The influence of in-stream processes on stream nutrient chemistry: insights from low- and high-resolution data


FONT DEL REGÀS IN AUTUMN

Photo: A. Lupon

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WORKSHOP ON HIGH RESOLUTION TIME SERIES
HELMHOLTZ UFZ
MAGDEBURG
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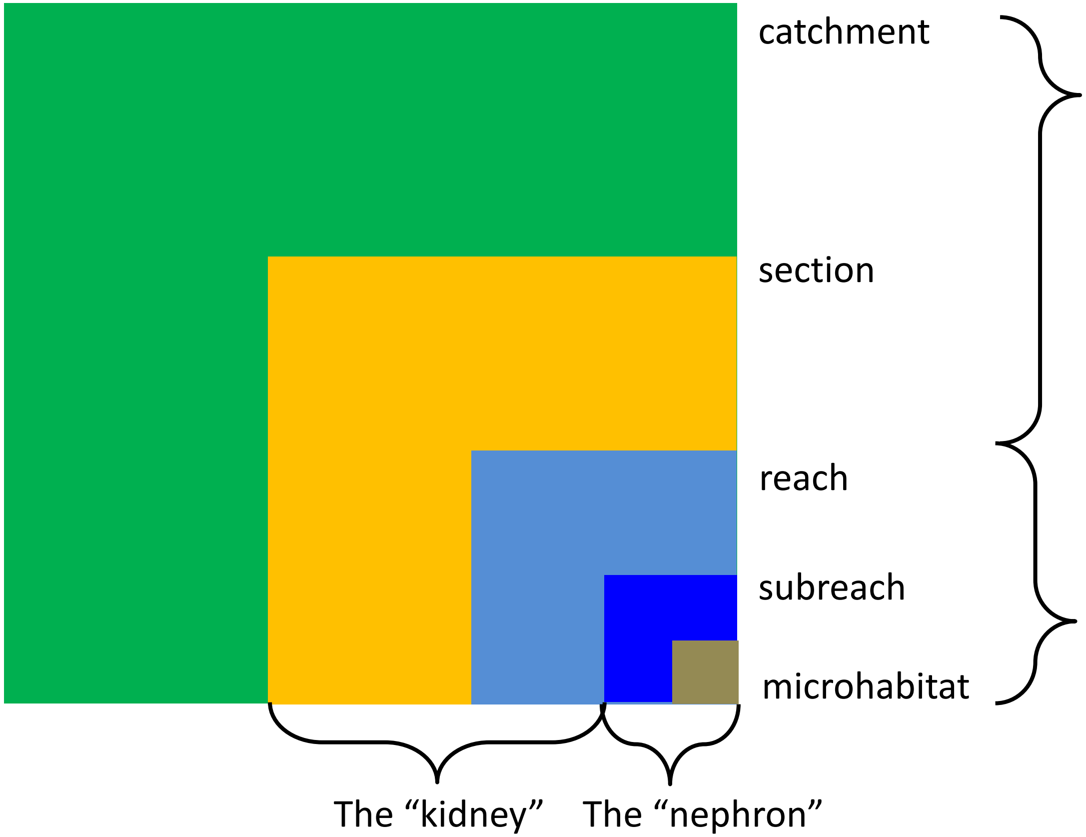
UNIVERSITAT DE BARCELONA

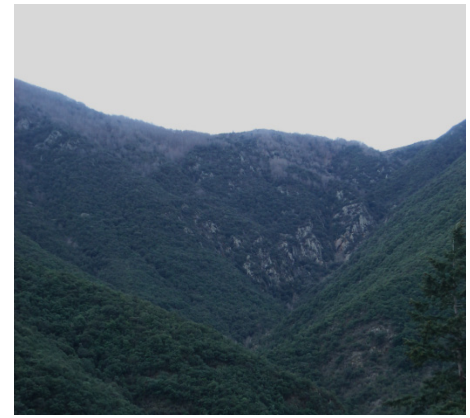
CENTRE D'ESTUDIS AVANÇATS DE BLANES

Biogeodynamics & Biodiversity research group

Hierarchical organization of stream ecosystems



Forest & Landscape Ecology



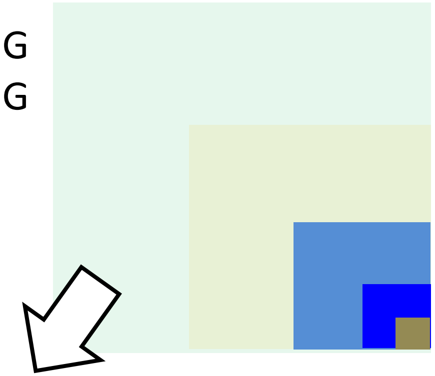
Stream Ecology

Based on Frissell et al. 1986

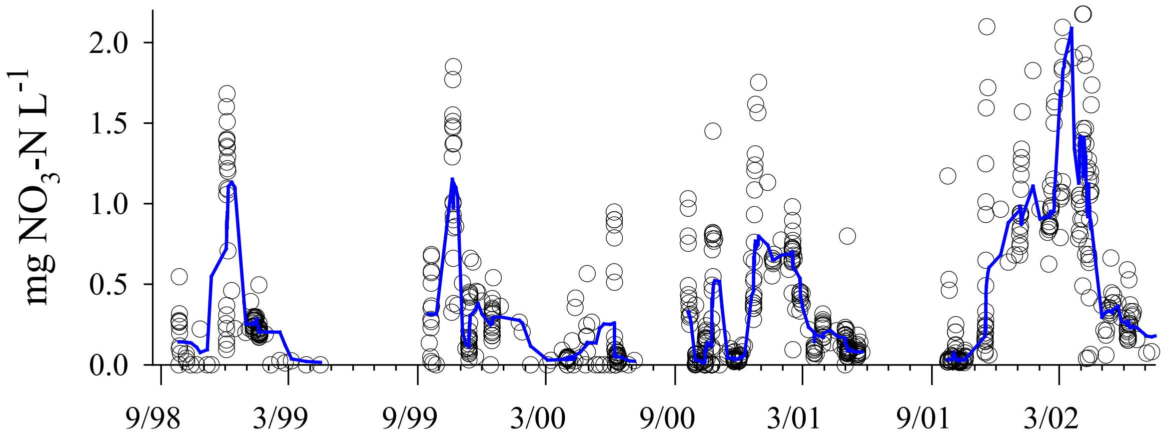
Characterization of stream nutrient dynamics

