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Peshmelba: a spatialized model of water circulation and pesticide fate at the catchment scale coupling the landscape elements

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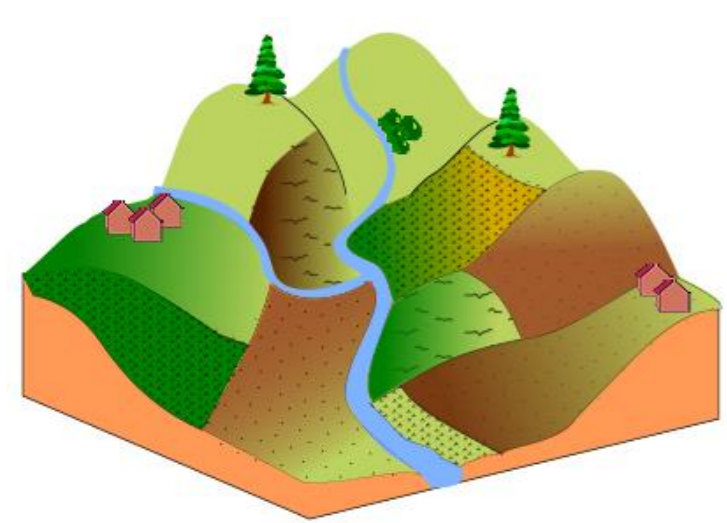
Établissement public du ministère de l'Environnement

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

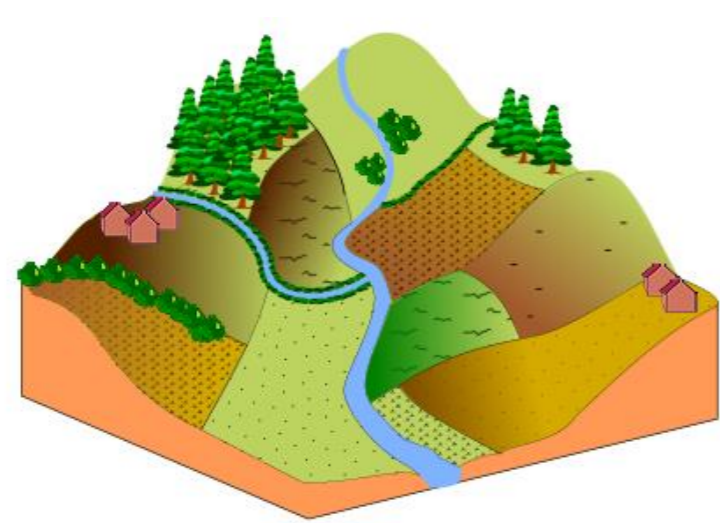
Objectives

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

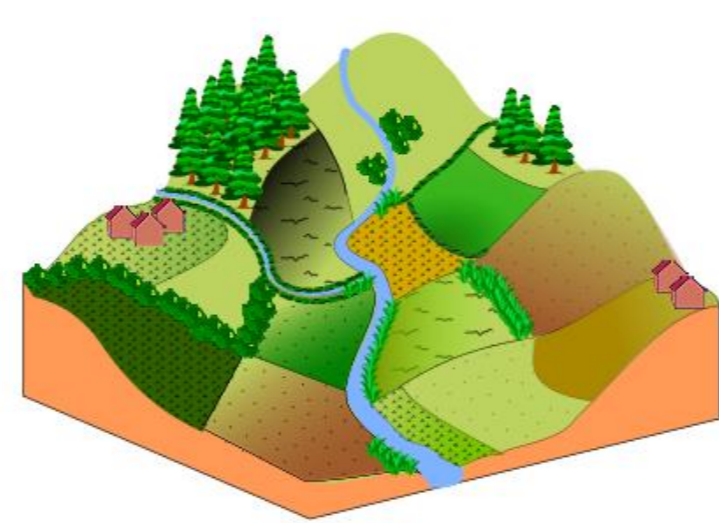
- An explicit consideration of the presence of discontinuities and of the spatial organisation of the landscape
- A modular structure in order to test different scenarios of agricultural/landscape management practices



Scenario with large plots, few discontinuities and some built-up areas.



