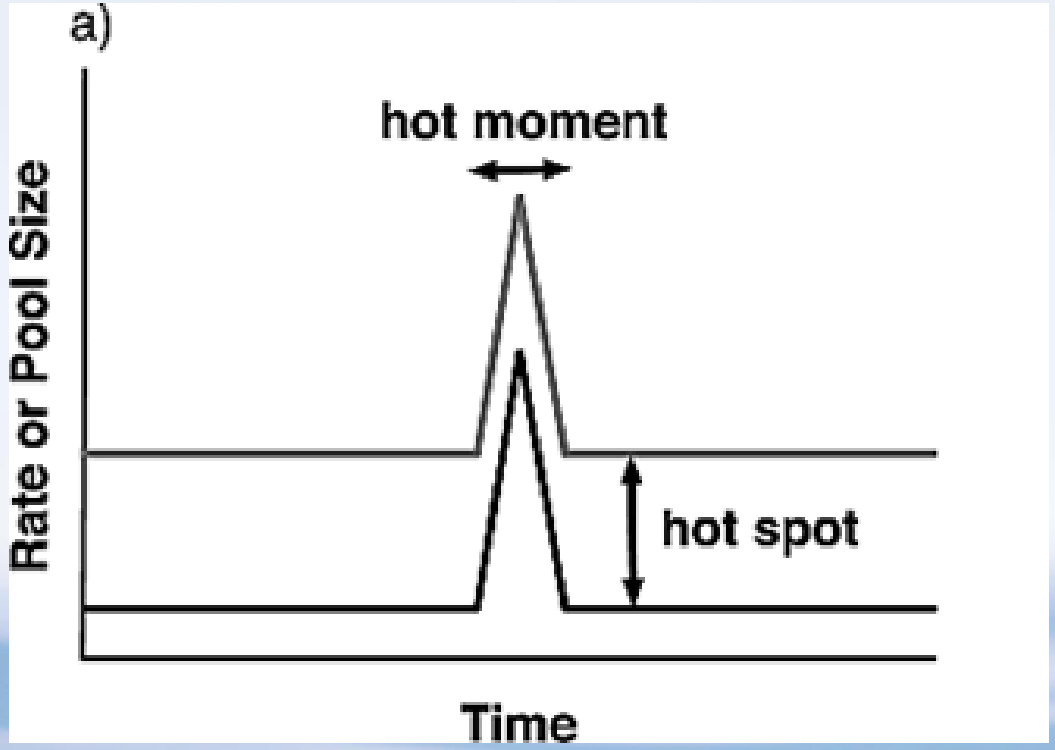
Sensor Group Progress Report

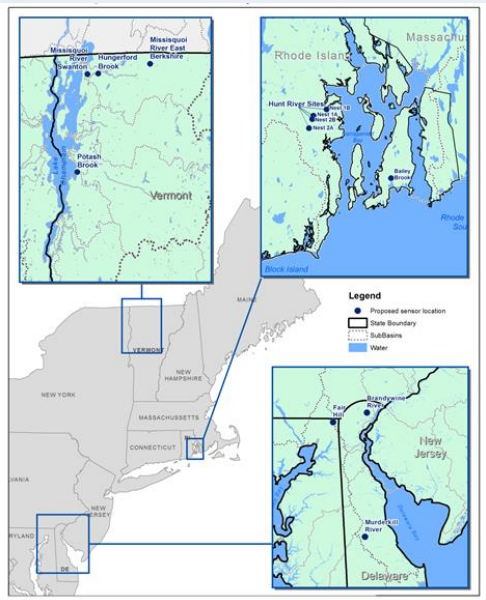
RII – Track -2 IIA 1330446

Regional Research Question

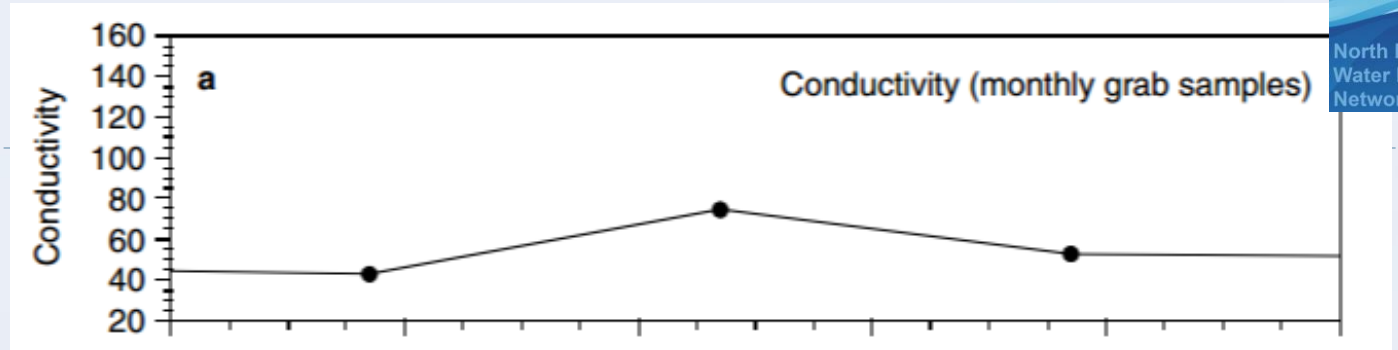
What is the impact of climate variability and extreme events on water quality for watersheds with different land uses extending across the N-S gradient (VT to DE)?



Harms and Grimm, 2008

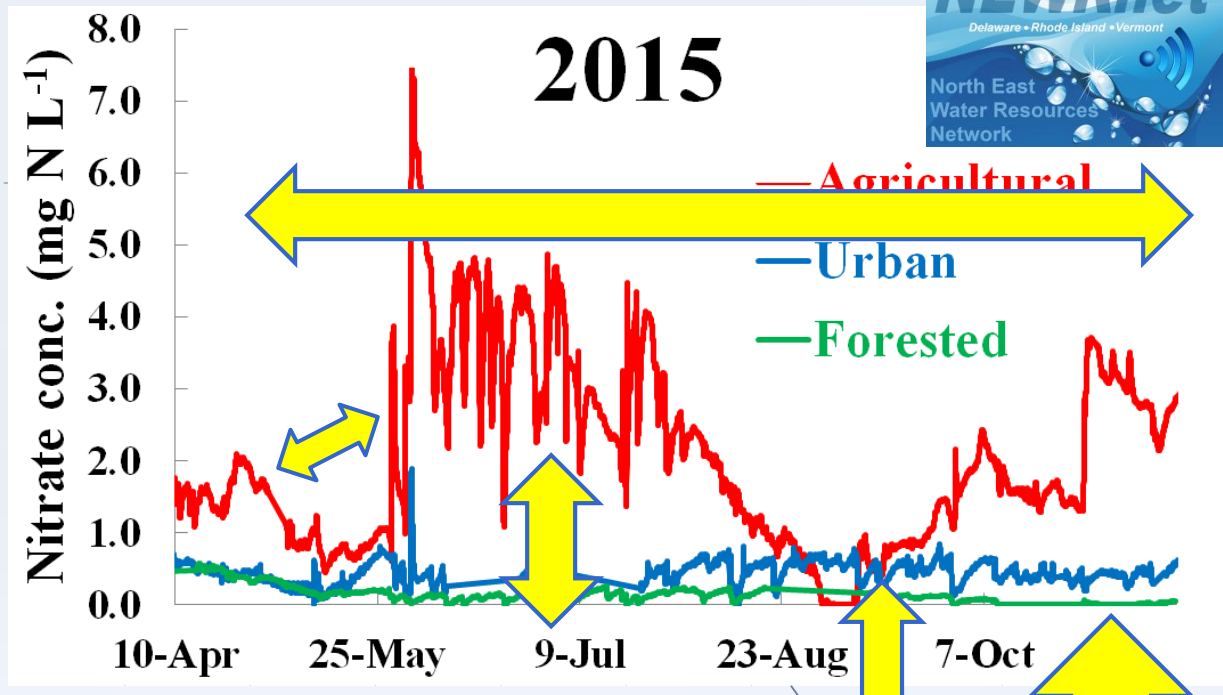


Sensors are a useful tool for capturing hot moments!



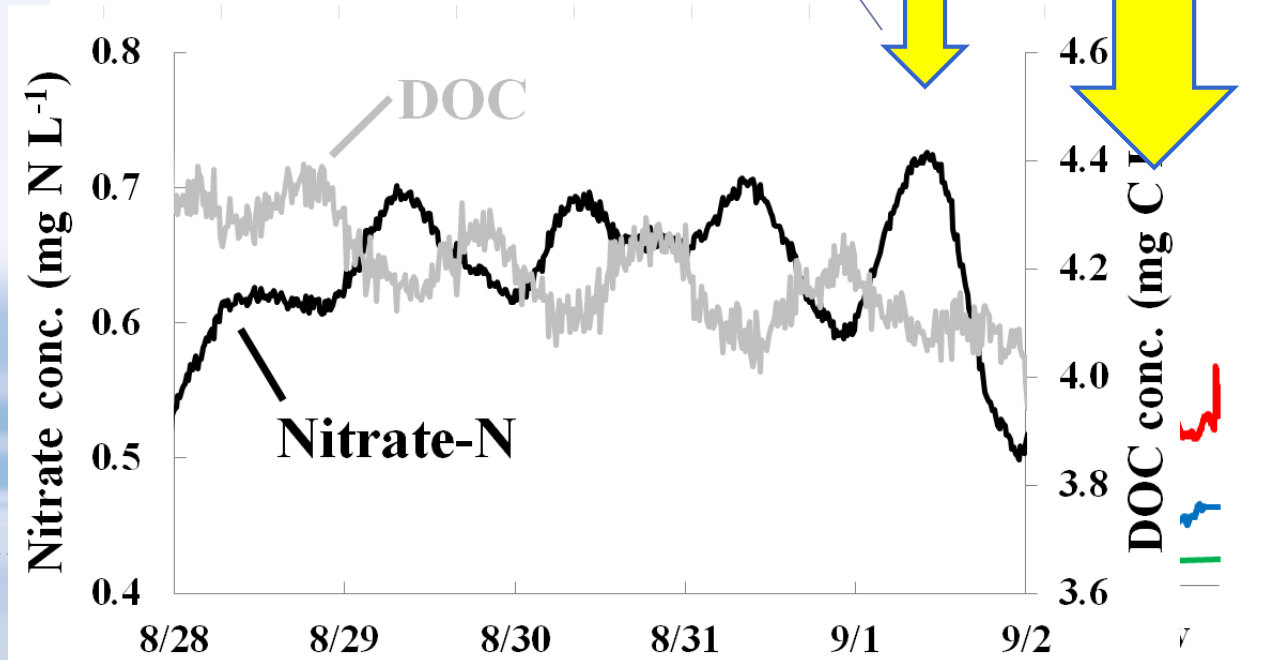
Kirchner et al. (2004)

