

# High Frequency Water Quality Data: The Next Leap in Hydrology?

François Birgand  
Associate Professor

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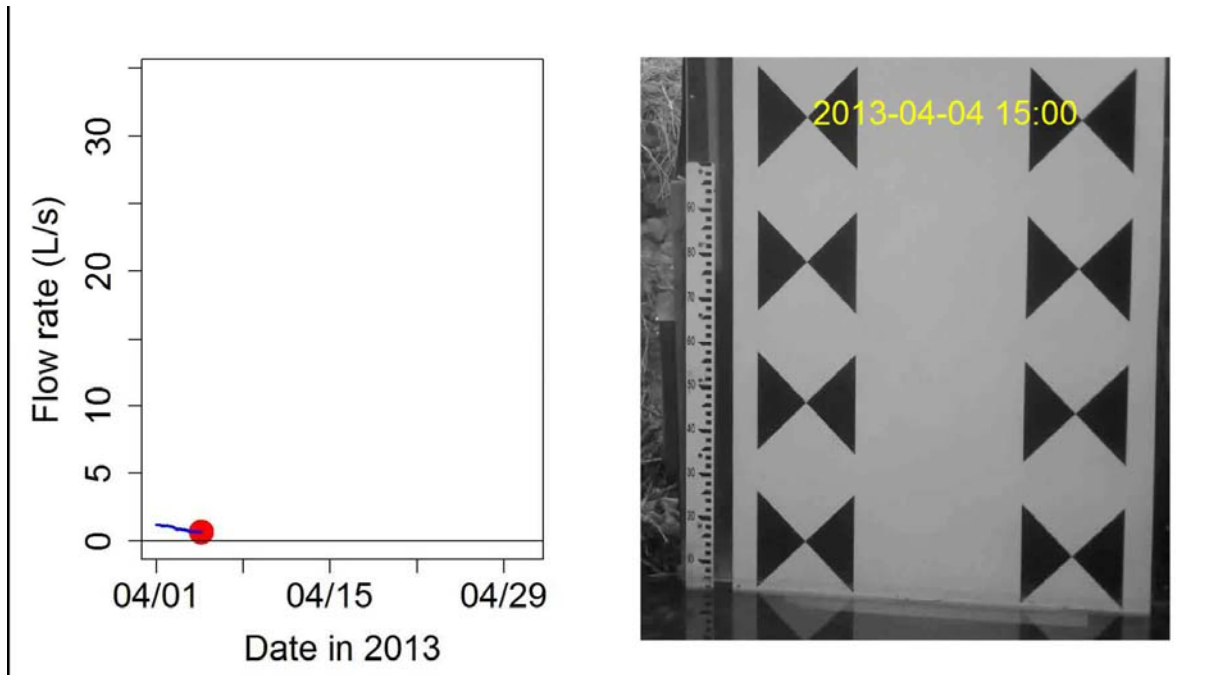
1

## In Environmental Sciences we...

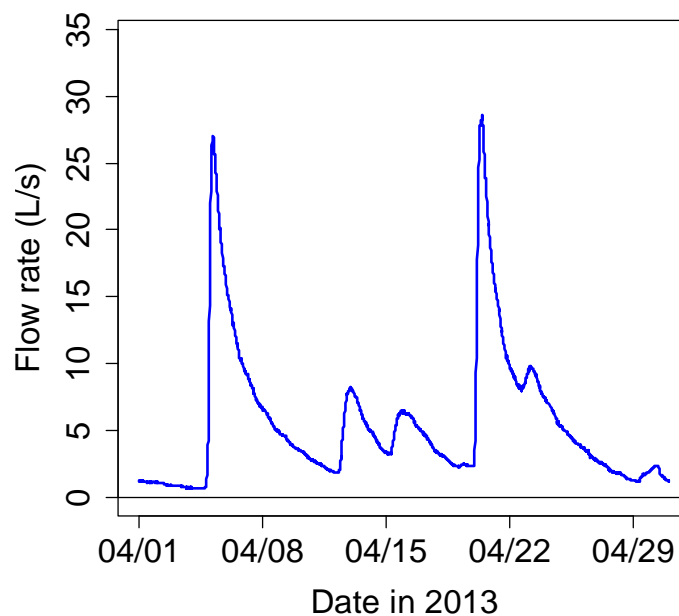
- ... want to tell the story of how the world functions
- ... make hypotheses
- ... we collect data *partial in space and in time*
- ... infer processes at play, quantify, extrapolate, model
- ... make conclusions on how the world functions and what we should do about it

# In hydrology, we have had access to 'the story'

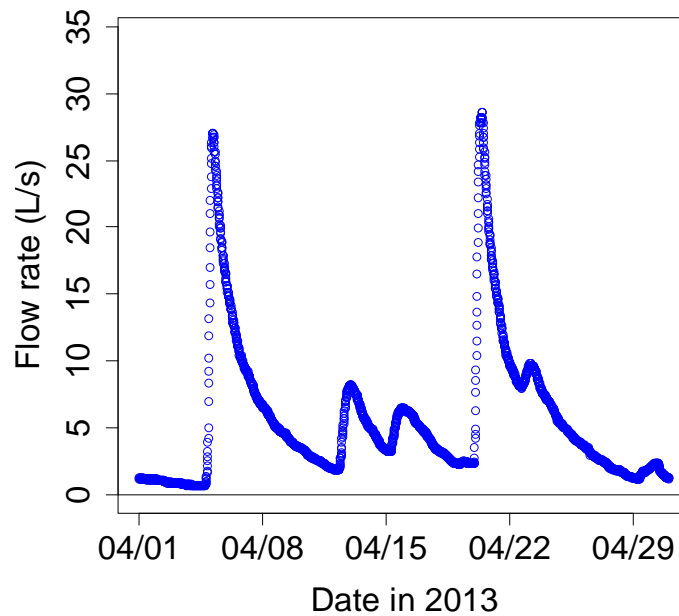
Images: GaugeCam.com



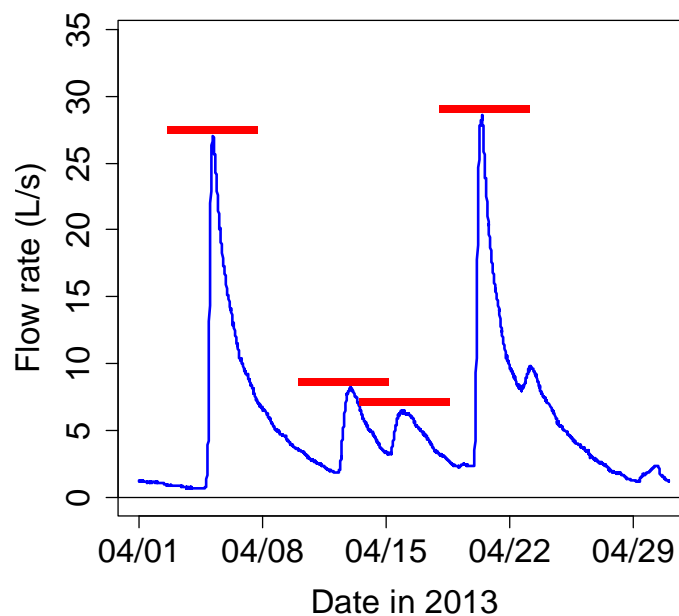
## 'Continuous' = high frequency



'Continuous' = high frequency

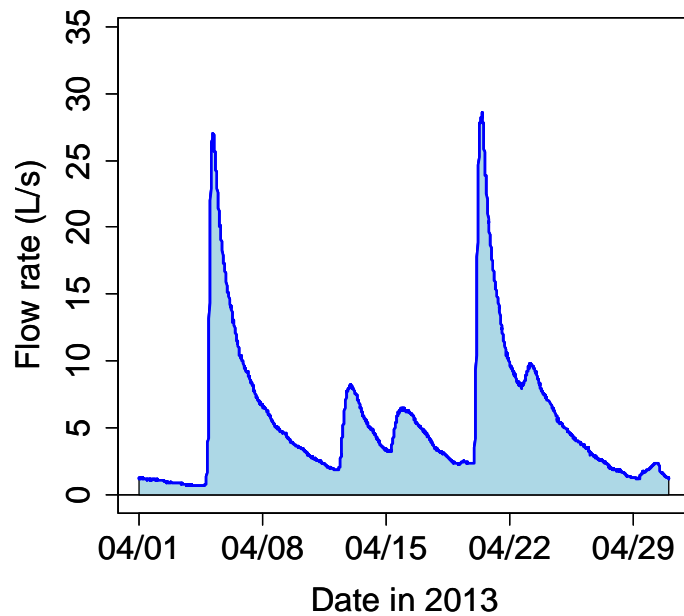


With the full story, we can...



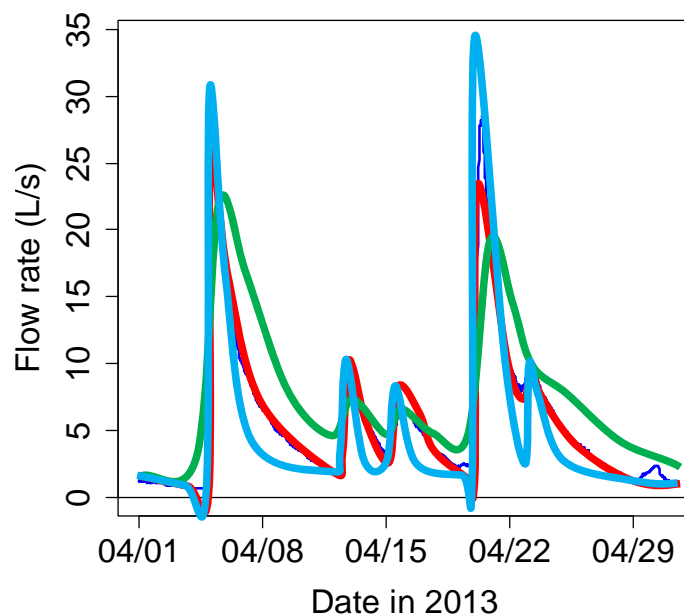
# With the full story, we can...

