



# Distributed hydrological modelling of farmed catchments :

## assessing the impact of man-made structures on hydrological processes

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### L I S A H

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A joint research unit of the :



**High School of Agronomy**



**National Institute for Agricultural Research**



**Institute of Research for Development**

The LISAH logo, with the letters 'LISAH' in a large, bold, multi-colored font (L is green, I is blue, S is green, A is blue, H is green).

# Context

- Understanding and modelling the environmental impact of farming systems on landscape hydrology
- Seeking new farming systems and landscape management that will :
  - limit environmental impacts : floods, erosion, contamination
  - allow for sustainable agricultural production
  - protect water resources

# Objectives

- Assess the role of man-made discontinuities at the plot and the catchment scales in farmed catchments



land use



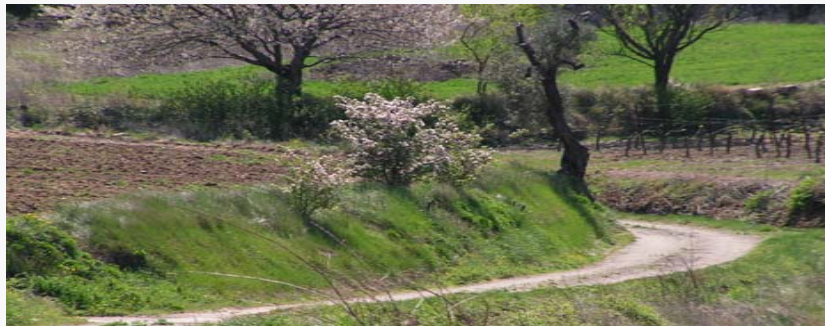
surface features



channels



tabias



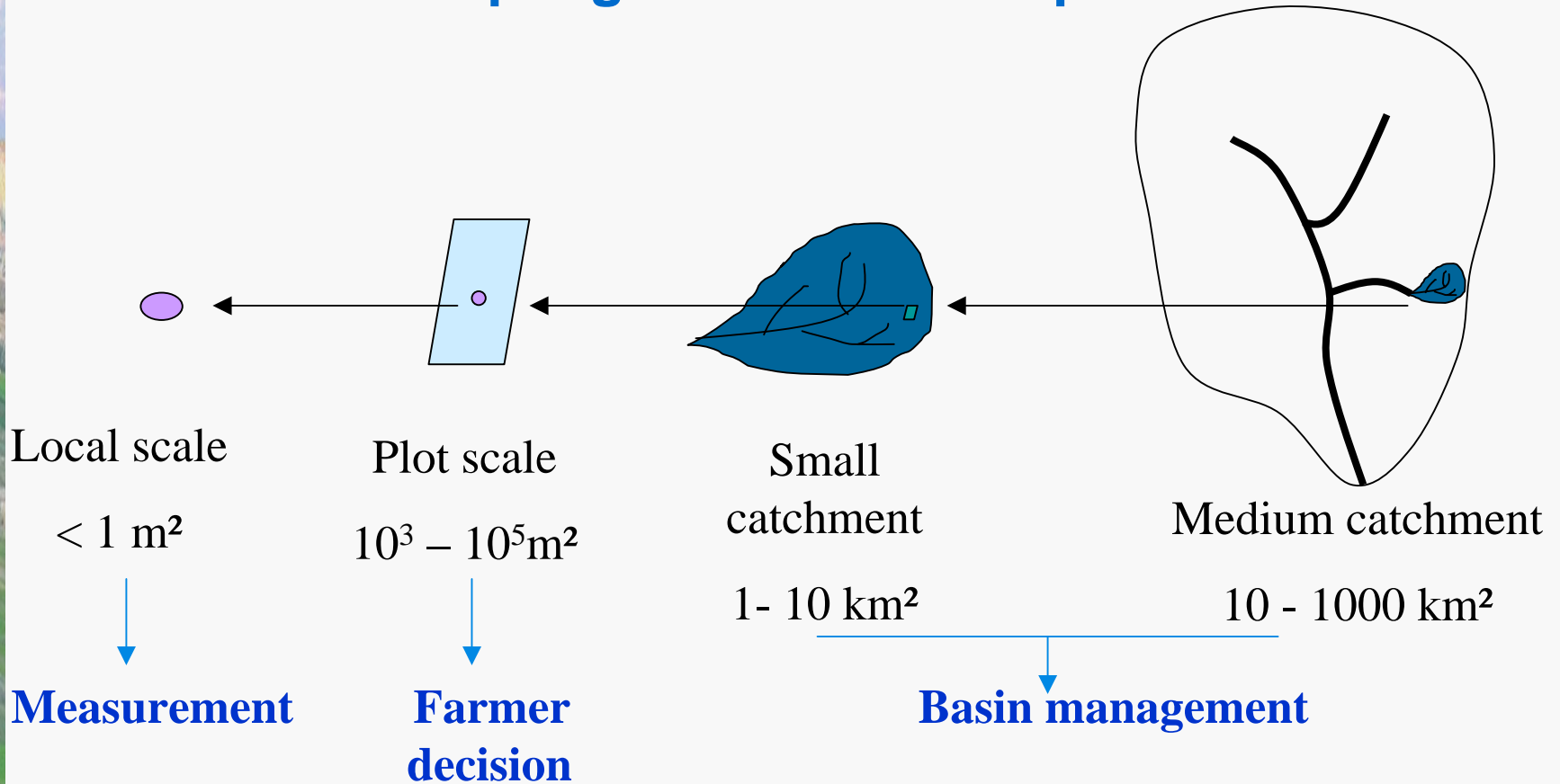
embankments, roads



lakes

- Modelling water, pollutant and erosion transport, and simulating the impact of scenarios of land use change

