Catchments exports and monitoring

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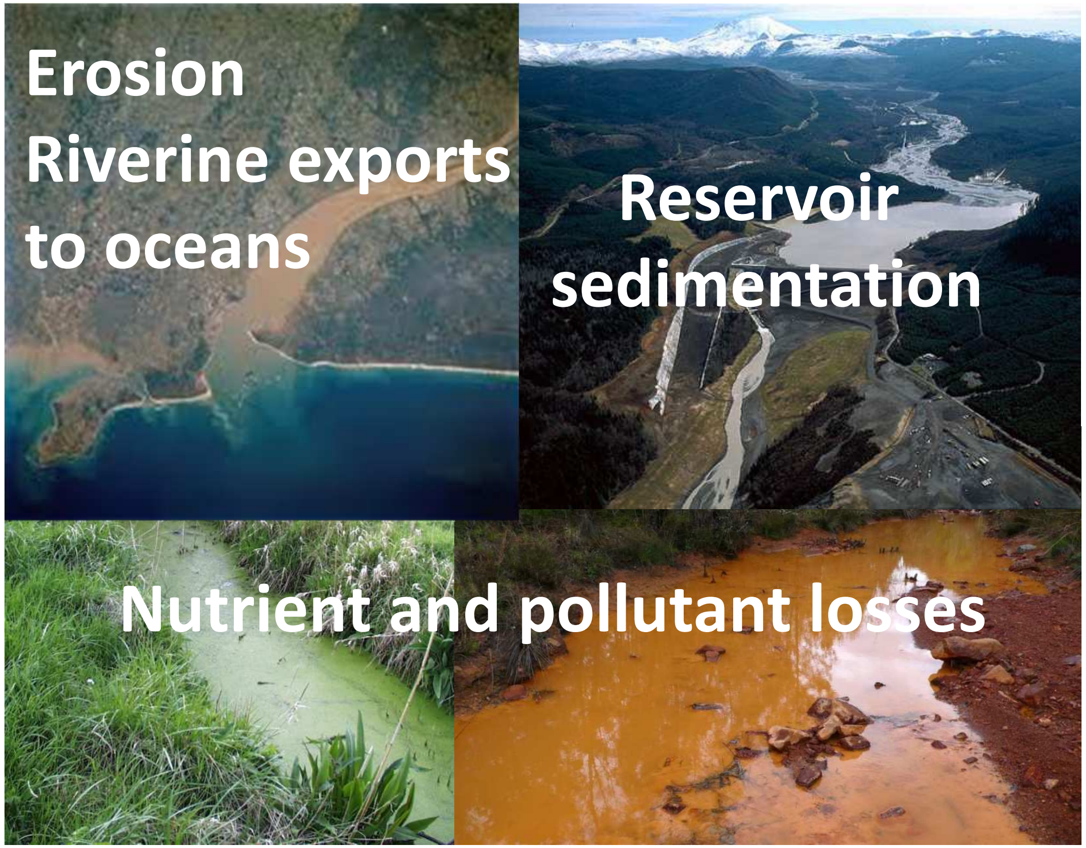
Why estimating riverine exports ?

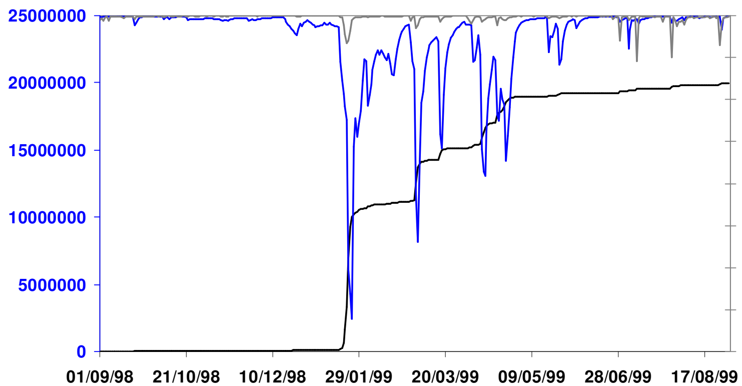


Why is challenging ?