## Calculate Cumulative flow volumes



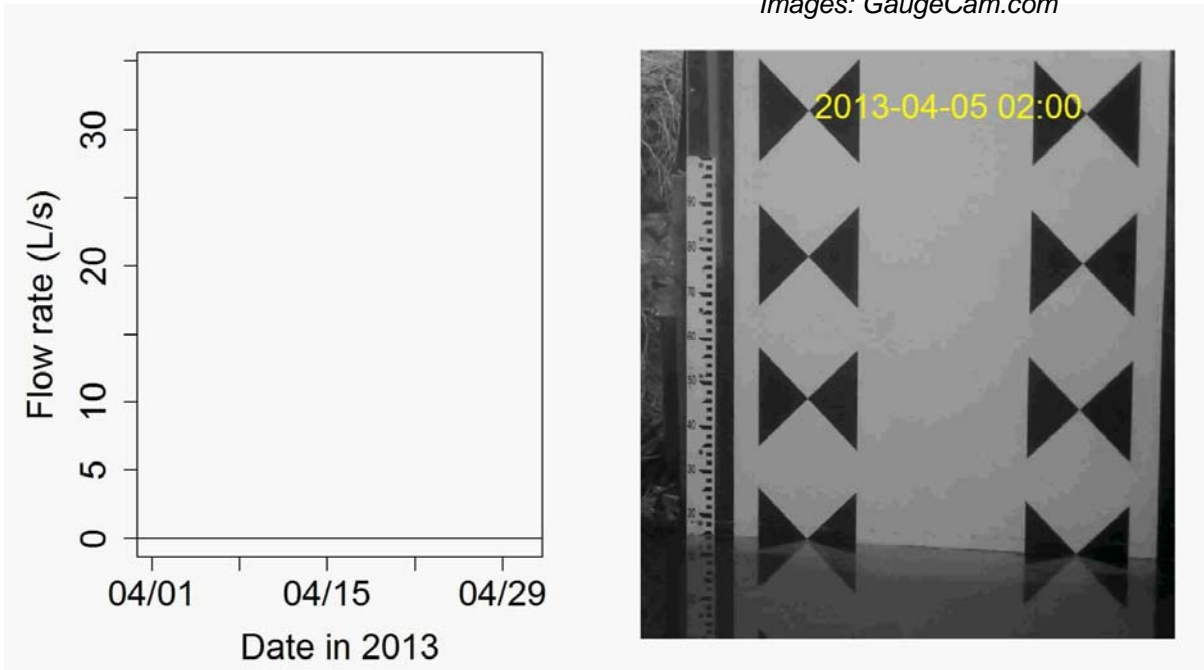
# With the full story, we can...

## Calibrate our models

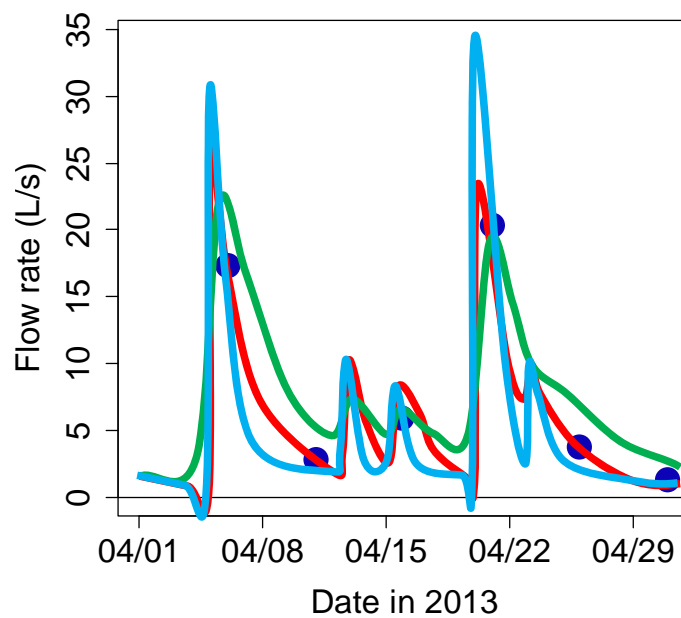


# Just Imagine...

Images: GaugeCam.com



# Just Imagine...

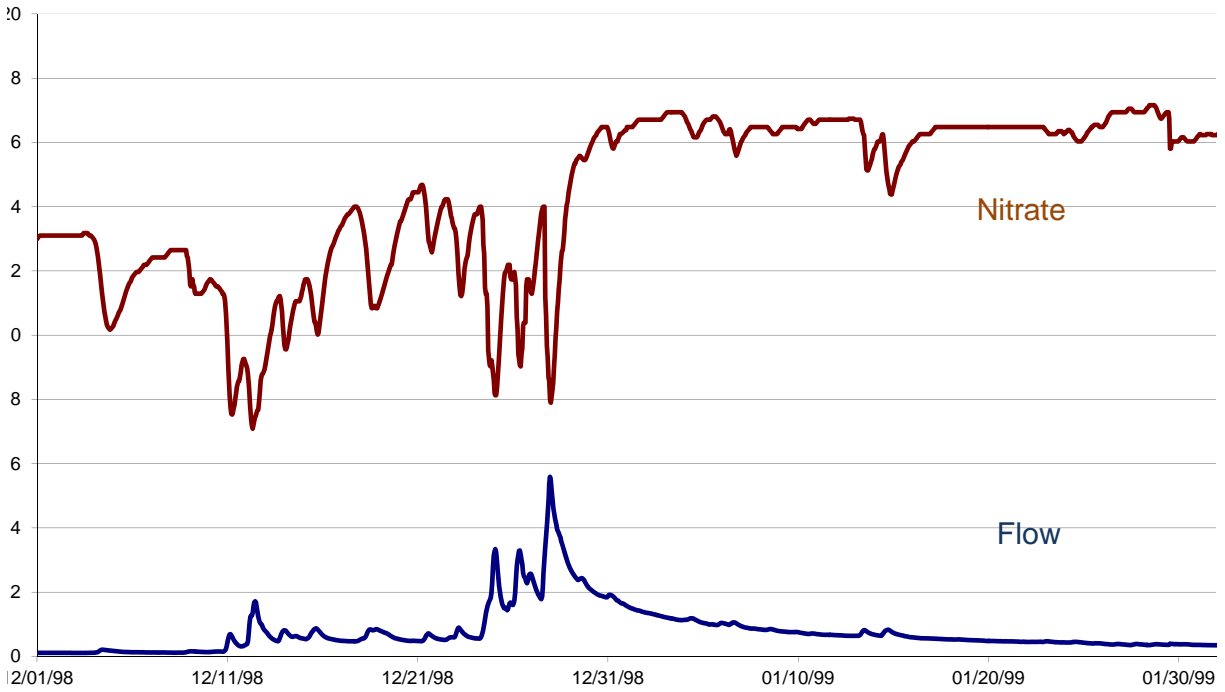


1 ?

2 ?

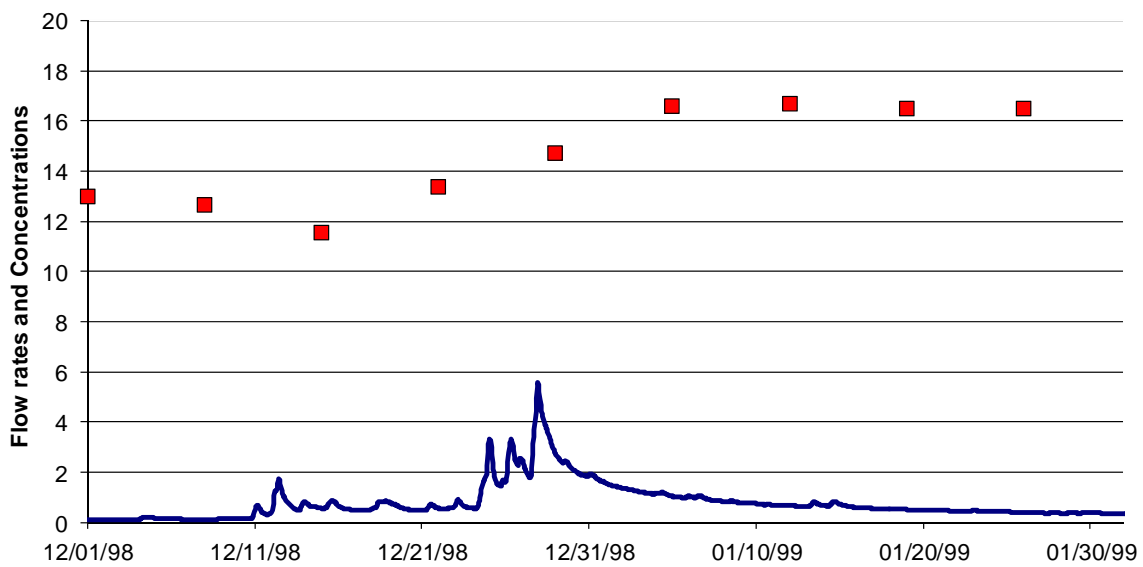
3 ?

# Continuous WQ data



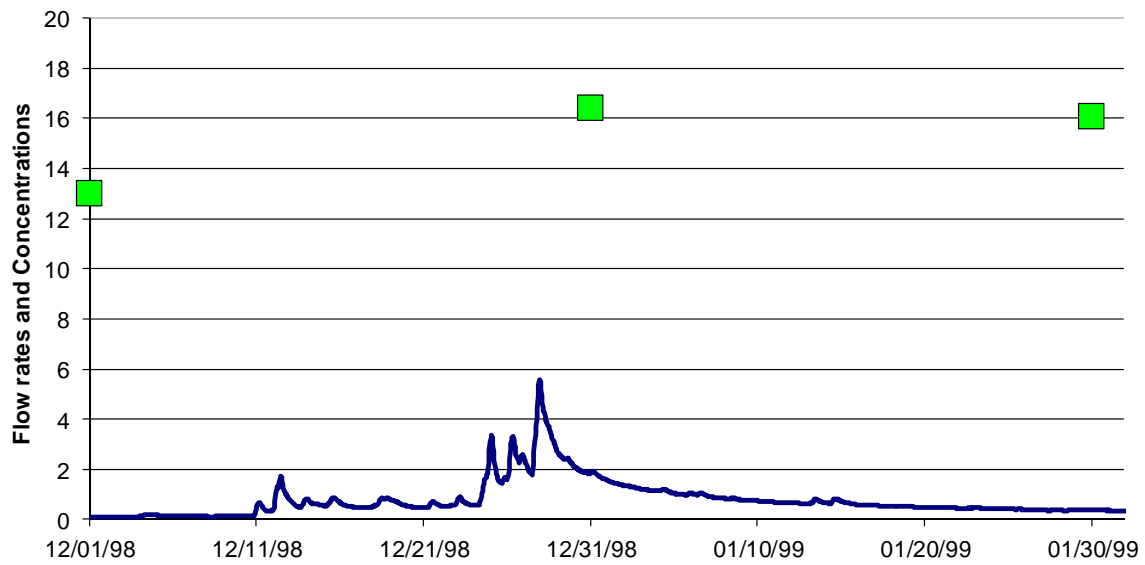
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# Weekly samples...



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# Monthly samples...



So there is no hope?