# Difficulties due to scale effects, and in coupling non-linear complex models



Assessing hydrological processes

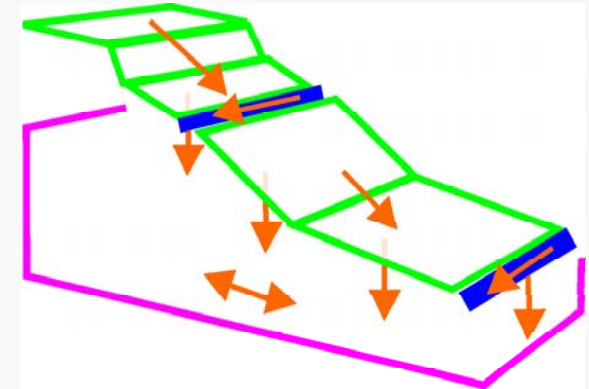
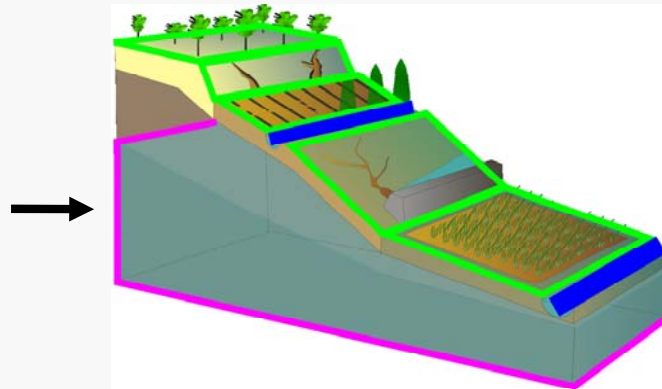
Engineering hydrology

For each problem, the user needs the most adapted model  
to the dominant processes

# The spatially distributed hydrological model MHYDAS (Modelling HYDrological AgroSystems)

1. Subdivision of the basin into hydrological units taking into account the hydrological discontinuities.
2. Representation of the main hydrological processes.
3. Multi-scale and multi-objective parameterisation, calibration and validation approach.

# MHYDAS : Model structure



- Surface unit
- Reach
- Aquifer unit

Need to represent hydrological discontinuities in farmed basins :

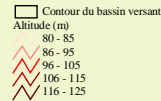
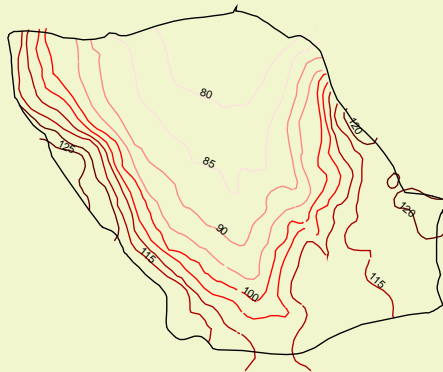
- Ditches
- Field limits
- Terraces
- Pipes
- etc.

# Geo-MHYDAS

## Subdivision of the basin into hydrological units

(Lagacherie et al., 2010)

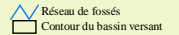
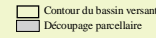
Topographie



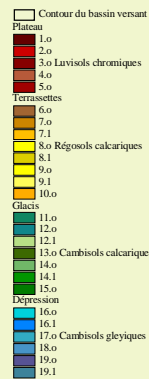
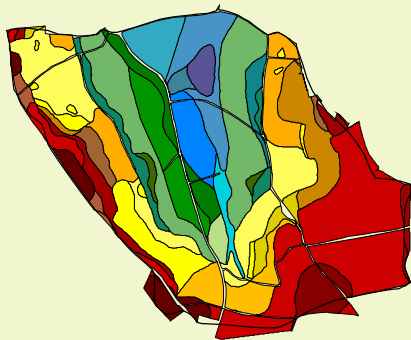
Parcellaire



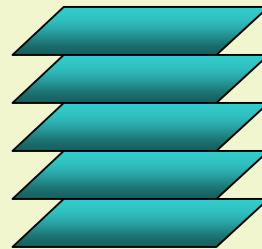
Réseau de fossés



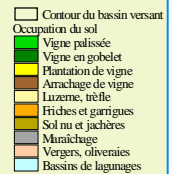
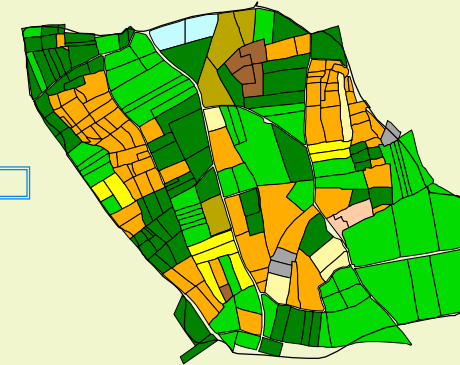
Carte des sols



GIS (GRASS)



Occupation du sol



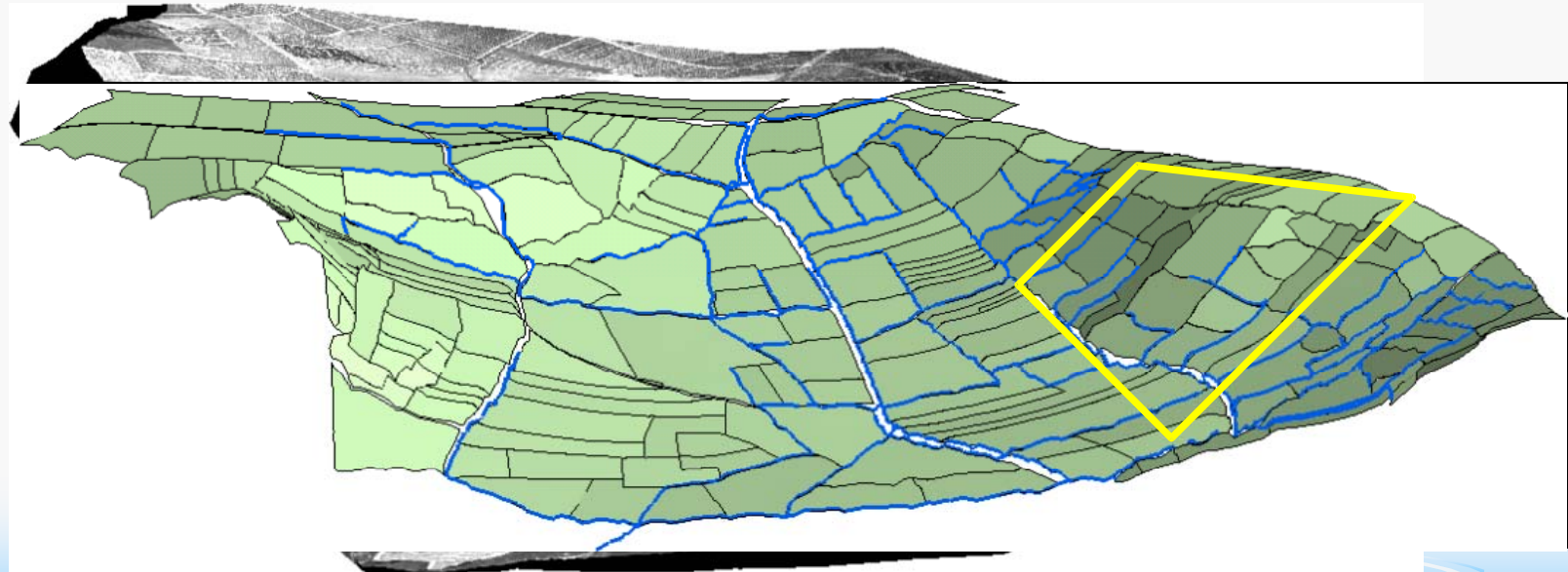
# Geo-MHYDAS : Representation of the catchment