SOURCES
HYDROLOGIC TRANSPORT

IN-STREAM CYCLING
BIOTIC PROCESSING

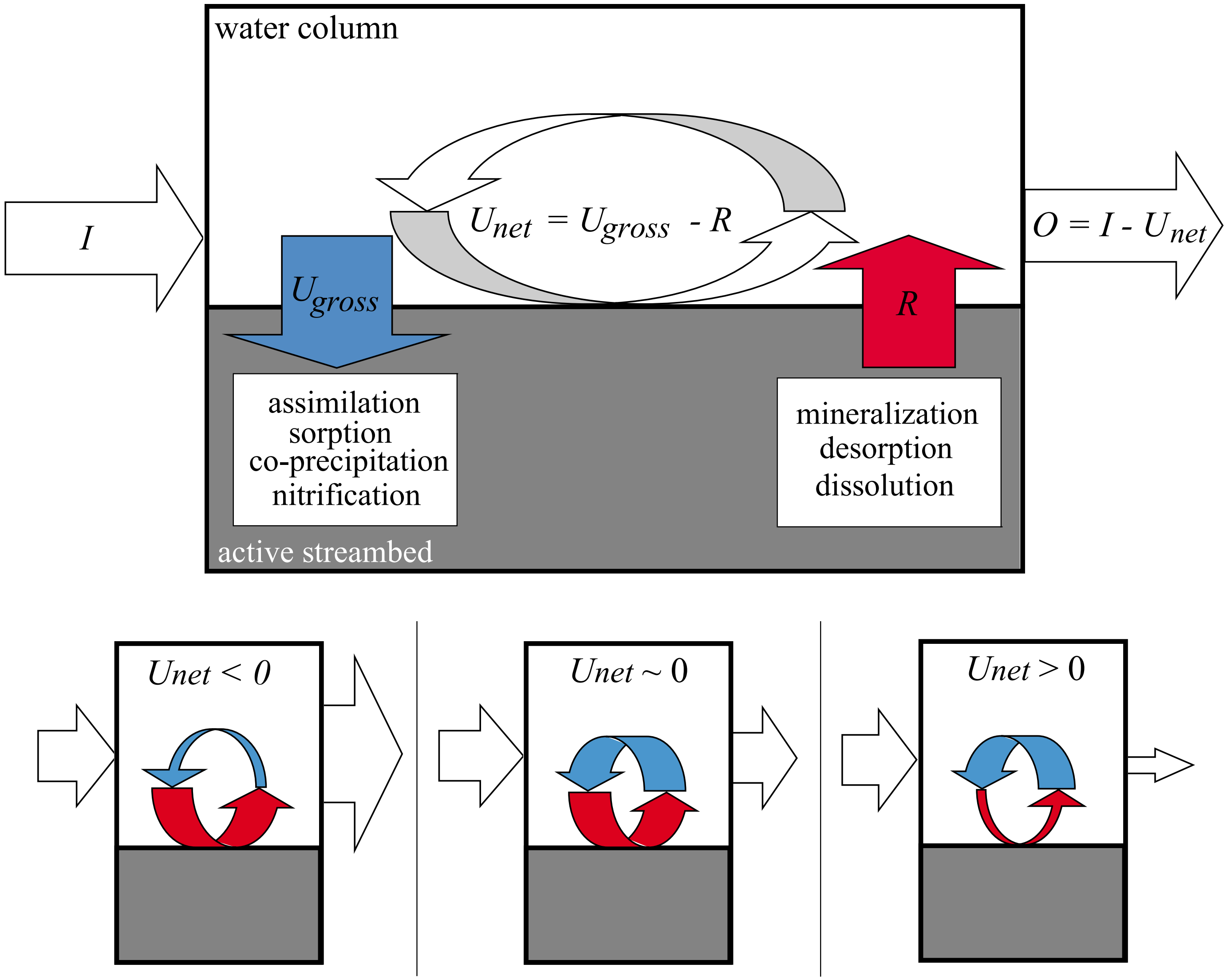


Stream nutrient dynamics result from the combination of sources and in-stream nutrient transformations.



The relevant time-scales for understanding biogeochemical transformation at each hierarchical level differ.

Conceptual model of in-stream nutrient cycling



von Schiller D., Bernal S., Sabater F., Marti E. 2014. Freshwater science (in press)

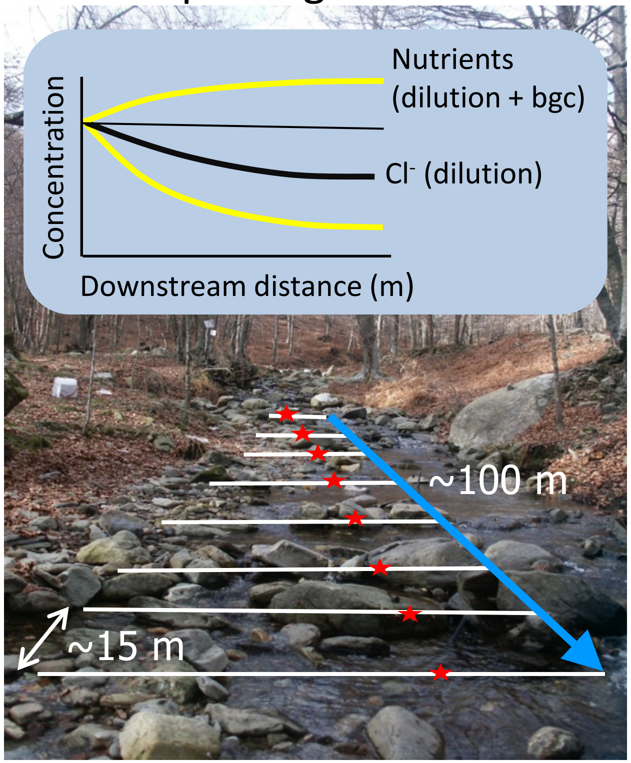
In-stream net areal uptake rate (Unet, in mg/m2/s). Empirical approaches

Mass balance

$$Unet = \frac{Q_{TOP} \cdot C_{TOP} + Q_{GW} \cdot C_{GW} - Q_{BOT} \cdot C_{BOT}}{\overline{ww} \cdot x}$$

Q discharge (L/s)
C concentration (mg/l)
ww wet width (m)
x lenght (m)

Spiraling method

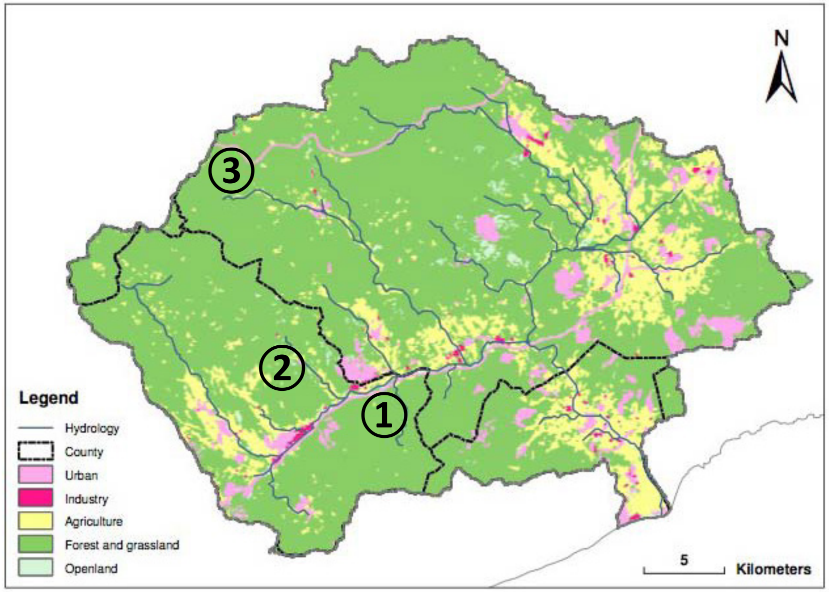


$$Unet = \frac{Q \cdot C}{(1/k) \cdot ww}$$

Q discharge (L/s)
C concentration (mg/l)
ww wet width (m)
k slope (1/m)

von Schiller, D., Bernal, S. Martí, E. 2011. Biogeosciences

A decade+ of stream ecology at La Tordera catchment (NE Spain)

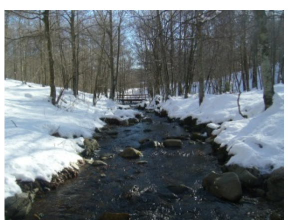


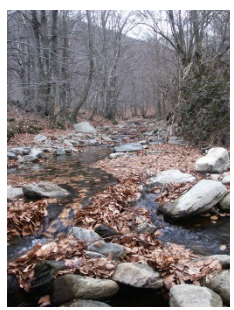
① **The Fuirosos stream** (since 1999)

14.3 km^2
m a.s.l. = 115
P = 470 mm
PET = 1390 mm
RC = 7%
Temporary
Semiarid Med

② **The Santa Fe stream** (since 2002)

