

Spatiotemporal Urban Creek Water-Quality Monitoring Using an Open-Source Buoy Style Sensor

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Outline

- Introduction
 - Importance of water quality monitoring
 - Present standard of water-quality test
 - Advantages of real-time spatial monitoring
- Methodology
 - Sensor node components and design features
 - Deployment in water bodies
- Experimentation & results
 - Benchtop accuracy test
 - Test result from an urban creek
- Conclusion and future work



Background

- Pollution alters crucial water quality parameters like pH, total dissolved solids (TDS), & turbidity.
- It is necessary to track these parameters to ensure healthy eco system and safeguard public health.
- Real-time spatial monitoring can help to understand how pollution spreads over time and thus helps with pollution source tracking



environmentalnote.com/understanding-pollution-causes-effects-and-prevention-strategies

Background

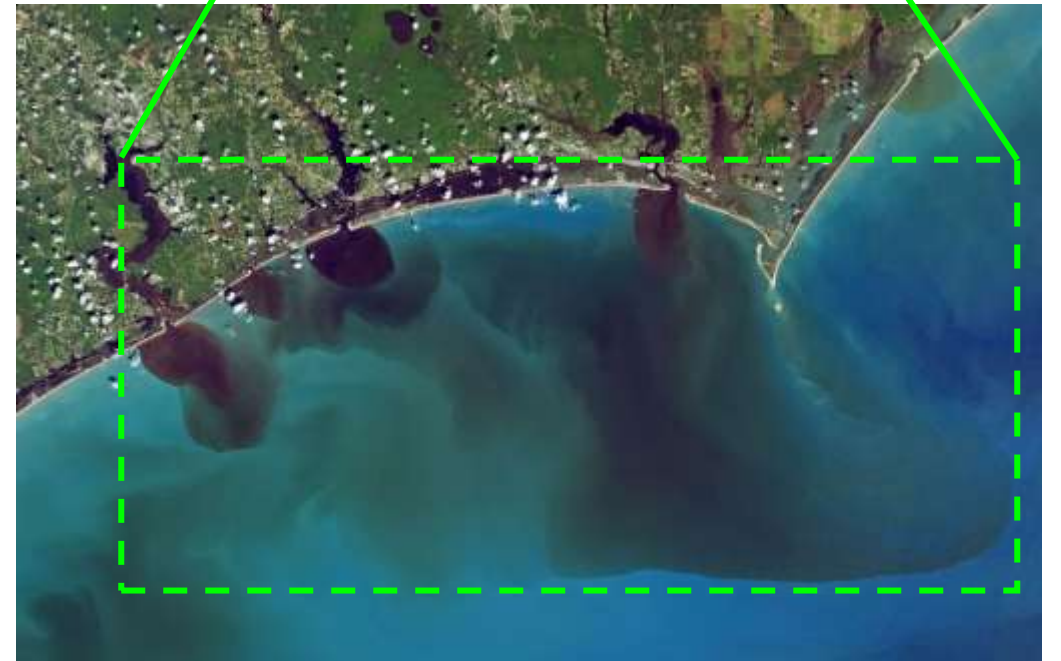


blog.geiworks.com/2018/02/wildfire-part-three.html

Wildfire runoff increases metal particles in water and increases conductivity

- Real-time spatial monitoring can help to passively track natural disasters like wildfires and hurricanes
- A rapidly deployable sensor cluster can be helpful in this regard

Hurricanes or storms increase water turbidity by mixing dirt/pollutants in water



livescience.com/63689-nasa-hurricane-florence.html

Background

- Present standard for water quality testing
 - Taking samples manually from waterbodies and performing analysis in lab
- Shortcomings
 - Requires manual labor
 - Poses health-risk
 - Doesn't allow real-time spatial monitoring
 - Doesn't allow rapid testing to track natural calamities