Scenario with different land uses and more discontinuities (hedges, buffer strips ...).

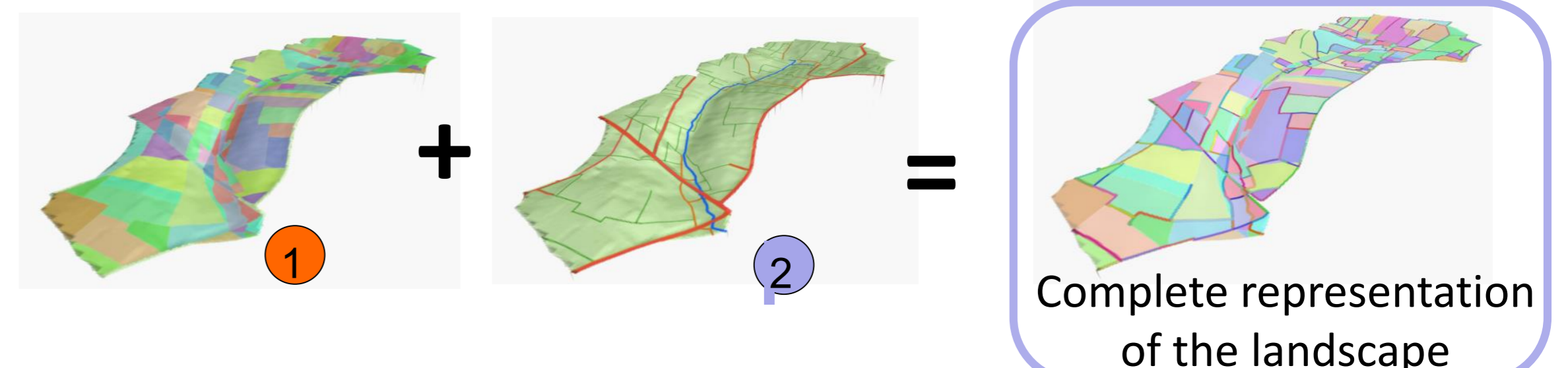


Scenario including smaller plots, different land uses and some more discontinuities.

Spatial analysis and catchment discretisation: GeoMelba

It is 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.