2.5 km^2
m a.s.l. = 1140
P = 992 mm
PET = 989 mm
RC = 17%
Perennial
Subhumid Med



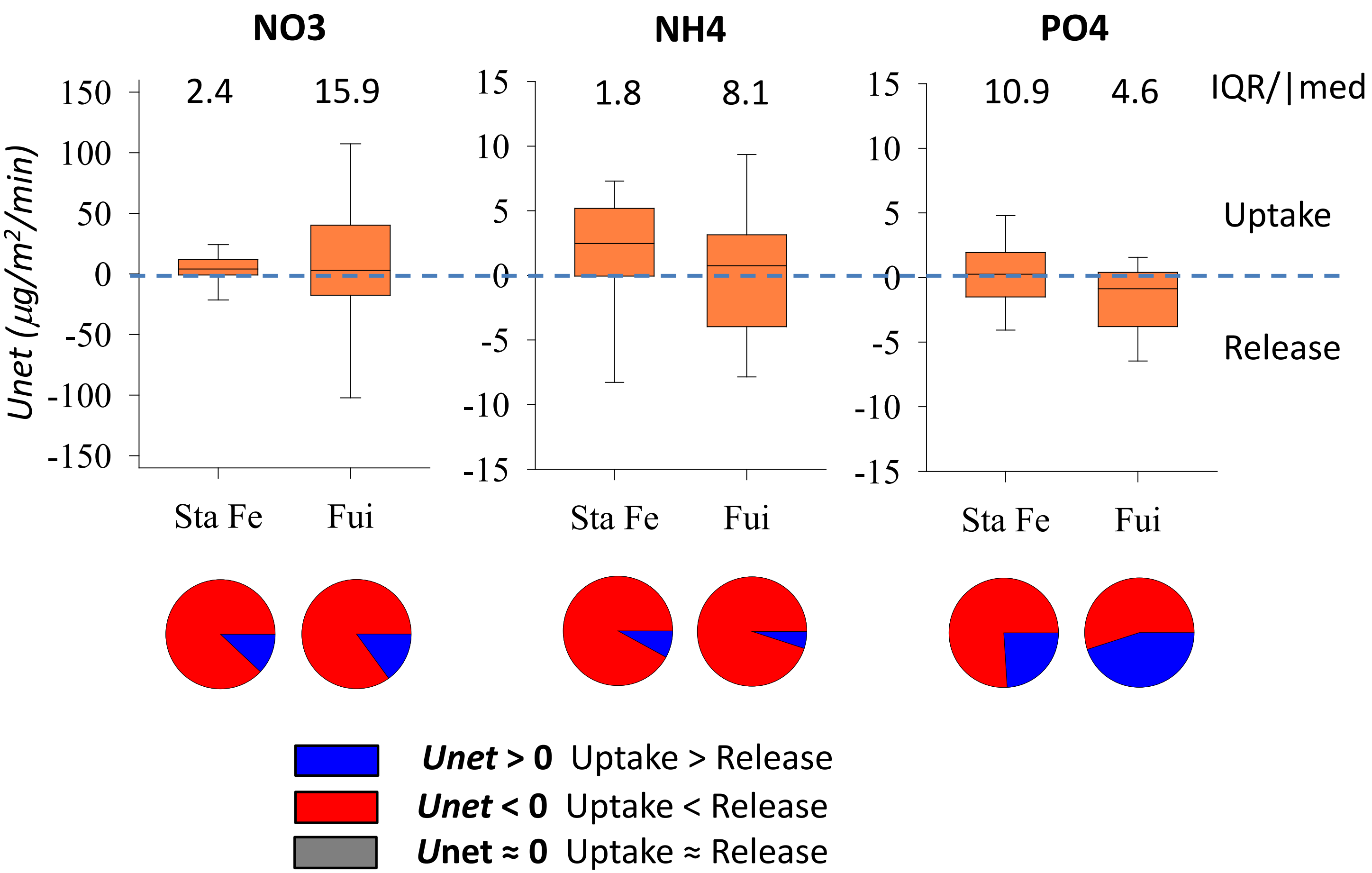


③ **The Font del Regàs stream** (since 2009)

13 km^2
m a.s.l. = 470
P = 857
PET = 1064 mm
RC = 28 %
Perennial
Subhumid Med

Temporal variation of in-stream net areal uptake rate (*Unet*)

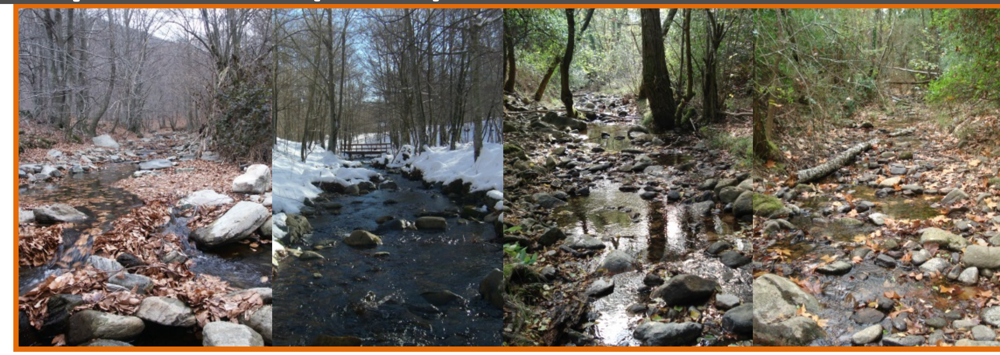
2004-2006. 2 YEARS OF MONTHLY SAMPLING at Sta. Fe and Fuirosos

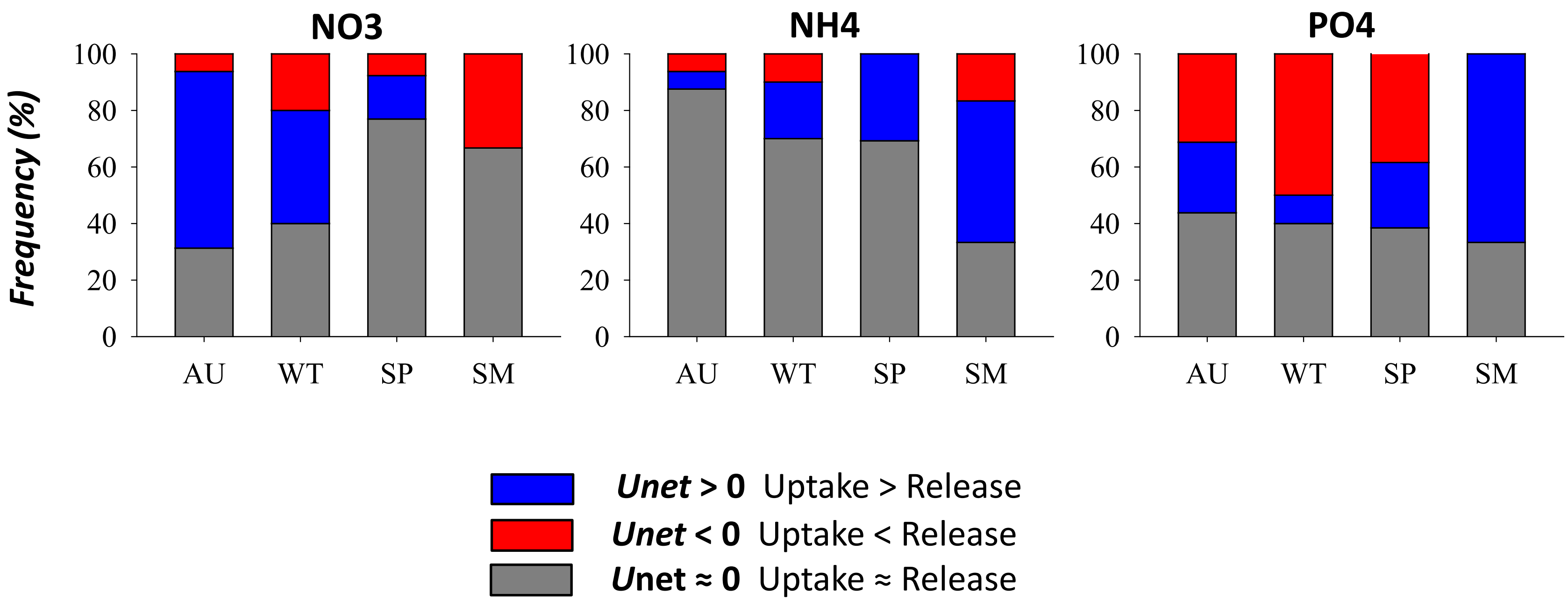


Unet can be highly variable over time within the same stream.
The stream can alternatively act as a net source, net sink, or be at bgc steady-state.

