A combining mixing model for high-frequency concentration-discharge relationships

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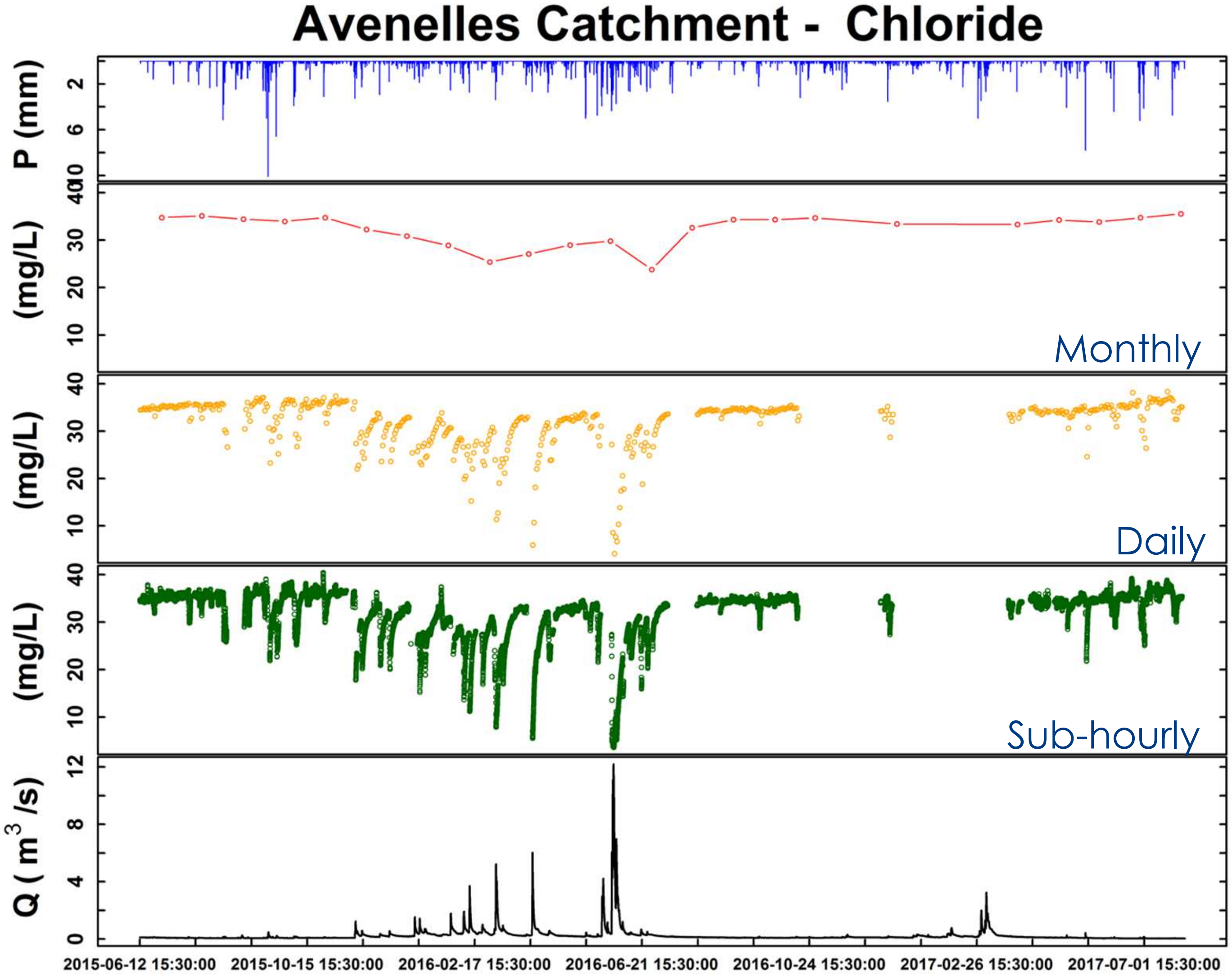
EGU - Tuesday 5 May 2020

