Modelling of surface water and groundwater exchange and denitrification process in the floodplain shallow aquifer at the catchment scale

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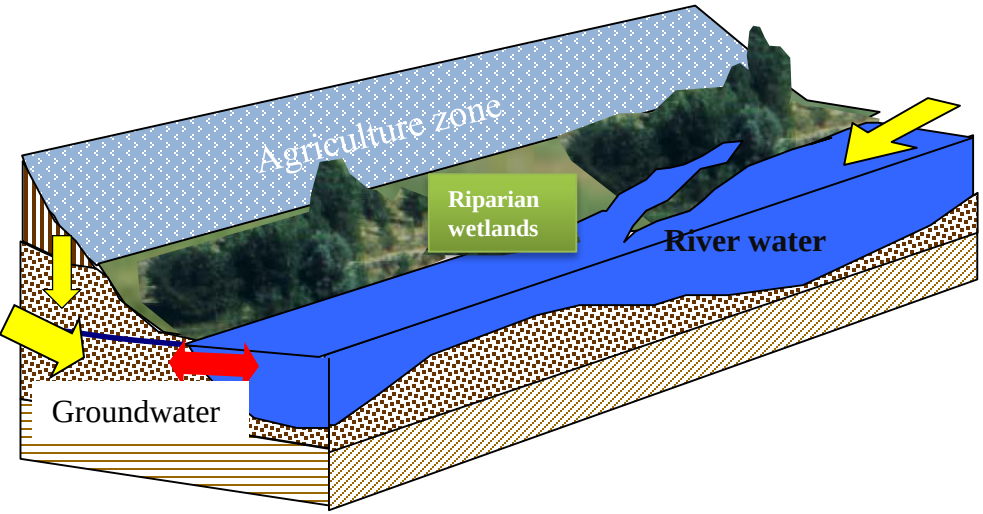
Introduction



Floodplain

- Biodiversity conservation
- Flood water retention
- Water quality control
  - e.g. NO_3 removal from agricultural area

Denitrification

riparian wetlands

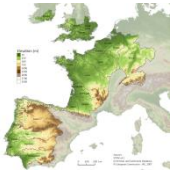
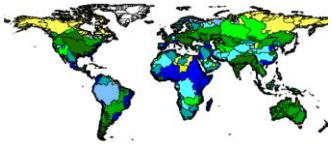
Groundwater ⇄ surface water

nutriment elements

organic matters

Hydrological Models



1 km² | 10 km² | 1000 km² | 10 000 km² | 100 000 km² | 1 000 000 km²

Physically based model

Complex

Require detail input data

Long computation time

MODFLOW
Mcdonald and Harbaugh 1988

MOHID
Braunschweig et al., 2004

Conceptual model

Simple

Basic input data

SW-GW exchange is not included

Empirical model

Input ex: precipitation

Output ex: discharge

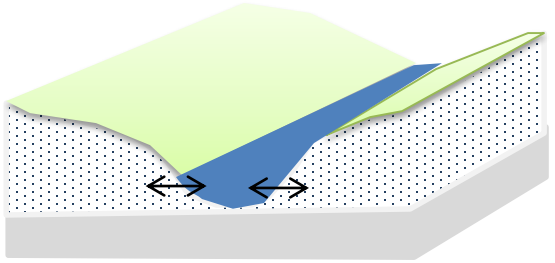
Seibert et al. 1997

GR4J
Makhlouf 1994

GR1A
Perrin et al. 2007

Objectives

- Quantify SW-GW exchange in the floodplain



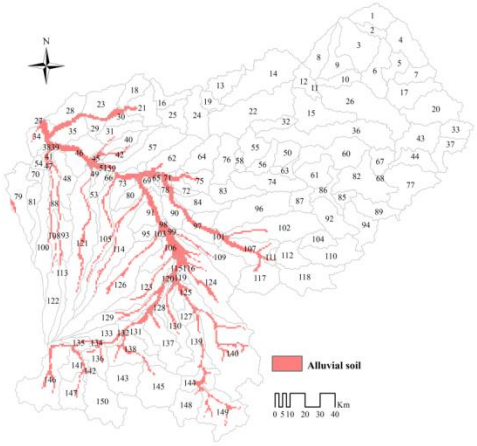
- Quantify nitrate removal in a simplified way