rpsgroup.com/services/laboratories/environmental-analysis/water-analysis

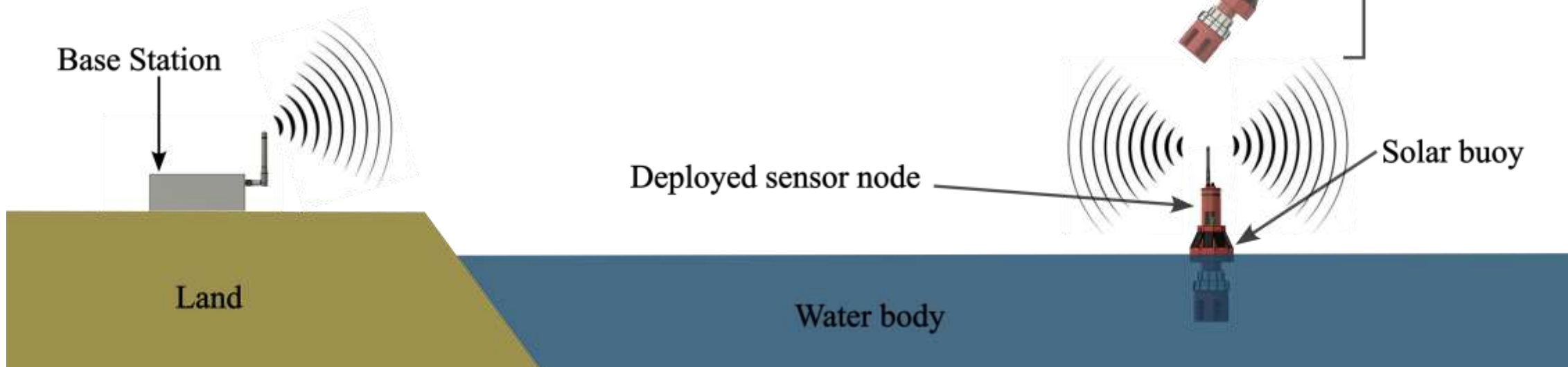
Proposed Buoy Style Sensor node

- Designed for autonomous, real time, in-situ monitoring of water quality conditions
- Open-source modular design with off the shelf hardware
- Senses pH, electrical conductivity, turbidity and temperature
- UAV-deployable package to enable deployment in remote environments



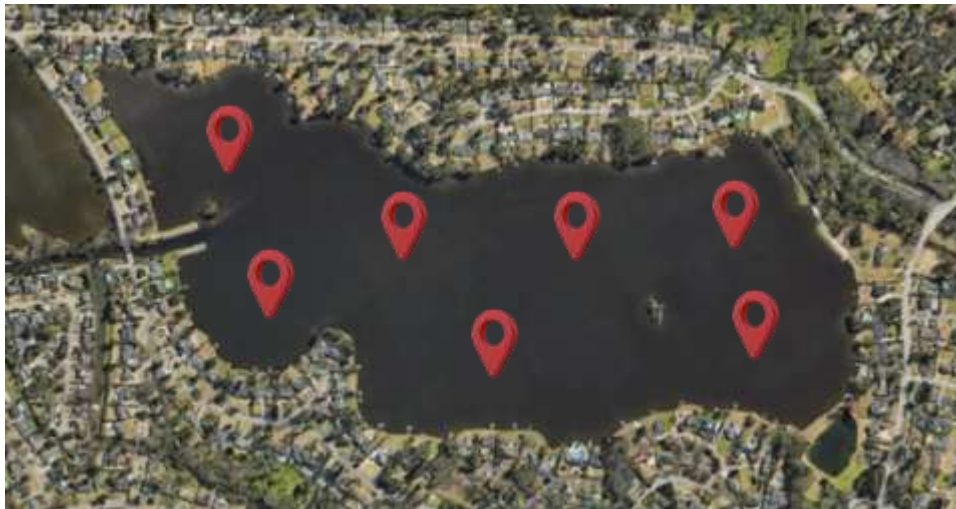
Rapidly deployable in water bodies

- Allows multiple rapid deployments in large water bodies
- UAV is guided by GPS to deploy in a specified location autonomously.
- Transmits data to base station wirelessly



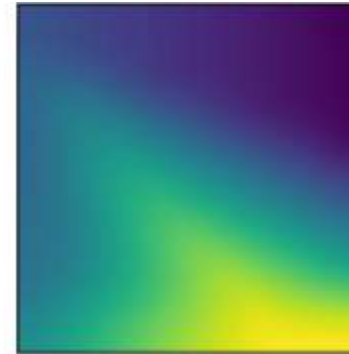
Enables real-time spatial monitoring

- Spatial maps of key water quality parameters using a cluster of GPS equipped sensor nodes in conjunction with Kriging
- Kriging is a geostatistical interpolation technique used for spatially correlated domains like water bodies

