USING THE ARDUINO MICRO-CONTROLLER TO BUILD CUSTOM INSTRUMENTATION FOR GROUNDWATER APPLICATIONS

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UW Extension
Wisconsin Geological and Natural History Survey

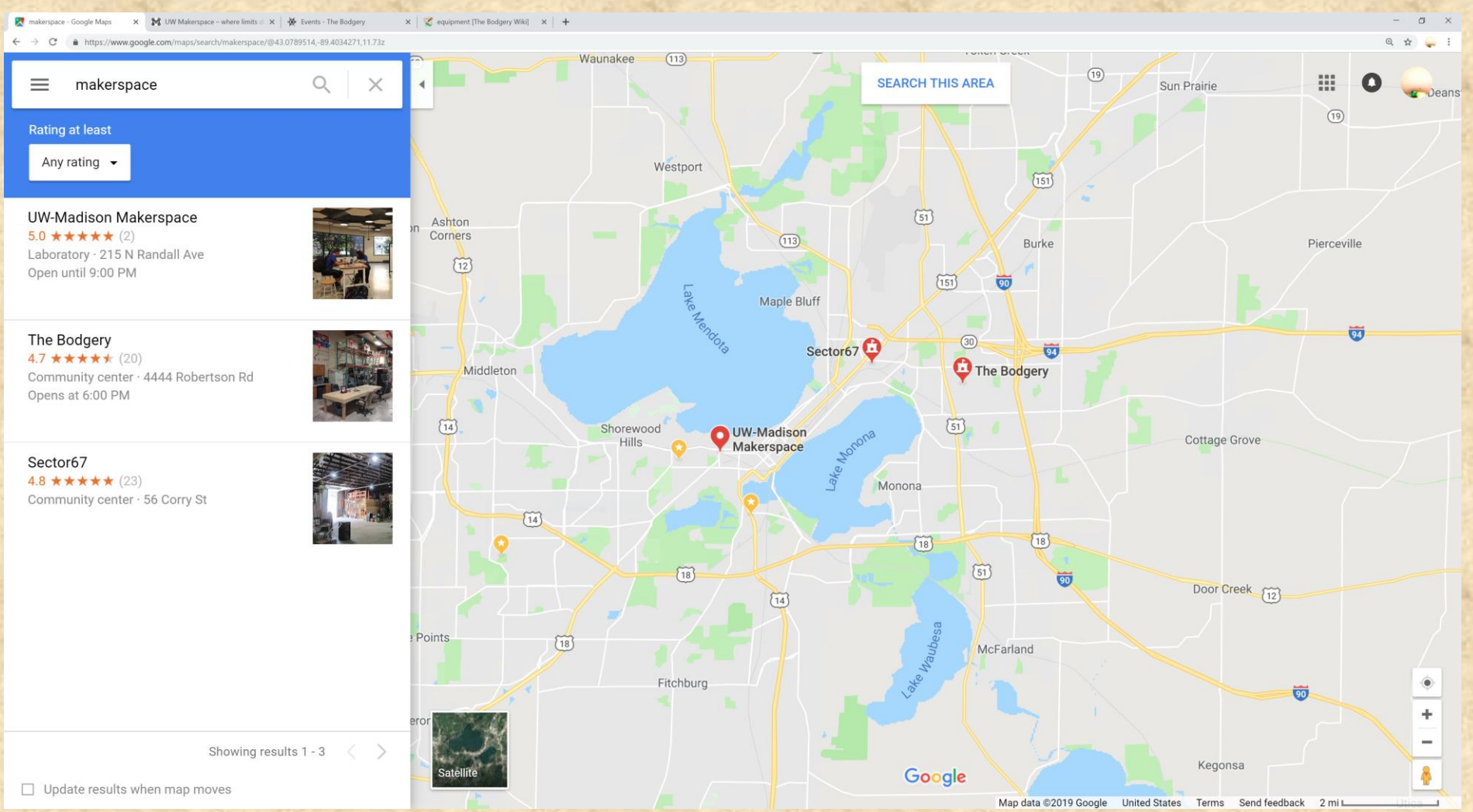
WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Funded by the Wisconsin Department of Natural Resources

Maker Culture - Combination of DIY, Hacker, and Artisan Cultures.

Cut-and-paste approach to standardized hobbyist technologies

Three makerspaces in Madison



Who We Are

We're a non-profit organization providing the tools, workspace, and guidance to people of all ages who want to make things. Whether learning a tool, honing a craft, building a business, or finding a creative group of makers – this is your place to build skills and community!

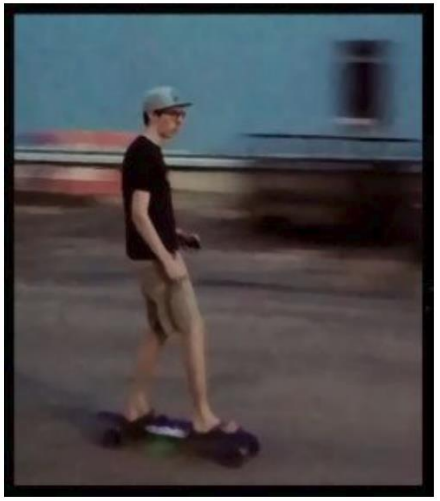
Our Tools

We have a full woodworking shop, welding and blacksmithing, a sewing studio, 3D printing, electronics lab, laser cutting/engraving, a machine shop, prop making and leather work, CNC milling and routing, screen printing, auto repair, and a giant wall of yarn.

A list of **our current tools** is on our wiki.

Check out the shop in our **Virtual Tour!**

The Bodgery



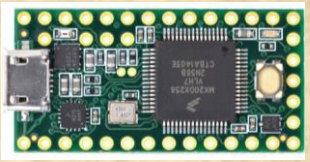
The Electric Long Board

Hi my name is Charlie and I built an electric longboard! The idea first came about a year ago when I saw a student on my campus blast past me while I was biking to class. I did a little research and learned that I desperately wanted one. Unfortunately a high quality electric skateboard is going to run around $1,000 to $2,000. I basically gave up hope.

