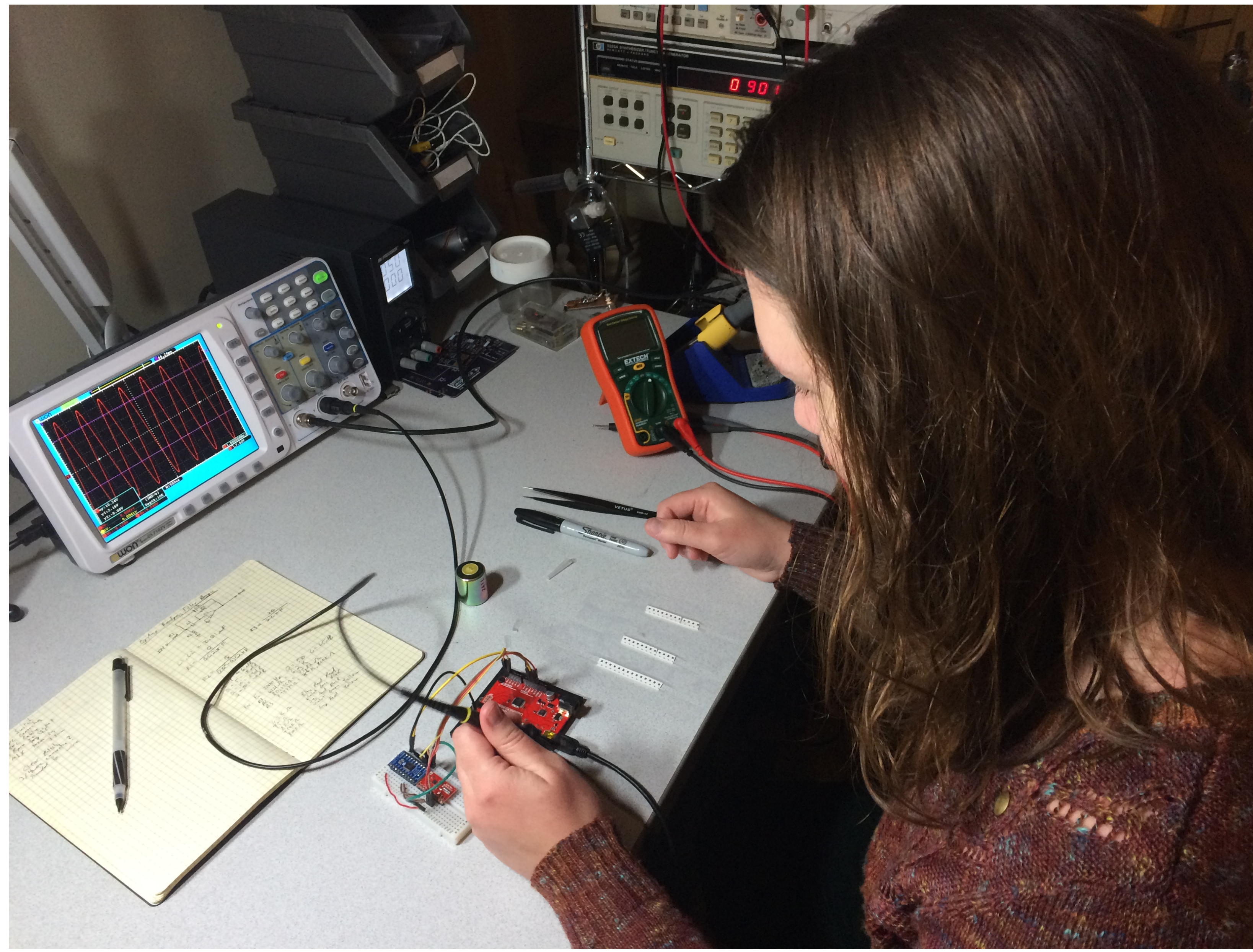
Using Low Cost Environmental Sensors in Geoscience Education

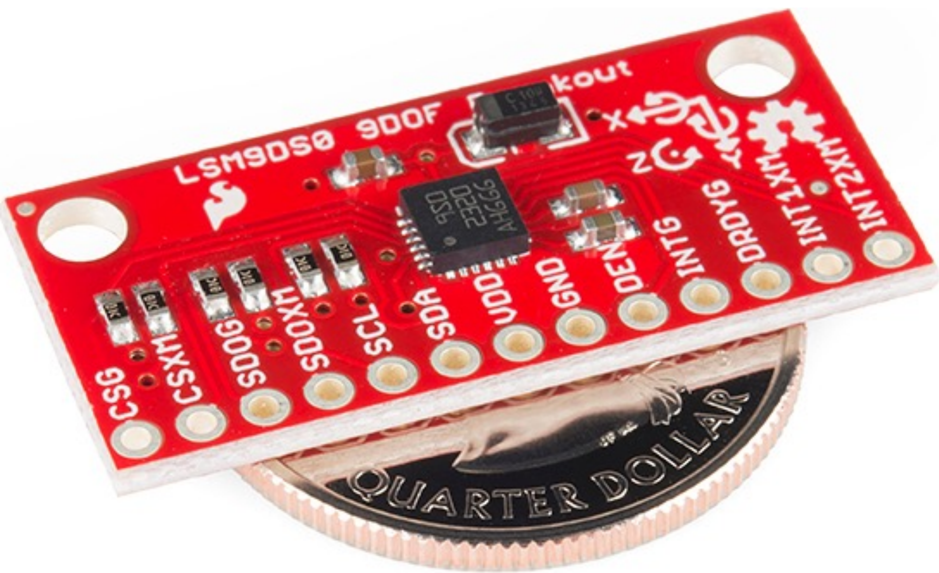
J.R. Leeman
C. Ammon
S. Anandakrishnan

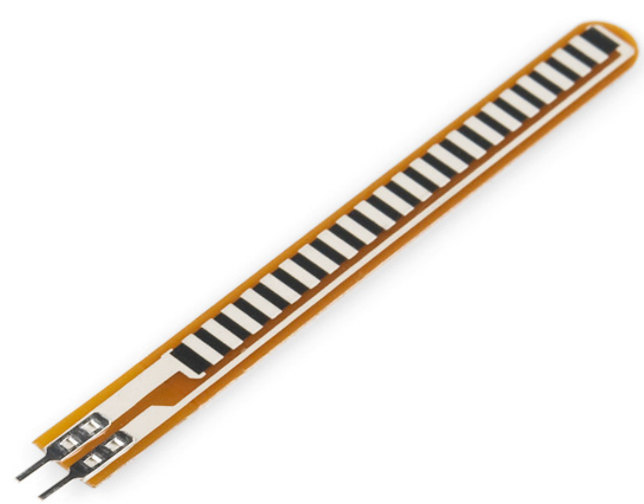
Department of Geosciences
The Pennsylvania State University

December 17, 2014



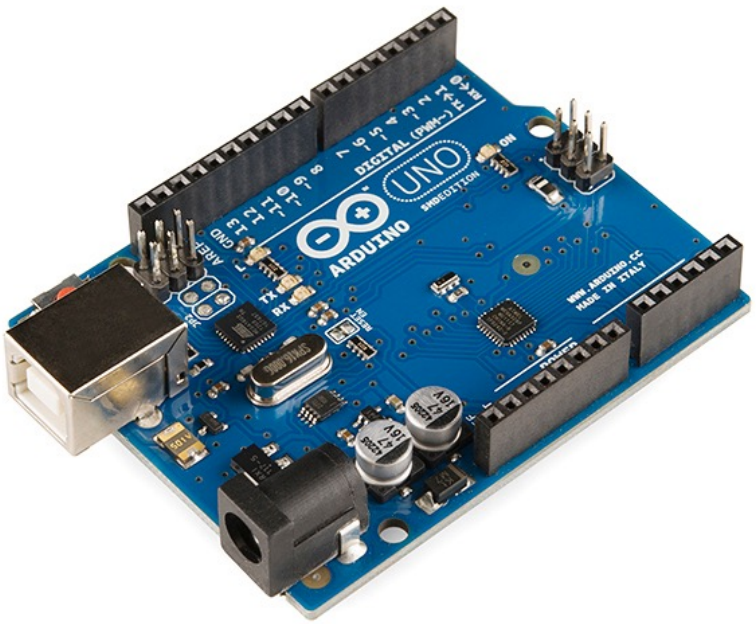
Sensors are becoming smaller, faster, lower power, and cheaper every year