## 1) Geographical data analysis



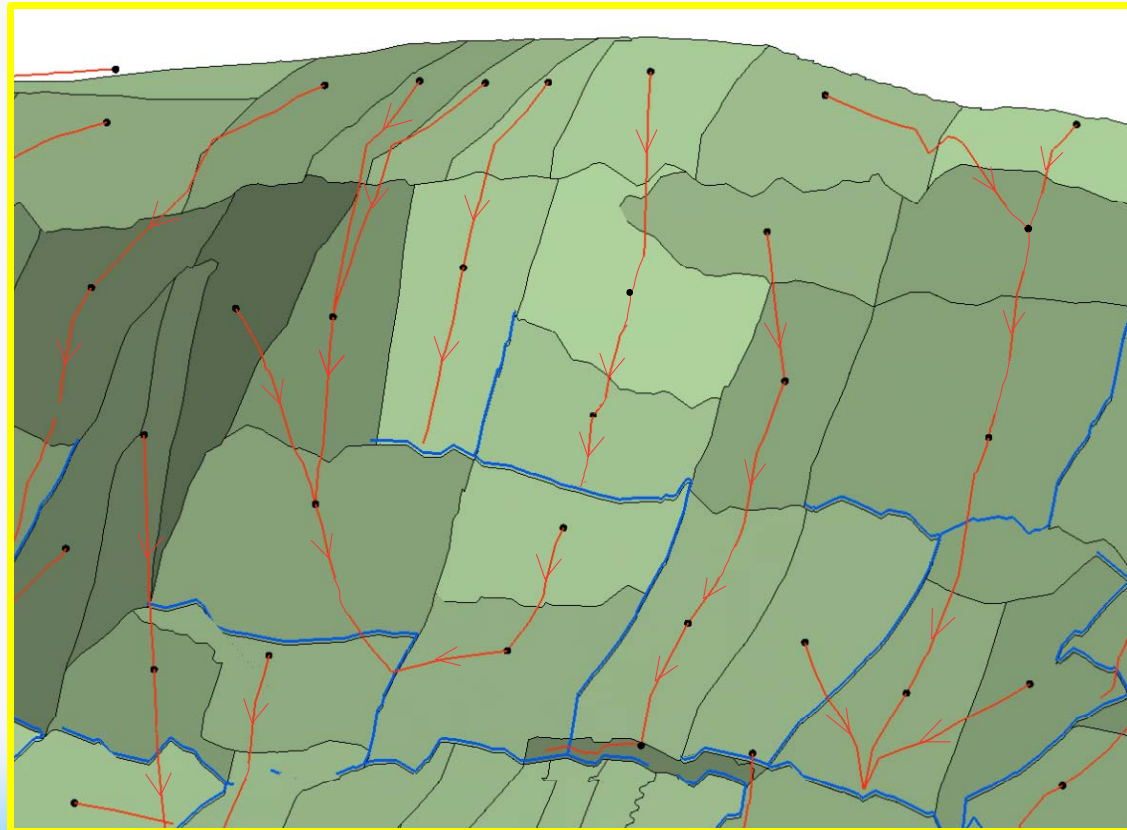
# Geo-MHYDAS : Representation of the catchment

- 1) Geographical data analysis
- 2) Catchment subdivision into hydrological units