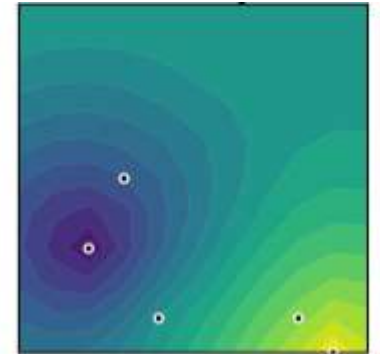


Sensor node cluster in a water body marked with red pin

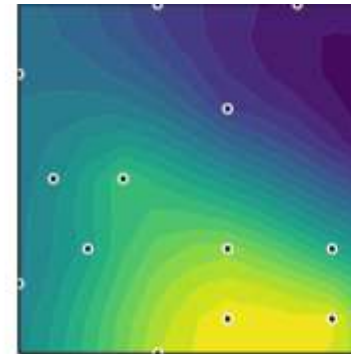
Ground truth



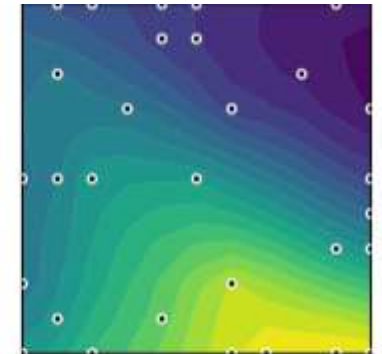
5 samples



15 samples

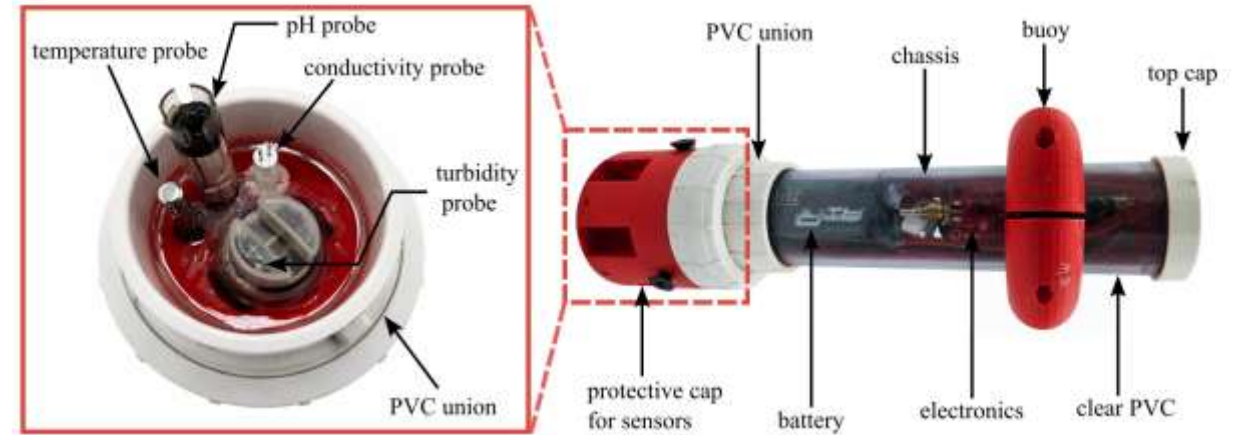
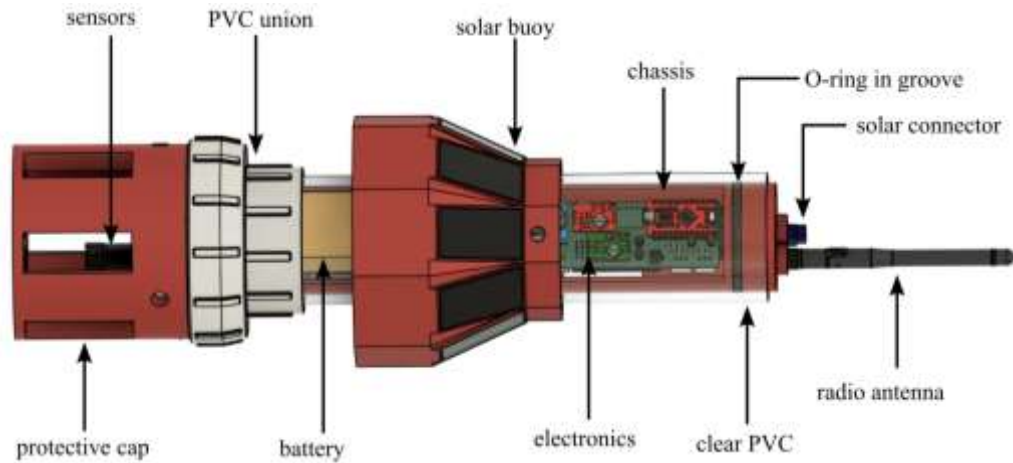


30 samples



A numerical simulation of lake sampling with kriging

The sensor node design



The advanced version with GPS and wireless telemetry



The basic version with onboard SD card

[M. A. Khan, M. Burnett, A. R. J. Downey, J. N. Satme, and J. Imran, "UAV deployable buoy-style sensor for in situ water quality monitoring," in *Ocean Sensing and Monitoring*, May 2025.]

UAV deployment mechanism

- Deployed using an Electro-Permanent Magnet (EPM) mounted on the UAV.
- EPM can retain its magnetization without constant energy input.
- EPM can be toggled on (magnetized) or off (demagnetized) using electrical pulses.



