

Transdisciplinarity approaches to analyzing hydrochemical time series: get a new look at data



Soil, Agro and HydroSystems
Rennes center



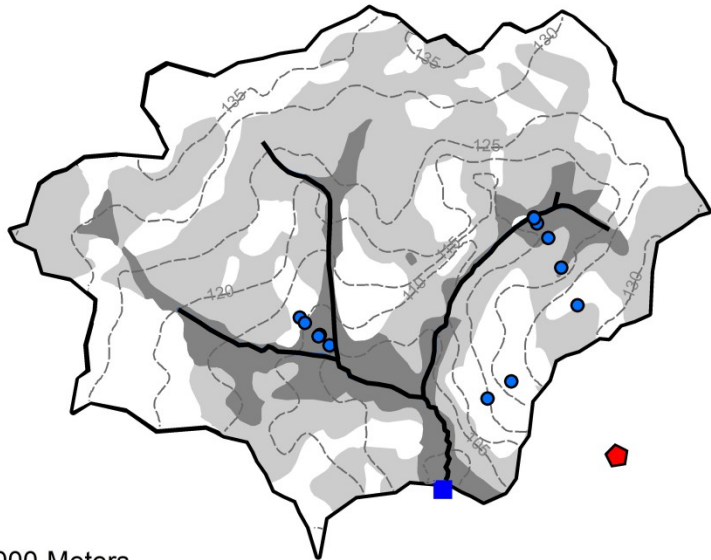
Workshop : High resolution water quality monitoring
Session 2 : Data driven analysis



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Kervidy-Naizin study site

Equipment and soils



- Outlet
- Well
- 120— Isoline of elevation (meters)
- Stream
- ◆ Weather station

Soil waterlogging classes:

- Well drained
- Intermediate
- Waterlogged

0 250 500 1 000 Meters

Meteorology: **Hourly**
 [solutes] / river: **Various***
 [major elements] / GW: **/3 months**
 Discharge: **/1 min**
 Water table depth: **/15 min**





Kervidy-Naizin study site

Various sampling rates of solutes in the river

Meteorology: **Hourly**

[solutes] / river: **Various***

[major elements] / GW: **/3 months**

Discharge: **/1 min**

Water table depth: **/15 min**

Manual
sampling,
Daily

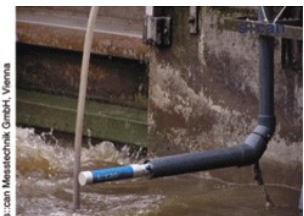
3 years of
about 30 elements

10 to 12 years of
NO₃⁻, DOC, Cl⁻ and SO₄²⁻

UV-spectrometry probe,
20-min.



1 year of
NO₃⁻ and DOC



OBJECTIVES

Many authors call for **extracting as much information from the data as possible.**

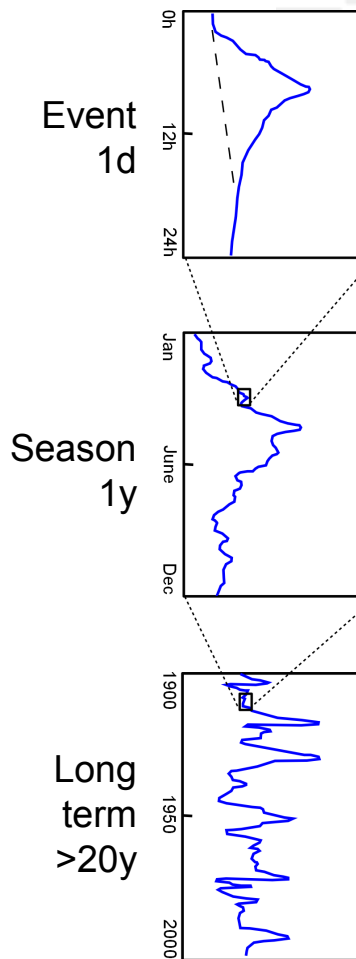
- *Babovic, HP, 2005*
- *Soulsby et al., HP, 2008*
- *Hrachowitz et al, HSJ, 2013*

“Reconciling environmental theory with observations [...] by defining **signatures** (dynamic, response, behaviours and patterns) [...] according to **conceptual filters**”

- *Gupta et al., HP, 2008*

1. **Defining signatures (+ methods)**
2. **... temporal variability**
3. **... hydro meteorological conditions.**

QUESTIONS



Q1- What is the mean annual pattern ?

Q3- Are there flood patterns ?

Q2- How does the mean pattern change with unusual hydro-meteorological conditions ?

Q4- What about studying signal structure to consider all time scales at once ?

