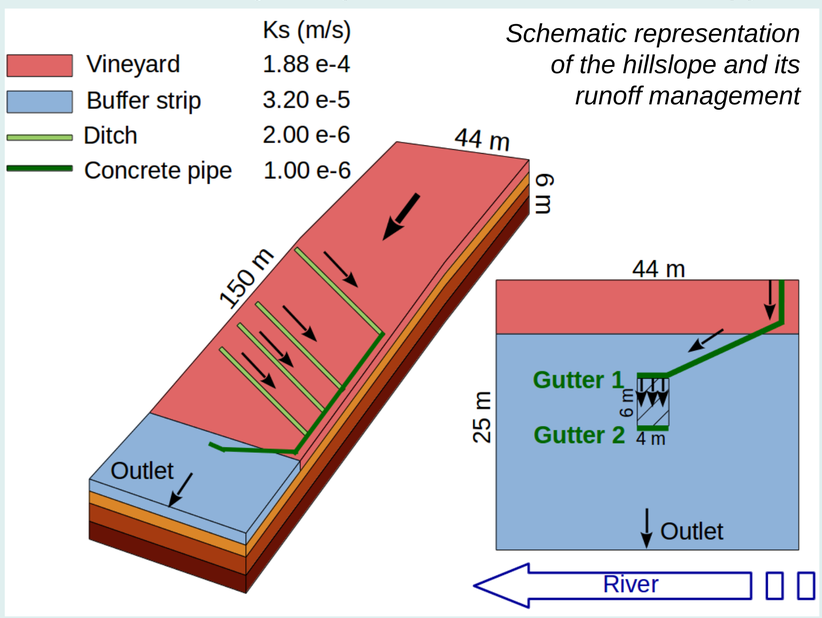
- 150-m long hillslope bordering a river
- connected ditches redirecting the surface runoff and creating a concentrated runoff situation



Simulation :

- natural rain event of 60 minutes (total of 29 mm)
- hydrodynamic parameters and initial watertable level are based on data
- Initial condition : pesticide (diuron) in the first ten centimeters of the vineyard (and not in the buffer strip).

Schematic representation of the hillslope and its runoff management



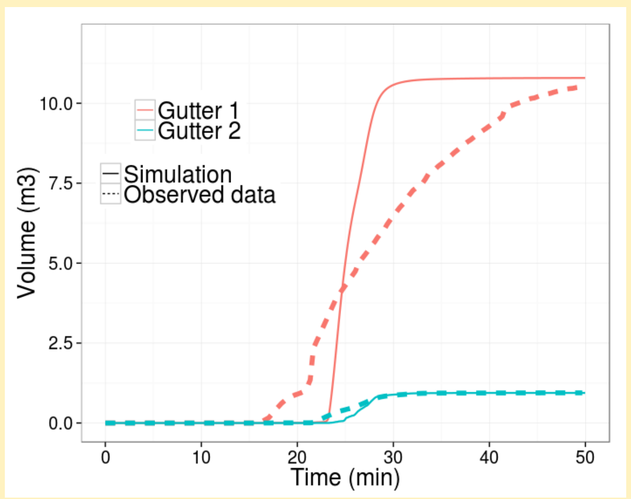
Challenges :

- some parameters are not well-known
- complex runoff repartitioning (connected ditches)
- strong surface / subsurface interactions

3- Consistency of results with field data

Calibration of the vineyard Ks on fied data

Cumulative flow in gutter 1 and 2 during the event.

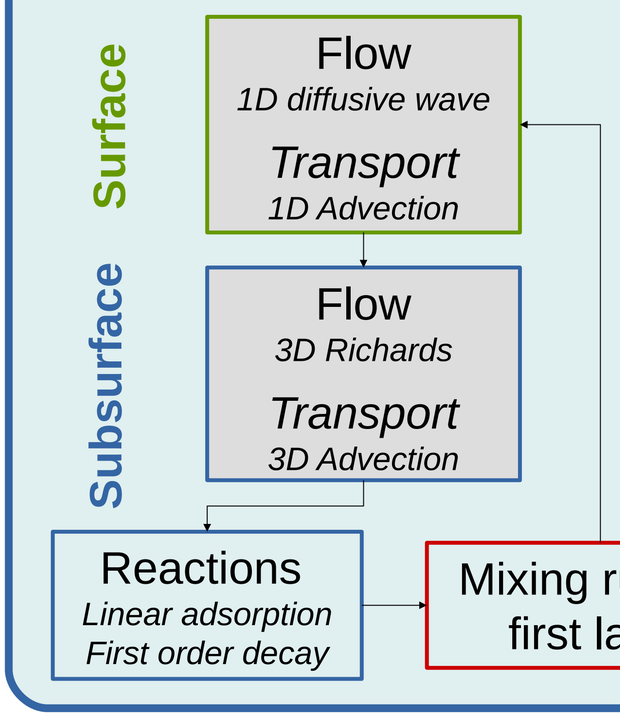


→ Simulated and observed total volumes passing through the gutters are close.

→ Flow dynamic is not well reproduced, probably because the heterogeneity over the vineyard is not represented (microtopography, surface roughness, etc.)

