Evaporometer Upgrades: improved Weatherproofing and Accuracy in Real-Time Environmental Data Gathering

Thomas DeBell[1]

[1]Co-Author / Developer

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Abstract

The original Evaporometer prototype was designed by the Openly Published Environmental Sensing (OPEnS) Lab at Oregon State University to remotely collect near real-time environmental data, including temperature, humidity, luminosity, and amount of precipitation, and transmit it to a receiver hub, where it can be viewed online by researchers worldwide. This eliminates costly and time-consuming site visits. Deployed during the summer of 2017 in OSU's HJ Andrew's Experimental Forest, the prototype failed after three months due to excess moisture entering the enclosure and damaging the hardware. Over its first two months, the prototype performed well, gathered over 90,000 data points, updating every five minutes. To extend the lifespan of the Evaporometer, the enclosure was redesigned to improve weatherproofing, include additional sensors, and improve the accuracy of data readings. These improvements will extend the Evaporometer's field life, allowing it to reliably gather and transmit data for longer periods of time while the ability to gather albedo measurement expands the device's sensing capabilities. The upgraded Evaporometer provides researchers with a reliable, low-cost, and open-sourced method of collecting environmental data in locations that may not have previously been feasible.

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Evaporometer Upgrades:

Improved Weatherproofing and Accuracy in Real-Time Environmental Data Gathering

Miranda Nelson, 1; Thomas DeBell 2 ; Dr. Chet Udell, 3 PhD ; Dr. John Selker, 3 PhD

1,2&3 [College of Engineering/College of Ag. Science, Department of Ecological & Biological Engineering]

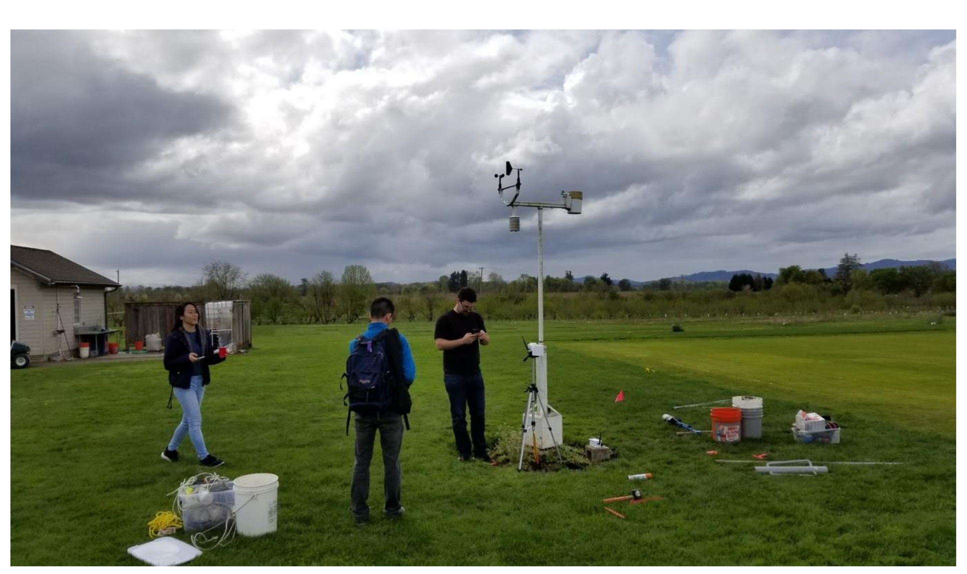
ABSTRACT: NEW CHANGES

The original Evaporometer prototype was designed by the Openly Published Environmental Sensing (OPEnS) Lab at Oregon State University to remotely collect near real-time environmental data, including temperature, humidity, luminosity, and amount of precipitation, and transmit it to a receiver hub, where it can be viewed online by researchers worldwide. This eliminates costly and time-consuming site visits. Deployed during the summer of 2017 in OSU's HJ Andrew's Experimental Forest, the prototype failed after three months due to excess moisture entering the enclosure and damaging the hardware. Over its first two months, the prototype performed well, gathered over 90,000 data points, updating every five minutes. To extend the lifespan of the Evaporometer, the enclosure was redesigned to improve weatherproofing, include additional sensors, and improve the accuracy of data readings. These improvements will extend the Evaporometer's field life, allowing it to reliably gather and transmit data for longer periods of time while the ability to gather albedo measurement expands the device's sensing capabilities. The upgraded Evaporometer provides researchers with a reliable, low-cost, and open-sourced method of collecting environmental data in locations that may not have previously been feasible.