OpenGrab
EPM V3



Sensor accuracy validation

- A benchtop test was performed to verify the accuracy of the pH, conductivity, and temperature sensors.
- Sensor readings showed deviations of 0.71–4.2% compared to industrial reference instruments, indicating high accuracy.

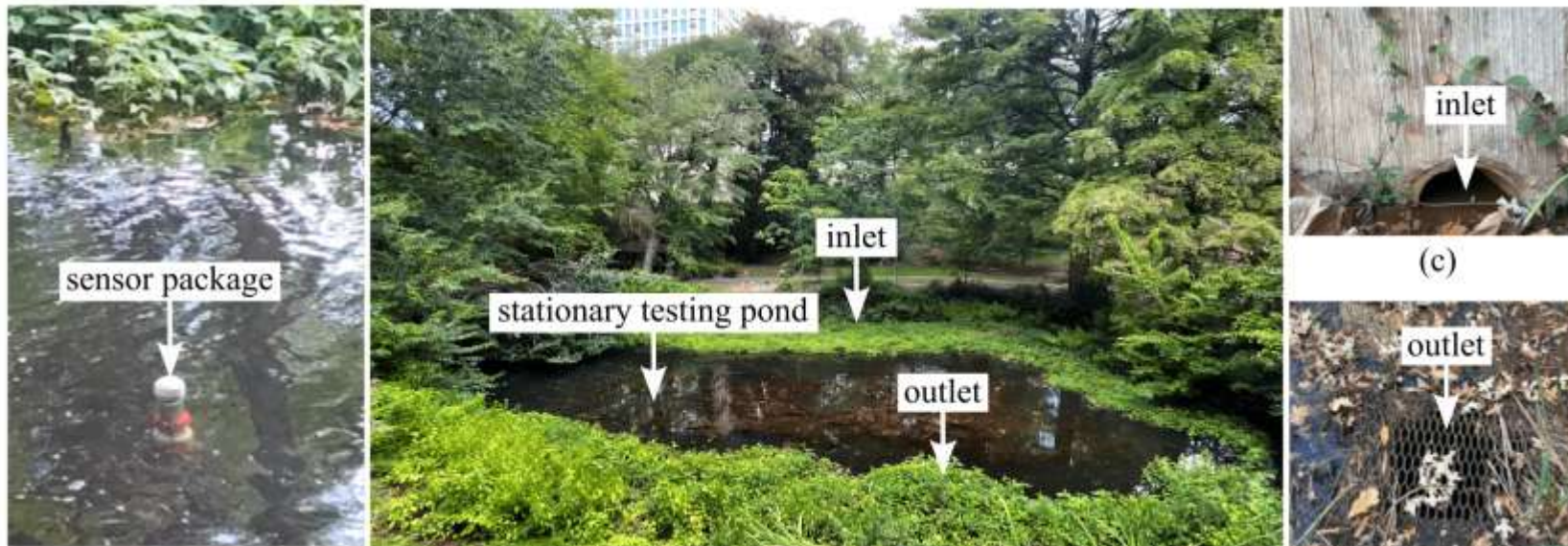
parameters	sensor node's value	reference sensor's value	error (%)
pH	7.01	6.96	0.71
electrical conductivity ($\mu\text{S}/\text{cm}$)	12619	12108	4.22
temperature ($^{\circ}\text{C}$)	25.7	26	1.15

Lentic System Monitoring

Still water (lakes, ponds)

