Factors controlling spatial patterns and time trends of multiple pesticides in groundwater (Hesbaye chalk aquifer, Belgium)

Vivien Hakoun, **Philippe Orban**, Alain Dassargues & Serge Brouyère

(p.orban@ulg.ac.be)

9th International Association of Hydrological Sciences (IAHS) Groundwater Quality 2016

Southern University of Science and Technology (SUSTech)

July 25-27, 2016

Université de Liège

Challenges

- Threat for groundwater resources
- Various (most often diffuse) sources
- Complex behavior in soil and groundwater (degradation, sorption…)
- At very low concentration/below detection limits
- Much more complex to study than classical agricultural pollutants such as nitrate

=> Need for a systematic methodology to determine the main factors controlling spatial pattern and temporal trends of pesticide concentrations in groundwater.

Methods

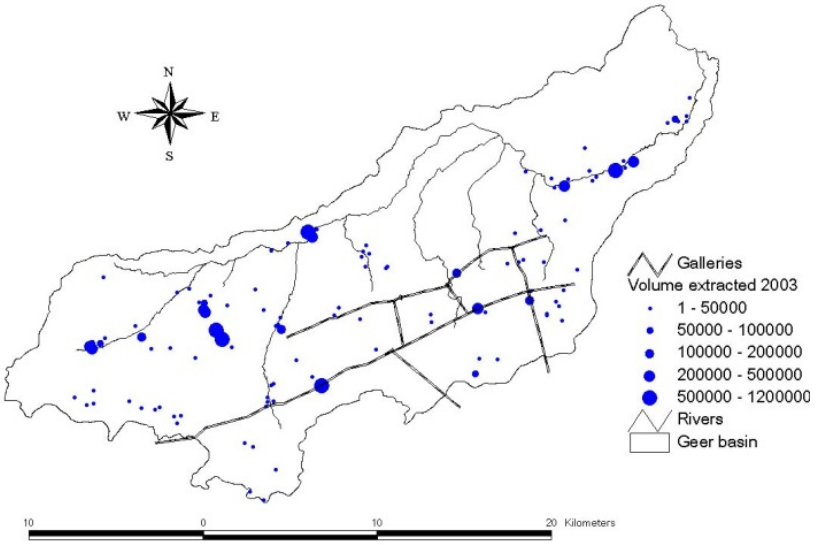
Université de Liège

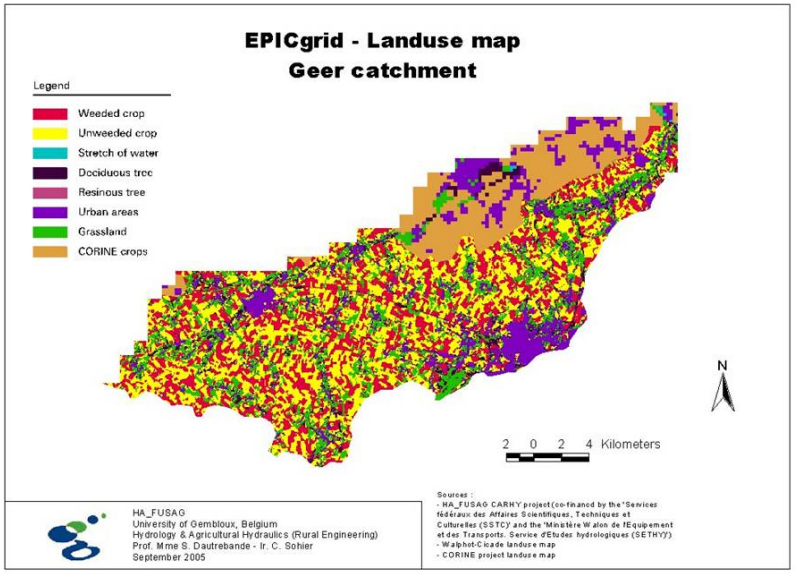
Combination of different methods/tolls :

