Integrative indicators as robust metrics of catchment biogeochemical function

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1. Background

- In catchment science, we are seeking, among many other things, to detect changes in generation of flow and loads that might correspond to human intervention
- In the anthropocene, many 'treatment systems' or Best Management Practices (BMPs) have been installed to improve water quality
- But quantification of impact of BMPs on Water Quality (WQ) has been difficult at best. Why?

2. Hypothesis

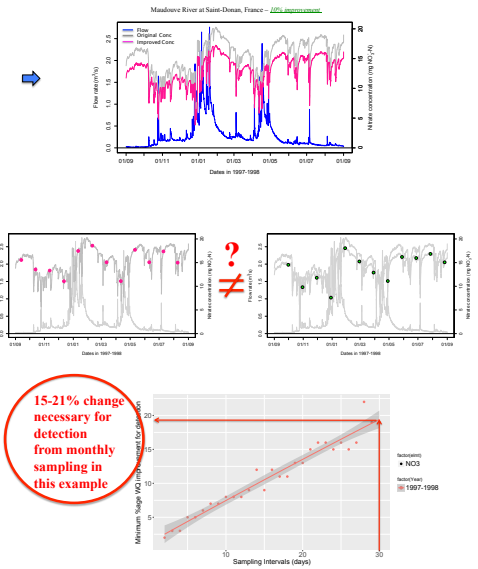
- We hypothesize that to detect water quality changes, one needs to obtain ***integrative indicators*** because these tend to be more ***robust*** indicators

3. Objectives

- Show that concentrations as water quality indicators are not robust in reactive catchments
- Introduce the concepts of *integrative vs derivative* indicators
- Show that the concept of replications are of very different nature for integrative *vs* derivative indicators
- Propose robust indicators as requirement to detect water quality improvements

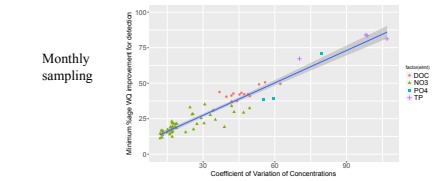
4. Minimum detectable WQ improvement from infrequent concentrations

- Use high frequency concentration data, and simulate WQ improvements from 1% to 200%
- Randomly sample the control (initial) and treatment (improved) concentrations at frequencies from 2 to 30 day intervals
- Run a paired t-test between subsample sets, and determine the proportion of the times the treatment subset is different from the control, for a range of improvement levels
- From this, determine the minimum WQ improvement level needed to be confidently determined (95% of the cases)



5. Concentrations are *not* robust indicators

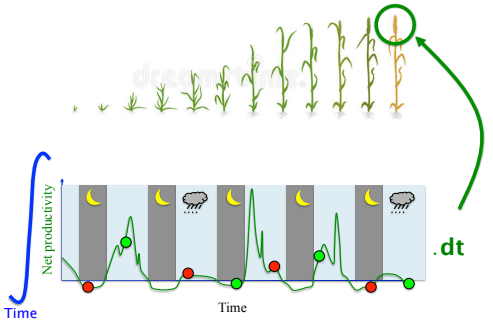
- Large WQ improvement needed to be detectable



6. Detecting treatment effect: the wheat yield analogy

7. Wheat yield: Integrative indicator

- Wheat yield corresponds to the integration over time of all the variations of instantaneous wheat productivity, which remove much of the noise



- Partial subsampling of the net productivity function, i.e., the ***derivative*** function of the yield indicator, would yield a lot less clear effect (green *vs* red dots)

8. Integrative vs derivative indicators

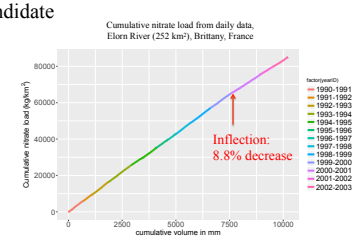
	Treatment tested	Processes & kinetics	*Derivative* indicators	*Integrative* indicators	Difference needed for treatment detection
Wheat	e.g., fertilizer	Inferred	Instantaneous net productivity, not measured	Yield: Measured + replications	SMALL
Catchment	e.g., BMPs	Inferred	Flow and concentrations, ~ measured	Average concentrations and Loads: Estimated, no replications	LARGE

9. Replications of different nature

- The equivalent of concentrations is the net productivity in the example
- True replications for wheat plots but apparent replication of few concentration values just a capture of derivative signal

10. Robust indicators for catchment WQ?

- No direct measurement of integrative indicator of water quality
- Integrative; Flow weighted concentrations calculated from WQ sensors and continuous flow: good candidate



11. Conclusions

- We propose that for research about catchment biogeochemical functioning, integrative indicators, being more robust, should be preferentially sought
- Integrative indicators able to integrate per unit of flow volume, would provide robust indicators of WQ
- Continuous WQ sensors currently provide a solid method to obtain integrative WQ indicators

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