Bernal, S., von Schiller, D., Sabater, F., Martí, E. 2012. J. Geophysical Res.
von Schiller, D., Bernal,S., Sabater, F., Martí, E. 2014. Freshwater Science (in press)

Temporal variation of in-stream net areal uptake rate (*Unet*)





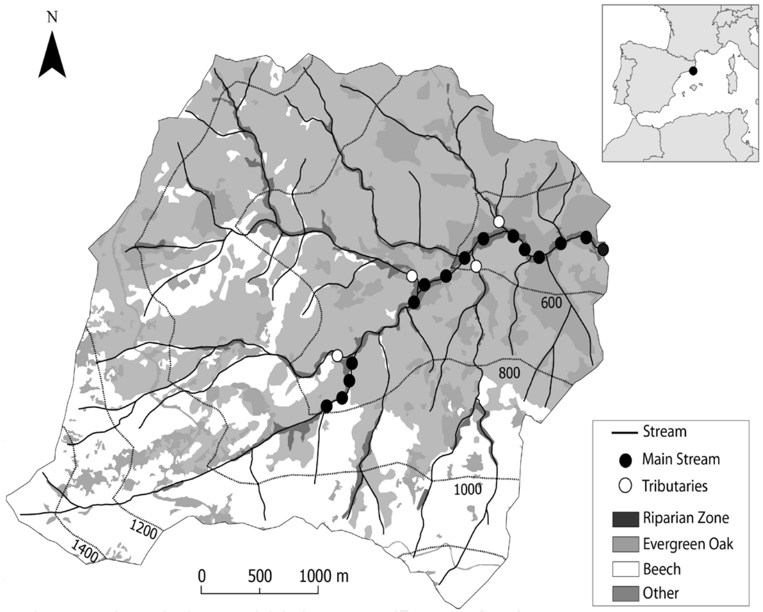
The temporal variation of *Unet* is not random,
but can follow a seasonal pattern that differs among nutrients.
Nutrient processing by stream biota responds to the seasonality of environmental variables.

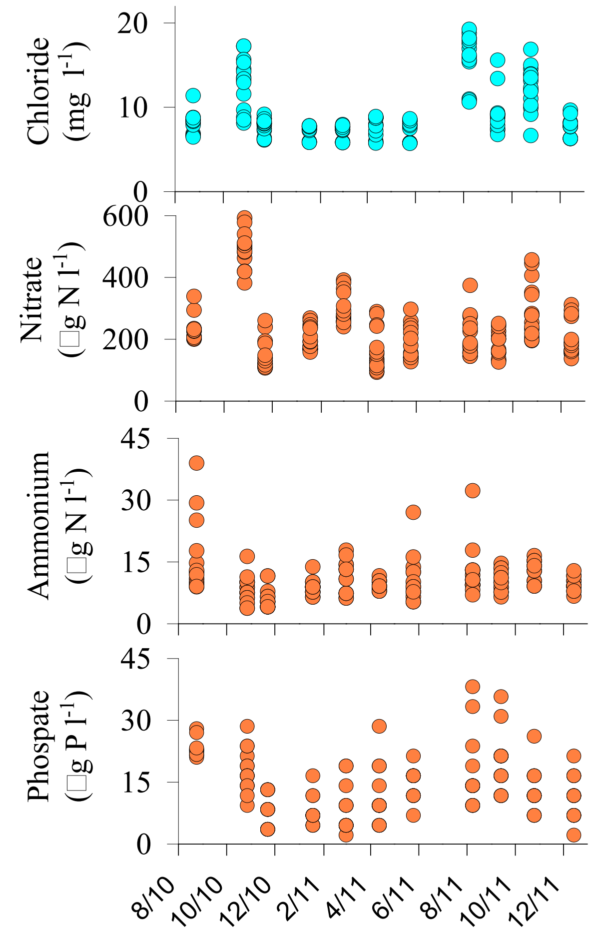
Adapted from Bernal, S., von Schiller, D., Sabater, F., Martí, E. 2012. J. Geophysical Res.

Spatio-temporal variation of stream nutrient concentration

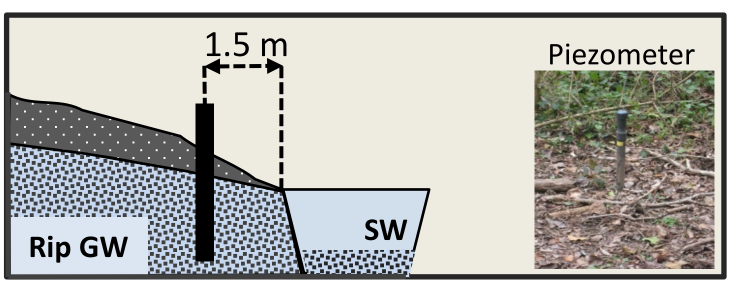
2010-2011. 2 years of bimonthly sampling at Font del Regàs

(a) Longitudinal pattern of stream nutrient concentrations



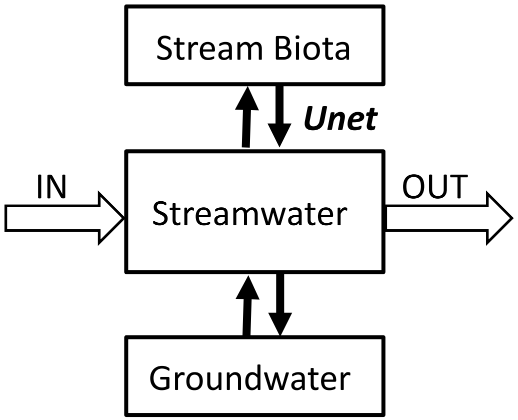


(b) Riparian groundwater nutrient chemistry along the reach

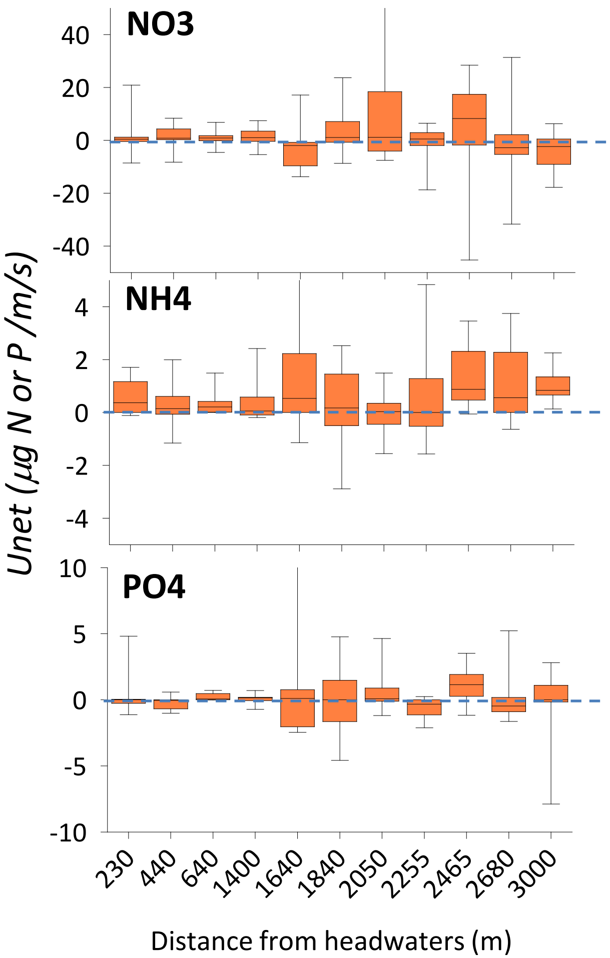


Bernal, S., Lupon, A., Ribot, M., Sabater, F., Martí, E. 2014. Biogeosciences (in review)