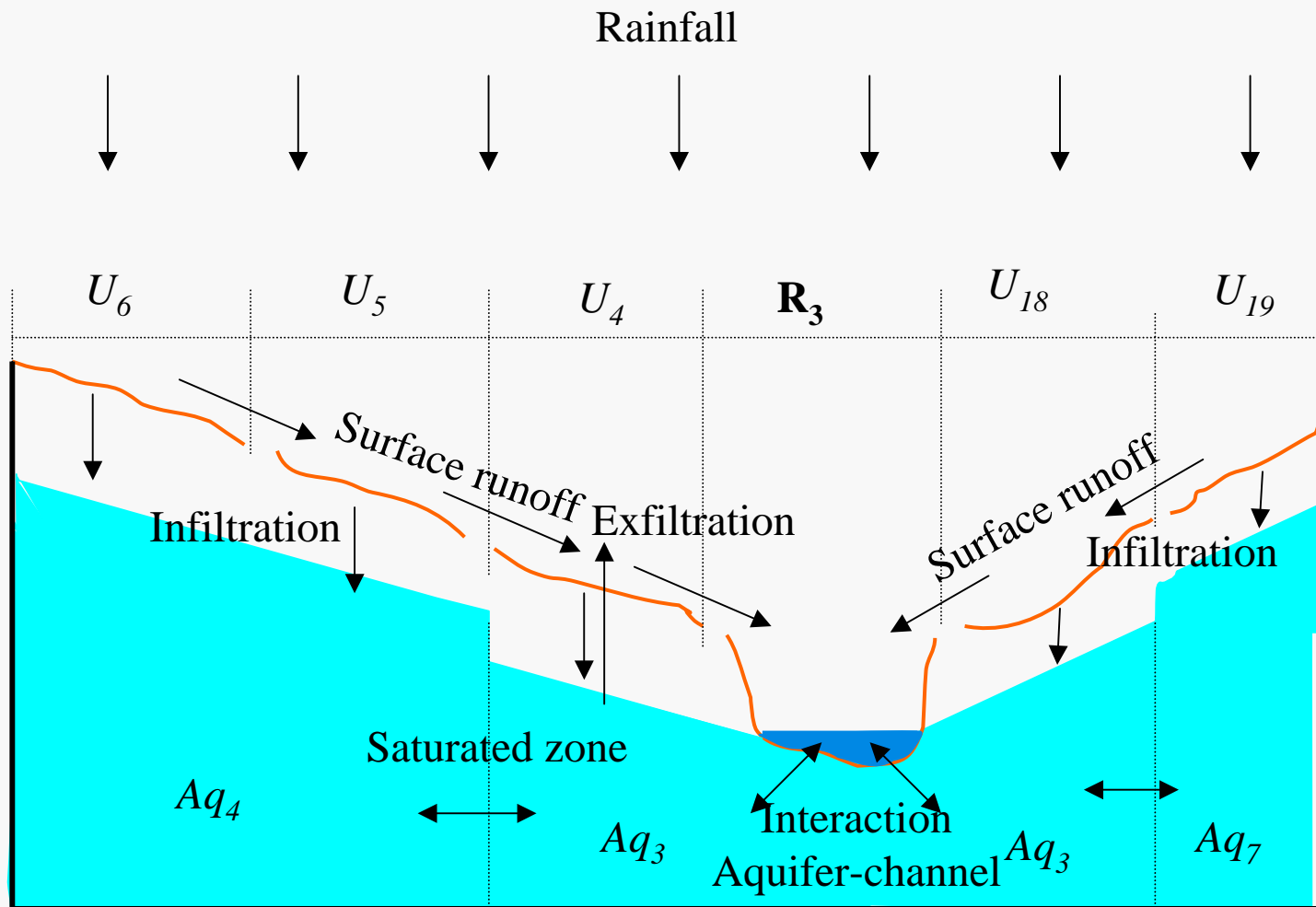


# Geo-MHYDAS : Representation of the catchment

- 1) Geographical data analysis
- 2) Catchment subdivision into hydrological units
- 3) Define the connectivities



# MHYDAS : Main hydrological processes

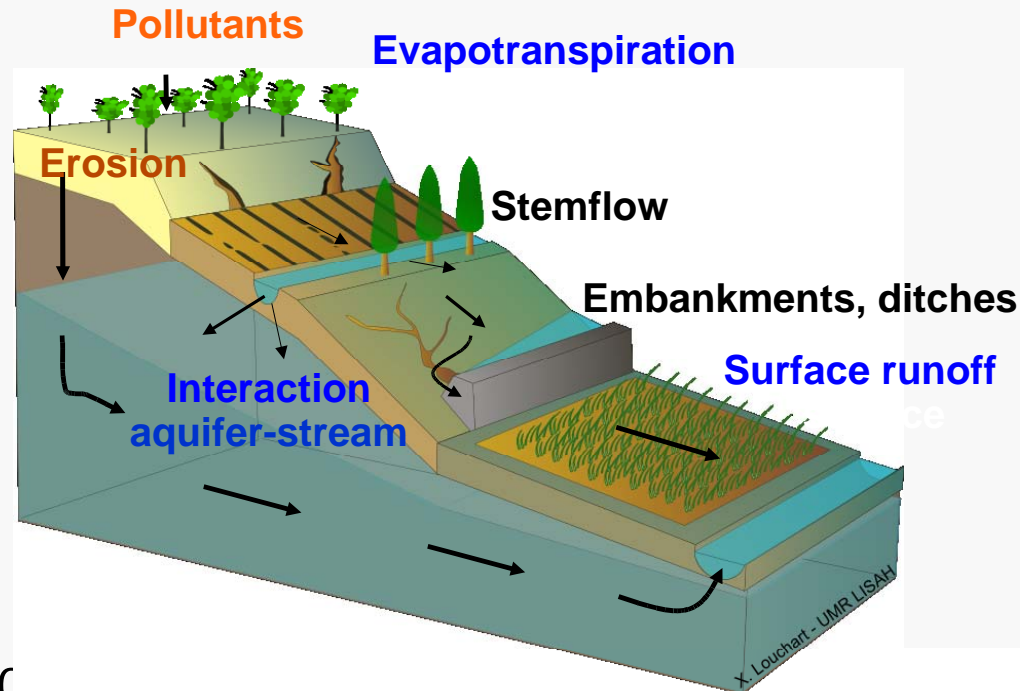


+ pollutant transfer

+ erosion transfer

# MHYDAS : Modular structure

A modular approach was undertaken using the platform OpenFLUID, which enables the user to build his own version of MHYDAS by combining various processes :



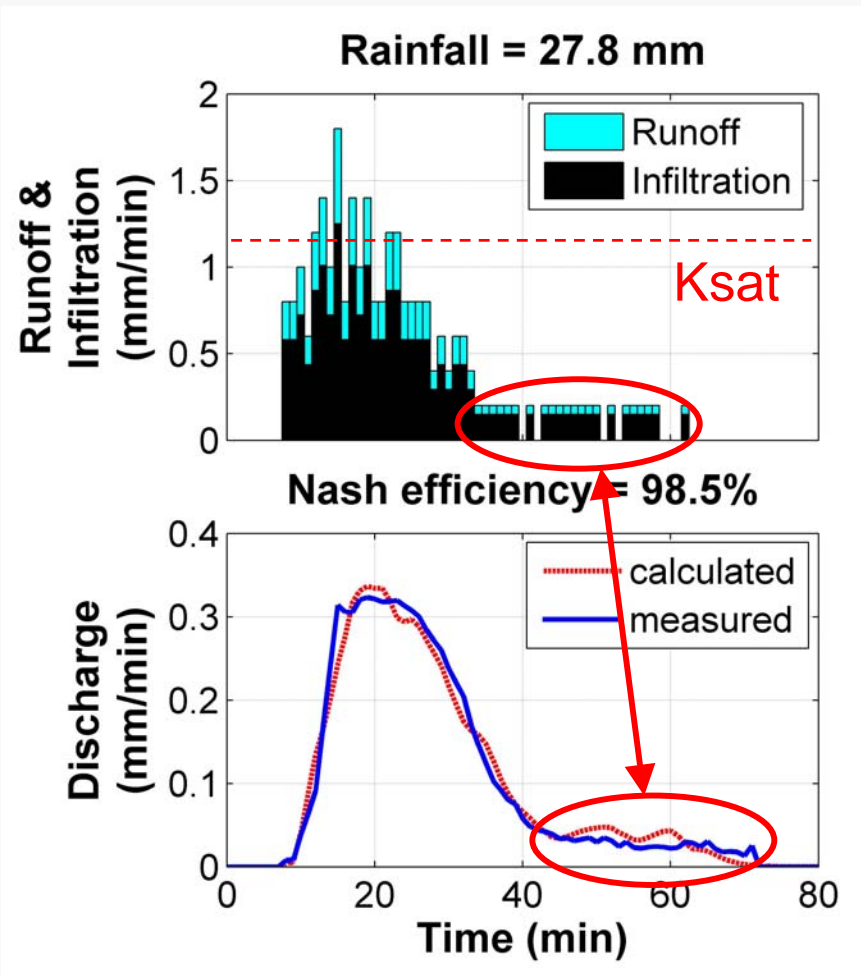
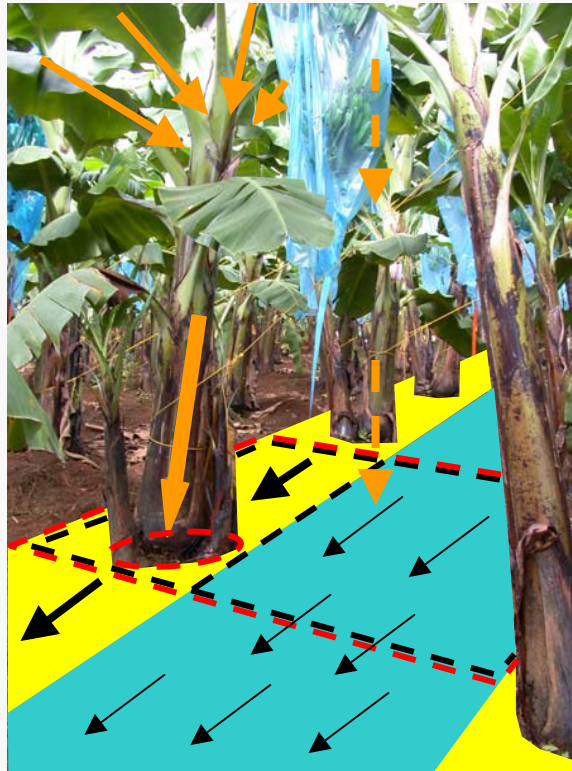
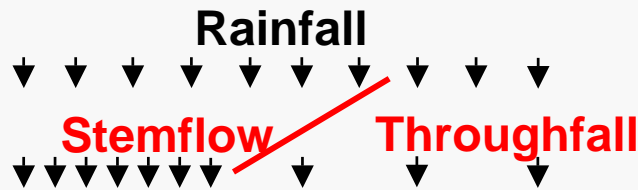
as a function of the :

