Drone Warriors

MICHAEL BENGSTON, MICHAEL HABISOHN, JUSTIN LANGUIDO, CHRISTIAN WILLIAMS

Background

- 4 main variables in crop growth
  - solar radiation
  - air temperature
    - has the greatest effect on growth.
  - humidity
  - precipitation
- This work focused on the last three

Prior Works

- Steven E. Hollinger and James R. Angel looked at a 30 year period to define "normal" weather conditions
- From normal conditions, they defined four thresholds
  - Absolute minimum
  - Absolute maximum
  - Optimum minimum
  - Optimum maximum
- Correlation between amount of precipitation and crop growth
  - Too little→ weak roots and talks, too much→ disease

Applications

- Industry is currently focused on thermal imaging
  - Existing options are very expensive
  - Data quickly becomes obsolete
  - Only provides information about one of four variables
- To measure all of the variables, we used the following
  - Bosch BME680 Breakout Board
  - MLX 90614 IR Thermometer
  - MT3339 All-in-one GPS

Data Acquisition (DAQ) Program: Setup

```
14 // Include Libraries
15 #include <SD.h>
16 #include <Wire.h>
17 #include <SPI.h>
18 #include <Adafruit_Sensor.h>
19 #include <Adafruit_BME680.h>
20 #include <Adafruit_MLX90614.h>
21 #include <Adafruit_GPS.h>
22
23 // Definitions found in BME library
24 #define BME_SCK 13
25 #define BME_MISO 12
26 #define BME_MOSI 11
27 #define BME_CS 10
28 #define SEALEVELPRESSURE_HPA (1013.25)  // This will calibrate altitude calculations
29
30 // Global Variables
31 Adafruit_MLX90614 mlx = Adafruit_MLX90614();
32 Adafruit_GPS GPS(&Serial2);
33 Adafruit_BME680 bme; // I2C
34 File myFile;
```

DAQ Program: GPS Setup and Data Retrieval

```
81  // Ultimate GPS
82  // 9600 NMEA is the default baud rate for MTK - some use 4800
83  GPS.begin(9600);
84
85  // You can adjust which sentences to have the module emit, below
86  // uncomment this line to turn on only the "minimum recommended" data for high update rates!
87  GPS.sendCommand(PMTK_SET_NMEA_OUTPUT_RMCONLY);
88
89  // Set the update rate
90  // Note you must send both commands below to change both the output rate (how often the position
91  // is written to the serial line), and the position fix rate.
92  // 10 Hz update rate - for 9600 baud you'll have to set the output to RMC only (see above)
93  // Note the position can only be updated at most 5 times a second so it will lag behind serial output.
94  //GPS.sendCommand(PMTK_SET_NMEA_UPDATE_10HZ);
95  //GPS.sendCommand(PMTK_API_SET_FIX_CTL_5HZ);
96
97
98  // Request updates on antenna status, comment out to keep quiet
99  GPS.sendCommand(PGCMD_ANTENNA);
100
101 // the nice thing about this code is you can have a timer0 interrupt go off
102 // every 1 millisecond, and read data from the GPS for you. that makes the
103 // loop code a heck of a lot easier!
104 useInterrupt(true);
```

```
153 {
154   if (GPS.newNMEAreceived())
155   {
156     GPS.parse(GPS.lastNMEA());
157   }
158 }
```

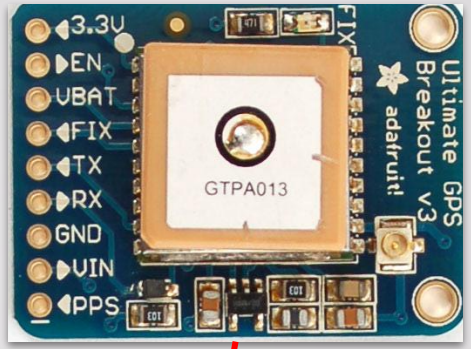
DAQ Program: .csv Format

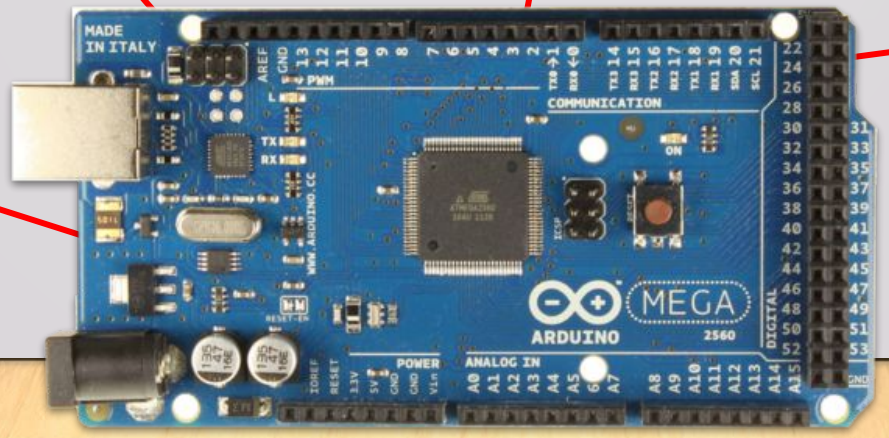
```
199  // SD Card Writing
200
201  myFile = SD.open("50ft.txt", FILE_WRITE);
202
203  // BME Data
204  myFile.print(bme.temperature);
205  myFile.print(",");
206
207  myFile.print(bme.pressure / 100.0);
208  myFile.print(",");
209
210  myFile.print(bme.humidity);
211  myFile.print(",");
212
213  myFile.print(bme.gas_resistance / 1000.0);
214  myFile.print(",");
215
216  myFile.print(bme.readAltitude(SEALEVELPRESSURE_HPA));
217  myFile.print(",");
218
```

```
219  // GPS Data
220  myFile.print(GPS.latitude, 4);
221  myFile.print(",");
222  myFile.print(GPS.longitude, 4);
223  myFile.print(",");
224
225  // MLX Data
226  myFile.print(mlx.readAmbientTempC());
227  myFile.print(",");
228  myFile.print(mlx.readObjectTempC());
229  myFile.print(",");
230  myFile.print(mlx.readAmbientTempF());
231  myFile.print(",");
232  myFile.print(mlx.readObjectTempF());
233  //myFile.print(",");
234
235  myFile.println();
236  myFile.close();
237  delay(500);
238 }
```