Spatio-temporal variation of in-stream net uptake rate (*Unet*)



$$Unet = \frac{Q_{TOP} \cdot C_{TOP} + Q_{TRIB} \cdot C_{TRIB} + Q_{GW} \cdot C_{GW} - Q_{BOT} \cdot C_{BOT}}{segment\ lenght}$$

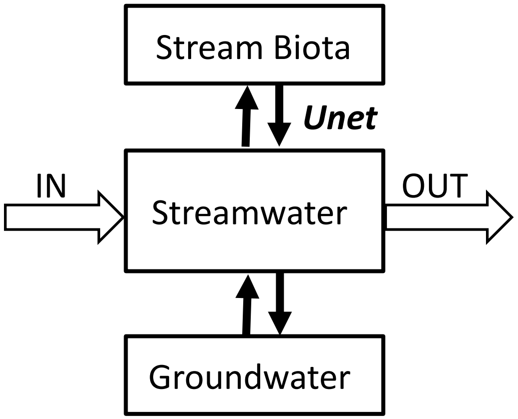


The longitudinal variation of *Unet* within a single date can be as high as within the same stream segment over time.

	Among sites		*Within sites*	
	σ^2	%	σ^2	%
NO3	334.0	59.9	224.0	40.1
NH4	4.8	51.6	4.5	48.4
PO4	12.1	52.2	11.1	47.8

Adapted from Bernal, S., Lupon, A., Ribot, M., Sabater, F., Martí, E. 2014. Biogeosciences (in review)

Spatio-temporal variation of in-stream net uptake rate (*Unet*)



$$Unet = \frac{Q_{TOP} \cdot C_{TOP} + Q_{TRIB} \cdot C_{TRIB} + Q_{GW} \cdot C_{GW} - Q_{BOT} \cdot C_{BOT}}{segment\ lenght}$$

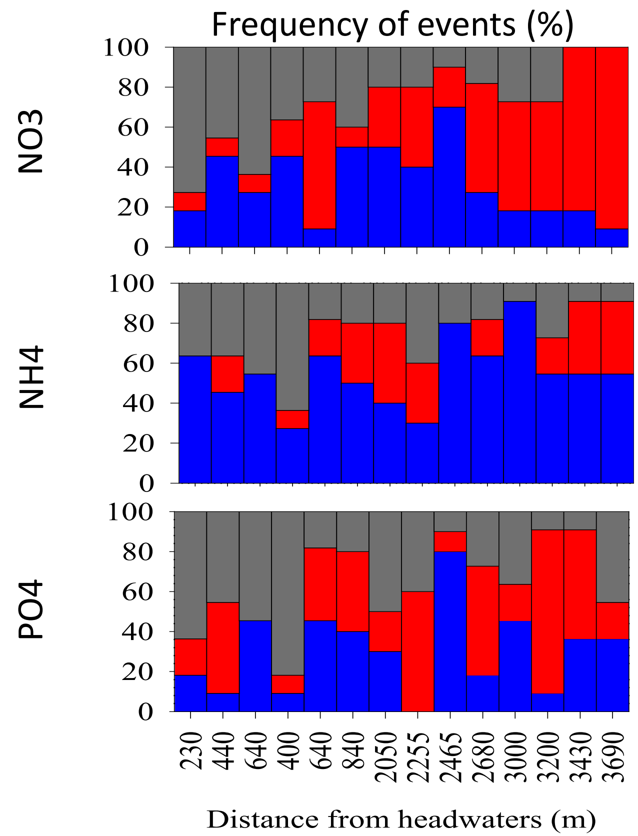
In-stream bgc transformations can either follow a spatial pattern (NO3), or be consistent along the reach (NH4).

Nutrient processing by stream biota responds to the spatial pattern of environmental variables.

***Unet* > 0** Uptake > Release

***Unet* < 0** Uptake < Release

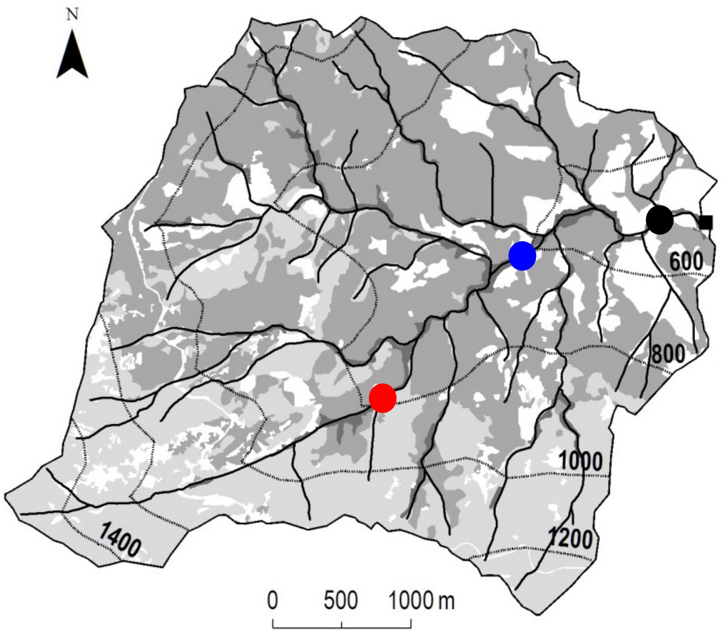
***Unet* ≈ 0** Uptake ≈ Release

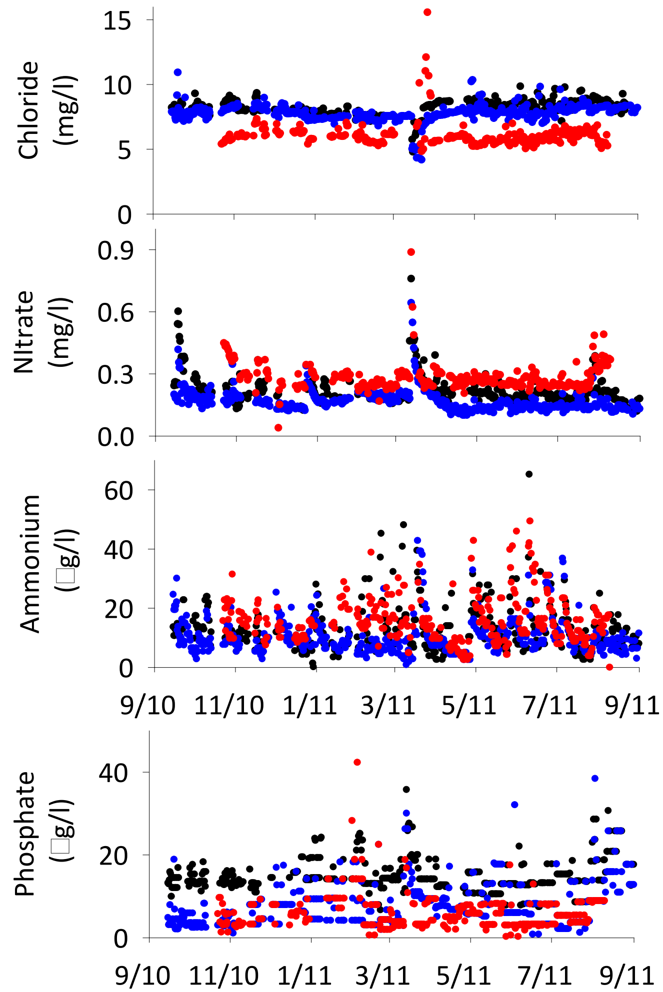


Bernal, S., Lupon, A., Ribot, M., Sabater, F., Martí, E. 2014. Biogeosciences (in review)