Because a large proportion of annual load of most elements are exported during short time period

To better optimize sampling periods we need to better characterize load flashiness during these hot moments (high water periods)

$$L = K\int_{t_0}^{T} Q(t)C(t)dt$$



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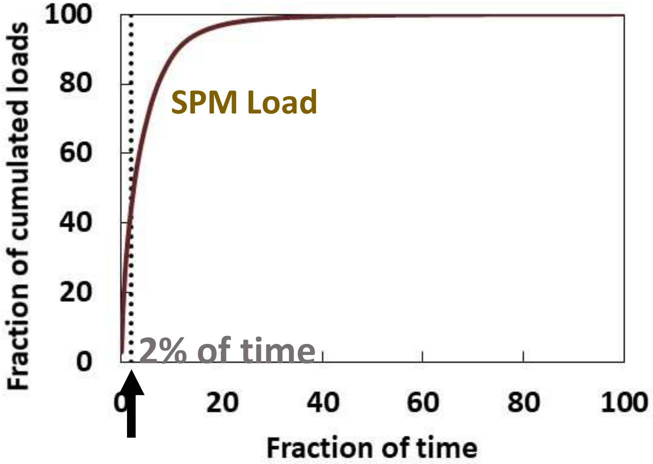
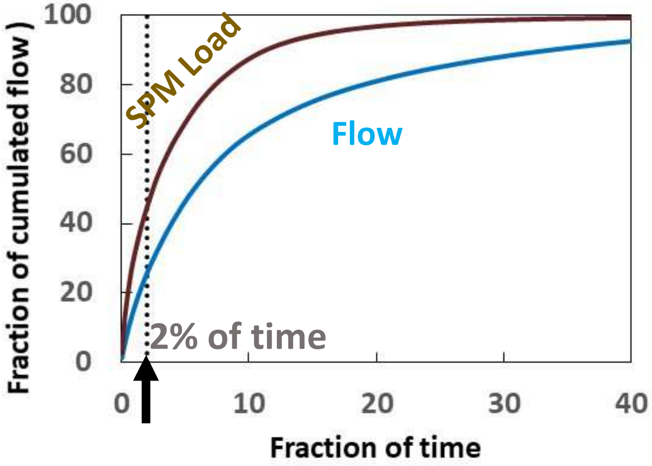
How to characterize load and flow flashiness?

Duration curve of loads
% of cumulated loads starting with highest vs % of time



Duration curve of Flows
% of cumulated loads starting with highest vs % of time



M_2 : % of cumulated loads in 2% of time
Good indicator to characterize load flashiness

W2% : % of cumulated flows in 2% of time
Good indicator to characterize flow flashiness

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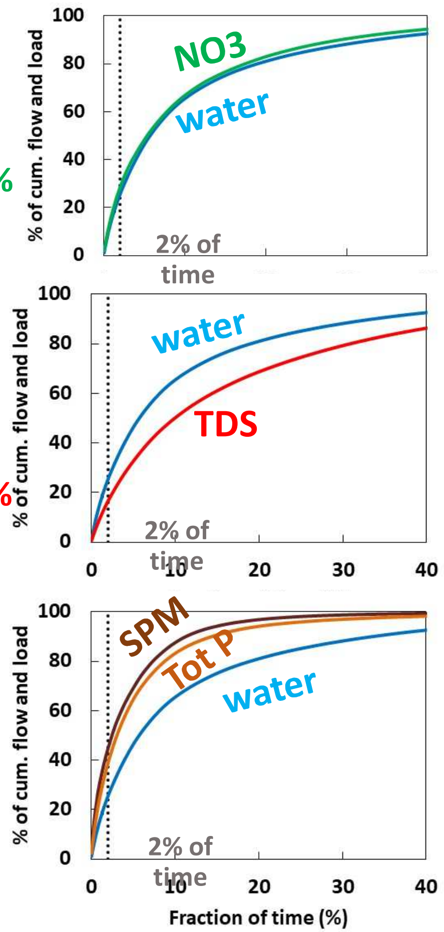
Load flashiness is linked to flow flashiness and type of elements