Hot Moments Across Time and Space



Sensor team studies:

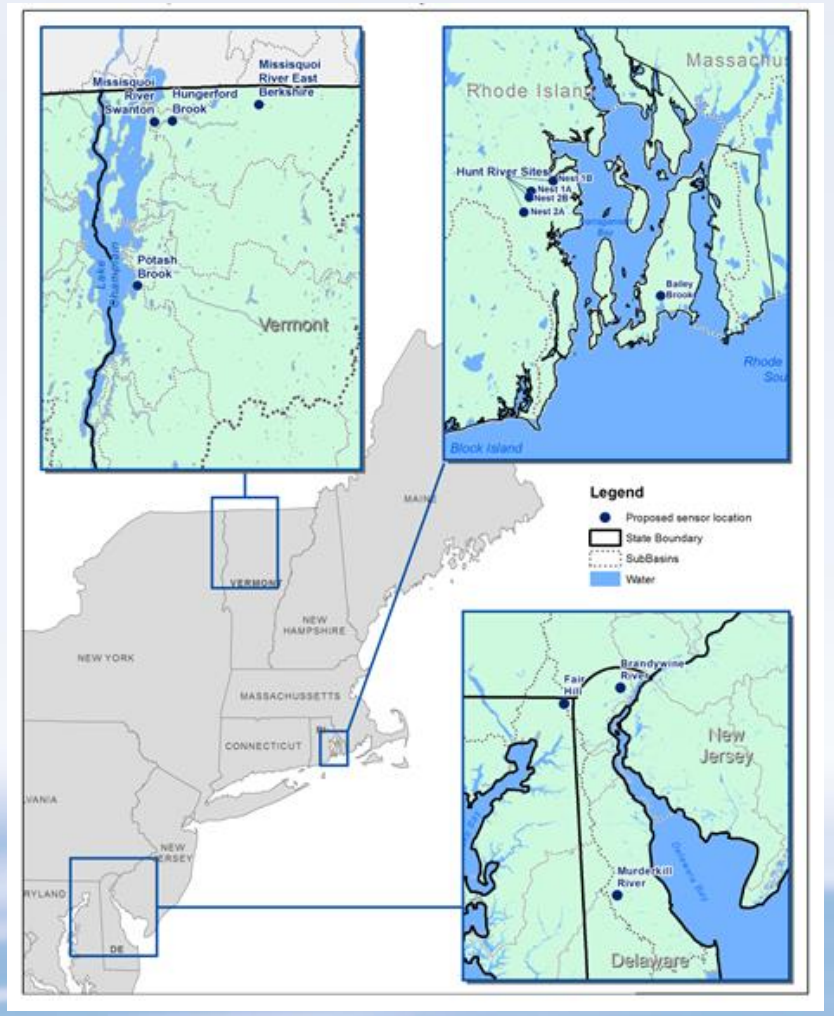
- Landcover Effects
- Seasonal Dynamics
- Event Variability
- Inter-Annual Variability (in all of the above)
- Diurnal Cycling



NEWRnet Sensor Group 2013-14 Report Outline

- Collective Motivation
- Progress Highlights
- Sensor Selection
- Site Selection
- Deployment
- Synoptic Water Sampling
- Sensor Performance
- Hot Moments Across the Network
- Novel Sensor Development
- Autonomous Mobile Sensors

(afternoon demonstration)



Summary of Group Activities and Highlights

- Group meetings/calls to foster productive collaborative dynamics
- October 2013-Initial meeting and sensor demonstration by vendors
- May 2014-Sensor configuration, RI site visits, coordinated research plan development
- Involvement of undergraduate interns in research
- Extensive local stakeholder engagement in all states
- Group development of QA/QC protocols and data flow

- Successful installation and maintenance of functional regional sensor array (summer 2014-present)
- Heavily featured in 2 sensor-based AGU sessions, AGU award and invited presentation, invitation to contribute to special issue of Water Resources Research (2 papers in development for this issue)

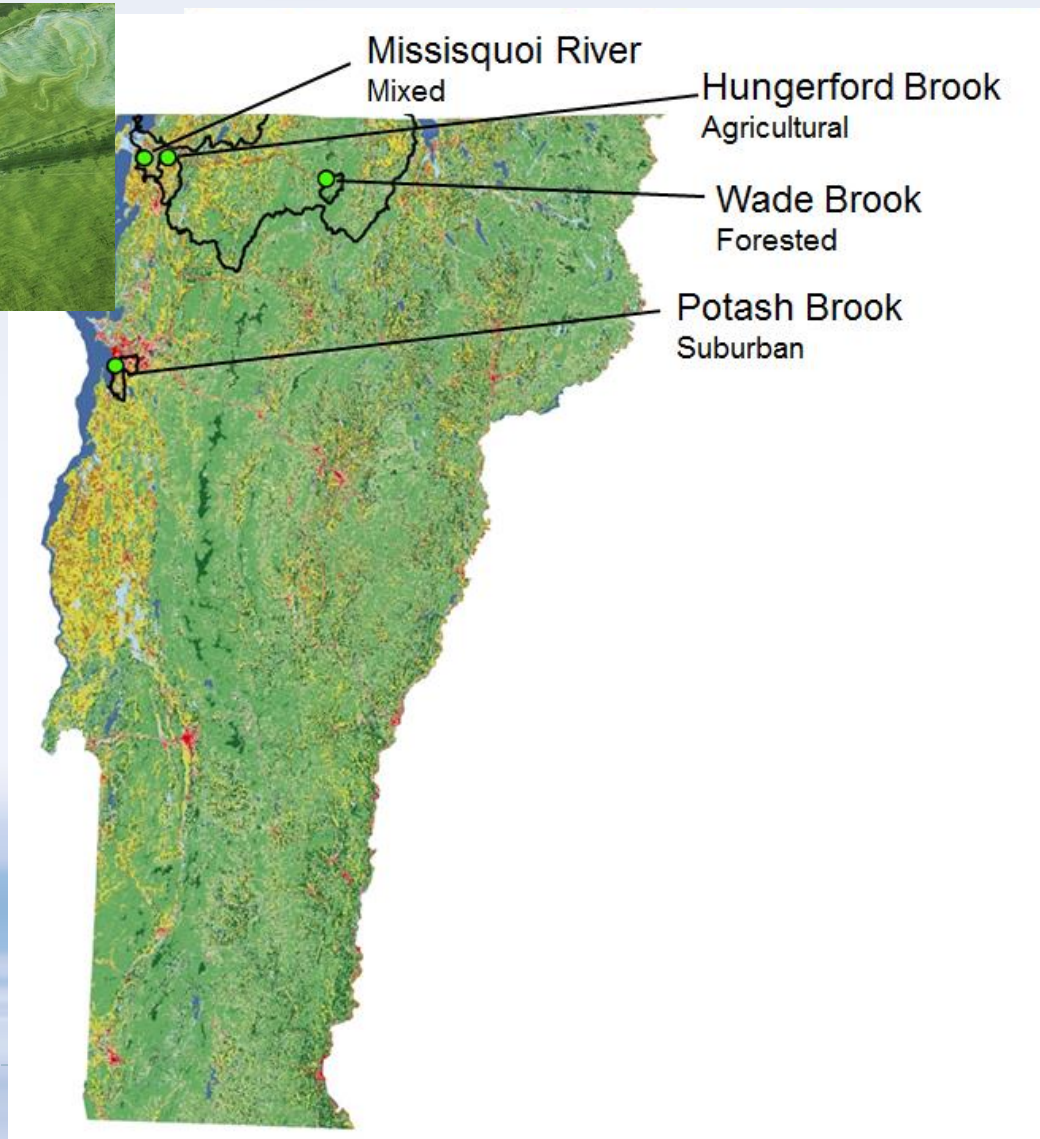
Sensor Selections
(15-30 minute measurement frequency)

- YSI EXO2
  - Temperature/Conductivity
  - Dissolved Oxygen
  - pH
  - Turbidity
  - Fluorescent Dissolved Organic Matter(fDOM)
  - BGA/Chlorophyll

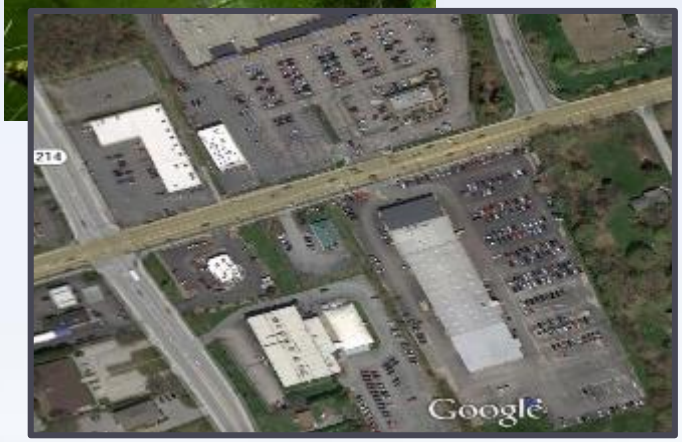
- s::can Spectrolyser
  - Nitrate-N
  - Dissolved Organic Carbon
  - Total Organic Carbon
  - Turbidity
  - Full UV/Visible ‘Fingerprint’ scan

Vermont NEWRnet Sensor Network:

Schroth, Bowden, Vaughan, Sleeper (UVM), Shanley (USGS), Vermilyea (Castleton)



RI Sensor Sites: Gold, Addy, Pradhanang (URI), Chace (Salve Regina) :



- **Forested Watershed (Pristine Reference)**
  - Cork Brook, Scituate, RI
  - 4.7 km^2 watershed
  - Providence Water (600,000 customers)
- **Urban Watershed: Bailey's Brook**
  - Middletown, RI
  - 8.3 km^2 watershed
  - Newport Water (50,000 customers)
- **Agricultural Watershed, Maidford River**
  - Middletown, RI
  - 8.0 km^2 watershed
  - Newport Water(50,000 customers)