# Our (recent) lucky experience with new sensors

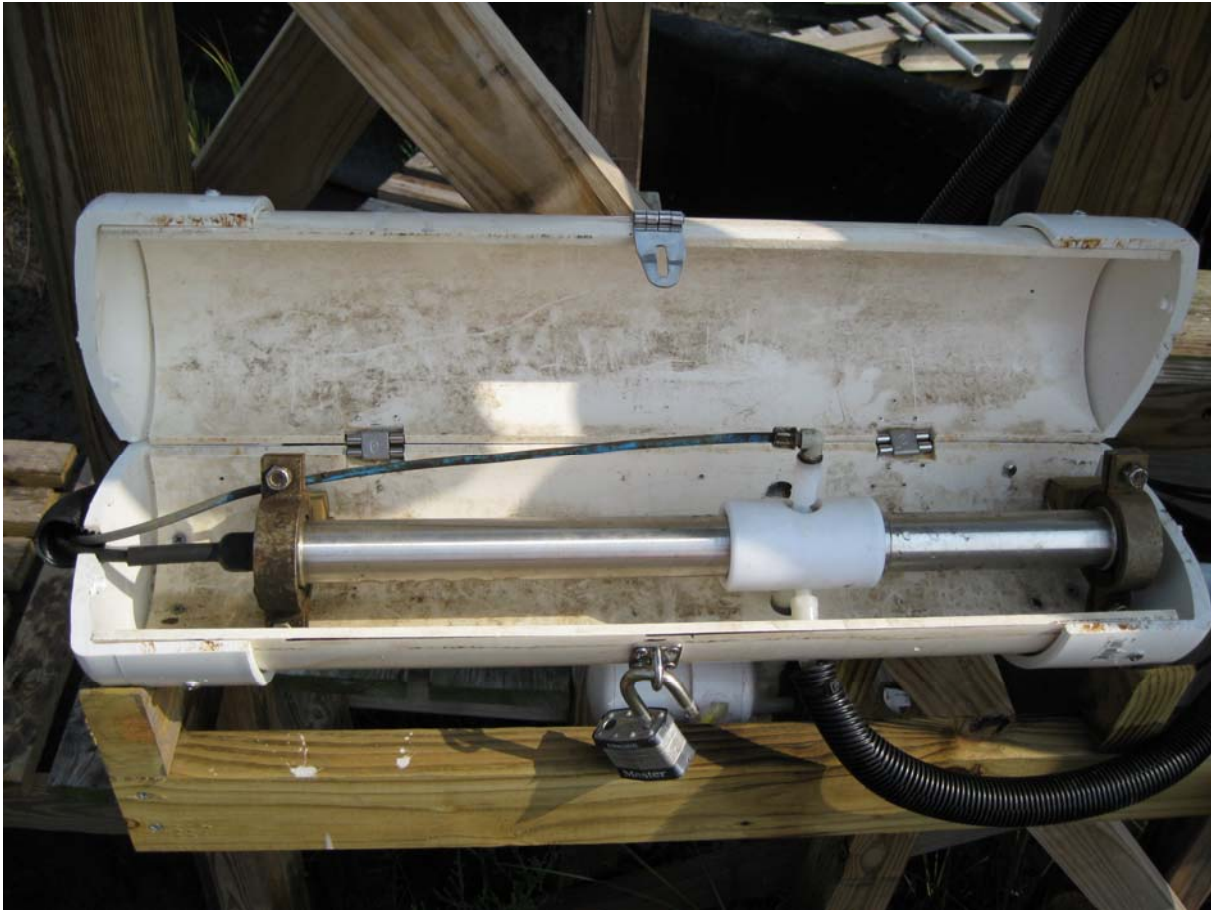
## We tried our chance

- Field UV-vis spectrophotometers



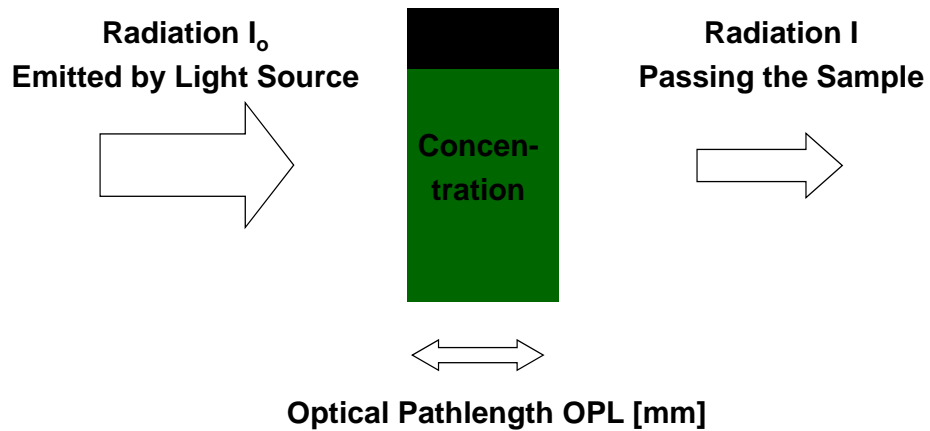
- Spectro::lyser from S::CAN, Austria



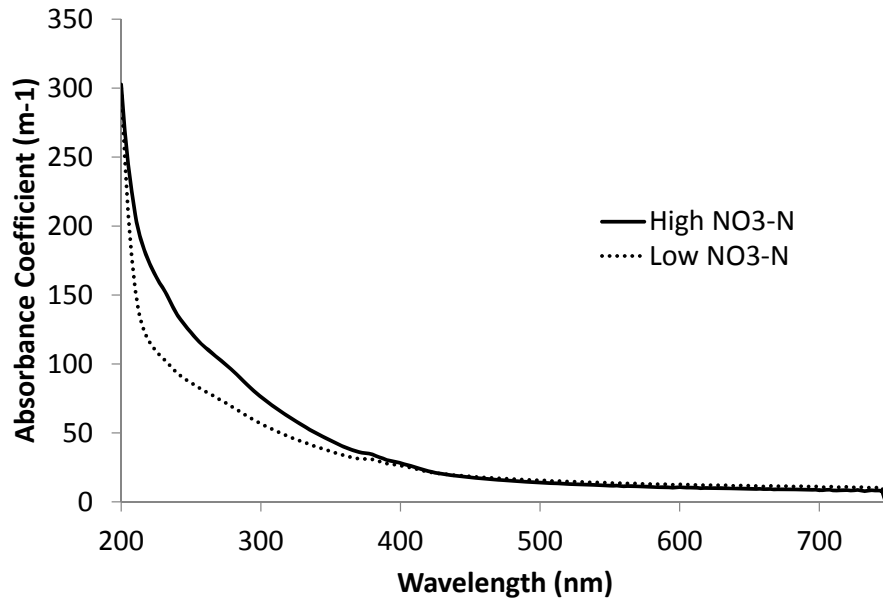


# The spectrometric process analyser

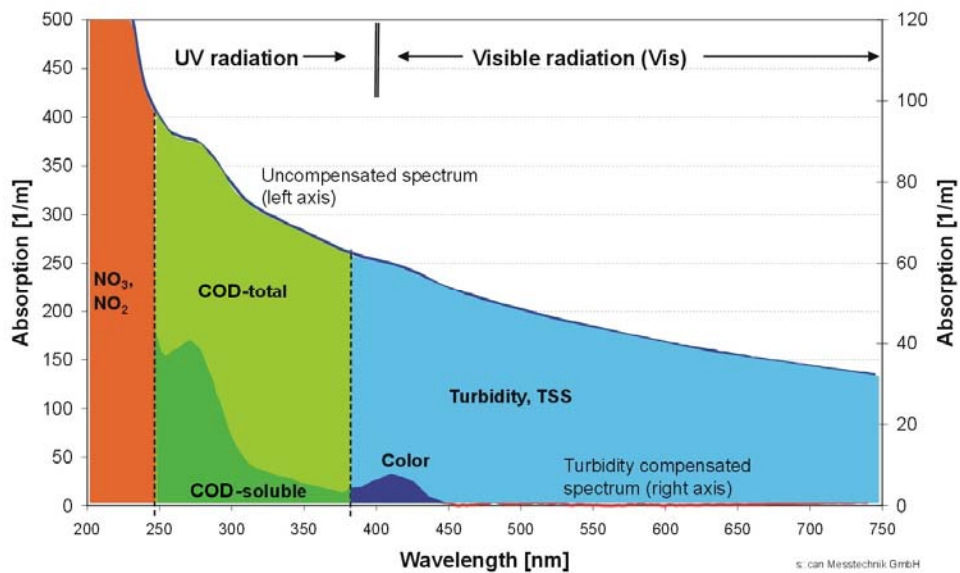
The measuring principle – Lambert Beer



## Absorption Spectra



## Absorption Spectra



# What parameter can we measure?

- Most manufacturers advertise for Nitrate
- Some add DOC and Turbidity
- Other parameters may be linked to turbidity (e.g. TP, PON) or to DOC (e.g. DON)
- Possibly covariability between light absorbance and other parameters?

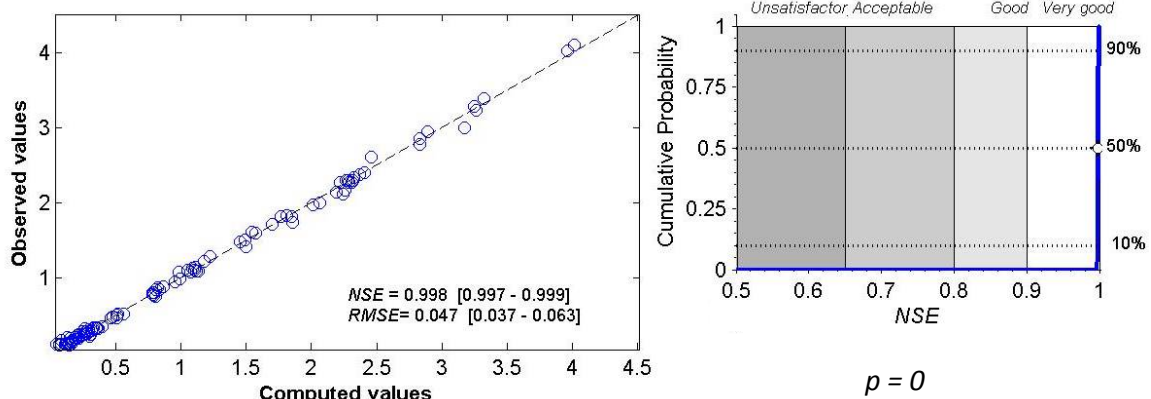
## Breaking the manufacturers code

- Manufacturers have created algorithms able to calculate reliable concentrations
- Relatively simple to require affordable computational capabilities
- Use chemometrics to create regressions between absorbance and concentrations
- Main tool: Partial Least Square Regression (PLSR)

# plsr

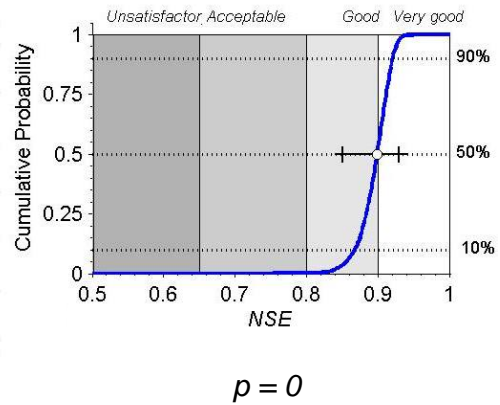
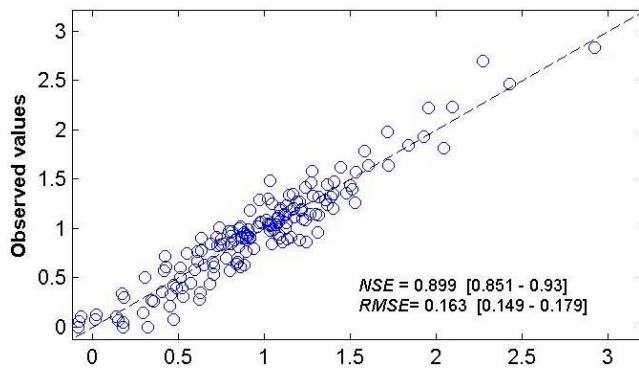
- Partial least squares regression correlates spectral data with chemical concentrations
- Reduces dimensions of system
- Allows selection of the number of dimensions to use in modeling the relationship between uv/vis spectral fingerprint and concentrations