W_2 = 26 %
M_2 NO3 = 29%

W_2 = 26 %
M_2 TDS = 17 %

W_2 = 26 %
M_2 SPM = 45
M_2 TotP = 39



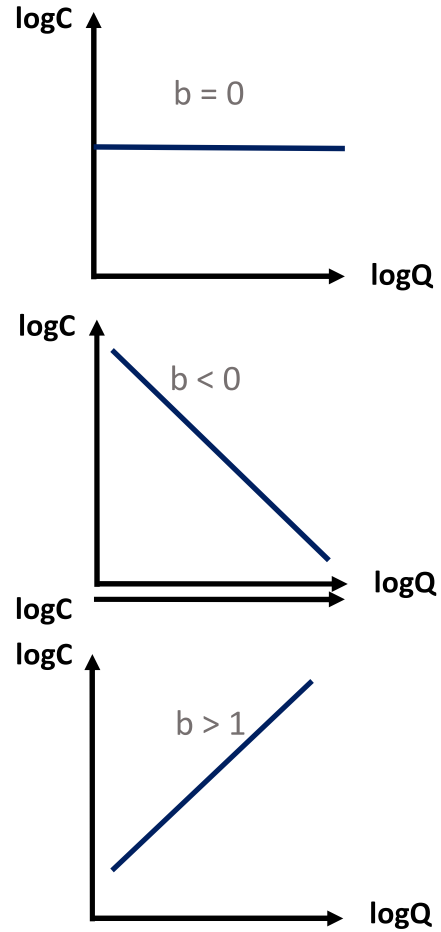
$C = aQ^b$

$Load = aQ^{b+1}$

Nitrate load variability is similar to flow variability (chemostatic behaviour)

TDS load variability is lower than flow variability (negative chemodynamic behaviour)

SPM and Total P load variabilities are higher than flow variability (positive chemodynamic behaviour)



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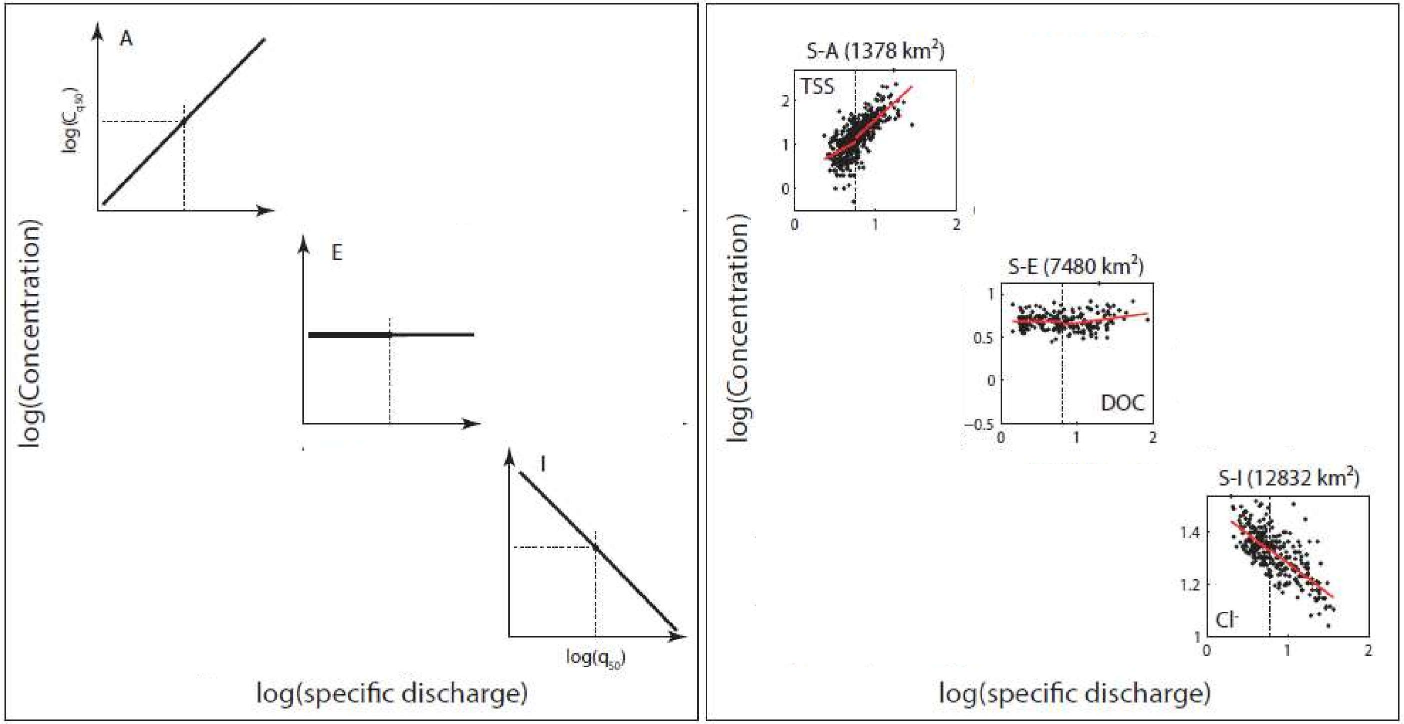
Segmented C – Q relationships



Meybeck and Moatar, Hyp, 2012. Daily variability of River concentrations and Fluxes: indicators based on Segmentation of the Rating curve