NO_3 + Carbon

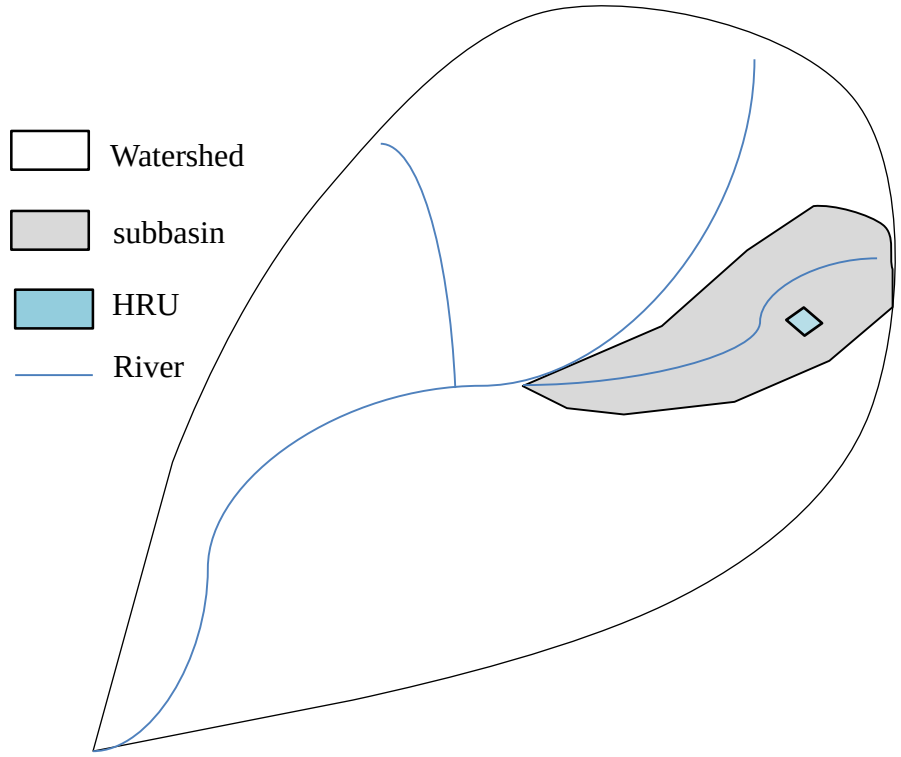
↓

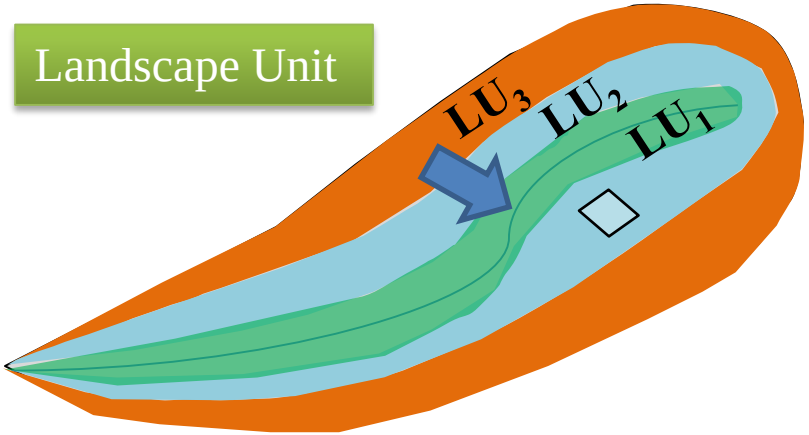
Denitrification

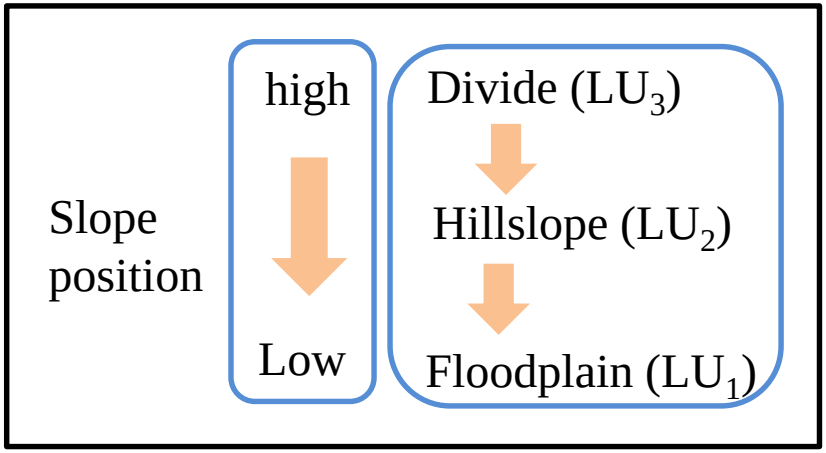
- Apply at large catchment scale



SWAT-LU (Landscape Unit) model

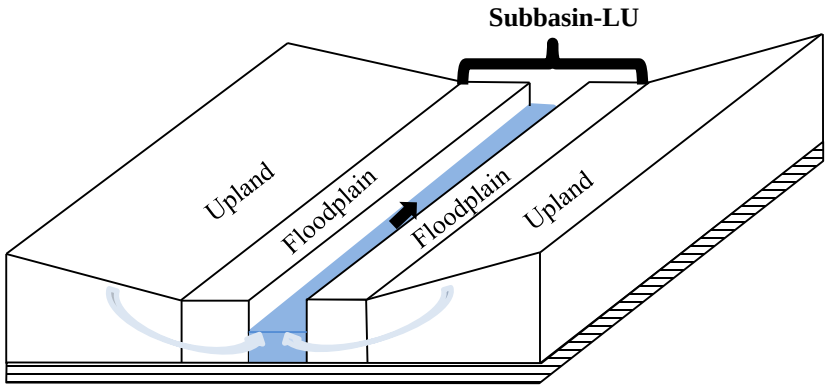


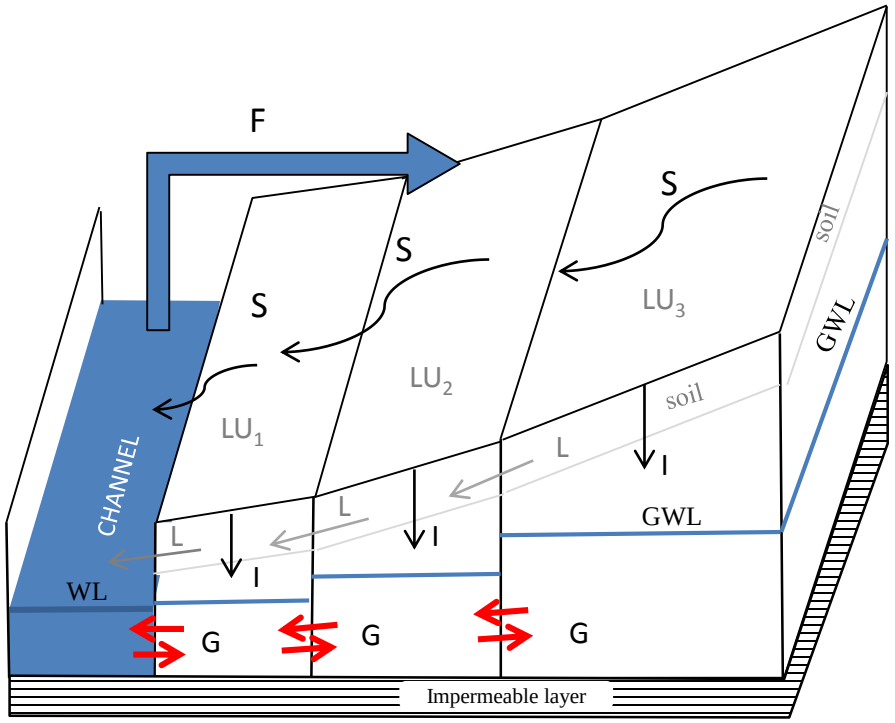




Volk et al. 2007

SWAT-LUD (Landscape Unit Darcy) model

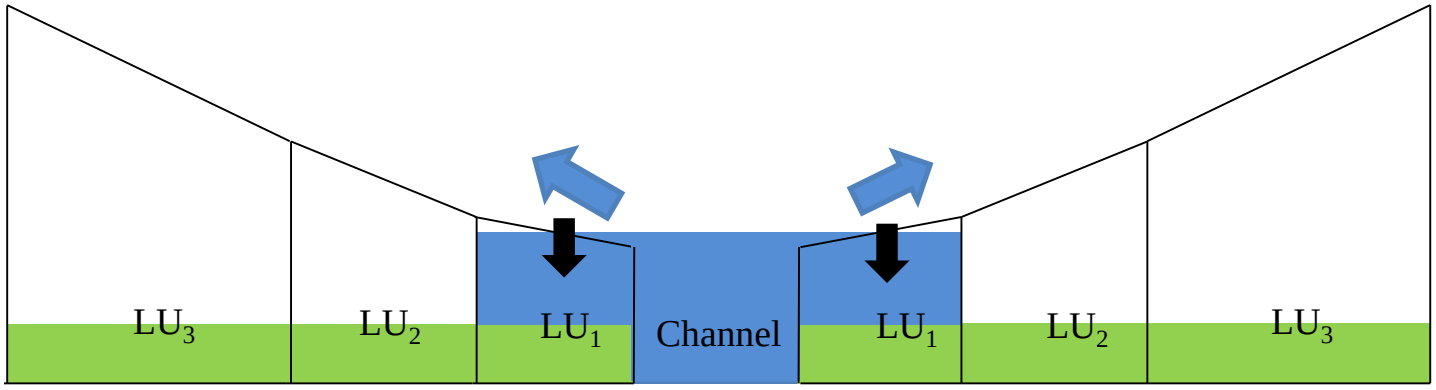




Subbasin-LU

Darcy's equation (1856):