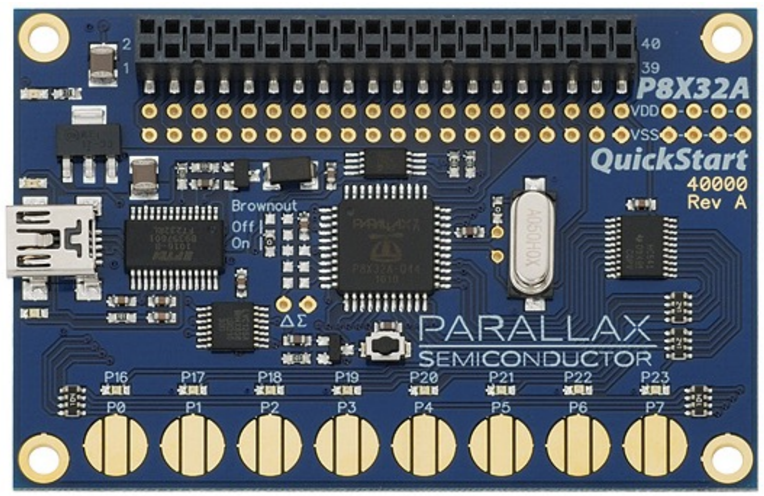


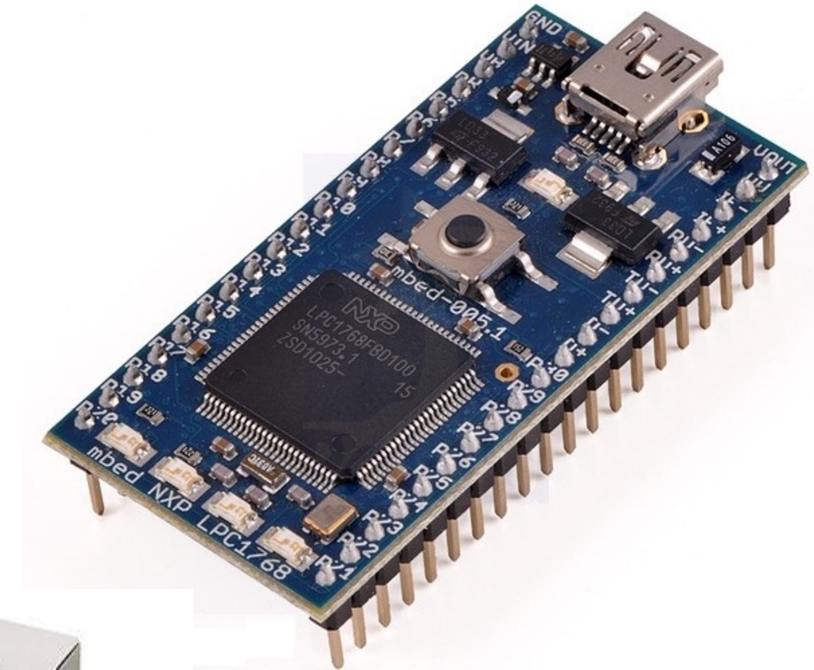


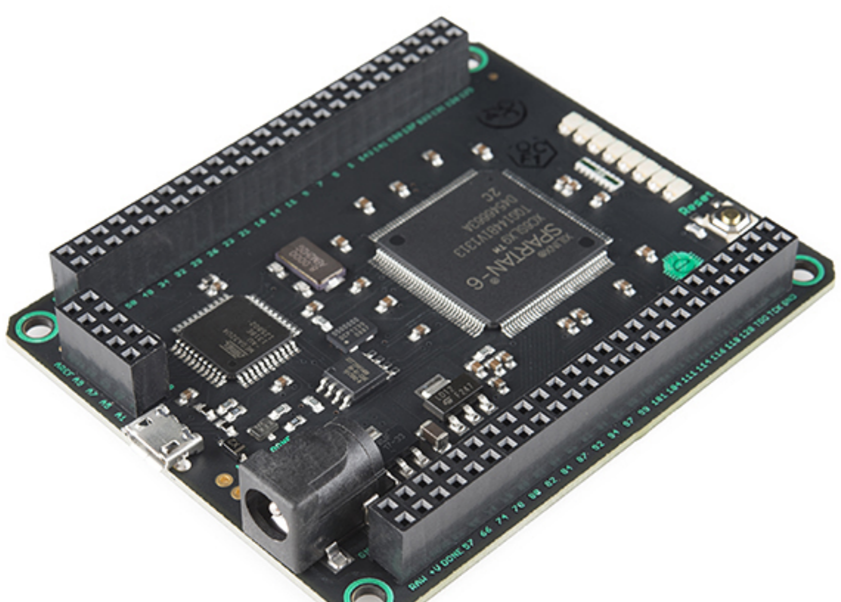
Acceleration
Orientation
Magnetic Field
Light Intensity/Color
Gas Concentration
Ground Motion
Force/Pressure
Temperature
Humidity
Wind Speed/Direction
Distance
Position
Tilt/Angle
Sound Level
Strain
Radiation

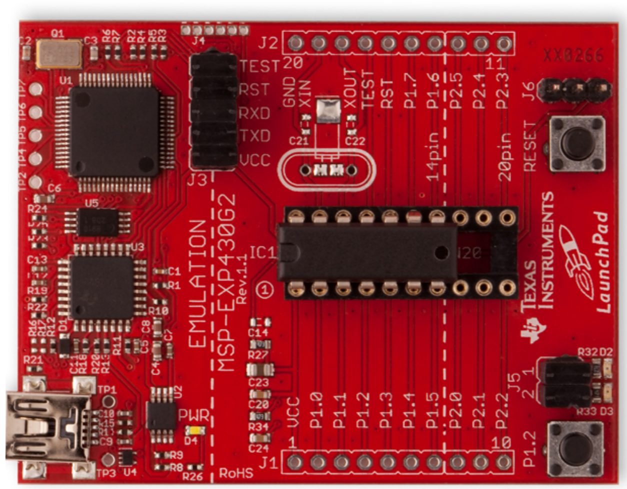
Many micro computing platforms are available ranging from Linux machines to micro-controllers