High resolution spatio-temporal variation of stream nutrient concentration

2010-2011. 1 year of sampling at 12-h intervals

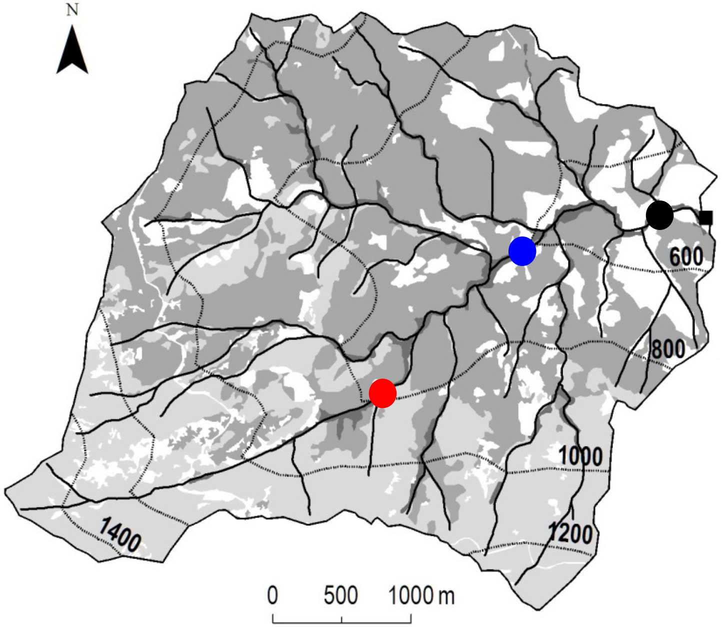


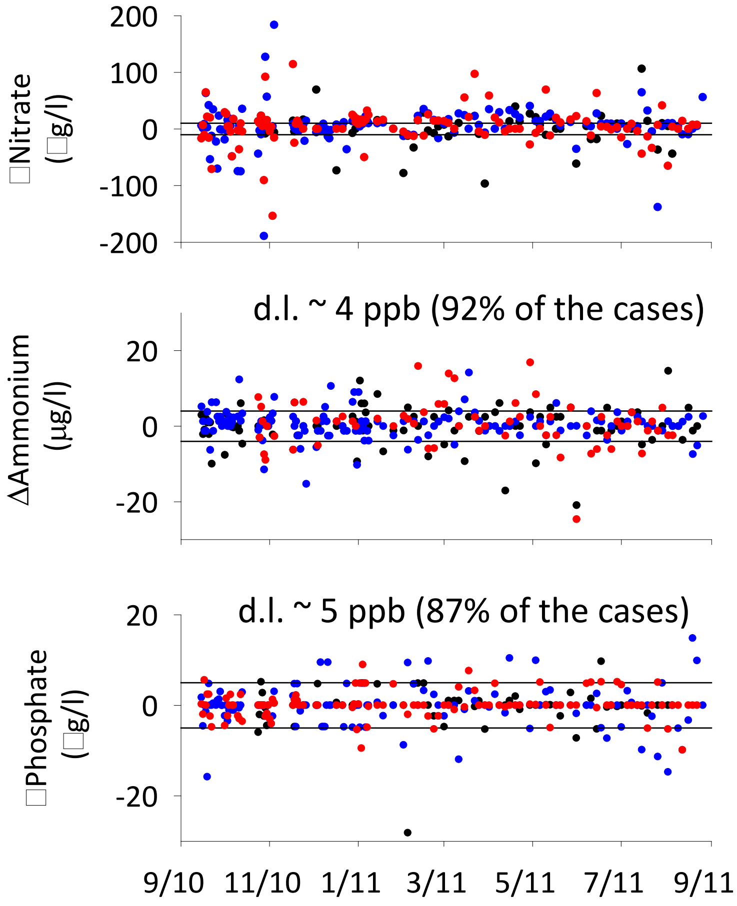


Can high resolution data provide some mechanistic explanation on the spatio-temporal variation of in-stream nutrient processing?

High resolution spatio-temporal variation of stream nutrient concentration

2010-2011. 1 year of sampling at 12-h intervals



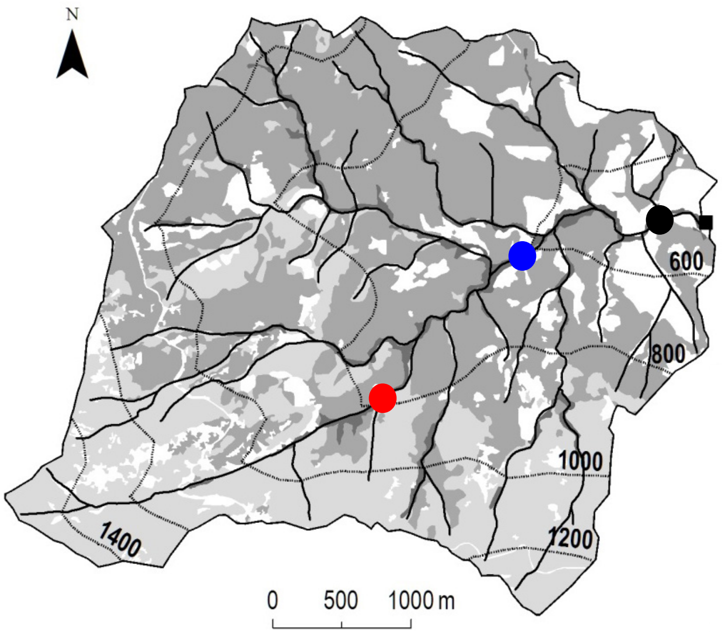


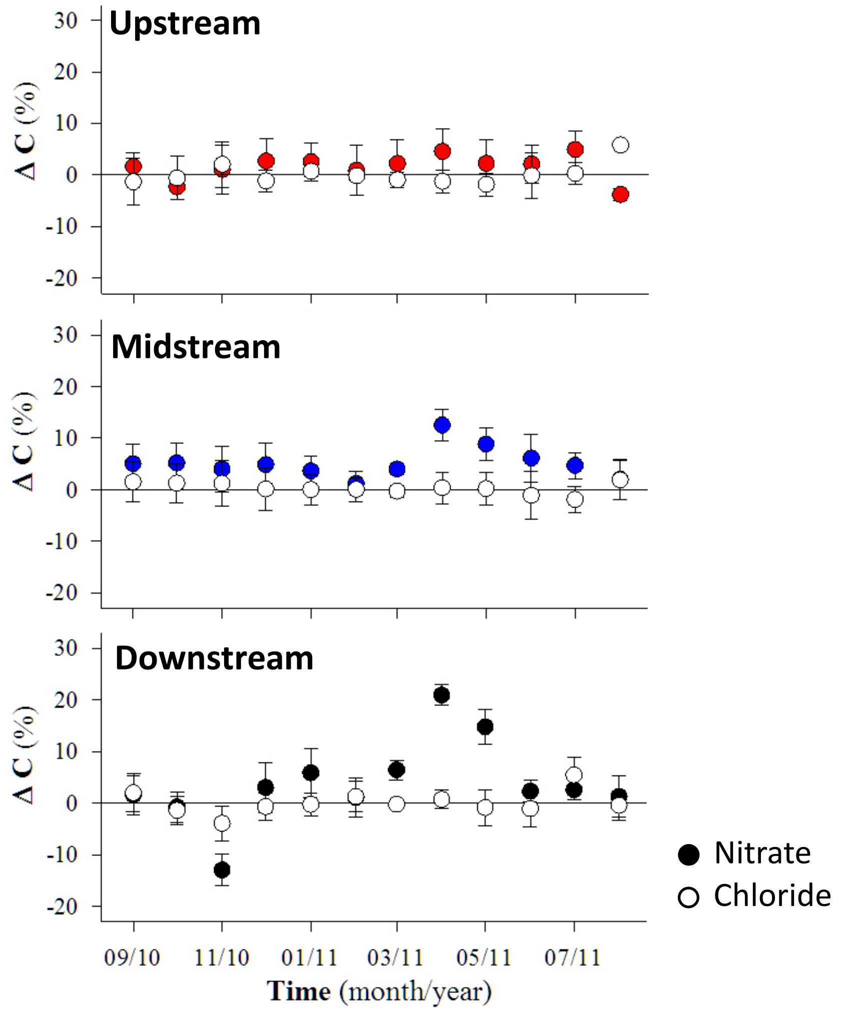
Analytical resolution can still be a limiting factor.