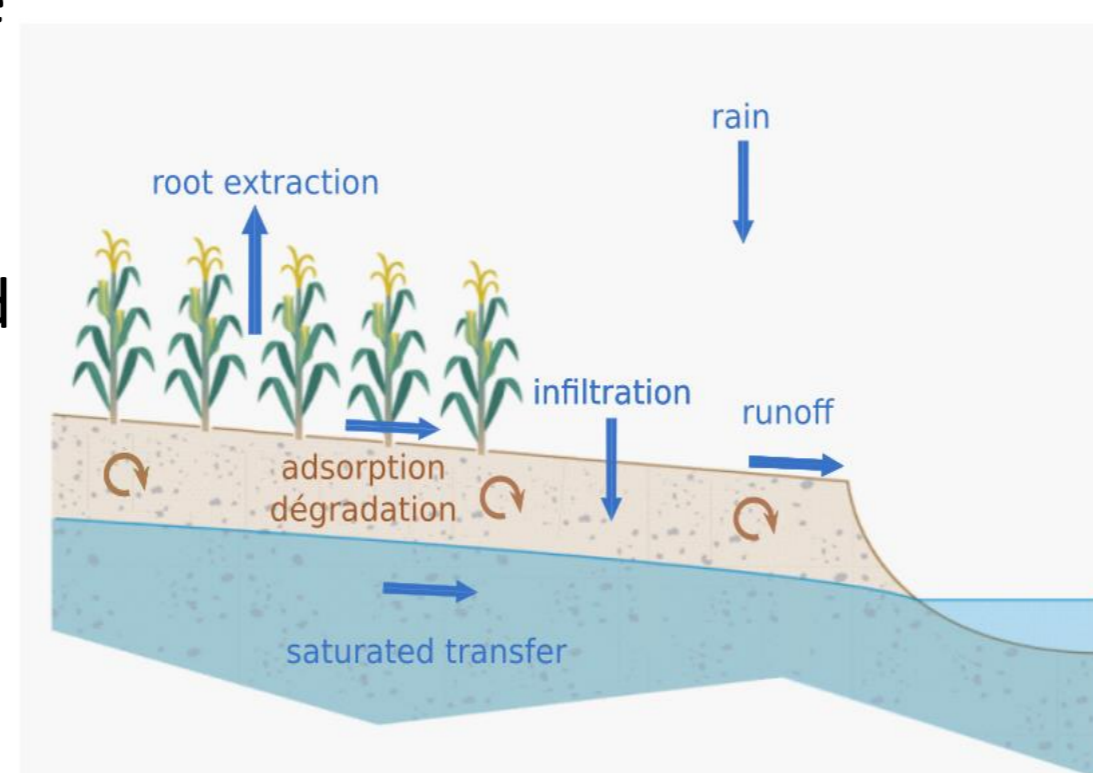


Connections between elements are also produced and will determine lateral transfers through interfaces.

Representation of processes

- Each process or element is represented by an independent module
- Possibility to combine different levels of complexity in processes representation:

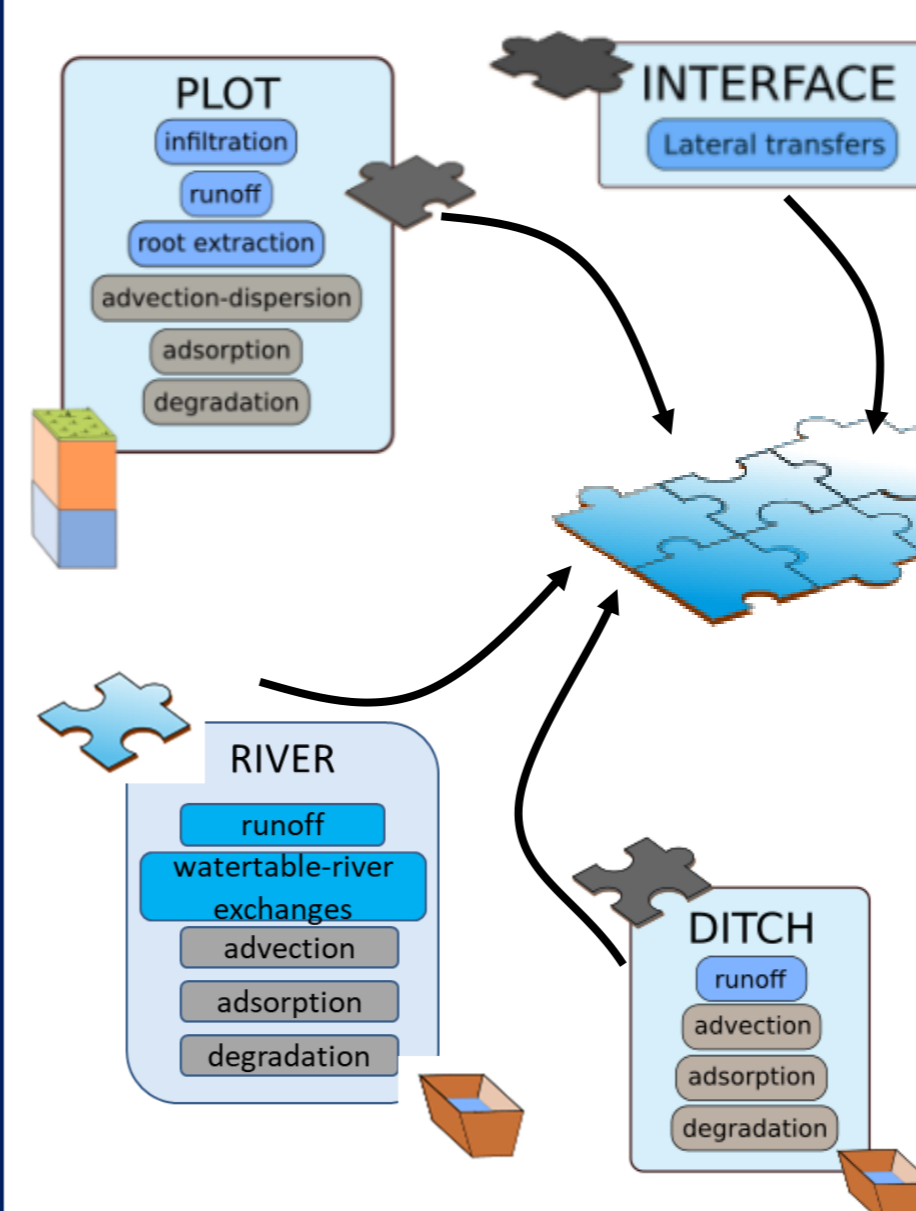
- **Vertical infiltration in a plot:** module FRER1D solving Richards' eq (1D) [1]
- **Lateral saturated transfer:** development of a new module based on Darcy law
- **Root extraction:** existing module based on Li et al. (2001) root water uptake formulation [2][3]
- **Runoff:** Manning velocity
- **Routing** in river and ditch networks
- **Advection-dispersion** equation
- **Adsorption/Desorption:** Freundlich or linear isotherms
- **Degradation:** first order reaction