1° Data collection on pesticides and hydrogeological data	
2° Analysis of leachability	GUS Indicator (Gustafson, 1988)
3° Account of concentrations below detection limits	Robust Regression on Order Statistic (ROS) (Helsel, 2011, 1988)
4° Multicriteria analysis and clustering	PCA and HCPC
5° Trend analysis	Theil-Sen slope estimator (Theil, 1950)

Case study : The Hesbaye chalk aquifer

30 millions m³/year of drinking water to supply approx. 600,000 people in the region of Liège





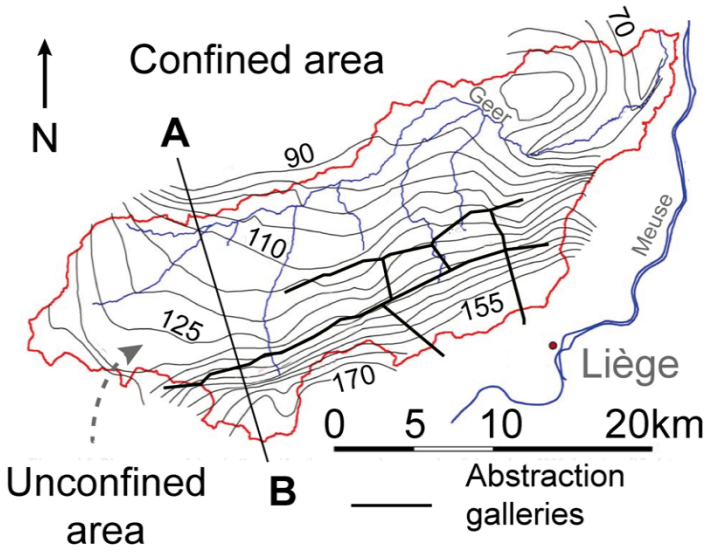
Intensive agriculture (65% of the basin) nitrate concentrations approach or are even above the drinking water threshold of 50mg/L NO_3

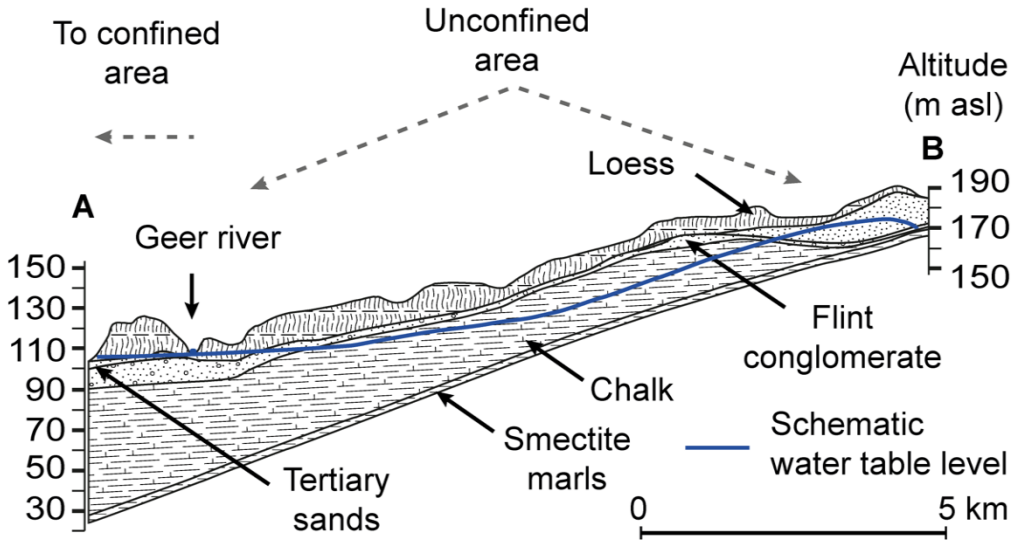
The Hesbaye chalk: **site** and monitoring networks

