

# Energy Budget Analysis of SWaP-Constrained UAV-Deployable Water-Level Sensors with Varying Sampling Intervals and Idle Currents

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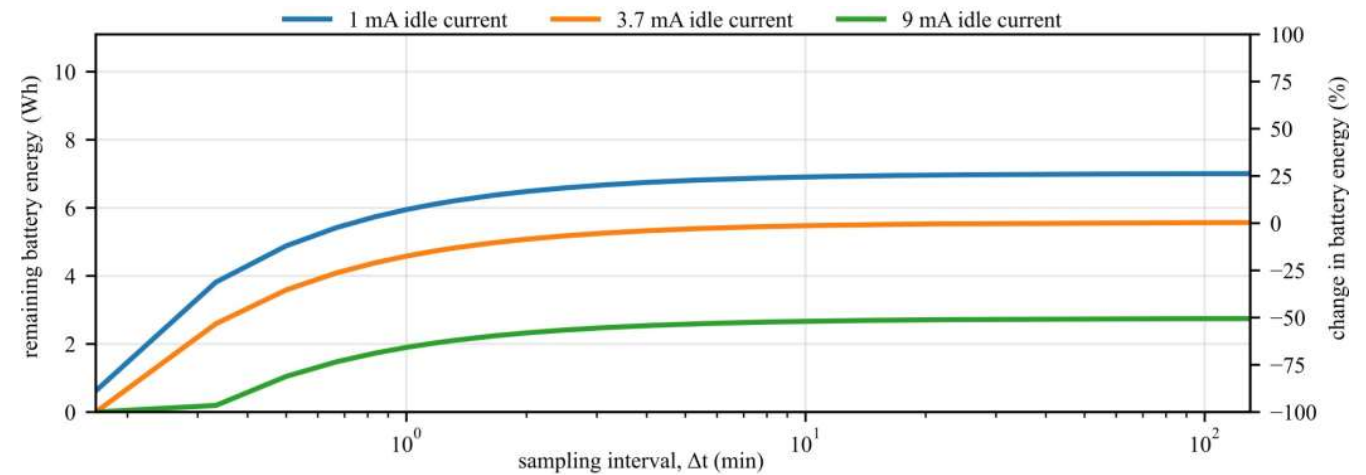
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# Outline

- Background
- The sensor
  - SWaP Constraints
  - UAV deployable platform
- Field deployment and data
- Energy budget analysis
- Conclusion & future work

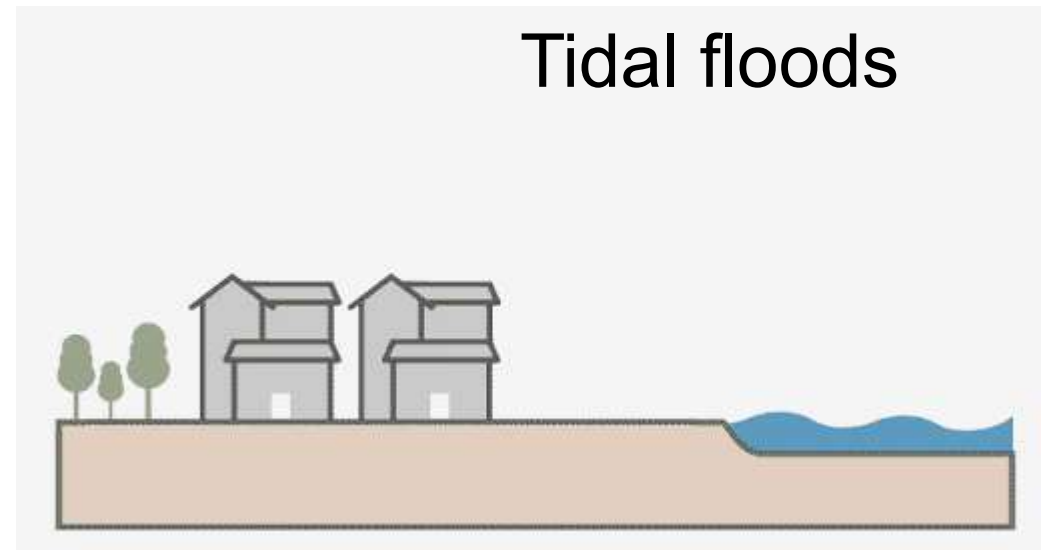
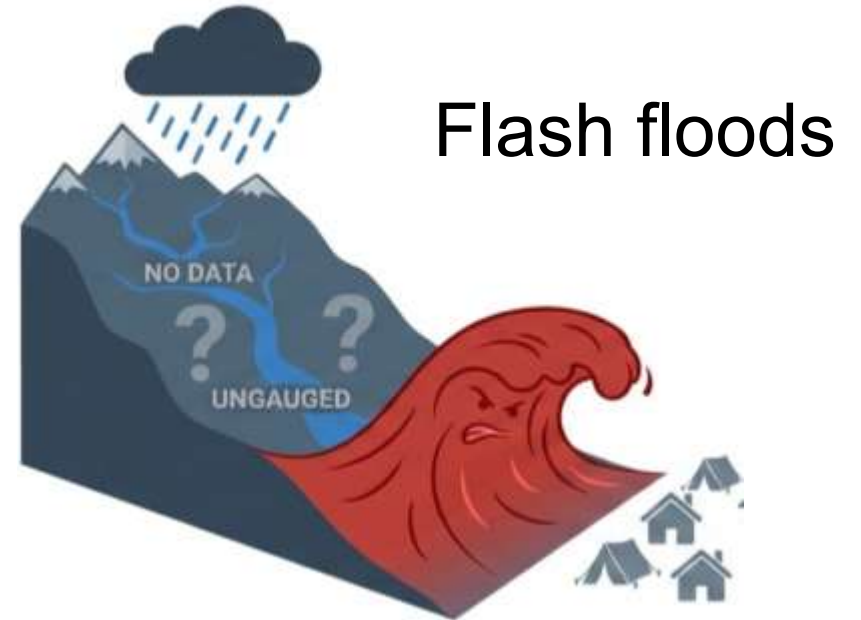