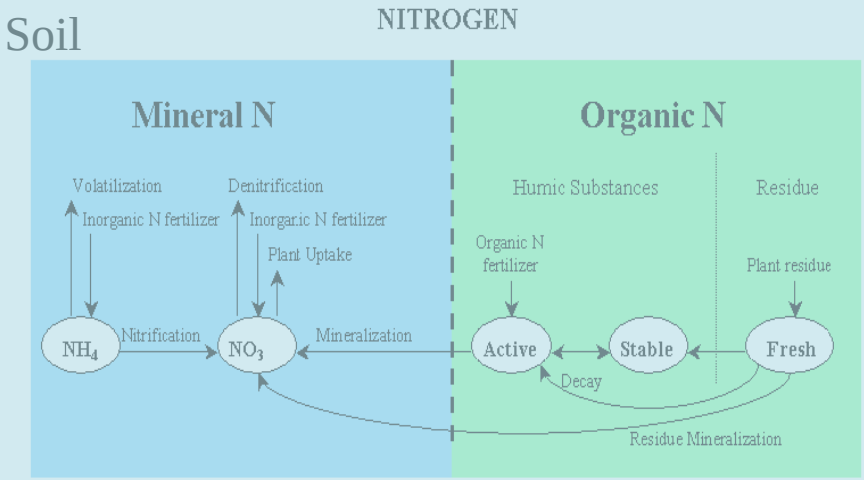
$$Q = K \times A \times \frac{\Delta H}{L}$$

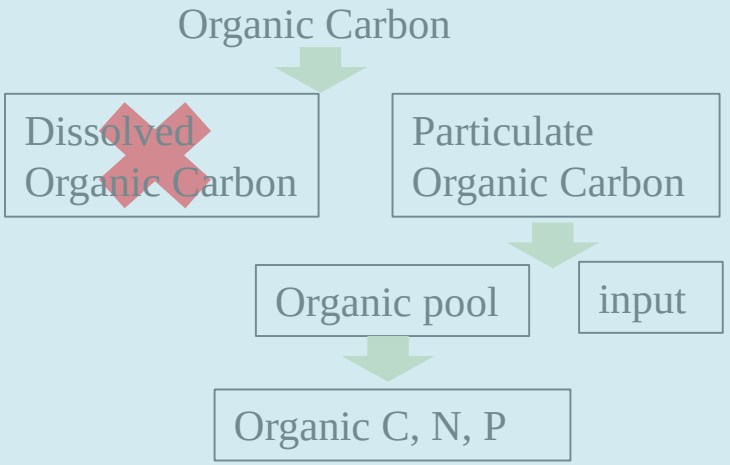


Based on flooded water volume

Sun et al. Hydrological processes. Accepted

Nitrogen and organic carbon in SWAT-LUD model



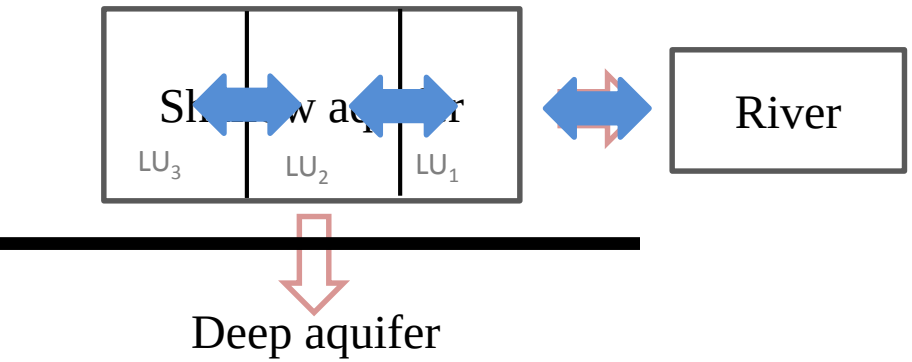


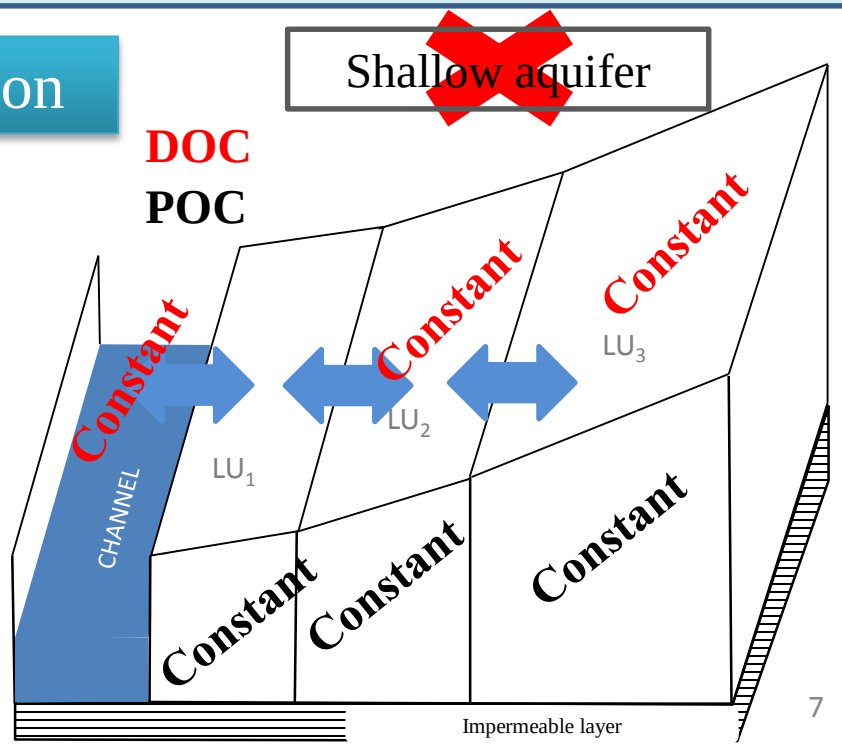
Plant uptake

Leaching

Flood leaching

Denitrification





SWAT-LUD model-denitrification

Nitrate consume rate:

$$R_{NO3} = -0.8(\rho \frac{1-\varphi}{\varphi} . k_{POC}[POC] . \frac{10^6}{M_C} + k_{DOC}[DOC]) . \frac{[NO3]}{k_{NO3}+[NO3]} . anaerobiose\ term$$

DOC consume rate:

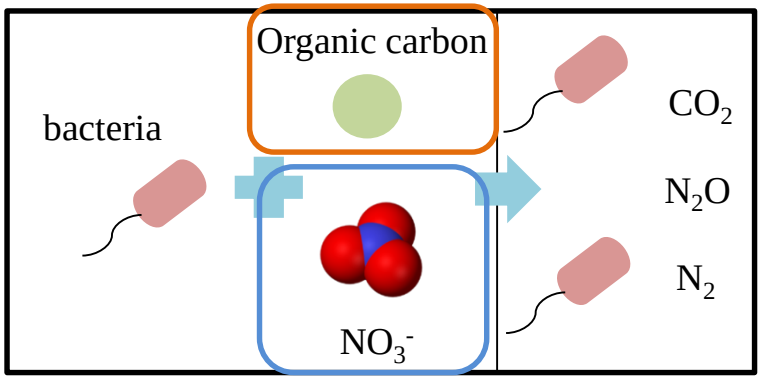
$$R_{DOC} = -k_{DOC}[DOC]$$

POC consume rate:

$$R_{POC} = -k_{POC}[POC]$$

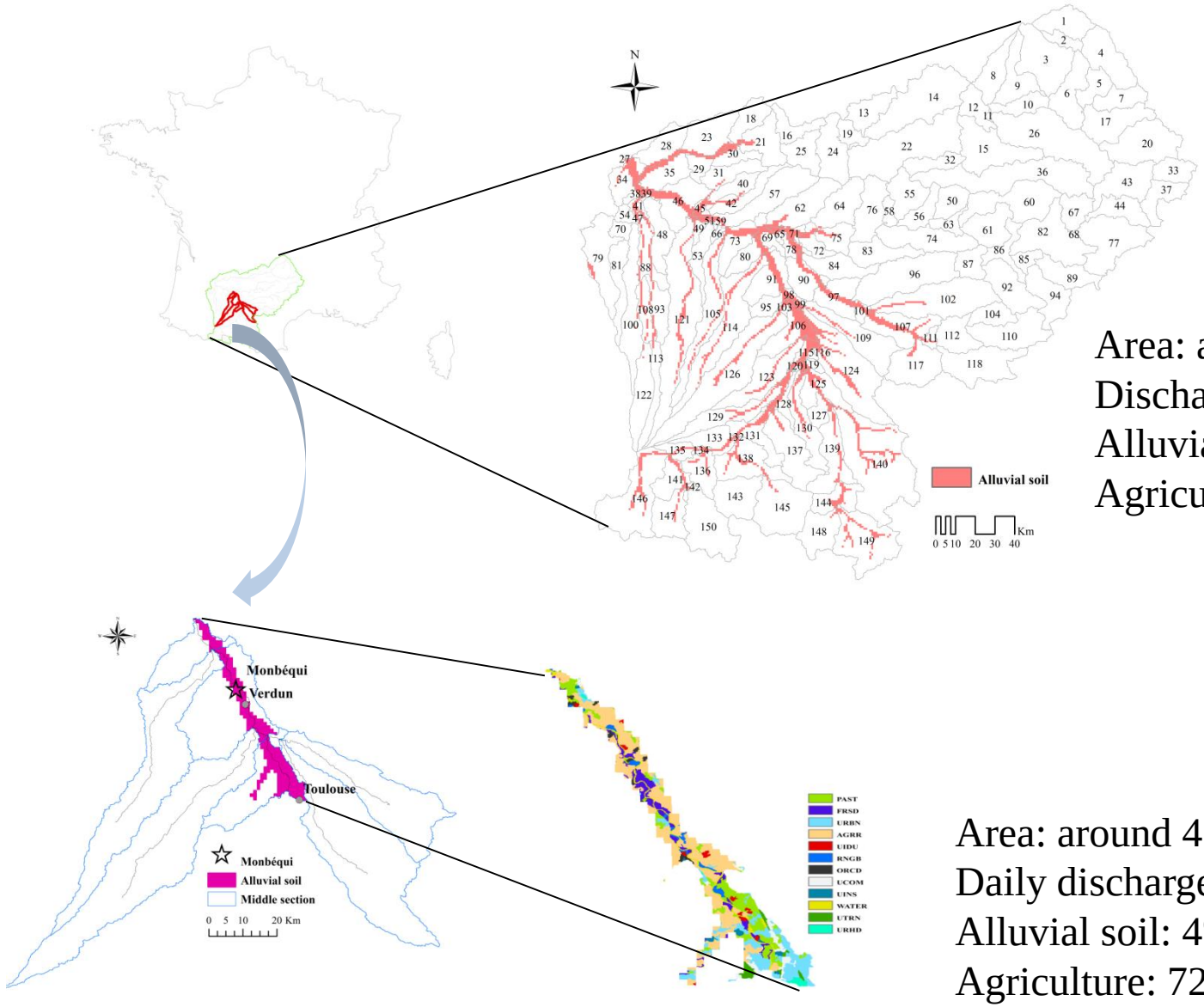
POC → particulate organic carbon

DOC → dissolved organic carbon



Parameters	Units	Description
φ	-	Sediment porosity
ρ	kg.dm^{-3}	Dry sediment density
k_{POC}	d^{-1}	Mineralisation rate constant of POC
k_{DOC}	d^{-1}	Mineralisation rate constant of DOC
k_{NO3}	µM	Half-saturation for nitrate limitation

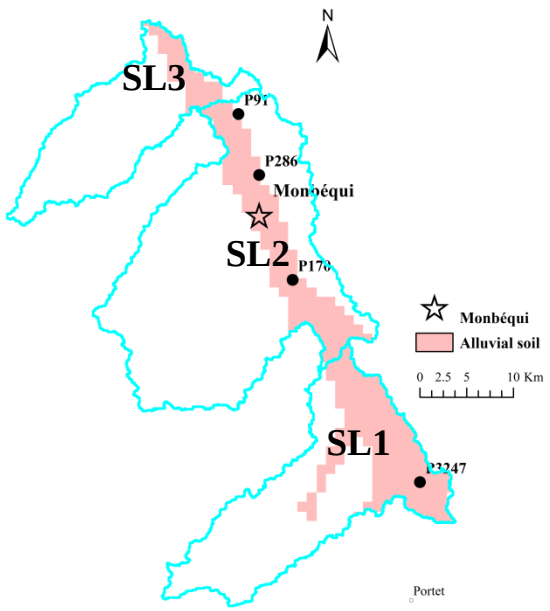
Study sites



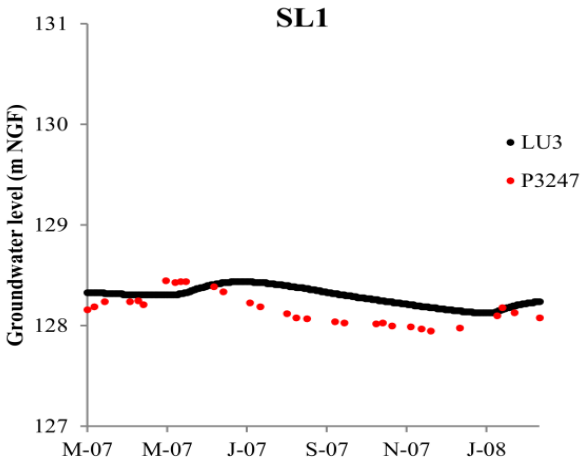
Area: around 51 500 km^2
Discharge: 600 m^3·s^{-1}
Alluvial soil: 6%
Agriculture: 31%

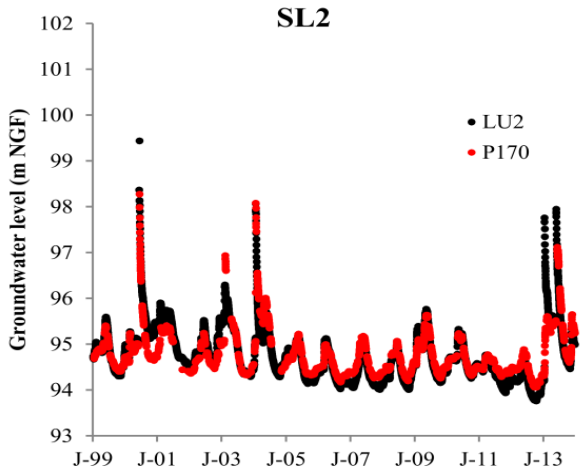
Area: around 4 600 km^2
Daily discharge: 200 m^3·s^{-1}
Alluvial soil: 4%
Agriculture: 72%