PURPOSE: INCREASE LIFESPAN AND ACCURACY OF READINGS

The original Evaporometer successfully transmitted data to a receiver hub, which then uploaded the data to a google spreadsheet from late summer to early fall, before likely succumbing to water damage. Ideally, a redesigned enclosure would be able to protect the sensors and hardware through rainy Oregon winters. The new enclosure features a stacked design that shades the metal strain gauge, protecting it from direct sunlight and increases in heat that alter the resistance of the gauge and cause inaccurate fluctuations in the recorded mass of precipitation. Waterproof conformal coating was added to all electrical connections and a cork gasket lining was added to the seals to protect the hardware from moisture. The updated enclosure includes an attachment for a second light sensor that is directed at the ground to measure albedo, the amount of incident light that is reflected from a surface. The load cell amplifier used in the original prototype was replaced with a more accurate version.

The updated enclosure created by Manuel Lopez.



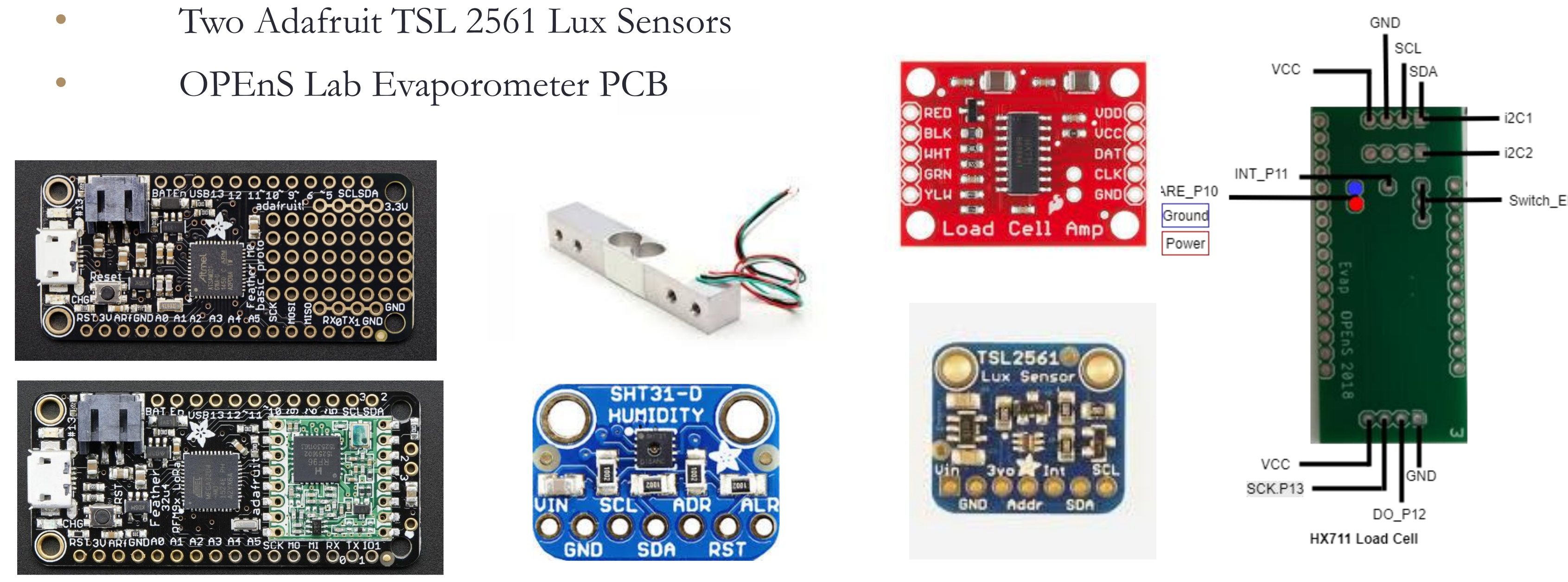
Left Marissa Kwon, middle Michael Woo, and right Tom DeBell set up an Evaporometer on a tripod at LB Farms, near Corvallis, OR.