• *Bloschl et Sivapalan, HP, 1995*

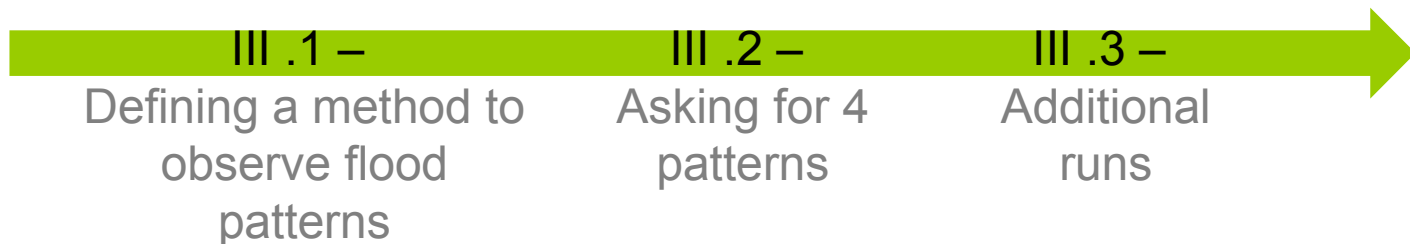


Flood patterns, on water chemistry



- ❖ Previous studies have observed flood patterns
 - Elements considered as tracers • *Morel et al., HP, 2009*
 - Use of flood descriptors, temporality loss • *Seeger et al., JoH, 2004*

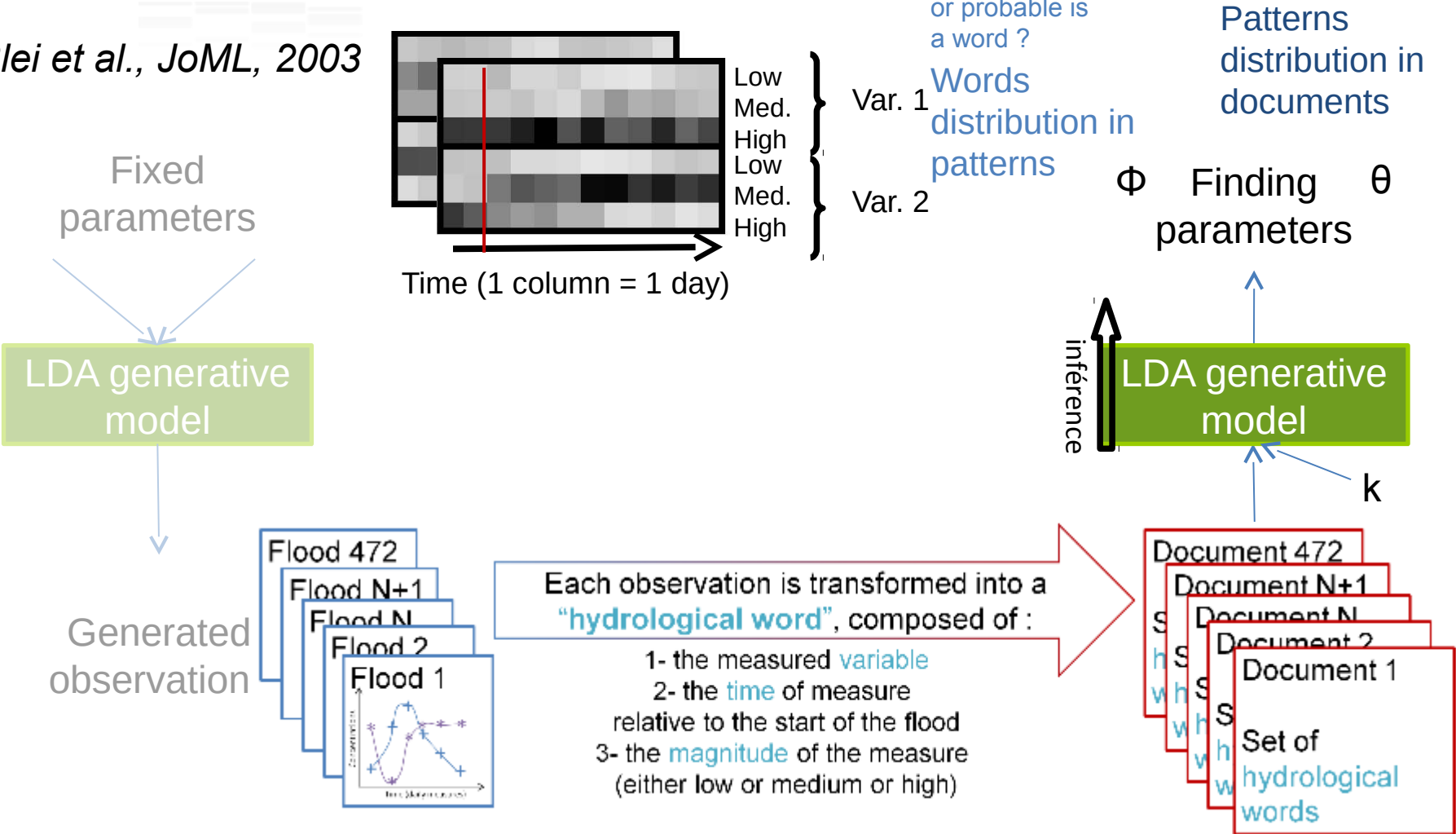
- ❖ We proposed to study
 - Several solutes at a time
 - On 12 yrs long records: 472 12-days periods
 - Using automated method newly applied in hydrology
 - Using a clustering method, as often used in quantitative hydrology