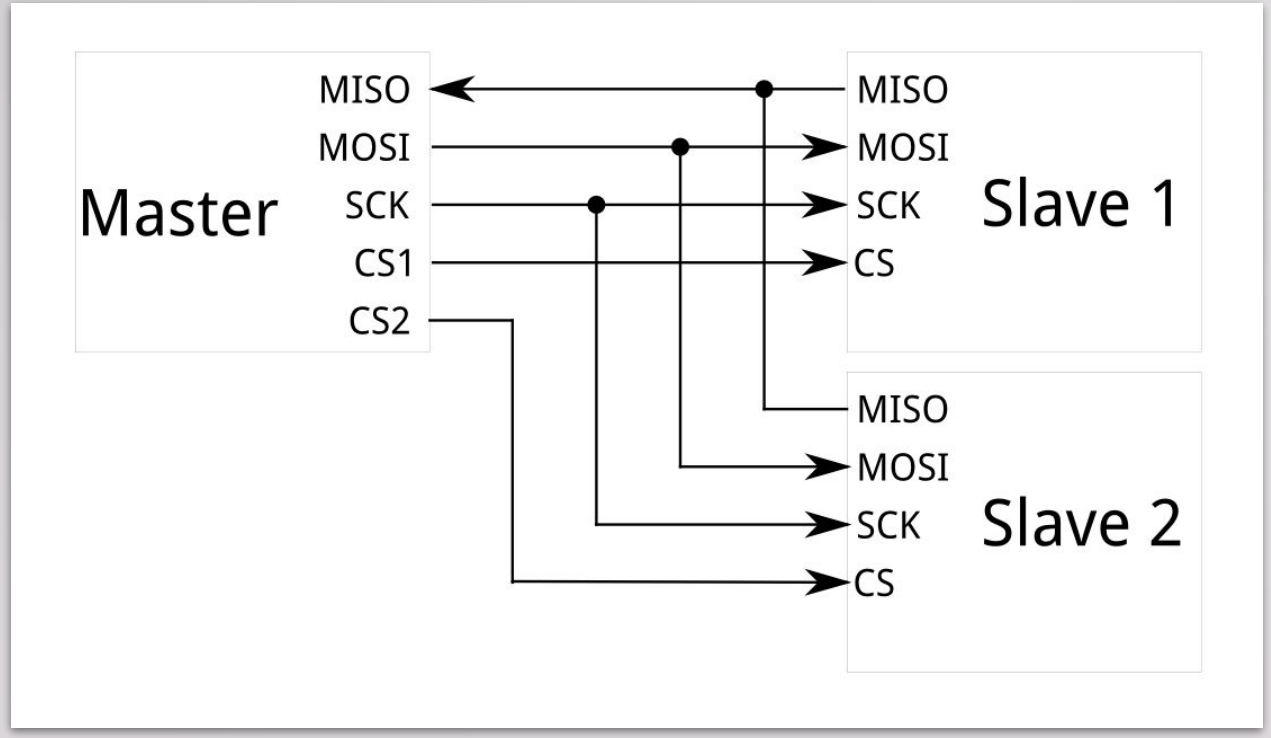
Hardware


BME680
VIN
GND
SDO
CS
3Vo
SCK
SDI


3.3V
EN
VBAT
FIX
TX
RX
GND
VIN
PPS
GTPA013
Ultimate GPS
Breakout v3
adafruit!


MADE
IN ITALY
COMMUNICATION
POWER
ANALOG IN
MEGA
ARDUINO
2560

Communication



Bosch BME680

PARAMETER	
Operation Range (for full accuracy)	
Pressure	300 - 1100 hPa
Humidity	0 - 100%
Temperature	-40 - 85°C
Avg. Current Consumption (1 Hz refresh)	3.7µA
Gas Sensor	
Response time	< 1 s
Sensor-to-sensor deviation	+/- 15 %
Output data processing	Direct output of Index for Air Quality
Humidity Sensor	
Response time	8 s
Accuracy tolerance	± 3 % relative humidity
Hysteresis	≤ 1.5 % relative humidity
Pressure Sensor	
RMS Noise	0.12 Pa
Sensitivity Error	± 0.25 %
Temperature coefficient offset	± 1.3 Pa/K

MLX90616 IR Thermometer

$$A = \pi (h \tan(X))^2.$$

MT3339 All-in-one GPS

$GPRMC,081836,A,3751.65,S,14507.36,E,000.0,360.0,130998,011.3,E*62

```
$GPBOD - Bearing, origin to destination
$GPBWC - Bearing and distance to waypoint, great circle
$GPGGA - Global Positioning System Fix Data
$GPGLL - Geographic position, latitude / longitude
$GPGSA - GPS DOP and active satellites
$GPGSV - GPS Satellites in view
$GPHDT - Heading, True
$GPR00 - List of waypoints in currently active route
$GPRMA - Recommended minimum specific Loran-C data
$GPRMB - Recommended minimum navigation info
$GPRMC - Recommended minimum specific GPS/Transit data
$GPRTE - Routes
$GPTRF - Transit Fix Data
$GPSTN - Multiple Data ID
$GPVBW - Dual Ground / Water Speed
$GPVTG - Track made good and ground speed
$GPWPL - Waypoint location
$GPXTE - Cross-track error, Measured
$GPZDA - Date & Time
```


```
$GPBOD - Bearing, origin to destination
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$GPWPL - Waypoint location
$GPXTE - Cross-track error, Measured
$GPZDA - Date & Time
```
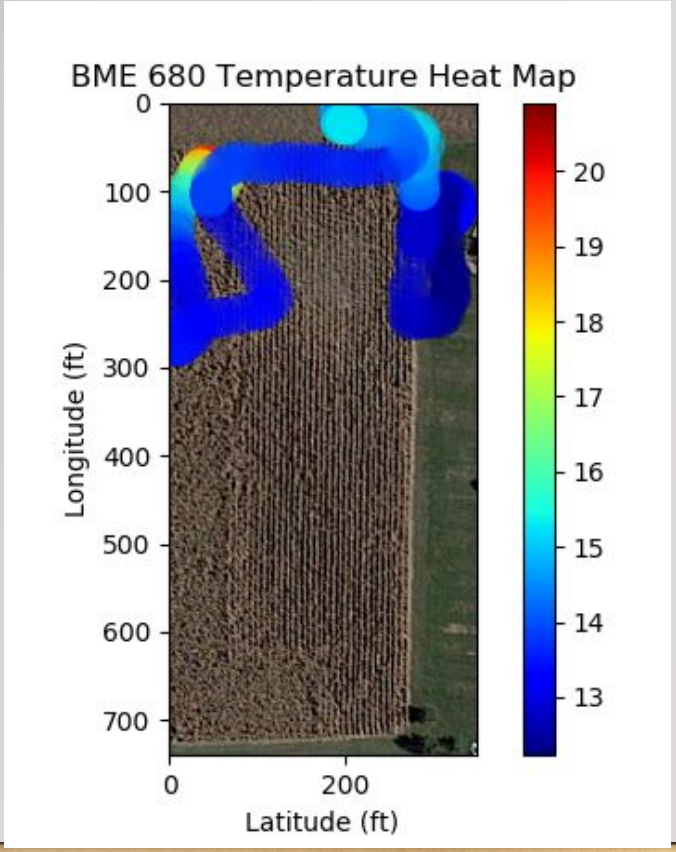
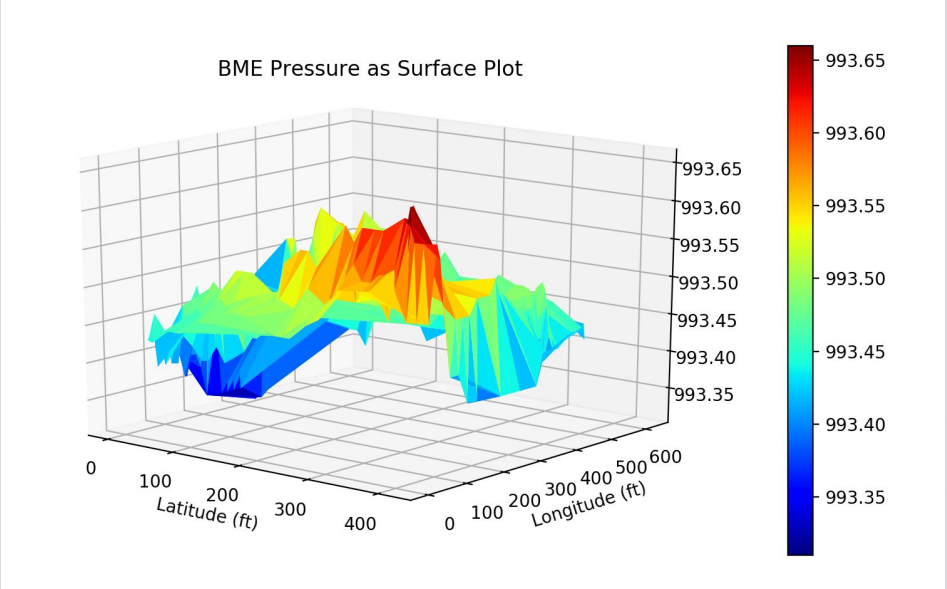

