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

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

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

3. Representation of processes
- Modélisation 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 FERERID solving Richards’ eq. (ID) [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 developed by the CERFACS. [6]
- The different components representing one process or one element are aggregated in OpenPALM in order to reach the catchment scale.
- 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)

- 6-hour rainfall at the beginning of the simulation
  - Application of isoproturon on the upstream plot. (Aoc, DT50 from 35)
  - No initial water table in plots
  - Plot and ditches geometry

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

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

→ Solute quickly transferred to outlet by the ditch network

→ Slower transfers along plots