



# Geographic Environmental Module (GEM)

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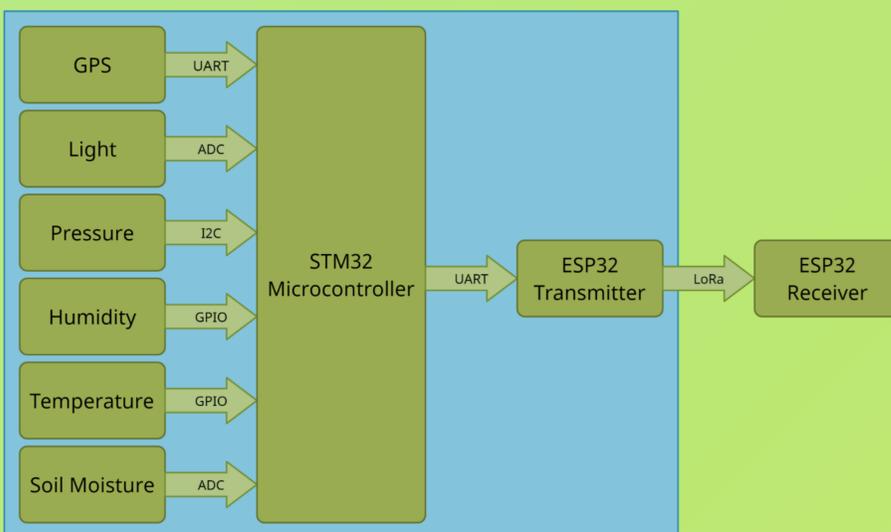
## Background

Geographic Environmental Module (GEM) is a programmable system which monitors local weather conditions via multiple sensors. Multiple modules are deployed in rural or remote areas, such as farmland or forests, where they monitor humidity, temperature, pressure, light and solid moisture levels. This data is read by MATLAB where it is analyzed to understand patterns and predict future weather conditions. By detecting data outliers, GEM can help predict and prevent wildfires and natural disasters.

## Overview

The system consists of multiple deployed nodes and a central receiver. Each module is comprised of a low-power microcontroller, seven peripherals, and an external battery source. The local temperature, humidity, barometrics, light, soil moisture, and GPS conditions are monitored and sent to the central receiver via LoRa communication protocols. The central receiver contains a LoRa gateway capable of sending the data to the cloud. At the host, the data is then analyzed to create trends and graphs of how the data changes over time.

## Block Diagram



## Wireless Infrastructure



### ESP32 LoRa Single Channel Gateway

- WRL-18074 Antenna
- ESP32 microprocessor
- RFM95W LoRaWAN module

GEM utilizes the LoRaWAN communication protocol via this LoRa transceiver to efficiently send or receive data over long distances. On each deployed GEM node, the microcontroller collects data from the sensors and sends it to the ESP32 via UART. The ESP32 then utilizes the RFM95 LoRa transmitter embedded on board to send data as LoRa packets via the 915 MHz spectrum to the centralized gateway.

## Key Components



### Microcontroller

- STM32L072RBT6, LQFP64 package
- Support for I2C, UART, GPIO, & ADC
- Ultra-low power



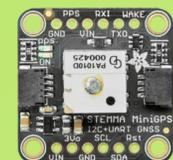
### Soil Moisture Sensor

- ADC Interface
- Returns a value which fits a specified region of soil moisture level



### Temperature and Humidity Sensor

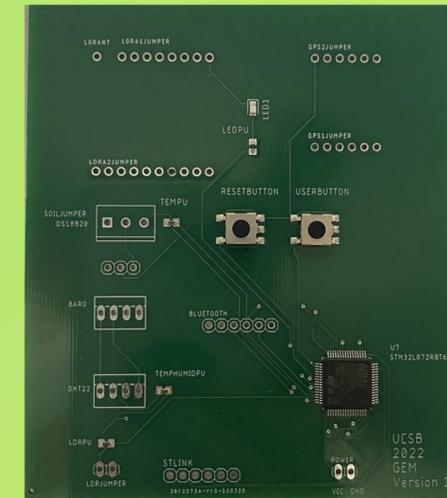
- GPIO Interface
- Reports internal temperature and humidity of area



### Global Positioning Sensor

- UART Interface
- Returns an NMEA sentence with global positioning data

## Printed Circuit Board



### Version 1

- External power supply
- More spacious



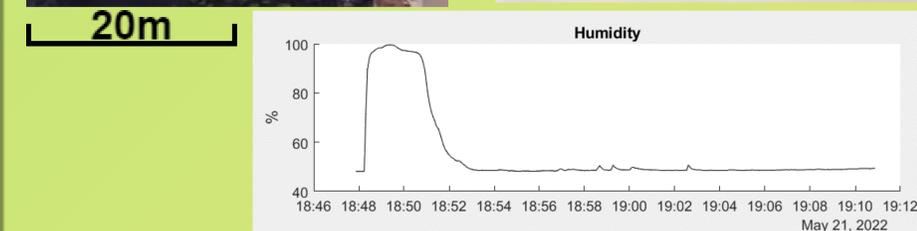
### Version 2

- Integrated power supply
- Compact, no external wires

## Final Product



- Node(s)
- Laptop/Gateway Readings



A field demonstration of the GEM system was successfully conducted. Three nodes were placed on the campus lawn with varied distances to the gateway. The maximum range for stable connection was found to be 40 meters. Readings were updated in real-time and stored in a CSV file.

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