MicroSD Card Reader/Writer

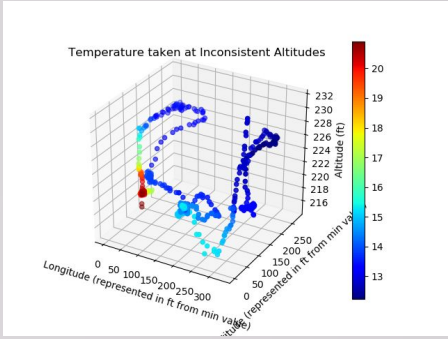
BMEtemp, BMEpress, BMEhumid, BMEgas, BMEalt, GPSlat, GPSlong, IR_ambC, IR_objC, IR_ambF, IR_objF

```
19.96,992.31,34.31,247.33,175.99,3958.0629,8816.5019,18.01,10.79,64.42,51.42
20.03,992.29,34.21,247.52,175.99,3958.0676,8816.5019,18.05,10.71,64.49,51.28
20.09,992.27,34.12,247.33,175.99,3958.0708,8816.5019,18.09,10.37,64.56,50.67
20.14,992.29,34.03,248.26,175.82,3958.0764,8816.5019,18.13,10.41,64.63,50.74
20.20,992.33,33.95,246.96,175.82,3958.0786,8816.5009,18.17,10.33,64.71,50.59
20.26,992.33,33.89,247.33,175.48,3958.0788,8816.5009,18.17,9.89,64.71,49.80
20.33,992.33,33.84,247.52,175.48,3958.0788,8816.5009,18.15,10.33,64.67,50.59
20.38,992.37,33.79,246.59,175.65,3958.0786,8816.4990,18.19,10.31,64.74,50.56
20.42,992.37,33.77,244.94,175.14,3958.0786,8816.4980,18.21,10.27,64.78,50.49
20.46,992.37,33.79,244.58,175.31,3958.0791,8816.4970,18.21,10.37,64.78,50.59
```