# Background

- Steep terrain → rapid runoff
- Small basins → short response time

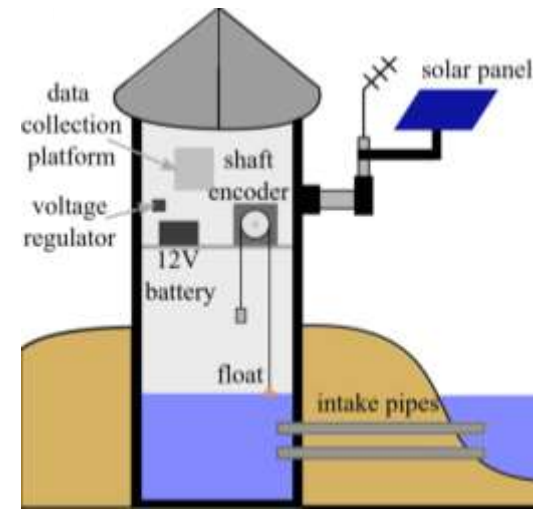
**No gauges = no warning !**

- High tide → water overtops banks and low areas
- Backwater effects → water drains more slowly in creeks and estuaries

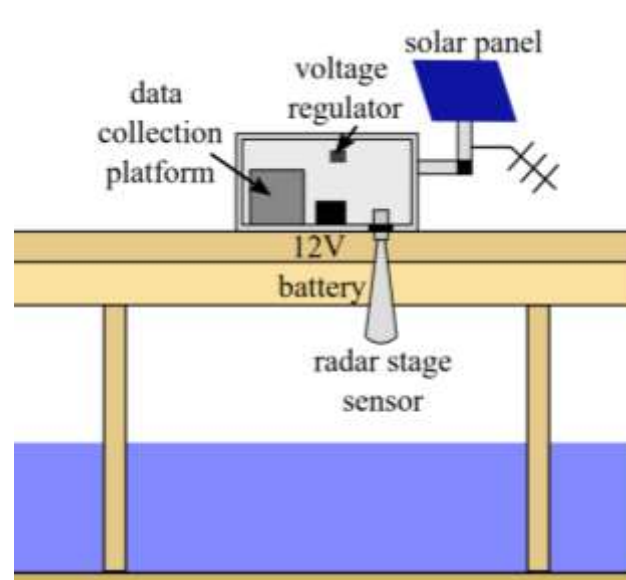


# Background

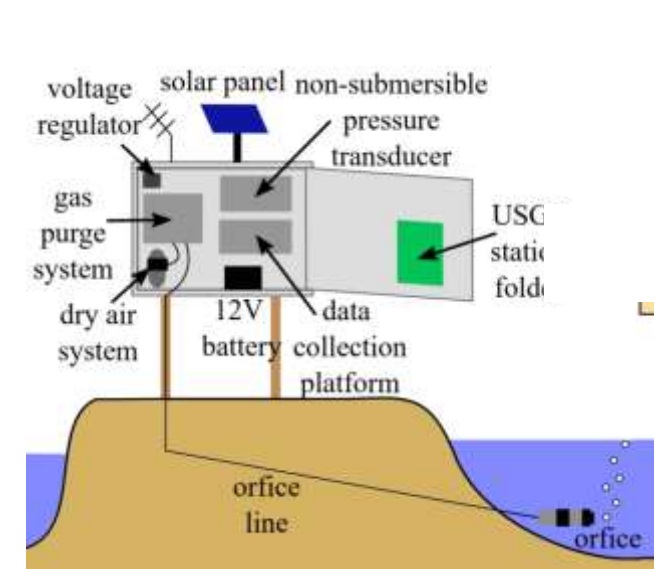
- Stage is the vertical height of water surface from a fixed reference point
- Stage data is crucial to monitor flood
- Typical gauges used by USGS-
  - Stilling wells
  - Bubble gauges
  - Radar level sensors
- Expensive to build, installed at permanent locations, manual labor required to deploy



