Identification of two concentration components to better understand the concentration-flow relationship(Obs. ORACLE)

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Goal

- ✓ **To study the concentration-flow relationships of a watershed by applying a two-component mixing equation :**
  - **A concentration associated with the base flow rate (C_1), to represent the regular flows,**
  - **A concentration associated with hydrometerological events (C_2), o represent the fluxes linked to the rapid transfer of water in the soil.**

Mixing equation

$$C_k = C_{1j} + \left(C_{2j} - C_{1j}\right)\frac{Q_{ext(k)}}{Q_{t\,(k)}}$$

Avec :

- C_k : Total concentration for the time step k (mg/L)
- $Q_{ext(k)}$: External rate flow for the time step k (m³/s)
- $Q_{t(k)}$: Total flow for the time step k (m³/s)
- C_{1j} : Base concentration parameter for the time step j (mg/L)
- C_{2j} : External concentration parameter for the time step j (mg/L)

1. Material and method

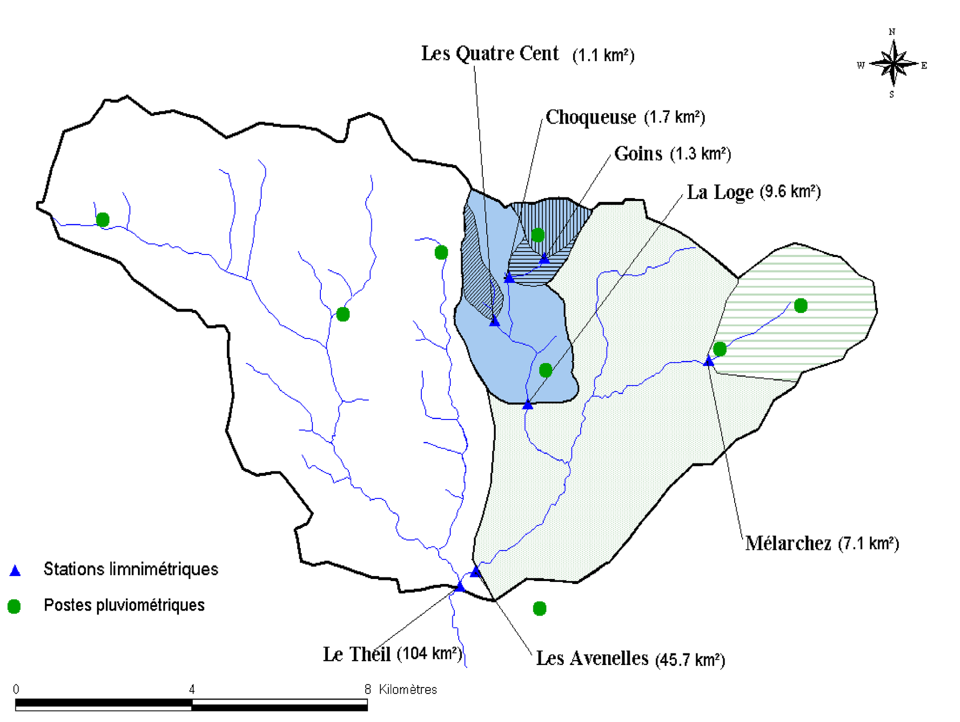

Figure 1: Orgeval catchment with its corresponding subs-catchments (source: Irstea-Antony)

- ✓ Study Zone: Catchment of Avenelles (45,7 km²)
- ✓ High-frequency measurements (approximately every 30 minutes) from June 2015 to August 2016.
- ✓ Ten chemical elements studied (Table 1)

Table 1: Summary of the mean values, min and max of the chemical elements studied from the high frequency measurements

item	Unit	Avenelles Catchment		
		Mean	Min	Max
magnesium	mg/L	8,58	2.98	11,46
potassium	mg/L	3,53	1.57	8,65
calcium	mg/L	118,55	56.51	168,04
sodium	mg/L	13,10	2.79	26,53
strontium	mg/L	0,35	0.17	0,57
fluoride	mg/L	0,15	0.03	2,88
sulfate	S mg/L	19,06	4.06	25,69
nitrates	N mg/L	11,85	3.08	18,36
chloride	mg/L	31,48	3.63	51,05
phosphate	P mg/L	0,13	0,00	0,22
rainfall	mm/30min	0,05	0,00	10,10
flow	m³/s	0,33	0,05	12,20