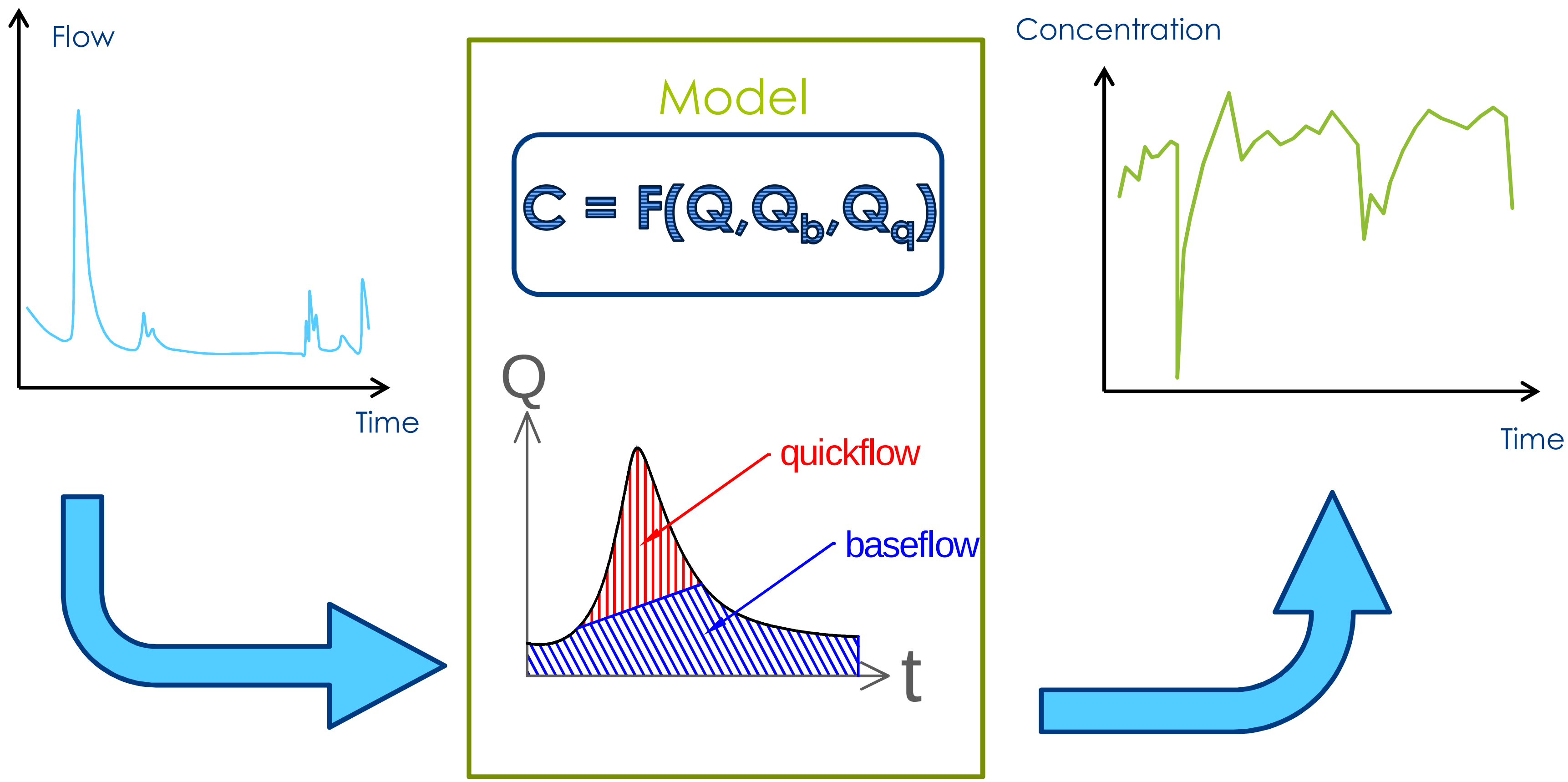
High-frequency measurement



➢ **How to use this valuable information?**

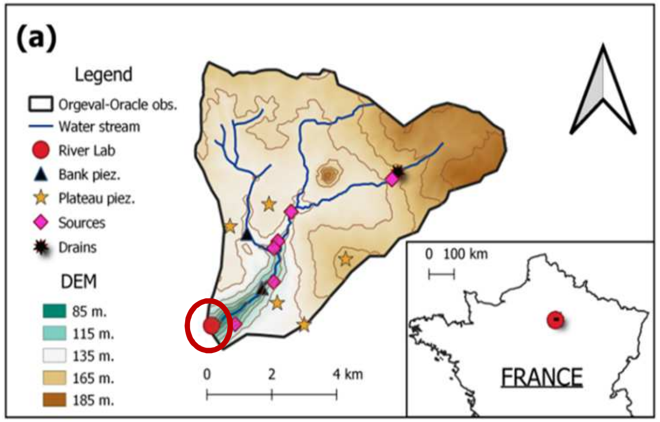
Aims of this study

Can the observed stream HF chemical concentrations be described by the dynamics of several sources related to flow?