Stilling well



Radar level sensor



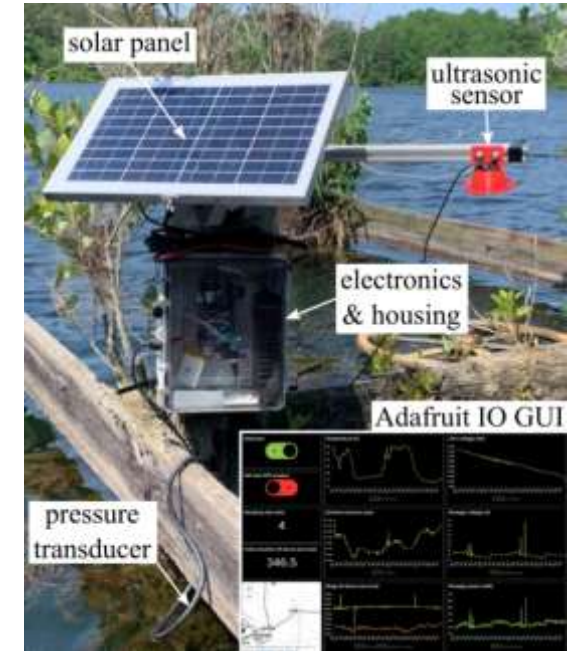
Bubble gauge

# Background

## Design Goal

- An easily portable SWaP constrained water height sensor
- Long operational endurance
- Focused on citizen-science

Network of sensors can provide early warning upon flood development

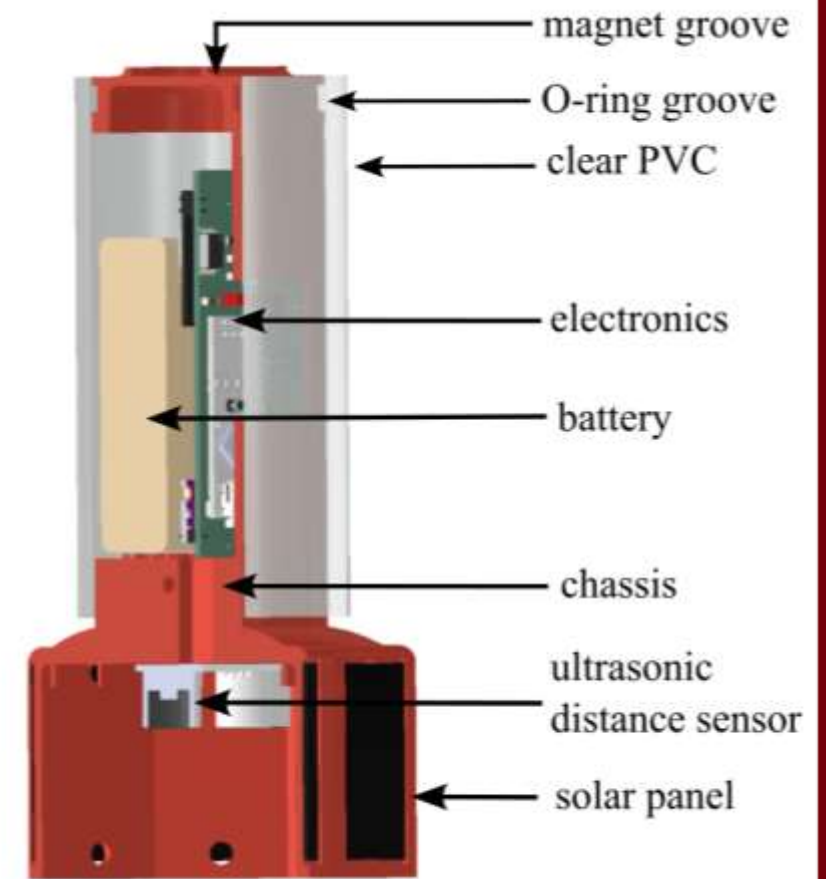


# Sensor design

- Based on open-source hardware and software
- 3D printed parts
- Size, Weight and Power constrained package