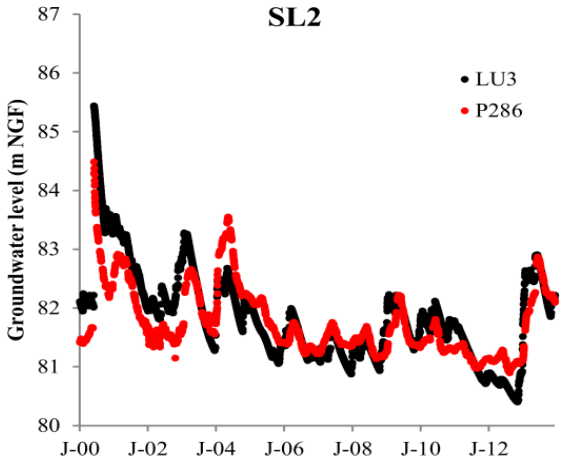
Results – floodplain section

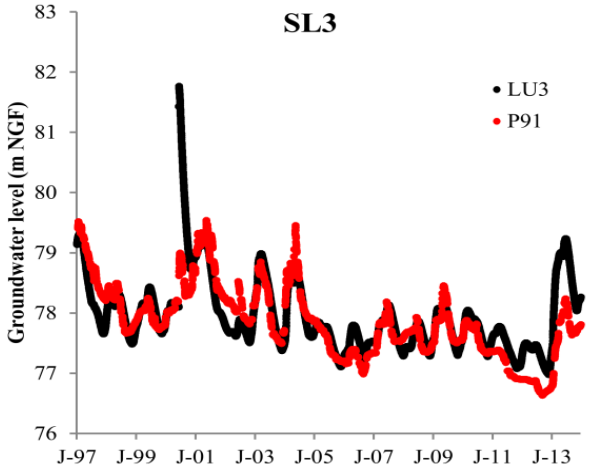


Input: discharge of Portet
Nitrate input: 5mg·L^{-1}

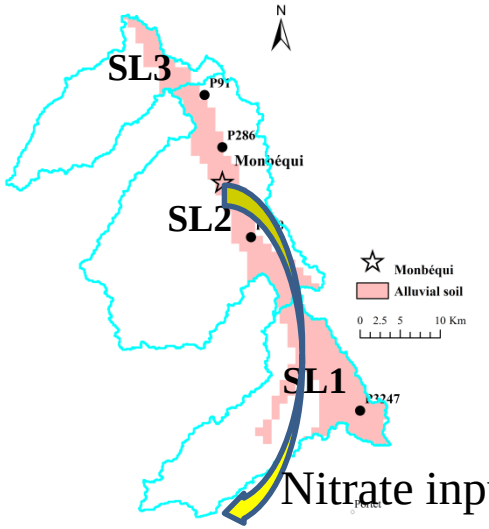




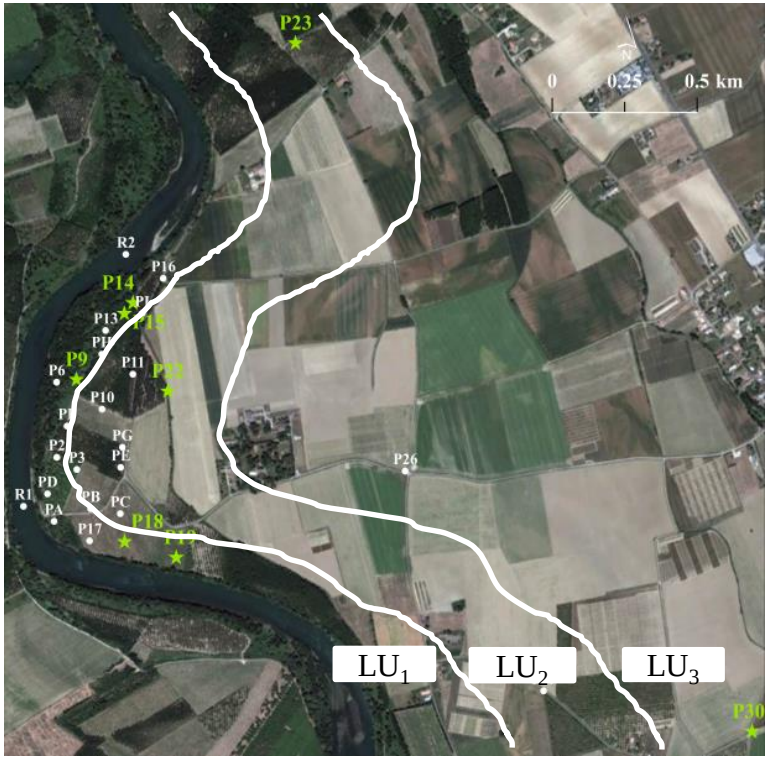




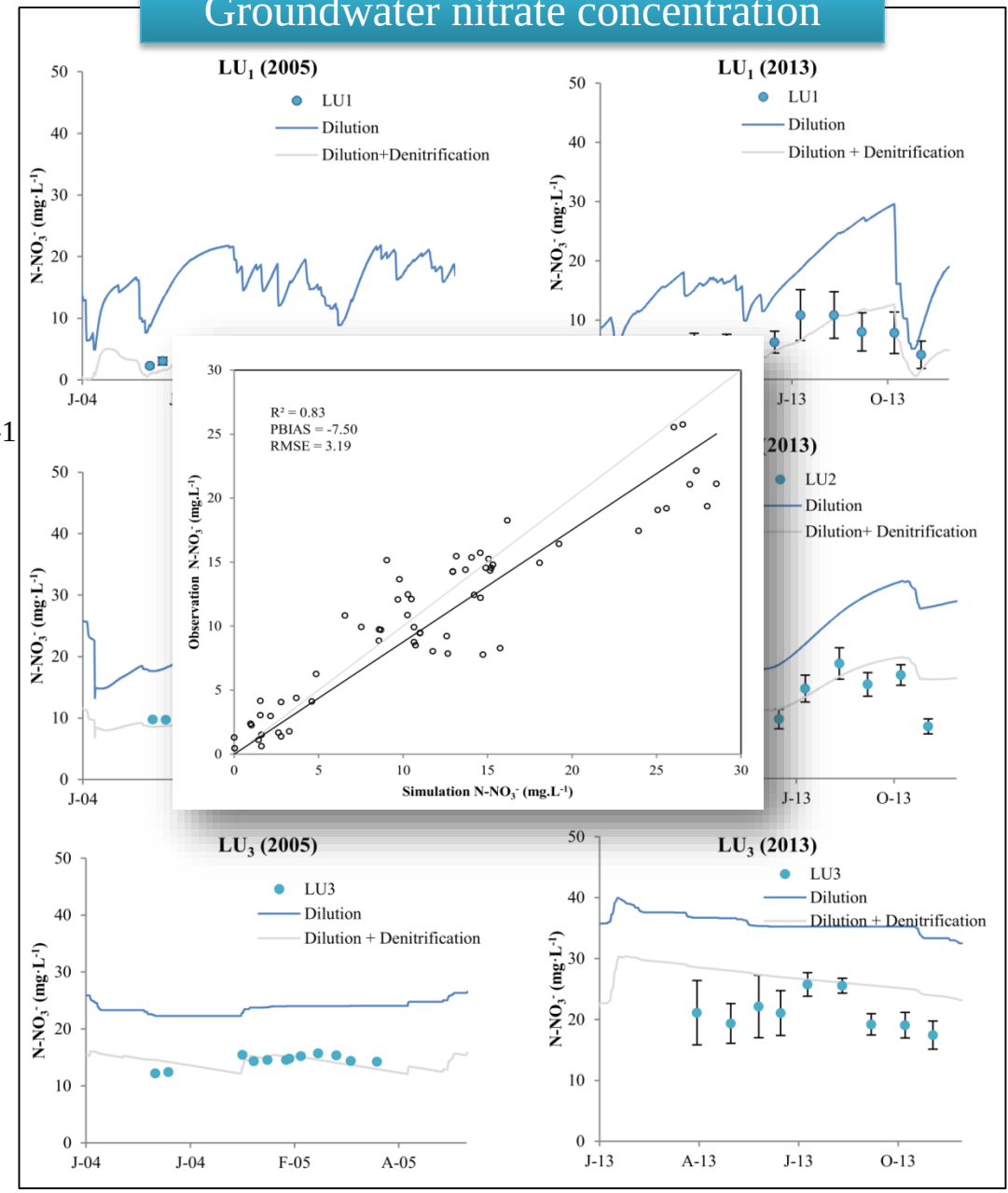
Results – Floodplain



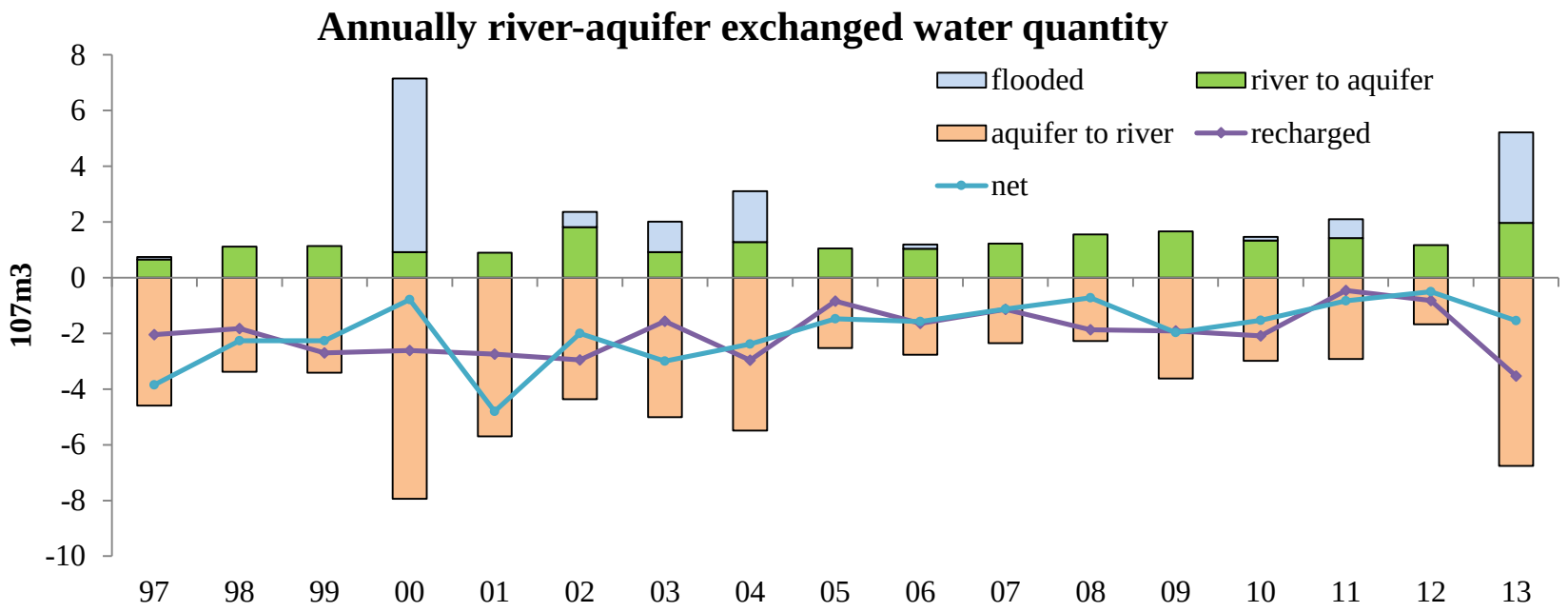
Nitrate input: 5 mg·L^{-1}

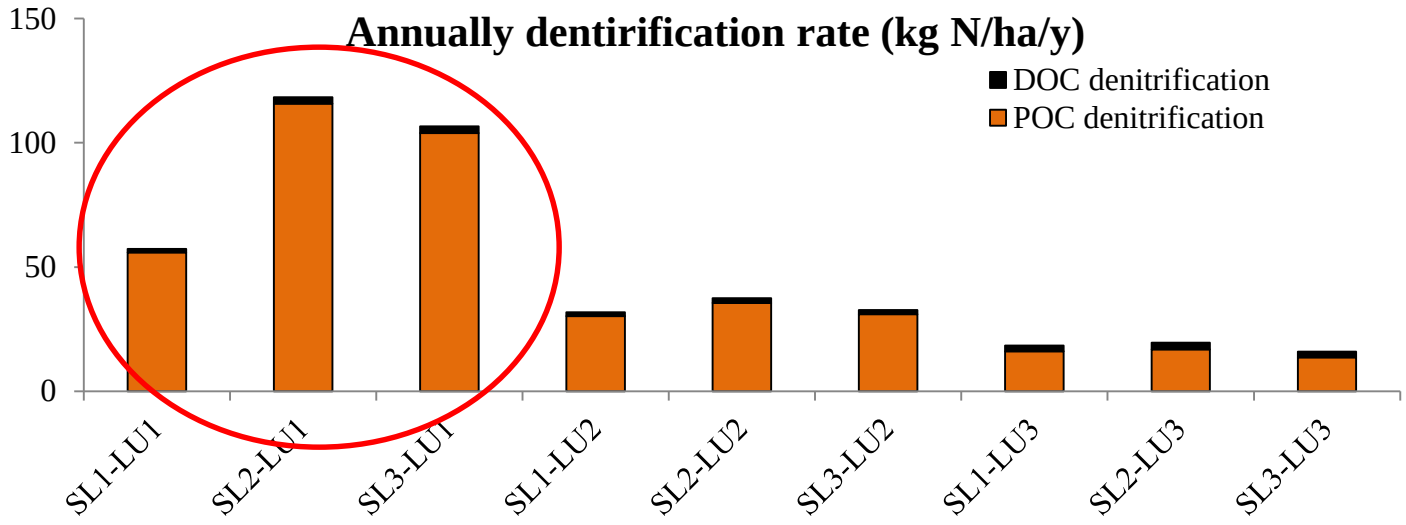


Groundwater nitrate concentration

