Analysis of concentration-discharge relationship of rivers in the TERENO observatory "Harz/Central German Lowland“

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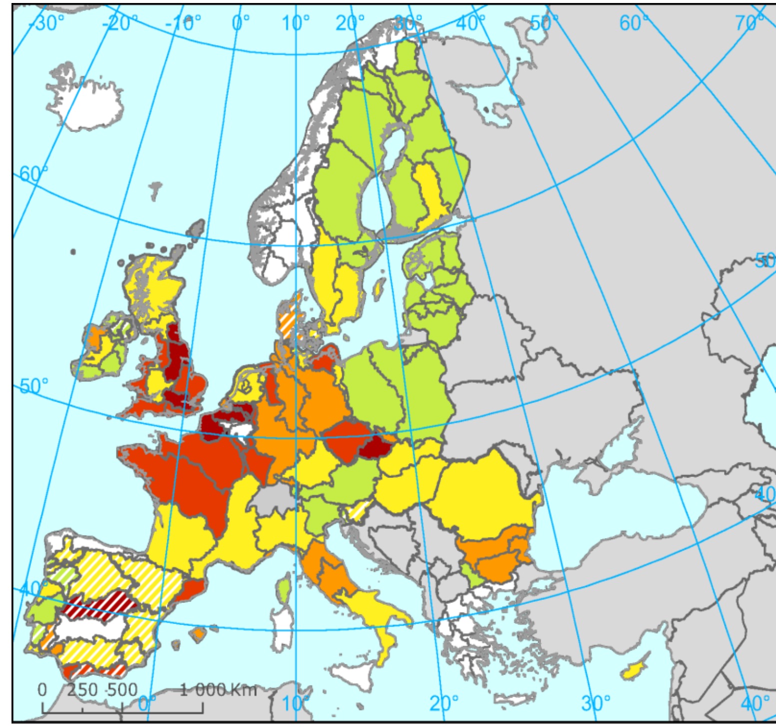
Introduction – Nutrient exports

- EU Water Framework Directive demands good status of water bodies
- Elevated nutrients from agriculture lead to downstream eutrophication
- Catchments as „natural“ management units

→ Concentration and load dynamics

- But: complexity of catchment structure and the multitude of the processes involved

→ Top-down, data-driven analysis of integrated catchment responses



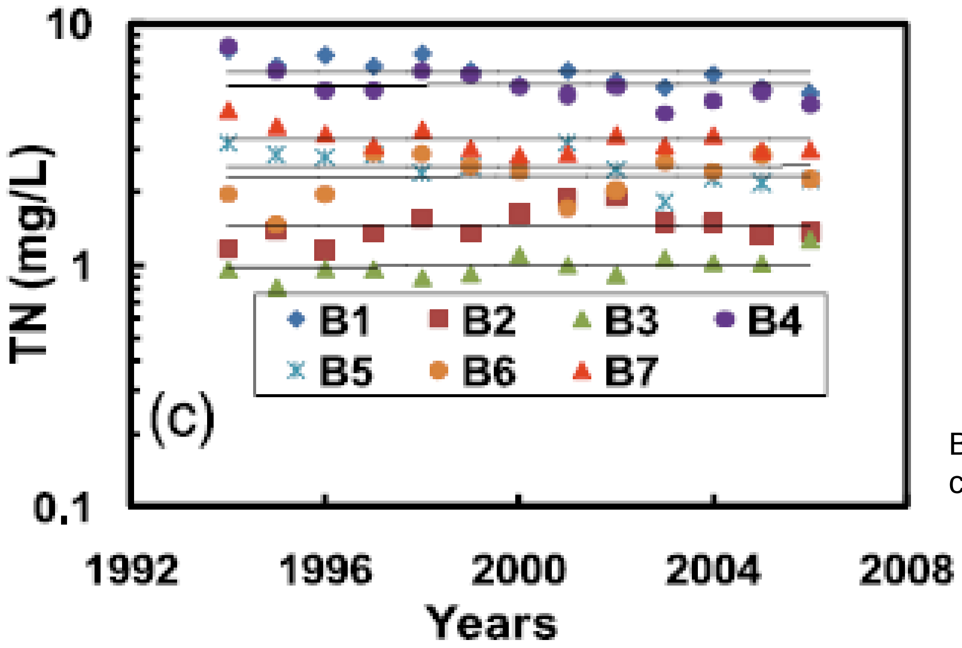
EEA

Percent of classified groundwater bodies with poor chemical status

- < 10 %
- 10–30 %
- 30–50 %
- 50–70 %
- 70–90 %
- ≥ 90 %
- No data
- RBDs with unknown area of groundwater bodies (count instead of area used) are hatched