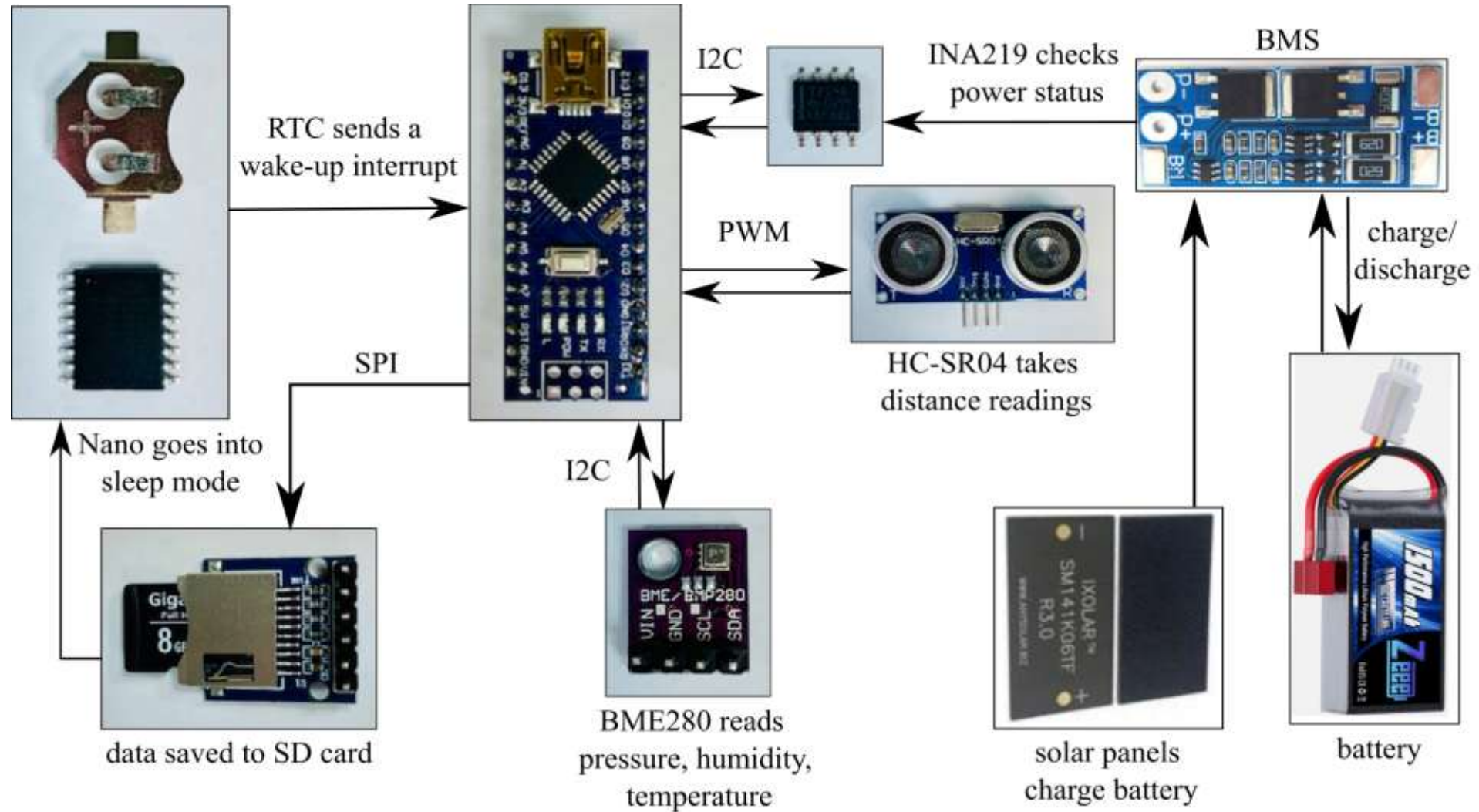


Full body view



Cross section view

# System Diagram



# Spec of the sensor

Current consumption during sampling	29 mA
Current consumption during idle	9 mA
Battery capacity	1500 mAh
Operational voltage range	8.4 – 6.6 V
Sampling rate	Dynamic (30, 60, 120 mins)
Operation duration without solar	7 – 8 days
Operation duration with solar	Variable, Approx 12 – 20 days
Ranging distance	4cm to 4m

