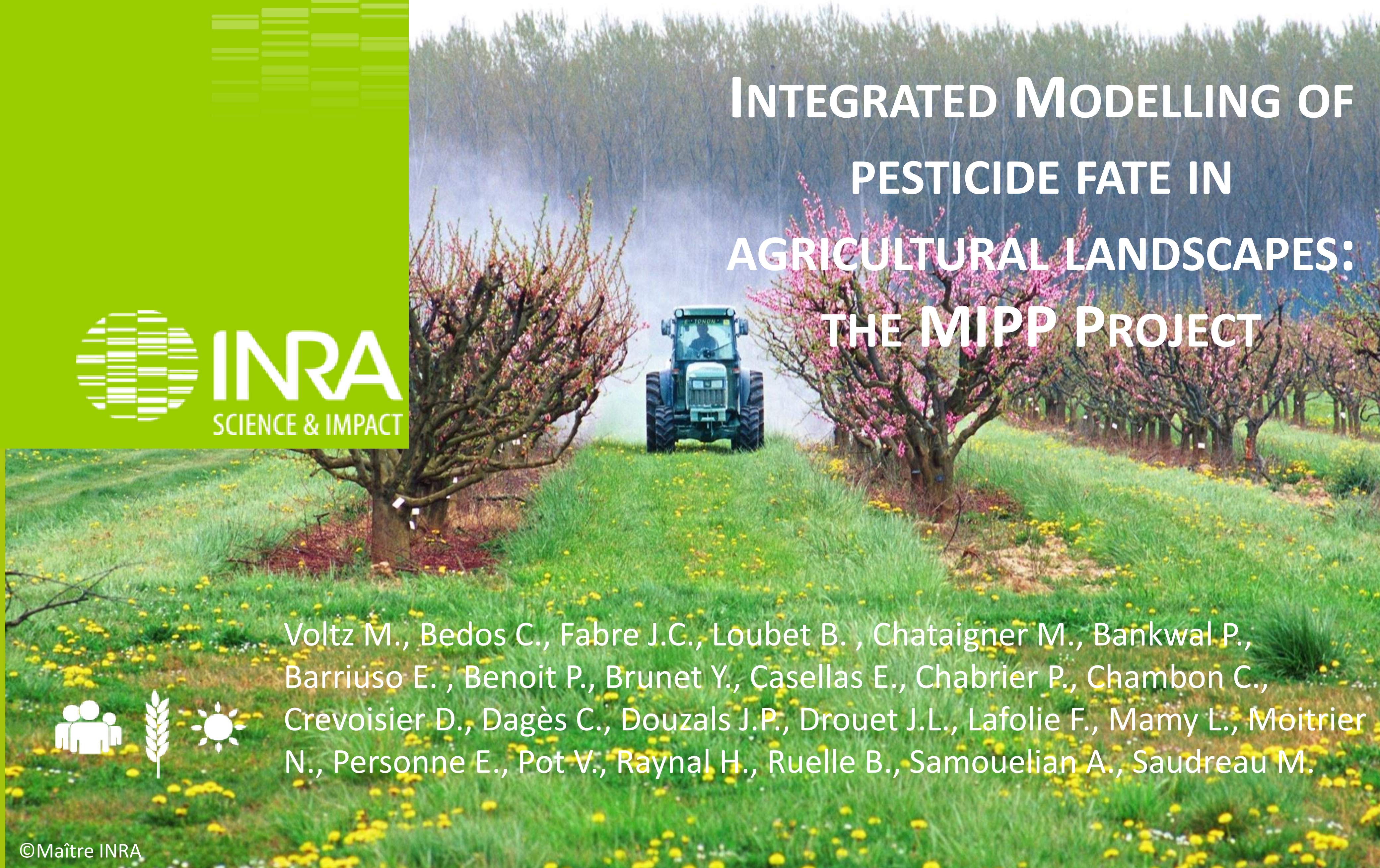


INRA SCIENCE & IMPACT

Integrated Modelling of pesticide fate in agricultural landscapes: the MIPP Project

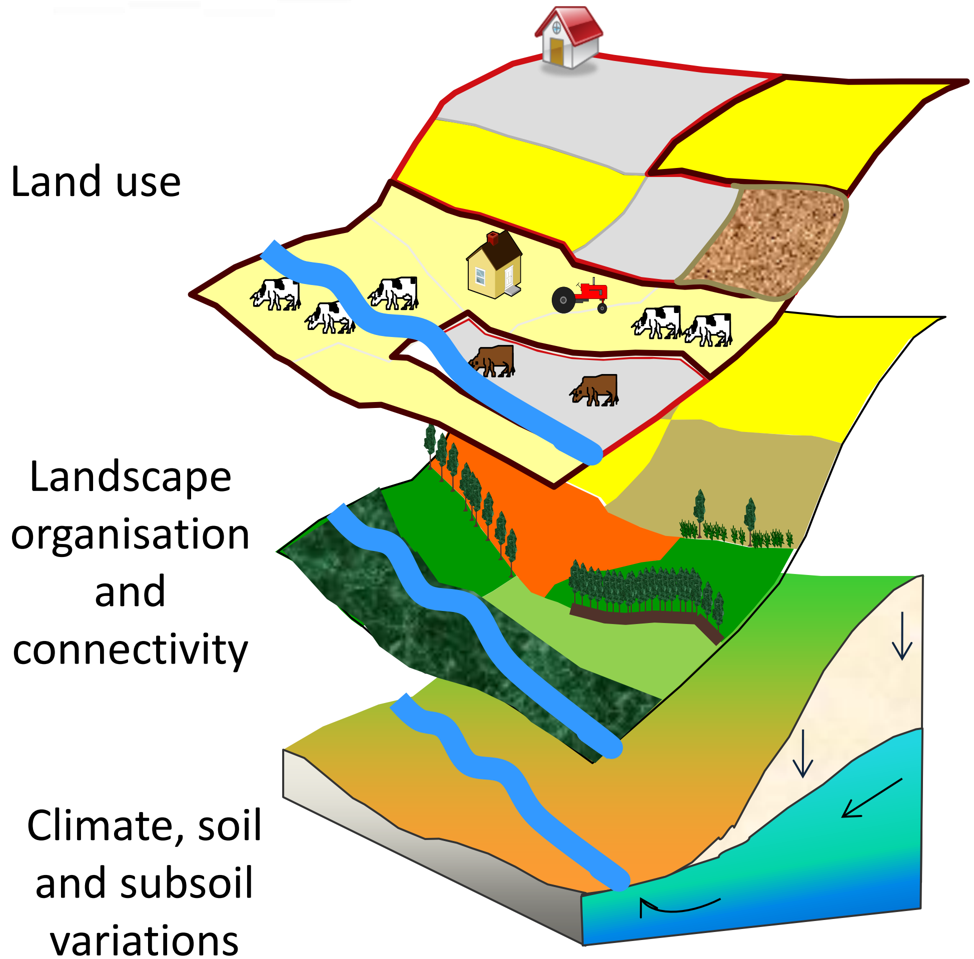
Voltz M., Bedos C., Fabre J.C., Loubet B. , Chataigner M., Bankwal P., Barriuso E. , Benoit P., Brunet Y., Casellas E., Chabrier P., Chambon C., Crevoisier D., Dagès C., Douzals J.P., Drouet J.L., Lafolie F., Mamy L., Moitrier N., Personne E., Pot V., Raynal H., Ruelle B., Samouelian A., Saudreau M.