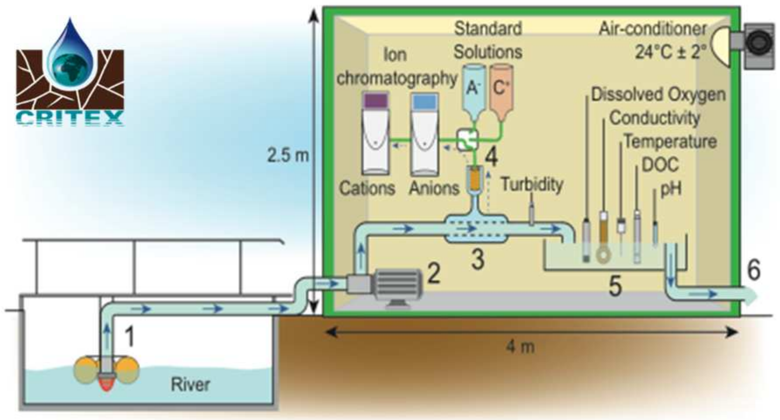
Study site

❑ ORACLE – Orgeval Obs. (1962 -) : Avenelles Sub-catchment



- High-frequency measurements (approx. 30 min.)
- June 2015 - August 2017 (17000 measurements/parameter)
- More than thirty hydrological events

Source : Floury et al. (2017)



River-Lab

item	Unit	River-Lab station (Avenelles outlet)			Rainfall
		Mean	Min	Max	
sulfate	S-mg.L^{-1}	19	2	32	0.38
nitrates	N-mgL^{-1}	12	3	18	0.75
chloride	Mg.L^{-1}	30	4	40	1.6
EC	µS.cm^{-1}	704	267	1015	NA

A combination of methods

$$Q_b = Q - Q_q$$

Hydrograph Separation(RDF *Lyne and Hollick,1979*)

C = F(Q)

$$C^{1/n} = a + bQ^{1/n}$$

Box-Cox Transformation
(*Tunqui Neira et al., 2020*)

C = F(Q_b,Q_q)

$$C = C_b \frac{Q_b}{Q} + C_q \frac{Q_q}{Q}$$

Mixing equation

(Pinder & Jones, 1969)

C = F(Q,Q_b,Q_q)

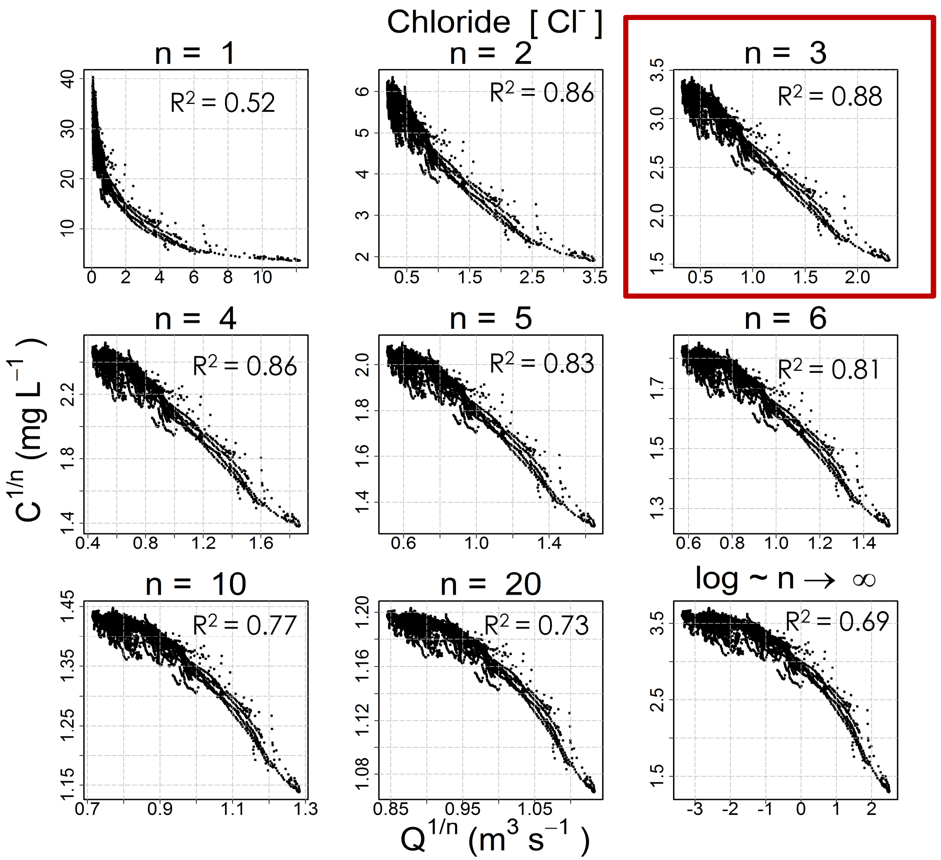
$$C = \underbrace{\left(a_b + b_b Q^{\frac{1}{n}}\right)^n}_{C_b} \frac{Q_b}{Q} + \underbrace{\left(a_q + b_q Q^{\frac{1}{n}}\right)^n}_{C_q} \frac{Q_q}{Q}$$