Introduction – Nitrate export behavior

- Basu et al. (2010), Thompson et al. (2011): Temporal invariance (chemostatic export regime) of nitrate from managed catchments



Basu et al. (2010) GRL, Annual flow weighted concentrations, Baltic Sea Drainage Basin

→ Export controlled by discharge

→ High availability/ large nitrate store in catchments

Objectives

- Transfer approach to a group of data-rich adjacent catchments with different degrees of agricultural management

→ Good databasis for C/ Q, land use, geology, climatic conditions

Hypothesis: Nitrate export regime is predictable from catchment characteristics and foremost driven by the share of agricultural land use within the catchments

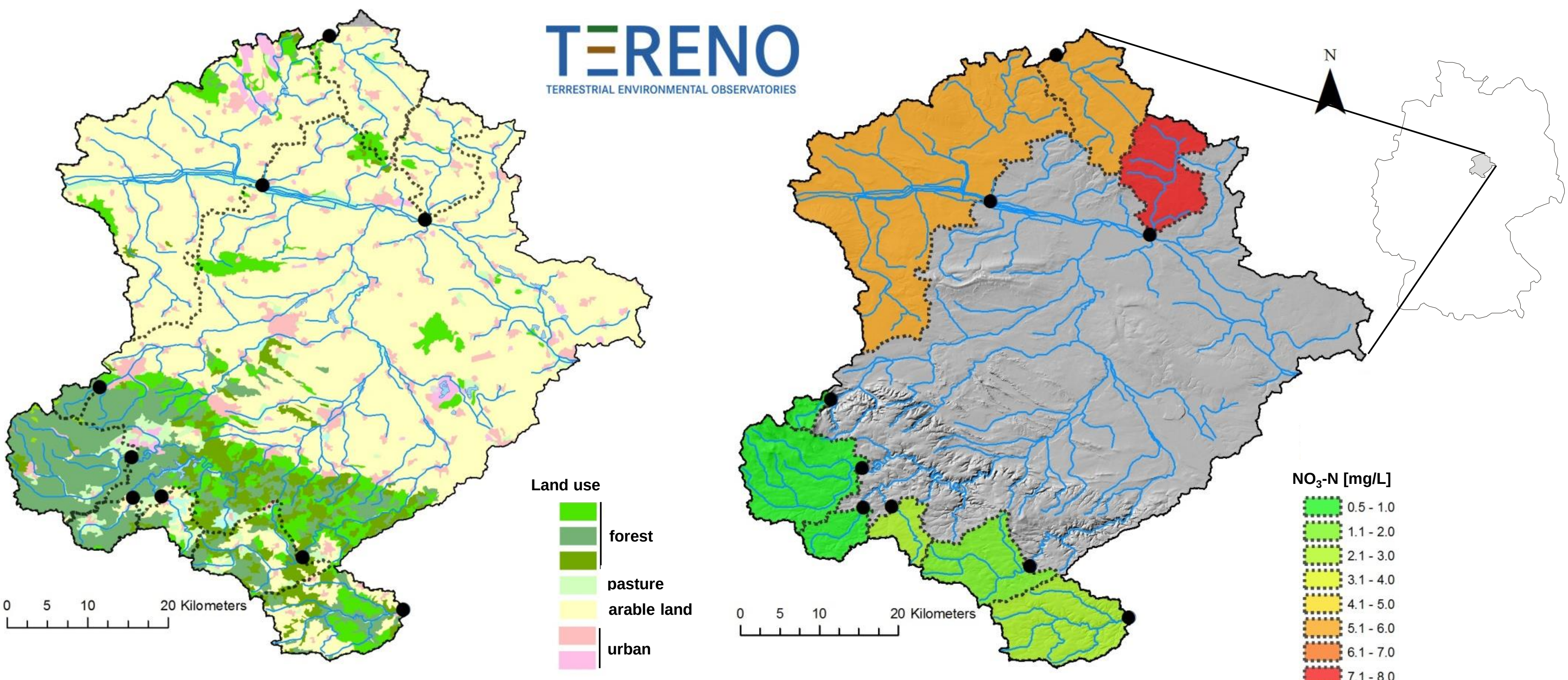
Longer run: Adapted monitoring protocols and parsimonious modelling approaches