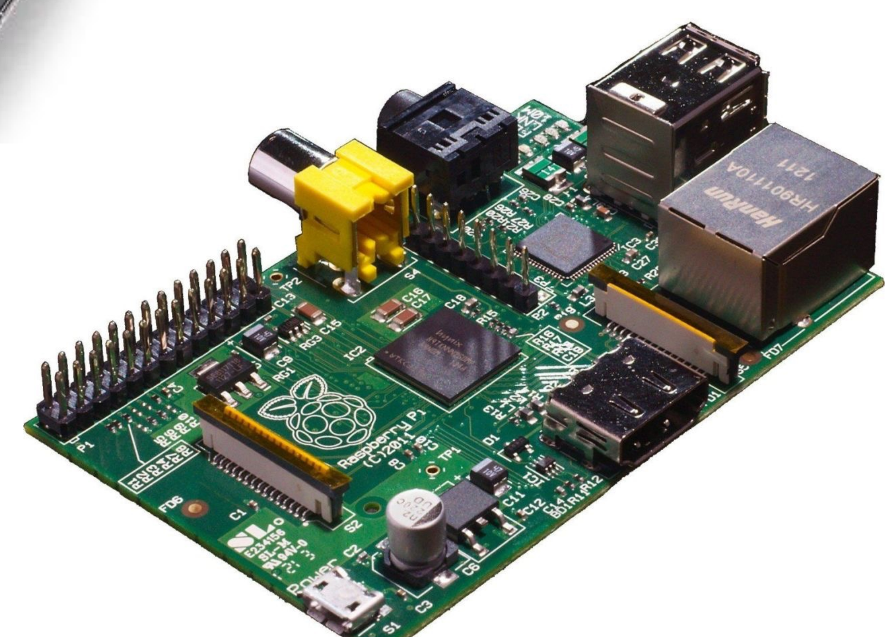




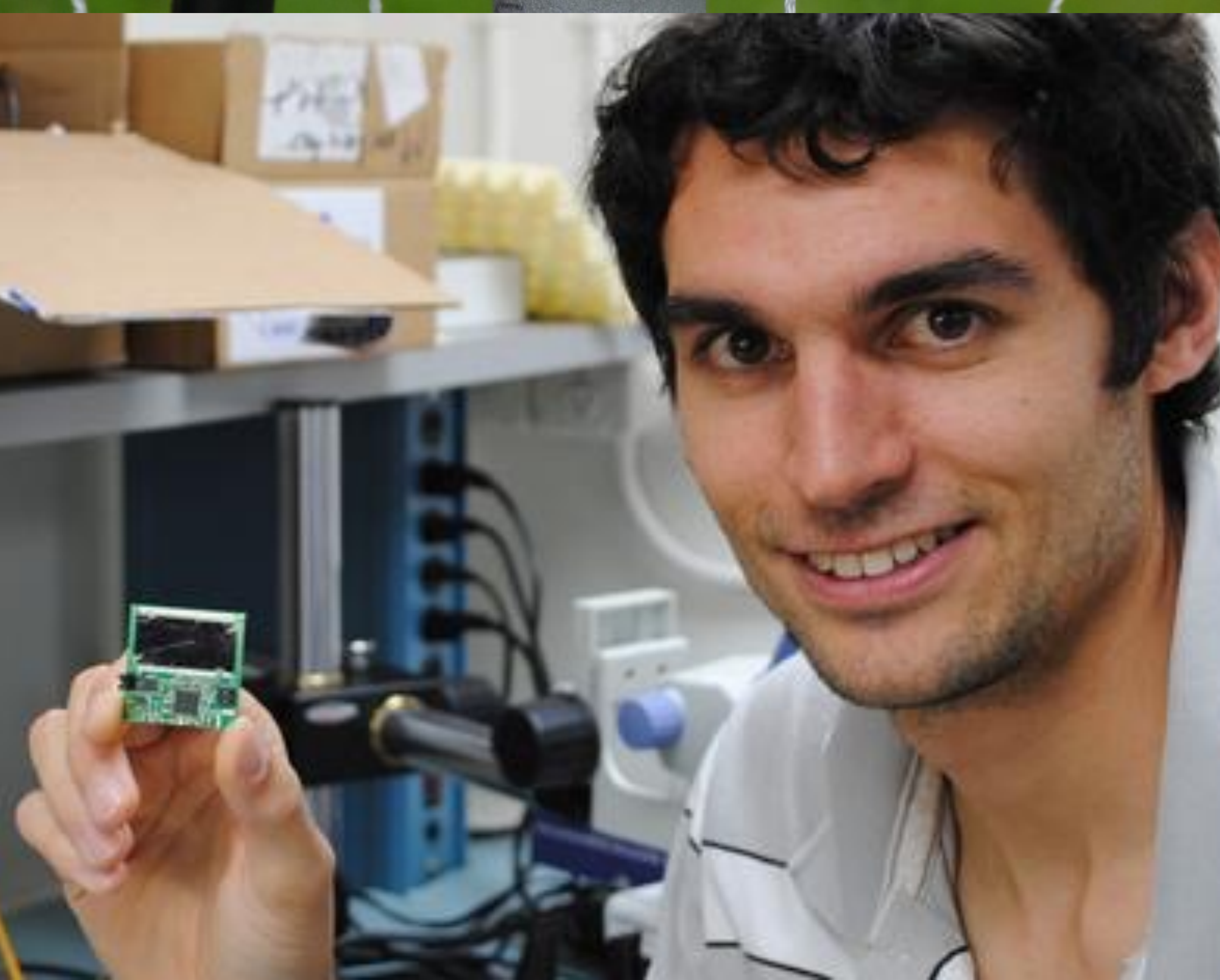
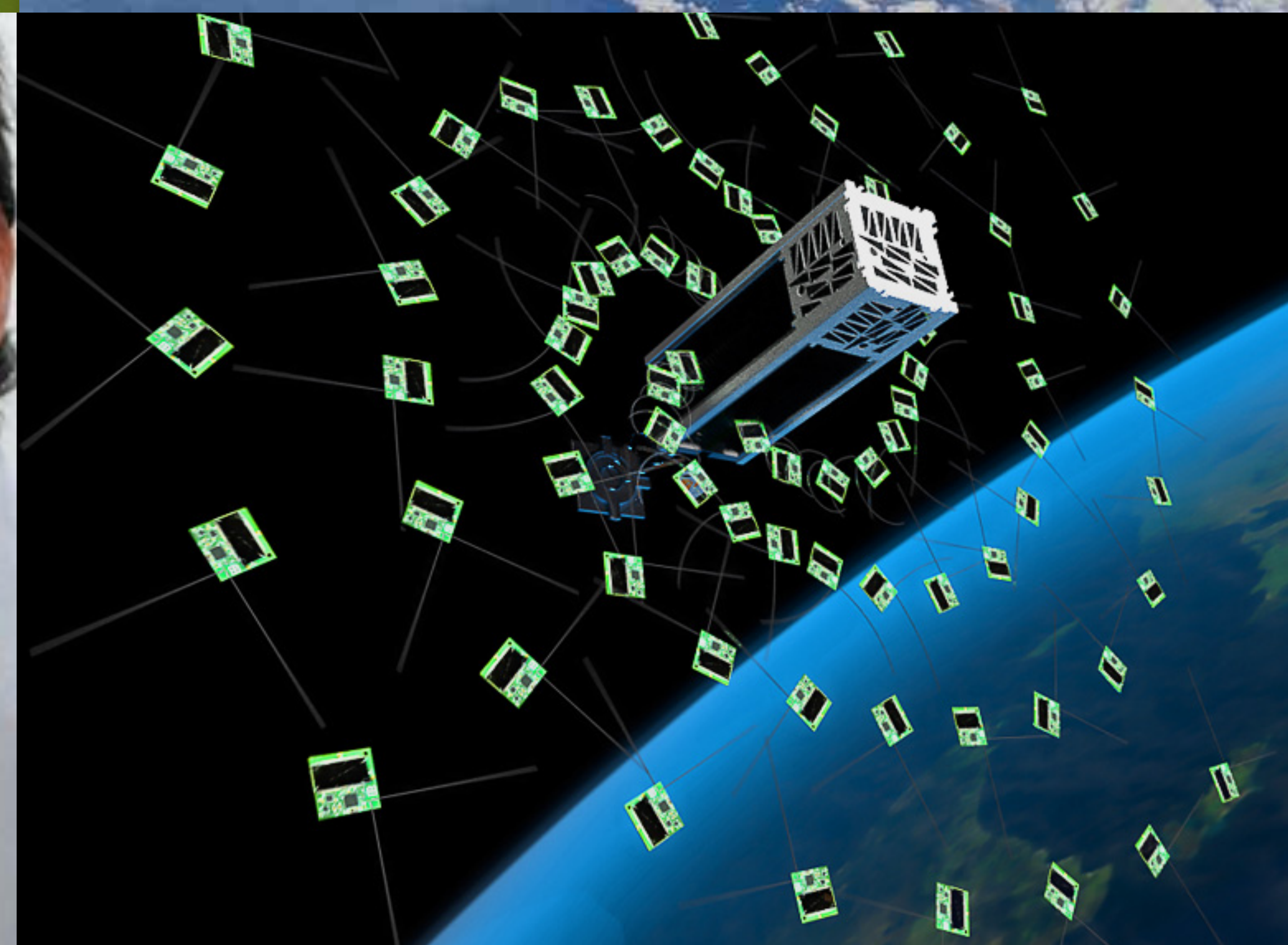