Defining a method to observe flood patterns

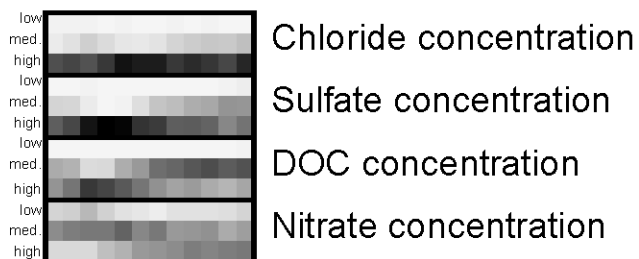
Latent Dirichlet Allocation

• Blei et al., JoML, 2003

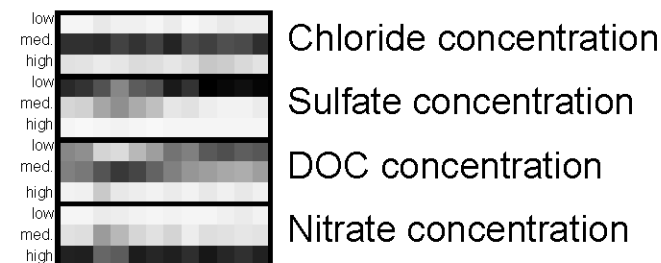


Asking for 4 patterns

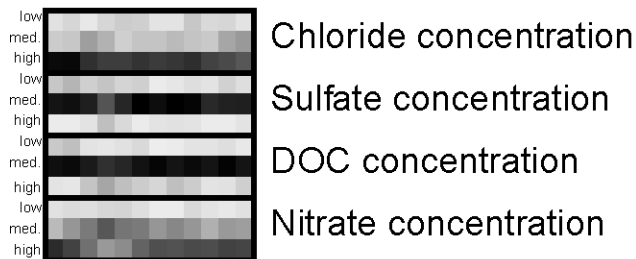
(a) Pattern 0



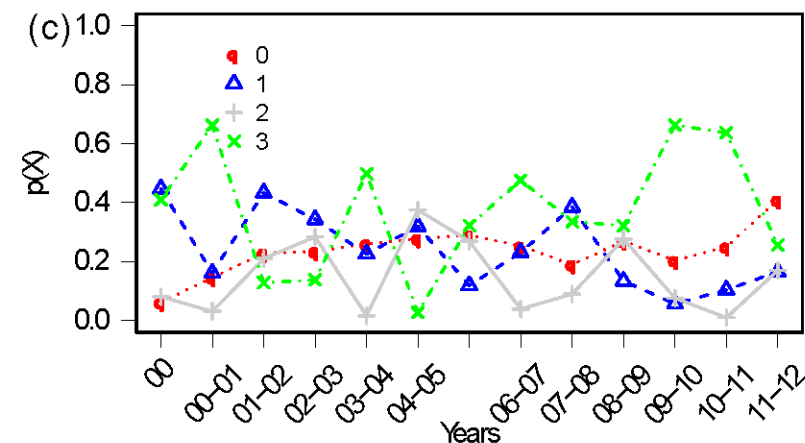
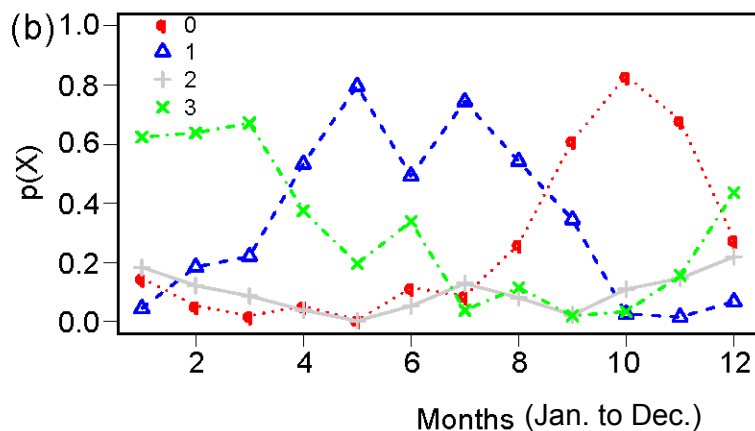
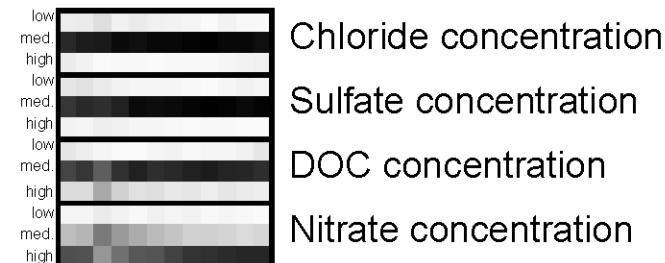
Pattern 1