## Results for NO<sub>3</sub> in our marsh



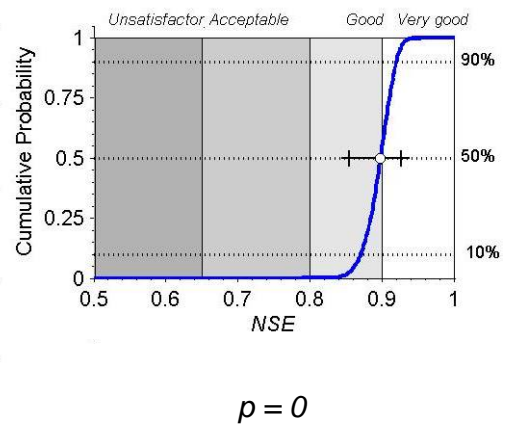
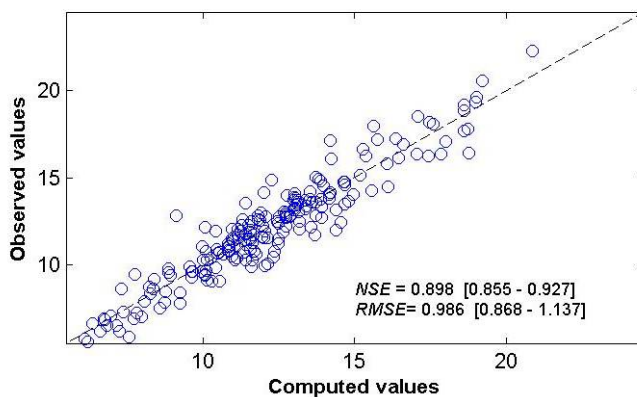
(Graphs from Fiteval, Ritter and Muñoz-Carpena, 2013, JH)

# Results for TKN in our marsh



(Graphs from Fiteval, Ritter and Muñoz-Carpena, 2013, JH)

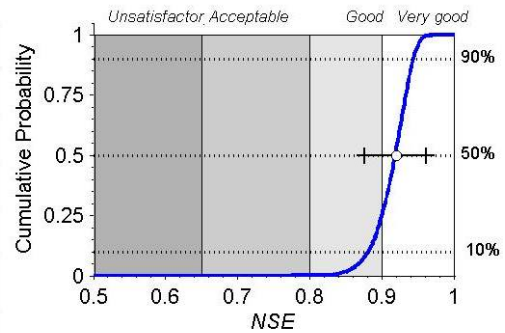
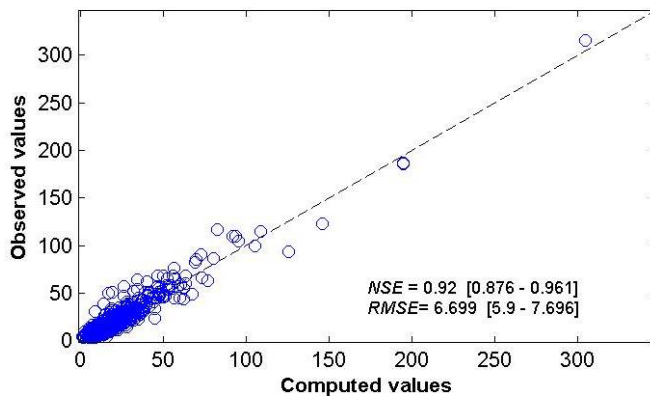
# Results for DOC in our marsh



*NB: FDOM did significantly improved regression*

(Graphs from Fiteval, Ritter and Muñoz-Carpena, 2013, JH)

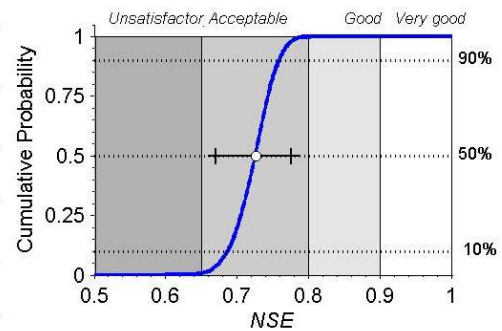
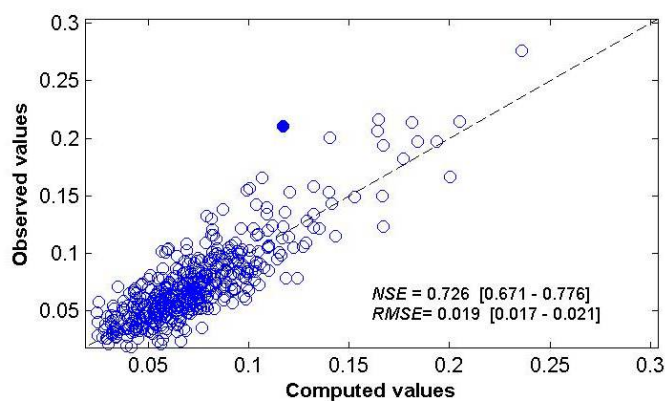
# Results for TSS in our marsh



$p = 0$

(Graphs from Fiteval, Ritter and Muñoz-Carpena, 2013, JH)

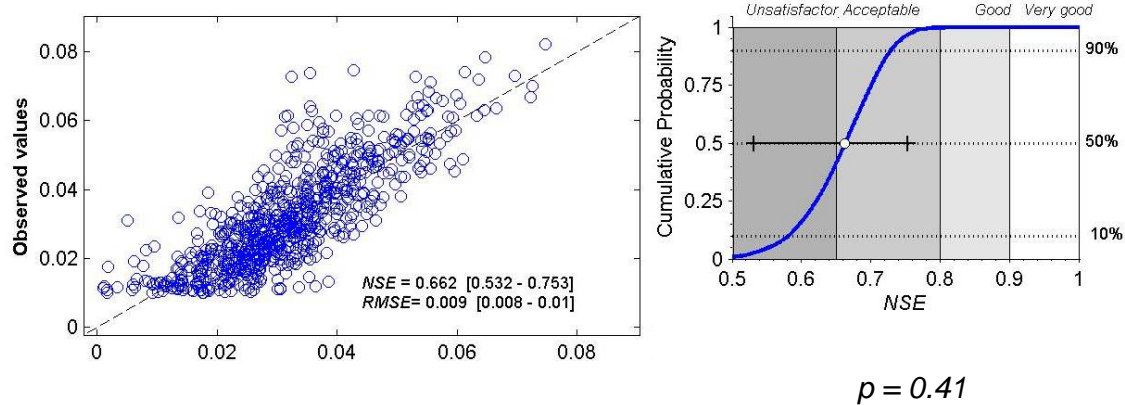
# Results for TP in our marsh



$p = 0.006$

(Graphs from Fiteval, Ritter and Muñoz-Carpena, 2013, JH)

# Results for PO4 in our marsh



(Graphs from Fiteval, Ritter and Muñoz-Carpena, 2013, JH)

## WQ Rating curves

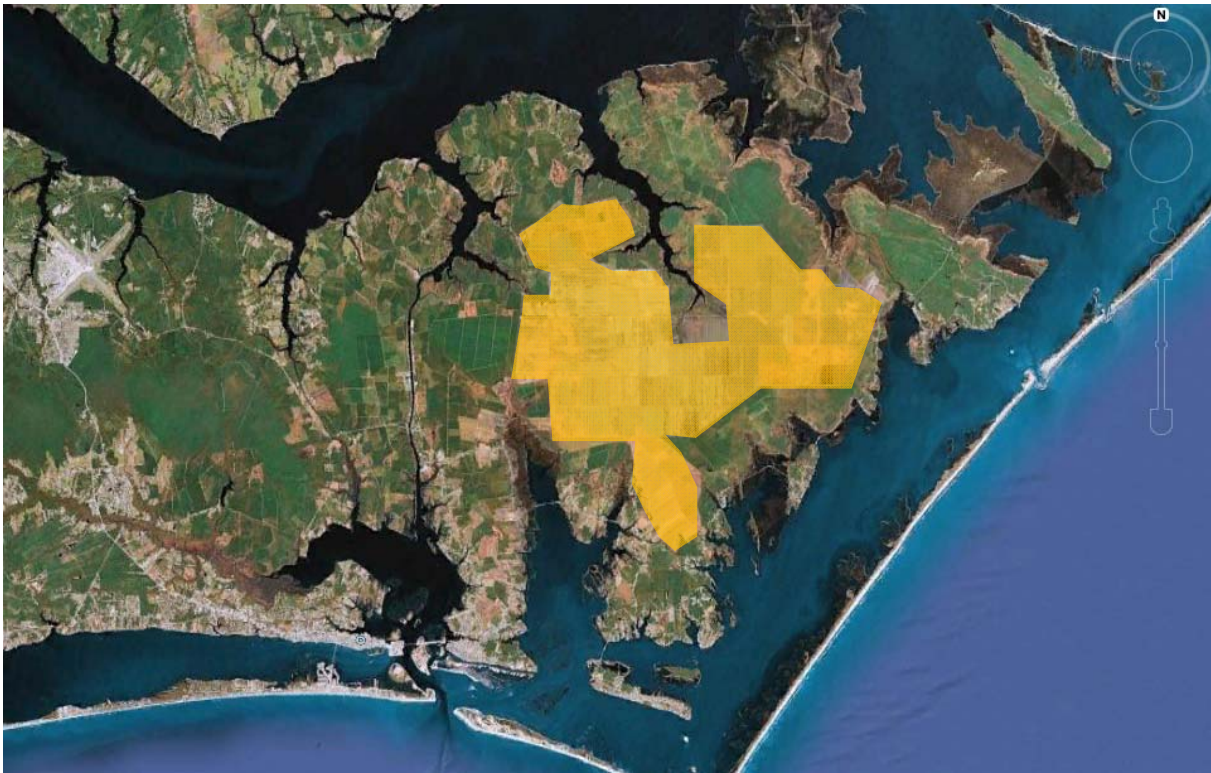
- We are essentially proposing to create water quality rating curves per station
- Plsr: no predictive power, however
- Need to quantify uncertainties