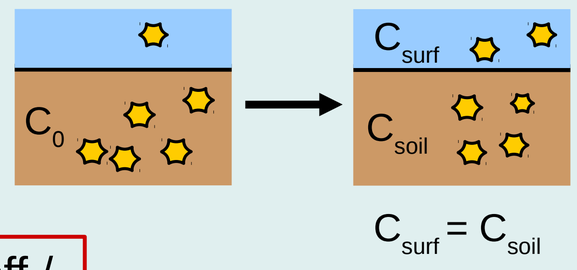
1- Implementation of mixing in the CATHY model

CATHY is a validated 3D flow and transport model (Camporese et al. 2010, Weill et al. 2011). Reactive processes have been recently implemented.



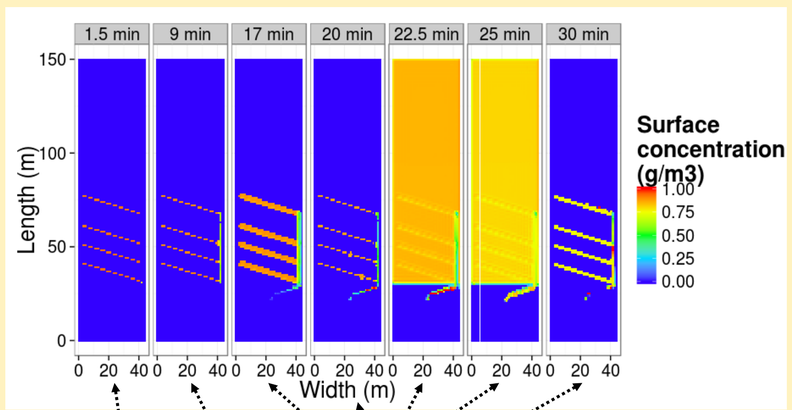
Mixing first layer / runoff

The mixing procedure evens out concentrations in the first subsurface layer and in the runoff on the surface..



$C_{surf} = C_{soil}$

4- Some surface and subsurface results

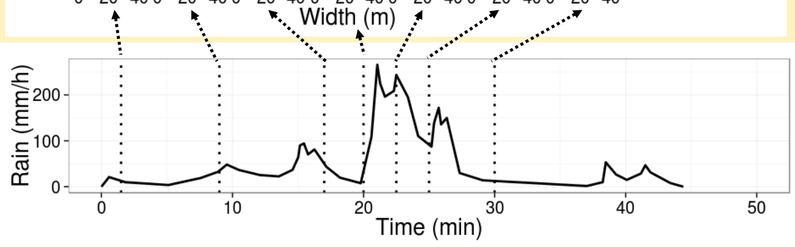


Runoff dynamic over the hillslope

Aerial view of the diuron concentration in the surface runoff.

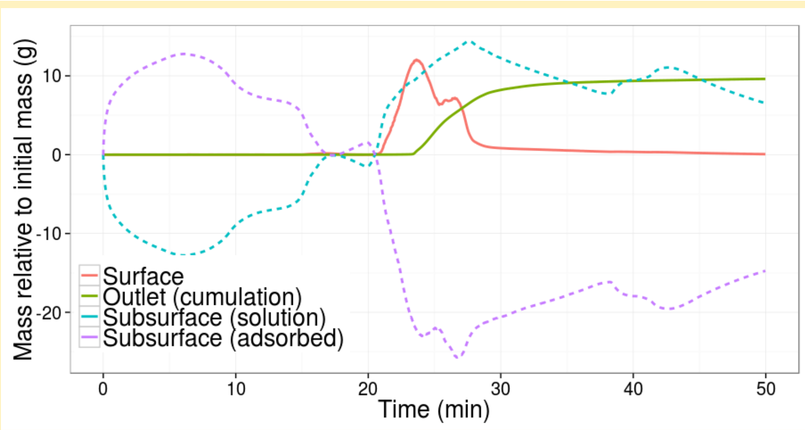
→ Runoff pathway through the ditches and the concrete pipe is well represented.

→ When the rain intensity exceeds the vineyard Ks, the whole vineyard surface generates runoff.



The adsorbed and dissolved pesticide behaviour

Evolution of adsorbed, dissolved and surface pesticide masses against initial situation.



→ Rain dilutes solute concentration and thus lowers adsorbed part of pesticides.

→ Mass balance is very well respected : the coupling procedure is mass conservative

Overview of the buffer strip efficiency in a situtation of concentrated runoff

- Mass exiting the system : 10 g (0,36 % of the total mass) in 5 minutes
- Mass stored in the buffer strip : 1 g

→ Buffer strip is not efficient in this particular situation

Conclusion & perspectives

Keep in mind : some processes are not represented (macroporosity, diffusion and dispersion, sediment transport)

- Simulations are **consistant with observed data** at the hillslope scale
- The CATHY model allows a better understanding of pesticide fate in **3D** at the hillslope scale, in particular in **complex surface / subsurface interaction** cases
- The model parametrisation is complex, and a **sensitivity analysis** is necessary to **prioritize influential parameters**.

References :

Camporese, M., Paniconi, C., Putti, M., and Orlandini, S.: Surface-subsurface flow modeling with path-based runoff routing, boundary condition-based coupling, and assimilation of multisource observation data, Water Resour. Res., 46, W02512, 2010.

Weill, S., Mazzia, A., Putti, M., and Paniconi, C.: Coupling water flow and solute transport into a physically-based surface-subsurface hydrological model, Adv. Water Resour., 34, 128–136, 2011.