Fast forward to a month ago. I'd just moved to Madison for an internship and was looking for a project. I discovered that building your own electric skateboard isn't all that difficult. With a bit of research, and a lot of hands on learning, you can quickly and easily build a board that goes 30 mph and 10 or more miles. It all depends on your budget. I chose to go with a 6S1P battery system. Basically this meant that I can go about 7 miles, and up to 26 mph on a single charge. After completing my first board in the Bodgery shop, I'm already planning my next. In fact, as I ...

Specific to earth sciences

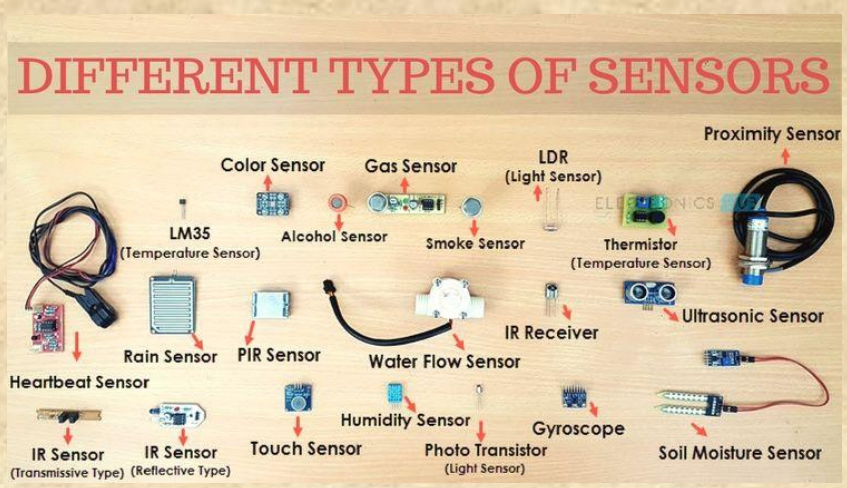
- Low cost micro-controllers



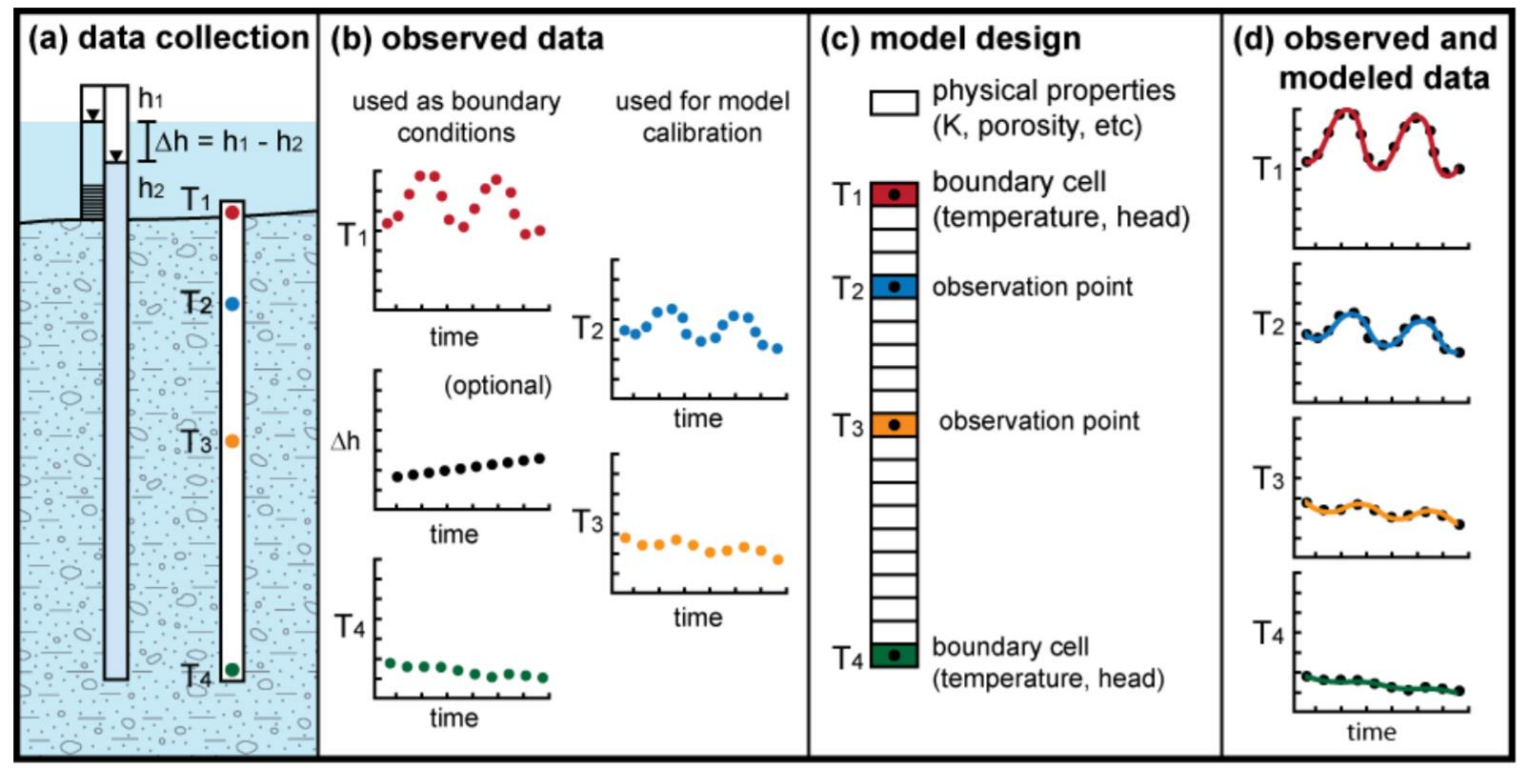
- Low cost memory storage

- Access to GPS

- Wide range of sensors

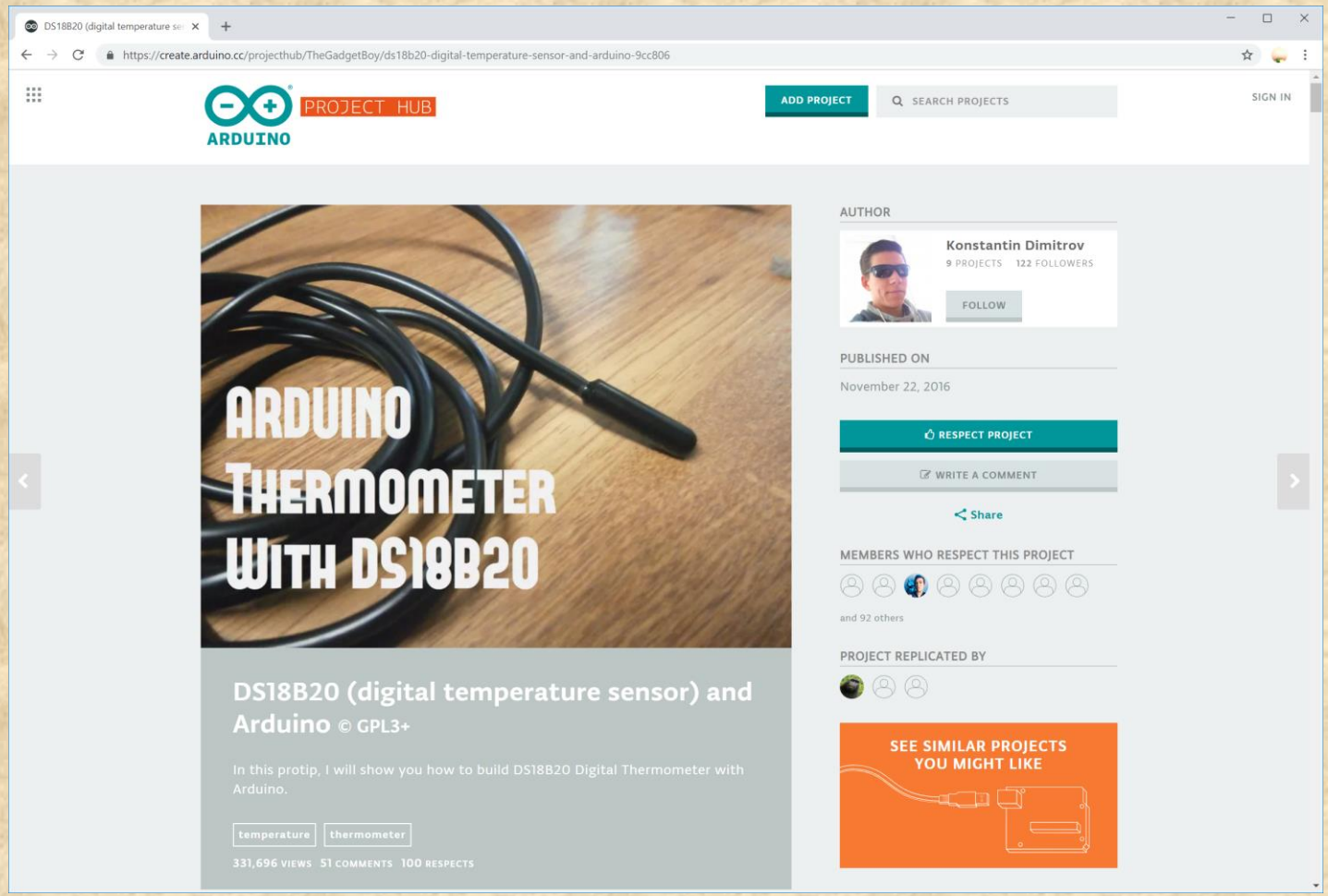


Wanted another way to measure GW/SW interaction. Temperature Flux Measurements



1DTempPro software from USGS uses temperature profile and heads to determine groundwater flux.
https://www.ncbi.nlm.nih.gov/pubmed/26372016