*Etheridge et al., 2014, LOM*

# Leap, really? Two examples







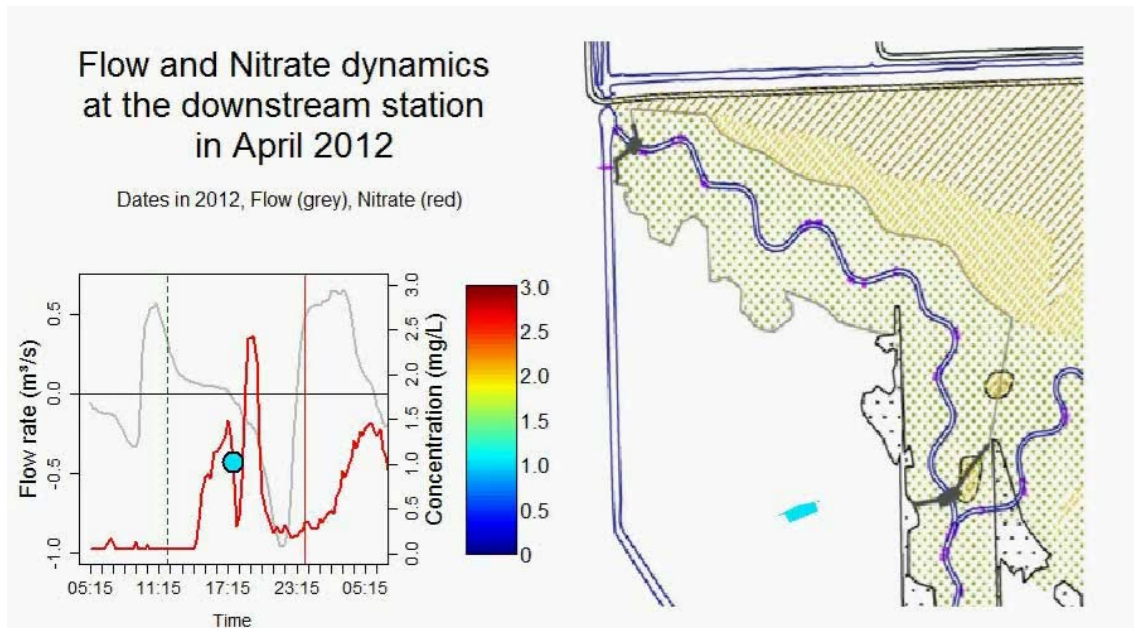
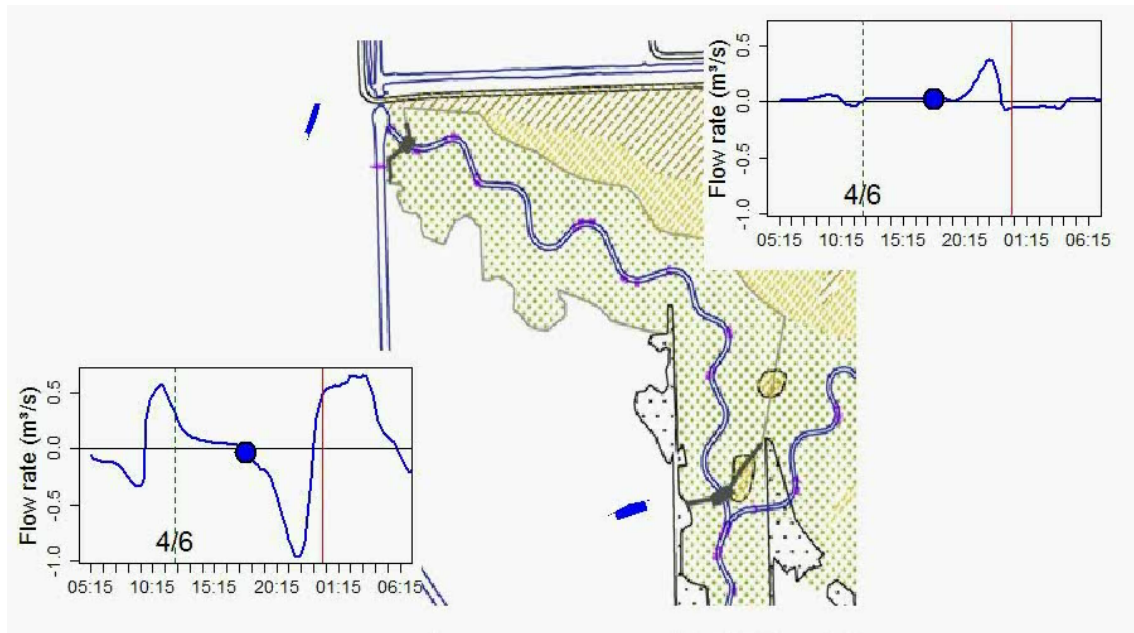


September 2007

November 2012

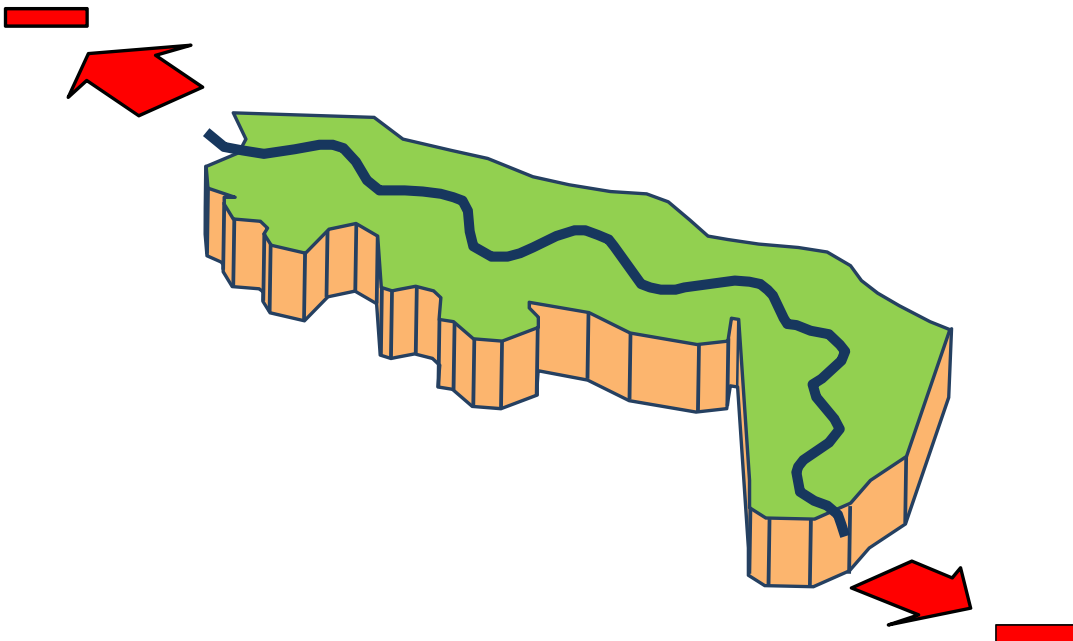


# Flow dynamics

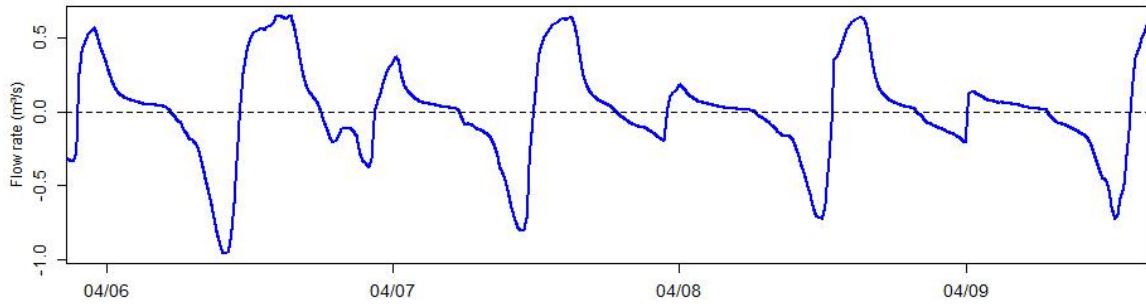




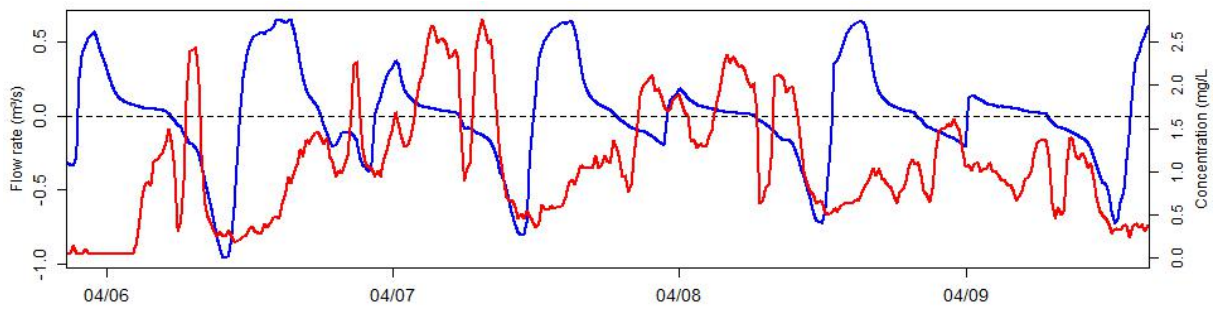
Positive Mass Balance = Retention  
Negative Mass Balance = Release