Both unconfined (South) and confined (North) contexts

Regional groundwater flow from South to North

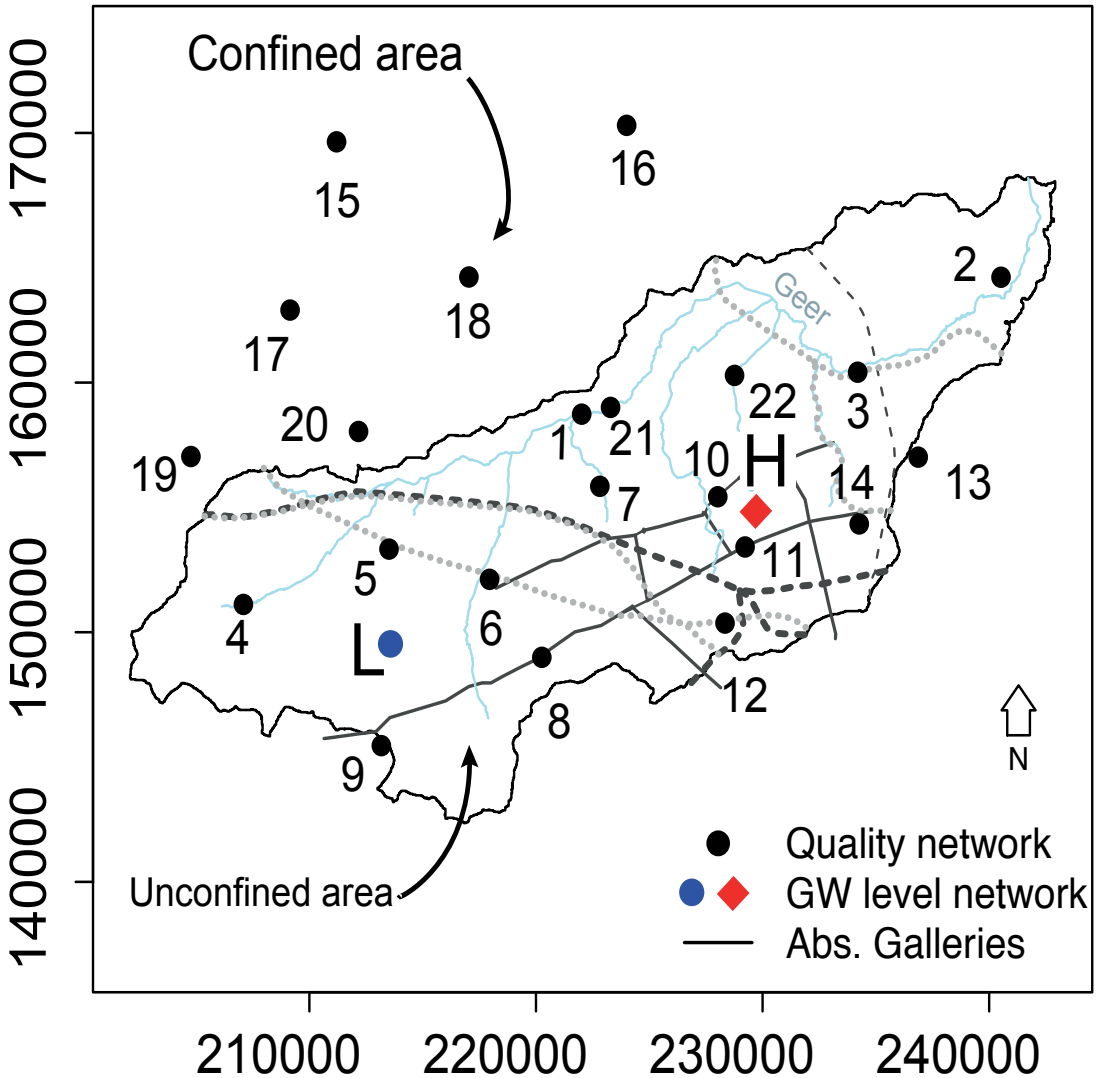
Thick layer of loess above the chalk





We expect the aquifer setting (and other factors) to play a role on the spatial and temporal patterns of pesticide compounds concentrations

The Hesbaye chalk: site and **monitoring** networks



- 2 sites with contrasting water level variability

Dedicated piezometers

- **22 sites** for groundwater quality (6 confined & 16 unconfined)

Mostly abstraction sites

- **Long time series** of pesticide concentrations collected from water companies and federal agency