Delaware Study Sites:
Inamdar, Levia, Leathers, Andres, Ullman, Rowland, Winters, Hudson (UDE)

- Sensor Site locations in Delaware & Maryland – 3 sites

- Brandywine Creek at Wilmington

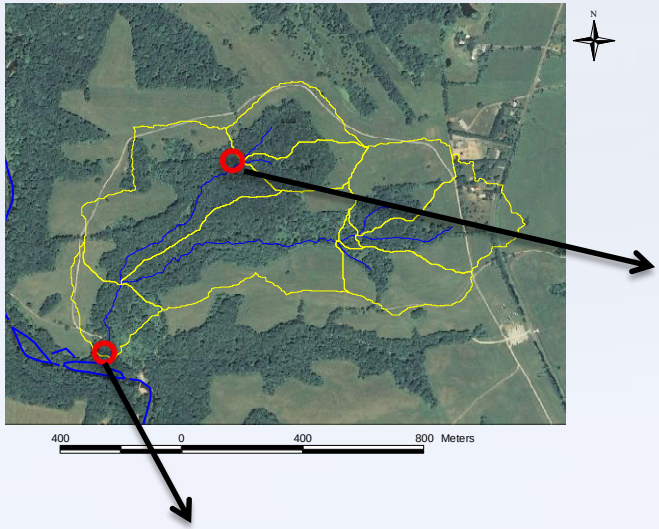
- Urban site
- Drainage area ~ 314 sq. miles
- Sensor near the water intake for Porter & Wills Water treatment plants in Wilmington

- Coursey Pond on Murderkill, Kent County, DE

- Agricultural site
- Drainage area = 9500 ha (at sensor)
- Landuse = 52% Ag, 23% forest

Delaware Study Sites

- Big Elk Creek nested subwatersheds



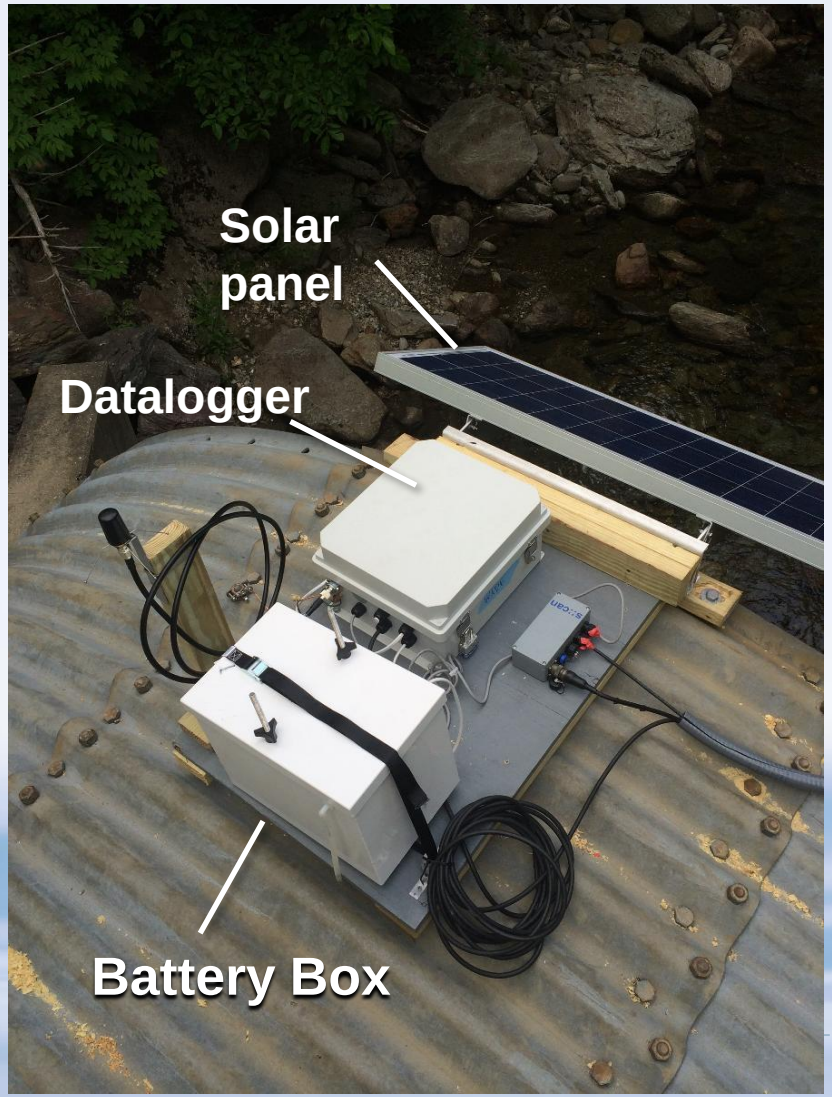
12 ha stream

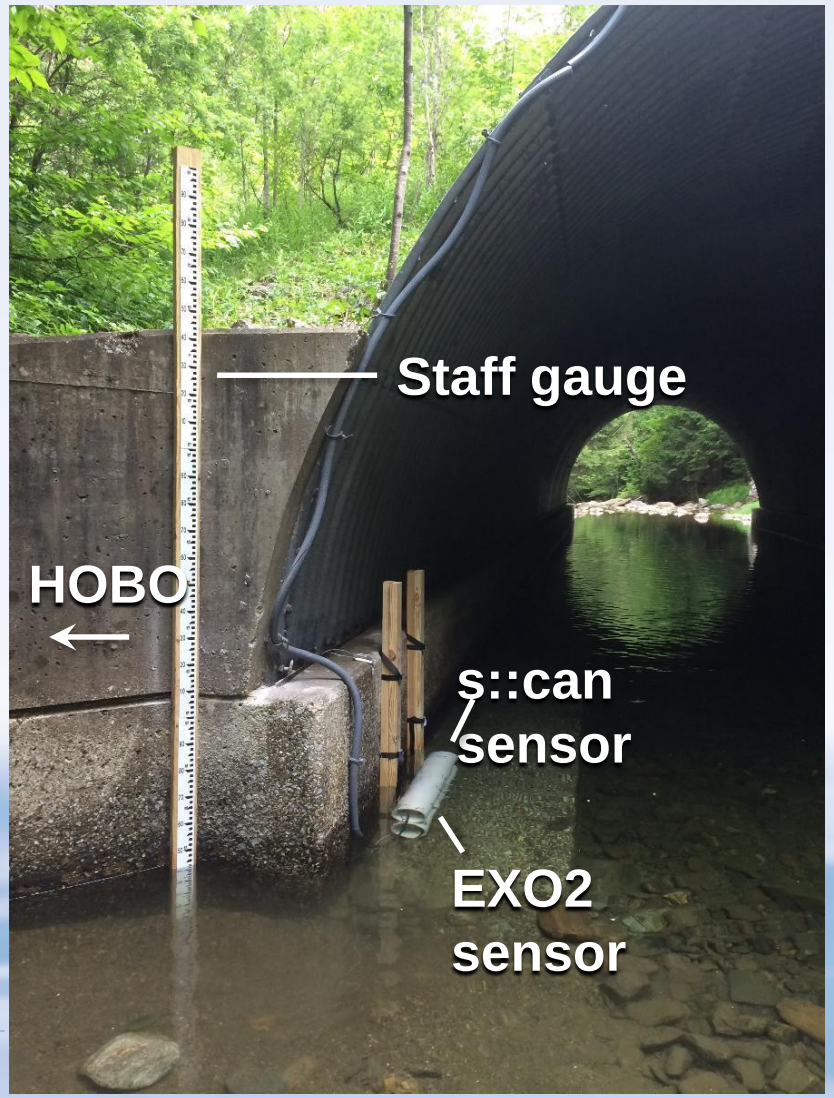
Big Elk Creek

79 ha stream

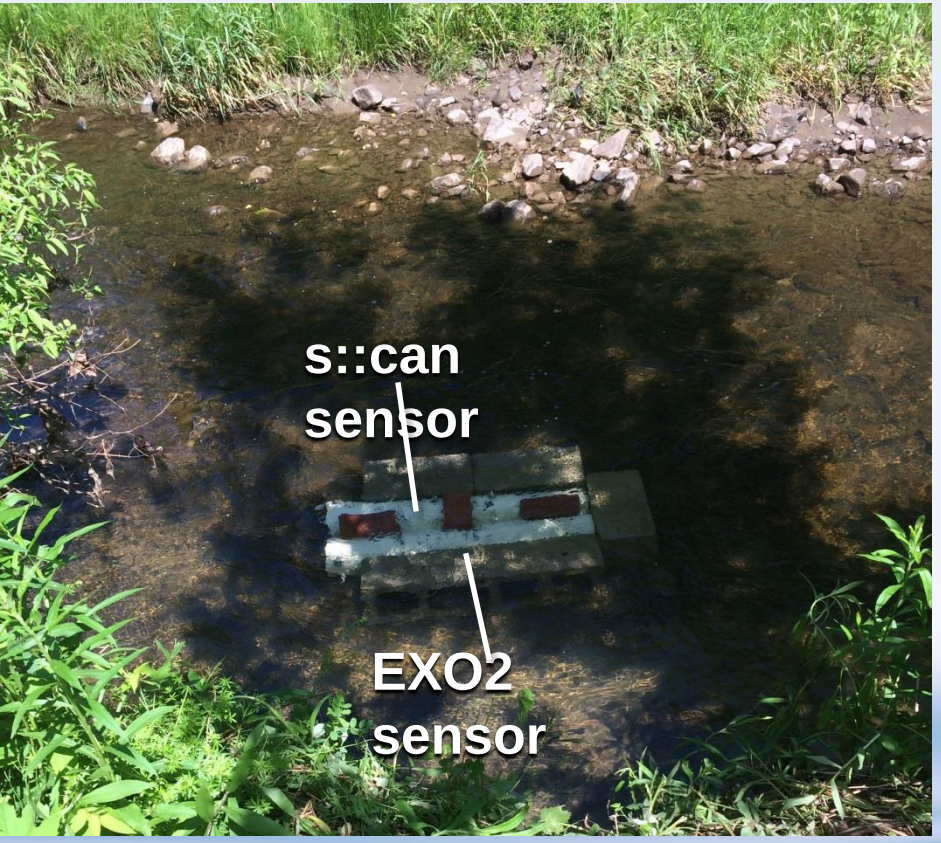
- Forested, “reference” sensor site
- Small, nested, subwatersheds = 79, 12 ha
- Long history of water chemistry (8 years)
- Good understanding of watershed behavior with numerous publications
- Drain into Big Elk Creek – water supply source for the town of Elkton, MD (pop. ~ 15,000)