Outline

- Background
- Objectives
- Modelling principles
  - landscape representation
  - Main processes
- First model developments
- Examples of target applications
- Conclusions and perspectives

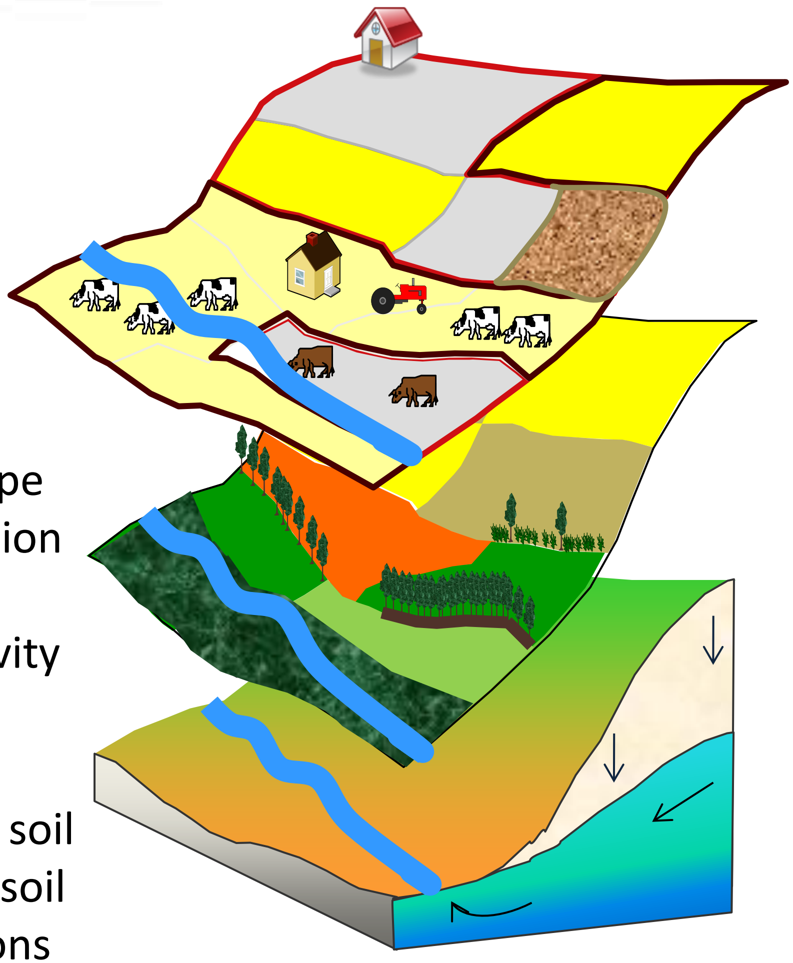
BACKGROUND AND OBJECTIVES

Interest of landscape approaches to study pesticide fate and exposure (see eg. Boivin&Poulsen, 2017; Topping et al, 2015)



- A comprehensive analysis of pesticide dispersal pathways in and between all compartments
- A realistic evaluation of environmental exposure of biological organisms
- A possibility for examining a larger number of mitigation measures for
  - risk assessment
  - deriving innovative agricultural management strategies

but landscape studies are difficult



- Observations and experiments are cumbersome at this scale
- Landscape modelling of pesticide fate is complex and most existing models only address specific processes or scales
  - Many field scale models (e.g. PEARL, MACRO…)
  - Hydrological models (e.g. SWAT)
  - Gis based models (e.g. GeoPEARL)
  - Multimedia box models (e.g. Great-ER)

Objectives

- To develop an integrative pesticide fate model at the landscape scale that
  - ✓ predicts pesticide concentrations in soil, water and air
  - ✓ is spatially explicit with field scale resolution
  - ✓ represents the impact of cropping systems on field and landscape properties affecting pesticide fate (e.g. tillage, mulching, fertilization…)
  - ✓ represents the effect of buffer zones (e.g. untreated buffer zones, vegetated filter strips, vegetated ditches, hedges, artificial wetlands…)
  - ✓ is pluriannual in order to allow test of agricultural management strategies

Project contributers

Research units

- INRA
  - UMR ECOSYS – Grignon
  - UMR EMMAH – Avignon
  - UMR ISPA – Bordeaux
  - UMR LISAH – Montpellier
  - UR MIA – Toulouse
  - UMR PIAF – Clermont-Ferrand
- IRSTEA
  - *UMR ITAP - Montpellier*