Time range: 1996-2013

Highest sampling freq.: 4 months

- Long time series of NO_3^-
- Snapshot (2005) of ^3H

The Hesbaye chalk: Pesticides data

Université de Liège

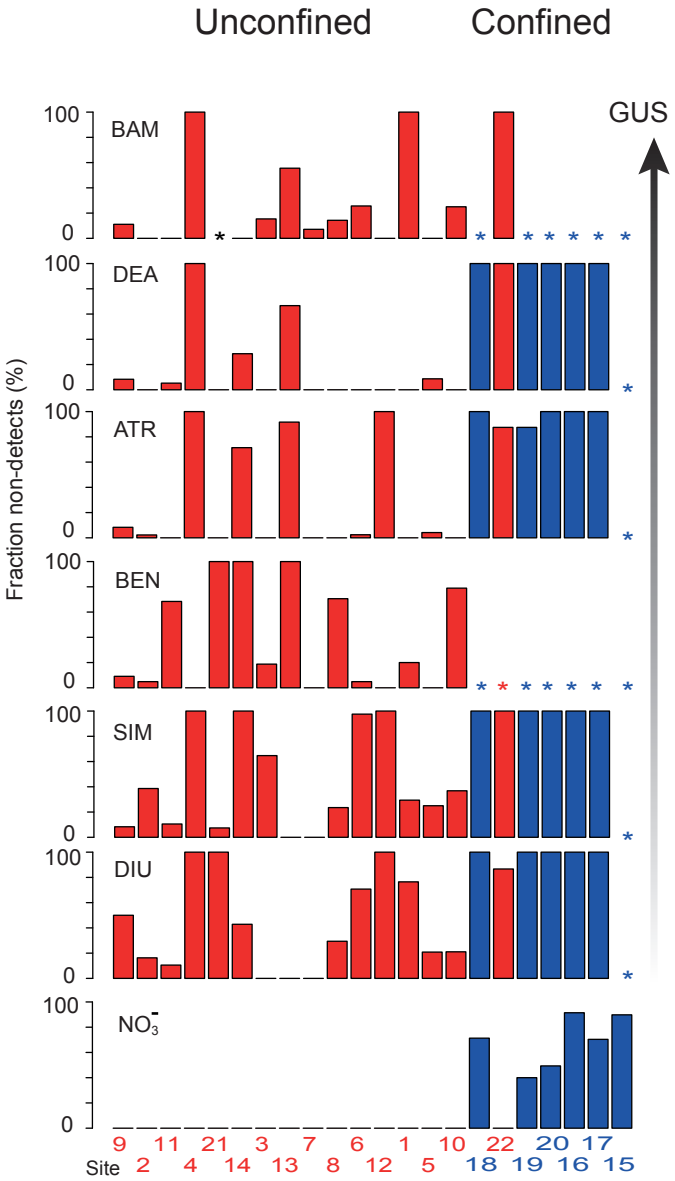
Focus on 4 pesticides and 2 metabolites :

- *withdrawn*: **atrazine, diuron, simazine** & *regulated*: **bentazone**
- **DEA**: desethylatrazine and **BAM**: 2,6-dichlorobenzamide

Advantages :

- Contrasting leachability properties (very high for bentazone and atrazine, low for diuron and simazine),
- Different use (mainly agriculture for atrazine and bentazone, while dedicated to urban areas for diuron and simazine),
- Use of withdrawn pesticides but with long available time series to identify key factors