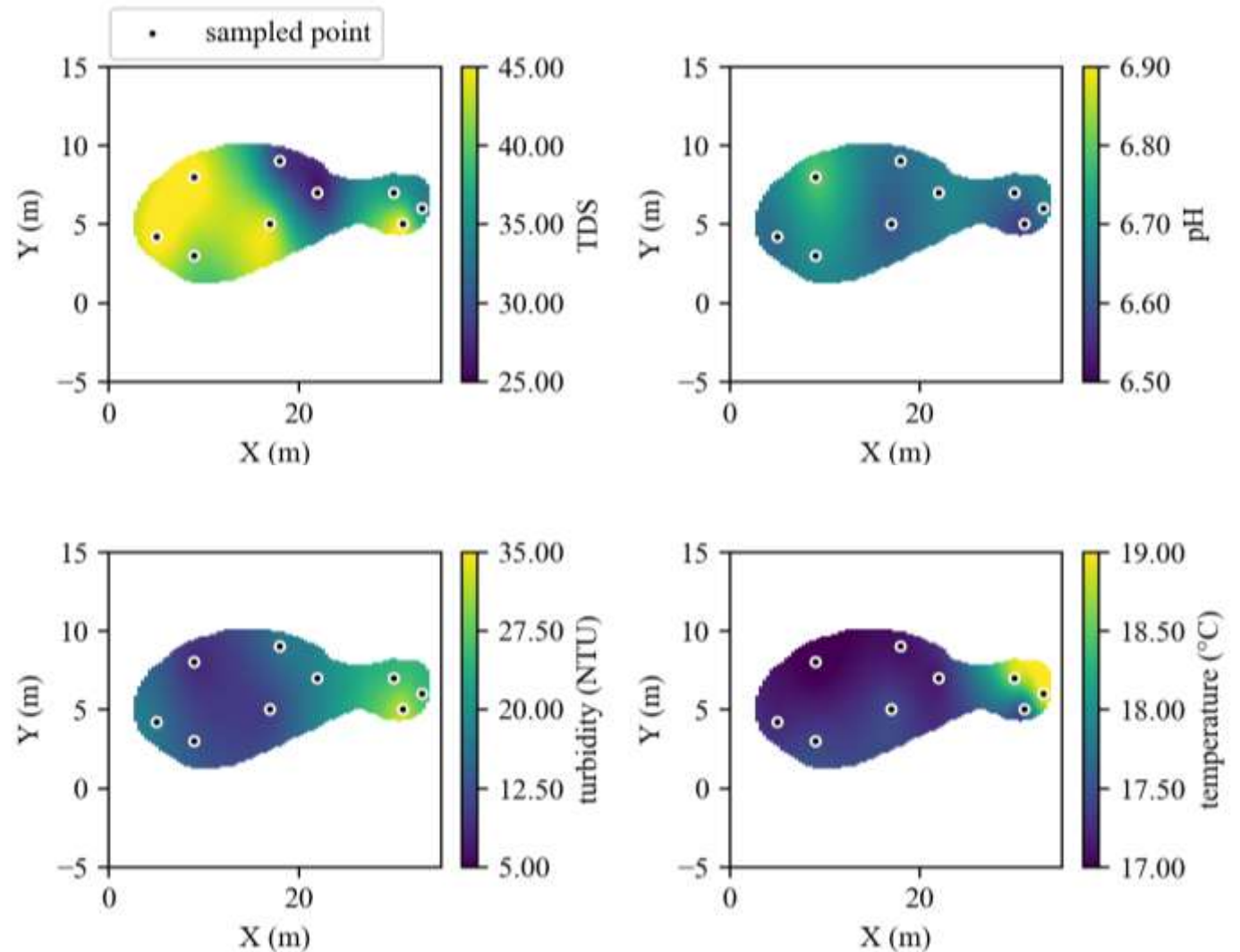
Spatial mapping in an urban pond

- Sensor package (without solar module) deployment test — buoyant module collecting data in a mostly stationary pond, with views of the pond's inlet and outlet.



Spatial Results

- Kriging interpolation revealed spatial trends in pH, TDS, turbidity, and temperature across the pond
- Single sensor package was repositioned across sampling locations to collect spatially distributed data
- Detected gradients linked to environmental factors like sunlight exposure, algae presence, and organic debris