CHECK OUT OUR CODE ON GITHUB: https://tinyurl.com/OPEnSLab

FOLLOW OTHER OPEnS LAB PROJECTS: http://www.open-sensing.org

COMPONENT BREAKDOWN

- Adafruit Feather MO with LoRa Radio (RFM95)
- 5 kg. Strain Gauge
- Adafruit Sensiron SHT31-D Temperature and Humidity Sensor
- 900Mhz Antenna Kit (not shown)
- Sparkfun HX711 Load Cell Amplifier
- Two Adafruit TSL 2561 Lux Sensors
- OPEnS Lab Evaporometer PCB



Above, Adafruit MO
Below, RFM95 LoRa Radio

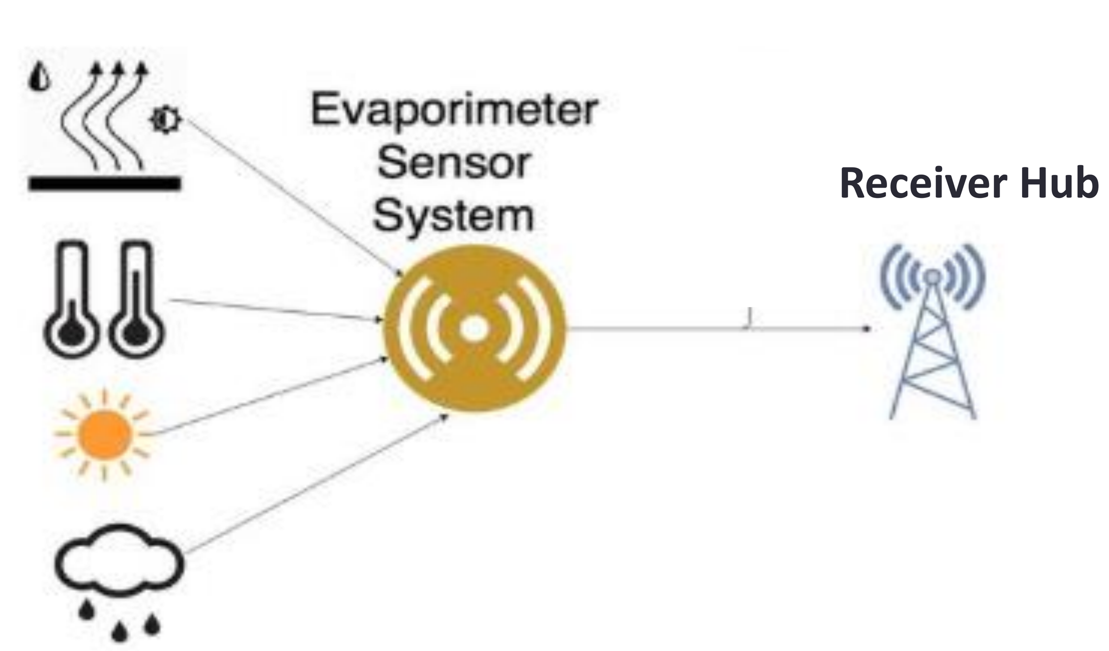
Above, strain gauge
Below, temp/humidity sensor

Above, load cell amplifier
Below, lux sensor

Above, OPEnS Lab custom Evaporometer PCB

METHODS: NEW HARDWARE

Measuring albedo required two Adafruit TSL2561 digital luminosity/lux/light sensor breakouts. The previous design used a single Adafruit TSL2591 high dynamic range digital light sensor to detect levels of sunlight. In the new design, one sensor was pointed upwards to detect sunlight, while the second was pointed downward to capture albedo. This process also required developing a new enclosure with an albedo attachment to hold the two light sensors that would also protect them from the elements without shading them. This setup required wiring two sensors with two different inputs to a single board, it requires two addresses. Because the TSL2591 only has a single address, the team decided to switch to the slightly less light-sensitive TSL2561.