Results: spatial patterns – Aquifer setting

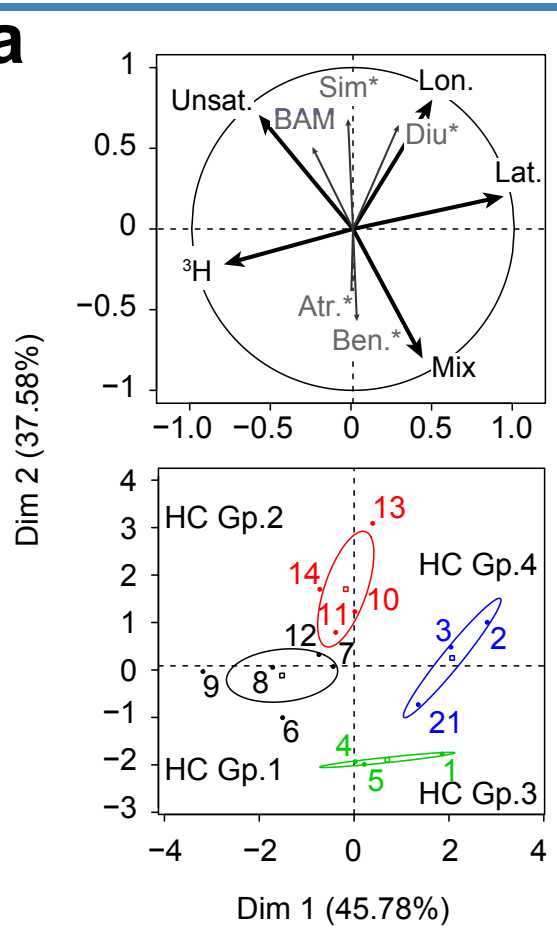


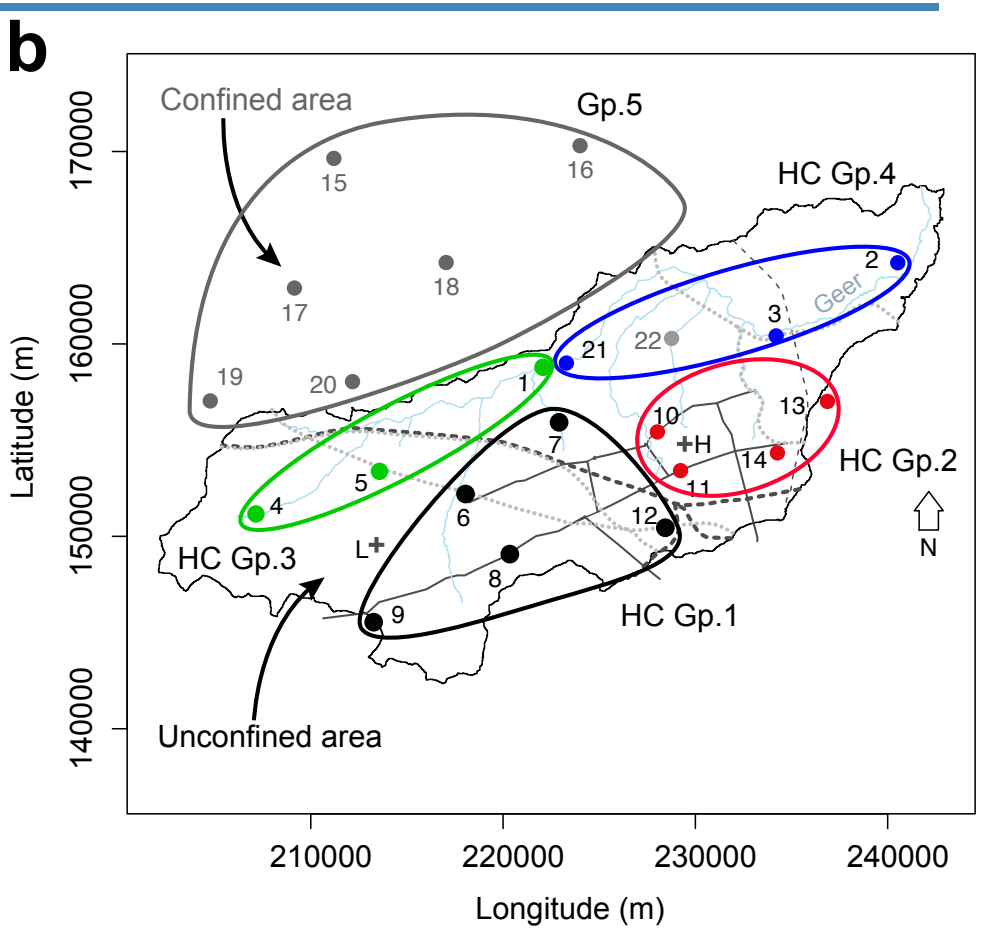
Confined area shows non-detects fraction > 80%