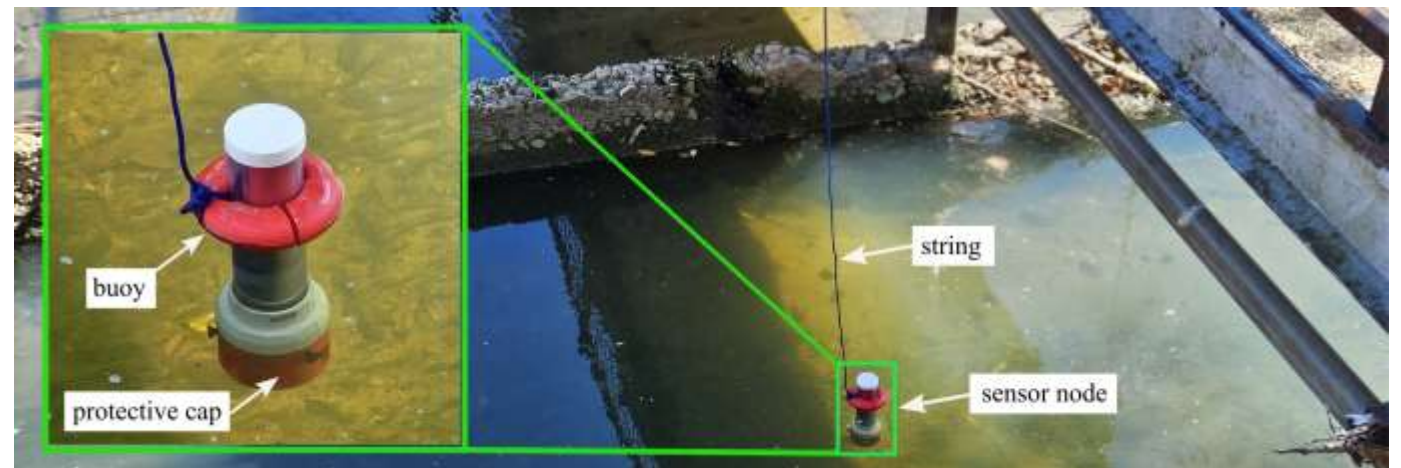
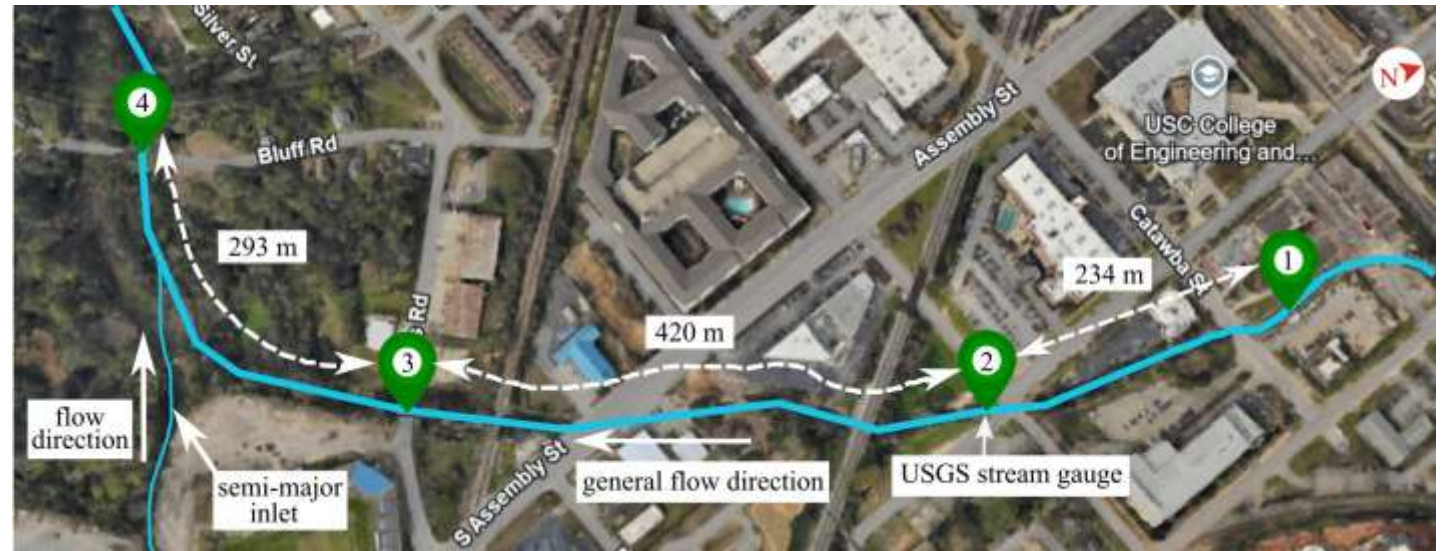


Lotic System Monitoring

Flowing water (creek, rivers)

