STARTRAM - Sensor Technology for Alaska Rural communities Targeting Remote Atmospheric Monitoring

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Background

The objective of STARTRAM is to explore and evaluate environmental sensor platforms that are suitable for reliable cold-climate deployments and educational contexts. This project seeks to empower Alaska's students, educators, and researchers to implement reliable atmospheric sensor systems, contributing to ongoing and future environmental monitoring initiatives.

The deployment of remote atmospheric sensors presents many challenges to ensure continuous operation in Alaska. For example, PurpleAir PM2.5 sensors currently in use by ACEP (Alaska Center for Energy and Power) researchers can experience failure at cold temperatures due to their reliance on active air circulation with fans which sometimes fail at temperatures below -20°F, resulting in the loss of crucial data. Few commercially available sensors are rated to operate at the extreme negative temperatures Alaskan climates can experience, resulting in uncertainty about whether they are suitable for year-round deployment.

Figure 1: High school students deploy a weather station at Murphy Dome in Chena Hot Springs during the T3 2024 summer program.

Integrating environmental sensors for learning and long-term observations presents opportunities for students to apply technological and observational techniques to contribute to community objectives and scientific datasets including the GLOBE (Global Learning and Observations to Benefit the Environment) program. Currently, PMS5003 sensors and Acurite weather towers are low-cost platforms for students to explore air quality concepts and prototype monitoring systems. However, these solutions are not suited for extreme cold climate, year-round outdoor deployments, which is a crucial technology role to fill to develop community observation networks as a platform for cyber-physical learning.

In order to fill this role, it is necessary to identify technologies that satisfy cold-climate reliability, cost, and ease of integration objectives. STARTRAM will address these information gaps by providing testing, analysis, and documentation for potential solutions.

Deliverables

This project aims to deliver the following products/actions:

- Identify sensor configurations and their potential roles as student projects.
- Publish a qualitative report to outline the factors to assist T3 educators and UAF researchers in the selection of atmospheric sensor platforms for use in educational, research and cold climate contexts.
- Generate and analyze weather dataset(s) to support reported findings.
- Provide a working demonstration of a sensor deployment suited towards cold-climate and educational contexts.
- Provide documentation to ease the use of the selected sensor platforms within T3 curriculum and researchers wanting to deploy these sensors.
- Engage T3 students to evaluate and assist in testing and refining the documentation.

Methods

This project explores multiple sensor technologies, including multi-sensor weather stations as well as standalone sensors. Quantitative evaluation includes cost, product specifications, and data generated by real-world sensor deployments.

Between December 14, 2024 and January 7, 2025, the sensors were deployed outdoors in a residential environment and generated several environmental datasets.

Sensor	Type	Data Interface	Cost
Linovision 8-in-1 Monitor	Weather Station + PM2.5	Wired Serial Modbus	$$$
AmbientWeather WS-5000	Weather Station	915MHz radio	$$$
AmbientWeather WS-1553-IP	Weather Station	915MHz radio	$$
AmbientWeather PM25	PM2.5	915MHz radio	$

Table 1: Sensor models and attributes.

Measured parameters include air temperature, relative humidity, barometric pressure, wind speed and direction, and PM2.5 and PM10 concentration. This test provided an opportunity to identify technical issues that could lead to data loss or gaps, as well as analyzing the cold-weather measurements to find any unusual behaviors or inconsistencies between sensors.