Study area

- Seven sub-catchments within River Bode catchment, two adjacent catchments

→ gradients in land use, geology, and climatic conditions

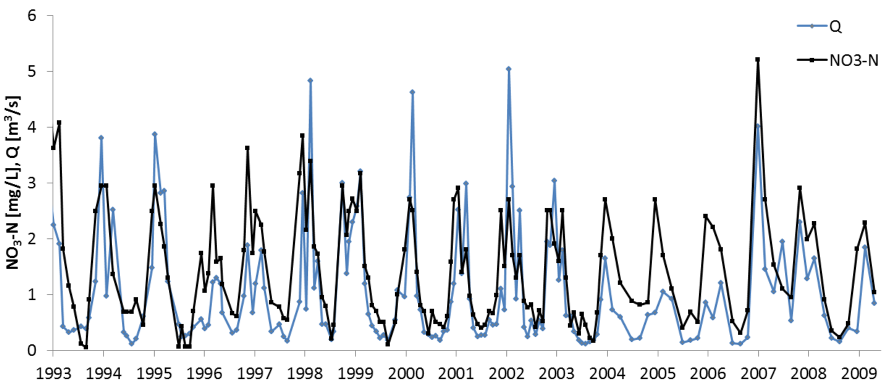
- 16 years time series of NO_3 concentration and discharge (n=74-159)

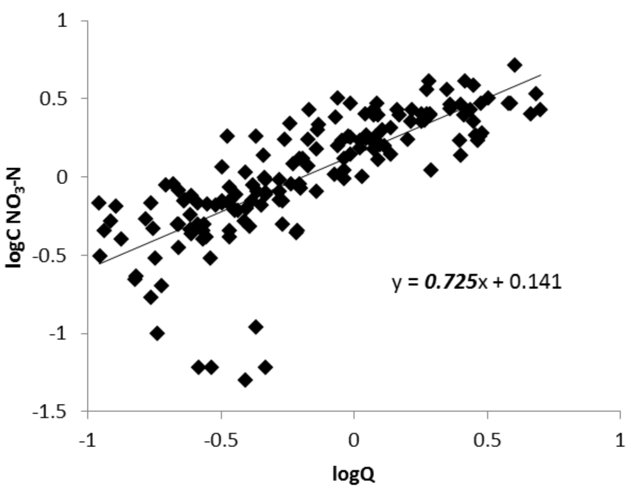


Musolff et al. 2015, AWR

Methods – Metrics of solute export

- CV_C/CV_Q → *regime* - C variance relative to Q variance
- *b* in $C = aQ^b$ → *pattern* - direction C-Q relation