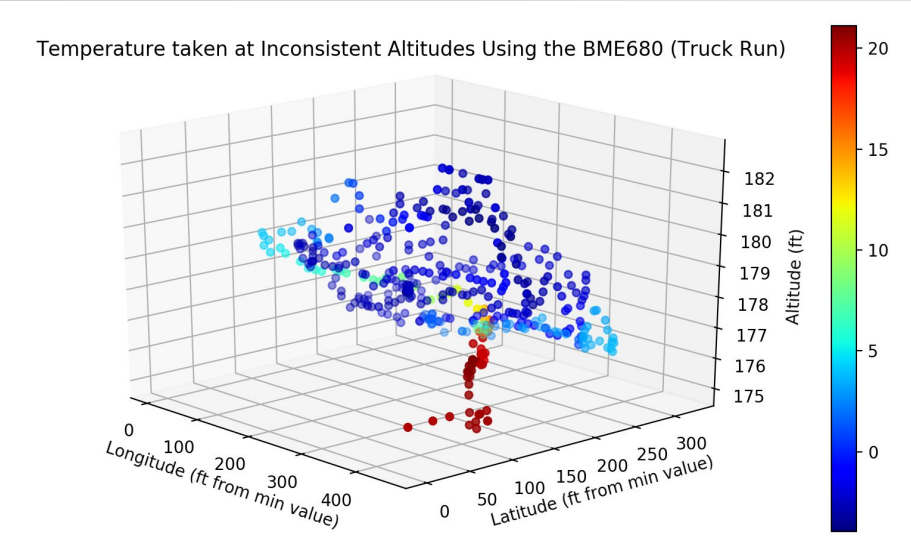
Offline Analysis

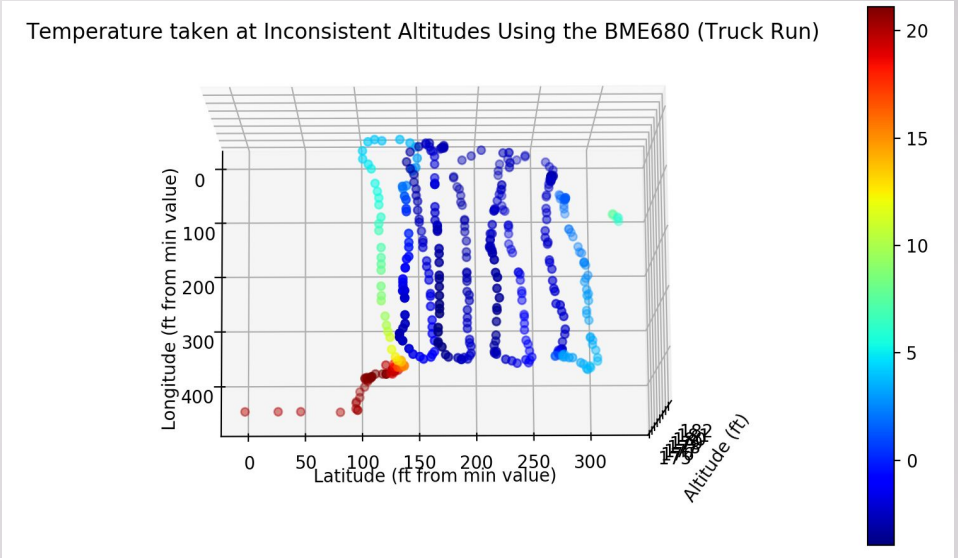




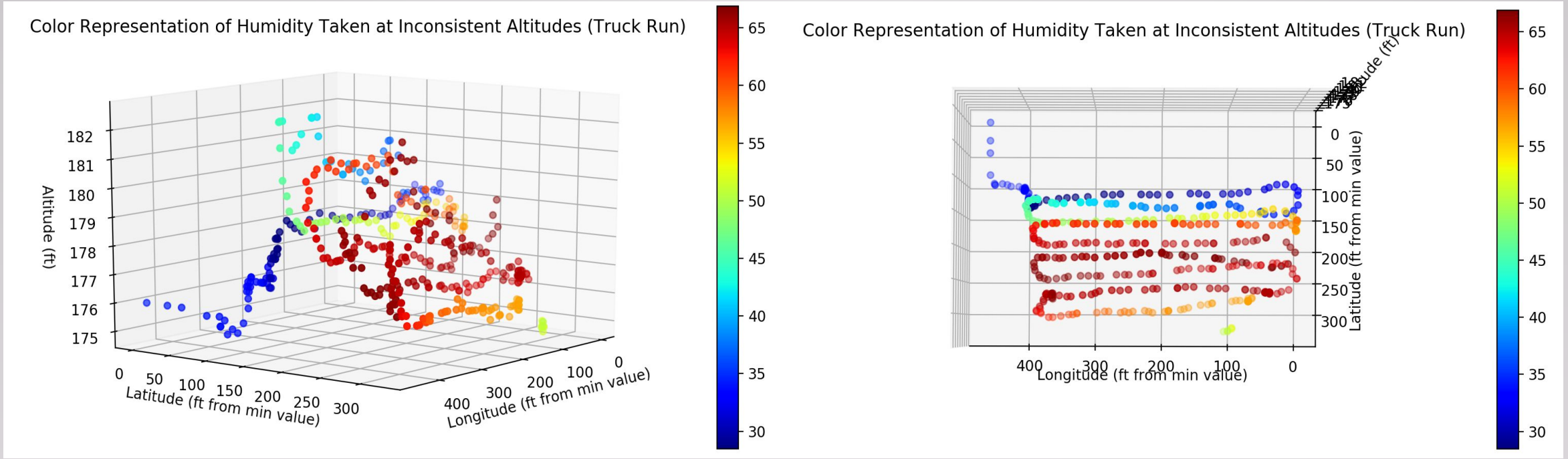


Truck Runs

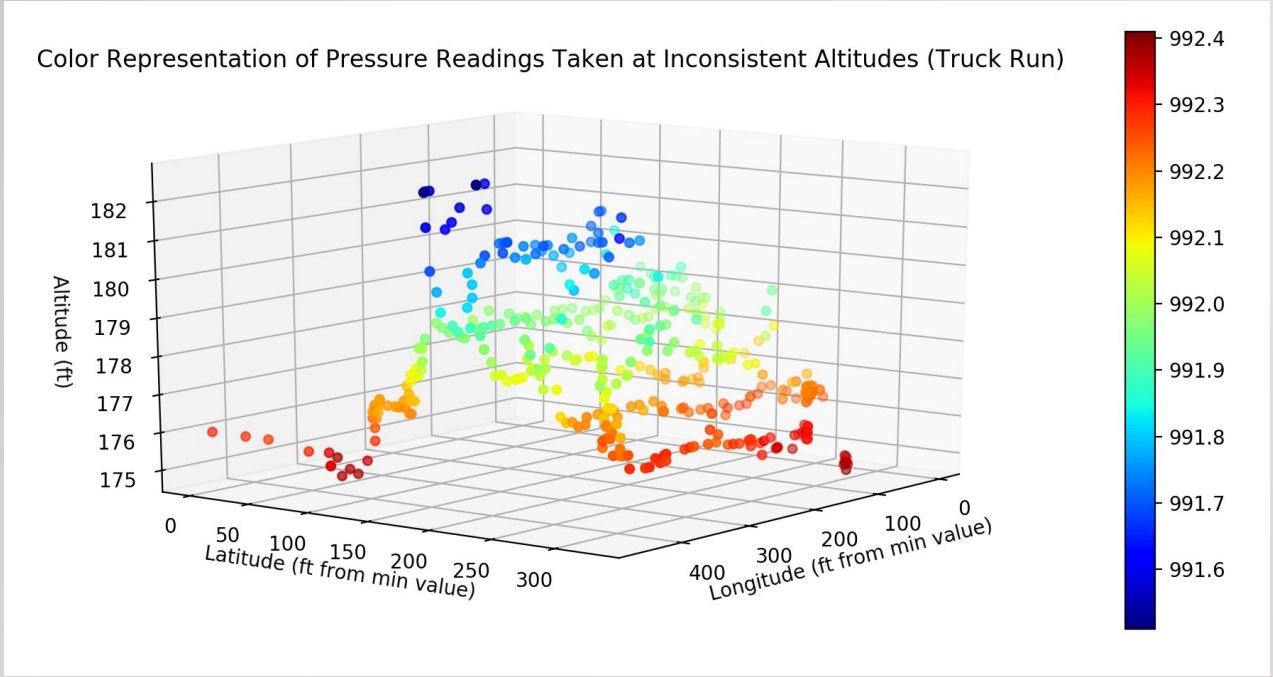

Temperature taken at Inconsistent Altitudes Using the BME680 (Truck Run)
Longitude (ft from min value)
Latitude (ft from min value)
Altitude (ft)
20
15
10
5
0

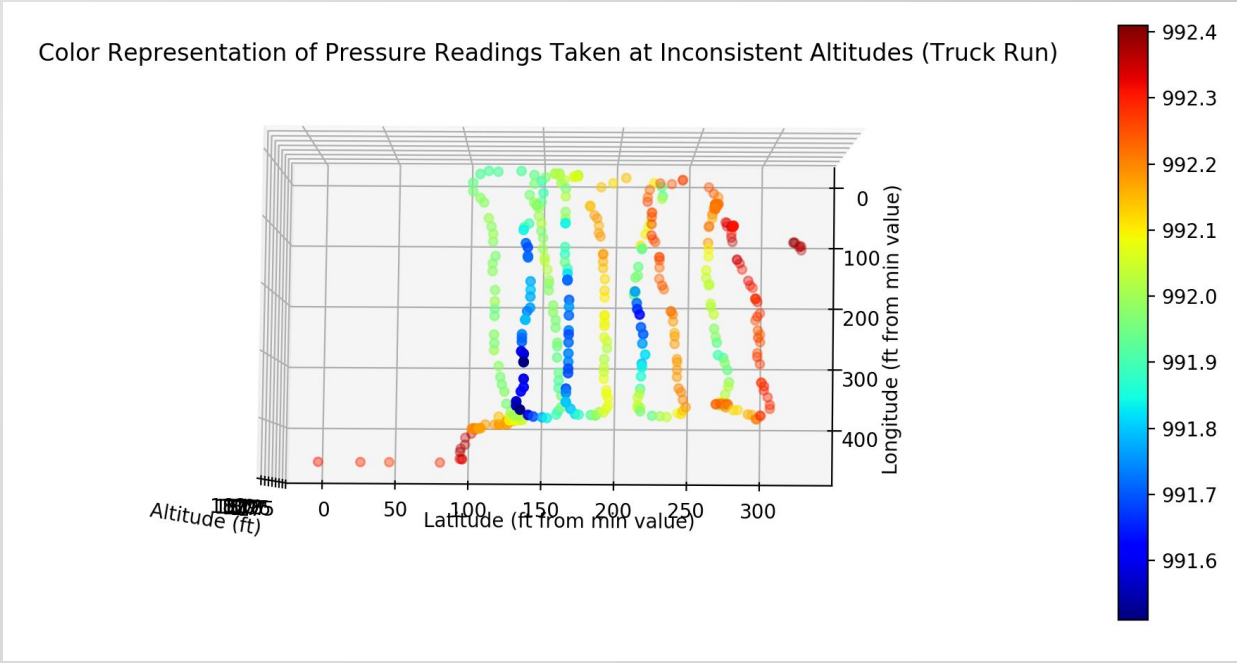

Temperature taken at Inconsistent Altitudes Using the BME680 (Truck Run)
Longitude (ft from min value)
Latitude (ft from min value)
Altitude (ft)
20
15
10
5
0