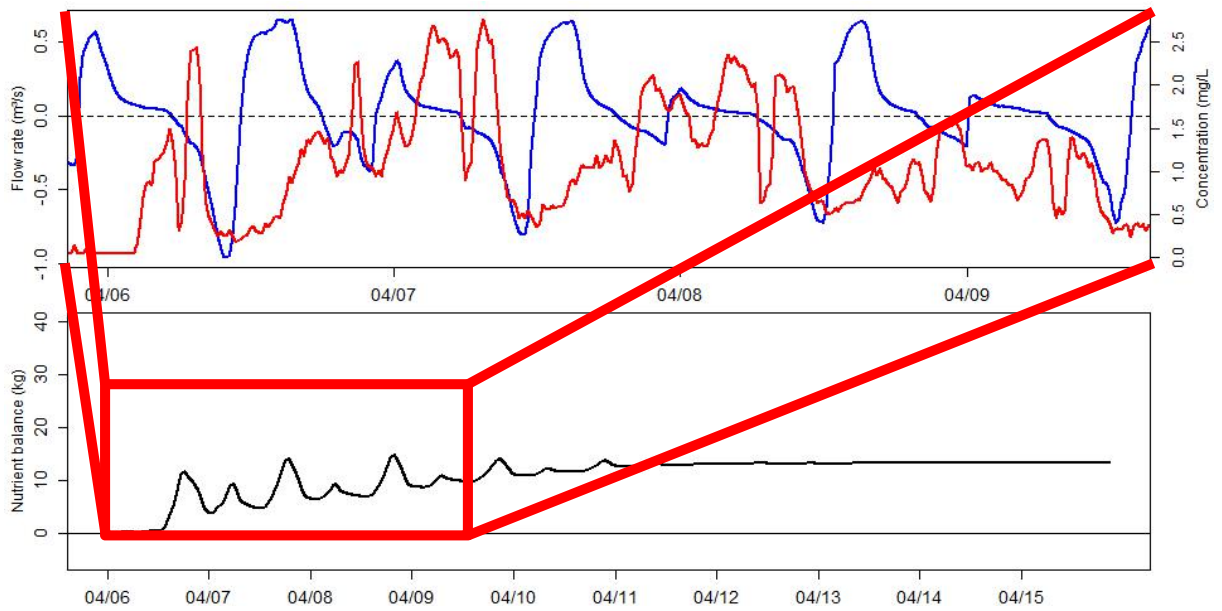
# Results



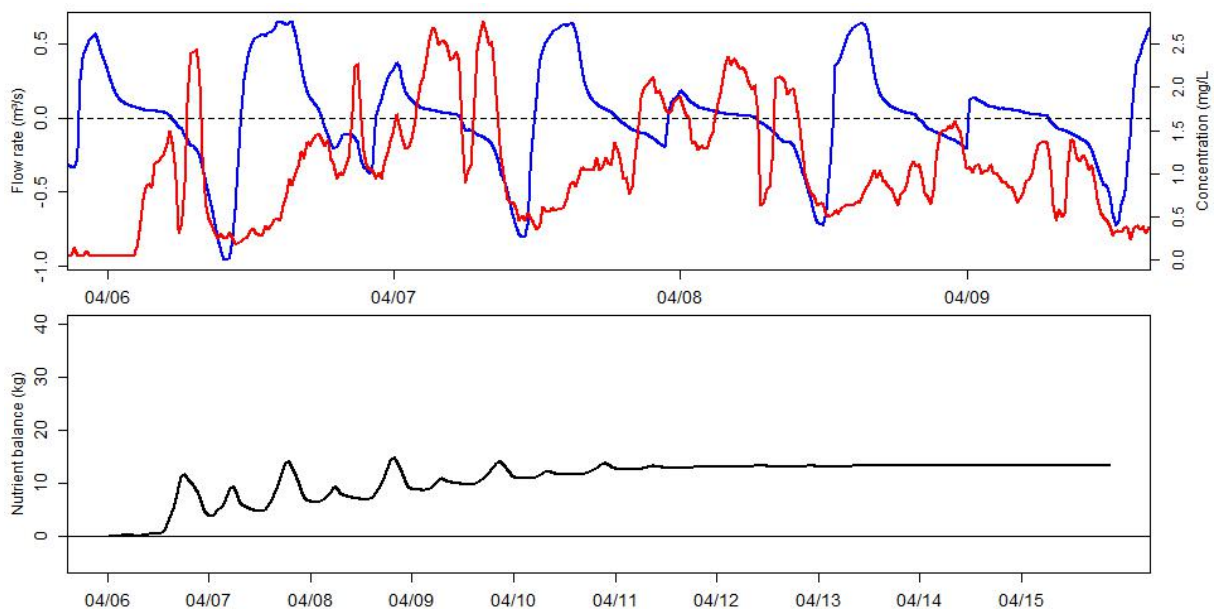
# Results



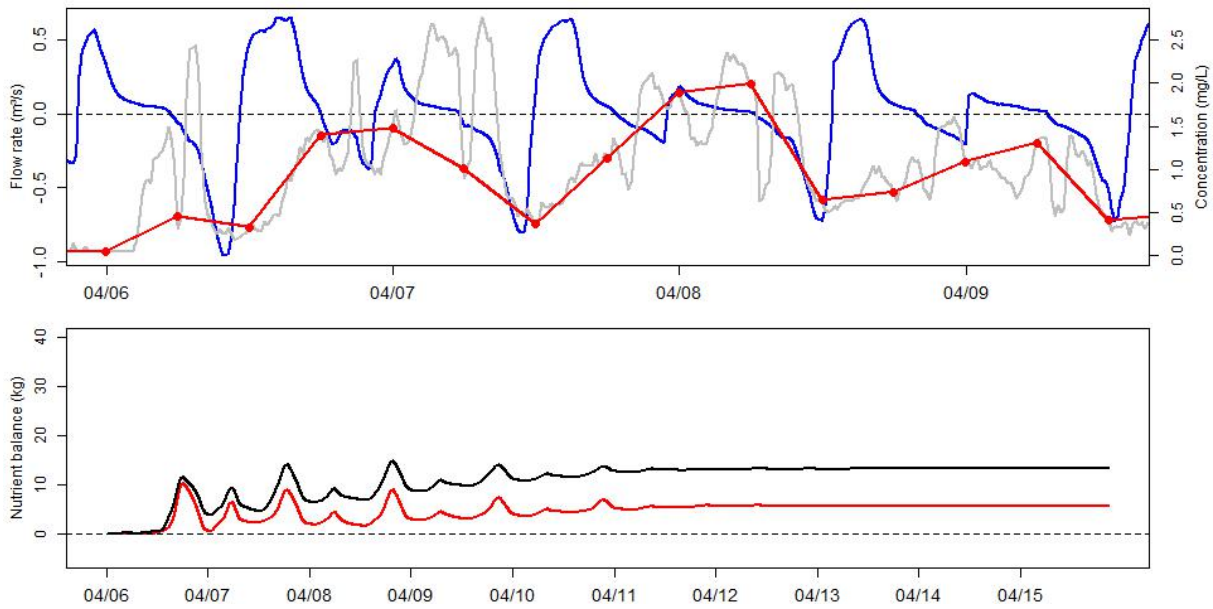
# Results



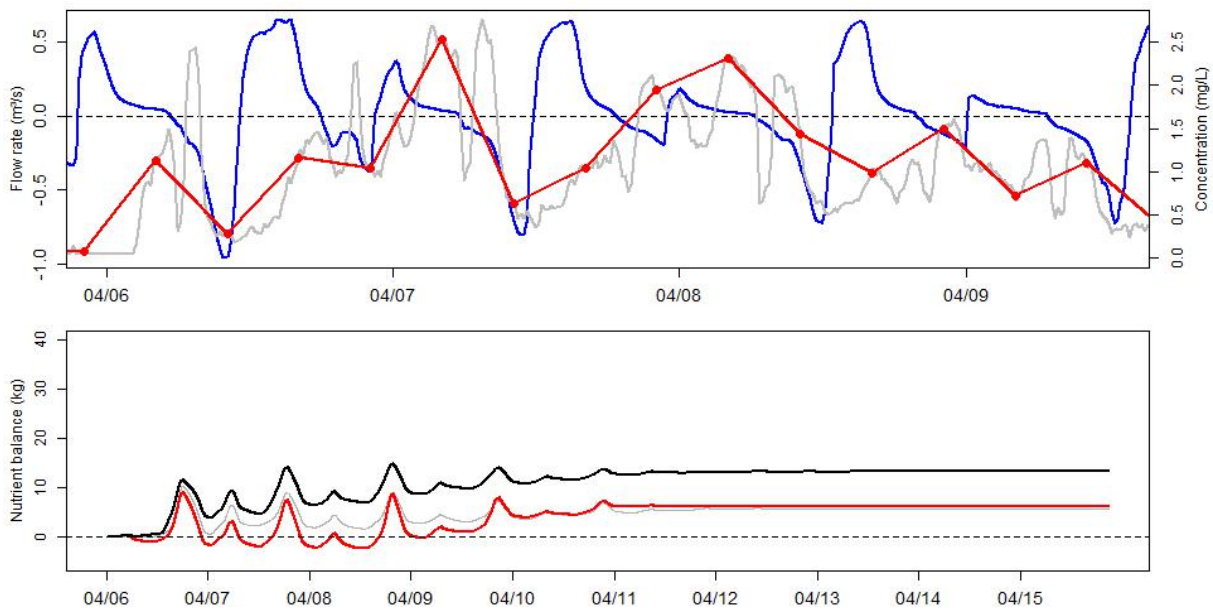
What if we had sampled *every 6hrs* ?



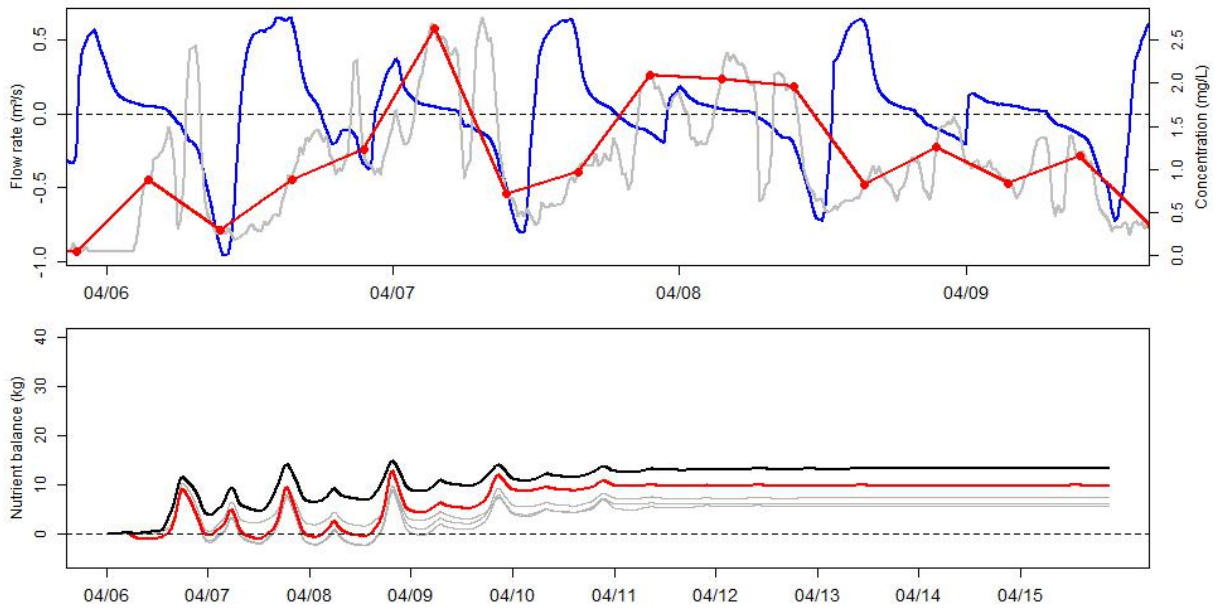
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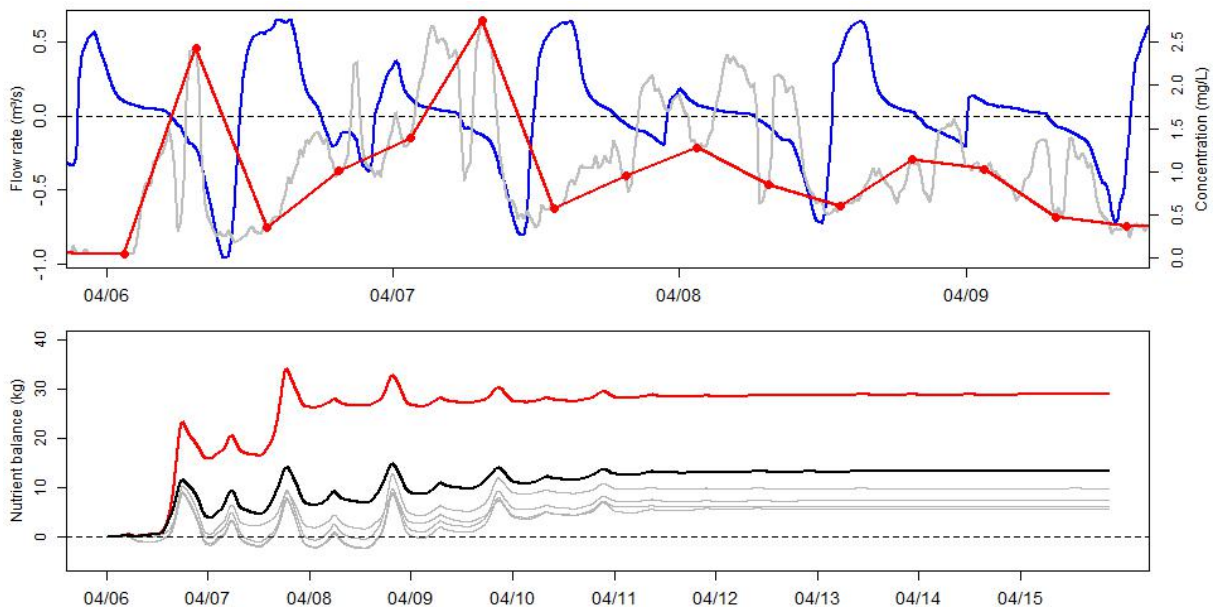
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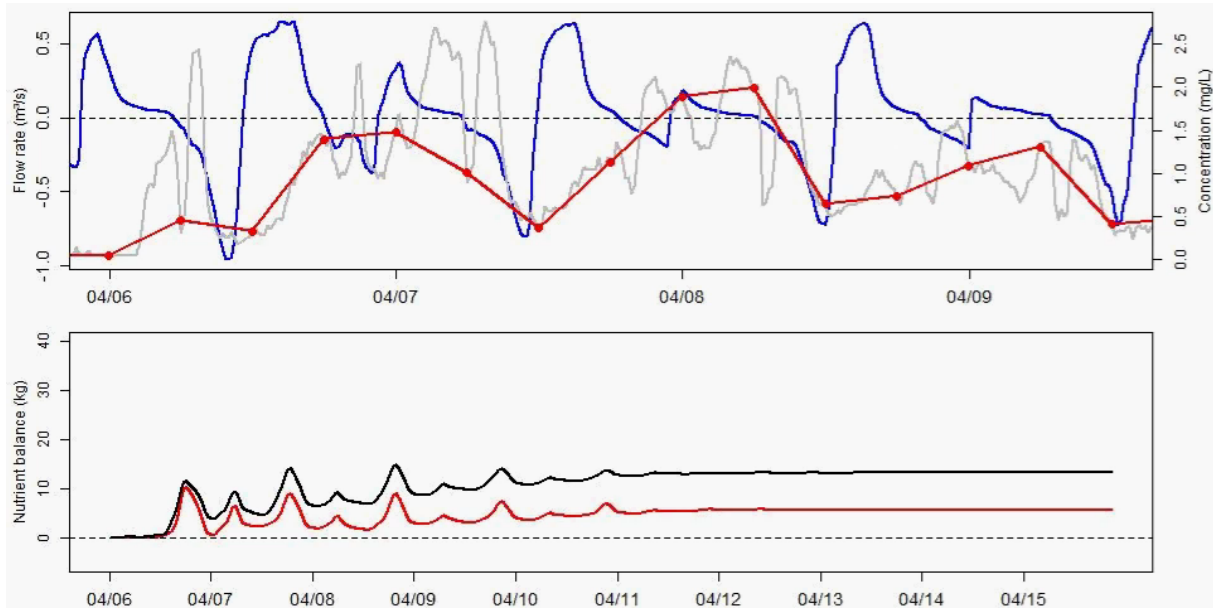


