Understanding water circulation and pesticide fate at the catchment scale by modeling the influence of landscape

Rouzies Emilie[1], Barachet C.[1], Lauvernet C.[1], Carluer N.[1]

[1]IRSTEA : National Research Institute of Science and Technology for Environment and Agriculture, UR MALY, centre de Lyon-Villeurbanne, 5 rue de la Doua, CS 20244, 69625 Villeurbanne Cedex, France

Contact : emilie.rouzies@irstea.fr

irstea www.irstea.fr

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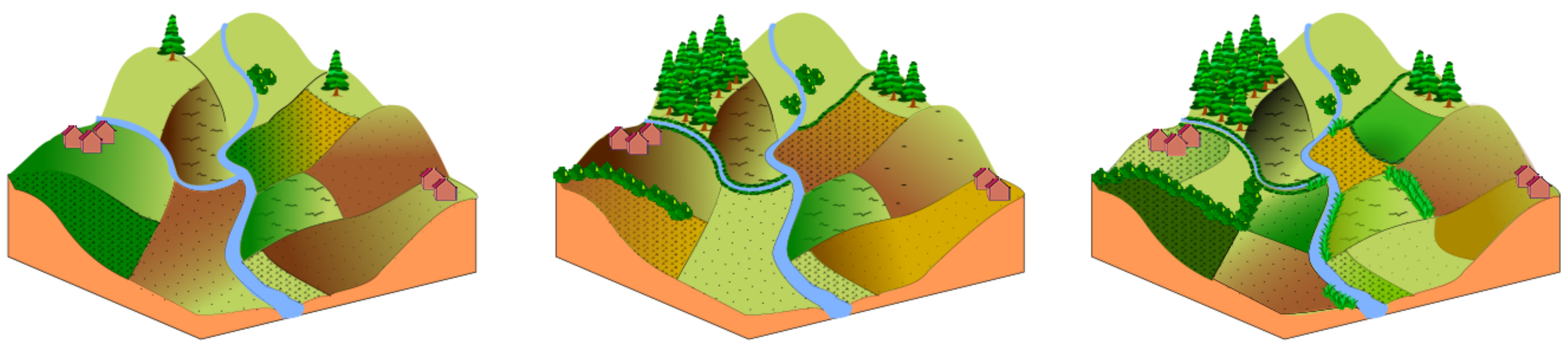
Pesticide transfers are highly influenced by the presence of discontinuities (grass strips, ditches, hedgerows,...) that can accelerate or slow down and dissipate water and contaminant fluxes. It is therefore important to take into account landscape features when modeling water and contaminant transfers at the catchment scale.

1. Objectives

To develop a modeling tool of water and contaminants circulation and fate at the scale of small catchments with :

- An explicit consideration of the presence of discontinuities and of the spatial organisation of the landscape
- A modular structure in order to test different scenarios of agricultural/ landscape management practices



Scenario with large plots, few discontinuities and some built-up areas. | *Scenario with a different land use and more discontinuities (hedges, buffer strips...).* | *Scenario including smaller plots, a different land use and some more discontinuities.*

2. Spatial analysis/catchment discretisation: GeoMelba

Important to design a mesh that suits the landscape configuration.

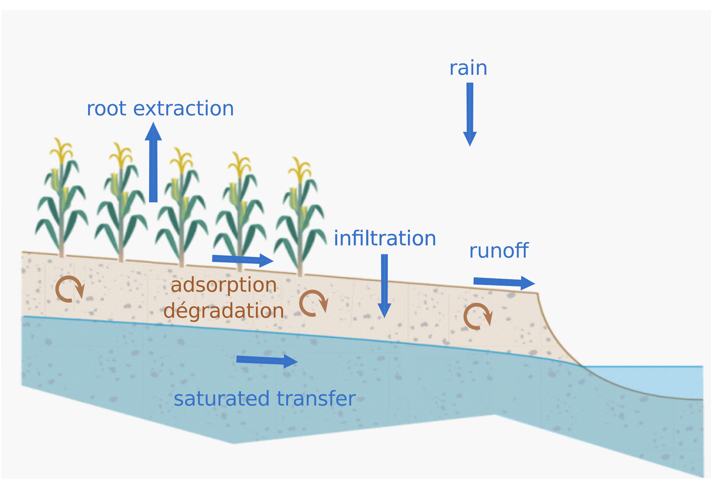
1. **Surface homogeneous units** are deduced from overlaying (soil map, land uses...).
2. Ditches, slopes, hedgerows and other discontinuities are integrated as **linear elements**.