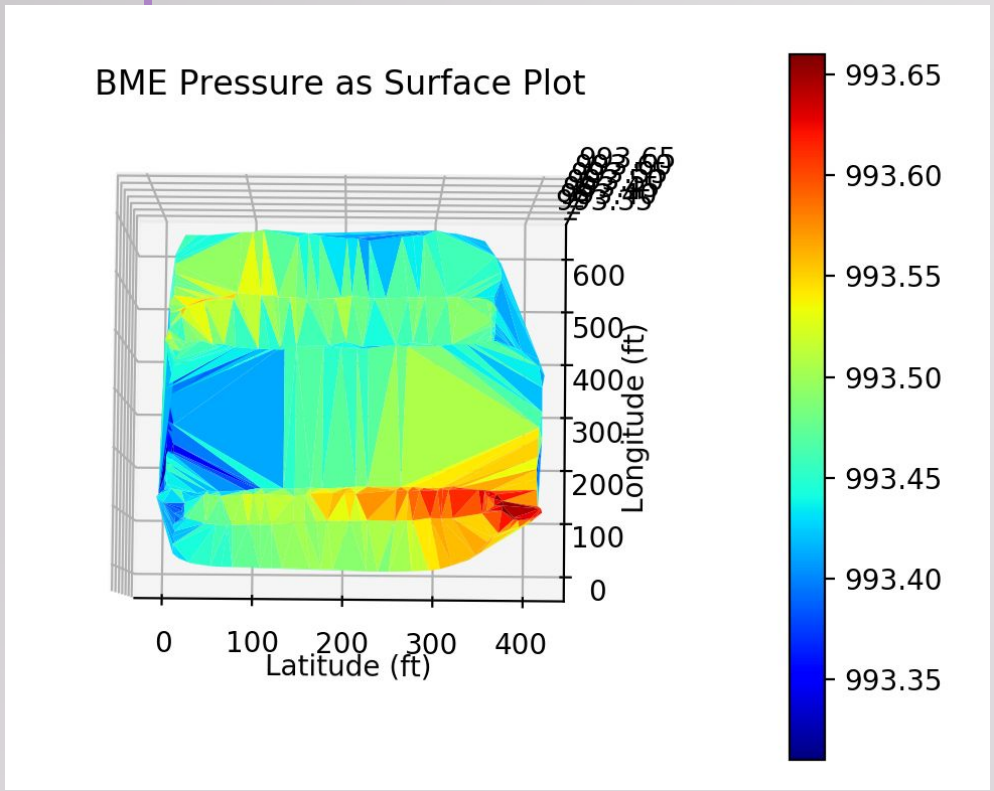
Truck Runs

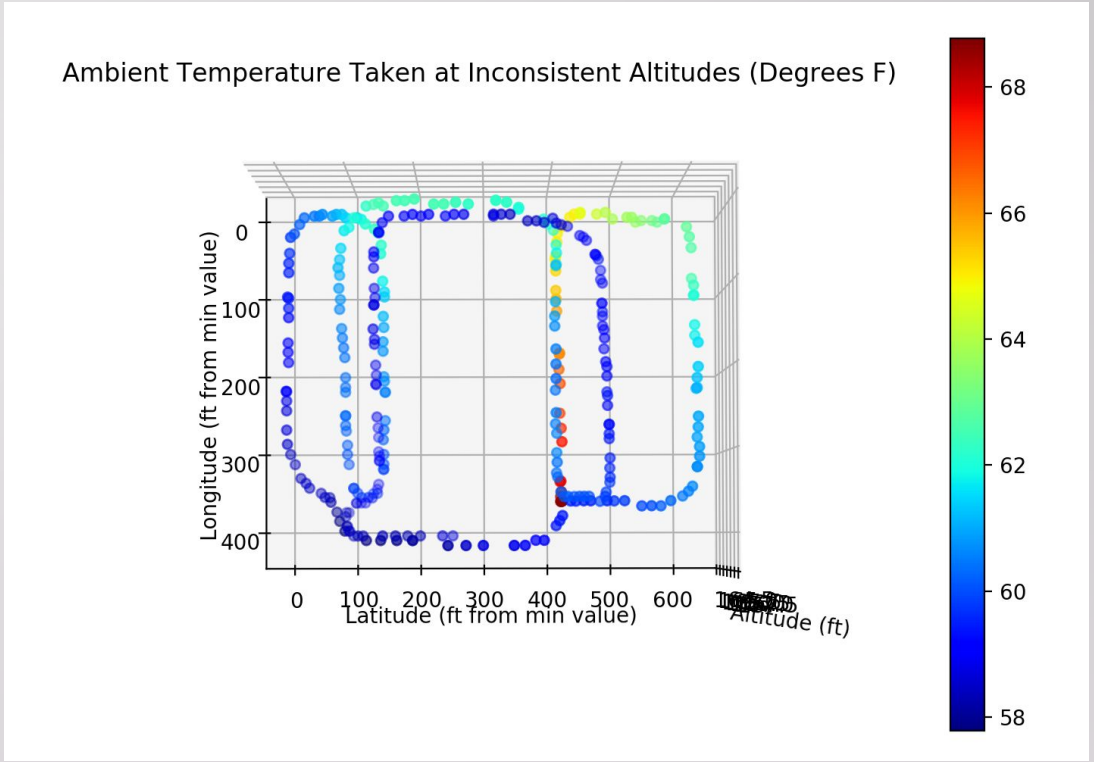

Color Representation of Humidity Taken at Inconsistent Altitudes (Truck Run)
Altitude (ft)
182
181
180
179
178
177
176
175
0
50
100
150
200
250
300
Latitude (ft from min value)
400
300
200
100
0
Longitude (ft from min value)
65
60
55
50
45
40
35
30
Color Representation of Humidity Taken at Inconsistent Altitudes (Truck Run)
Latitude (ft from min value)
Longitude (ft from min value)
400
300
200
100
0
65
60
55
50
45
40
35
30