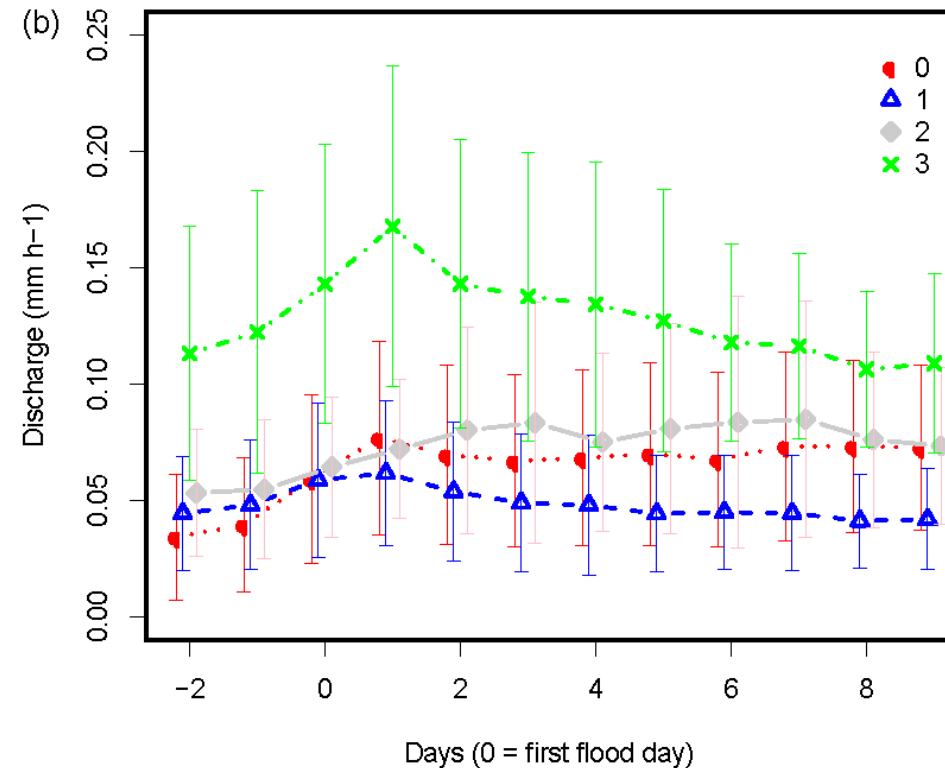
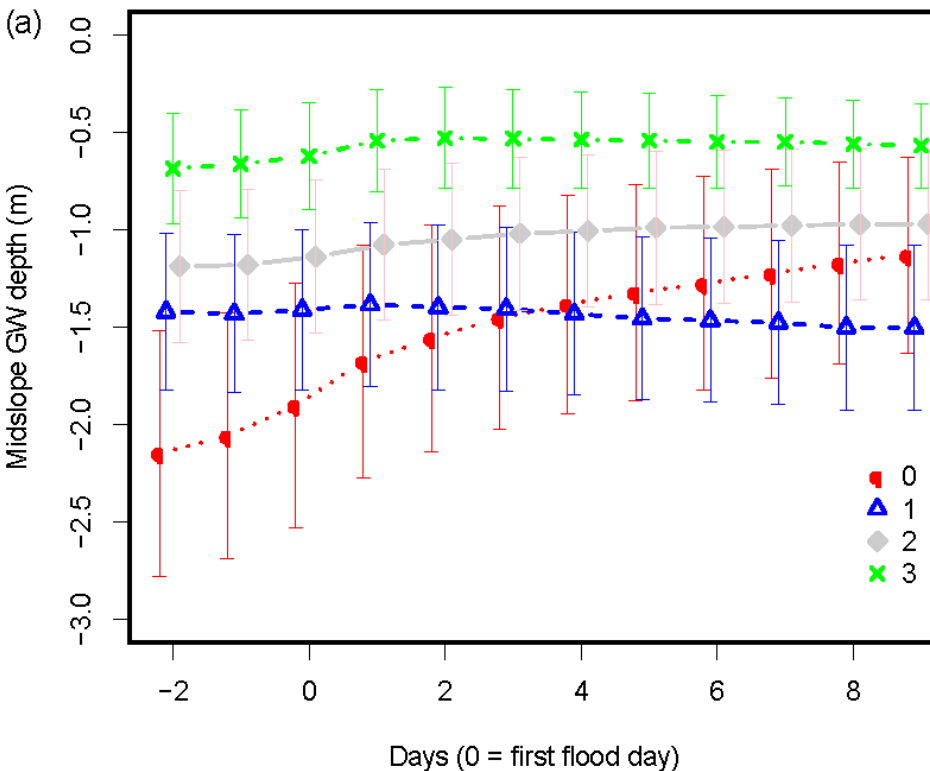
Pattern 2