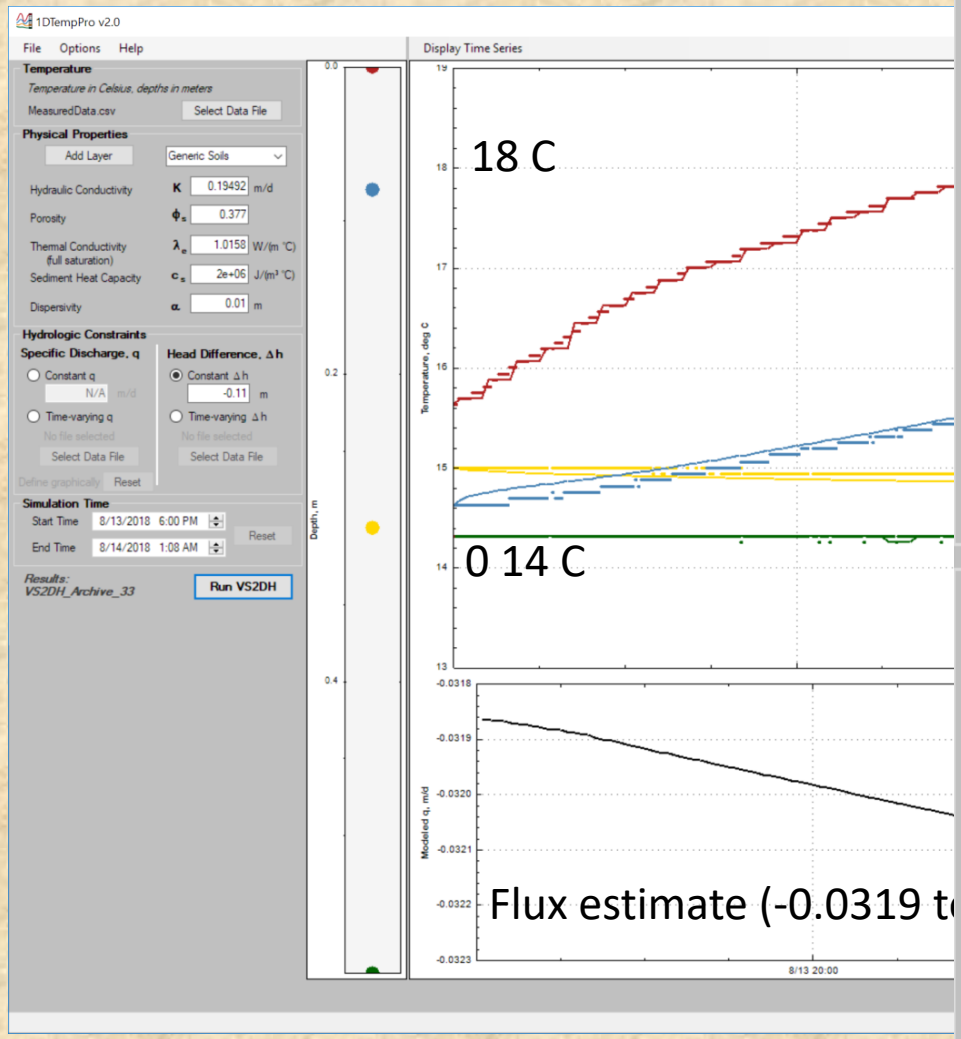
Google Arduino and temperature

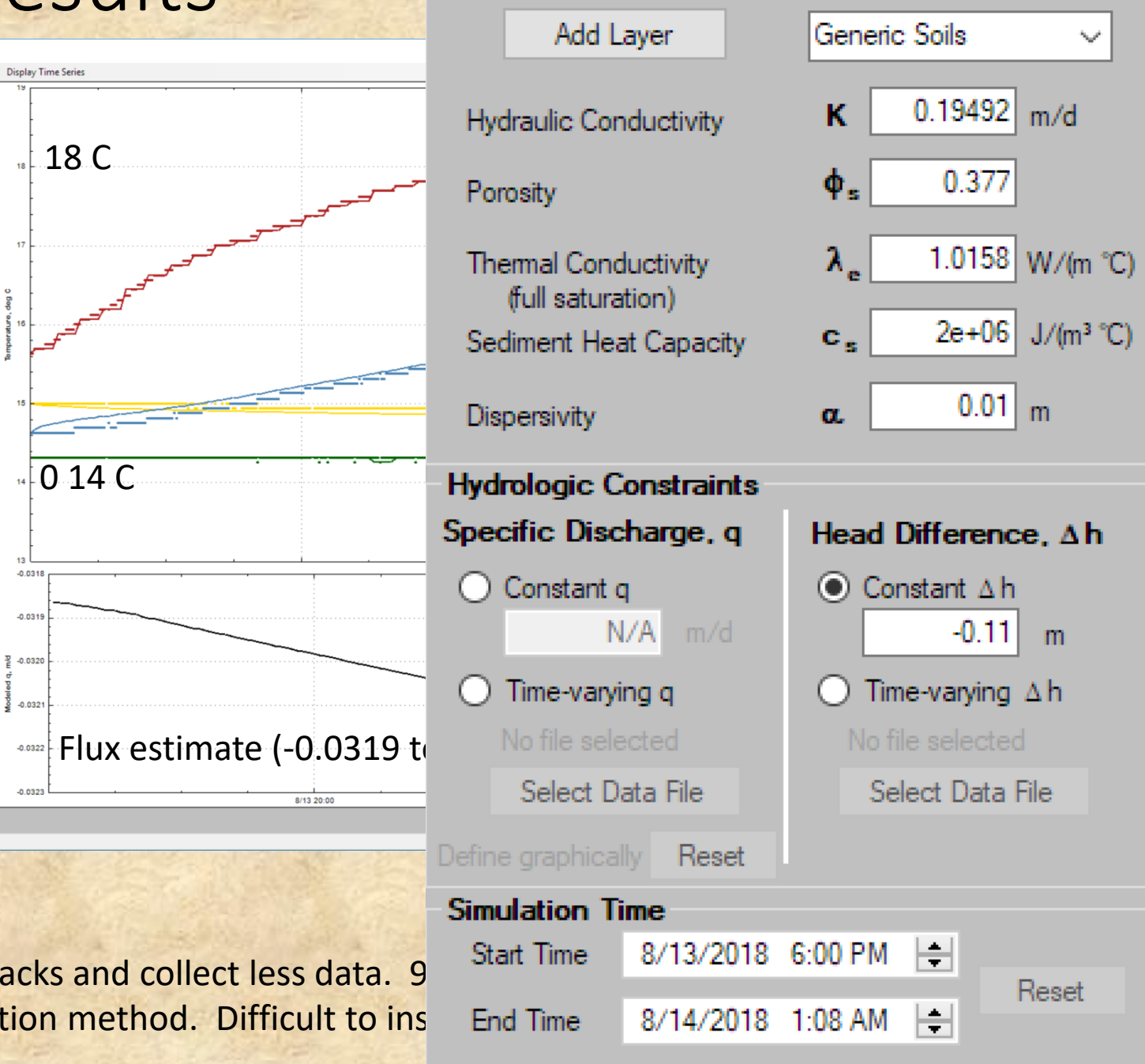


This page explains what materials are needed, how to connect the sensor and provides a working program or sketch. We used the DS18B20 sensor because they are accurate, water proof, easy to install, and many can be connected into a single port pin.