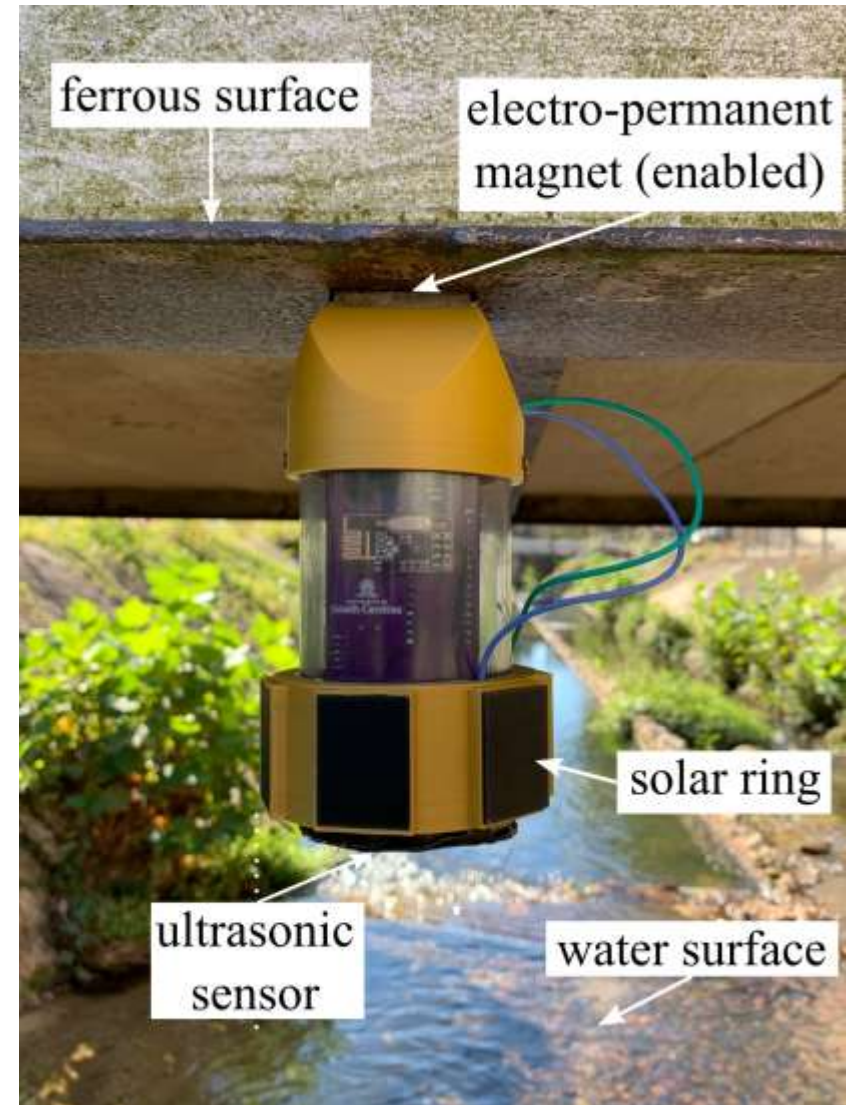
- The onboard solar panels are kept small considering compact size
- So power usage needs to be limited
- Higher sampling rate results in more power consumption

# The UAV deployable version

- An electro-permanent magnet (EPM) combines a permanent magnet with an electrically switchable magnetic field.



OpenGrab  
EPM V3



# Field deployment



**HANAHAN**  
South Carolina



maps.google.com

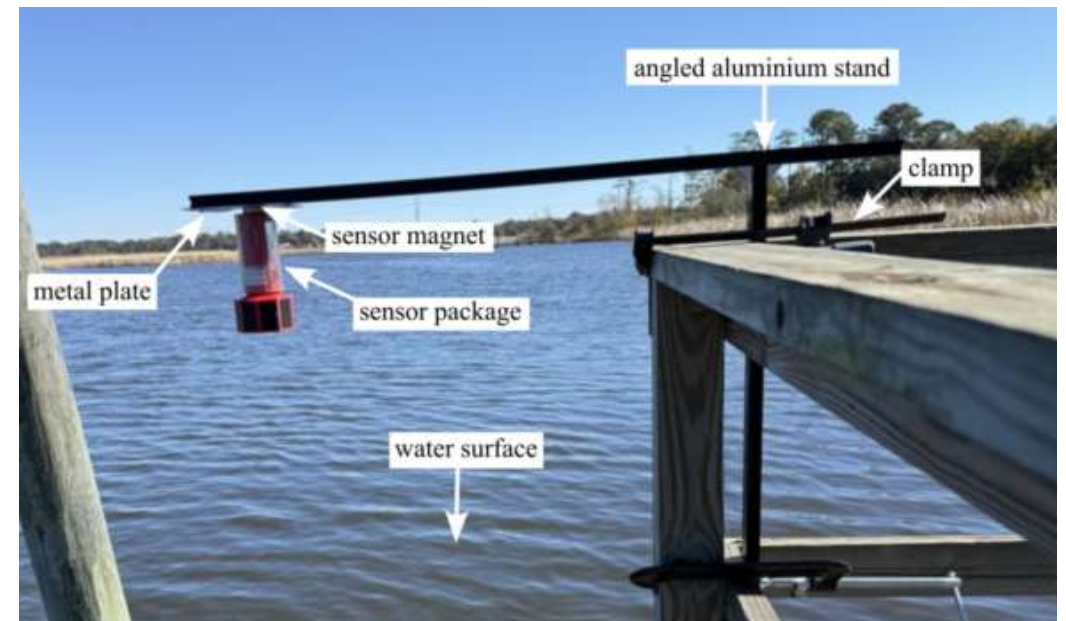


<https://www.live5news.com/story/32358268/flood-advisory-issued-for-charleston-berkeley-and-dorchester-counties/>