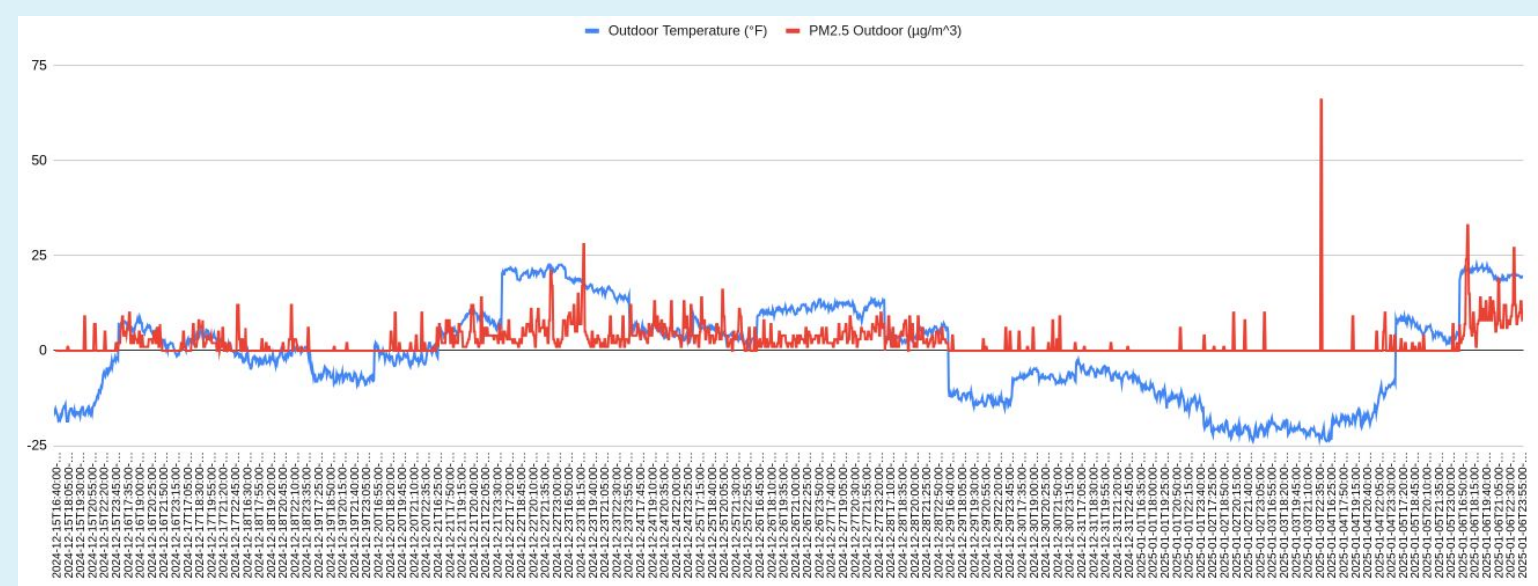

Figure 2: Comparison of PM2.5 and temperature measurements collected from AmbientWeather sensors.

In addition to quantitative methods, qualitative analysis and direct student engagement play a large role in evaluating sensor platforms. These evaluations include:

- Hardware setup process
- Integration process for data collection
- GLOBE program compliance
- Compatibility with T3 technology ecosystem
- Student feedback

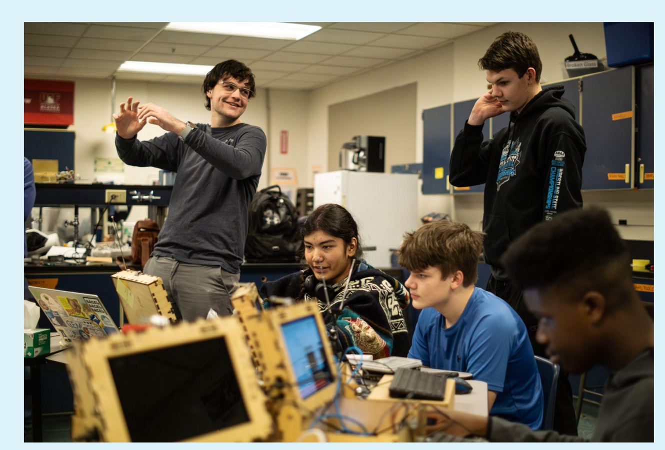

Figure 3: Adrian Burke guide students through raspberry pi data collection from sensors during NPHS workshop.

In coordination with the PULSE (Powering and Unifying Long-range Sensor Ecosystems) grant, a workshop hosted at North Pole High School's (NPHS) T3 Makerspace classroom introduced students to the process of intaking data from these sensors and routing sensor data feeds through the Node-RED visual scripting software. This activity was greatly beneficial in identifying technical hurdles for students and gauging the time and difficulty level of future student projects.

Technologies

In addition to the sensors themselves, this project explores the hardware and software interfaces needed to collect sensor data. Multiple interfaces were used to integrate this data into the single-board Raspberry Pi computers and ecosystem currently used by T3 for education.