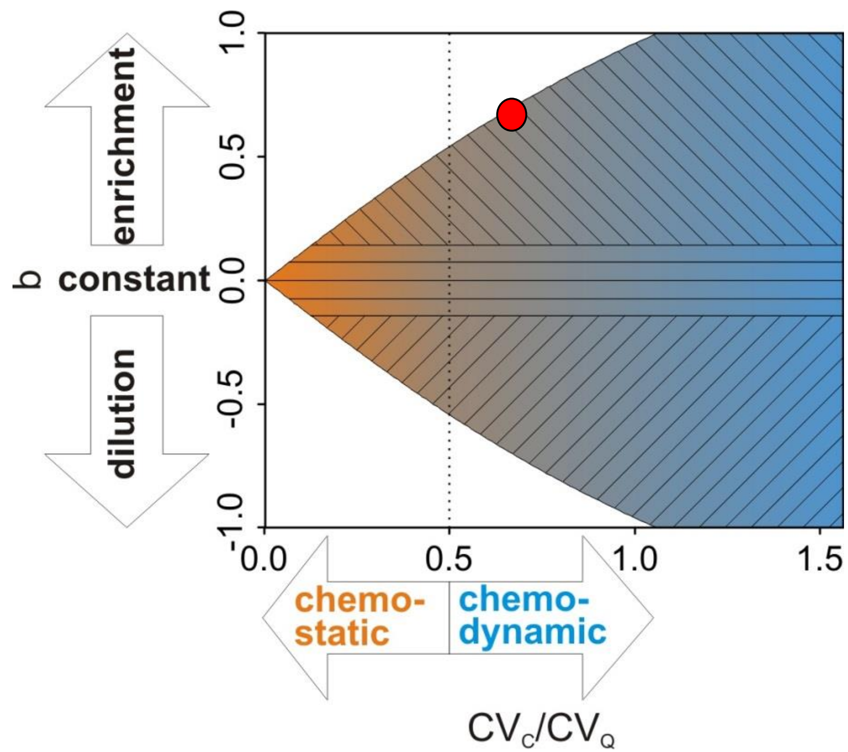


$CV_Q = 0.99$

$CV_C = 0.71$

$CV_C/CV_Q = 0.72$

$b = 0.73$



Musolff et al. 2017, GRL

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Methods – Partial least squares regression

- Relevance of seven catchment characteristics as predictors for median NO_3 concentrations and metrics of export regime
- But: strong collinearity of catchment characteristics

Discharge per unit area						
0.97**	Runoff coefficient					
-0.85**	-0.72*	Share of drained ara. land				
0.80**	0.79*		topo. gradient			
-0.94**	-0.97**		-0.80**	Share of ara. land		
-0.75*	-0.83**			0.87**	BFI	
-0.86**	-0.91**		-0.75*	0.96**	0.83**	Available water content