Hardware and installations

Temp1D results



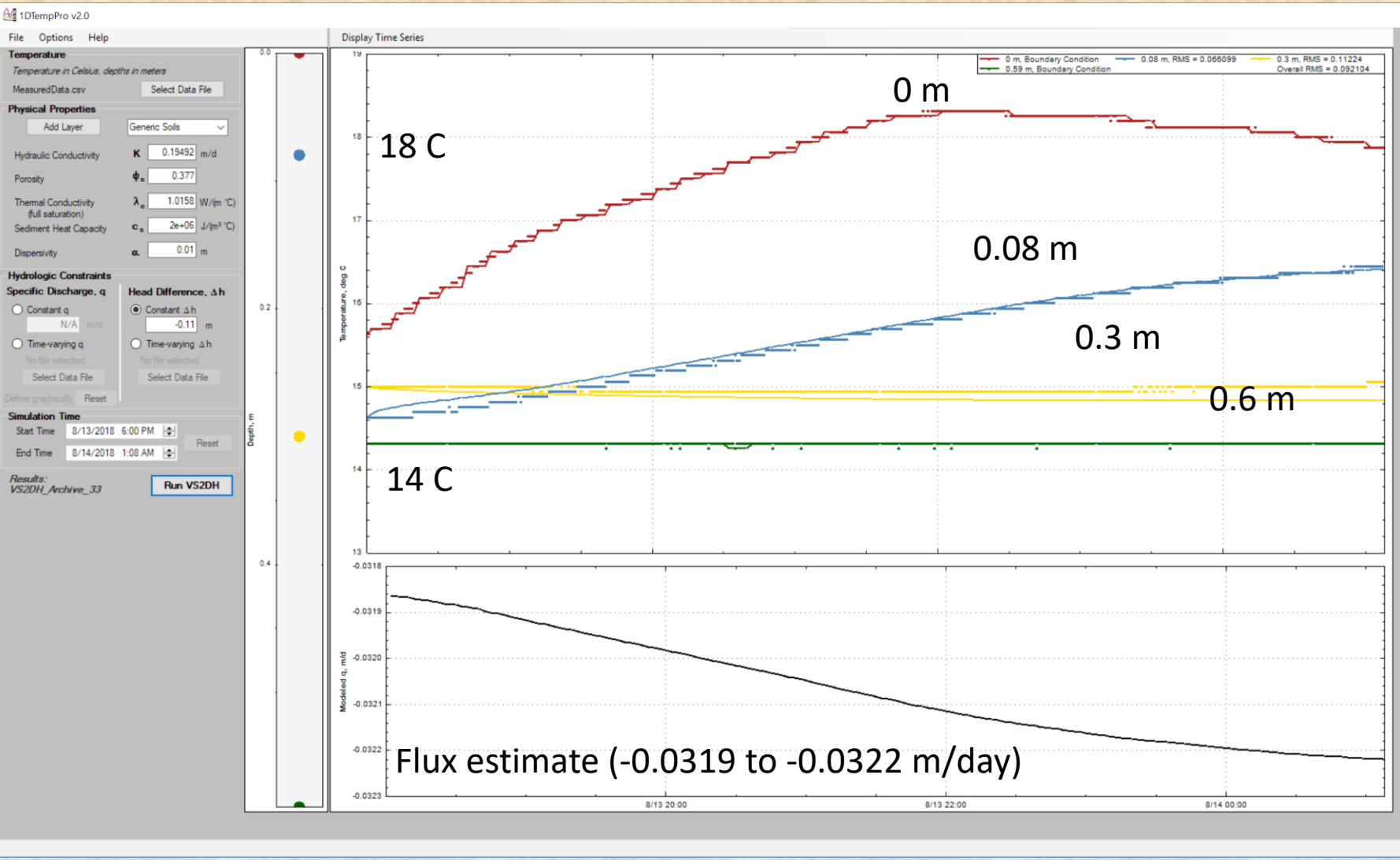


Lessons learned:

Use larger battery packs and collect less data. 9

Need better installation method. Difficult to ins

Temp1D results

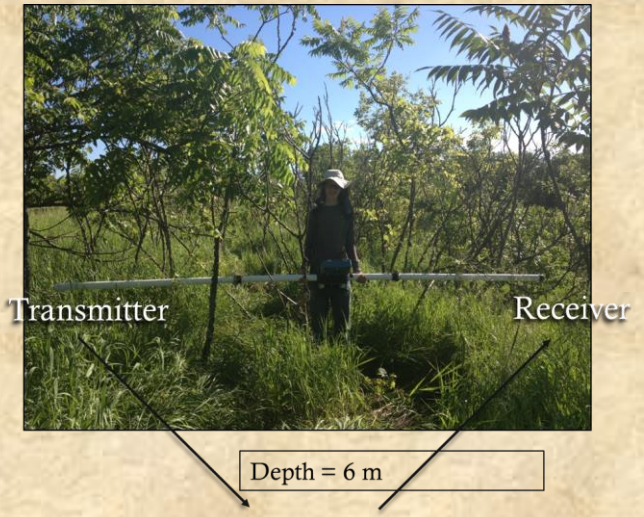


Lessons learned:

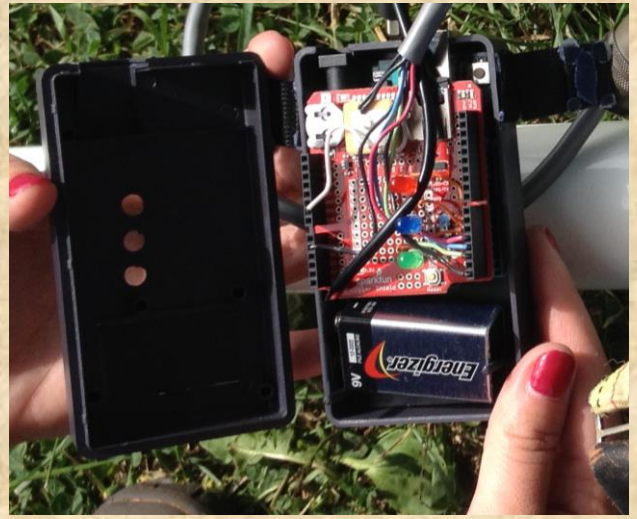
Use larger battery packs and collect less data. 9 Volt ran out after 7 hours.

Need better installation method. Difficult to install more than 0.6 meters.

EM-31 Ground Conductivity Meter



- Second example of Arduino application.
  - Record ground conductivity data, time and location.