Simulation platforms

Flow processes in Landscapes

OpenFLUID

Cropping systems

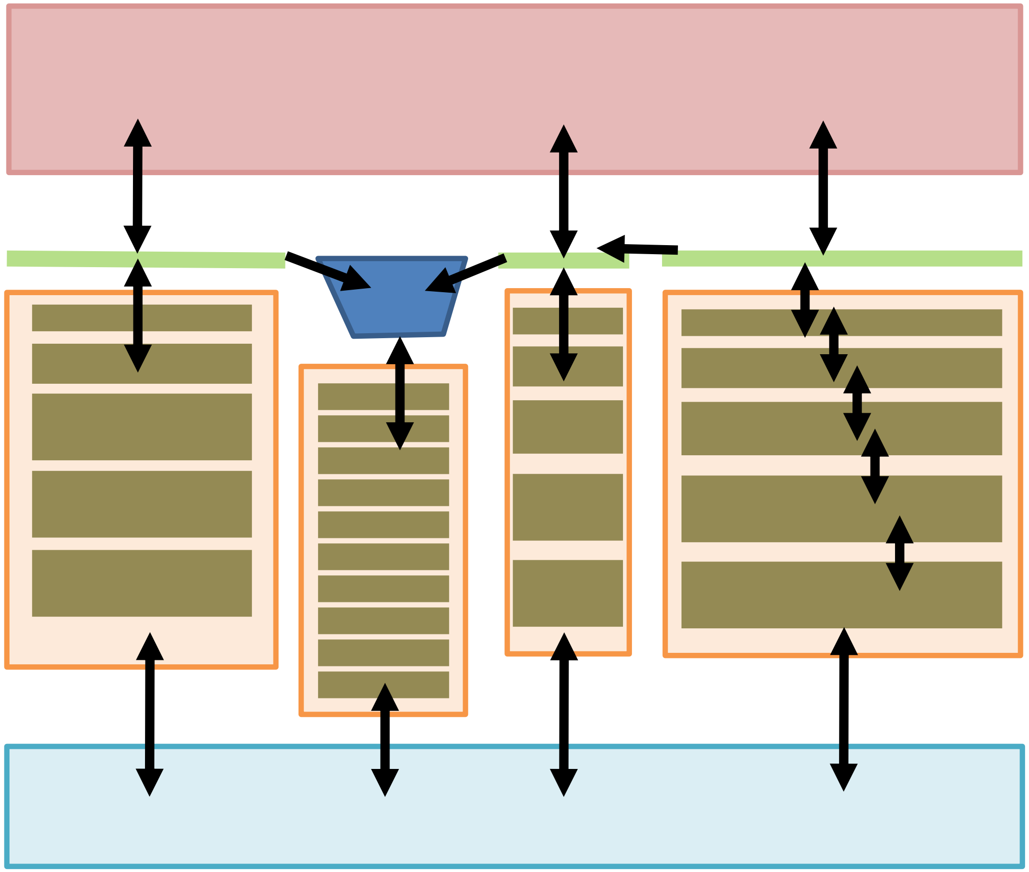
RECORD

Soil and soil-plant processes

Virtual Soil

MODELLING PRINCIPLES OF MIPP

MIPP distinguishes several types of landscape units from the lower atmosphere to the aquifer levels



AU : Atmospheric units (2D)

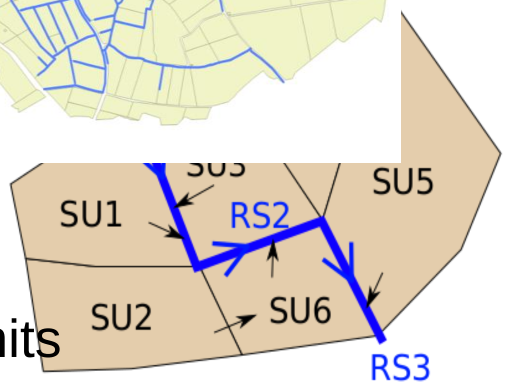
SU : Soil Surface units (2D polygons)
RS : River segments (1D lines)

SL : Soil Layers (3D)

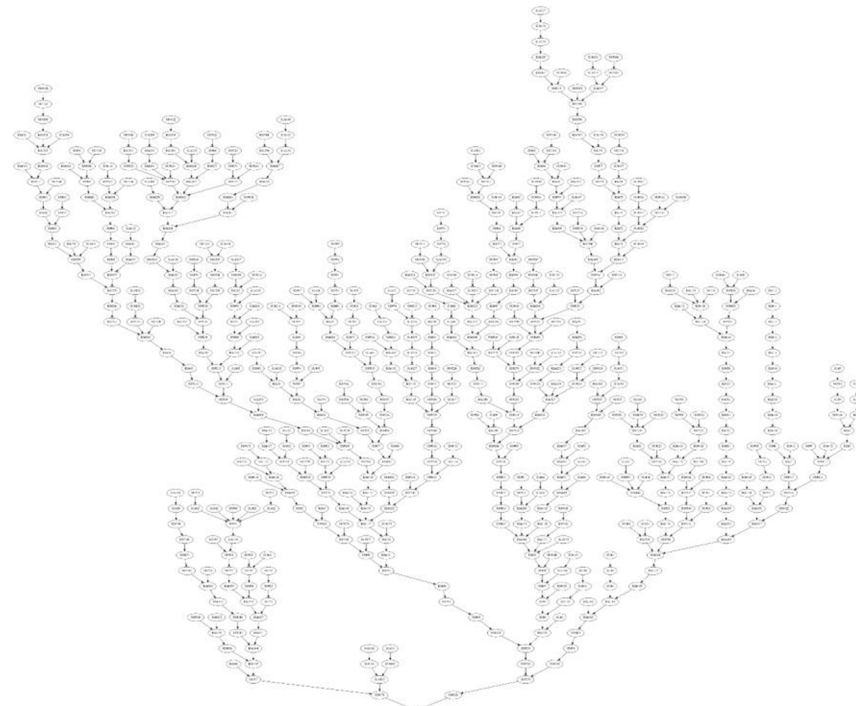
SBU : Subsurface units (3D)

GU : Groundwater units (3D)