PLS: finding covariance structure in predicting and responding variables

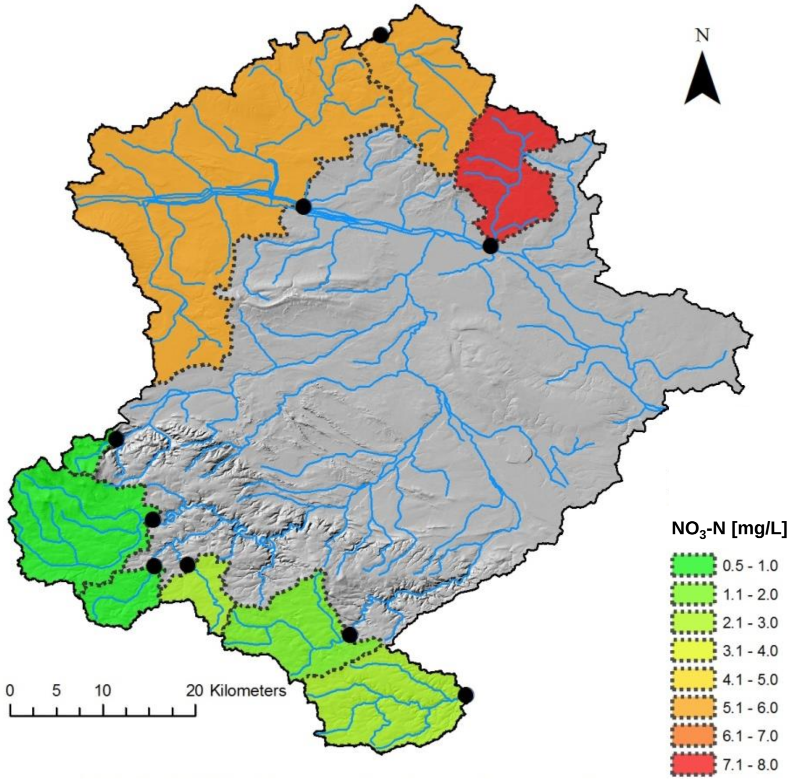
→ Can handle collinearity

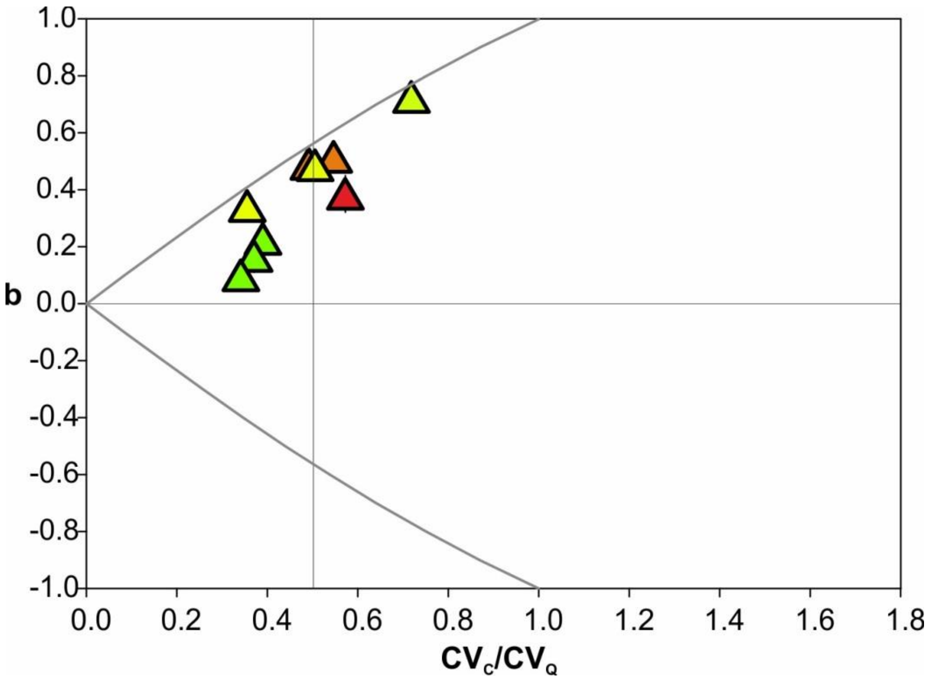
→ Can handle large number of predicting variables

→ Interpretation using VIP (variable influence on projection) ranking and regression coefficients

Results – nitrate export

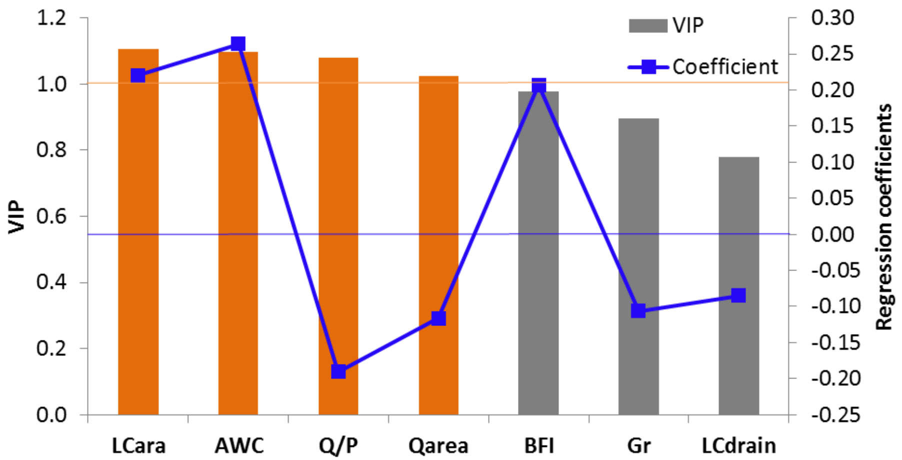
- Export regimes from chemostatic to chemodynamic with constant to enrichment patterns



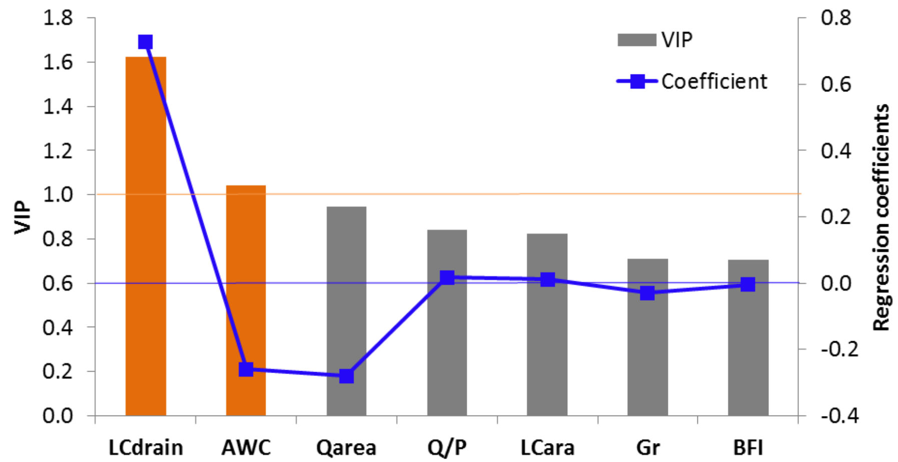


Results – PLS regression

- Median concentrations (R^2 0.97) and slope *b* (R^2 0.72) can be well reproduced by catchment characteristics
- CV_C/CV_Q with less good performance