Pattern 3



Hydrological insight



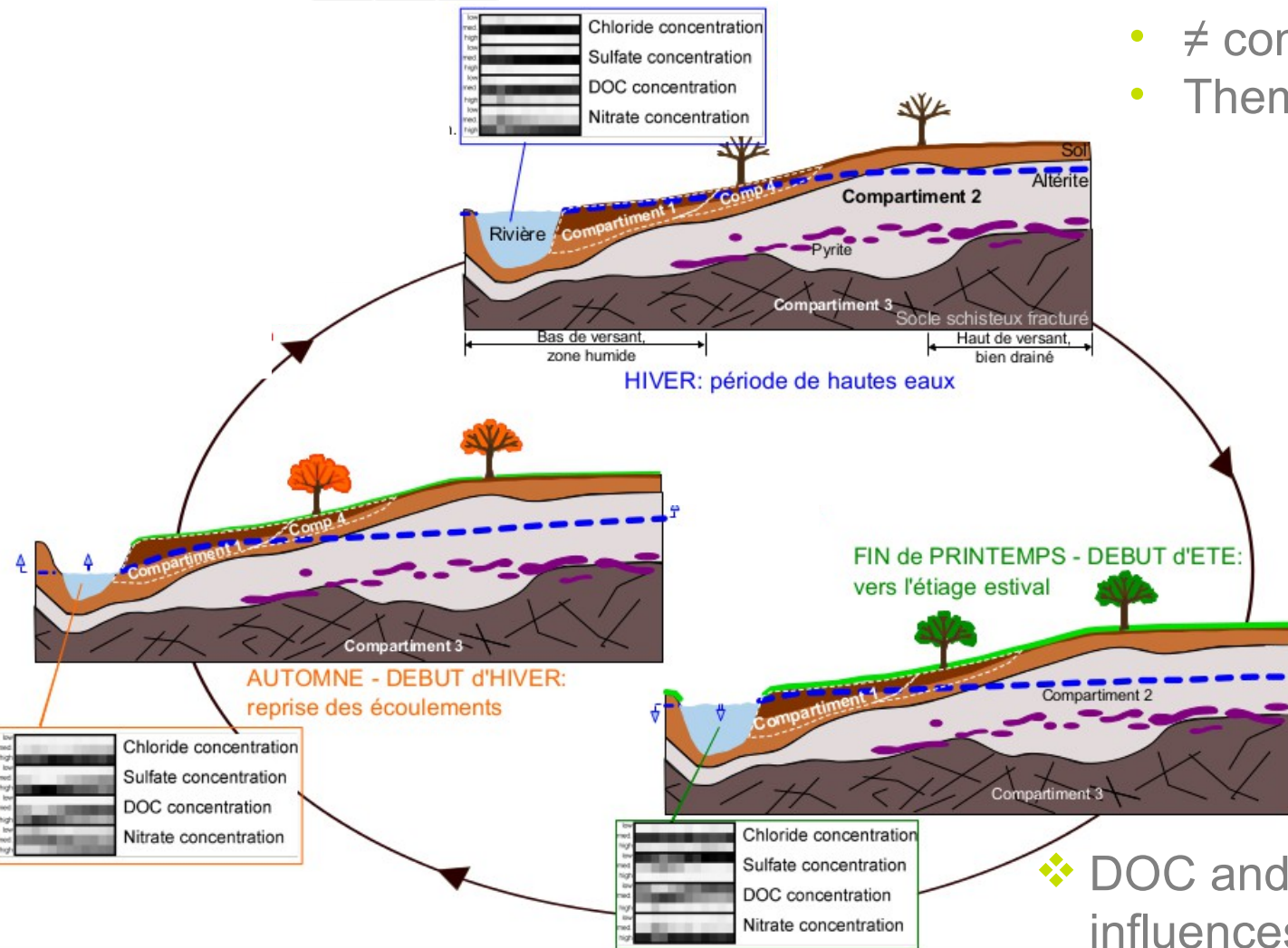
- ❖ A set of hydrological conditions corresponds to each pattern: an hydrologic season corresponds to an hydro-chemistry flood signature.