Moatar et al, 2017, WRR, Shapes and causes of C – Q relationships

- **Non-linear relationship on 60 % of catchment – element combination**

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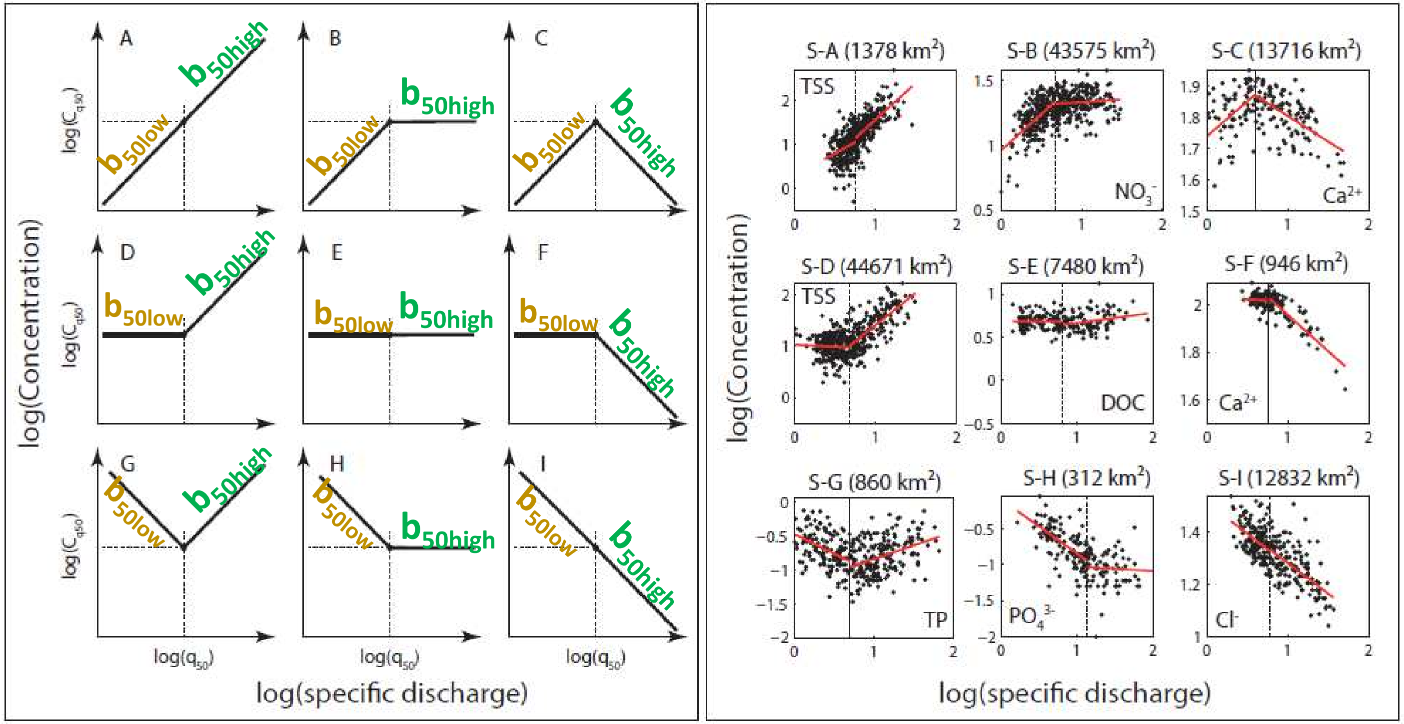
Segmented C – Q relationships : 9 types



Meybeck and Moatar, Hyp, 2012. Daily variability of River concentrations and Fluxes: indicators based on Segmentation of the Rating curve

Moatar et al, 2017, WRR, Shapes and causes of C – Q relationships

- **9 potential C – Q relationships and 2 or 3 dominant possibilities for each element**
- **b_{50low} - biogeochemical processes during low flow period**
- **b_{50high} – export pattern during high flow period**