median NO_3-N



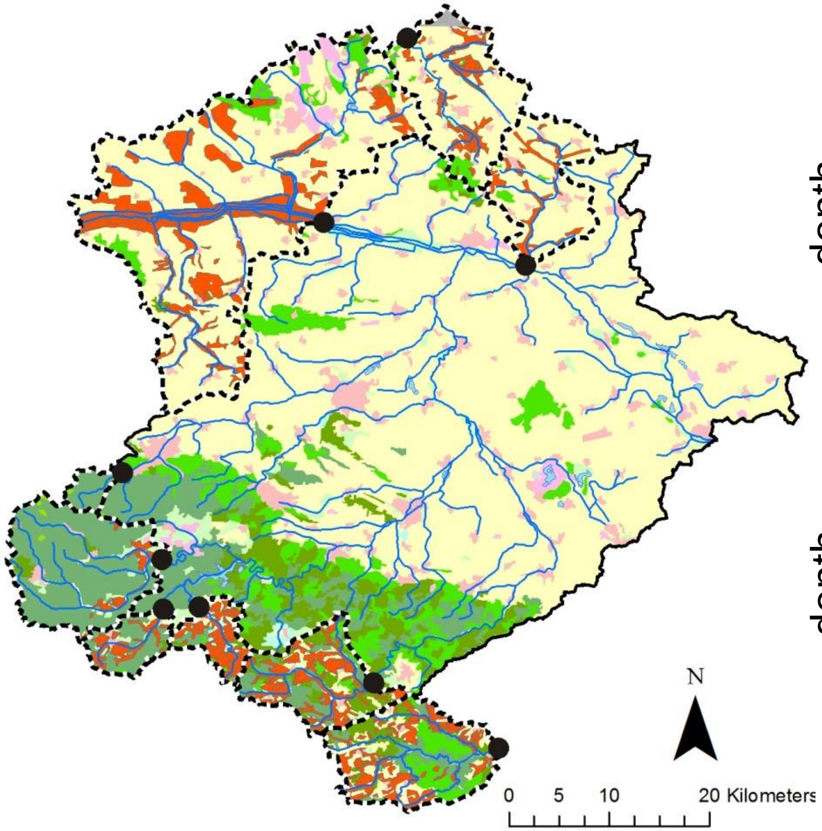
slope *b* NO_3-N

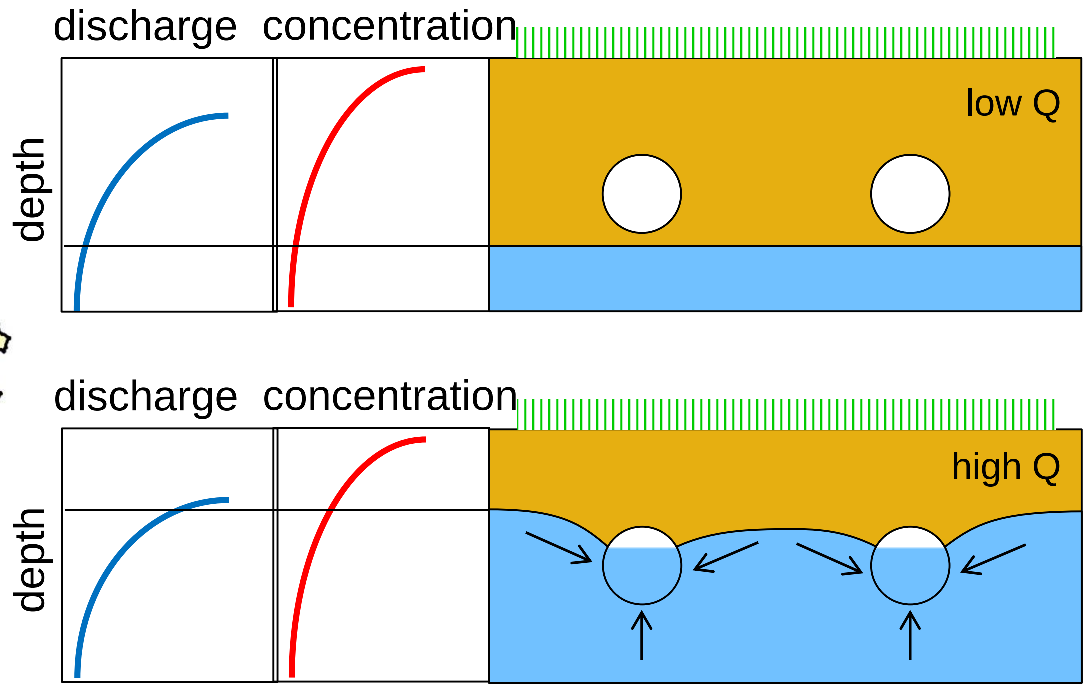
- Median nitrate concentrations are driven by agricultural land use
- Export regimes driven by arable land being artificially drained