Combined model

A new HF methodology

- Logarithmic transformation : $\ln(C) = \ln(a) + b\ln(Q)$
- Box – Cox transformation : $C^{1/n} = a + bQ^{1/n}$

Source: Tunqui Neira et al. (2020)



Ion	*n*
Sulfate	5
Nitrates	5
Chloride	3
EC	5

- **New transformation, with only 1 additional parameter improves fit**

Combined model

$$C = \underbrace{\left(a_b + b_b Q^{\frac{1}{n}}\right)^n}_{C_b} \frac{Q_b}{Q} + \underbrace{\left(a_q + b_q Q^{\frac{1}{n}}\right)^n}_{C_q} \frac{Q_q}{Q}$$

→ **Cas 1: $a_b = a_q = 0$** ; C_b et C_q constants — **C = F(Q$_b$,Q$_q$)**

→ **Cas 2: $a_b = a_q$ et $b_b = b_q$** ; $C_b = C_q = \left(a_b + b_b Q^{1/n}\right)^n$ — **C = F(Q)**

→ **Cas 3: a et b variable** ; C_b et C_q variables — **C = F(Q,Q$_b$,Q$_q$)**

- **To compare the performances of the 3 models we use the sRMSE and the Bias**

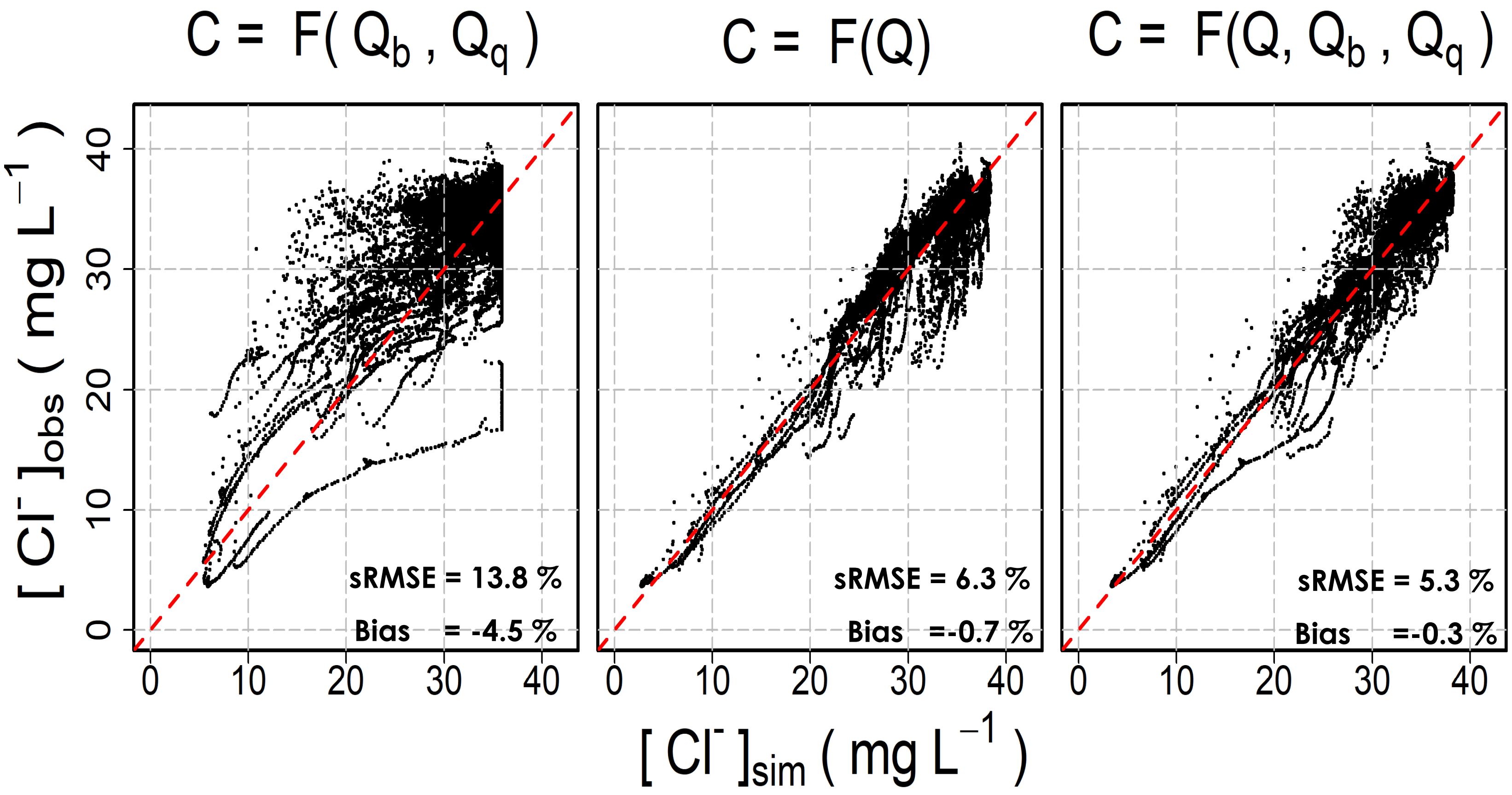
Combining HF methods

Solute	Case	*sRMSE* %	Bias %
Sulfate	1	18.3	7.3
	2	11.5	3.8
	3	**11.3**	**0.4**
Nitrate	1	48.9	46.7
	2	31.8	30.4
	3	**27.6**	**-11.2**
Chloride	1	13.8	-4.5
	2	6.3	-0.7
	3	**5.3**	**-0.3**
EC	1	10.3	1.5
	2	6.0	2.4
	3	**5.2**	**-0.5**

➢ **Case 3 better than cases 1 and 2**

Combining HF methods

❑ Case of Chlorure



➢ **Case 3 better than cases 1 and 2**

Outcomes and Perspectives

Can hydrograph separation help describe concentration-discharge relationships ?