- objective of the study
- availability of data
- required accuracy of results

  
**OpenFLUID**  
Software Environment  
for Modelling Fluxes in Landscapes  
(<http://www.umr-lisah.fr/openfluid/>)

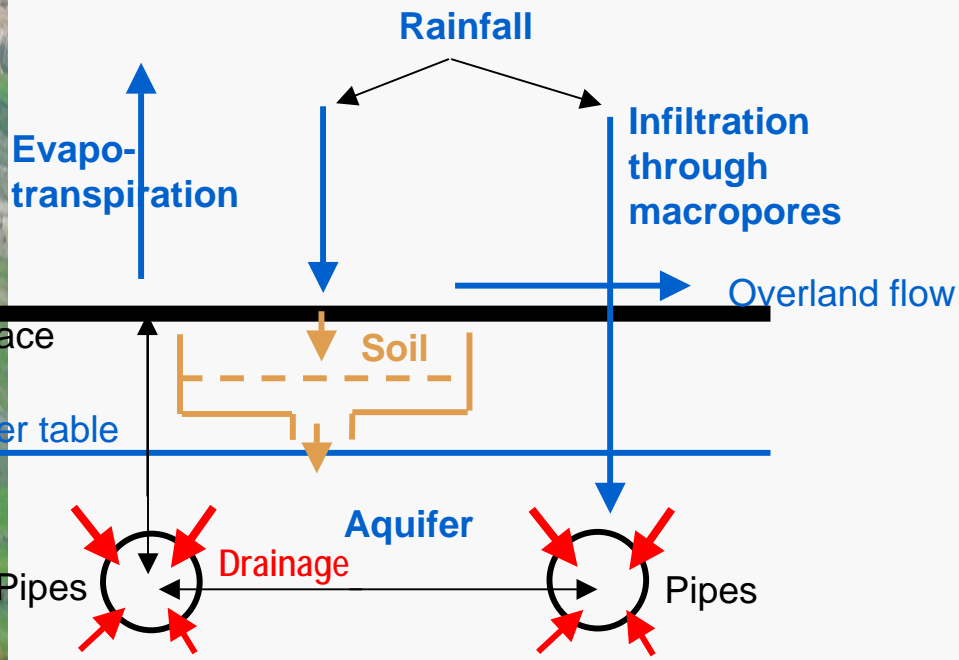
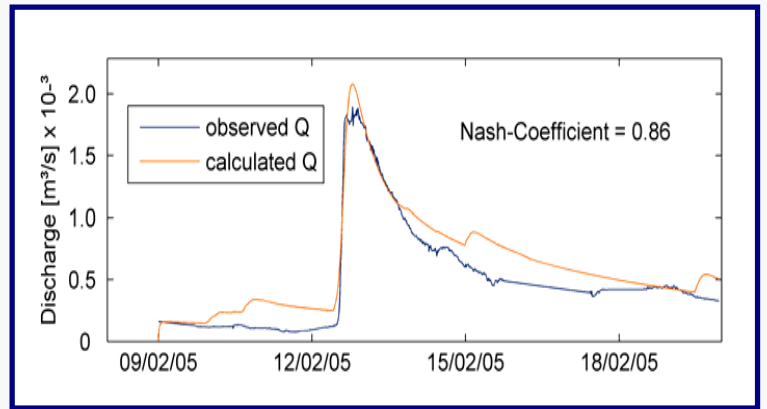
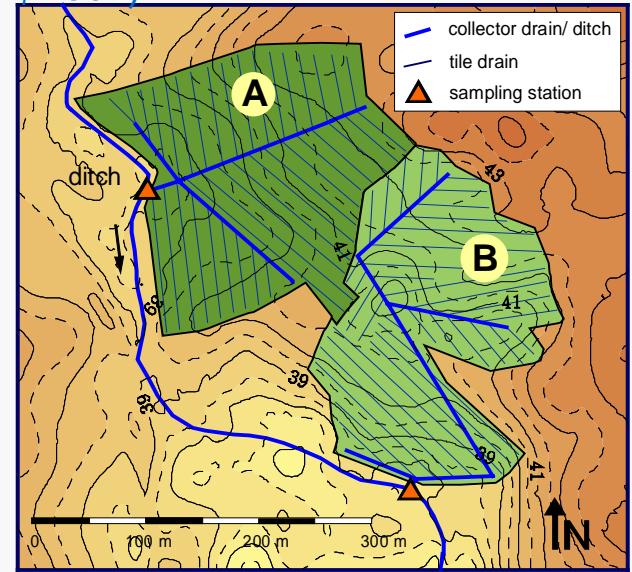
# Plot scale : Influence of stemflow on surface runoff

(Féfé catchment 19 ha, Guadeloupe ; Charlier, 2007)