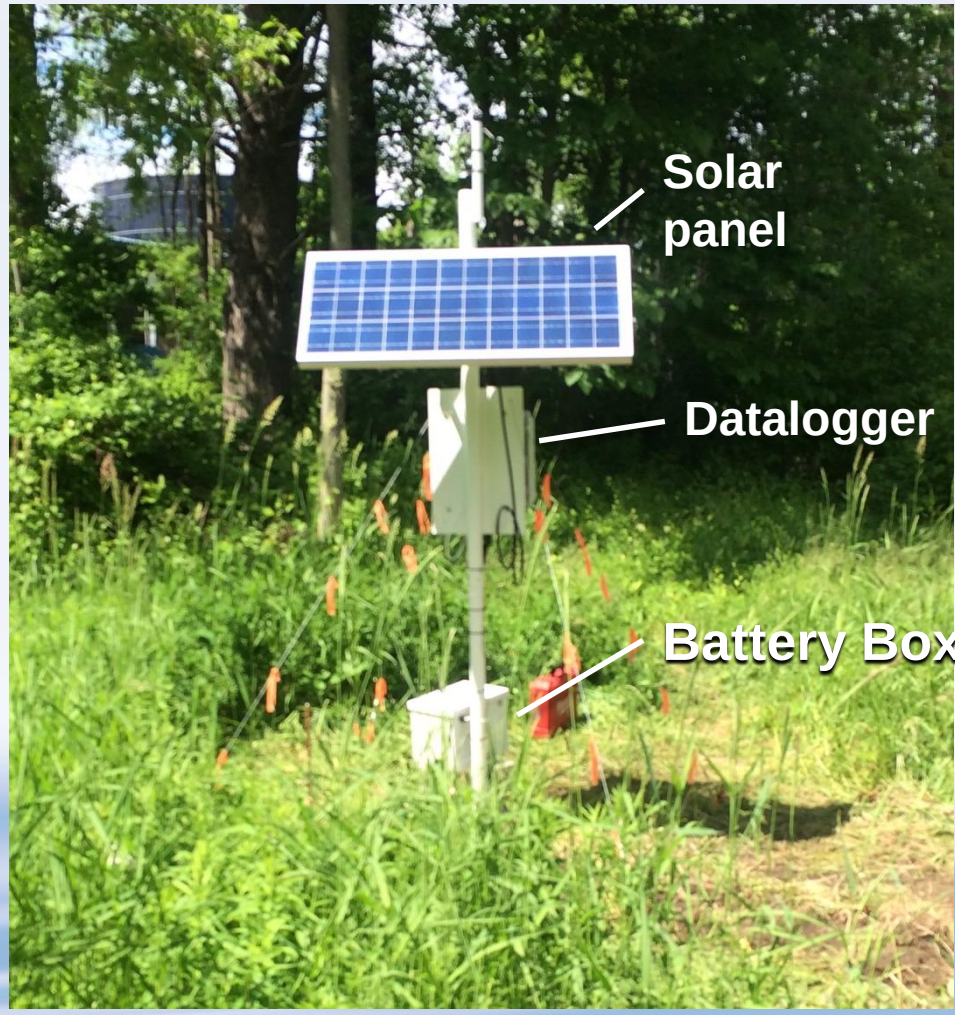
Field Installations





Field Installations



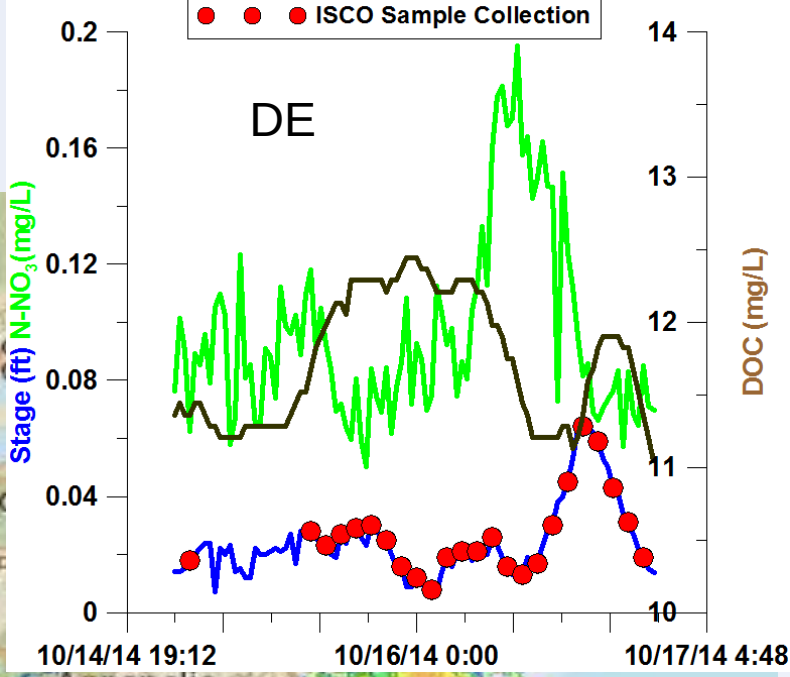


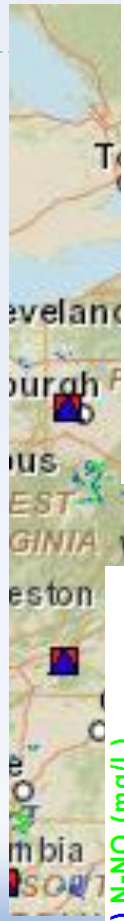
Synoptic Water Sampling

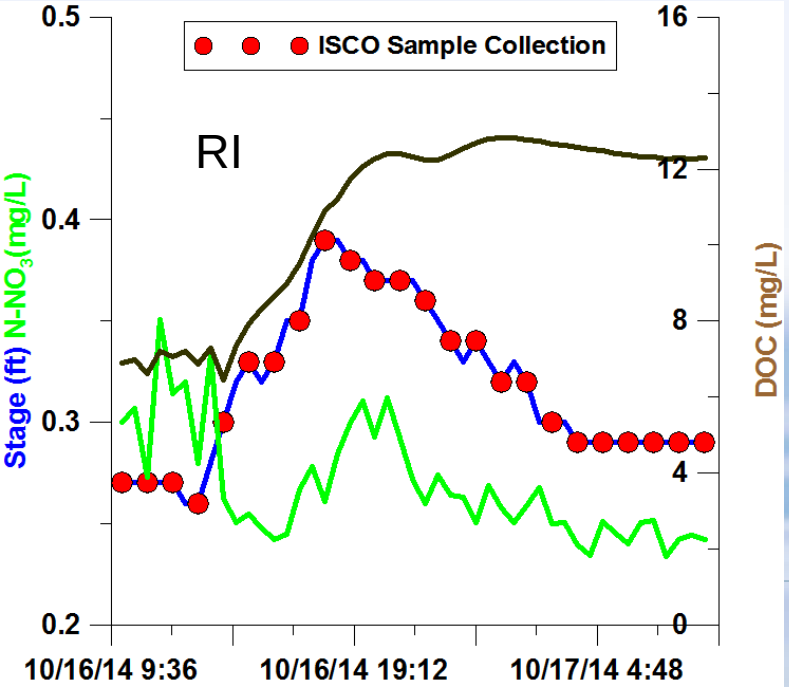
- 1) Samples collected periodically at all sites across range of conditions to asses sensor data accuracy and develop local calibrations or corrections if necessary and possible (grab and Isco-automated)
  - Consistent sampling protocols, standard suite of analyses for each sampling event
- 2) Additional synoptic sampling events and detailed analyses for particular research questions.

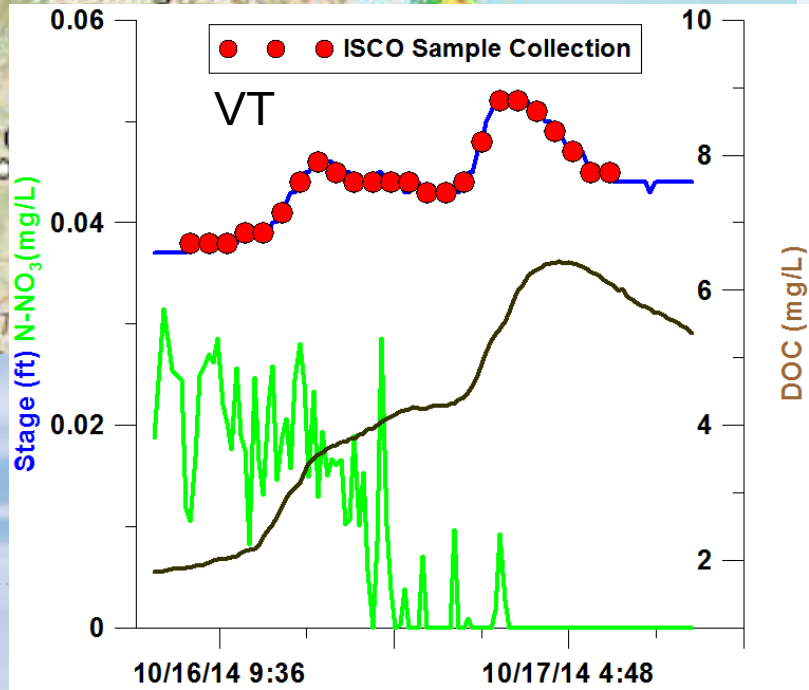
Coordinated Regional Sampling

- Example Regional Precipitation Event (10/15-17)
- Storm Driven Synoptic Sampling