Yes, a hydrograph separation **$C = F(Q, Q_b, Q_q)$** can be used, but only if source variability is introduced as a function of flow.

$$C = \underbrace{\left(a_b + b_b Q^{\frac{1}{n}}\right)^n}_{C_b} \frac{Q_b}{Q} + \underbrace{\left(a_q + b_q Q^{\frac{1}{n}}\right)^n}_{C_q} \frac{Q_q}{Q}$$

Should be applied :

- at other catchments and at different time scales
- with hydrograph separation calibration (Q_b,Q_q)

Analyzing model parameters with catchment functioning

Further readings

- Floury, P., Gaillardet, J., Gayer, E., Bouchez, J., Tallec, G., Ansart, P., Koch, F., Gorge, C., Blanchouin, A., and Roubaty, J. L.: The potamochemical symphony: new progress in the high-frequency acquisition of stream chemical data, Hydrol. Earth Syst. Sci., 21, 6153-6165, 2017.
- Tunqui Neira, J. M., Andréassian, V., Tallec, G., and Mouchel, J. M.: Technical note: A two-sided affine power scaling relationship to represent the concentration–discharge relationship, Hydrol. Earth Syst. Sci., 24, 1823-1830, 10.5194/hess-24-1823-2020, 2020.
- Lyne, V., and Hollick, M.: Stochastic time-variable rainfall-runoff modelling, Institute of Engineers Australia National Conference, 1979, 89-93,
- Pinder, G. F., and Jones, J. F.: Determination of the ground-water component of peak discharge from the chemistry of total runoff, Water Resources Research, 5, 438-445, 1969.

What do you think?

EGU - Tuesday 5 May 2020