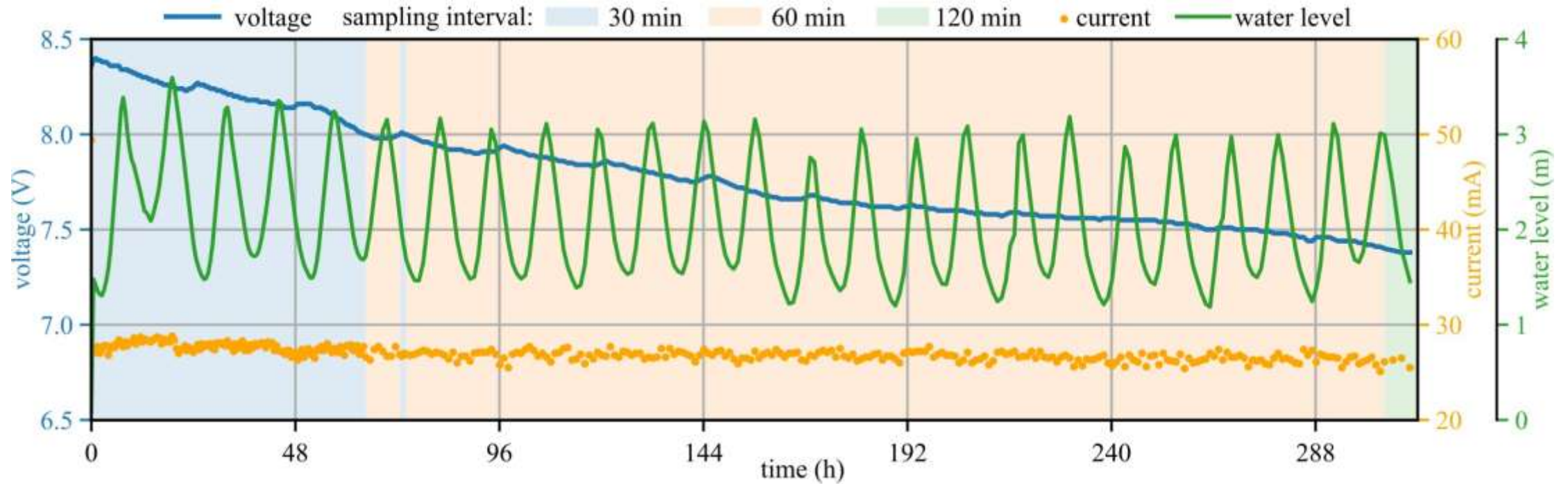
- Prone to tidal flooding as it's close to Goose creek
- 4,581 buildings, with 27.8% located in the Special Flood Hazard Area

<https://www.cityofhanahan.com/>

Deployed sensor at a dock at the intersection of Turkey Creek and Goose Creek in Hanahan, SC.