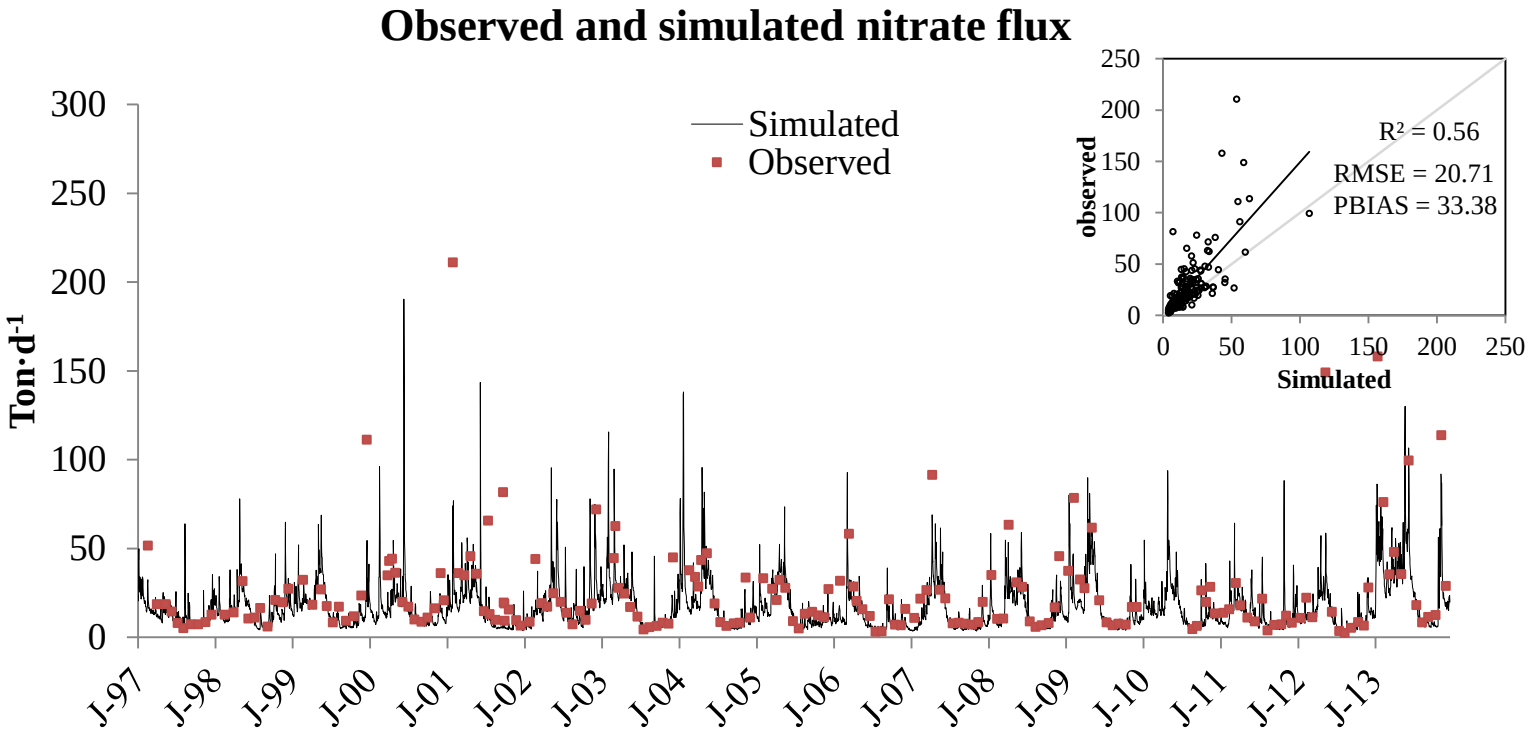


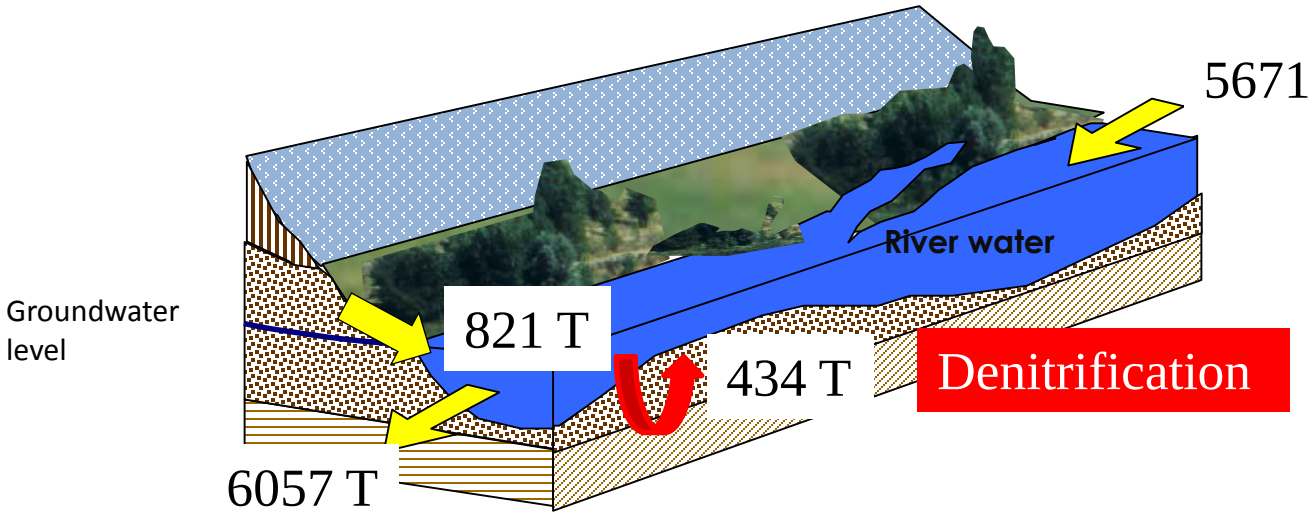
Results – Floodplain



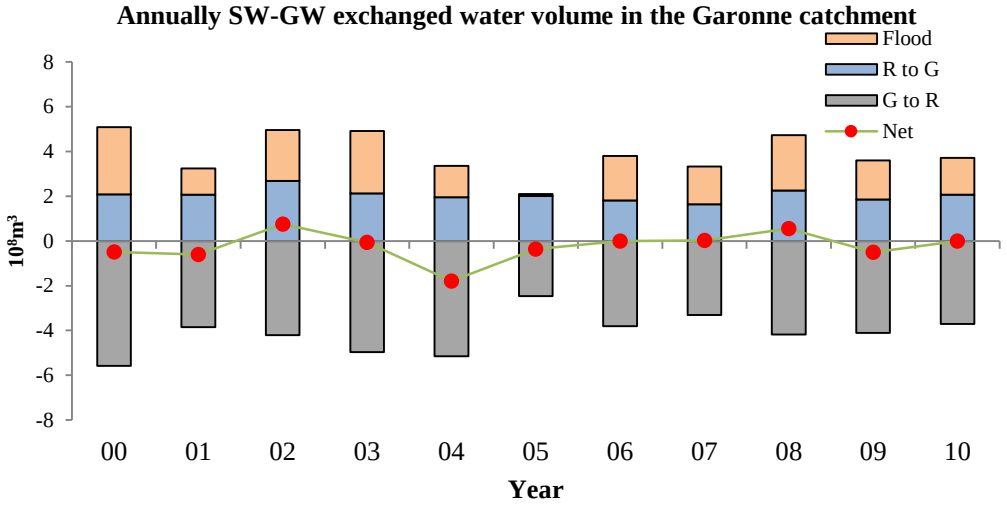


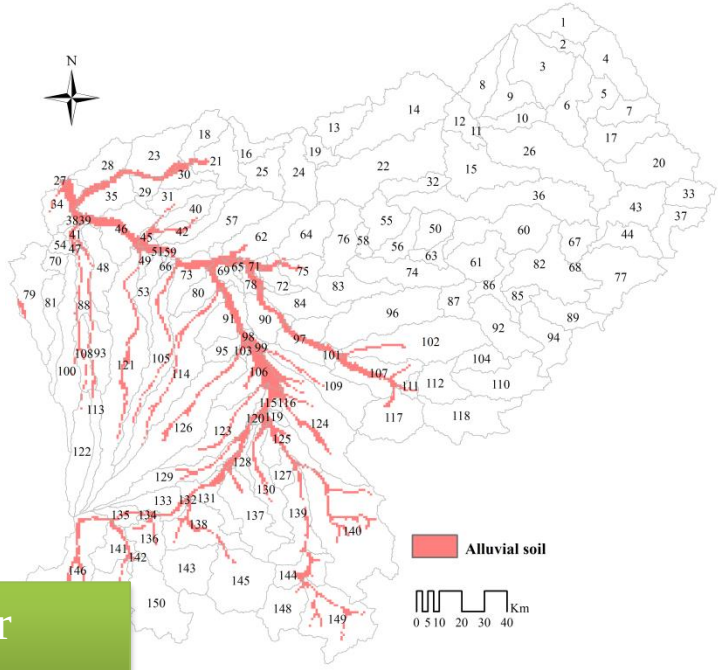
Results – Denitrification



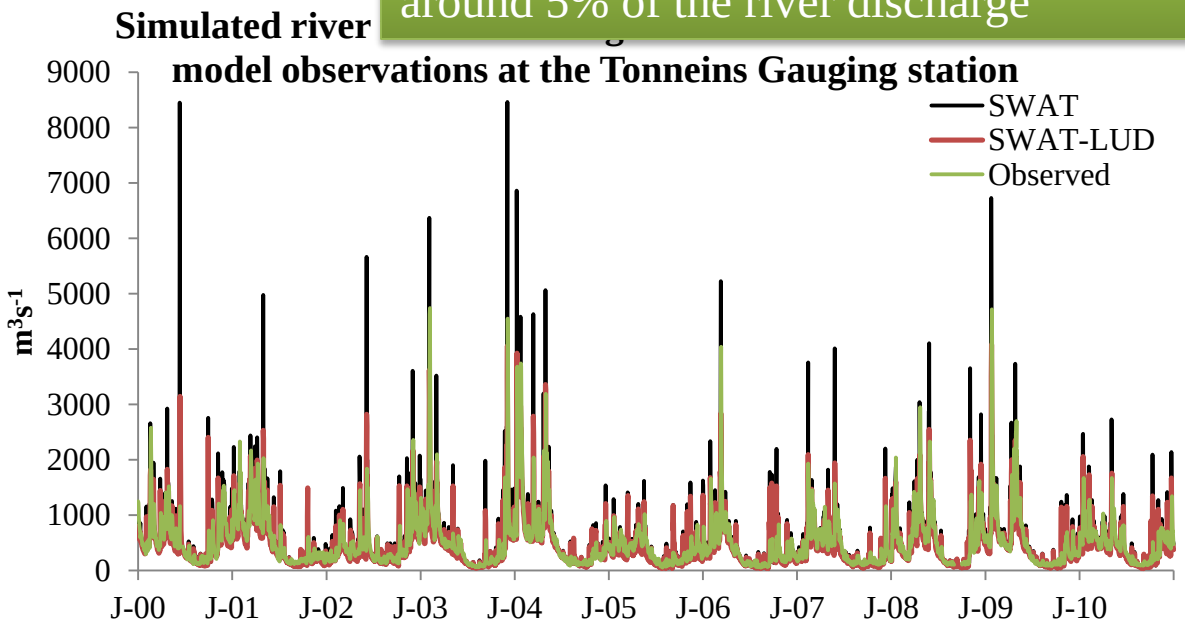


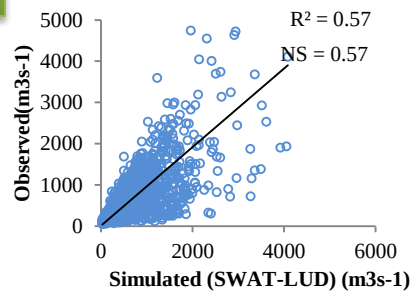
Results – Garonne Catchment

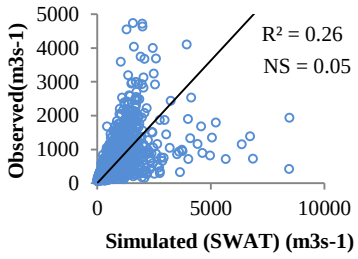




SW-GW exchanged water accounted for around 5% of the river discharge