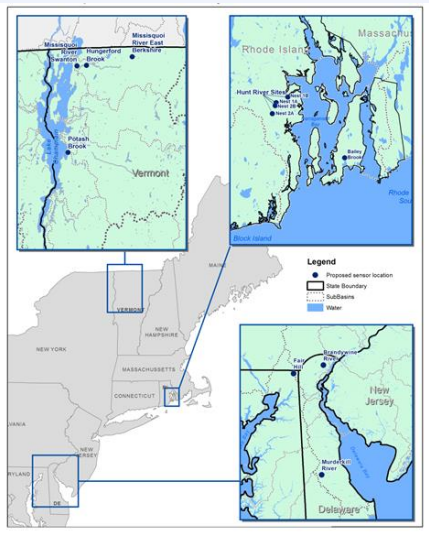




Inamdar: NEWRnet Results

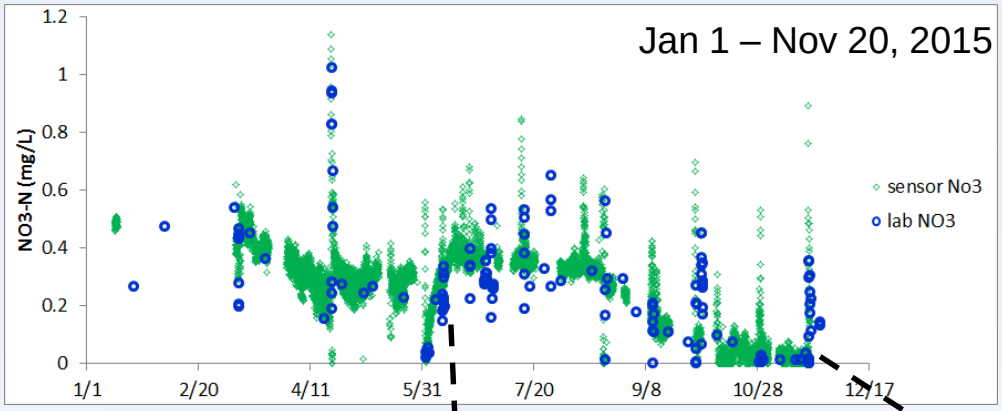
Highlight selected lessons and results from the use of in-situ, high-frequency, optical sensors to characterize **dissolved organic carbon (DOC) and nitrate-N** in stream waters

1. **Key challenges and methodological issues with the sensors**
2. **Process insights and watershed responses**

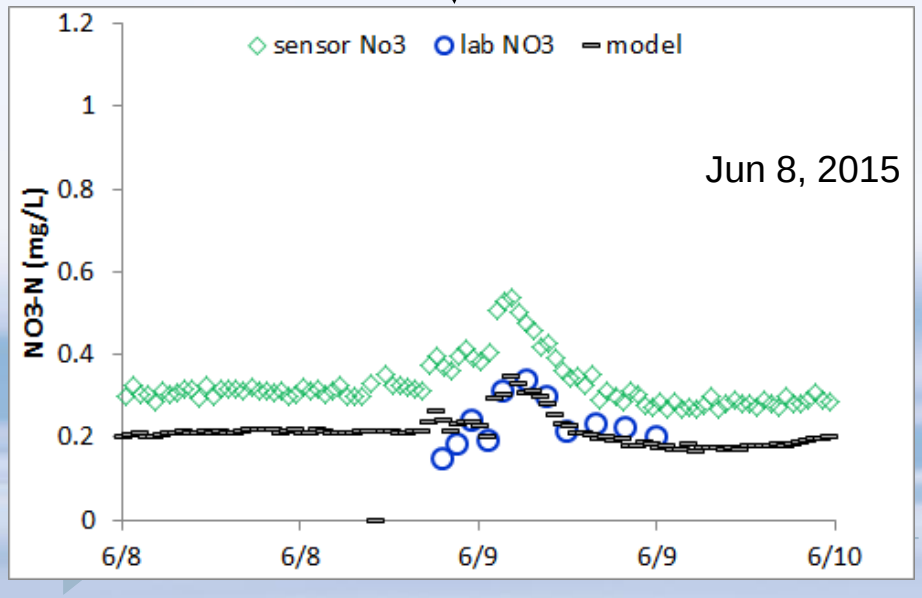


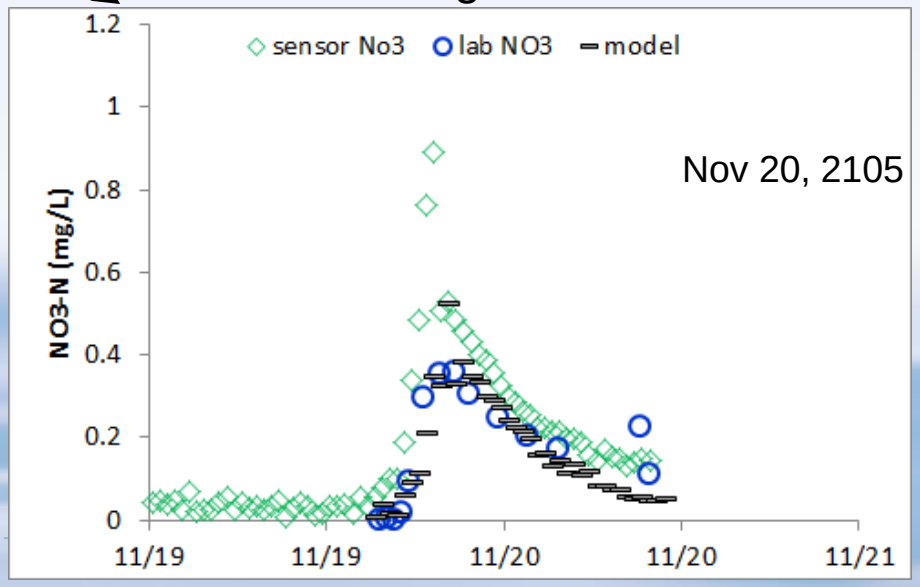
1. Sensor Calibration & Performance

Spectrolyser NO3-N predictions - 79 ha, forested stream, DE



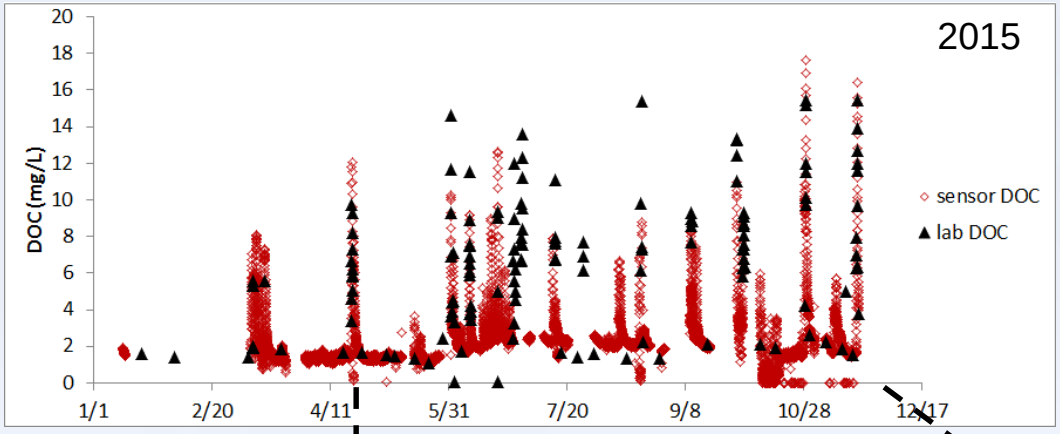
- Global calibration over-predicts
- High variability for low NO3-N concentrations because of 5 mm sensor path length
- Local calibration “model” could improve fits using UV: 220, 240 nm wavelengths