Truck Runs

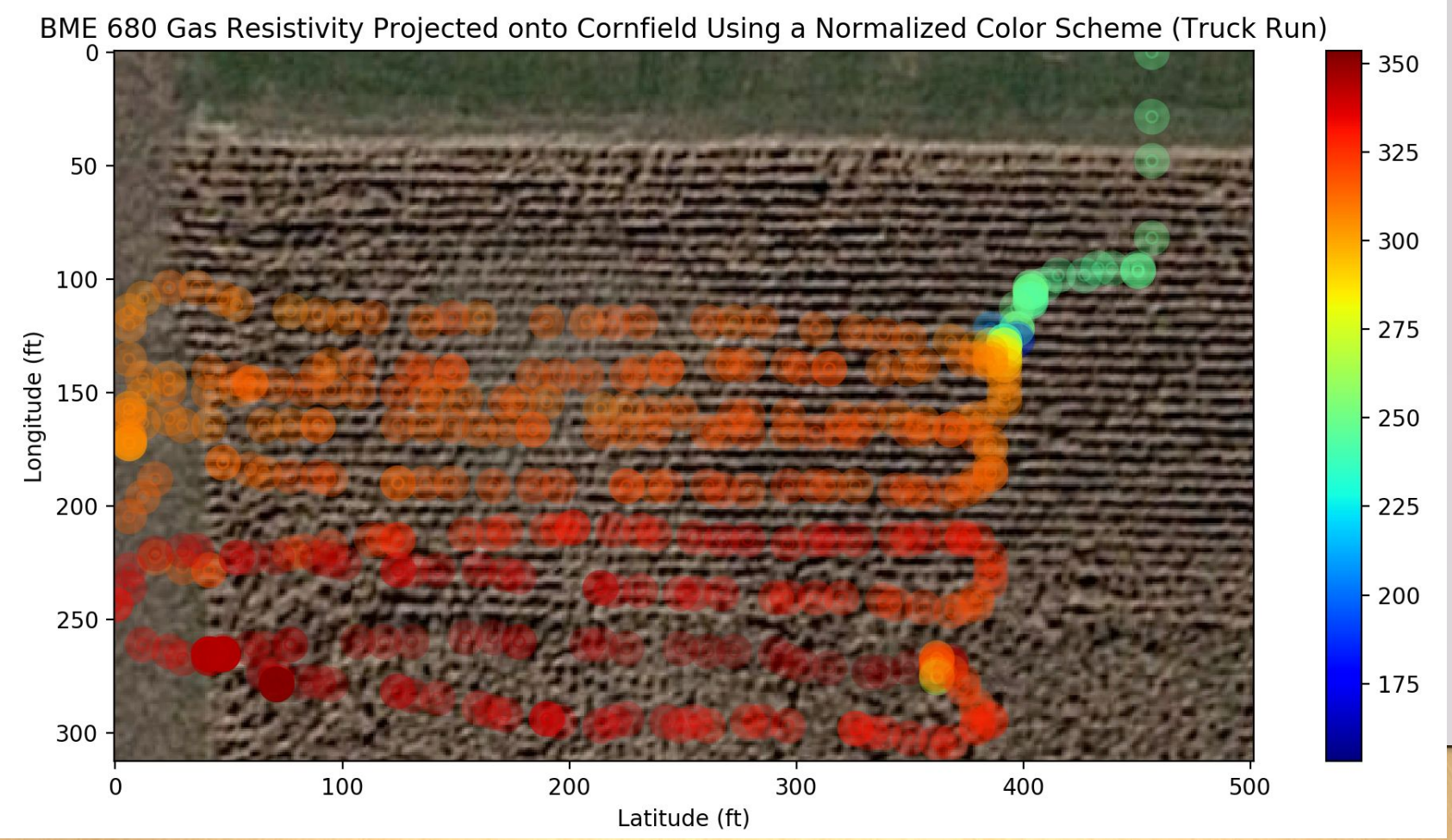

Color Representation of Pressure Readings Taken at Inconsistent Altitudes (Truck Run)
Altitude (ft)
182
181
180
179
178
177
176
175
0
50
100
150
200
250
300
Latitude (ft from min value)
0
100
200
300
400
Longitude (ft from min value)
992.4
992.3
992.2
992.1
992.0
991.9
991.8
991.7
991.6


Color Representation of Pressure Readings Taken at Inconsistent Altitudes (Truck Run)
0
50
100
150
200
250
300
Latitude (ft from min value)
0
100
200
300
400
Longitude (ft from min value)
992.4
992.3
992.2
992.1
992.0
991.9
991.8
991.7
991.6


BME Pressure as Surface Plot
993.65
993.60
993.55
993.50
993.45
993.40
993.35
600
500
400
300
200
100
0
Longitude (ft)
0
100
200
300
400
Latitude (ft)

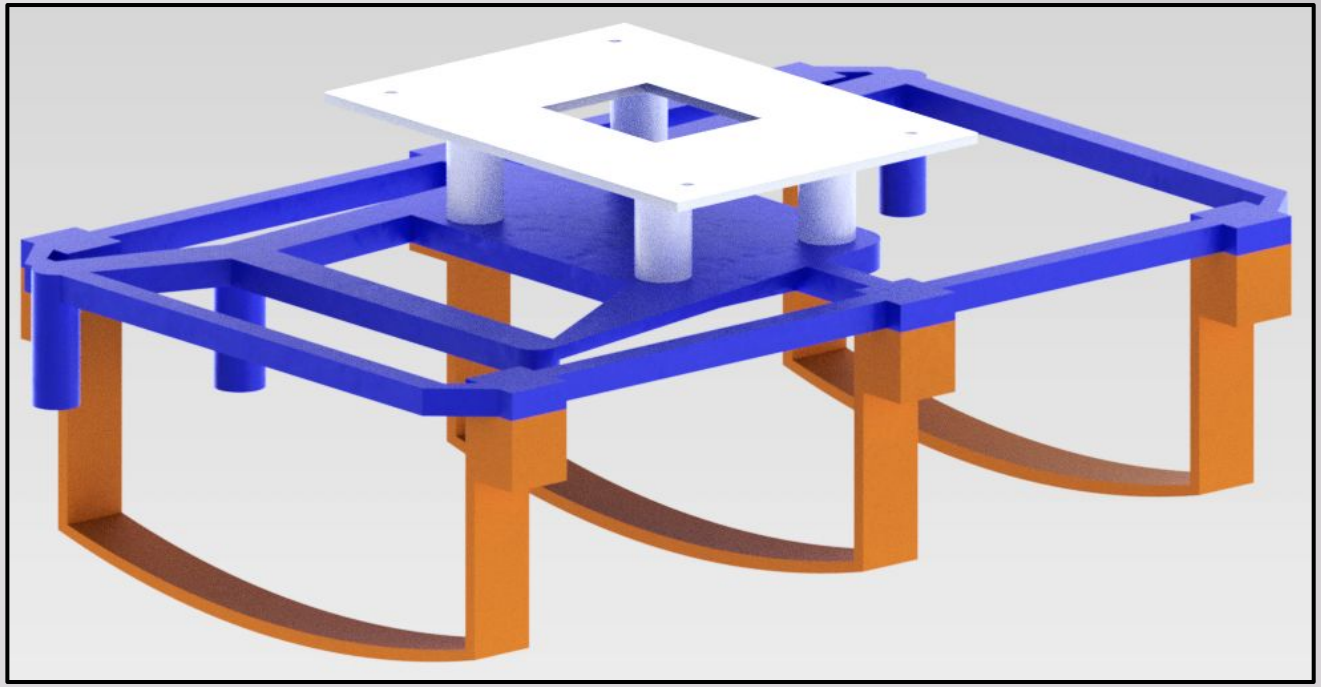

Ambient Temperature Taken at Inconsistent Altitudes (Degrees F)
68
66
64
62
60
58
0
100
200
300
400
Longitude (ft from min value)
0
100
200
300
400
500
600
Latitude (ft from min value)
Altitude (ft)

Truck Runs


BME 680 Gas Resistivity Projected onto Cornfield Using a Normalized Color Scheme (Truck Run)
Longitude (ft)
0
50
100
150
200
250
300
Latitude (ft)
0
100
200
300
400
500
350
325
300
275
250
225
200
175