# Data from field deployment

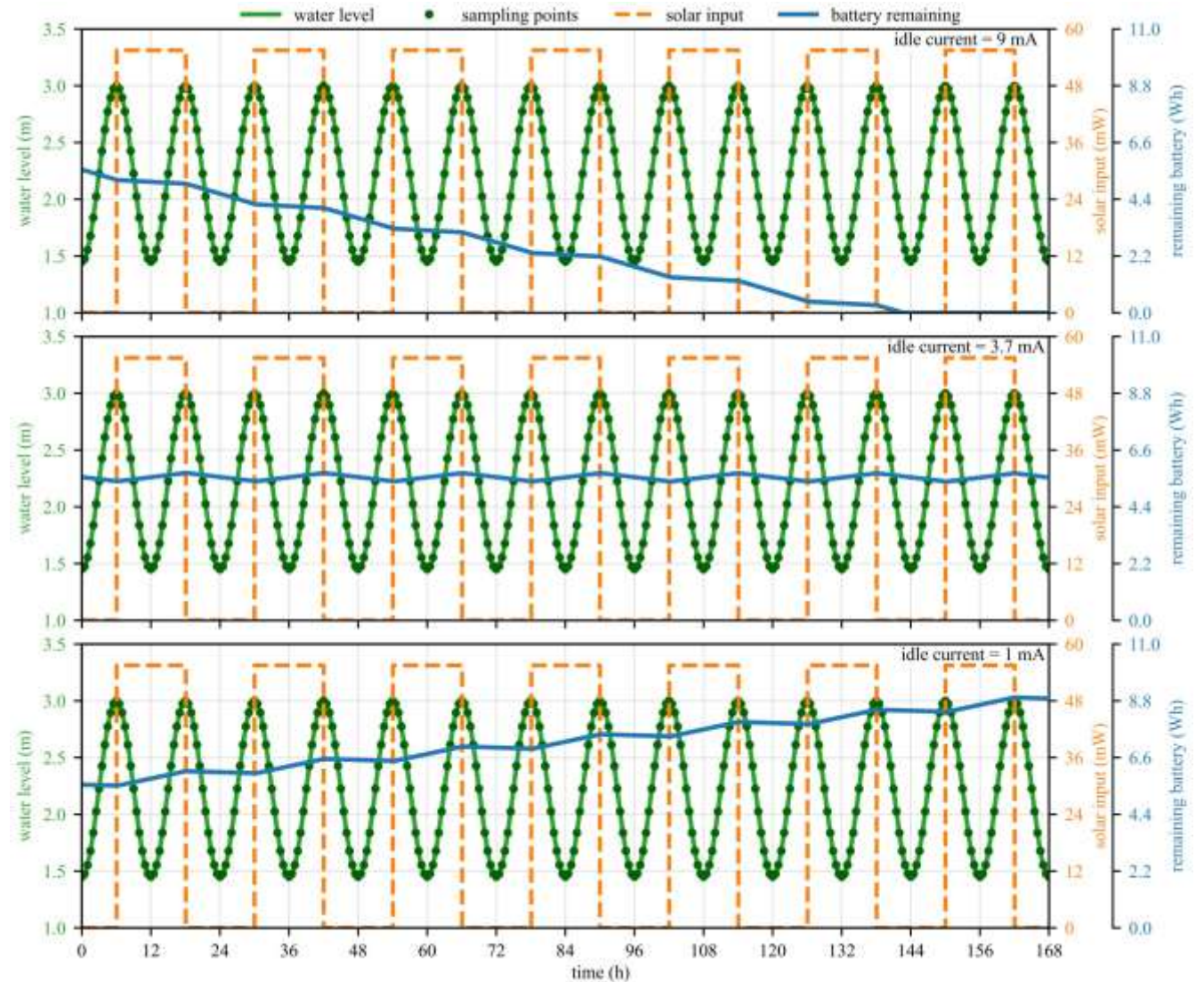


- Water level rising periodically consistent with tidal period of 12 h
- Battery voltage increasing slightly during day-time
- But shows an overall downward trend due to high idle current consumption

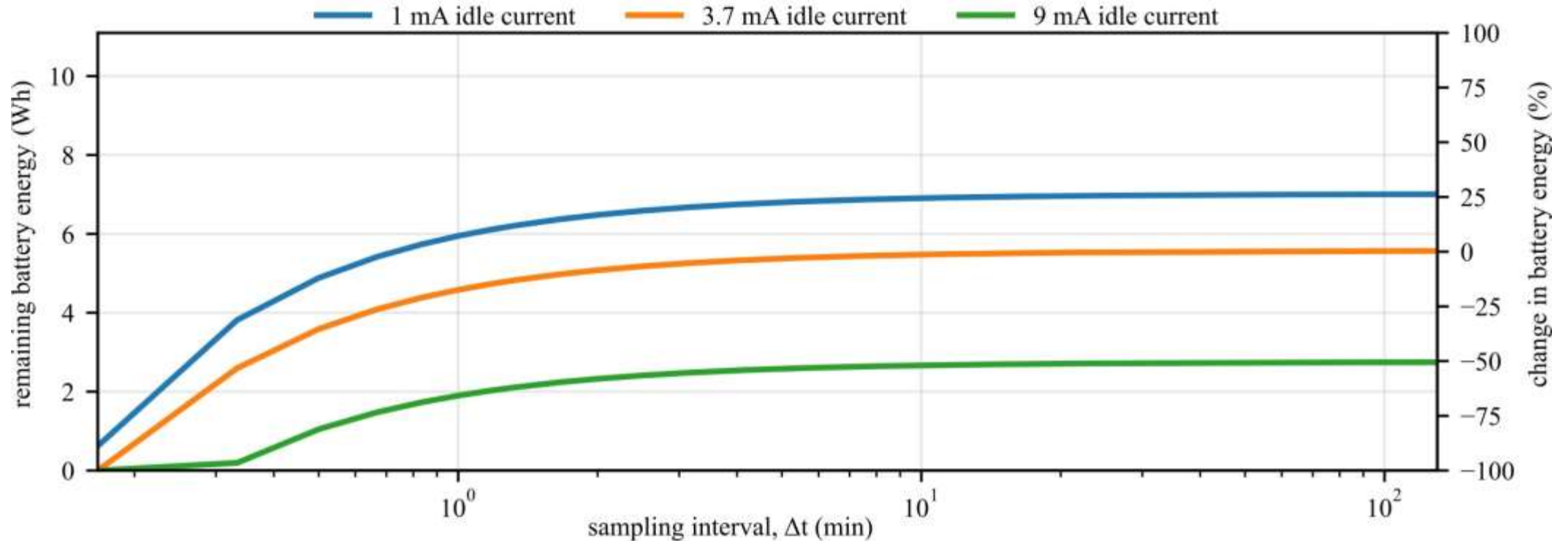
# Energy budget analysis: idle current

Simulation starting at Half battery capacity  
total 168 hrs of operation

- 9 mA consumption fully drains battery
- Reduction to 3.7 mA creates steady state
- Reduction to 1 mA results in energy gain