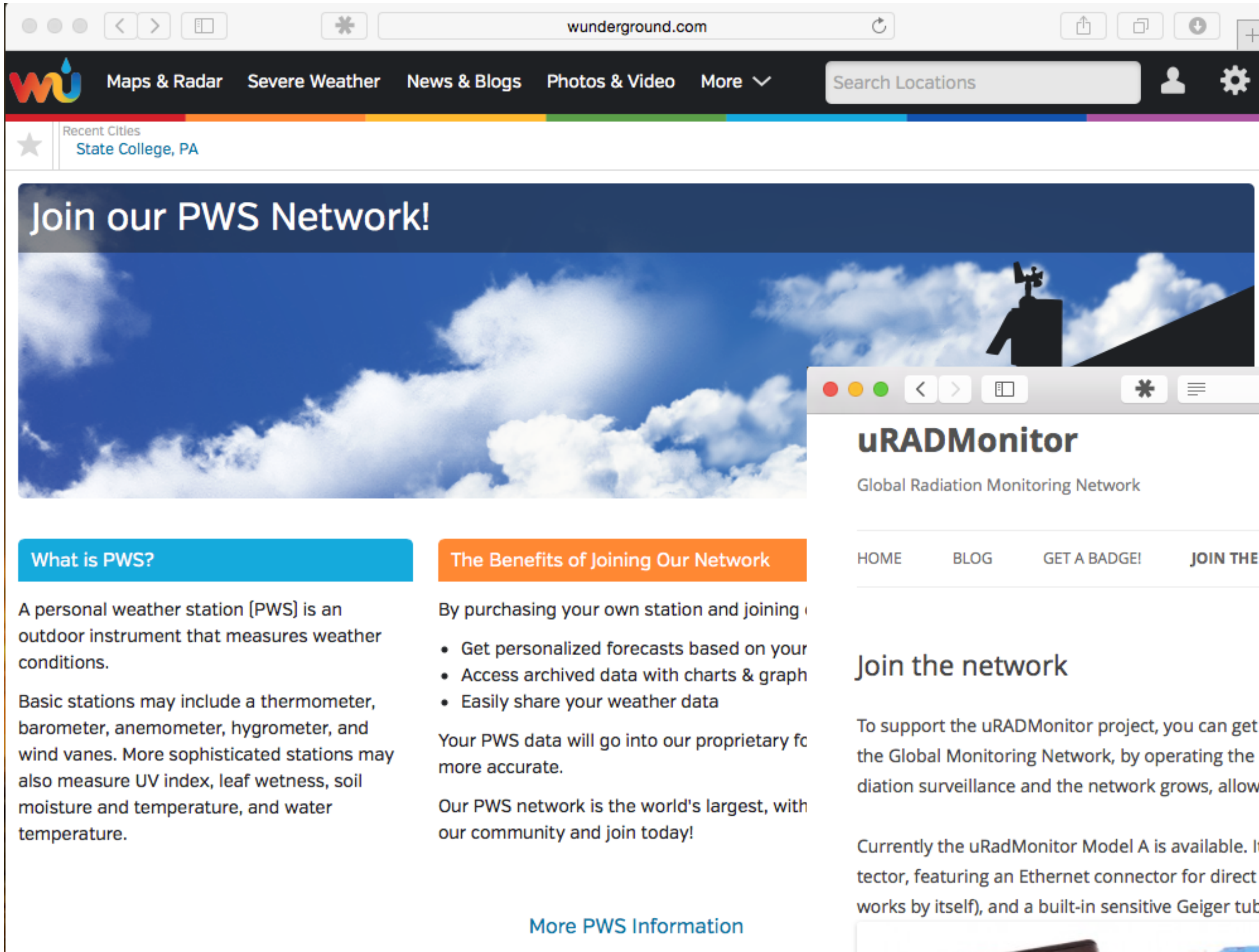


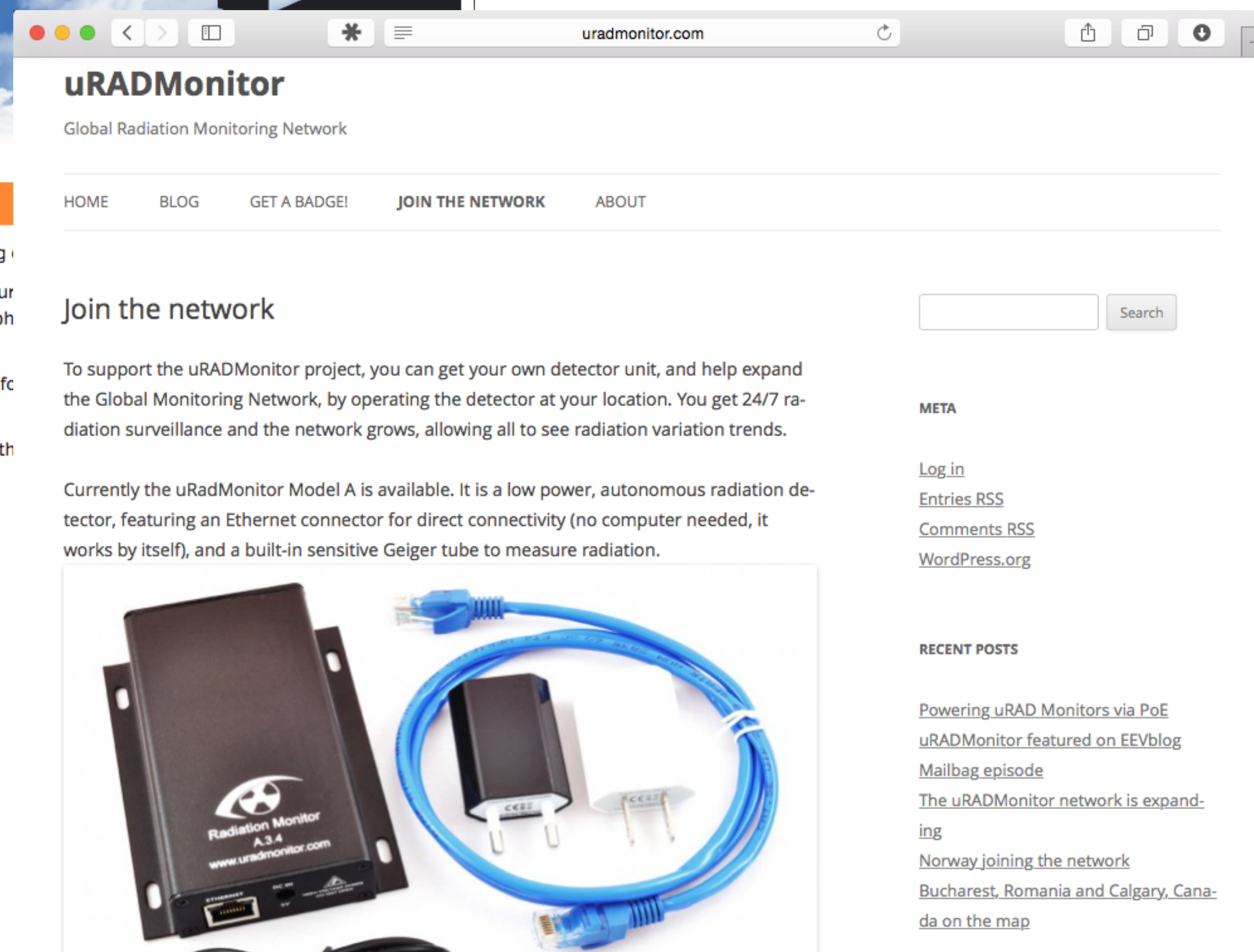



Raspberry Pi
In The Sky

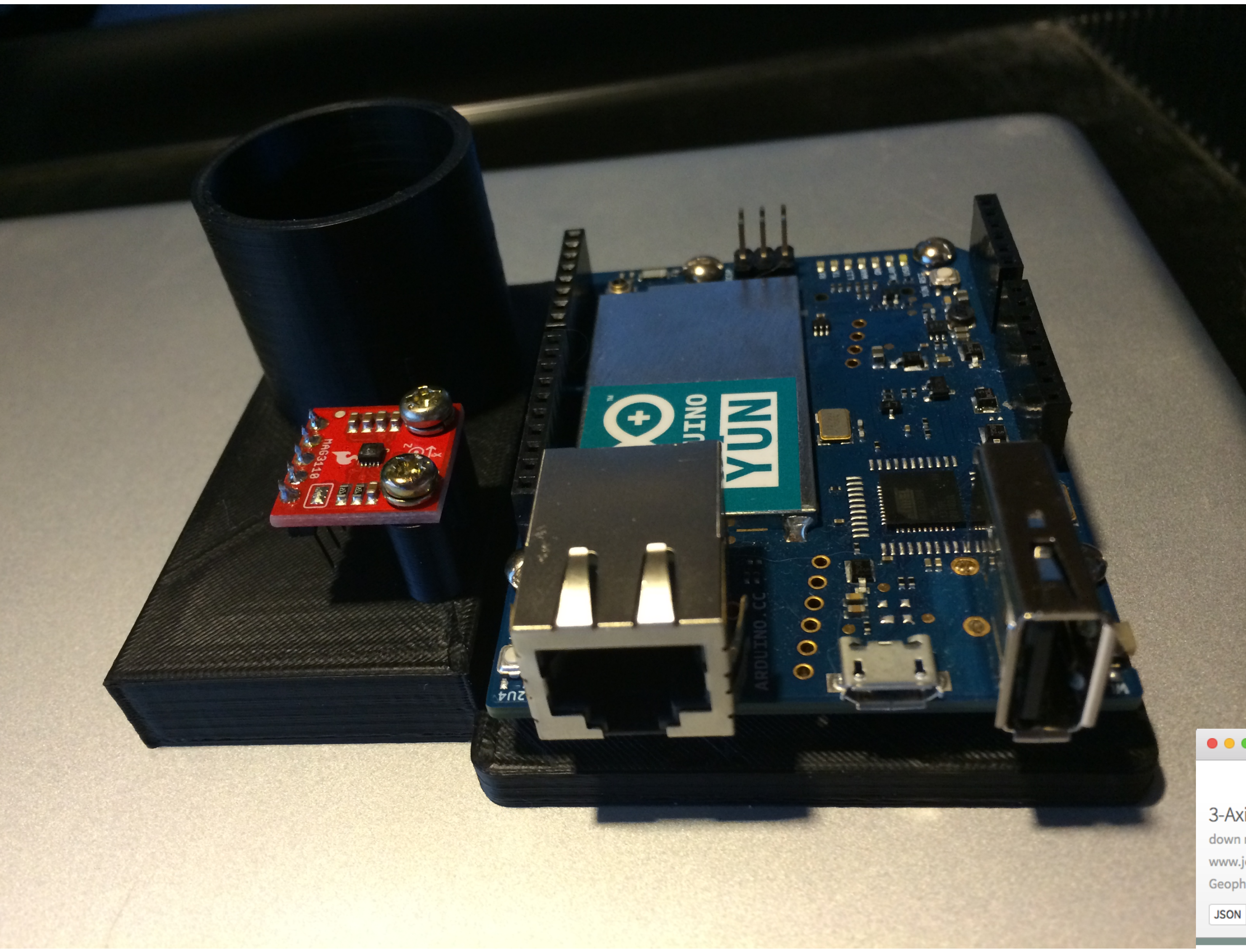



The Internet of Things (IoT) is quickly gaining traction in many communities



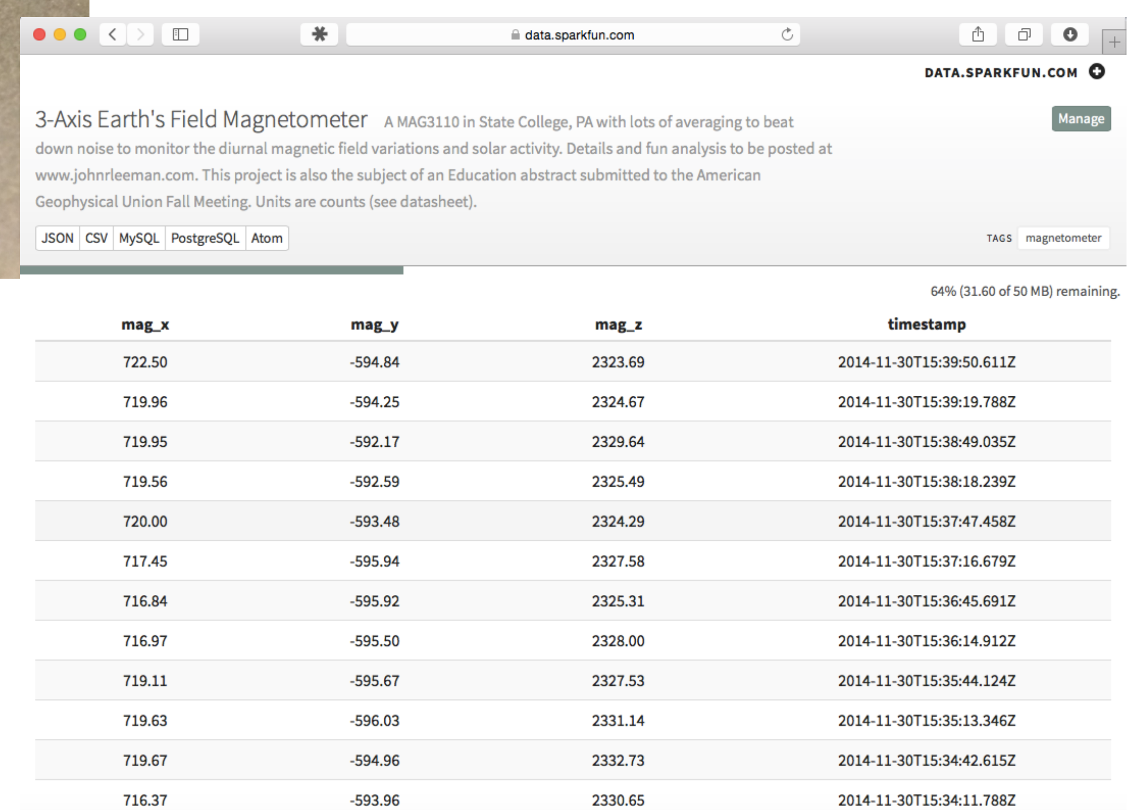


Getting a magnetometer online is easy and provides lots of things to examine



Sensitivity: 0.1 µT
Noise: 0.25 µT

2 readings/minute for over 2 months



data.sparkfun.com

DATA.SPARKFUN.COM

3-Axis Earth's Field Magnetometer A MAG3110 in State College, PA with lots of averaging to beat down noise to monitor the diurnal magnetic field variations and solar activity. Details and fun analysis to be posted at www.johnrleeman.com. This project is also the subject of an Education abstract submitted to the American Geophysical Union Fall Meeting. Units are counts (see datasheet).