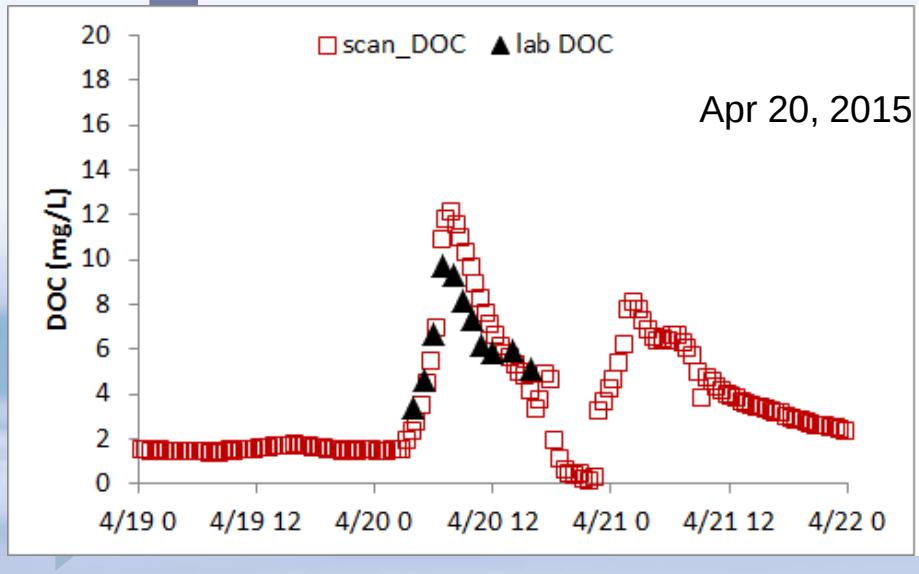


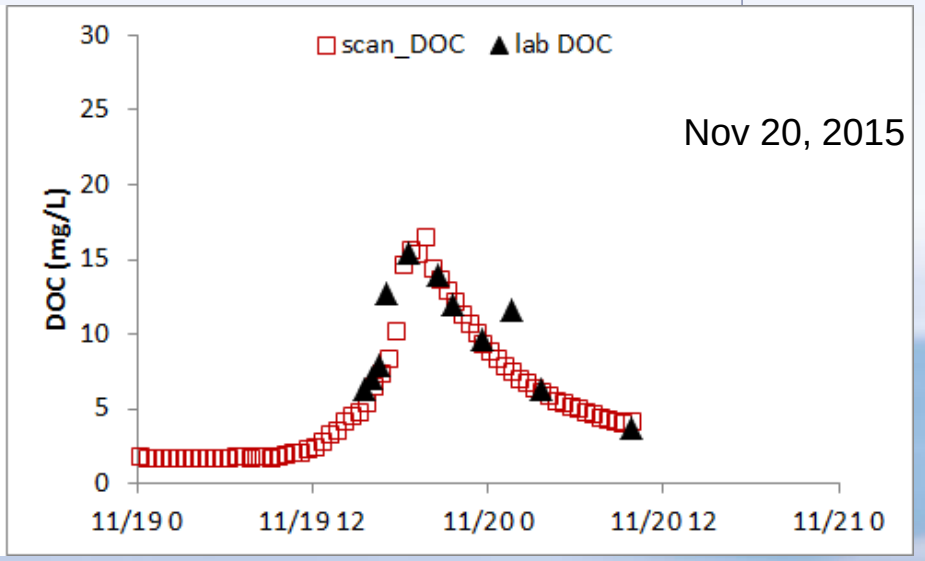
1. Sensor Calibration & Performance

Spectrolyser DOC predictions - 79 ha, forested stream, DE



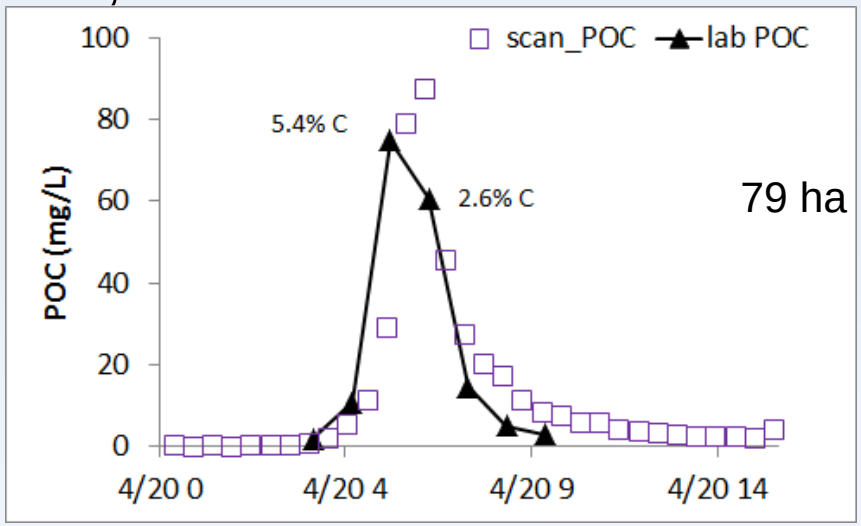
- Global DOC calibration using single wavelength (254 nm) does well, but over-predicts peak values
- Local calibration with multiple wavelengths can further improve fits

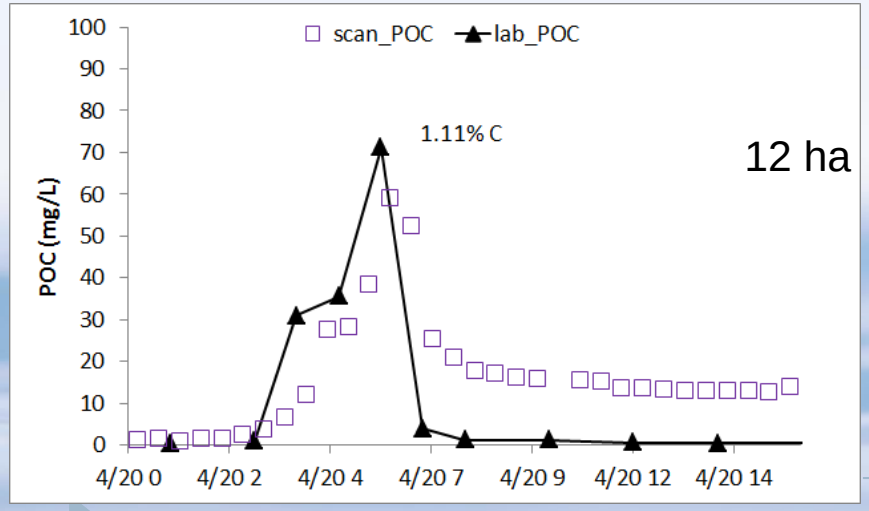




1. Sensor Calibration & Performance

Spectrolyser POC prediction – 12 & 79 ha forested streams, DE - April 20, 2015



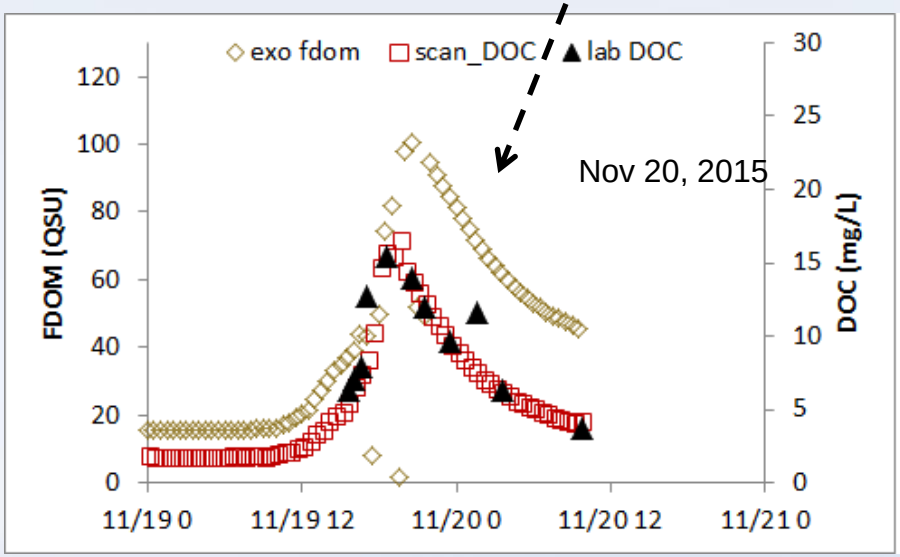


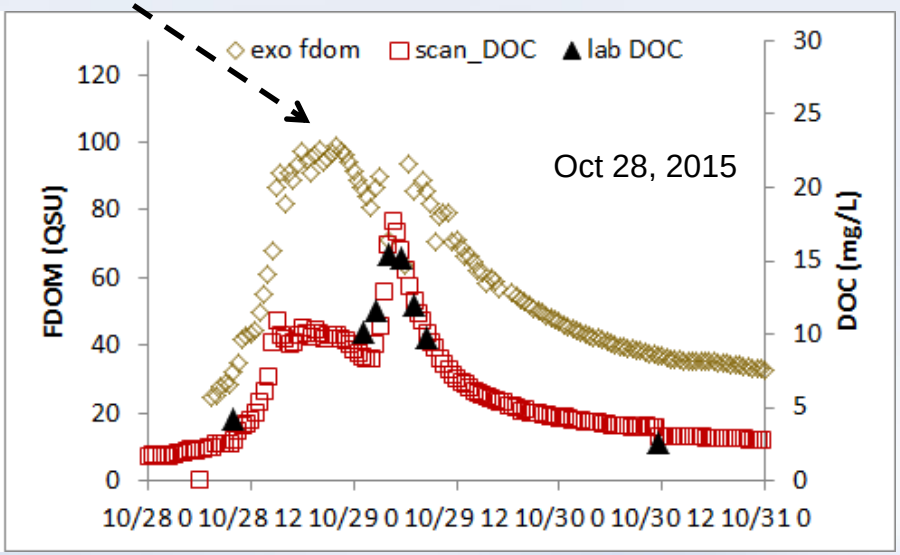
- SCAN POC = TOC – DOC
- POC $_{measured}$ = SS (mg/L) x %C
- Without calibration, POC magnitudes look good!
- Subtle differences on rising and falling limbs?
- Cause for these differences? - turbidity, particle size effects, DOM composition?
- Need to investigate!

1. Sensor Calibration & Performance

Spectrolyser UV-based DOC versus EXO FDOM (fluorescence *ex: 365nm; em: 480 nm)*

Note differences in peak times and the recessions!





Spectrolyser UV – better captures the DOC concentrations, whereas EXO FDOM values represent the humic DOM pool?