Flood patterns

Seasonality of flood chemistry


❖ Hydrometeorology → pattern distributions

- ≠ compartments
- Themselves, modified



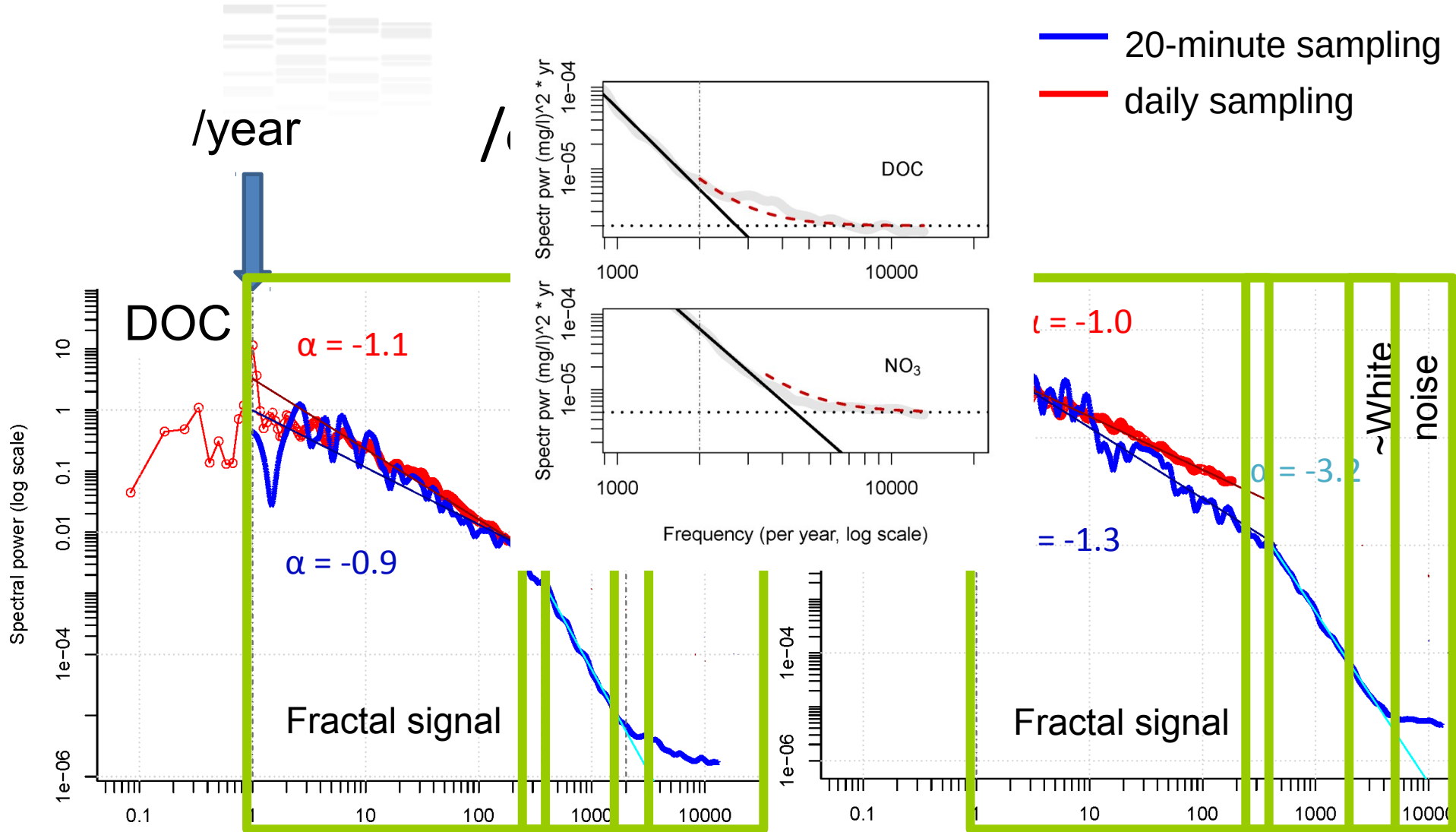
❖ DOC and SO₄²⁻ strongly influences patterns definition.