Geonics supplied pin-out

Google Arduino and GPS

27 gps Projects - Arduino Project Hub - Arduino Create
https://create.arduino.cc/projecthub/projects/tags/gps

Real-Time 2G/3G/LTE **Arduino GPS** Tracker +... ... **GPS** Tracking Using Helium, Azure IoT Hub, and Power... ... DIYmall GPRS/**GPS** SIM908 Module - NMEA...

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Explore 62 **projects** tagged with 'tracking'. Find these and other hardware **projects** on **Arduino Project** Hub. ... Real-Time 2G/3G/LTE **Arduino GPS** Tracker +.

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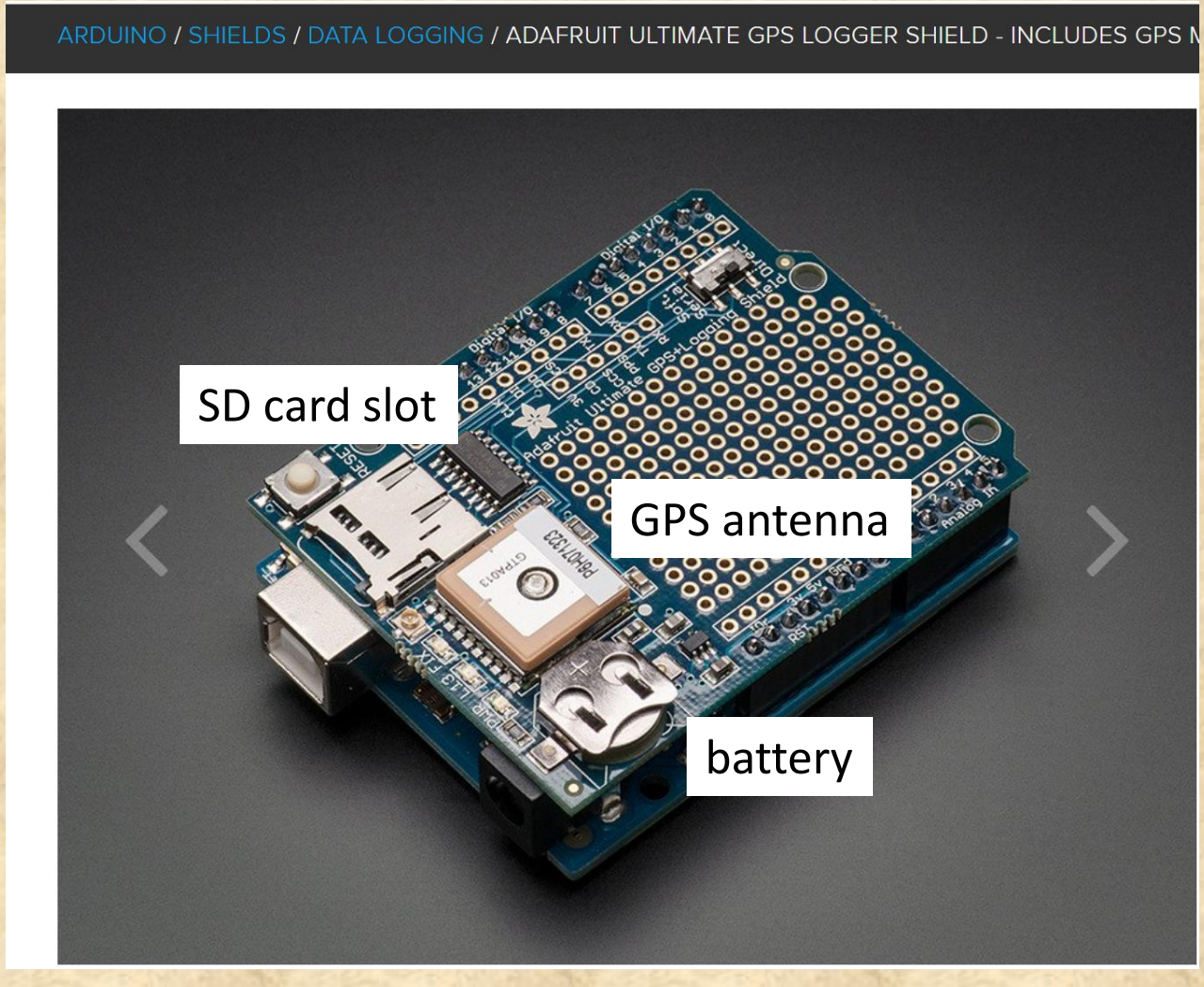
Interested in **gps**? Explore 132 ... '**gps**'. Find these and other hardware **projects** on Hackster.io. ... Real-Time 2G/3G/LTE **Arduino GPS** Tracker + IoT Dashboard.