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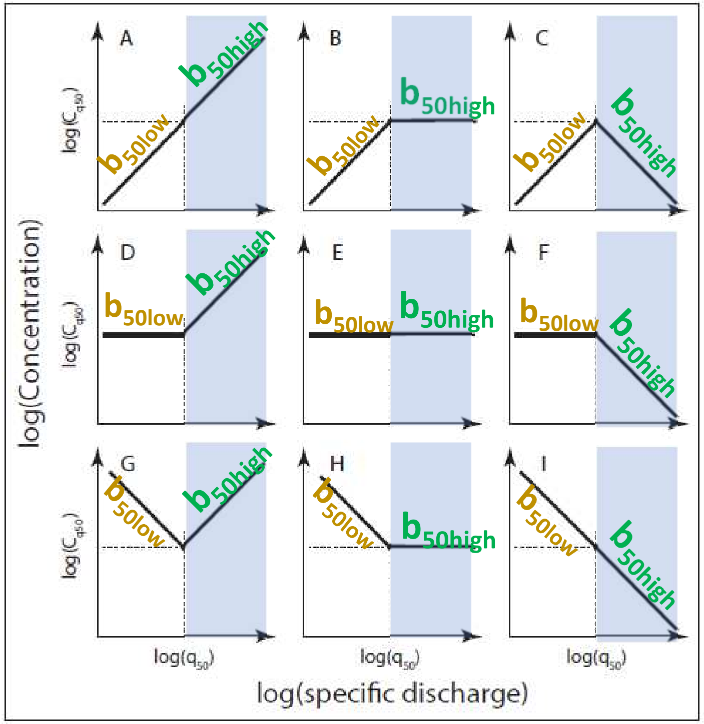
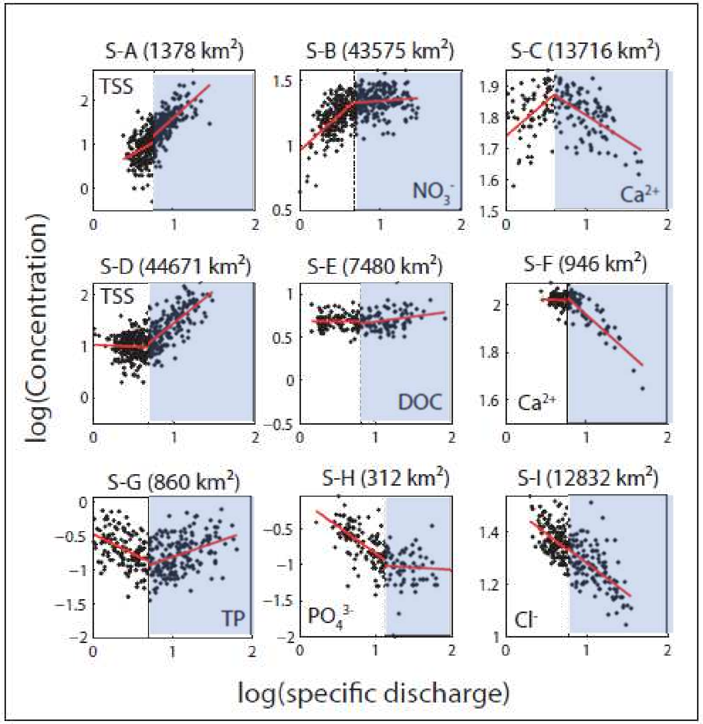
For solute and sediment export regimes : importance of b_{50high}





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Moatar et al, 2017, WRR, Shapes and causes of C – Q relationships

- 9 potential C – Q relationships and 2 or 3 dominant possibilities for each element
- b_{50low} - biogeochemical processes
- **b_{50high} - export pattern during high water (60 to 99% of annual load transported for Q > Q50)**
- **Therefore we use W_2 and b_{50high} to estimate M_2**