EXO FDOM - *ex: 365nm; em: 480 nm – humic region of fluorescence spectrum*

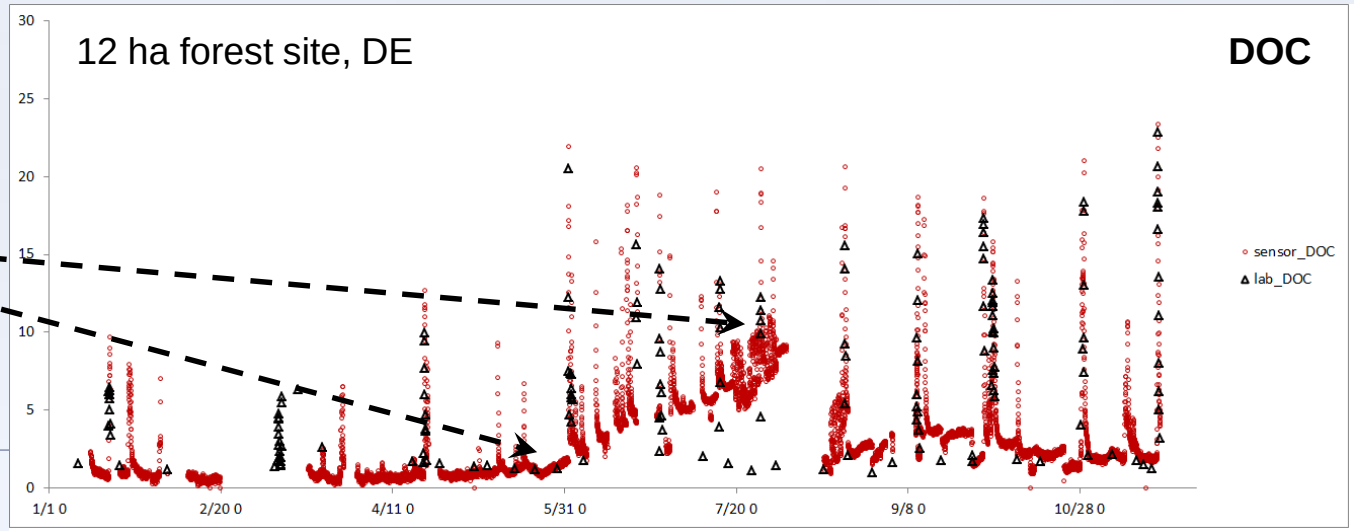
1. Sensor Calibration & Performance

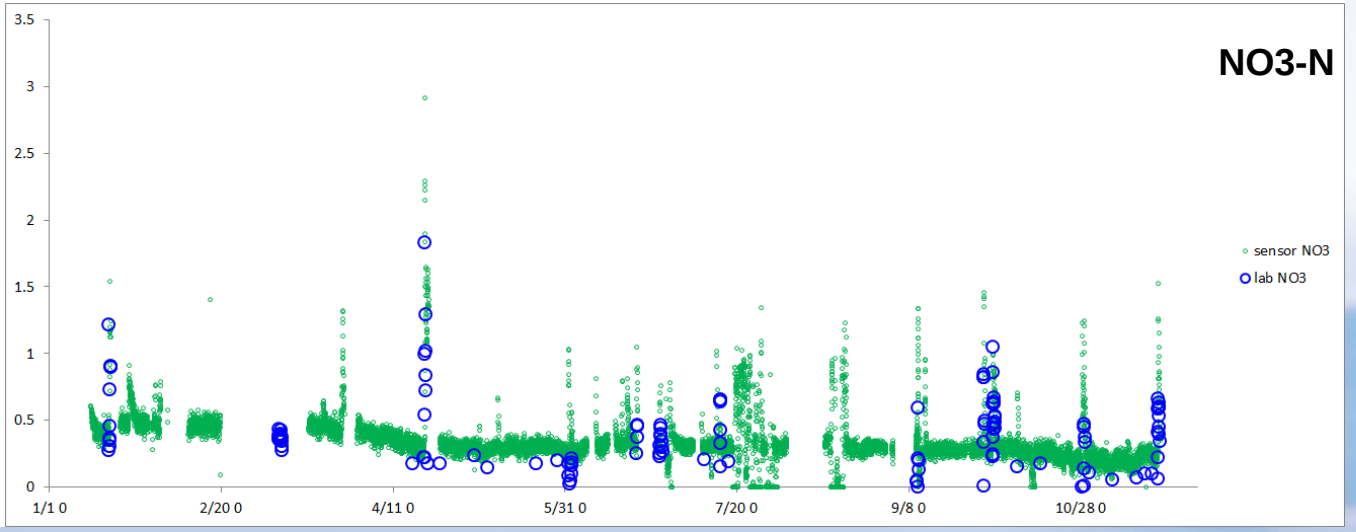
Sensor fouling issues

Fouling drifts need careful attention and corrections

Greater effect on DOC than NO3-N

Cleaning required with acid

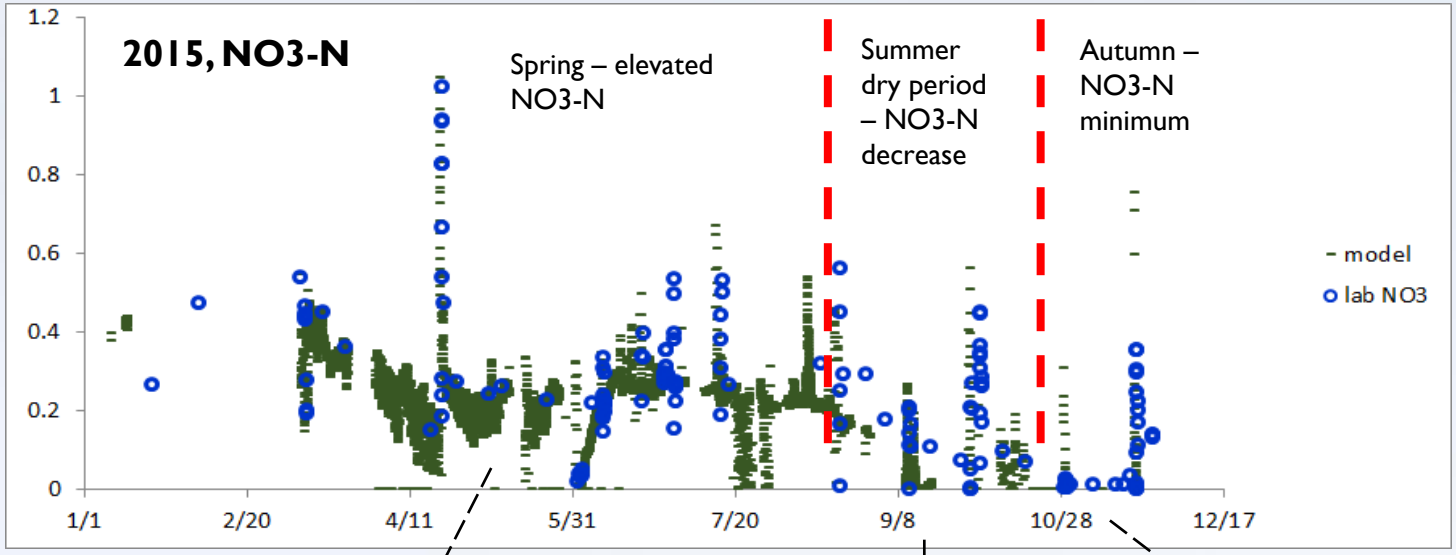




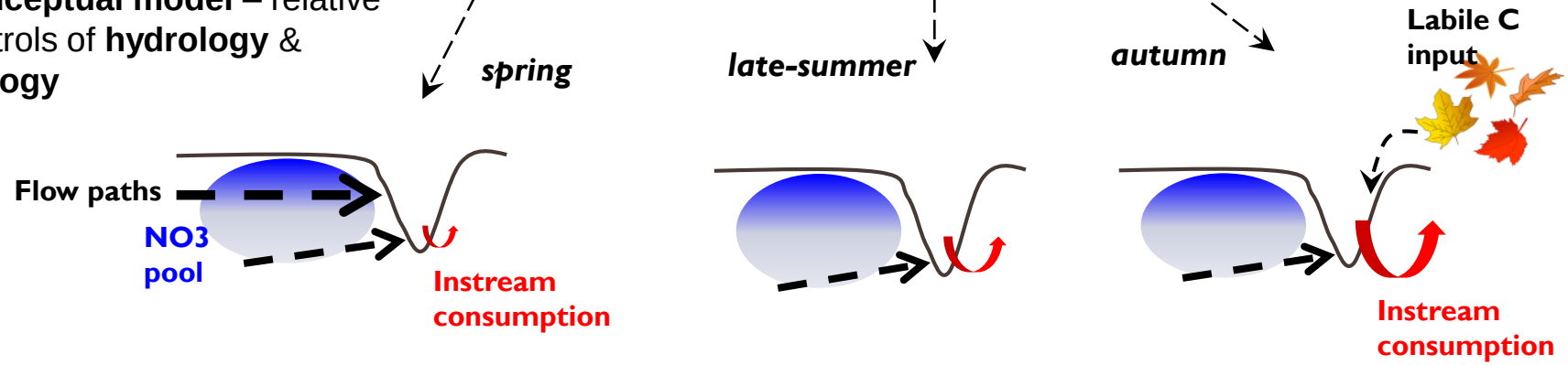
2. Process Insights & Watershed Response

Nitrate-N concentrations decreased over summer and reached a minimum during autumn leaf fall

79 ha forest stream, DE

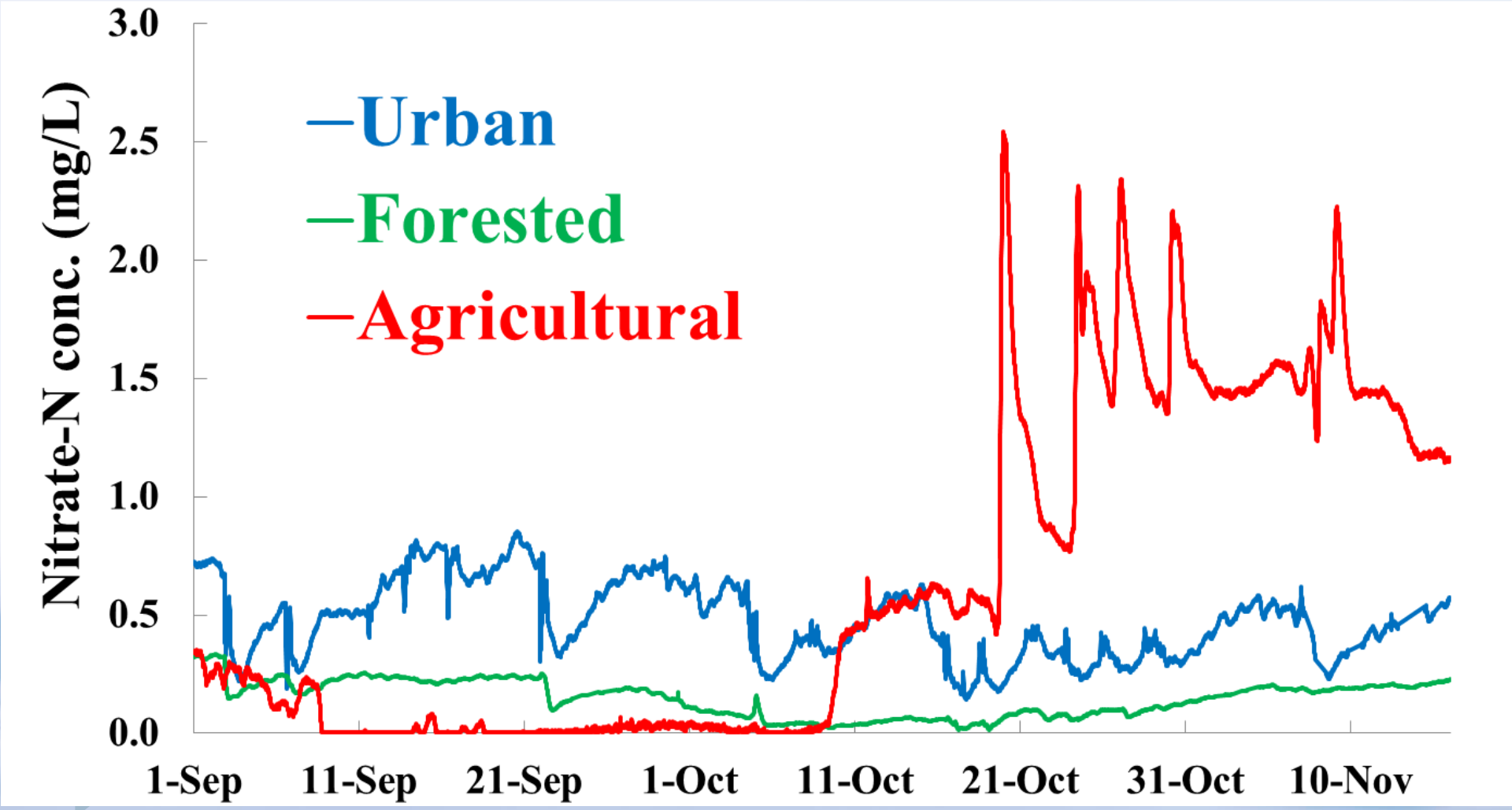


Conceptual model – relative controls of **hydrology** & **biology**



2. Process Insights & Watershed Response

VT Nitrate-N concentrations: similar (but later) crash in forest, algal bloom triggers crash in agricultural system, no crash in urban