Manage

JSON CSV MySQL PostgreSQL Atom

TAGS magnetometer

64% (31.60 of 50 MB) remaining.

mag_x	mag_y	mag_z	timestamp
722.50	-594.84	2323.69	2014-11-30T15:39:50.611Z
719.96	-594.25	2324.67	2014-11-30T15:39:19.788Z
719.95	-592.17	2329.64	2014-11-30T15:38:49.035Z
719.56	-592.59	2325.49	2014-11-30T15:38:18.239Z
720.00	-593.48	2324.29	2014-11-30T15:37:47.458Z
717.45	-595.94	2327.58	2014-11-30T15:37:16.679Z
716.84	-595.92	2325.31	2014-11-30T15:36:45.691Z
716.97	-595.50	2328.00	2014-11-30T15:36:14.912Z
719.11	-595.67	2327.53	2014-11-30T15:35:44.124Z
719.63	-596.03	2331.14	2014-11-30T15:35:13.346Z
719.67	-594.96	2332.73	2014-11-30T15:34:42.615Z
716.37	-593.96	2330.65	2014-11-30T15:34:11.788Z

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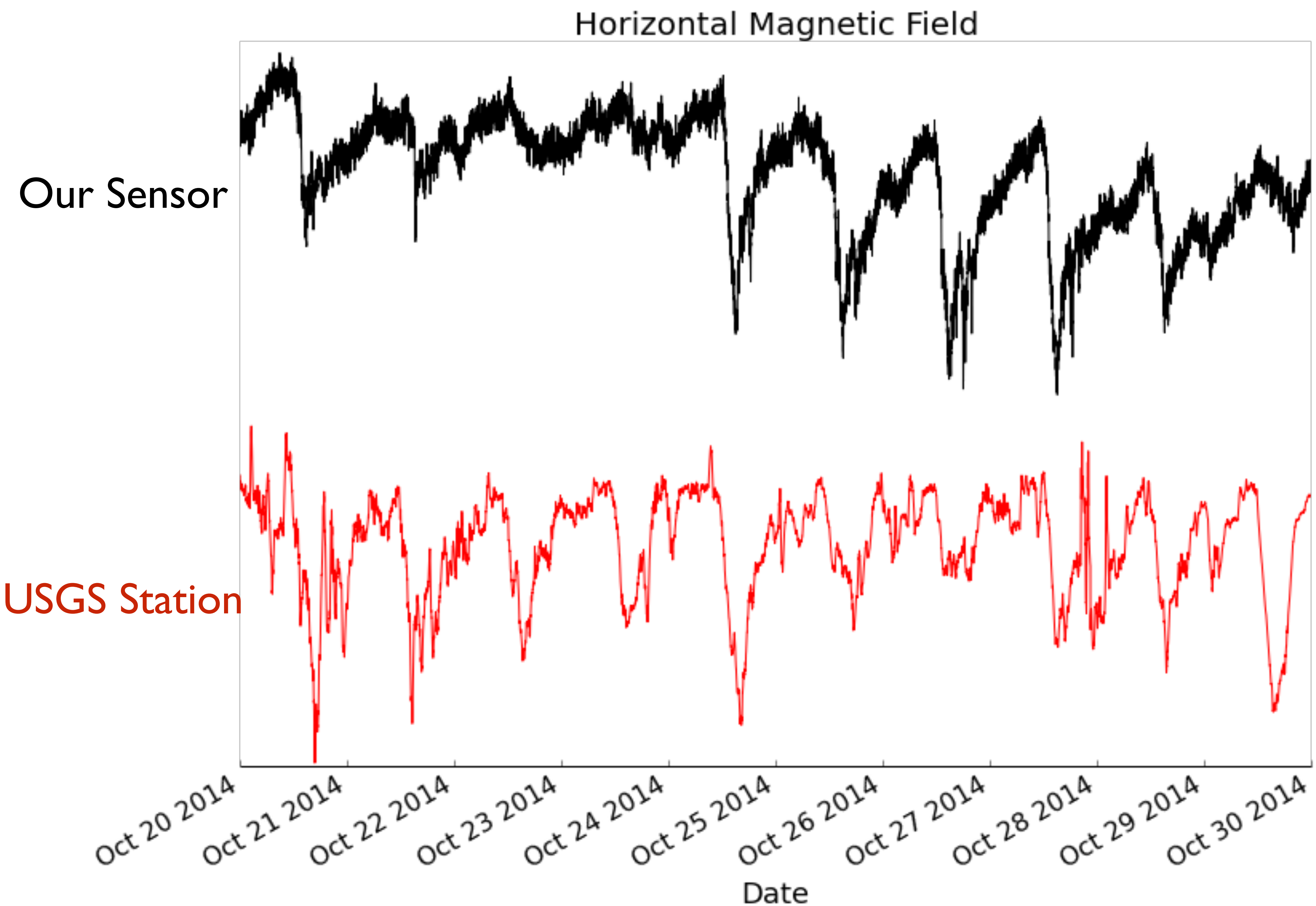

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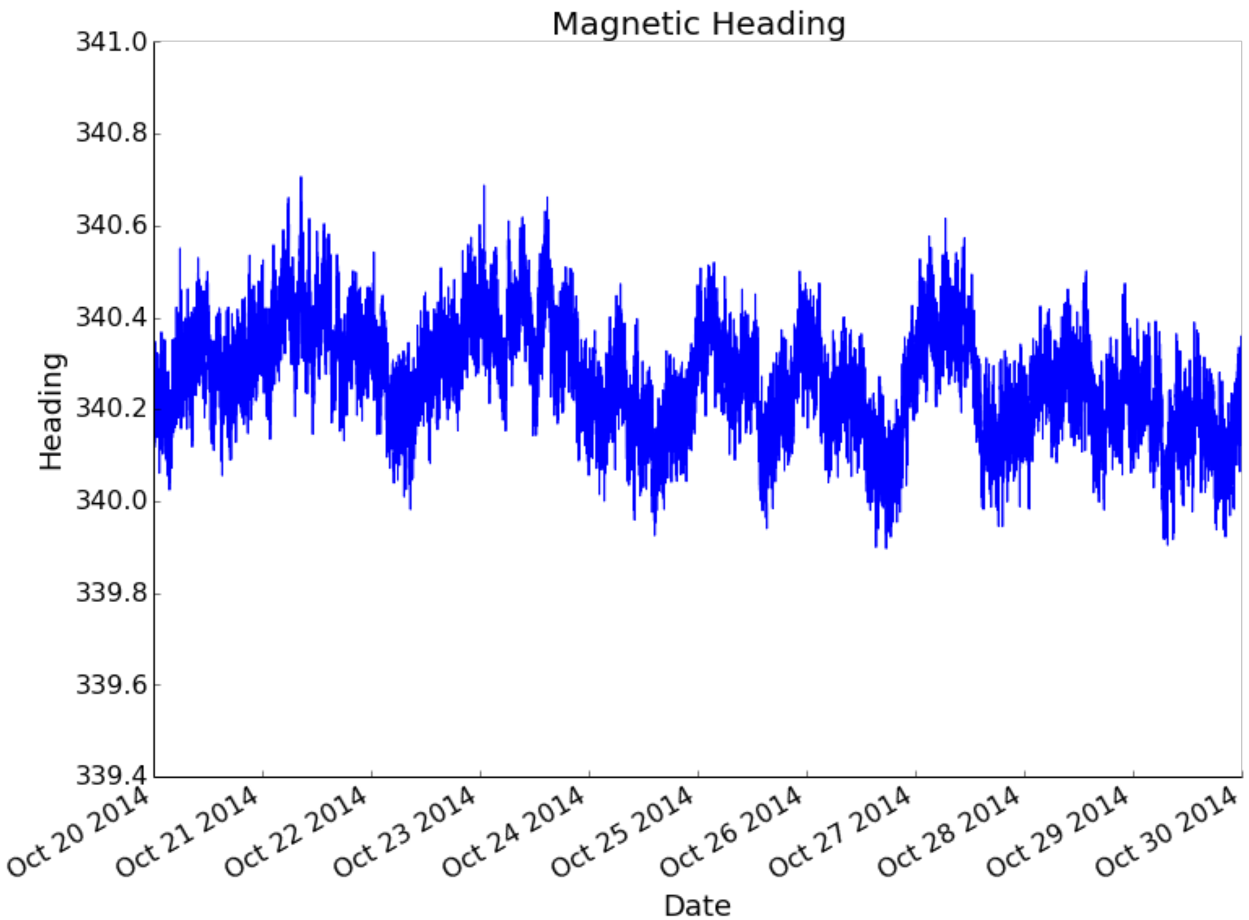