Discussion

- Tile drains most active under high Q situations
- Downward decrease of nitrate concentrations (age, retention)

→ Spatial correlation of nitrate source zone and discharge producing zone is the dominant control of export regime

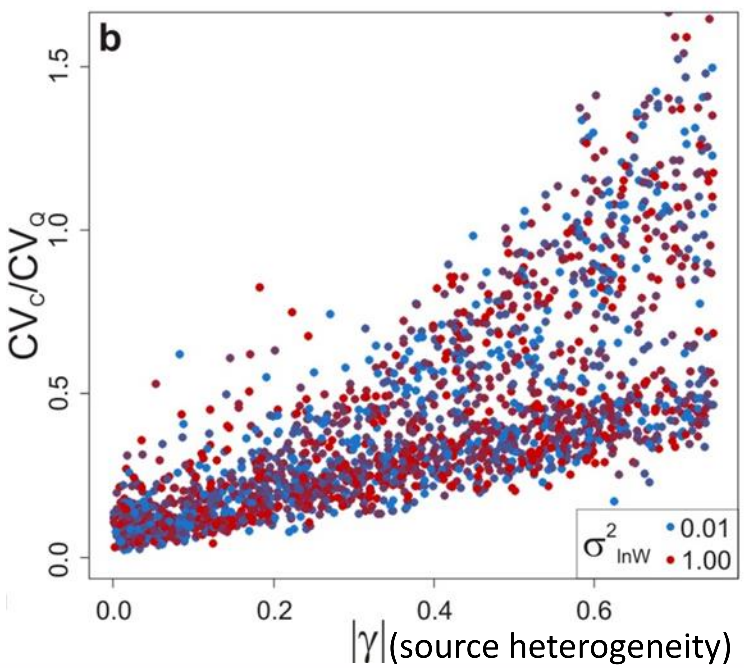


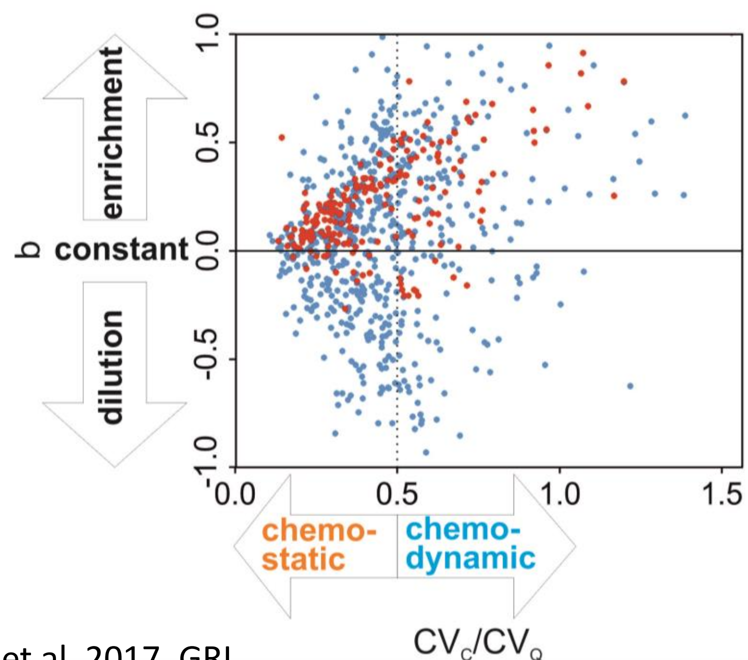


Musolff et al. 2016, AWR

Conclusions

- Export regime is predictable from catchment characteristics
- High nitrate inputs and high store does not necessarily lead to chemostatic export regimes
- Trajectory in time from pristine conditons to managed agricultural catchments may be replicated in space
- Endpoint in heavily managed catchments with high degree in hydrological/ land use homogenization





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