Modelling tool: OpenPALM, a coupling platform

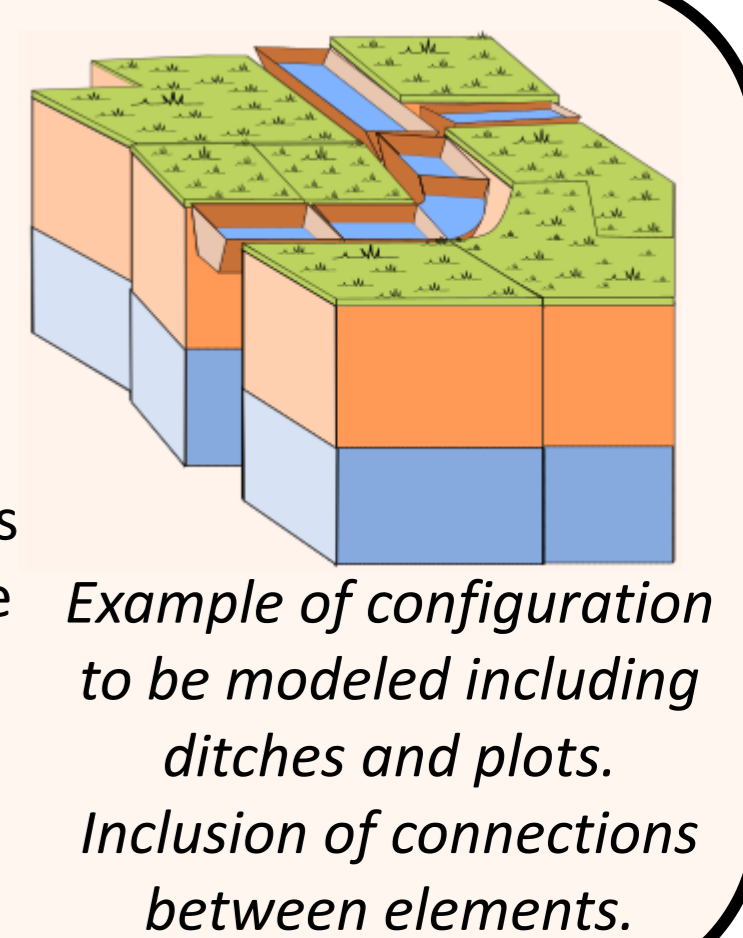
O-Palm OpenPALM is an open-source code coupler developed by the CERFACS. [4]