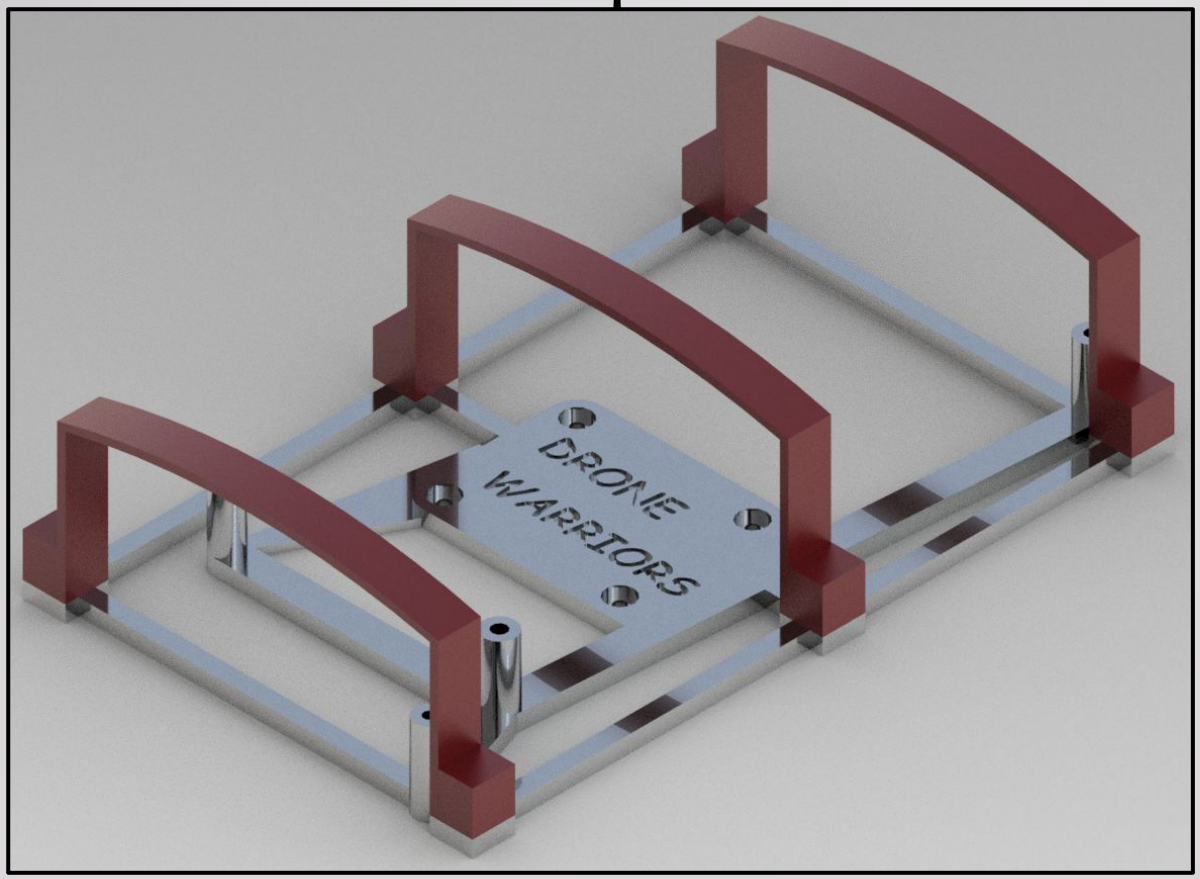
The Roll Cage

- Designer
  - Designer: Justin Languido
  - Program: Autodesk Inventor 2019
- Design Constraints
  - Low weight
  - Open yet protective
  - Secure attachments
  - Justin is clumsy
- Materials
  - Polylactic acid
  - Cyanoacrylate

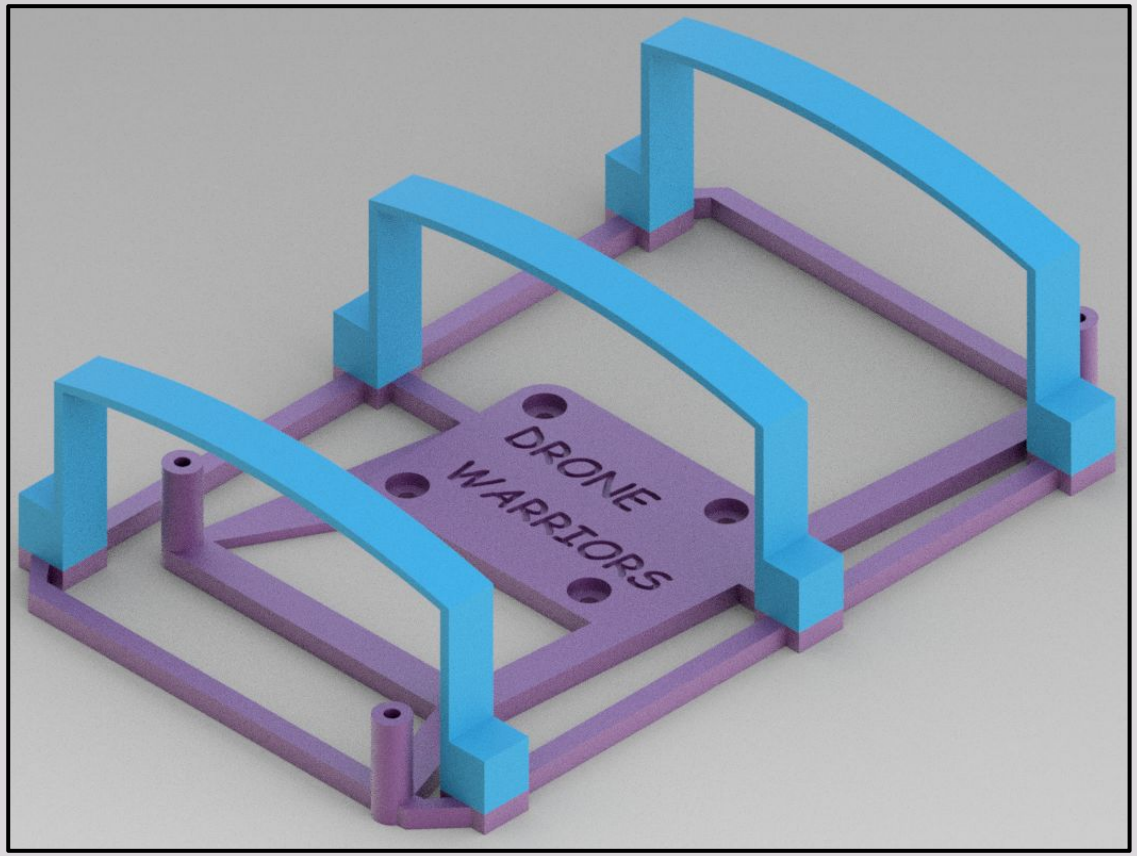


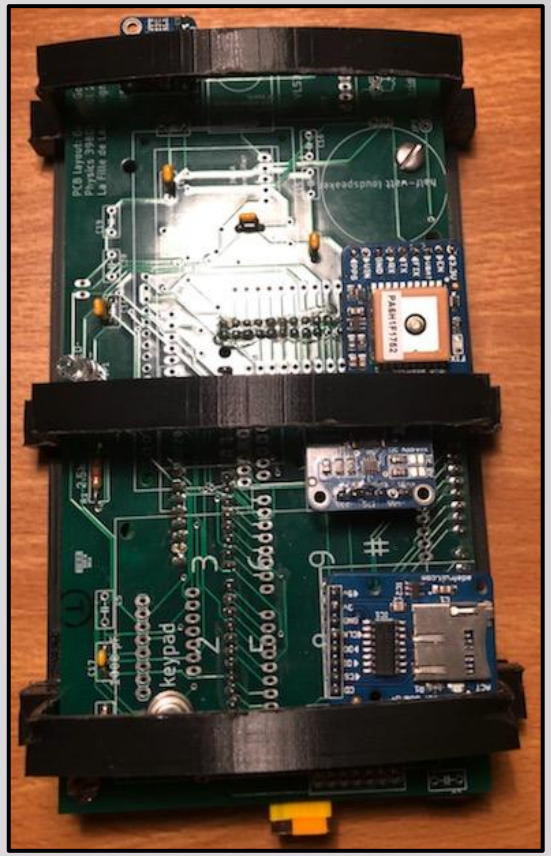
Pictured: Crossbars (Orange), Main body V2 (Blue), Harness designed by Professor Gollin (White)