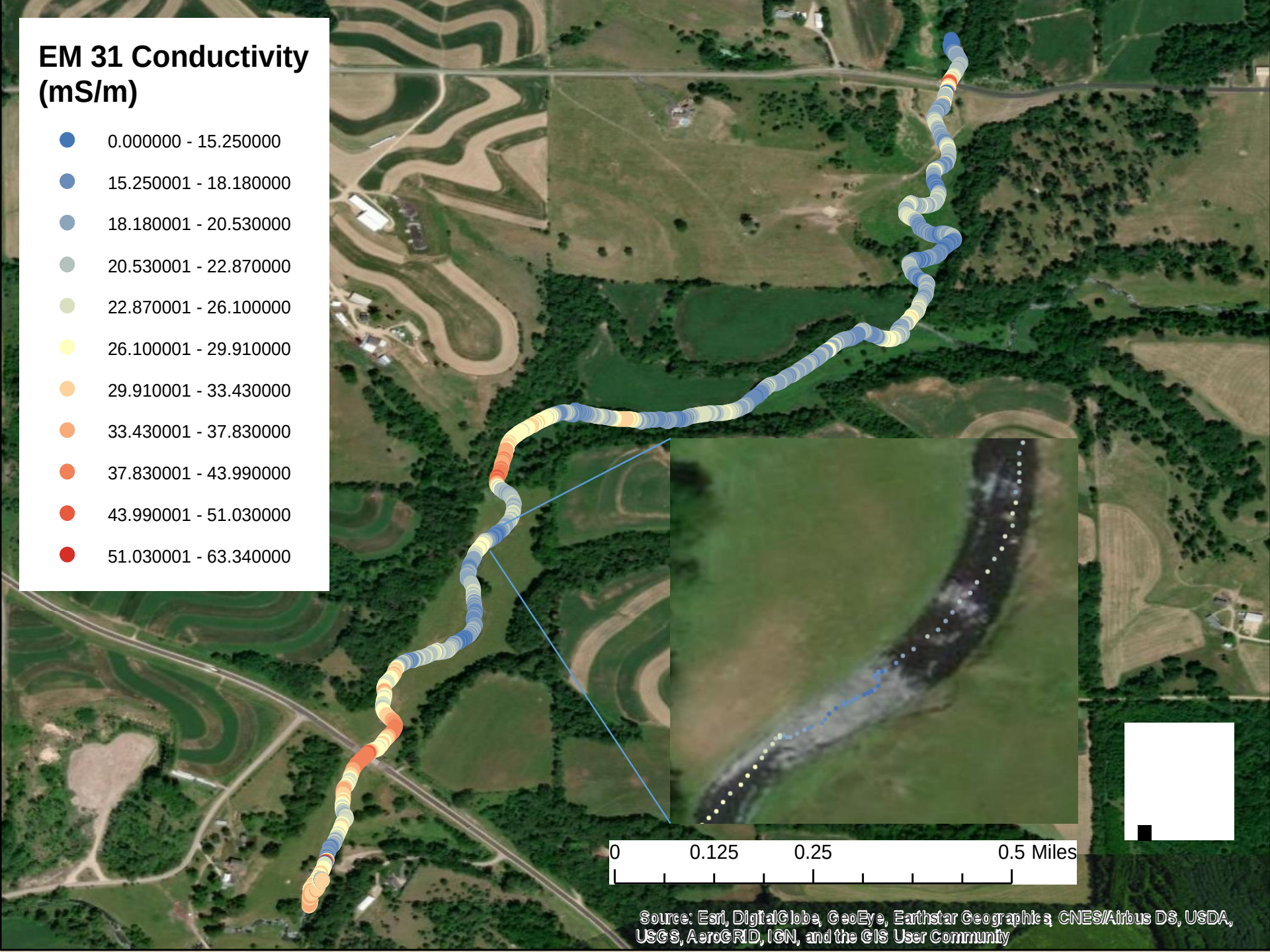
The Complete Understanding Made Simple - GPS With ARDUINO: 6 ...
https://www.instructables.com › technology › arduino

Here i am providing with ways of connecting, testing and programming Global positioning system(**GPS**) using **Arduino**... Further, i have worked out **projects** ...

Google Arduino and GPS



This “shield” plugs into microcontroller. It has a keep alive battery, real time clock, SD card slot, and GPS antenna.


EM 31 Conductivity (mS/m)
0.000000 - 15.250000
15.250001 - 18.180000
18.180001 - 20.530000
20.530001 - 22.870000
22.870001 - 26.100000
26.100001 - 29.910000
29.910001 - 33.430000
33.430001 - 37.830000
37.830001 - 43.990000
43.990001 - 51.030000
51.030001 - 63.340000
0
0.125
0.25
0.5 Miles
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Arduino water chemistry instrumentation

Multiple sensors, GPS, SD card recording

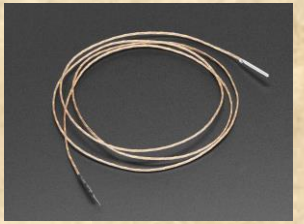
GPS

These data will be stored on the Arduino board and geolocated with GPS board at sample rate of once every 2 seconds.
Total cost ~ $1000 mostly sensors. Dr. Fratta and Susie Richmond