Representing the stemflow flow process in MHYDAS enables to improve the simulation of flood events with low rainfall intensities

# Plot scale : Modelling drained basins (Rostock, Germany; Tiemeyer, 2007)

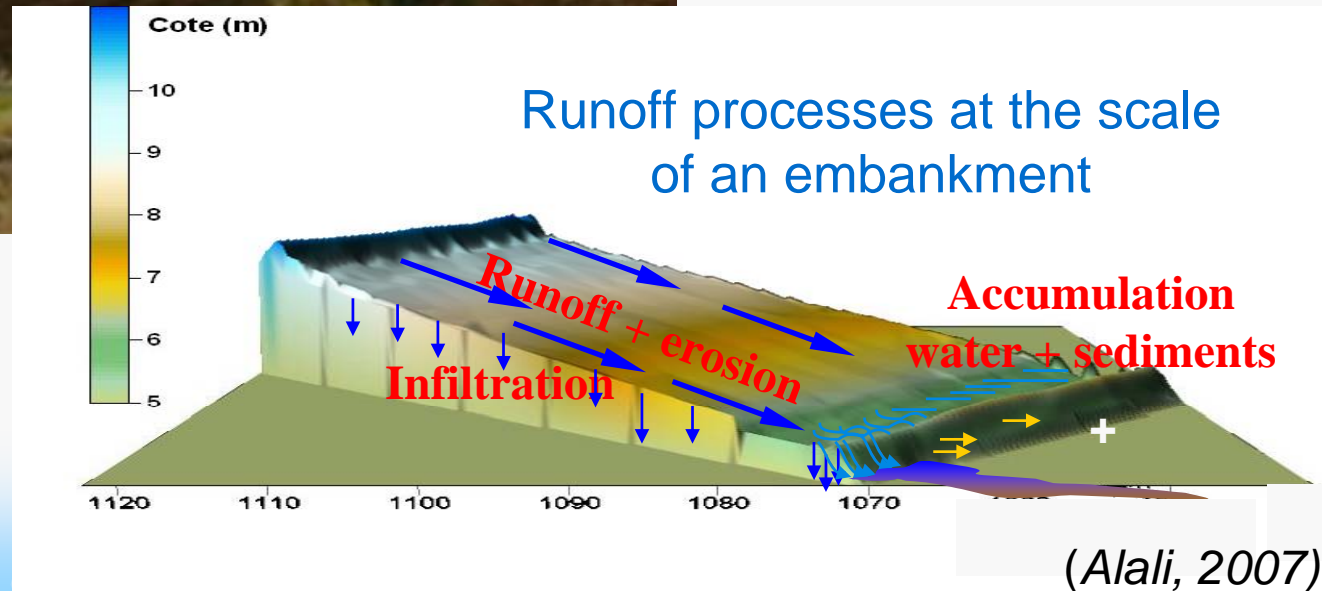


Pipes modify pathflows for water and pollutant transfer

# Hillslope scale : Role of embankments (tabias) to reduce erosion and increase water storage in an aquifer (Tunisia)



IRD, Tunisia



# Case study on the Roujan catchment : tillage and weeding practices



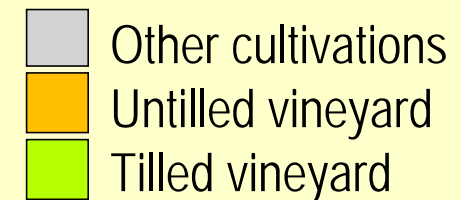
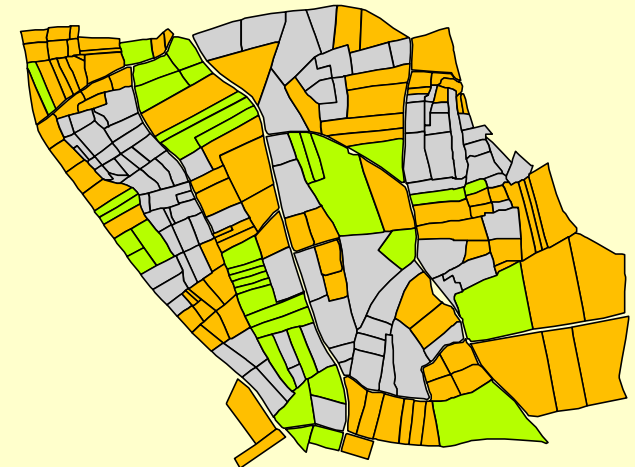
## Two main practices

- no tillage
- chemical weeding on the whole vineyard
- high runoff coefficient



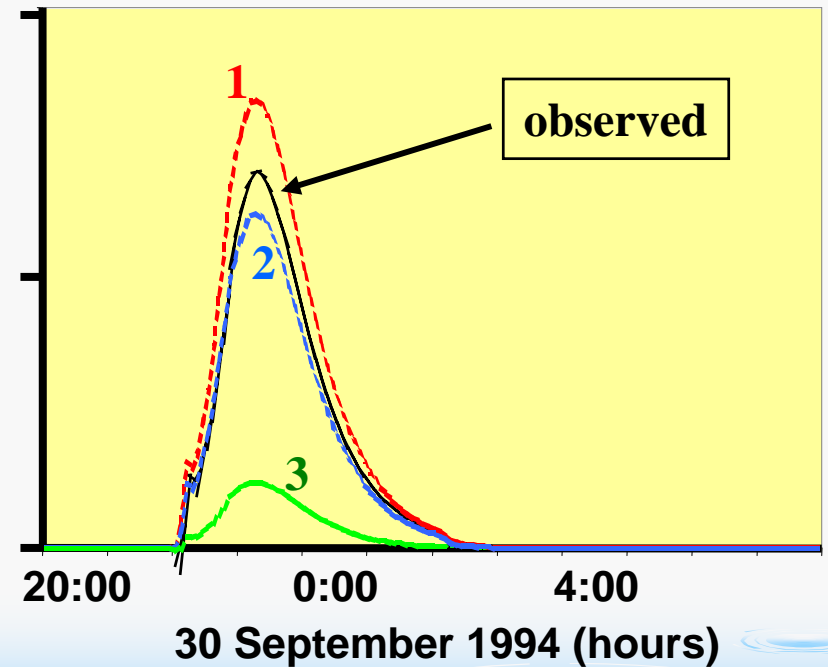
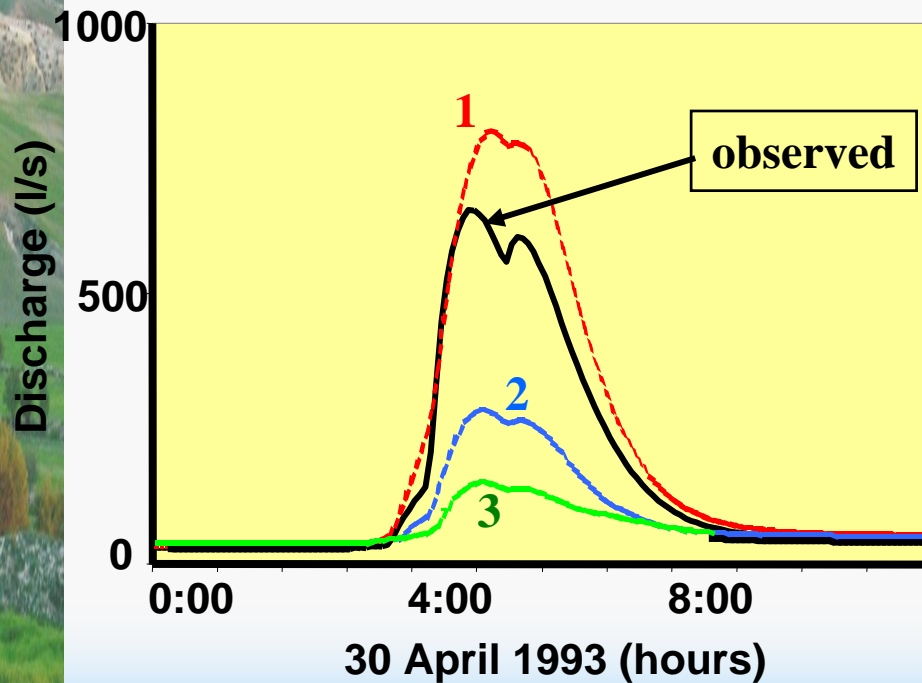
- tillage
- chemical weeding along the rows only
- low runoff coefficient