Spatio-temporal pattern of diel cycles of stream nitrate concentration

2010-2011. 1 year of sampling at 12-h intervals

$$\Delta C = \frac{C_{night} - C_{day}}{C_{night}} \times 100$$





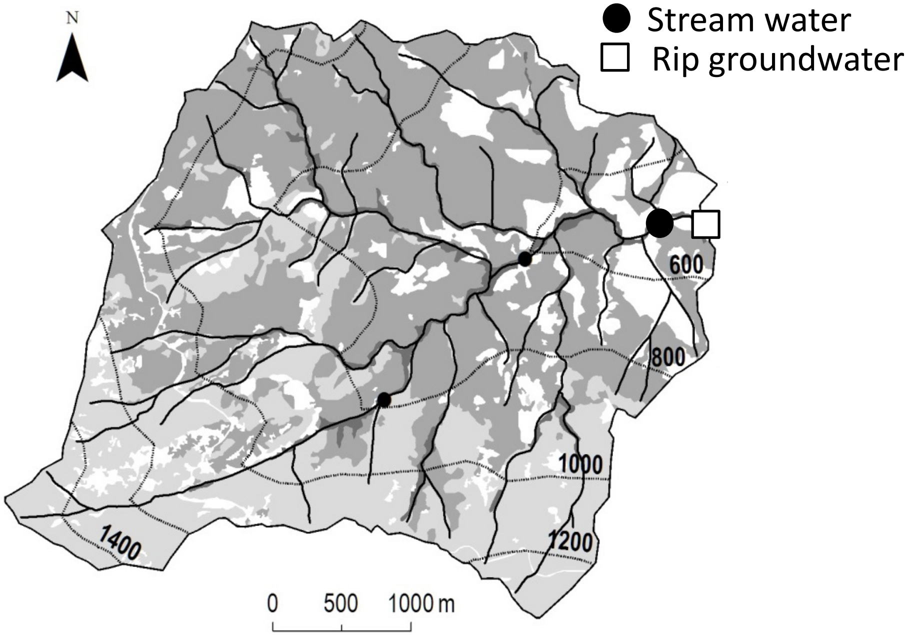
ΔNO3 during base flow conditions was conspicous at the MID and DOWN sites in spring.

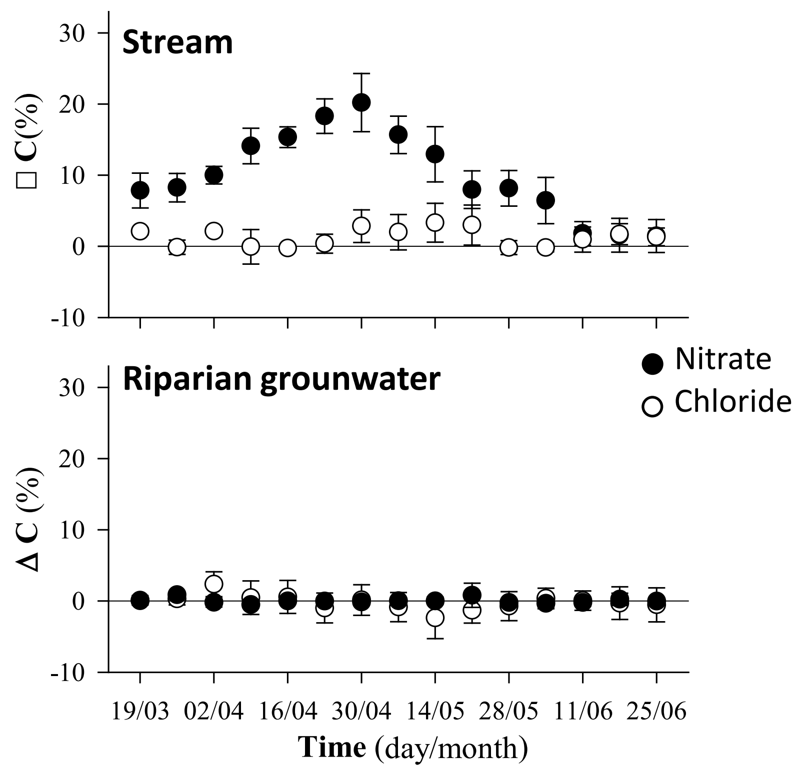
Lupon, A., Marti E., Sabater, F., Bernal, S. 2014. Ecology (in review)

Spatio-temporal pattern of diel cycles of stream nitrate concentration

2012. Spring (4 months) of sampling at 6-h interval + GPP

$$\Delta C = \frac{C_{night} - C_{day}}{C_{night}} \times 100$$



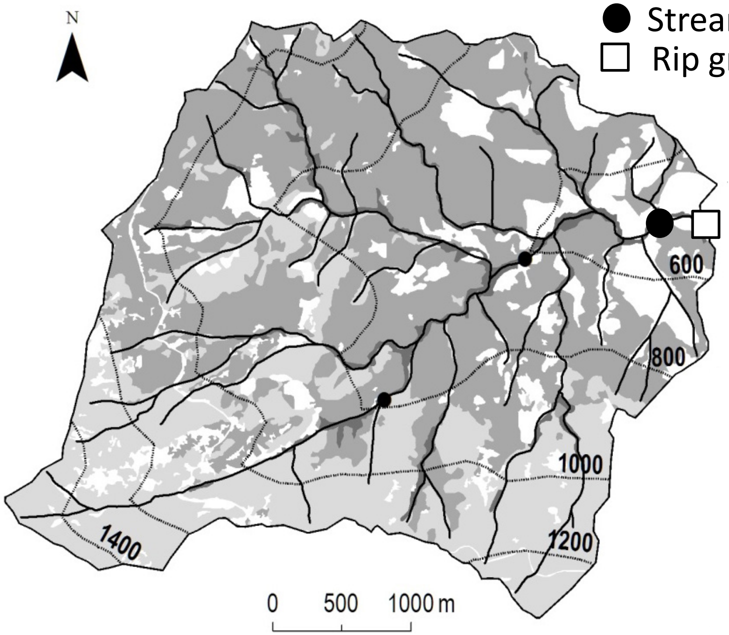


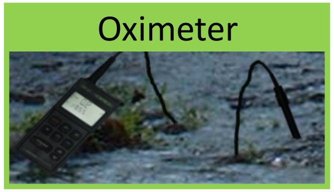
ΔNO3 resulted from in-stream bgc processes.

Lupon, A., Marti E., Sabater, F., Bernal, S. 2014. Ecology (in review)