Studying signal structure

- 
- ❖ Sampling frequency is a key issue in the design of operation of water quality observatories
 - Temporal filter
 - Emerging technologies monitor water quality almost continuously
 - *Kirchner et al., HP, 2004*
 - *Halliday et al., Stoten, 2012*
 - Assessing the value of quasi-continuous monitoring data for spectral analyses of water quality
 - ❖ $1/f$ scaling was recently found all across the periodic table
 - On plynlimon observatory, which is rather pristine
 - Both for low- and high- frequencies • *Kirchner & Neal, PNAS, 2013*
 - Testing the universality of $1/f$ scaling on an intensively farmed catchment & many elements

Signal structure

— 20-minute sampling
 — daily sampling



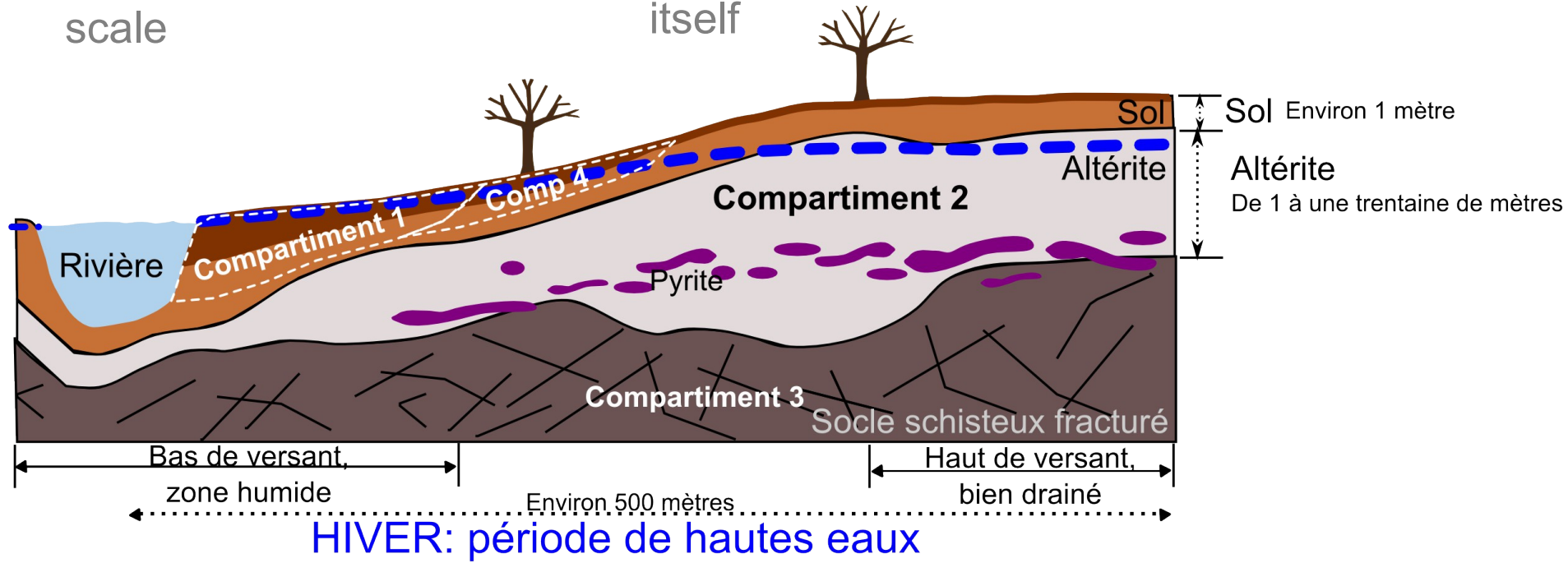
“ Damping ” processes



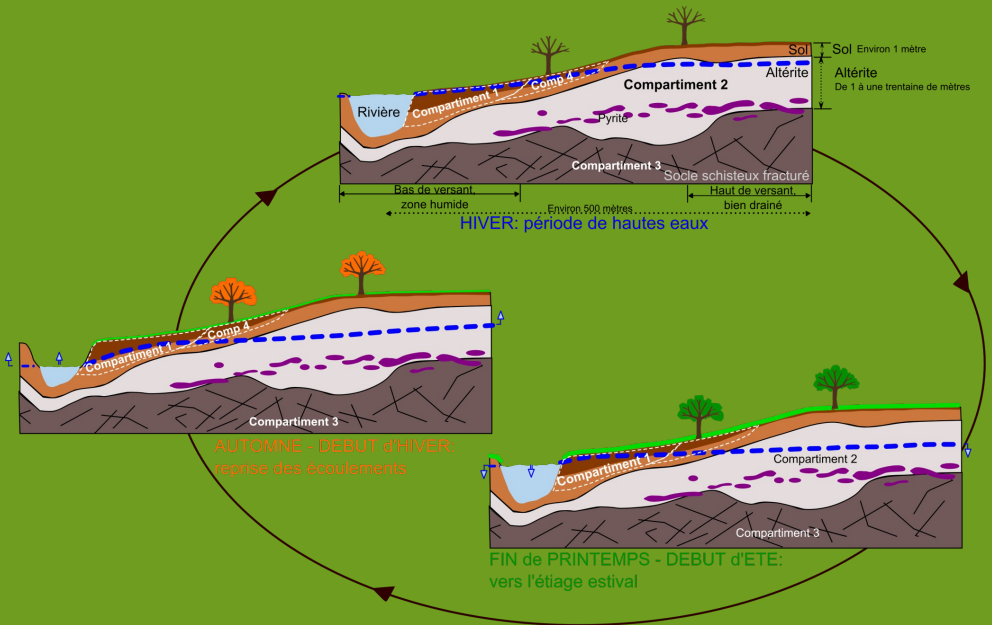
❖ Downslope advection and dispersion acting across a range of transport length scale