Land use  
5 June 1997



# Influence of tillage on runoff flow

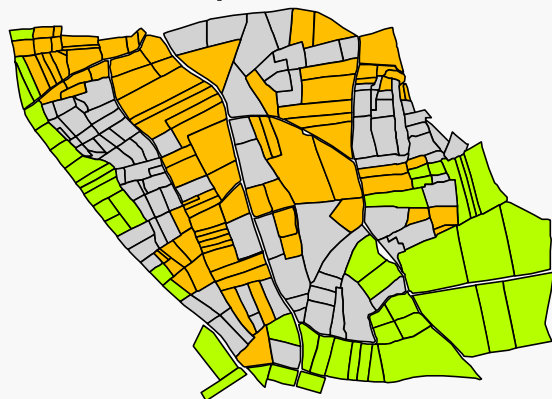
- ..... Scenario 1 : All vineyards are non-tilled.
- ..... Scenario 2 : All vineyards are tilled on April.
- ..... Scenario 3 : All vineyards are freshly tilled.



# Scenarios of spatial allocation of weeding practices

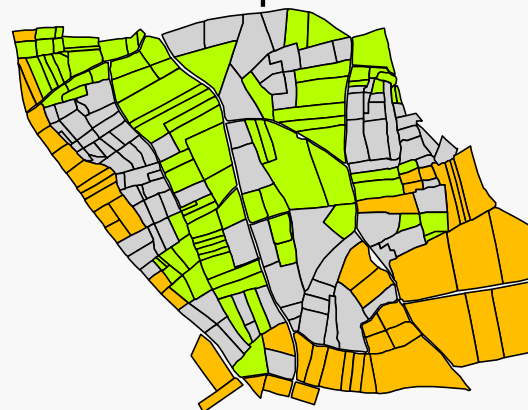
## Scenario A




Most chemical weeding  
in the depression



## Scenario B

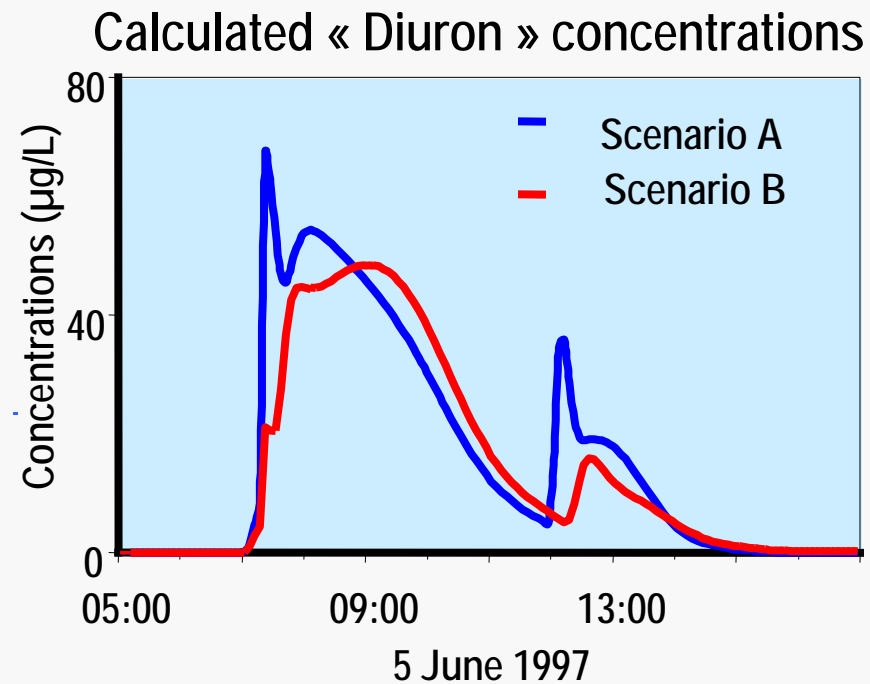
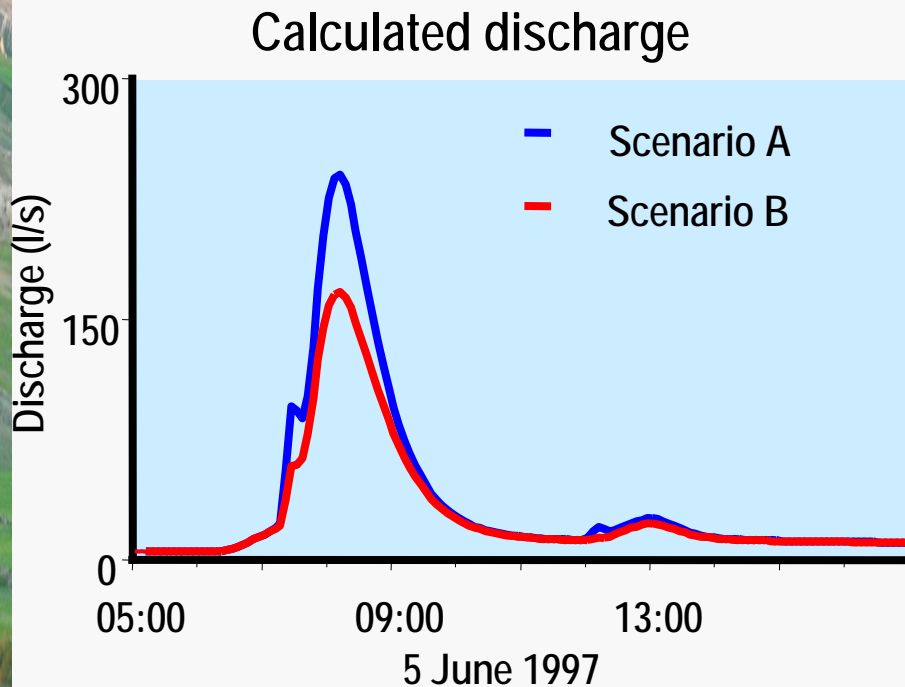
Most chemical weeding  
on the plateau