Nature of concealment (confined v. unconfined) explains variability in non-detects fractions over the entire aquifer

GUS does not clearly explains variability in non-detects fractions in the unconfined area

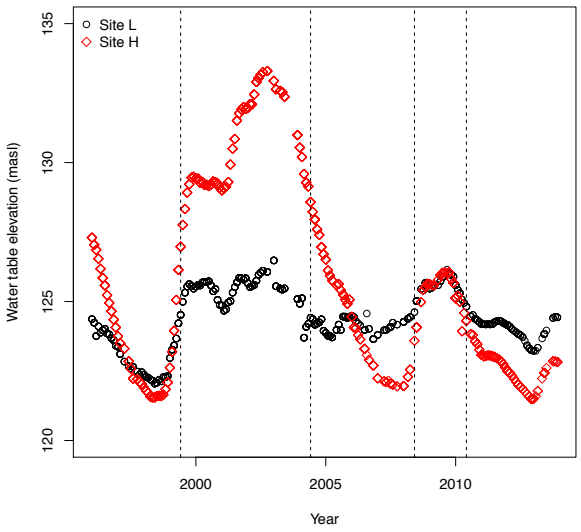
Results: spatial patterns – Unconfined area





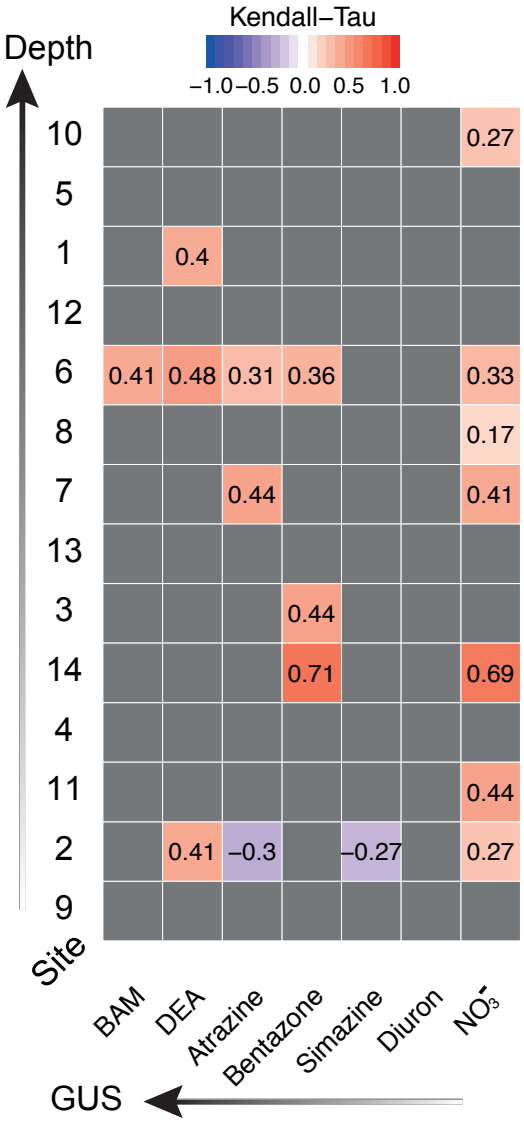
The combination of mixing, localization and hydrogeological setting influence the spatial distribution of pesticide compounds in the unconfined area.