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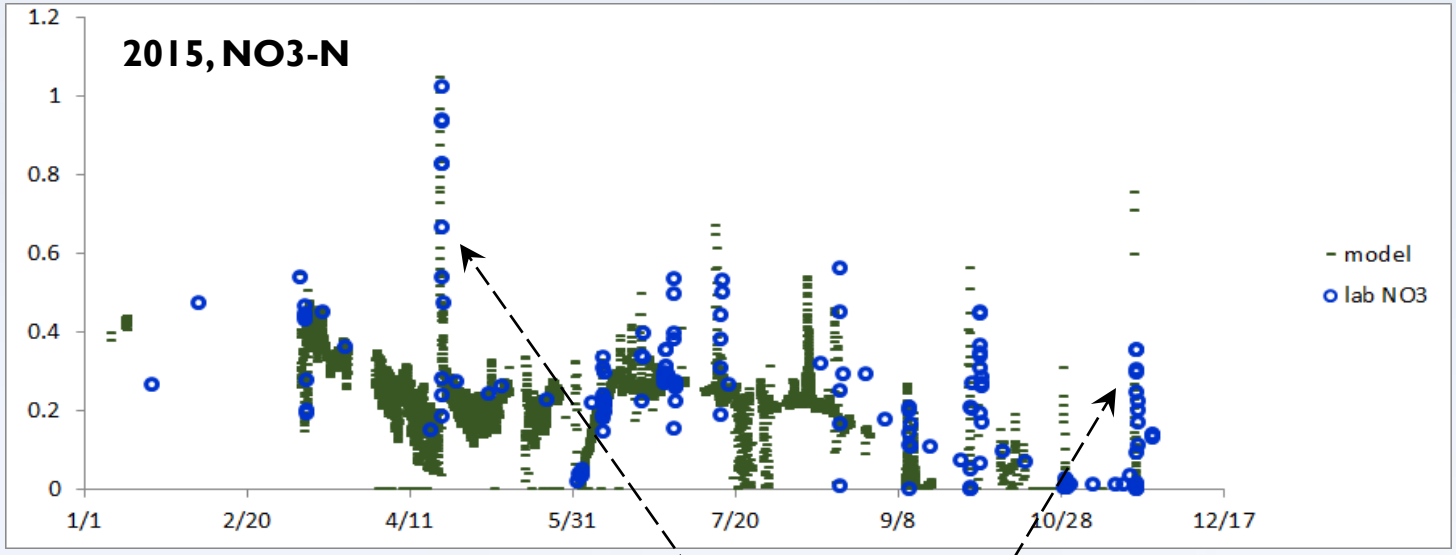
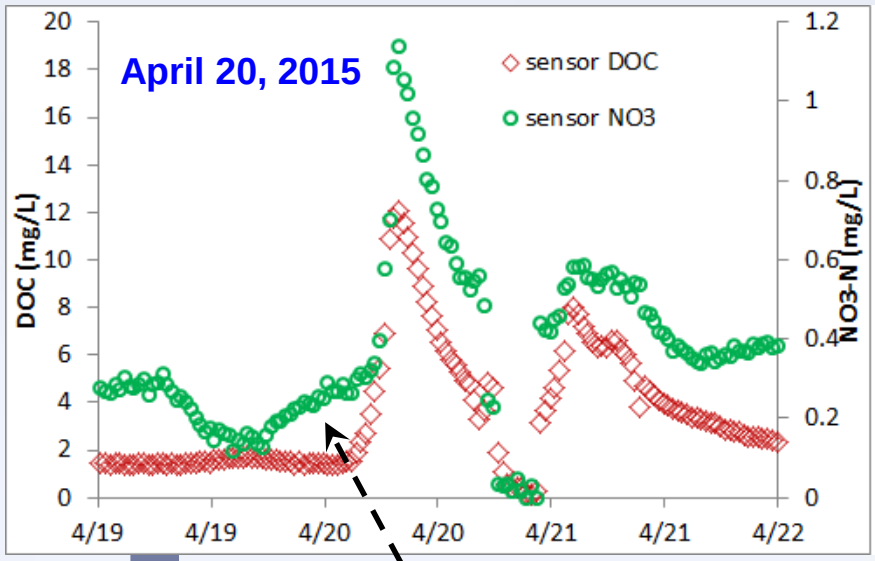
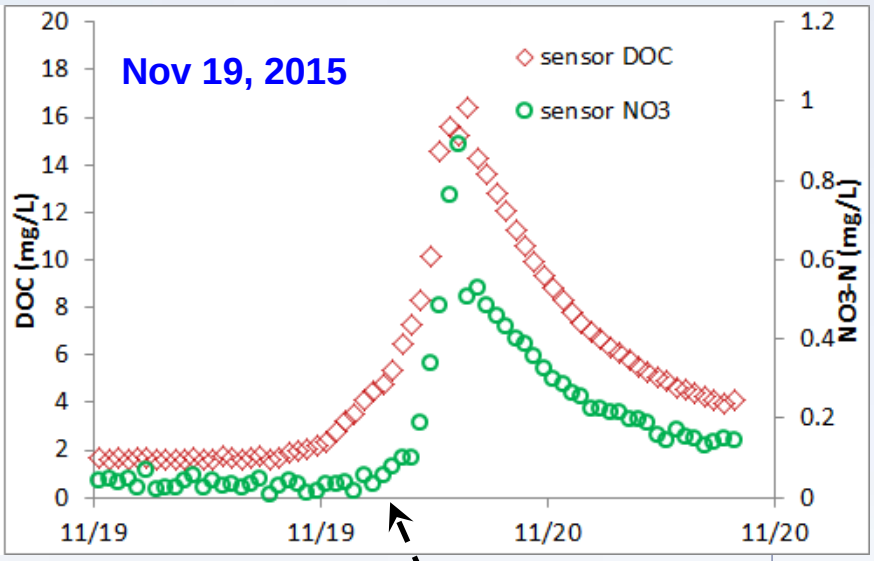


Lets zoom into individual spring and autumn storms to study within-event NO3-N response

2. Process Insights & Watershed Response

Differences in within-event nitrate-N response



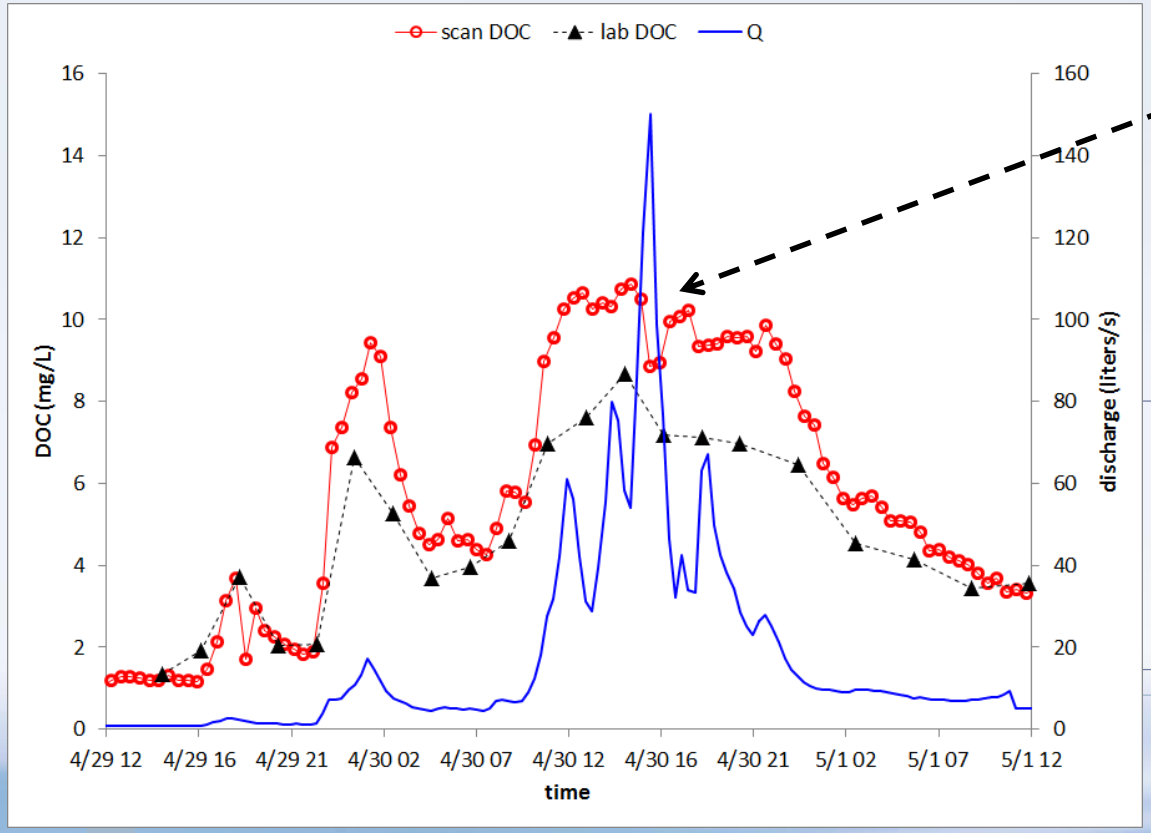


- higher pre-storm NO3-N conc.
- NO3-N increase occurs early,
- **NO3-N available in- & near-stream pools**

- low pre-storm NO3-N conc.
- NO3-N increase occurs later,
- **NO3-N depleted in- & near-stream pools?**

2. Process Insights & Watershed Response

Large storms & scan sensor DOC response



12 ha forest stream, DE

Sensor captures dilution at peak flow!
(30-min sensor frequency)

Apr 30, 2014 storm:

Rainfall = 6 inches in 48 hrs!

Big Elk Creek, DE