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



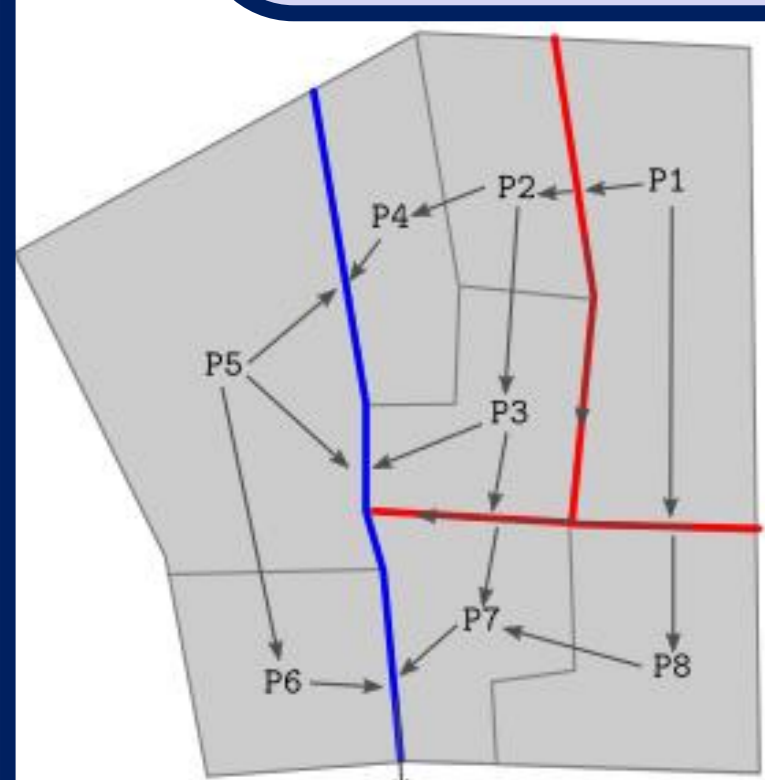
Coupling in OpenPALM

- Dynamic exchange of state variables
- Water and solute flows circulating between the elements



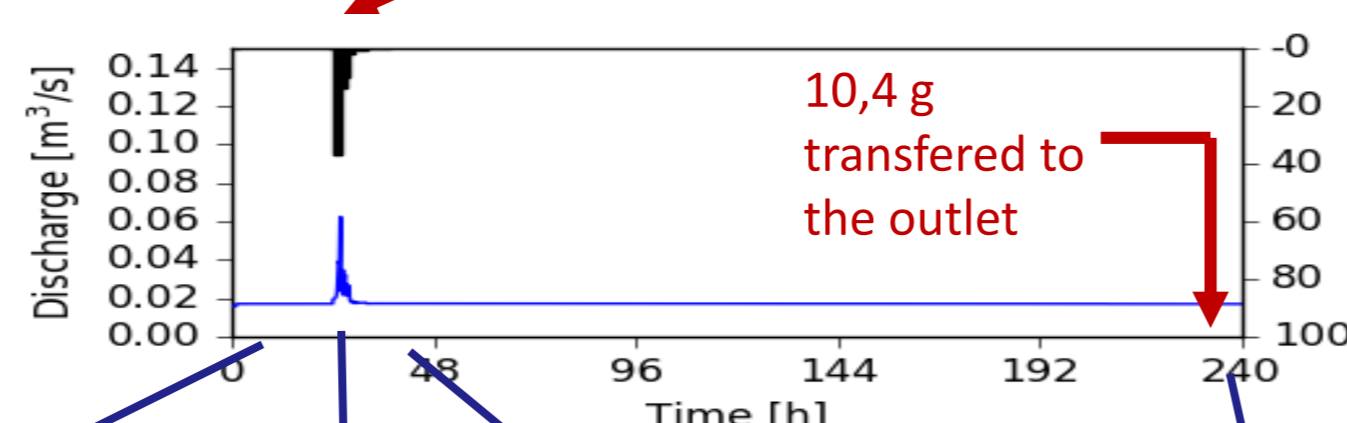
- Global time-step is handled and dynamically adapted by the coupler depending on weather conditions (but refined in rainy periods)
- Within this global time-step, each component can run with its own refined time-step.