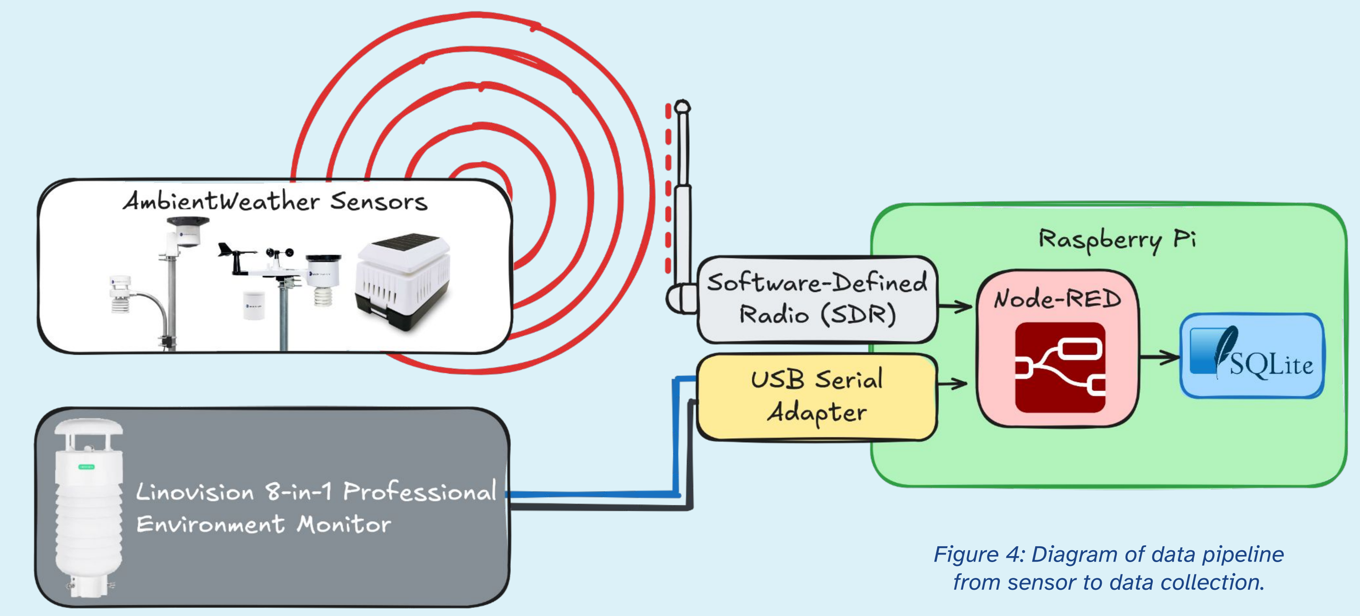

Figure 4: Diagram of data pipeline from sensor to data collection.

Next Steps

This spring, the Linovision weather station will be deployed at ACEP's solar test site with remote power and data transmission support provided by the PULSE project. This deployment will be located near a high-quality meteorological station maintained by the ACEP solar team, which creates an opportunity for evaluating the accuracy of the Linovision sensor platform by direct comparison of the two datasets. This will address some of the issues of the winter deployment such as human interference and lack of reliable high quality source data for comparison to the project's selected sensors.

The next phase of the project will focus on analyzing data and documenting the systems and findings to support the development of project deliverables. Looking beyond these deliverables, we will continue to work with T3 educators to support the development of formal curriculum and integrate of these technologies into student projects.

Acknowledgements

The broad applicability and direct relevance to multiple research and education efforts has allowed this work to be supported by the **URSA program**, along with programs at ACEP and UAF CEM:

- **UAF Upward Bound Program**, funded by the Dept. of Education;
- **ARCTIC Program**, funded by the Department of the Navy, Office of Naval Research under ONR award number N00014-22-1-2049
- **Project STORM**, funded by National Science Foundation EPSCoR (RII Track-2 FEC) award number (FAIN) 2316402

Thanks to the Undergraduate Research and Scholarly Activity (URSA) program, the University of Alaska Fairbanks Teaching Through Technology (T3) and Upward Bound Programs, the Alaska Regional Collaboration for Technology Innovation and Commercialization (ARCTIC) Program, Project STORM (Data-Driven Approaches for Secure Electric Grids in Communities Disproportionately Impacted by Climate Change), and the Alaska Center for Energy and Power (ACEP).