Spatio-temporal pattern of diel cycles of stream nitrate concentration

2012. Spring (4 months) of sampling at 6-h interval + GPP





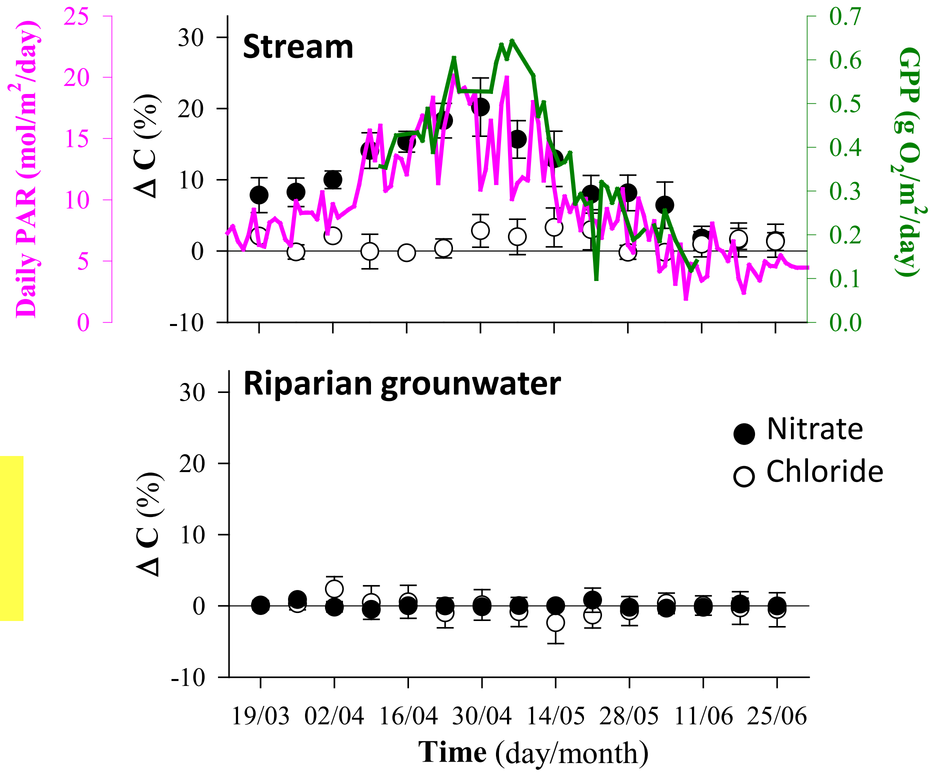
[DO] = GPP– R ± E

GPP gross primary productivity
R respiration
E reaeration

single-station diel DO change method (Bott 2006)
30 min-interval

GPP vs PAR: $R^2 = 0.74$

ΔNO3 vs GPP: $R^2 = 0.74$

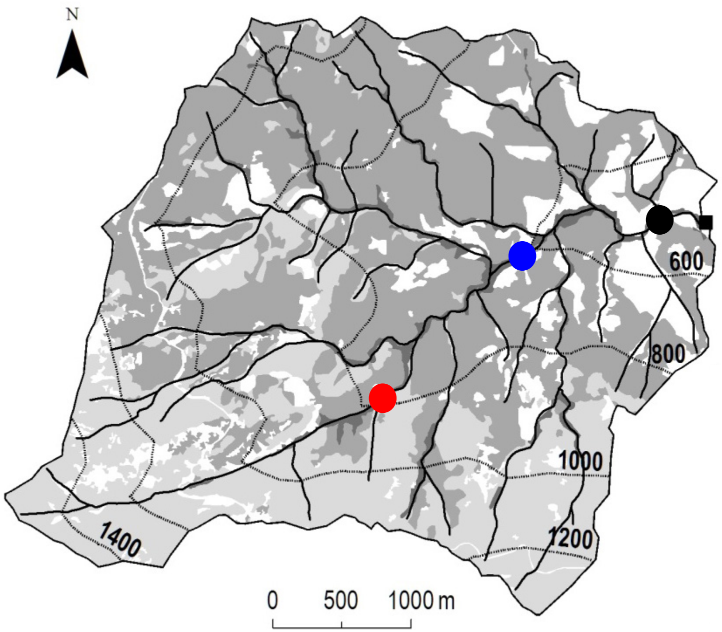


Temporal variation of ΔNO3 explained by the influence of light inputs on the assimilation of NO3 by stream photoautotrophs.

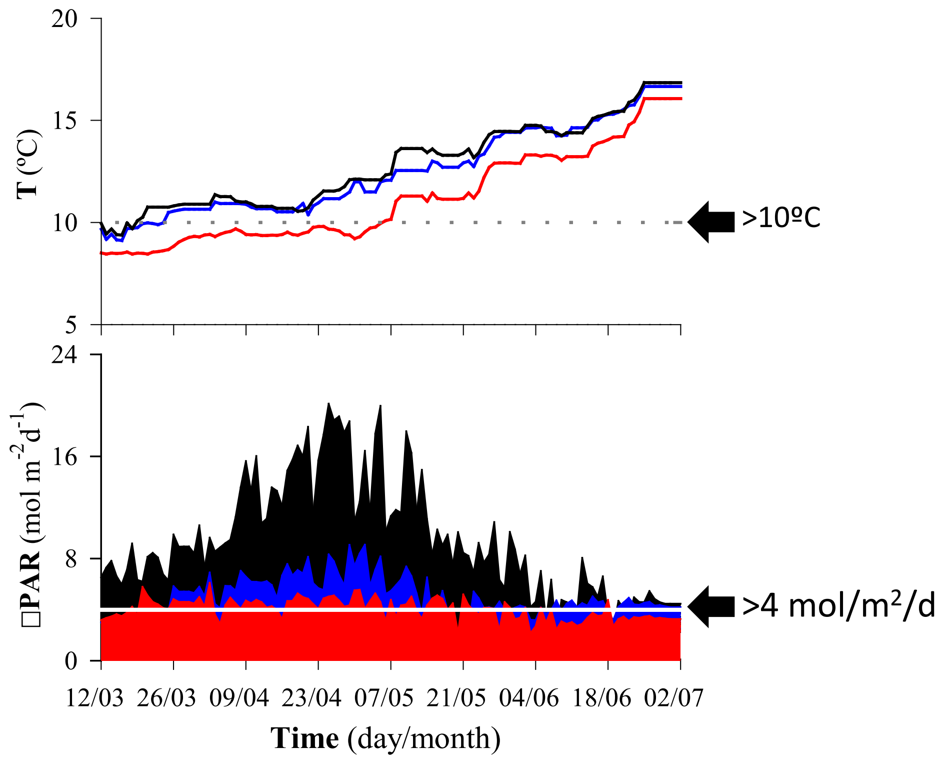
Lupon, A., Marti E., Sabater, F., Bernal, S. 2014. Ecology (in review)

Spatio-temporal pattern of diel cycles of stream nitrate concentration

2012. Spring (4 months) of sampling at 6-h interval + GPP



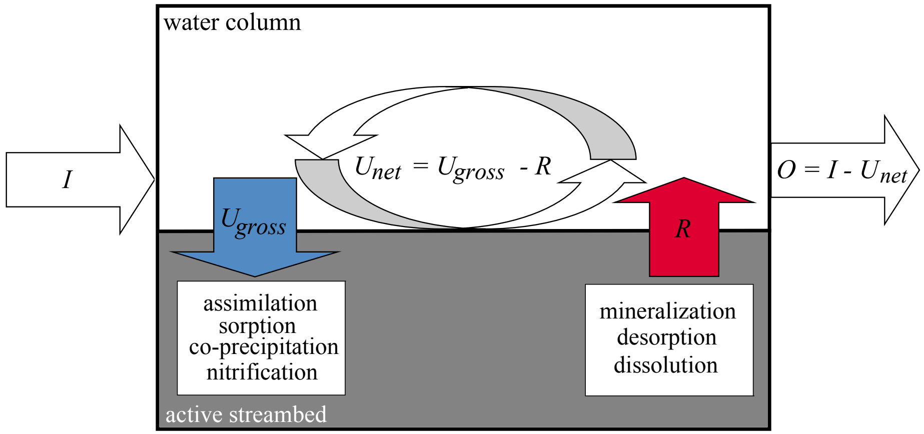
	T>10ºC days	%	ΣPAR>4 mol/m²/d days	%
UP	57		66	
MID	99	73	83	25
DOWN	103	80	104	57



Spatial variation of ΔNO3 explained by changes in light and temperature regimes along the stream.

Lupon, A., Marti E., Sabater, F., Bernal, S. 2014. Ecology (in review)

Past, Present, Future



High resolution temporal data

Provide some mechanistic explanation on the spatio-temporal variability of in-stream nutrient processing shown by low resolution data.

Advances

Understand environmental drivers of in-stream nutrient processing.

Better assessment of the contribution of in-stream processes to stream nutrient dynamics.

Perspective

Powerful tool for exploring major drivers of in stream solute concentrations within and between catchments at different spatio-temporal scales.

Hands on work

Long term monitoring vs. hypothesis-driven studies.

Analytical resolution issues (PO4, NH4).

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