Test on a simplified catchment



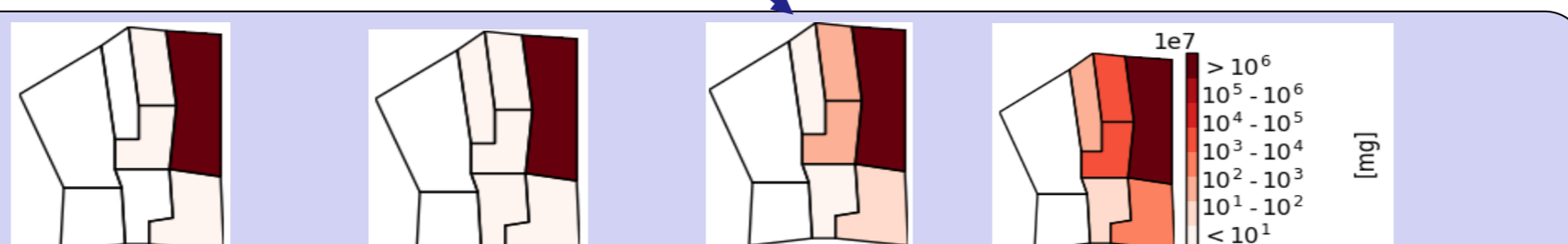
Simplified catchment composed of 8 plots + ditch network + river (8 ha)

6 hours rainfall event
Application of Isoproturon on P1. (1400 g/ha : 2940 g)

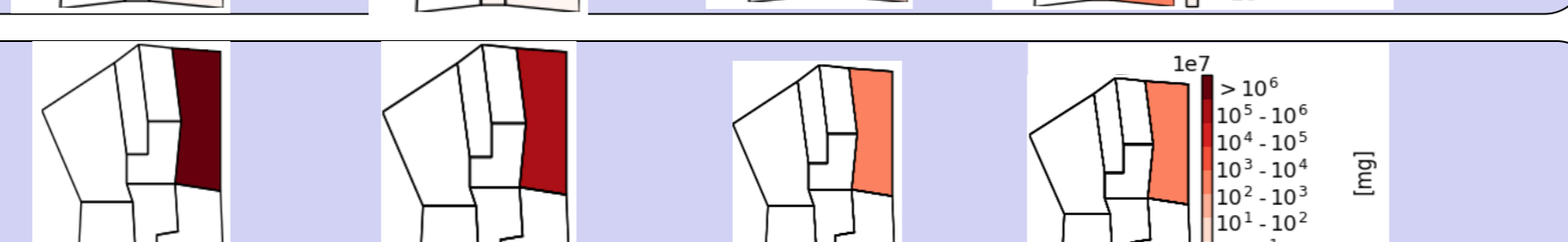


t=3h t=25h t=34h t=240h

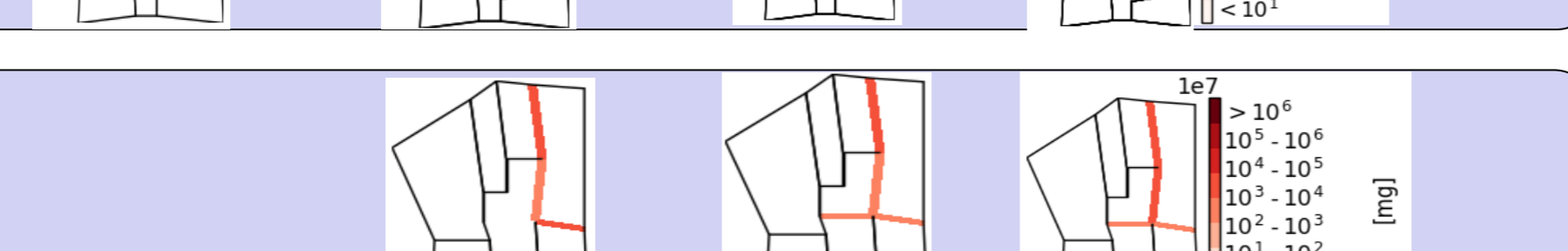
Mass of isoproturon in subsurface



Mass of isoproturon on surface



Mass of isoproturon in the ditch network



Perspectives and conclusions

- Promising modelling framework to represent pesticide fate on agricultural landscapes.
- Advantage of the modular structure: possibilities to improve the representation of processes over time.
- Next steps:
 - Integration of other landscape elements/processes: grass buffer strips, hedges, roads, sediments
 - Validation (Fontaine du Theil –Brittany- and Morcille – Beaujolais- catchments)
 - Definition of relevant management scenarios

[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, 252:189-204

[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, 323: 258-275

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

[5] Madrigal-Monarez I. 2002. *Rétention de pesticides dans les sols des dispositifs tampons enherbés et boisés, rôle des matières organiques*. Thèse INAPG. 212pp