- ✓ We present here only the calculations and results related to the chloride ions

2. Resolution of equation

- ✓ Computation of base flow and extern flow using the Base Index Flow (BFI) method [1]

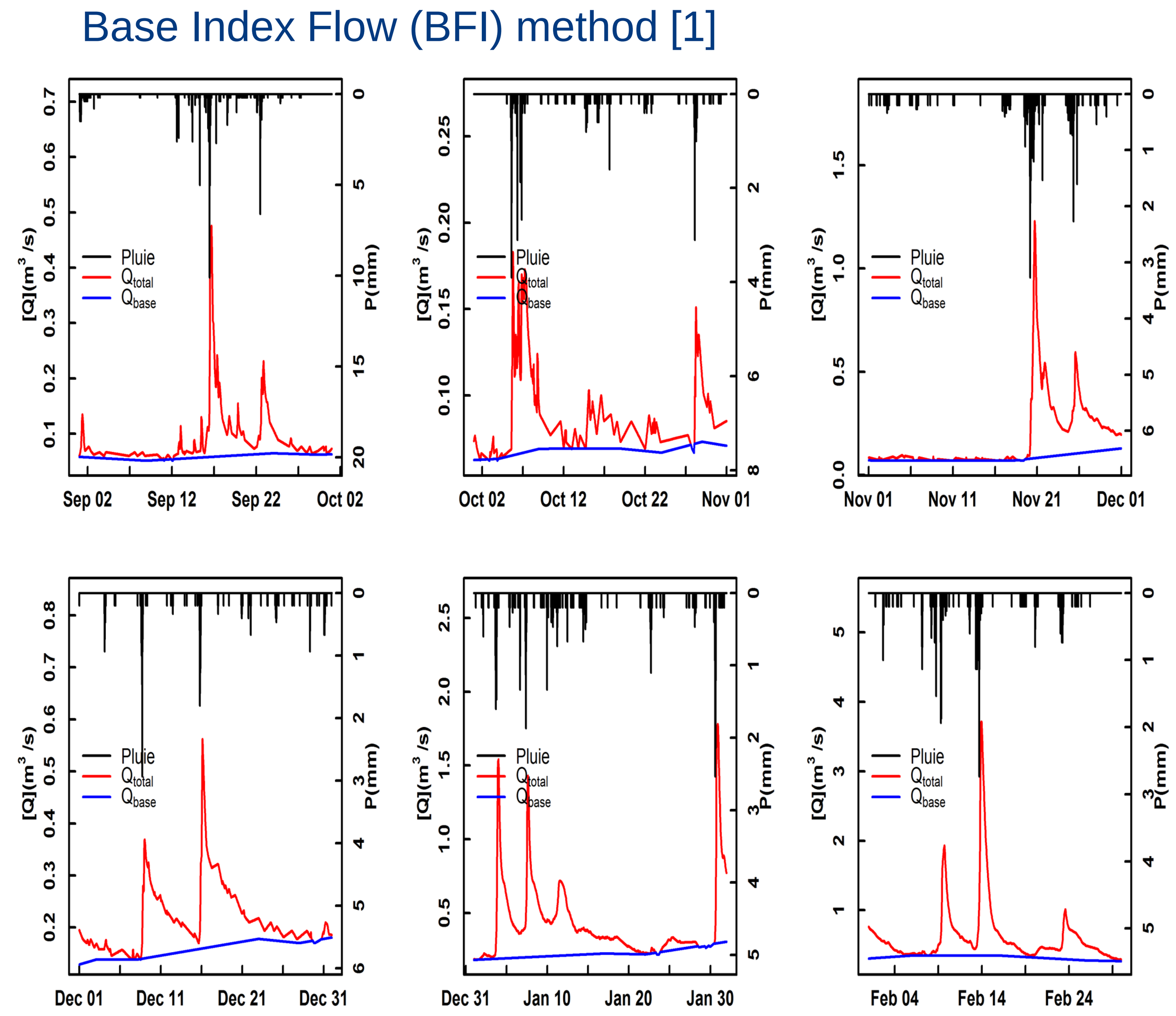

Figure 2: Calculation of Q_{base} (blue) from Q_{total} (red) using the BFI method for each month in the Avenelles catchment. Rain in black.