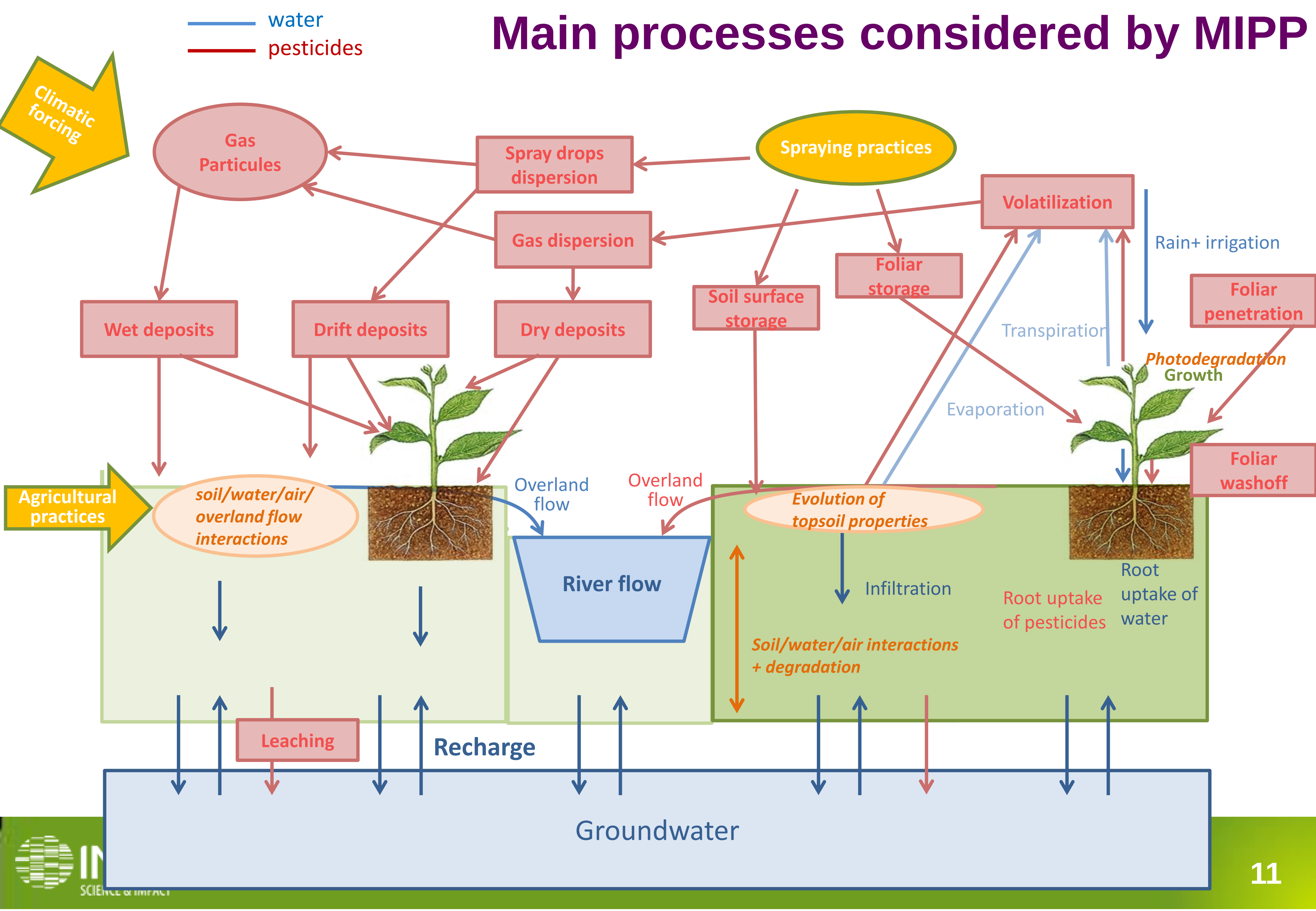
…and represents the spatial connections between the landscape units by a graph



- ~1 km^2
- Spatial units
  - 237 Surface and Subsurface units (SU and SBU)
  - 372 River segments (RS)
  - 25 Groundwater units (GU)