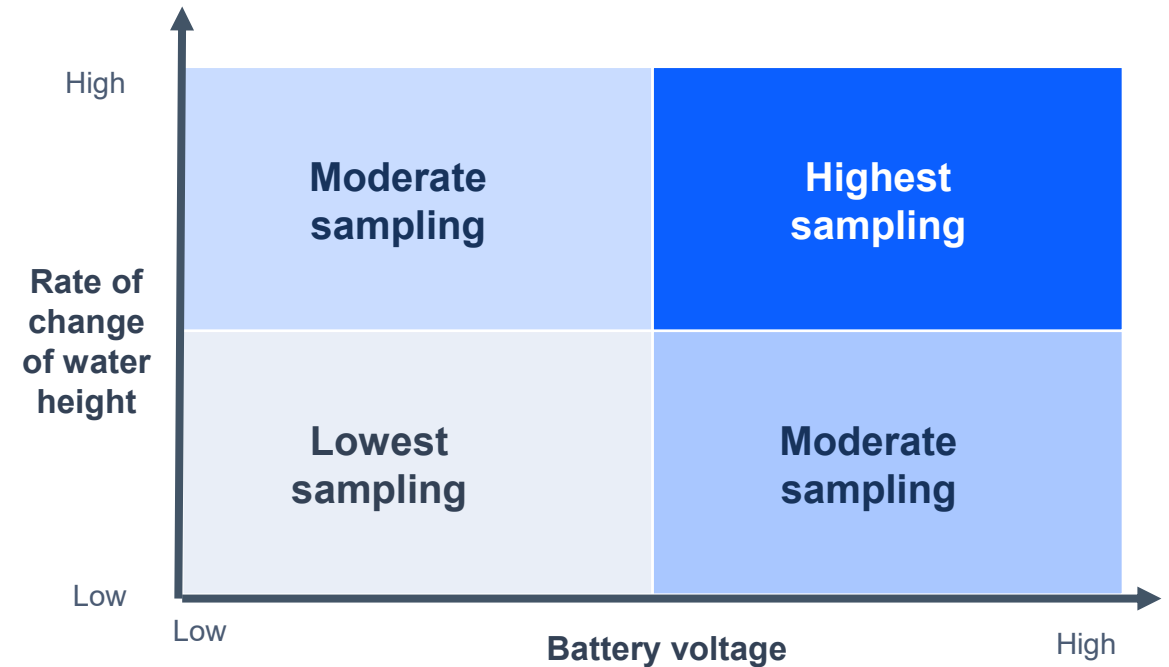
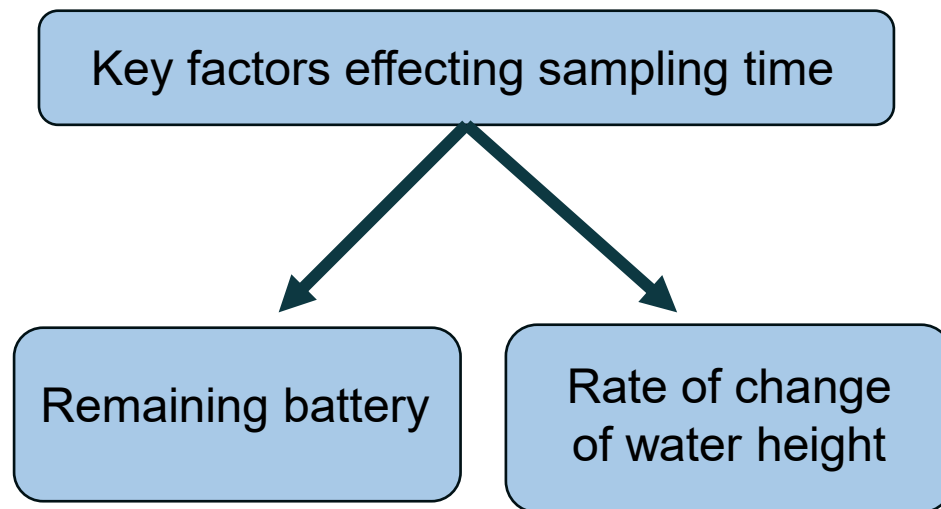
# Energy budget analysis: sampling interval



At 1 mA idle current, the system can operate at approximately 1 min sampling intervals while still maintaining battery energy slightly above the zero-change condition

# Conclusion & future work

- Goal is to create a controller that dynamically sets the sampling interval for optimal power usage



**Fast change + strong battery -> short interval**  
**Stable water level + weak battery -> long interval**

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# Thank You



[https://github.com/ARTS-Laboratory/  
UAV-Deployable-Stage-Height-Sensor](https://github.com/ARTS-Laboratory/UAV-Deployable-Stage-Height-Sensor)



## Questions?

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