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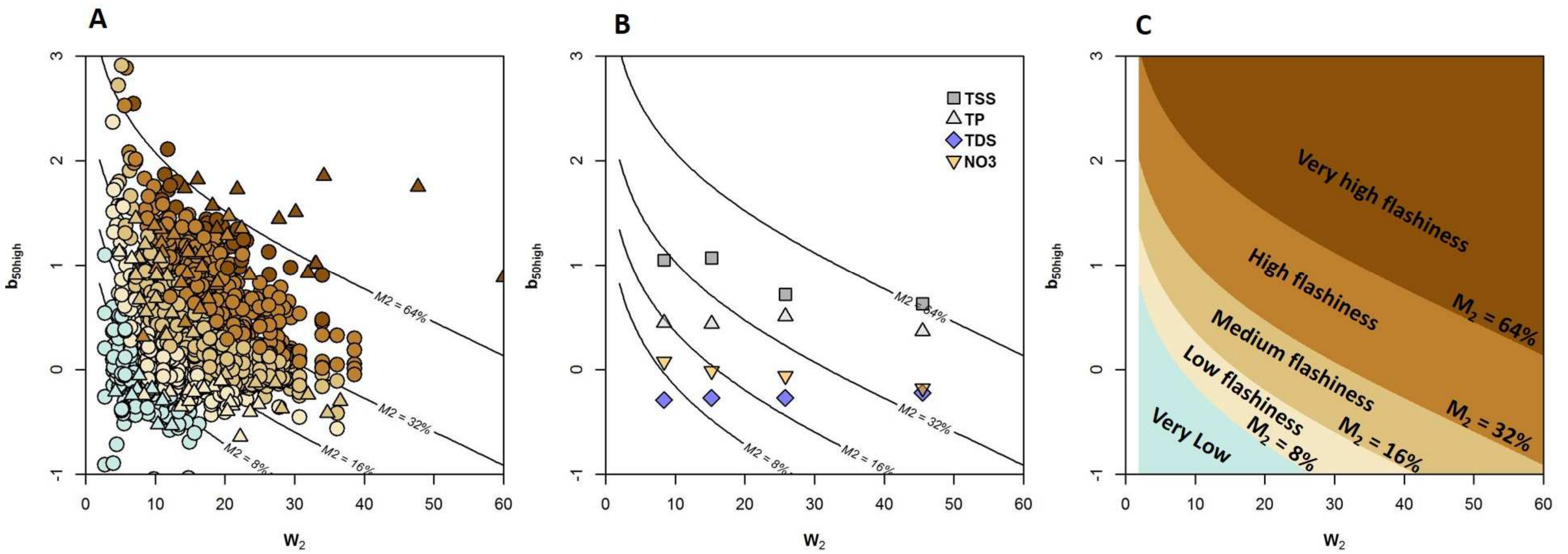
Load Flashiness (M2) Evaluation With Flow Flashiness (W2) and Export Pattern (b50high)

Probit(M2) = Probit(W2) + 0.79 b50high



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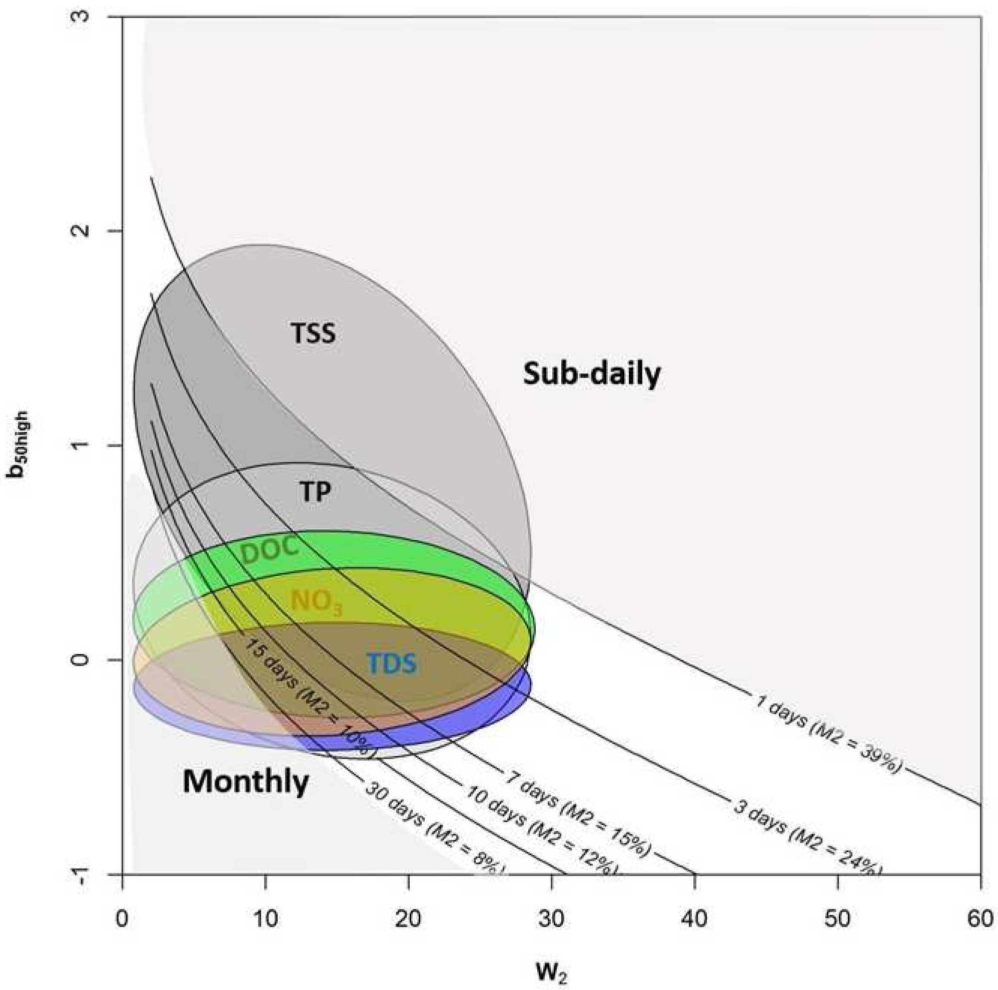
Optimizing Sampling Frequency for Reducing Load Calculation Uncertainty