Complete representation of the landscape

Connections between elements are also produced and will determine lateral transfers through interfaces.

3. Representation of processes

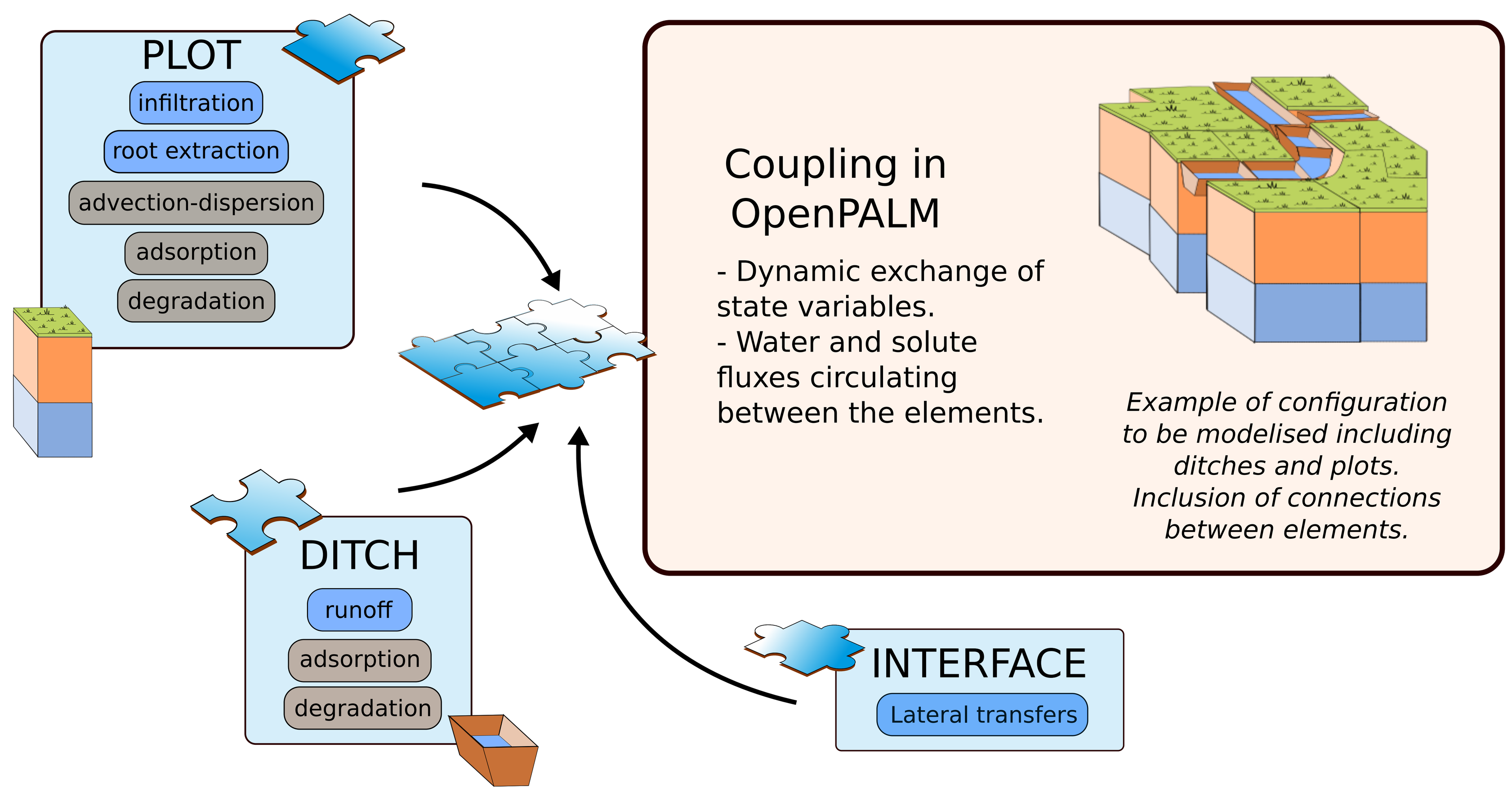
- Modelisation of each process or element by an independant module
- Possibility to combine different levels of complexity in the processes representation :
  - **Vertical infiltration in a plot** : module FRER1D solving Richards' eq. (1D) [1]
  - **Lateral saturated transfer** : development of a new module based on Darcy law
  - **Root Extraction** : existing module based on Li et al, (2001) root water uptake formulation [2][3]
  - **Runoff** : kinematic wave
  - **Advection-dispersion** equation
  - **Adsorption/Desorption** : Freundlich or linear isotherms
  - **Degradation** : first order reaction



4. Modeling tool : OpenPALM, a coupling platform

OpenPALM is an open-source code coupler developped by the CERFACS. [4]

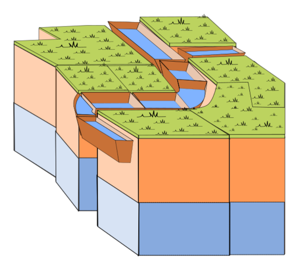
- The different components representing one process or one element are agregated in OpenPALM in order to reach the catchment scale.