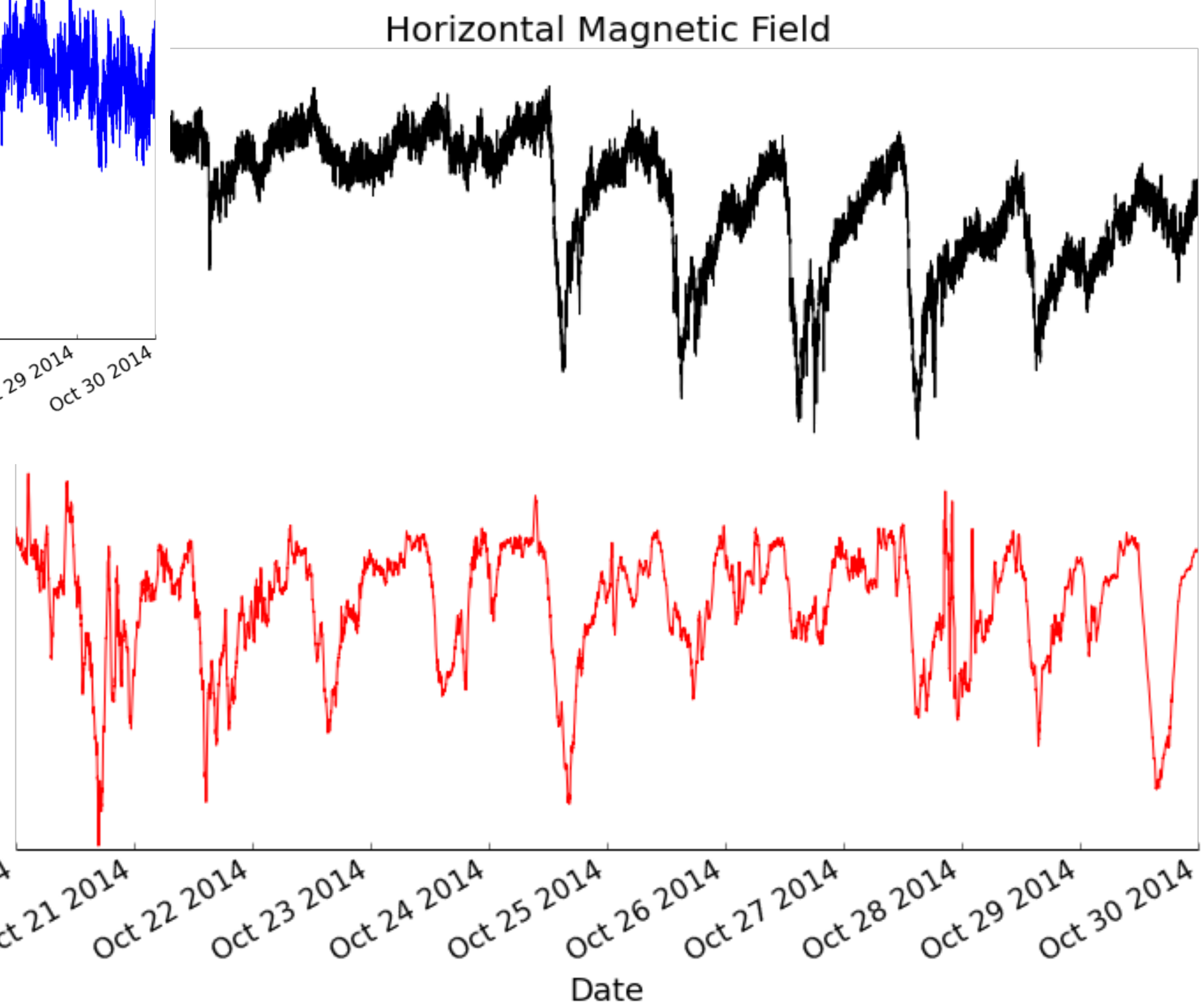

Data analysis can be done in open-source tools that encourage documentation and data

localhost

RSF_Friction_JRL/ | Rate and State Friction

IP[y]: Notebook Rate and State Friction Last Checkpoint: Nov 22 11:05 (autosaved)

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Markdown Cell Toolbar: None

Two State Variables

In an effort to explain more laboratory data, especially friction at high temperatures, some have started using an additional state variable, changing the formulation to be:

$$\mu = \mu_0 + a\ln\frac{V}{V_0} + b_1\ln\frac{V_0\theta_1}{D_{c1}} + b_2\ln\frac{V_0\theta_2}{D_{c2}}$$

Two copies of the same state variable law are used to track θ_1 and θ_2. The final formulation comes to:

$$\frac{d\mu}{dt} = k\left(V - V_0\exp\left[\frac{\mu - \mu_0 - b_1\ln(\frac{V_0\theta}{D_{c1}}) - b_2\ln(\frac{V_0\theta}{D_{c2}})}{a}\right]\right)$$