Using the nomograph published by Moatar et al, HyP, 2013, for discharge-weighted concentration method And the relationship between M2, W2 and b50high

The optimal temporal monitoring frequency of the studied constituents decreases in the following order:

TSS, TP, DOC, NO_3, and TDS.



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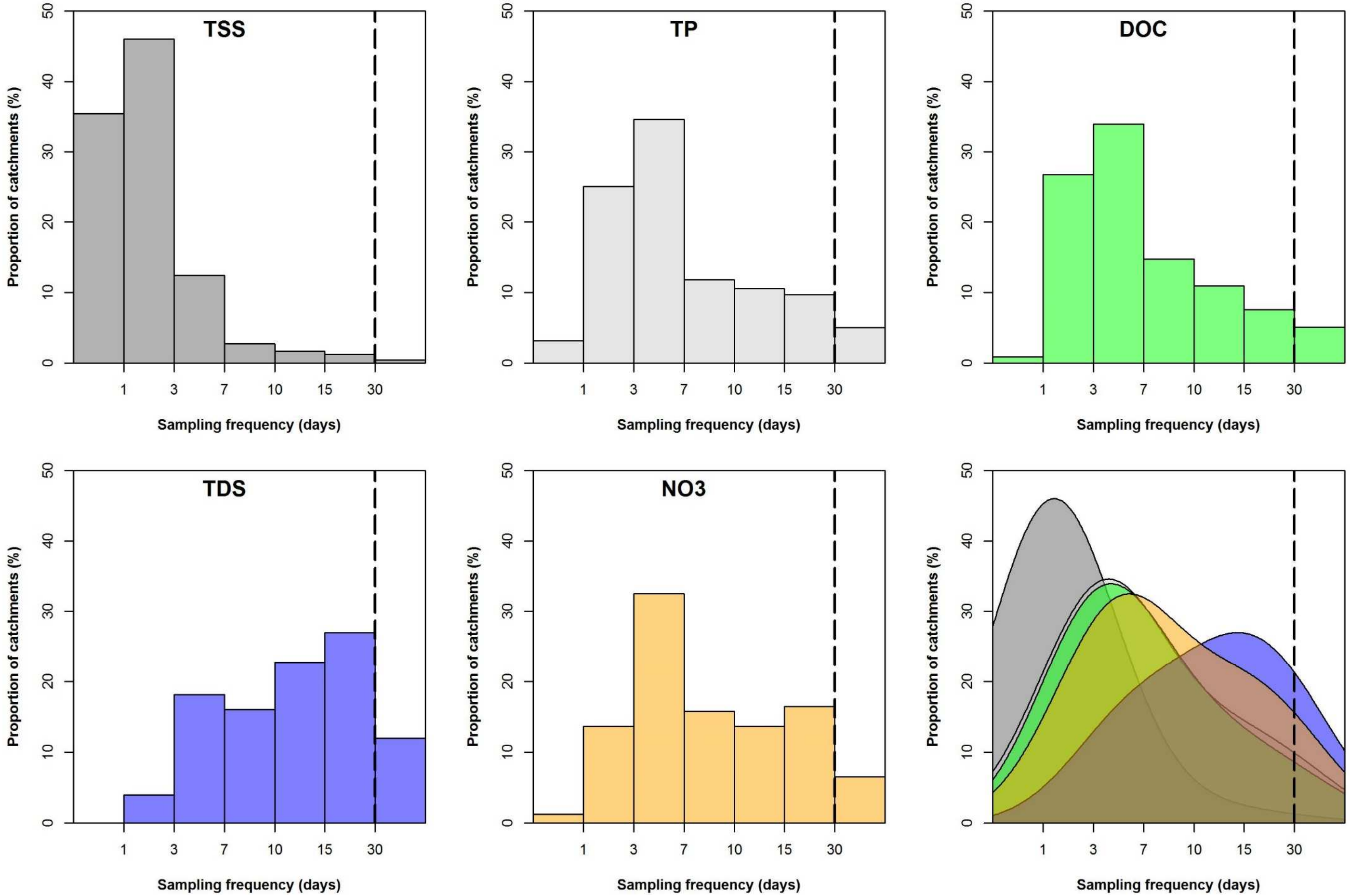
Distribution of optimal sampling intervals required for 475 French stations for each parameter. The vertical dashed lines represent the current sampling frequency, i.e., monthly