Conclusion and perspectives

Conclusions

- SWAT-LUD could represent the SW-GW exchange and shallow aquifer denitrification appropriately at the floodplain scale
- The main water flow direction is from aquifer to river: 66% of the total exchanged water volume
- Consumed nitrate correspond to 50% of nitrate originated from the surrounding area

Perspectives

- Simulation of dynamic variation of organic carbons
- Connection of upland and floodplain subbasin-LU
- Sensitivity analyses of the added parameters
- Application of the SWAT-LUD model at large catchments

THANKS

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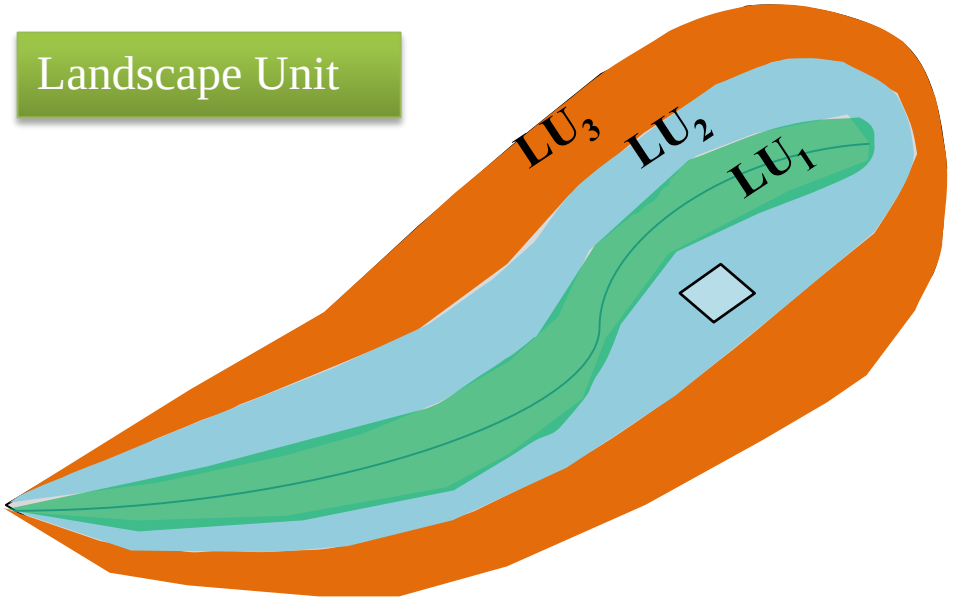
Definition of Landscape Unit



Flood return area

- LU1: one-year return flood area
- LU2: two to five years flood return area
- LU3: ten or more years flood return area

The area has the probability to be flooded in certain period (N years)