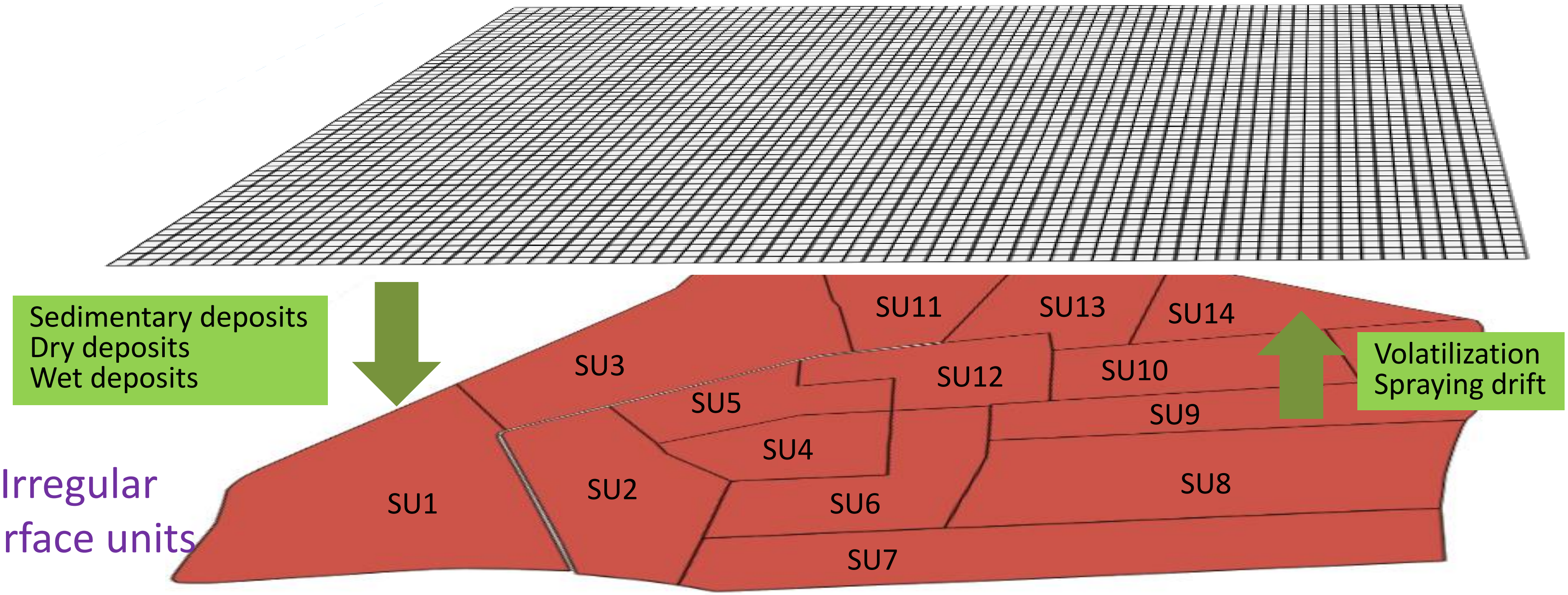
Main processes considered by MIPP



FIRST MODEL DEVELOPMENTS

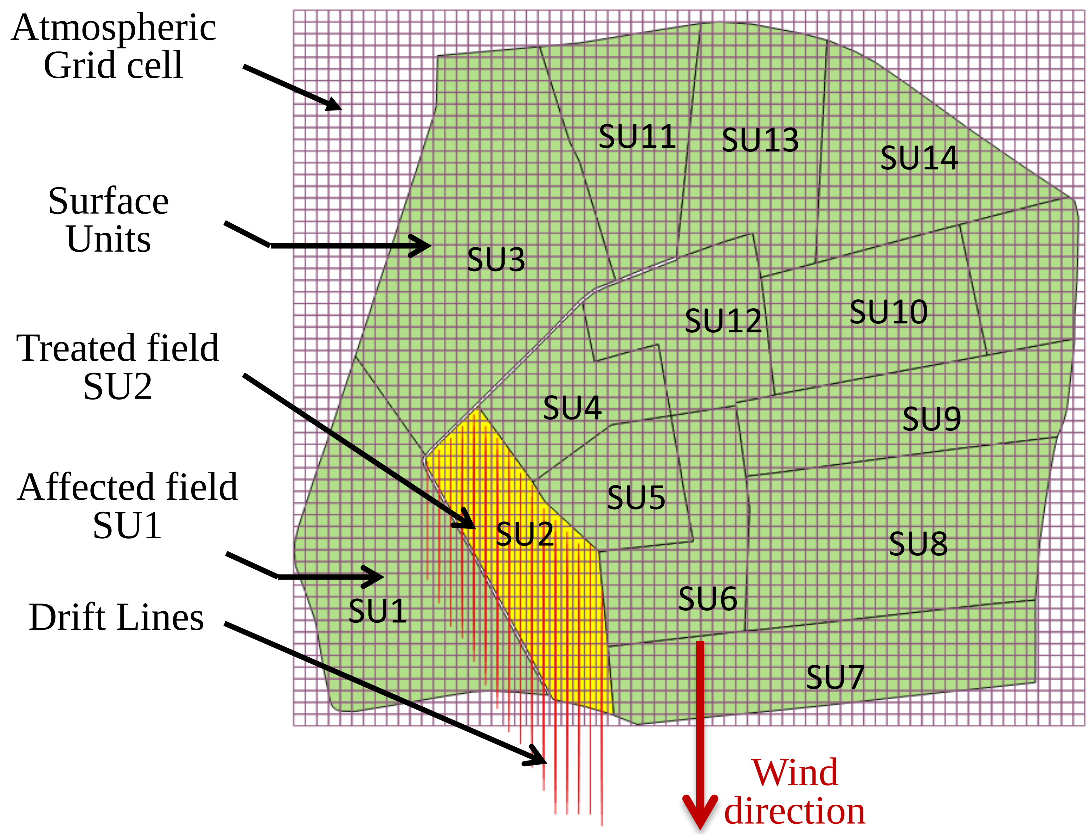
Spatial coupling between atmospheric and soil surface units

Gridded atmospheric unit (support of atmospheric concentrations and climate variables)