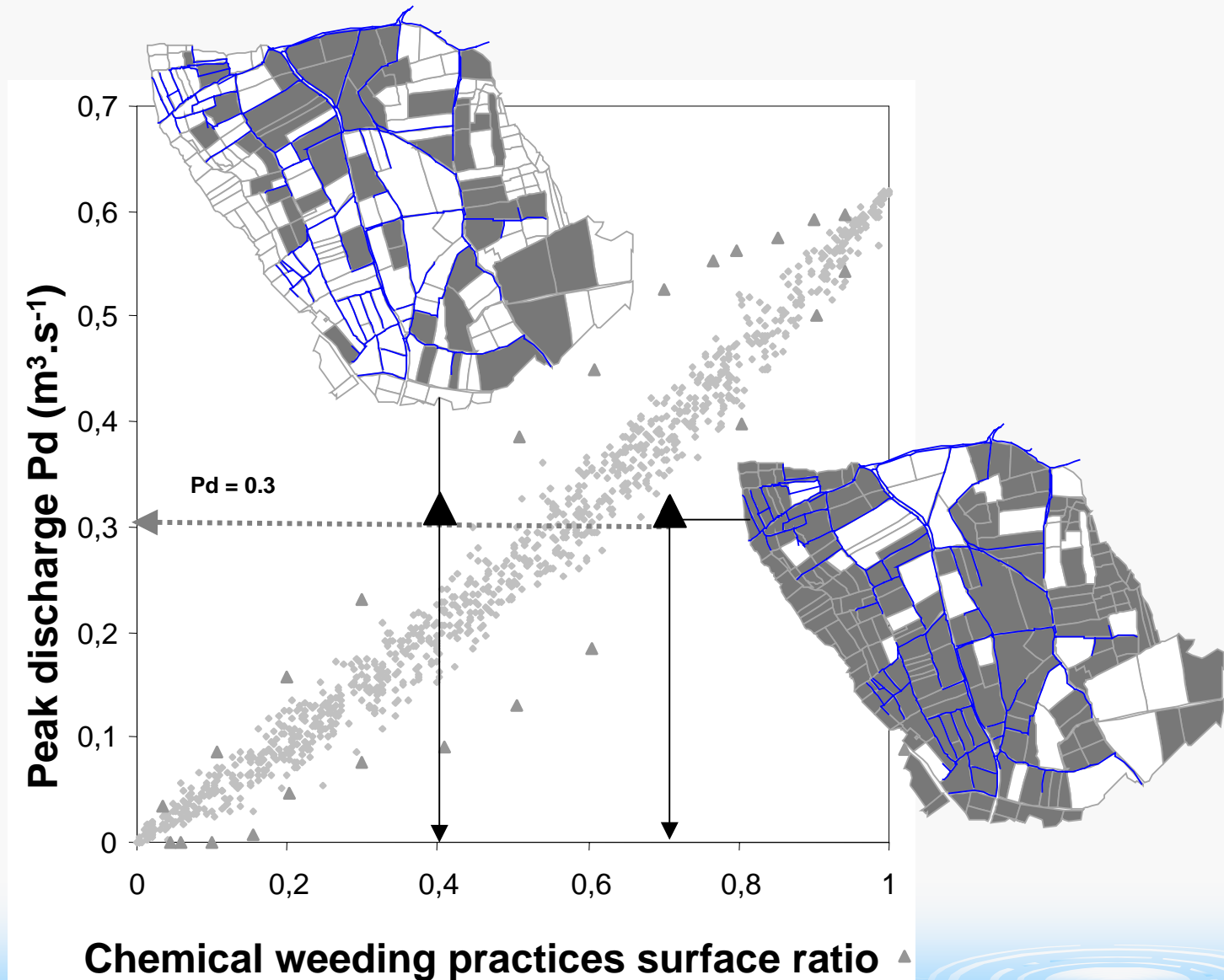
-  Other cultivations
-  Vineyard with no tillage and total chemical weeding
-  vineyard with inter-row tillage and chemical weeding on the rows

# Test of scenarios of tillage and weeding practices

## Results of the scenario simulations



# Comparison of scenarios of tillage and weeding practices



# MHYDAS applications

- Vineyard mediterranean catchment (Roujan, France) :
  - flood events (*Chahinian, 2004*)
  - interaction aquifer-channel (*Dagès, 2006*)
  - overbank flow (*Ghesquière, 2008*)
- Drained basins in temperate zone (Rostock, Germany)  
(*Tiemeyer, 2007; Coll. University of Rostock*)
- Stemflow on banana plantation in volcanic tropical zone  
(*Charlier, 2007; Coll. CIRAD-Guadeloupe*)
- Indicators of pollution (*Wohlfahrt, 2008; Coll. INRA-Colmar*)
- Erosion (*Gumiere, 2010*)

and actually :

- Pollutant transfer (*Bouvet*)
- Runoff on anthropogenic hillslopes (*Hallema*)
- Water balance under coffee plantations (*Gomez Delgado; Coll. CIRAD Costa-Rica*)
- Impact of agricultural practices (*Paré*)

# Conclusion

- MHYDAS uses a representation of processes well adapted to man-made discontinuities in farmed basins.
- A modular approach which enables the user to build his own version of MHYDAS as a function of the objectives and the available data.
- This modelling approach is useful to test scenarios of catchment management strategies.