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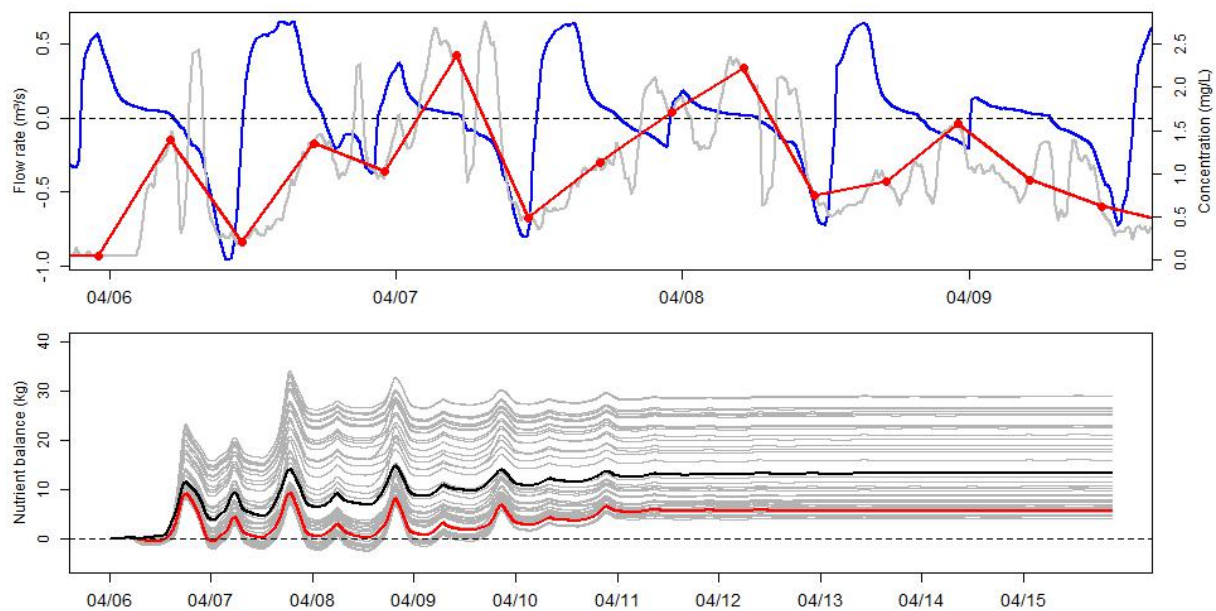




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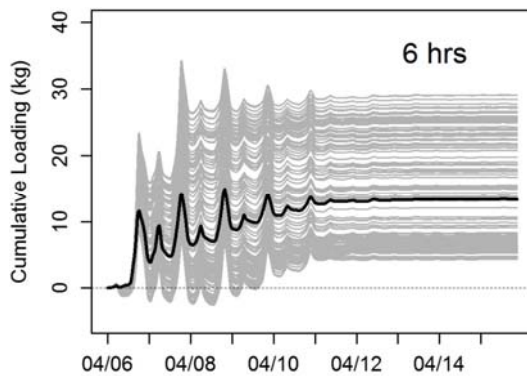


# What if we had sampled every 6hrs ?



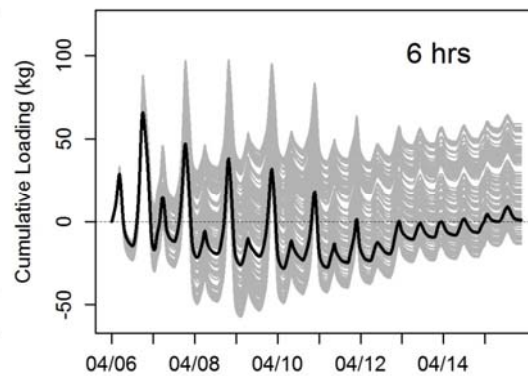
# What if we had sampled every 6hrs ?

**NO<sub>3</sub>**



Date in 2012

**DOC**



Date in 2012

*Etheridge et al., 2014, Ecol. Eng.*

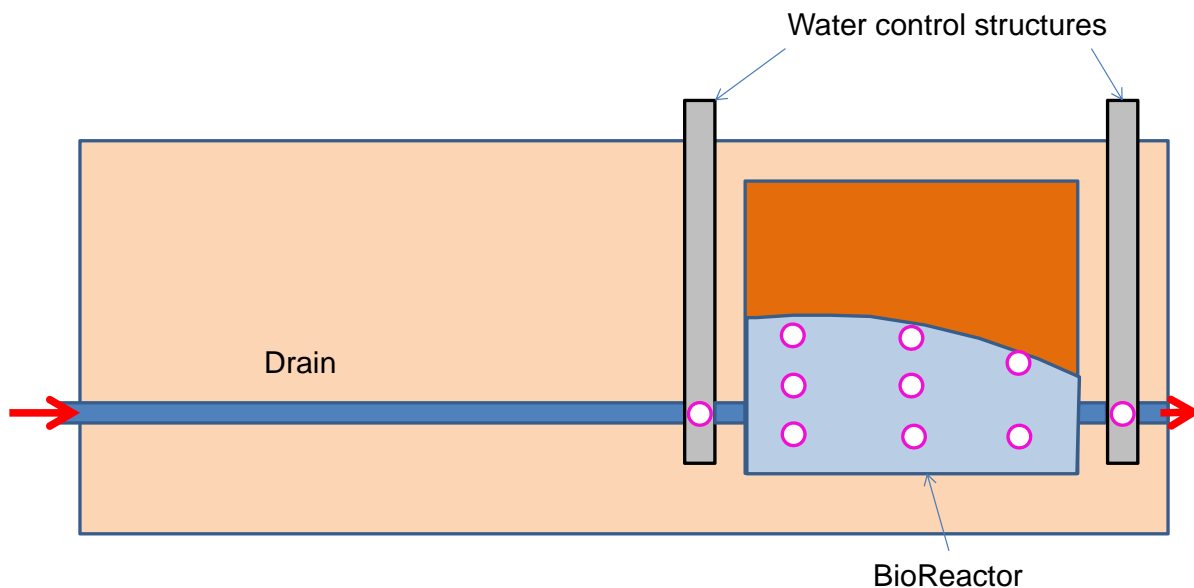
## Sampling 'infrequently' would have changed our conclusions...

- Could have concluded wrongly on the nitrate dynamics in the marsh
- Would have possibly under- or overestimated by -70% to +130% the nitrate retention
- And never know about it...

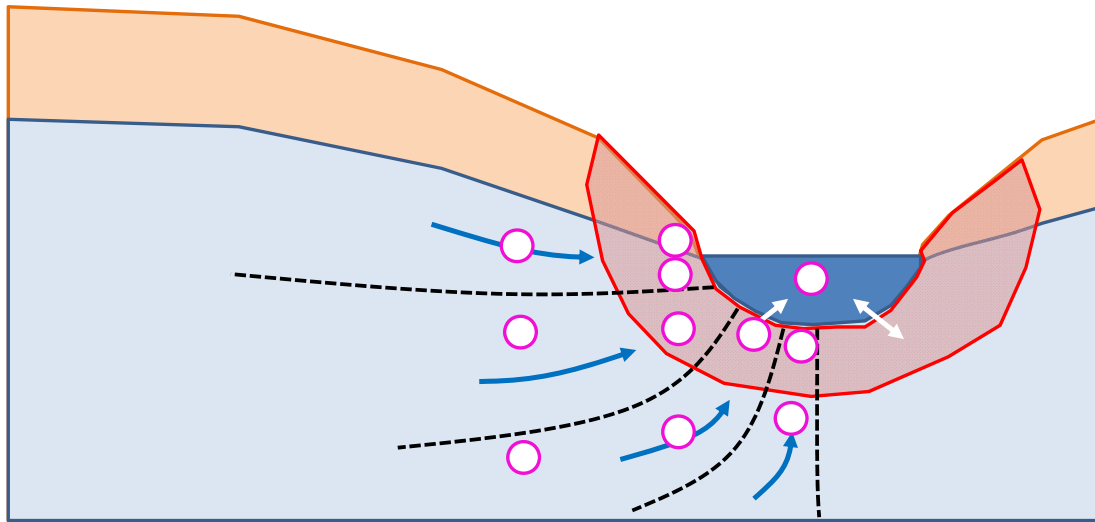
# What about long term results?