Example of configuration to be modelised including ditches and plots. Inclusion of network of connections between elements.

- Global time-step is handled and dynamically adapted by the coupler depending on weather conditions (but refined in rainy periods).
- Within this global time-step, each component can run with its own refined time-step.

5. Results on a simplified catchment (single event)



Scenario composed of 7 plots and a ditch network (3.6 ha)

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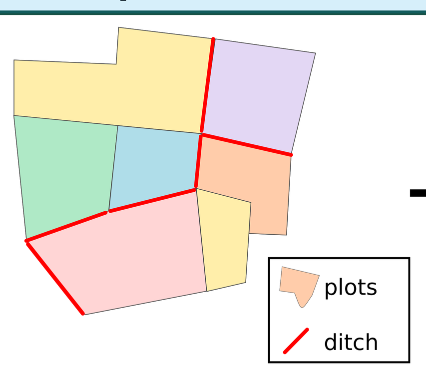

Definition of surface and linear units

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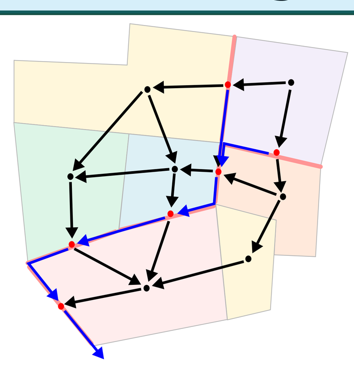

Assessment of connections between elements

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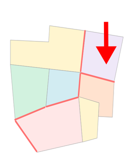
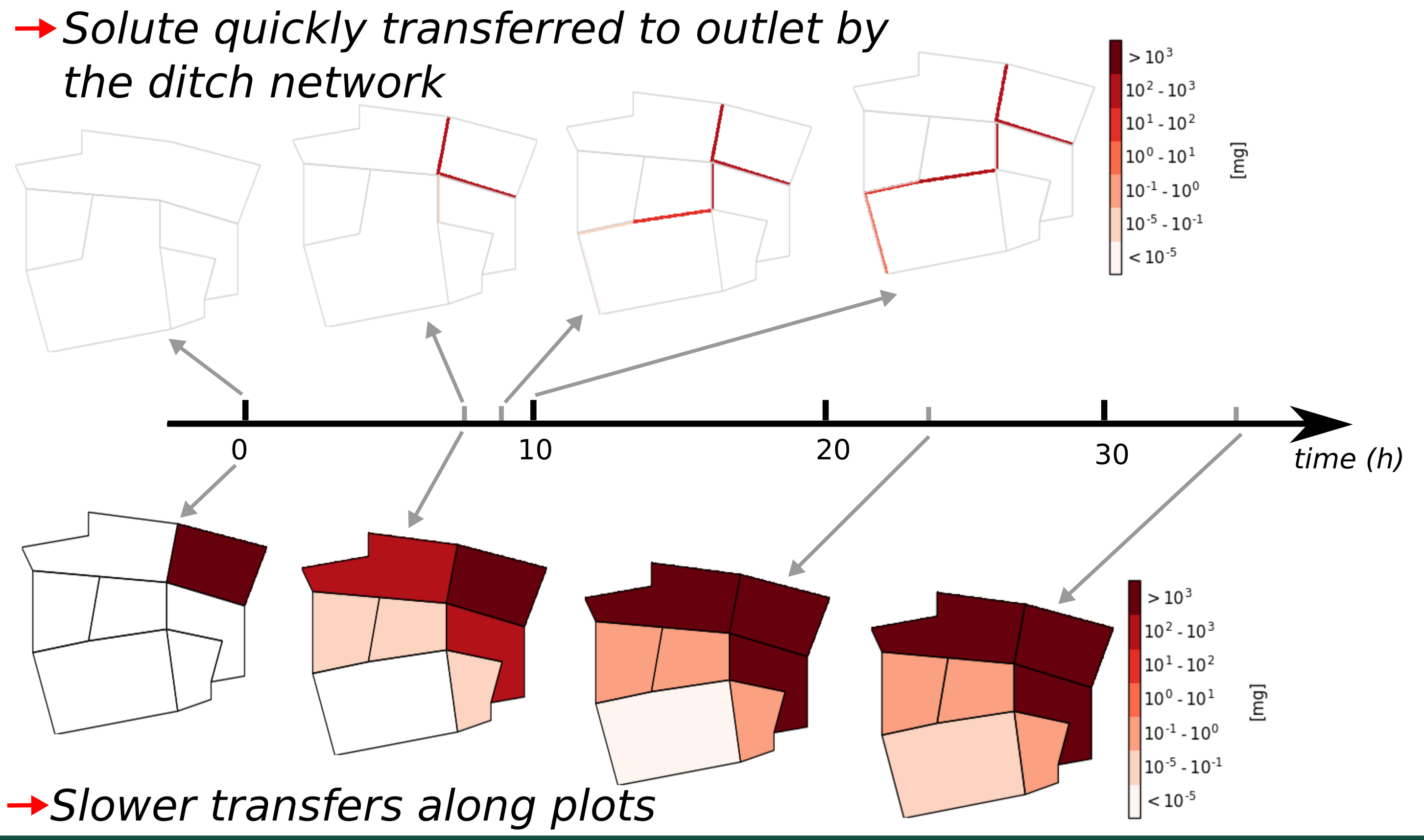
- 6-hour rainfall at the begining of the simulation
- Application of **Isoproturon** on the upslope plot. *(Koc, DT50 from [5])*
- No initial water table in plots
- Plot and ditches geometry