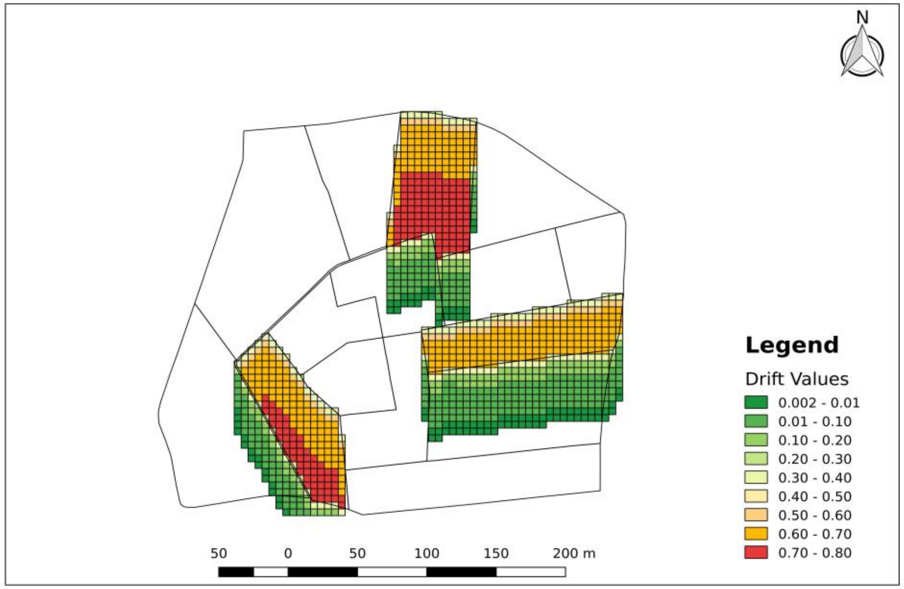


Irregular surface units

Simulating drift deposits with Ganzelmeier approach



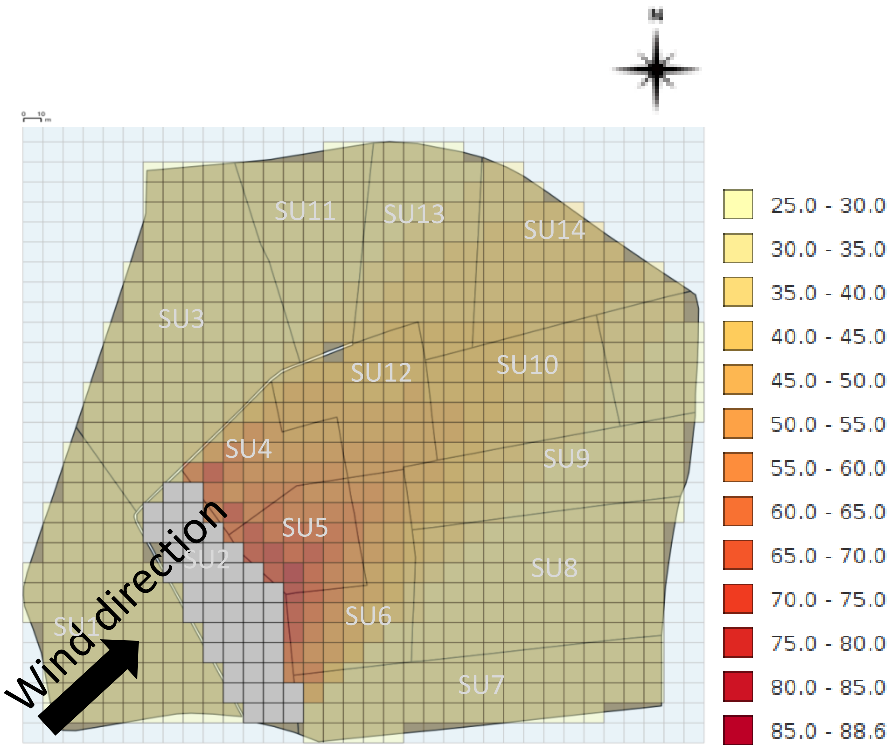
Three treated fields



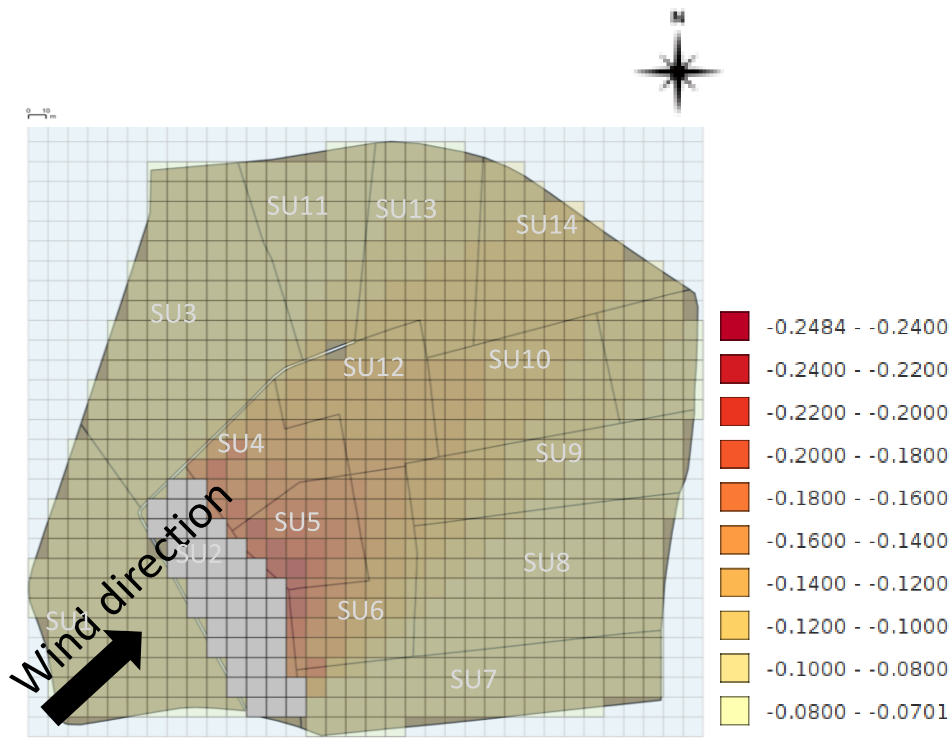
Simulating atmospheric dispersion and dry deposits with the FIDES Model (Bedos et al., 2013)

Case study of an emission by volatilization on a treated field (20 ng/m²/s) with

- a background concentration in the air (25 ng/m²/s)
- realistic micrometeorological conditions (u_*=0.42m/s, L_{MO}=-1000m), given wind direction