[1] Gustard A., Bullock A., Dixon J. (1992) Low-flow estimation in the United Kingdom. Institute of Hydrology.

- ✓ Resolution of the mixture equation with two unknowns C_1 and C_2, using the linear regression method

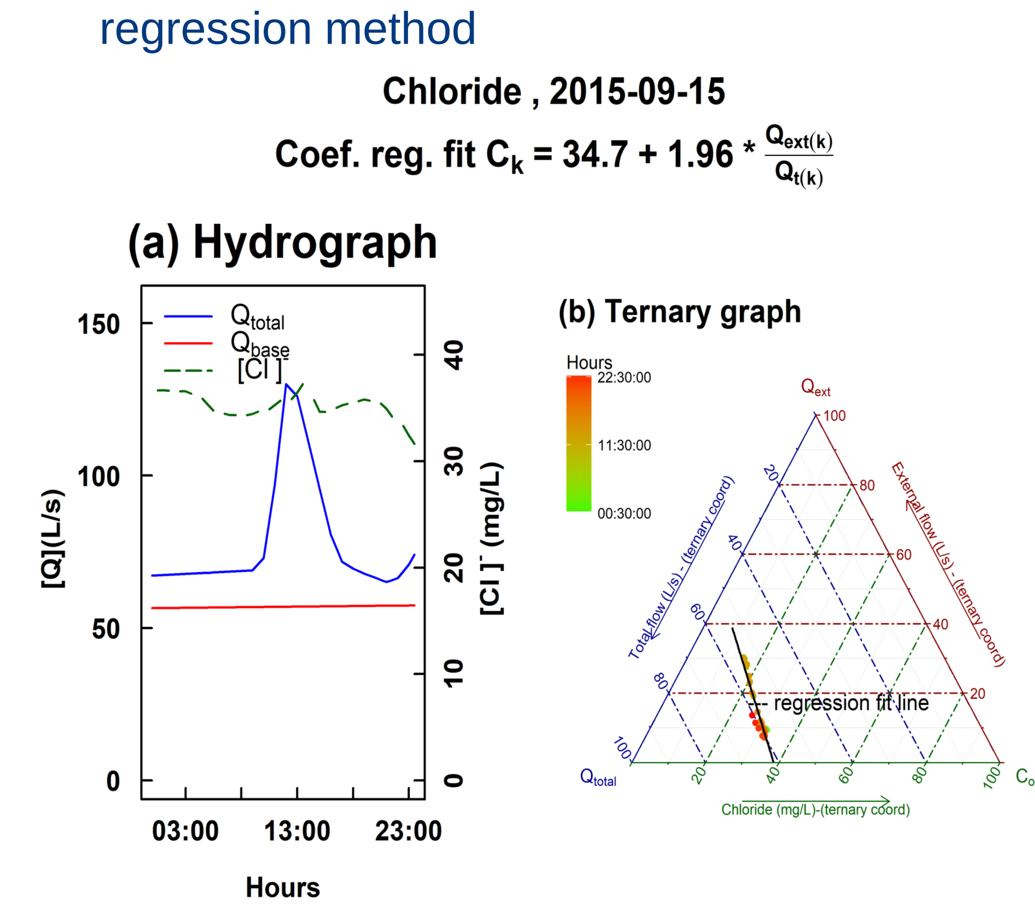

Figure 3: a) Daily hydrograph showing flows (Q_{total} and Q_{base}) and observed concentration. b)Example of calculation of C_1 and C_2 for Chloride, from C_{obs} and Q_{ext} and Q_{total} using the linear regression method, for the date of 15/09/2015.

- ✓ Thanks to the high frequency we can calculate values of C_1 and C_2 for each day.