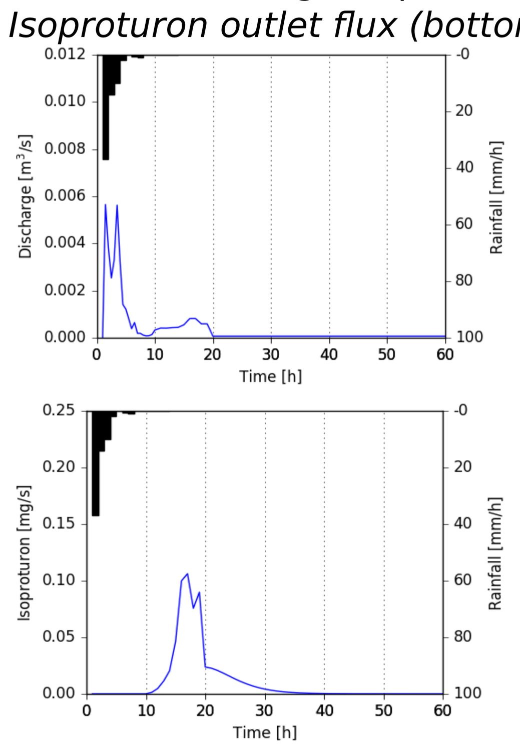
Initial conditions/characteristics *(based on la Fontaine du Theil catchment (France))*

→*Solute quickly transferred to outlet by the ditch network*



→*Slower transfers along plots*

Water discharge (top) and Isoproturon outlet flux (bottom)



6. Perspectives and conclusions

- Promising results on first tested scenario (7 plots + ditch network).
- Advantage of the modular structure : possibilities to improve the representation of processes over time.
- Next steps:
  - Coupling with a surface runoff module (kinematic wave)
  - Other landscape features/buffer zones
  - Inclusion of a representation of preferential flow
- Need for an evaluation framework for the tool
- ➡ Relevant management scenarios to define

References

[1] Ross, P 2003. *Modeling Soil Water and Solute Transport - Fast, Simplified Numerical Solutions.* Agronomy Journal(95):1352-1361.

[2] Li, K, De Jong, R, & Boisvert, J 2001, *An exponential root-water-uptake model with water stress compensation*, Journal of Hydrology, vol. 252, pp. 189-204.

[3] Varado, N, Braud, I, & Ross, P 2006, *Development and assessment of an efficient vadose zone module solving the 1D Richards' equation and including root extraction by plants*, Journal of Hydrology, vol. 323, pp. 258-275.

[4] Fouilloux, A, & Piacentini, A 1999, *The PALM project:MPMD paradigm for an oceanic data assimilation software*, 1685 LNC.

[5] Madrigal - monarrez, I 2004, *Rétention de pesticides dans les sols des dispositifs tampon, enherbés et boisés: rôle des matières organiques.*