❖ Retention, production or mixing in the riparian zone or in-stream OR
 ❖ Fluctuation of discharge itself

❖ Measurement noise aggregate to the real world signal

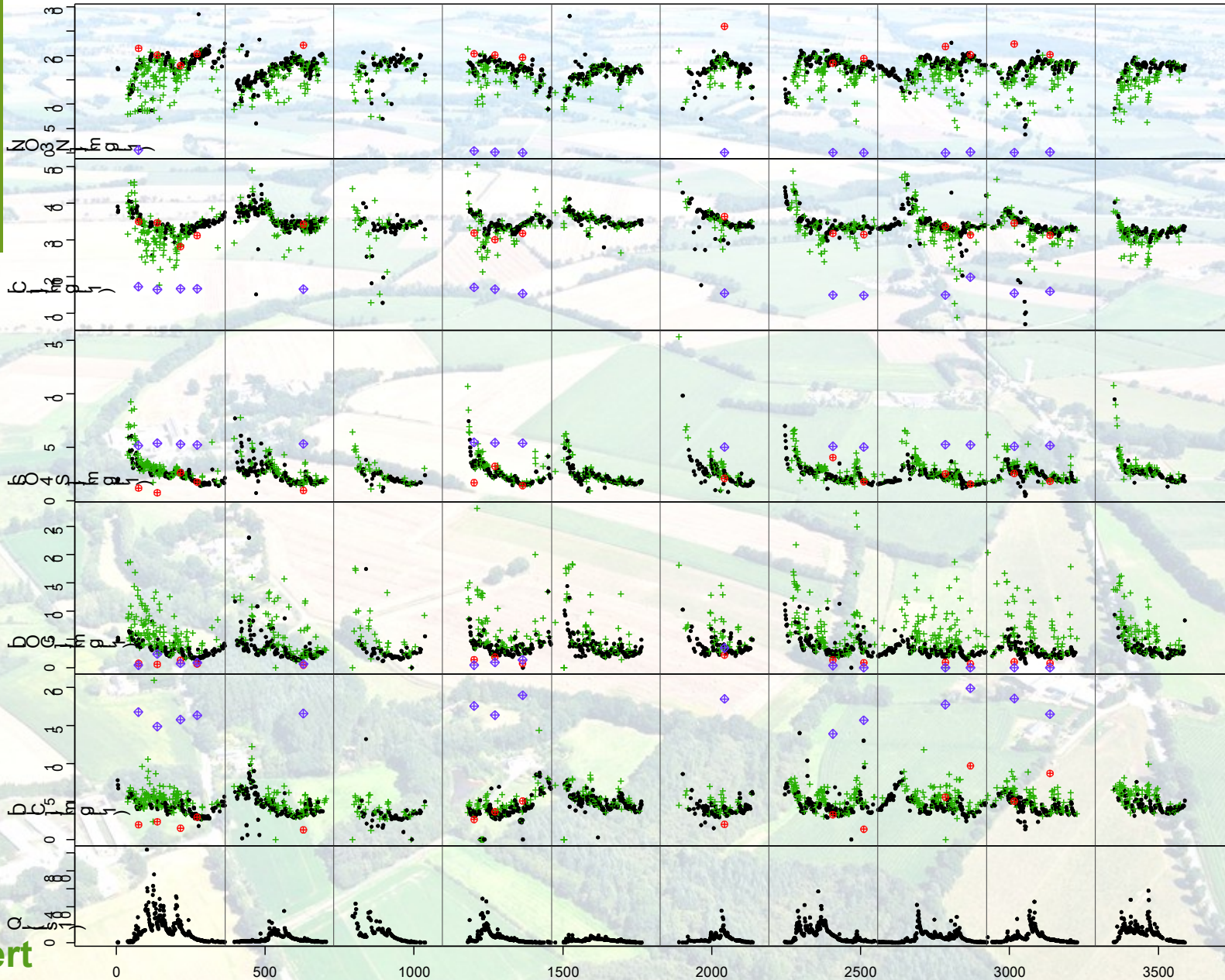


CONCLUSIONS



- ❖ Those methods borrowed to other disciplines brought new informations on the time structure of water quality signal
 - A step in comparative hydrology
 - Use of higher sampling frequency would allowed to get into more detailed processus

Thanks for your attention !



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