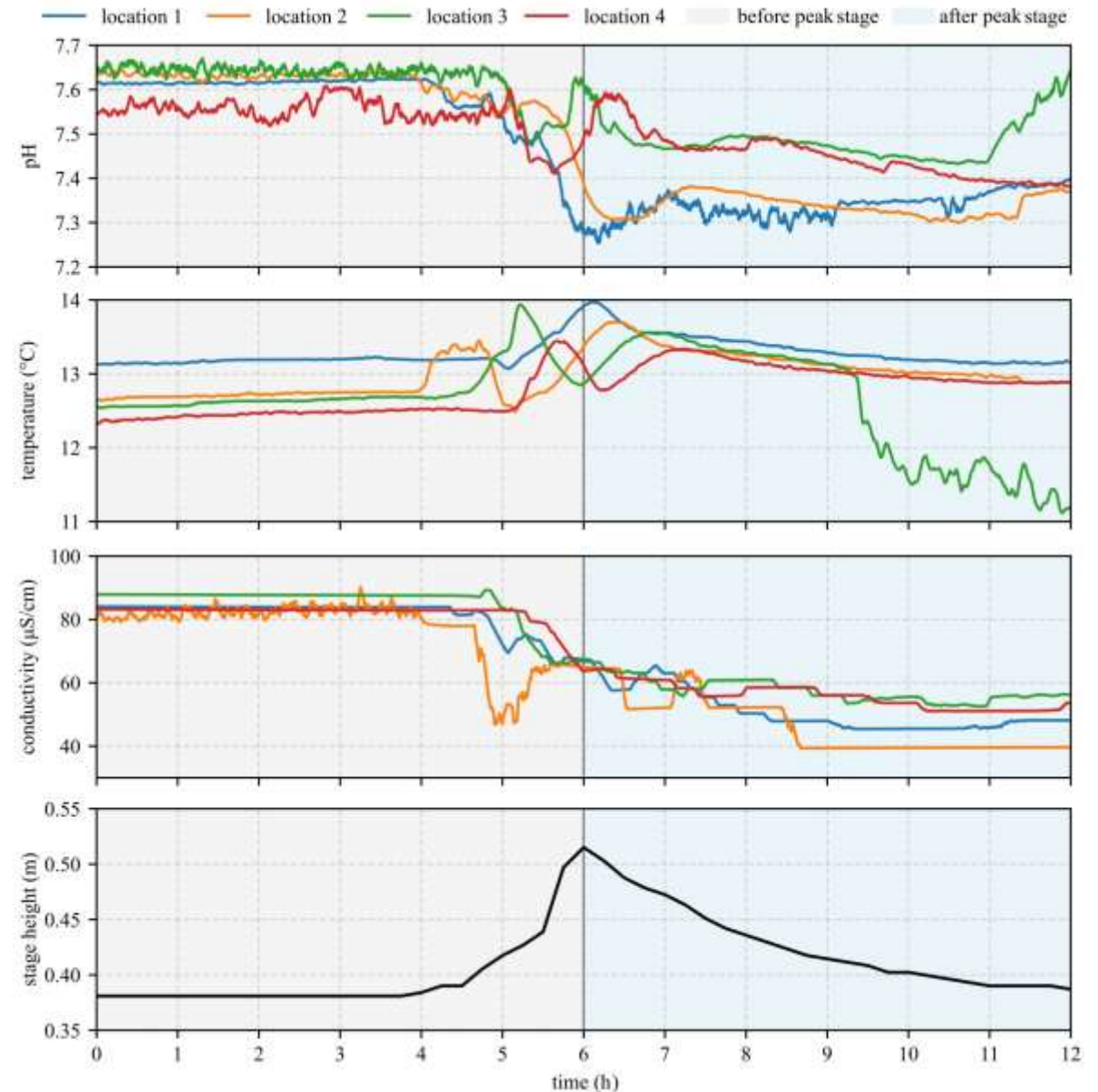
Deployment in an urban creek

- Experiment goal-
 - Check water quality parameters in local creek
 - Quantify parameter change before and after rain event
- Location-
 - Rocky Branch creek, downtown Columbia, South Carolina, USA.