Arduino Mega Microcontroller

Turbidity/preliminary

pH



Temperature

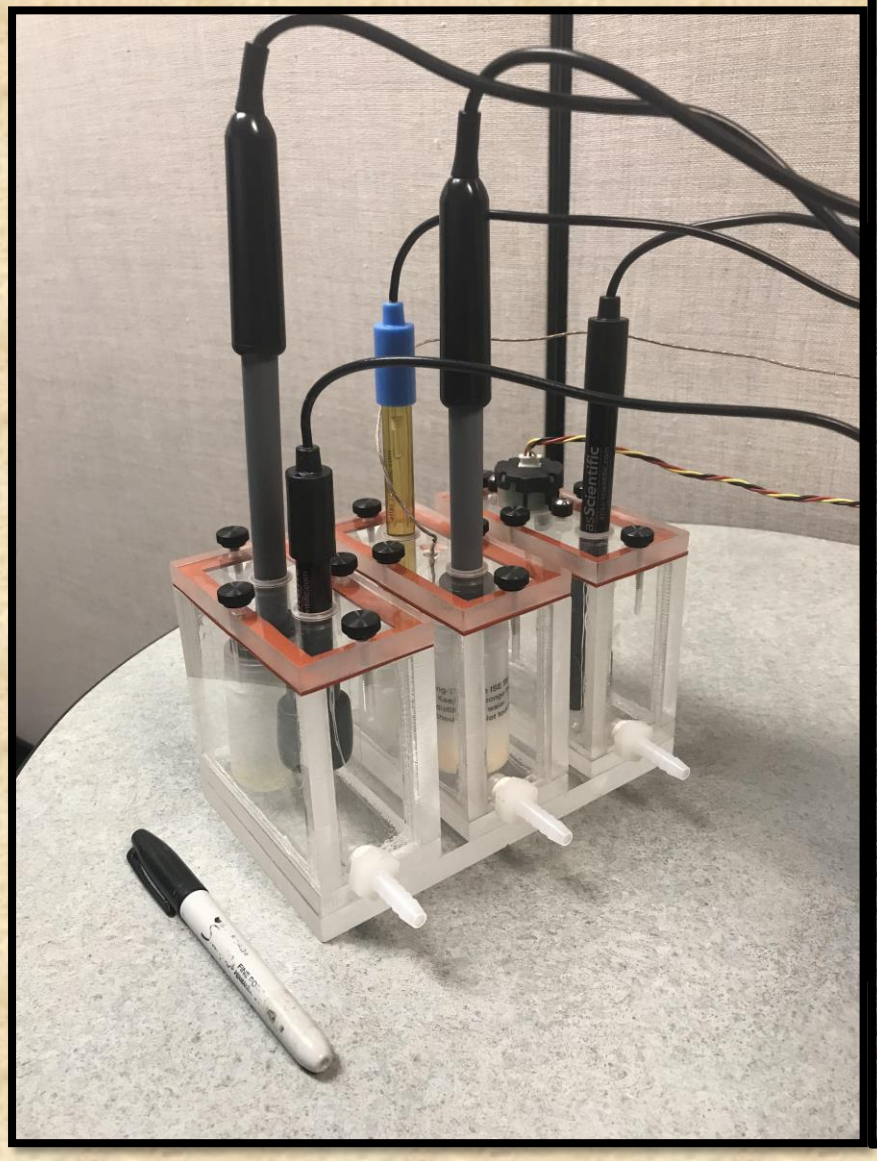
Nitrate

Chloride

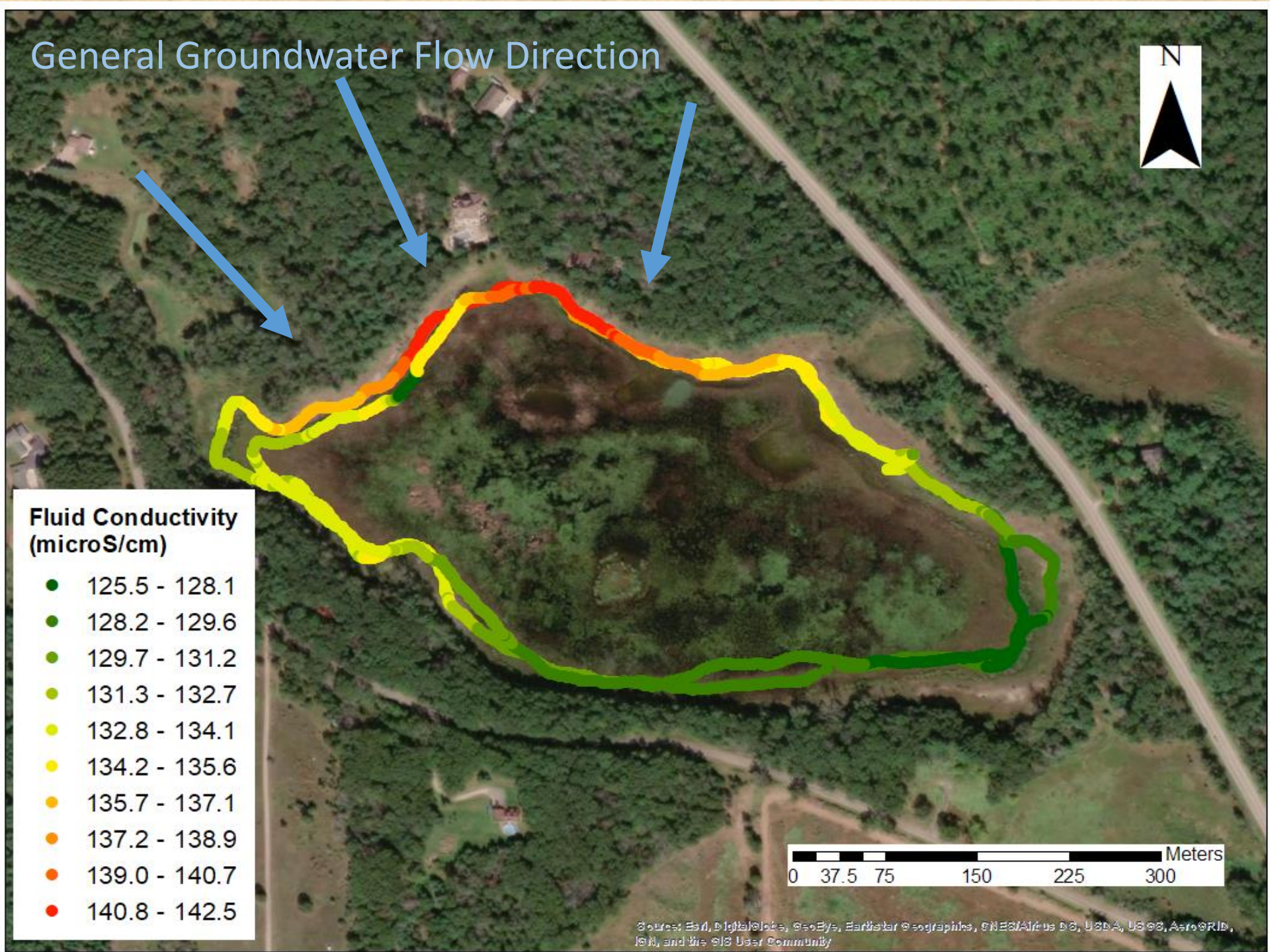
Conductivity

Dissolved Oxygen

Flow through cell and data controller



Flow through cell
Peristaltic Pump
Inlet
Data controller
Discharge
Mad River Canoe
ADVENTURE 16


General Groundwater Flow Direction
N
Fluid Conductivity (microS/cm)
125.5 - 128.1
128.2 - 129.6
129.7 - 131.2
131.3 - 132.7
132.8 - 134.1
134.2 - 135.6
135.7 - 137.1
137.2 - 138.9
139.0 - 140.7
140.8 - 142.5
Meters
0 37.5 75 150 225 300
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Conclusions

- Pros
  - Relatively easy
  - Relatively low cost
  - Have ability to collect very large amounts of data located in time and space
  - Expect dense data sets to provide insights not otherwise available
  - Great for tinkerers
  - Teaching tool
- Cons
  - Greater time commitment
  - Learning curve can be steep
  - Not as robust as engineered system
  - Might just want data.