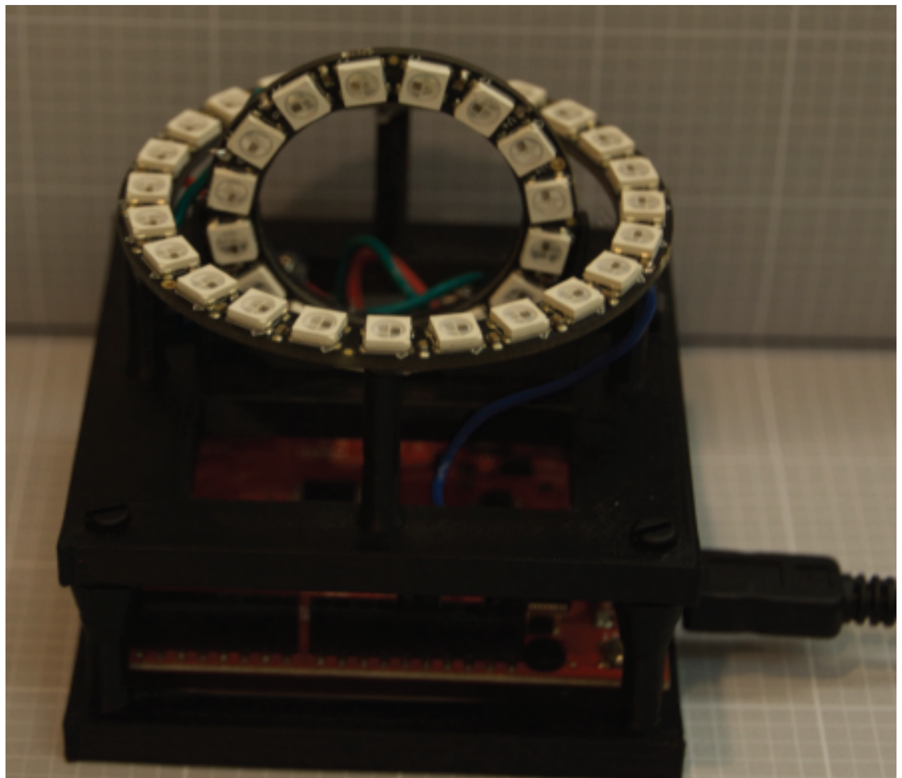
My Simple Demonstration

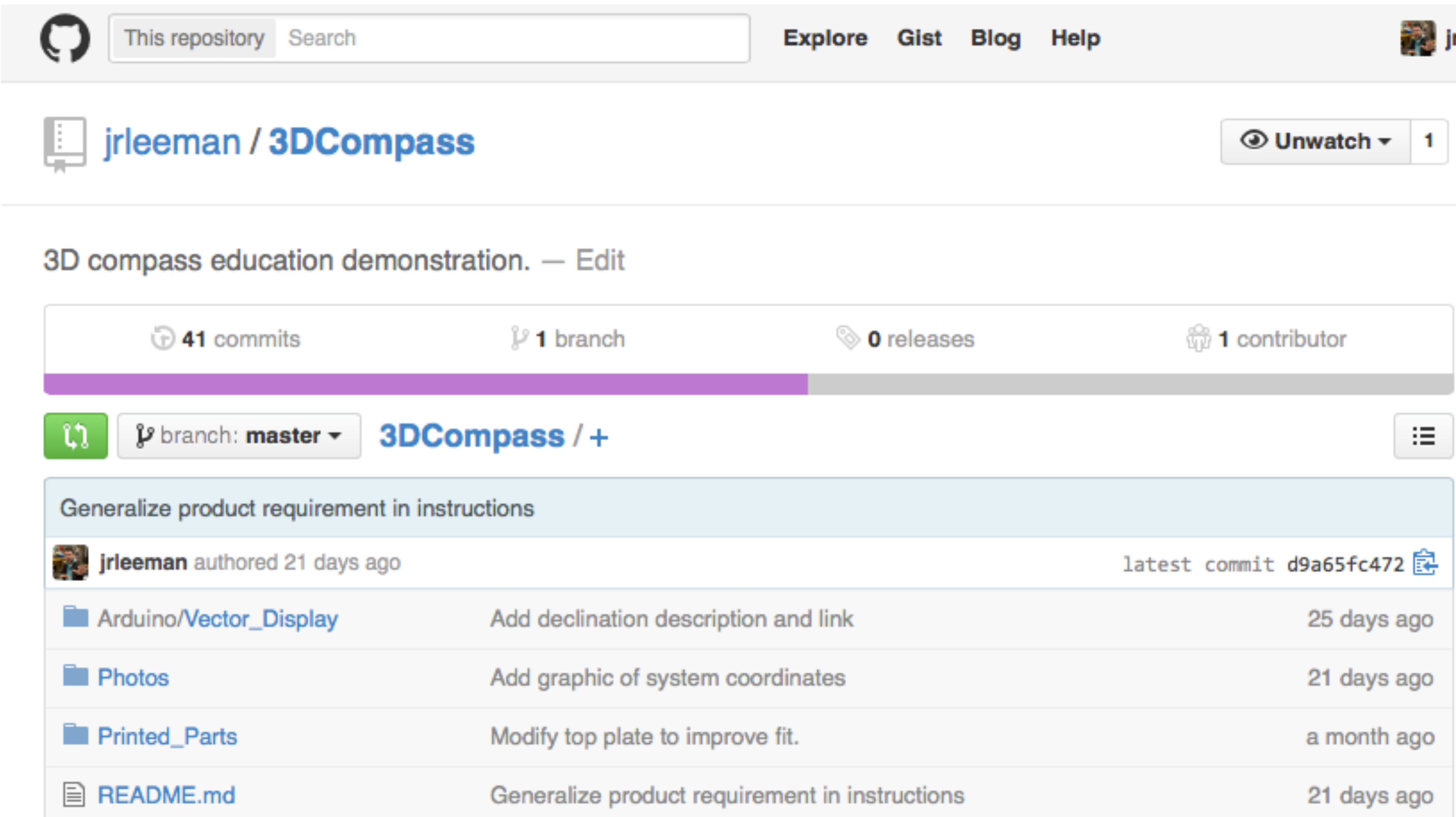
Here is a simple demonstration of solving a one-state-variable relation and comparing it to my advisor's legacy C code.

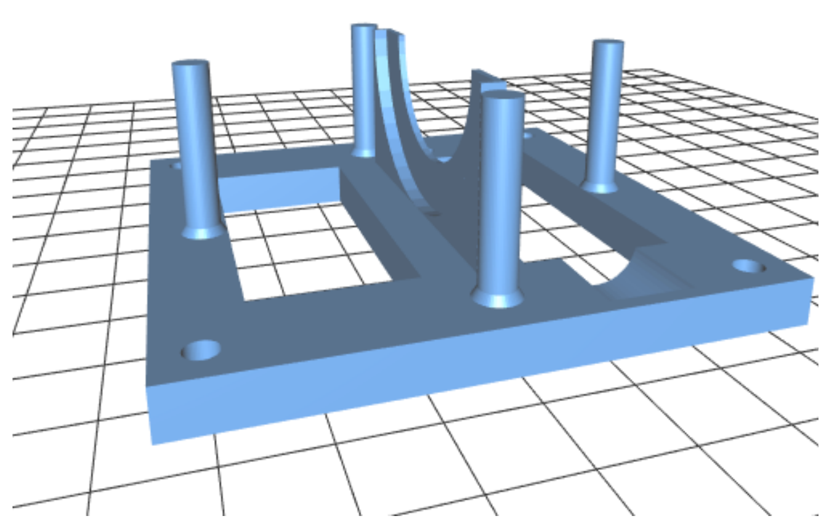
In [25]:

```
%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt
from scipy import integrate
from math import exp,log

def vectorfield(w,t,p):
    mu,theta,v = w
    mu0,vlp,a,b,dc,k = p

    v = v * exp((mu - mu0 - b * log(v * theta / dc)) / a)
    dmu_dt = k * (vlp - v)
    dtheta_dt = 1. - v * theta / dc

    return [dmu_dt,dtheta_dt]

mu0 = 0.6
a = 0.005
```

We can further expand student's interaction my making dynamic devices as demonstrators AND lab tools







```
/*
  Vector_Display.ino

  Displays the orientation of the magnetic vector on two neo-pixil rings.
  North and the inclination are marked by red, faded to blue for contrast.

  Created: 10/30/14
  Author: John R. Leeman
  Modified: 11/7/14
  www.johnrleeman.com
  www.github.com/jrleeman
*/


#include <Adafruit_NeoPixel.h>
#include <Wire.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_HMC5883_U.h>

#define PIXILPIN 13 // Pin on the Arduino that the NeoPixil chain is connected to
#define NUMAZ 24  // Number of pixils on the azimuth ring
#define NUMINC 16 // Number of pixils on the inclination ring
#define INCANGLE 259 //Angle that pixil "zero" is at on inclination ring (nearest de
#define AZANGLE 285 //Angle that pixil zero is at on azimuth ring (nearest degree)
#define STREAMDECIMATE 25 // Number of reads to write out to the serial stream
#define BRIGHTNESS 1 // Increase or decrease for brighter/dimmer colors
```

Go make something! Every field has “hackers” it’s time for geo-hackers!

All Presentation Content, Data, and more at
<u>www.johnrleeman.com</u> and the session blog