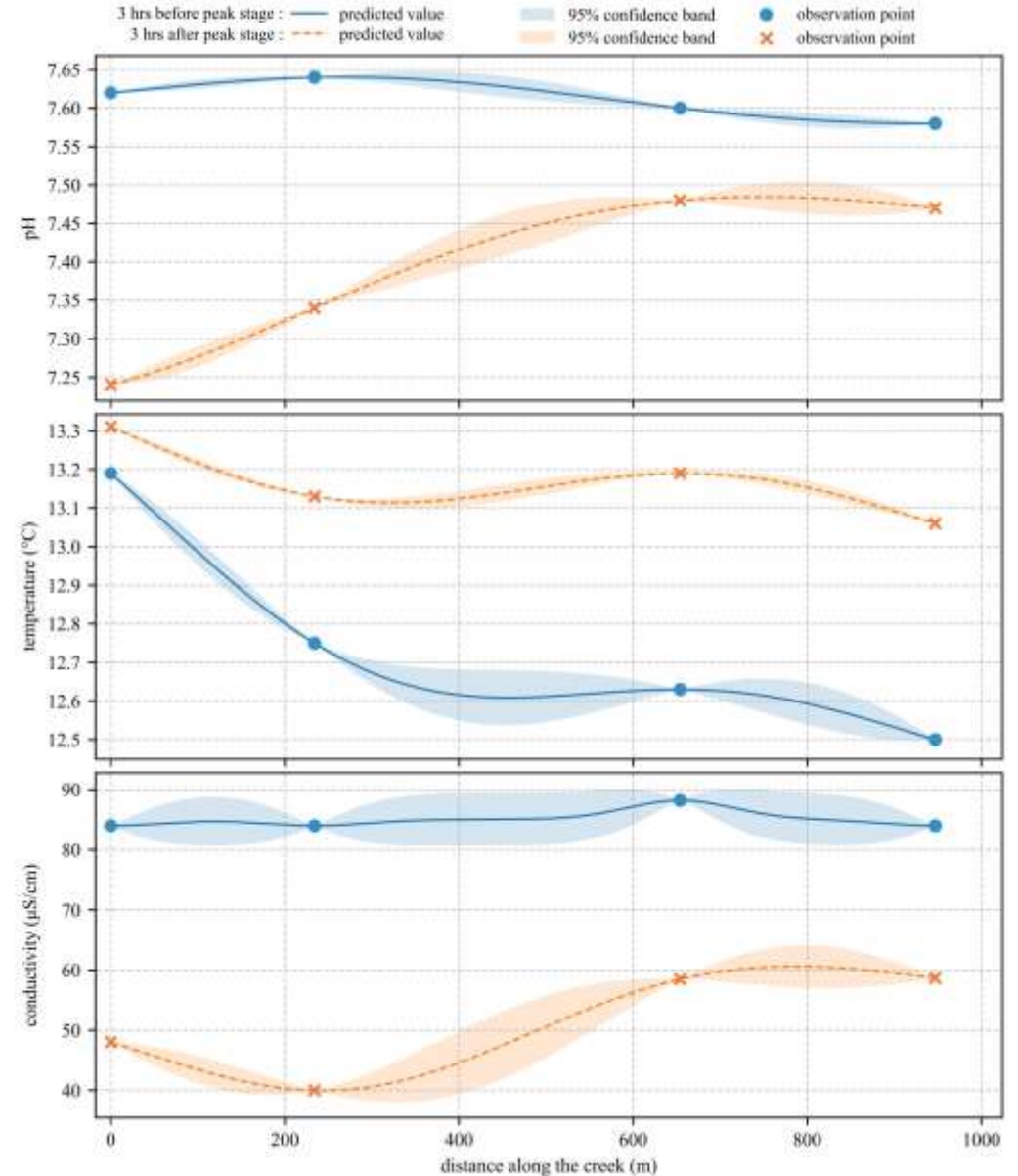
Data from urban creek

- Data analyzed for 12 h operation duration
- With rain event starting indication at 6th hour



Spatial mapping in urban creek

- Four-point spatial mapping conducted at Rocky Branch Creek
- Spatial distribution analyzed using Kriging interpolation, revealing variations linked to rain events

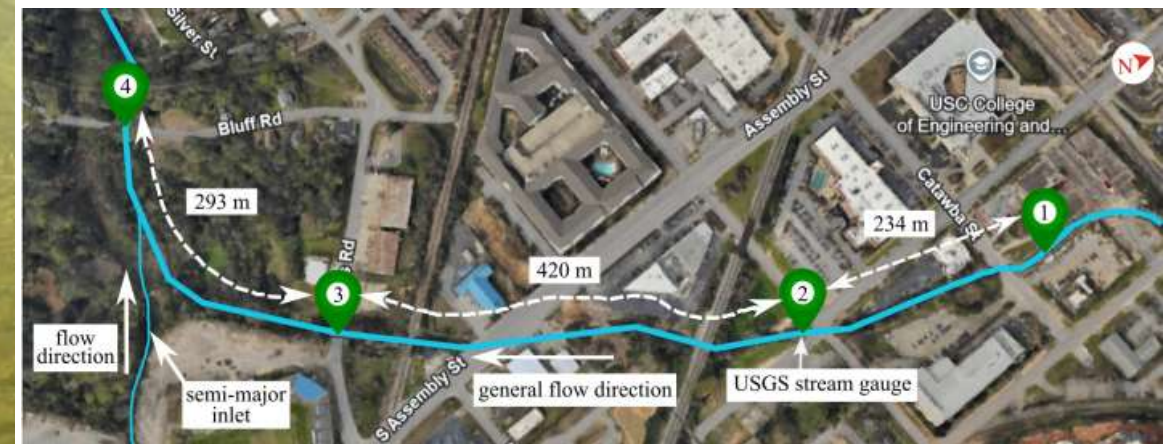


Percentage change in water-quality parameters from 3 hrs before to 3 hrs after peak stage height

parameter	% change				
	observation point 1	observation point 2	observation point 3	observation point 4	average
pH	-4.78	-3.77	-1.53	-1.39	-2.87
temperature	0.89	2.94	4.37	4.41	3.15
conductivity	-41.89	-51.23	-33.17	-29.37	-38.92



- Future goal is to use these parameter changes to detect natural events
- Creating a map of contaminant flow in creek



Acknowledgment



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Thank You for Your Time

GitHub Repository

github.com/ARTS-Laboratory/In-Situ-Water-Quality-Sensor



Questions?

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