Results: Temporal patterns – individual sites



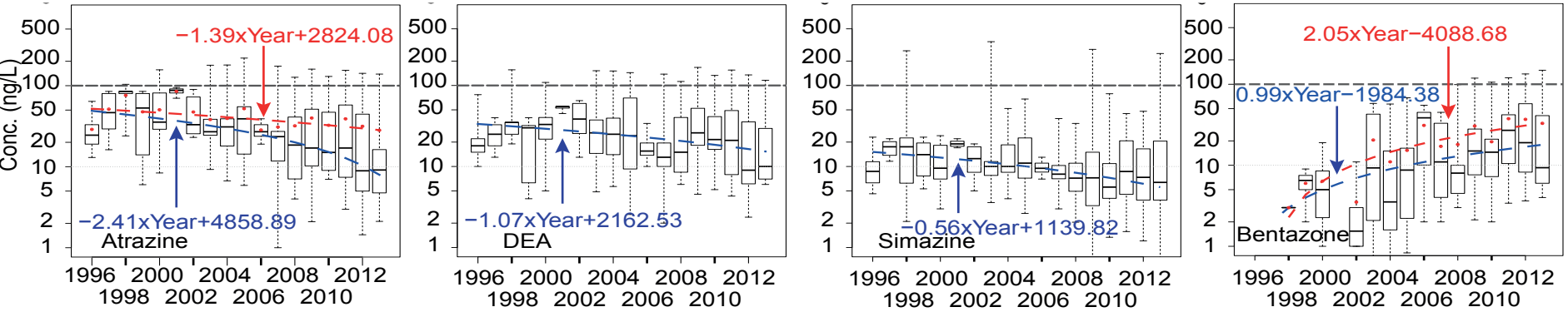
Multi-annual groundwater levels cycles. Reduced annual seasonality.

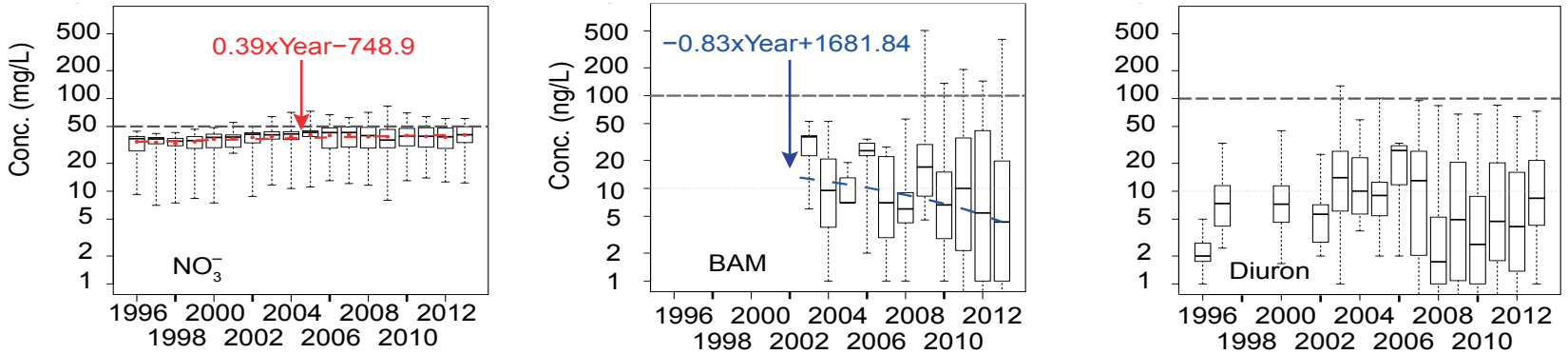
Remobilization of pesticide compounds occur due to multi-annual ground water level fluctuations and GUS partly explains variability in remobilization.



Results: Temporal patterns – Unconfined extent

Trend analysis performed on aggregated data: annual mean (red) and annual median (blue) for the whole unconfined area





Conclusions for the methodology

- GUS indicator is not enough to fully explain non detect and spatial distribution
- Multi criteria analysis combining pesticides concentrations and hydrogeological factors allows explaining the spatial pattern
- Even if site by site trend analysis is not possible, trend analysis on aggregated data gives a first understanding on temporal behavior

Conclusions for the case study

A combination of factors explains pesticide occurrence in the chalk

Factors influencing spatial patterns:

- Age of water
- Land use (urban and agriculture)

Factors influencing temporal patterns:

- Remobilization and leaching properties
- Application rates
- Low transit time

Acknowledgements

Research was funded by the European Community's Seventh Framework Programme (FP7/2007-2013 under grant agreement number 265063)

Thanks to
DGO3, CILE, SWDE and VMW and Santé publique, Sécurité de la Chaîne alimentaire et Environnement for providing data

V.H. acknowledges the support of the European Research Council (ERC) through the project MHetScale (617511)