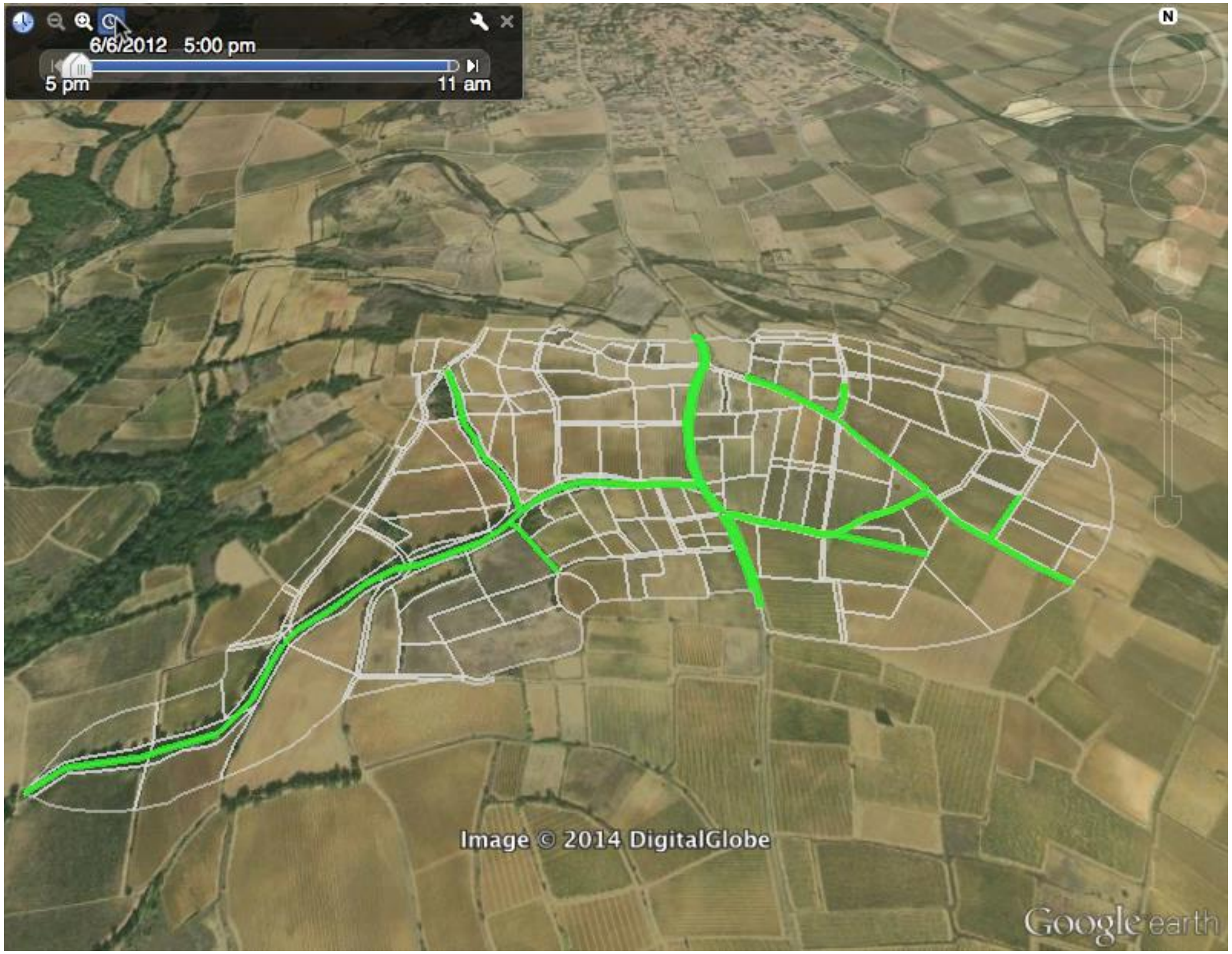


Concentration in the air (ng/m³)



Deposit fluxes (ng/m²/s)

Simulating pesticide fate in topsoil and overland flow by the hydrological model MHYDAS (Bouvet et al., 2011)



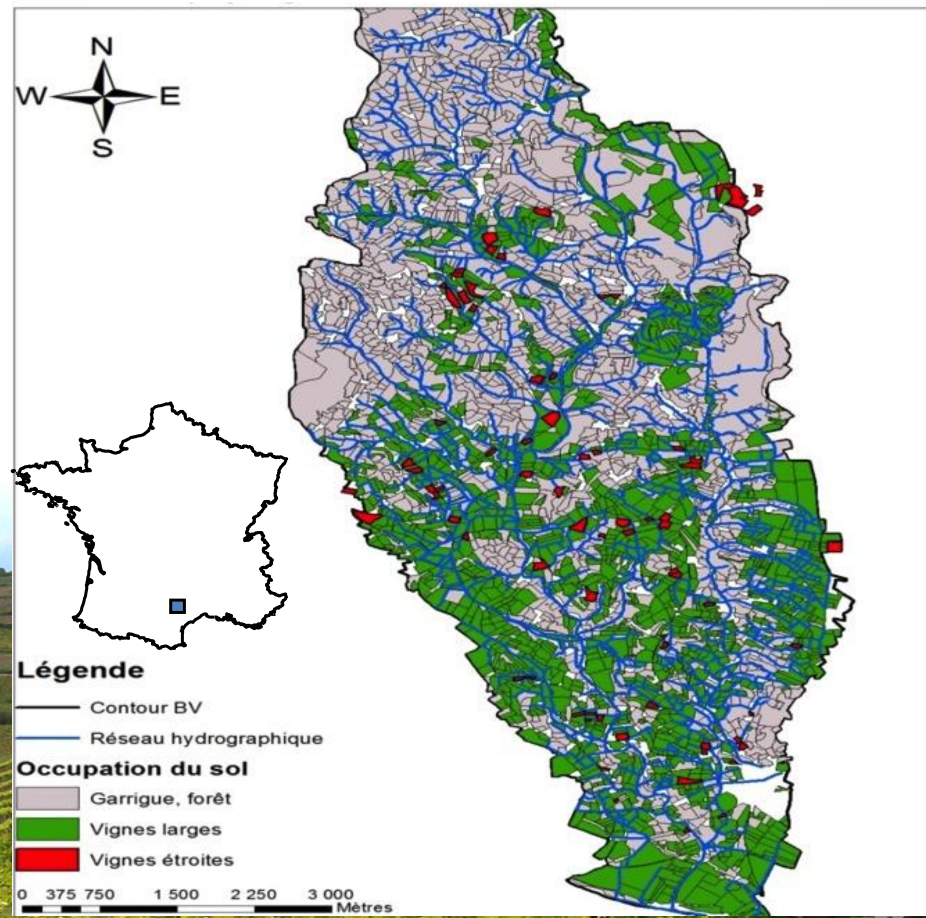
EXAMPLES OF TARGET APPLICATIONS

(1) Evaluating new weeding strategies in Mediterranean vineyard areas

A 45 km^2 catchment in south France with 150 vinegrowers and a drinking supply severely polluted by herbicides used in vineyards