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Catchment caracteristics can be used in a first approach to set up water quality monitoring design

TABLE 4 | Relationships between W_2, b_{50high}, and M_2 indicators and catchment characteristics: total percentage of variance explained by final regression models following a backward selection approach of explanatory variables (third column) and individual contributions (between 0 and 100%; next columns) of the selected variables according to hierarchical variation partitioning.

		Indicator/Constituent										
		W_2	b_{50high}					M_2				
	Units	–	TSS	TDS	TP	NO3	DOC	TSS	TDS	TP	NO3	DOC
% of explained variance	%	34.9	21.9	22.9	18.2	10.9	12.1	30.9	36.5	37.9	28.3	33.1
Area	km²	**21.3**	9.6		15.5			12.9	**16.9**	7	10.8	**19**
Stream network density	km/km²	**25.4**		11.7			20.6	**24.9**	**15.7**	**16.6**	**39.1**	**19.7**
Wetlands	%	7.3	**19**				**20.9**	1.4			6.8	13.5
Crystalline rocks	%		**44.1**	8	**30.9**	4.8	**41.3**	15.3	2.9		3.9	4.8
Low carbonate rocks	%	11.6		6.8		4		**27.8**	8.4	14.4		13.7
High carbonate rocks	%	5.1		12.7		5.6			4.5	2		
Riparian vegetation	%						4.6		5.8			
Forest	%	10.2			12.8	20.5		4.2			8.2	10.1
Extensive agriculture	%	2.6				**26.8**	3.7	2.8		3.2	3.3	3.3
Intensive agriculture	%	**13.6**		**18.5**		**27.1**		8.9	**31.1**	**33.9**	**14**	**15.9**
Urban area	%		17.2	**42.2**				1.7	10.9	5		
Population density	ind/km²	3				11.2						
Point source P	kg/ha/yr				**22.8**					9.8		
Soil P	g/kg									8.1		
Point source N	kg/ha/yr										7.8	
N surplus	kgN/kg										6.2	
Erosion risk	%		10.2		17.9		8.9		3.8			

Blue and red cells indicate positive and negative relationships, respectively. Bold numbers highlight variables with the greatest influence (cumulated contribution >50%).

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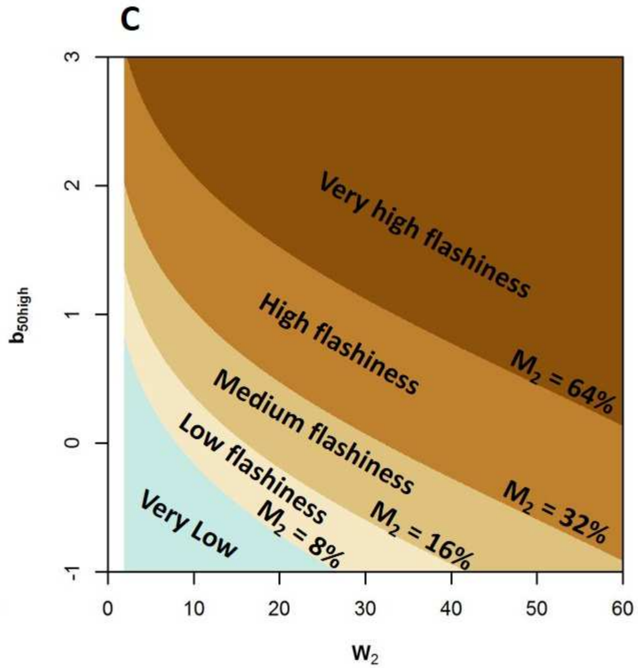
Conclusion

Solute and sediment export regimes are quantified by the load flashiness (M_2), which can be easily determined from flow flashiness (W_2) and b_{50high} (from high frequency data or long-term low frequency)

The load flashiness diagram can be used to:

- classify elements, catchments,
- quantify human impacts and mitigations,
- optimize sampling strategies
- calculate uncertainties of long-term monitoring surveys



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