- Session 308: Wednesday 511 D 8:00-10:45
- Session 311: Wednesday 511 F 8:00-10:45
  - Elizabeth Allen
- Session 346: Wednesday 513 C 10:15-12:30

## Denitrification Reactor installed on What about spatial resolution?... drains



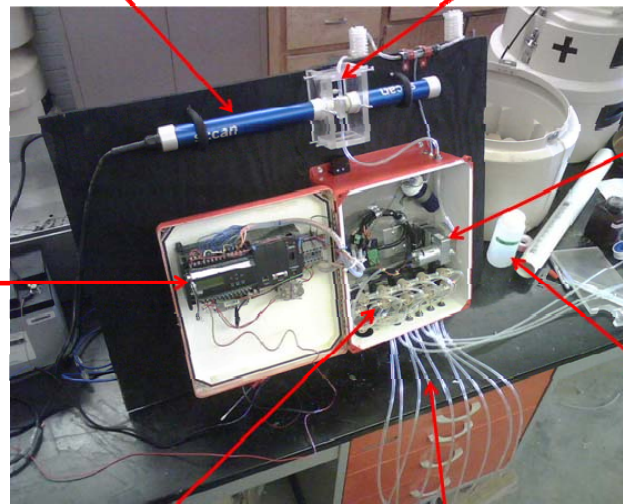
# Exchanges at the near stream zone



# Multiplexed automatic portable 'lab'

S::can  
Spectro::lyzer

Spectro::lyzer probe equipped with a cuvette



Peristaltic  
pump

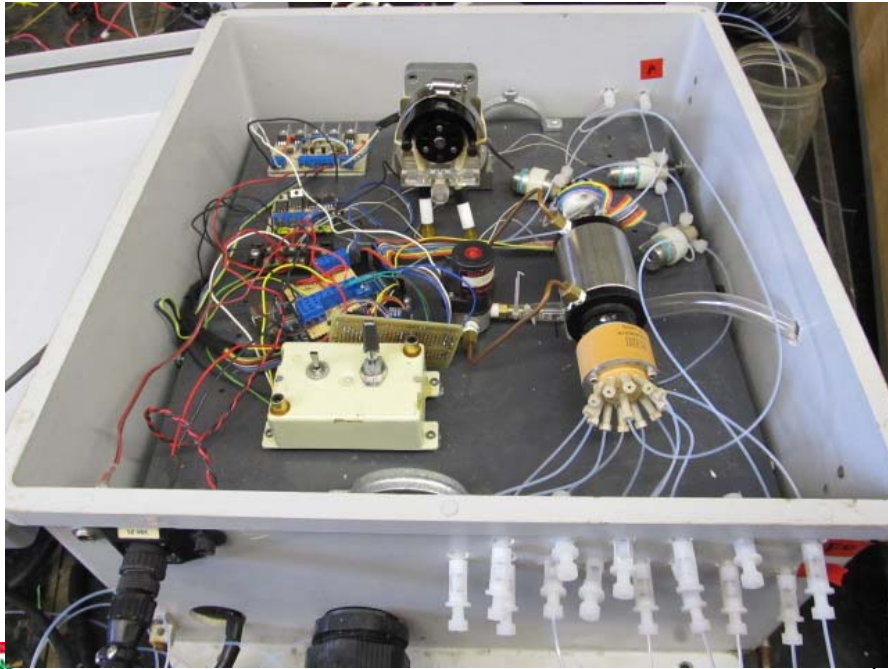
PLC  
controller

Cleaning  
solution

Solenoid valve manifold

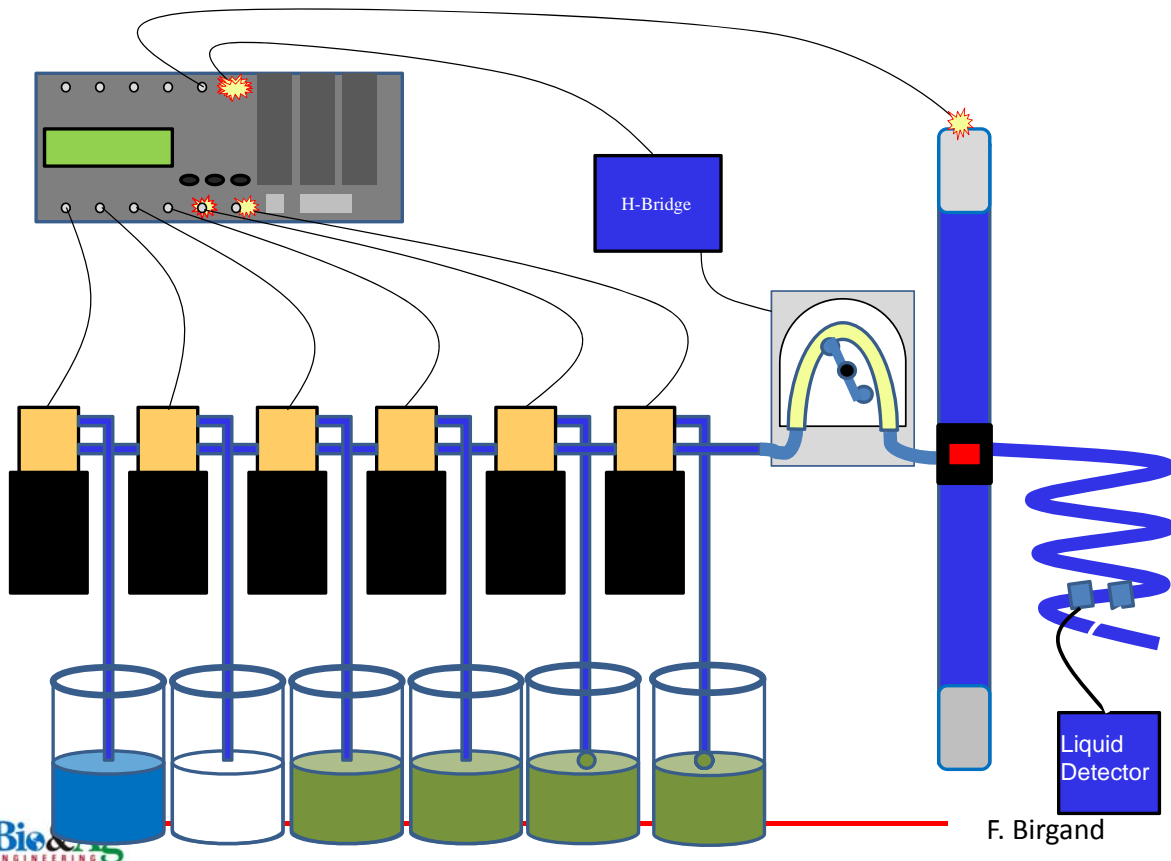
Up to 10 different sources

# Multiplexed *micro*'lab'



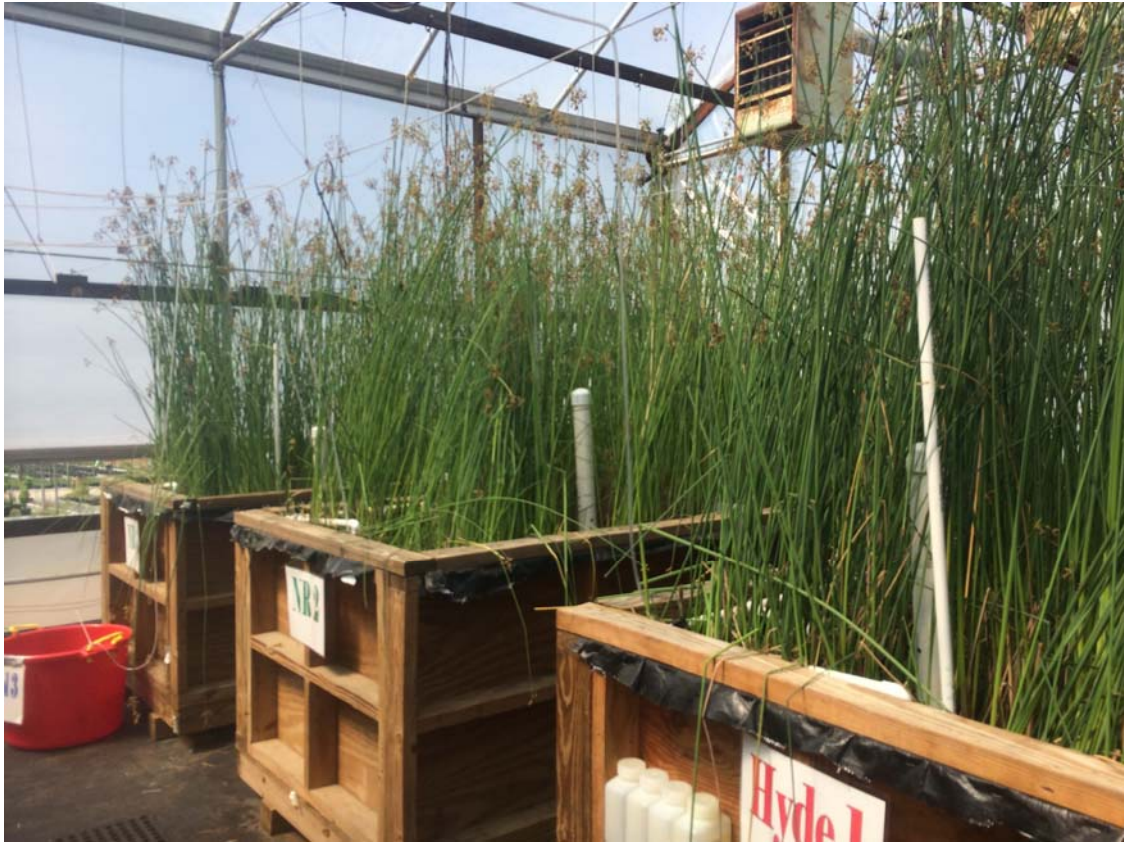
Bio&Ag  
ENGINEERING

F. Birgand

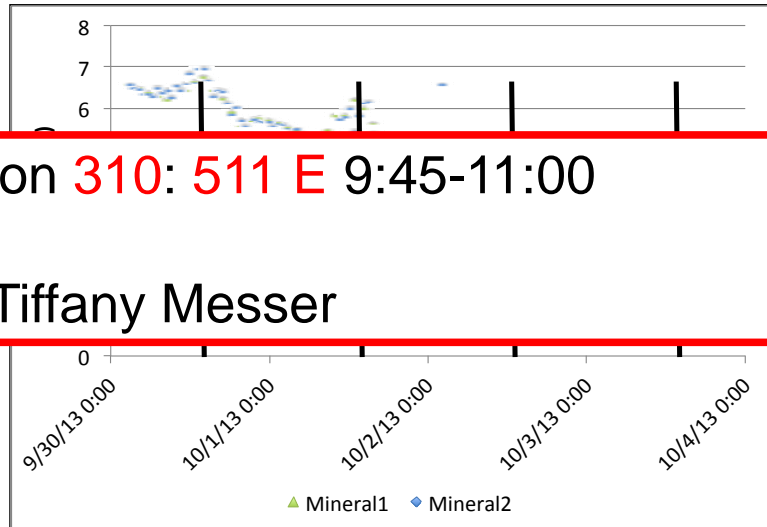


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F. Birgand



# Intriguing data from mesocosms...



## Next leap in hydrology?

- High frequency water quality data:
    - Only mean to capture stochastic events intrinsically linked with hydrological processes
    - Capture the effects of biogeochemical processes on water quality
    - Key to improve/revise our models
    - Glad that federal and state agencies are going in that direction
- **My opinion: They are absolutely necessary!!**

# The challenges...

- A lot more information that comes with...
  - ... A lot more work
  - ... A lot more money
- There are some 'dirty' little secrets: optics foul...
  - There are ways around that

Etheridge et al., 2013 JEQ

# The challenges...

- If we do not do it as agricultural engineers, other communities will come do it on our turf
- We need to invest into all possible continuous sensors
- We need to rapidly transfer know-hows
- We need to organize ourselves into networks like the NEON, GLEON, etc.



# Contributors

- Previous personel:
  - Dr. Randall Etheridge, Marc Horstman, Brad Smith
- Current personel:
  - Dr. Kyle Aveni-Deforge, Elizabeth Allen, Chiao-Wen Lin, Nicole Dobbs, Bryan Maxwell, Tiffany Messer, Troy Gilmore
- Colleagues:
  - Dr. Mike Burchell, Dr. Jason Osborne, Dr. Rafael Muñoz-Carpena