⬇

A need for identifying new weeding strategies that limit water contamination and human exposure to pesticides



(1) Evaluating new weeding strategies in Mediterranean vineyard areas

Standard practice

Rows	Chemical weeding		
Inter-rows	Chemical weeding	Soil tillage	Grass cover

Safer soil treatment practices are known but difficult to generalize
- cost increase
- labour increase
- risk of yield losses
- trafficability problems

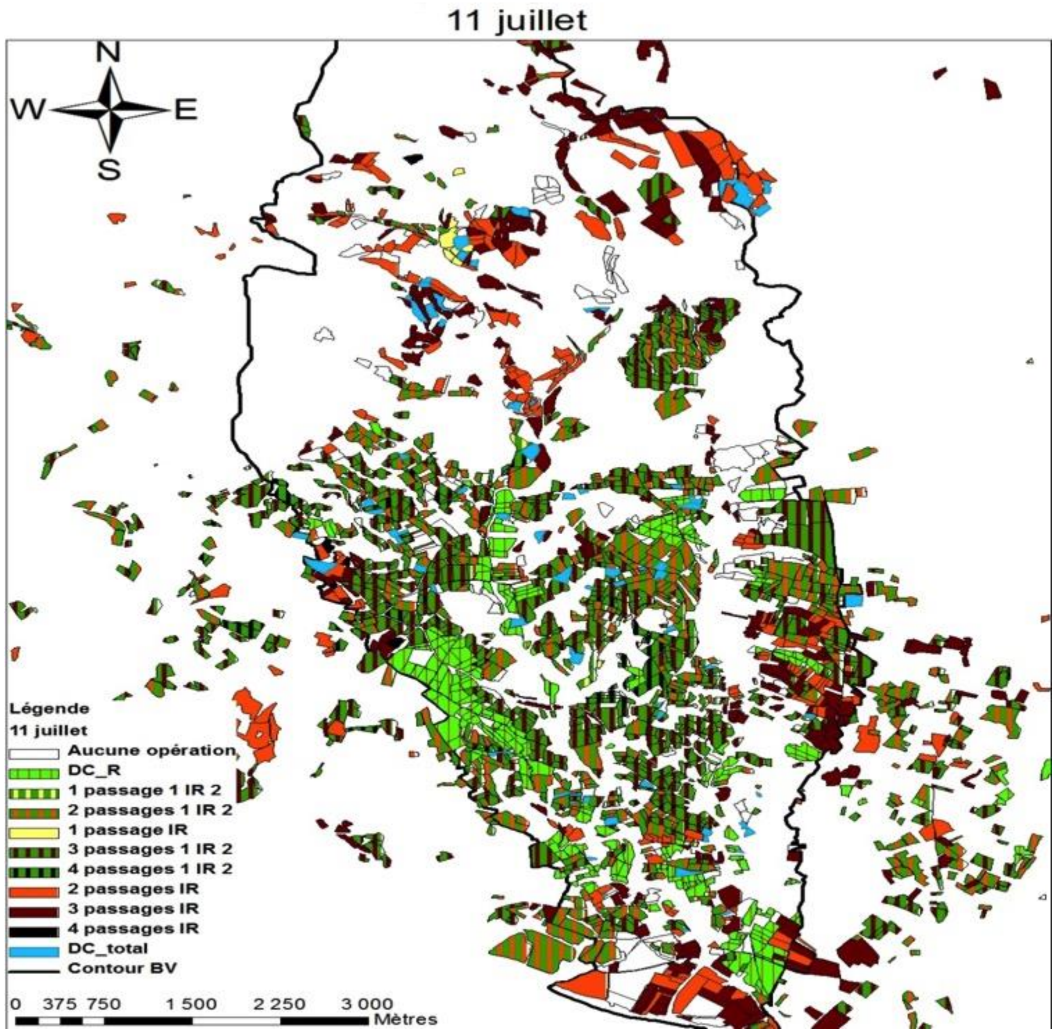
(1) Evaluating new weeding strategies in Mediterranean vineyard areas

An option is to recommend a diversity of soil management strategies according to

- soils (slope, available water capacity)
- vineyard geometry (interrow distance)
- vinegrower equipment
- …..

Is it cost effective? And what are the expected improvement in water quality and human exposure?

Landscape modelling can help to answer these questions

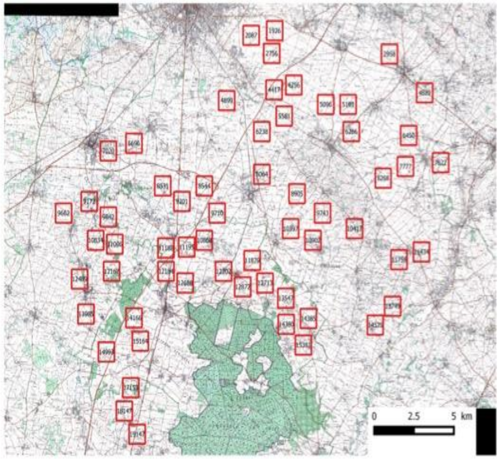


(2) Evaluating the links between pesticide exposure and biodiversity at the landscape scale

The RESCAPE project

Sampling of 60 windows of 1 km² with various pesticide usages and landscape fragmentation

In each window, measurements of
- *soil pesticide concentrations*
- *biodiversity (earthworms, beetles, small mammals)*



Application of landscape modelling over the windows will :
- Estimate the within-window variation of pesticide contamination and exposure
- Allow hypothesis testing of the main factors driving non target organisms exposure

Conclusions

- First version of MIPP expected beginning of 2018
  - Main remaining challenges:
    - coupling all submodels
    - limiting computing time of the whole model
- Evaluate parts of MIPP on observed data
- Test MIPP on applications
- MIPP is open for collaborations :
  - if interested please do not hesitate to contact us during the conference or by mail at marc.voltz@inra.fr or carole.bedos@inra.fr


Thank you for your attention
Pesticide Behaviour in Soils, Water and Air
York 2017