- Collect temperature and humidity data
- Collect light and albedo data
- Collect precipitation mass data.
- Transmit data to receiver hub.
- Data is uploaded to Google spread sheets.

Figure 1. A schematic of the data flow

Inaccurate fluctuations in the recorded mass were also a problem in the original Evaporometer. To combat this, the new enclosure was designed to shade the load cell. In addition, the accuracy and reliability of different load cell amplifiers In trials performed by another team member, the Sparkfun HX711 proved to be the most reliable and was chosen to replace the old HX711 amplifier.

RESULTS: LB FARMS DEPLOYMENT

- Successful deployment of two Evaporometers with OSU Capstone team during Spring 2018 at LB Farms in Corvallis, OR.
- No albedo attachment, luminosity sensors, or LoRa attachment

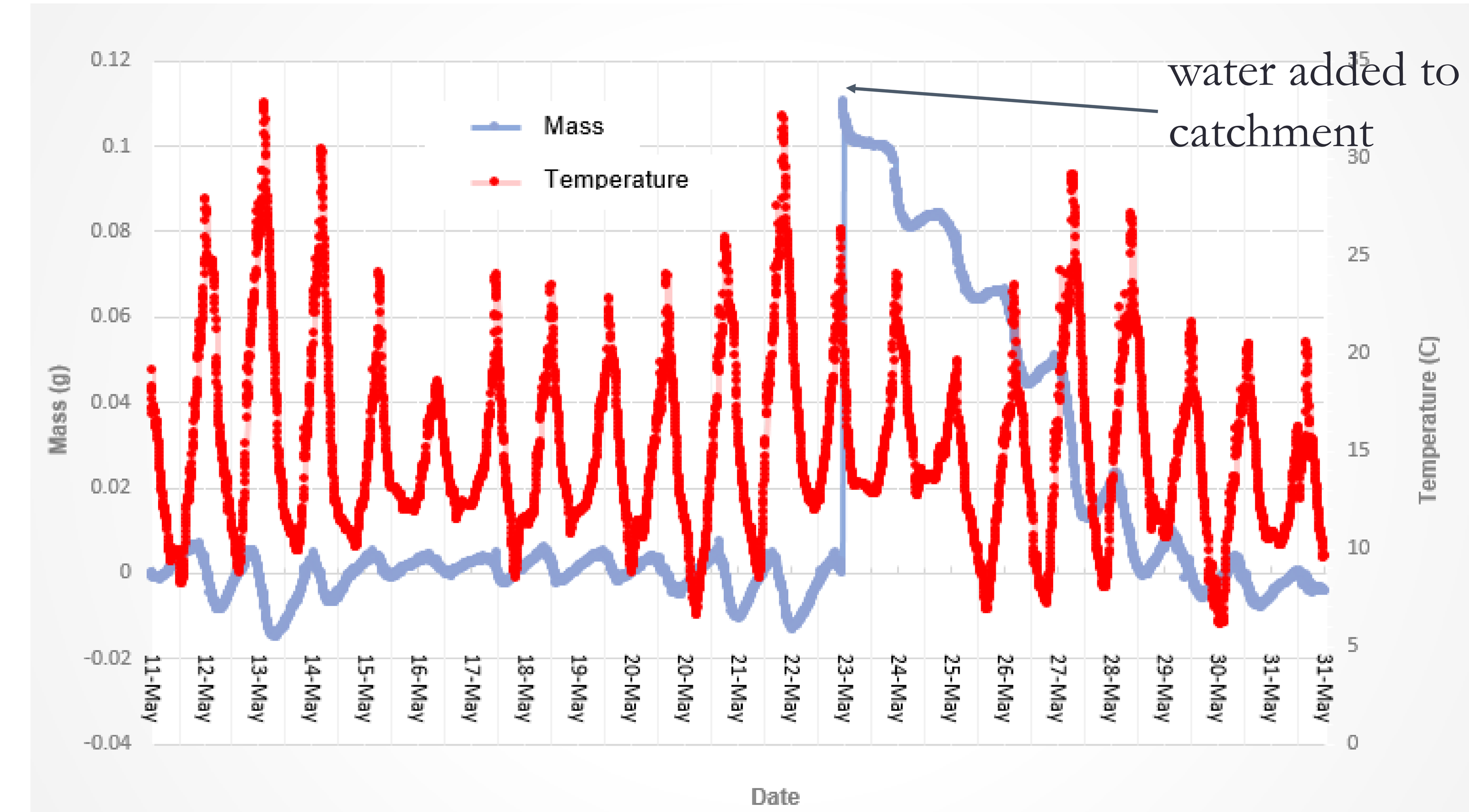


Figure 2. Precipitation (blue) and temperature (red) data gathered by the Evaporometerat LB farms from May 11 to May 31.

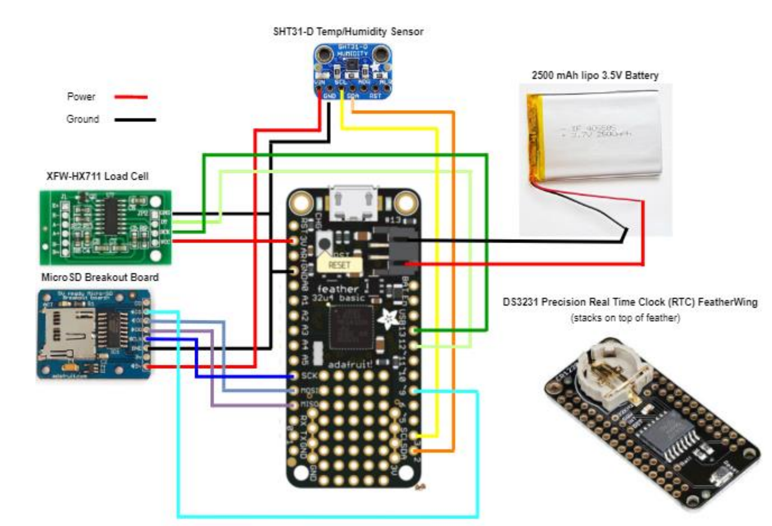


Figure 3. Wiring Diagram for Evaporometer without ETa attachment

Two Evaporomter prototype without the ET (evapotranspiration) attachment were deployed at LB Farms, outside of Corvallis, Oregon in April of 2018. Above is temperature and precipitation data collected from May 11 to May 31. To the left is the wiring diagram for the Evaporometers, without lux sensors.

Additionally, the new load cell amplifier was still experiencing fluctuations due to temperature.

CONCLUSIONS: FUTURE DIRECTIONS

These improvements will extend the Evaporometer's field life, allowing it to reliably gather and transmit data for longer periods of time while the ability to gather albedo measurement expands the device's sensing capabilities. The upgraded Evaporometer provides researchers with a reliable, low-cost, and open-sourced method of collecting environmental data in locations that may not have previously been feasible. The next step in the research process will be deploying and testing a network of transmitters to determine if the new design will with stand the elements. Moving forward, the main goal of the Evaporometer team will be investigating using a load cell amplifier with a built-in temperature sensor with compensation to address the problems experienced with the load cell readings. Eventually, the Evaporometer could be incorporated into the Internet of Things (IoT), an interconnected network of devices that exchange and share information.

ACKNOWLEDGMENTS

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