3. Résultats

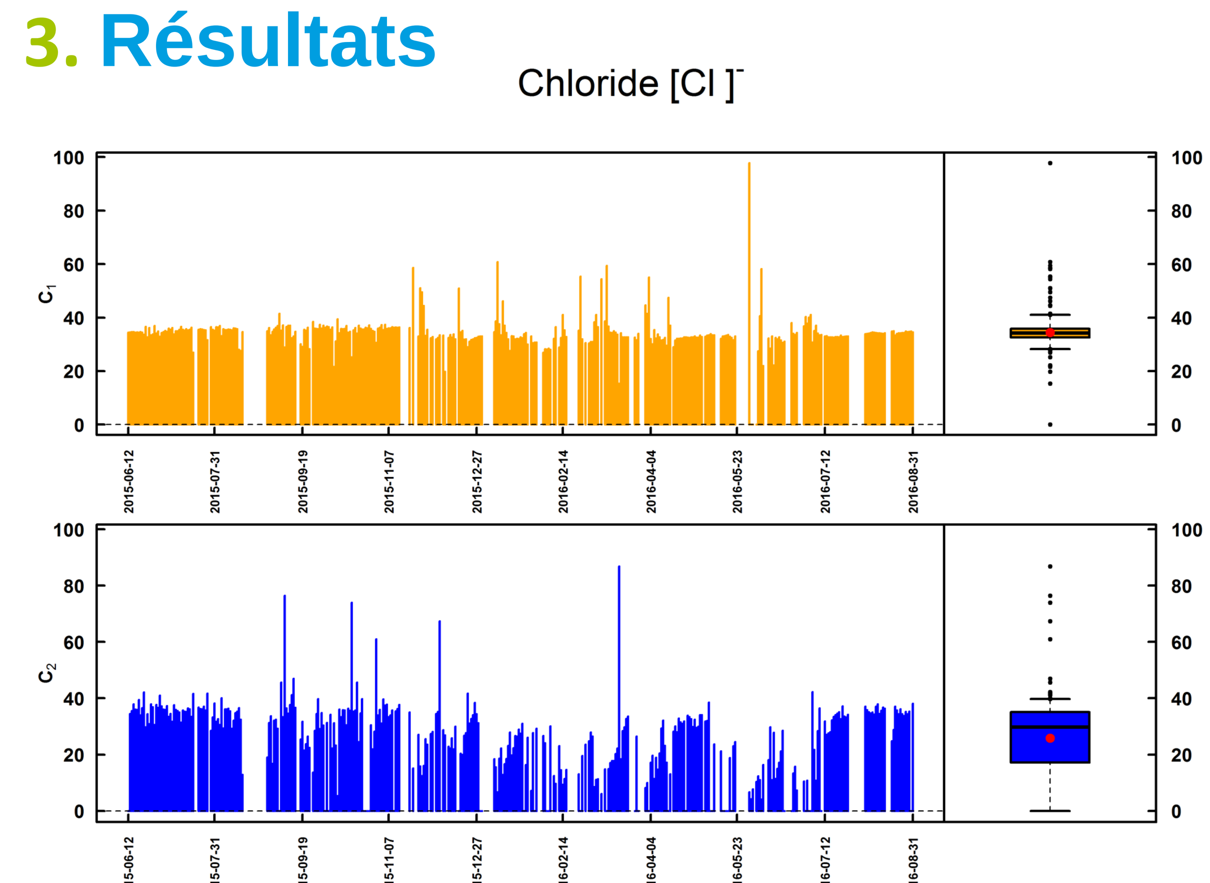

Figure 4: Values of C_1 (orange) and C_2(blue) for each day for the whole study period (from 06/12/2015 to 31/08/2016) for chlorides

- ✓ For each chemical element, the daily values of C_1 and C_2 were calculated from June 2015 to August 2016.
- ✓ For the majority of chemical elements, C_1 is very stable, C_2 much more variable.
- ✓ From these results it is envisaged:
  - ✓ To find a single parameter of C_1 and C_2 that efficiently encompasses interactions between flows and concentrations.
  - ✓ To apply this method to medium and low-frequency measurements

Conclusions

- ✓ It is possible to identify two components to explain the variations in the concentration of the ten chemical elements studied.

Perspectives

- ✓ Sensitivity analysis of parametersC_1 and C_2 to better understand how they vary.
- ✓ Make seasonal study of C_1 and C_2 parameters.
- ✓ Link C_1, C_2 and flow descriptors.

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