Version 1: Computer Render and Physical Prototype

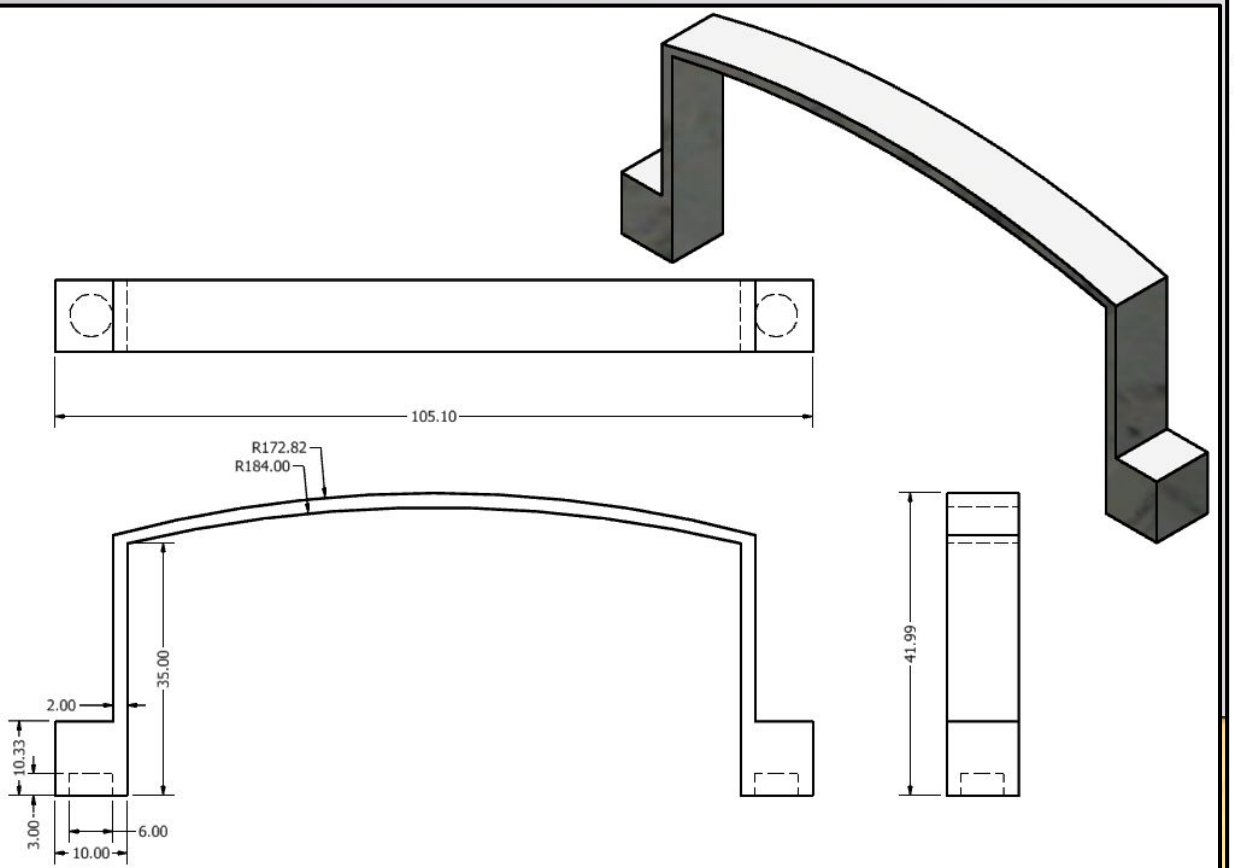


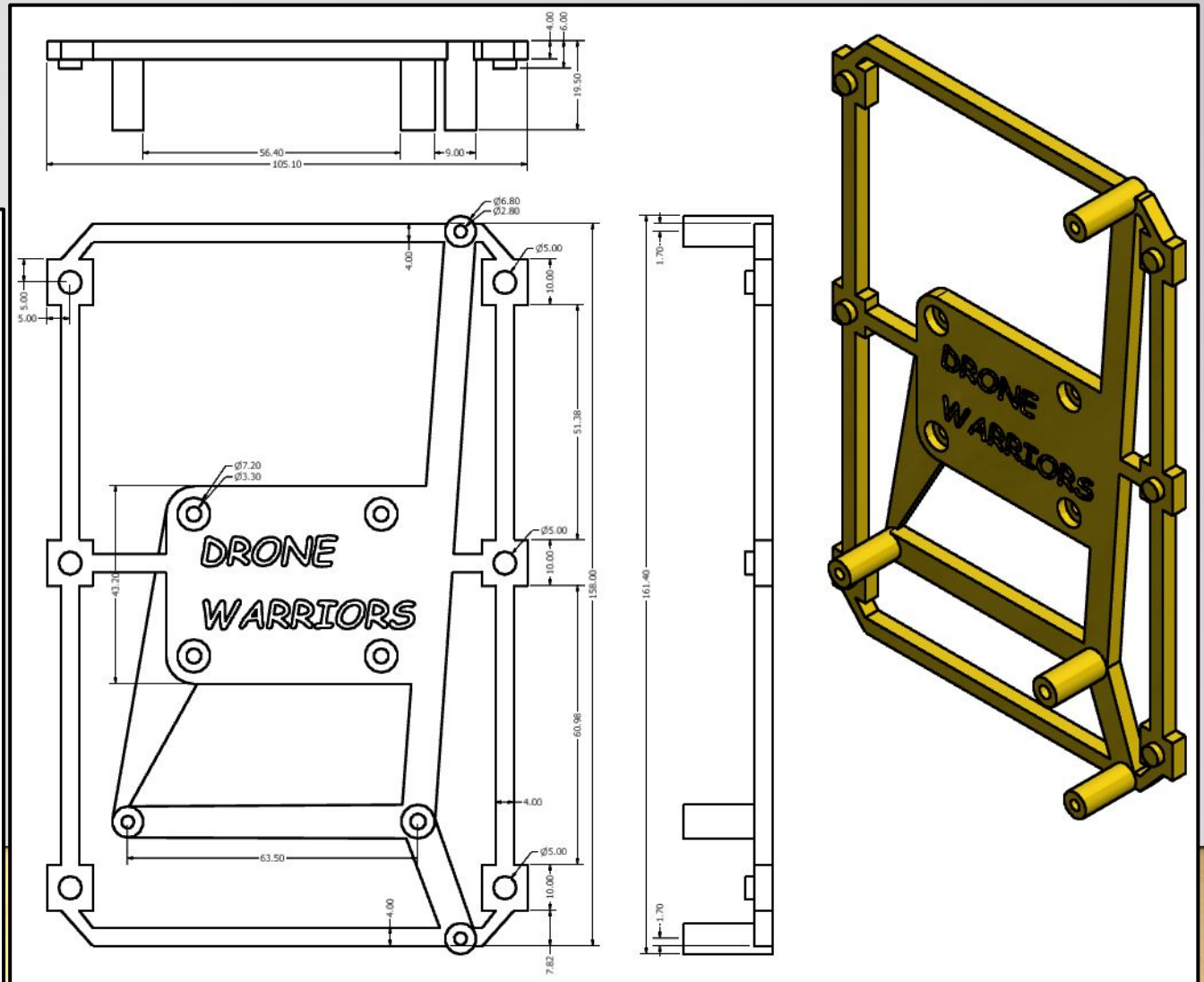
Version 2: Computer Render and Final Design





Schematics


105.10
R172.82
R184.00
35.00
2.00
10.33
3.00
6.00
10.00
41.99


4.00
6.00
19.50
56.40
9.00
105.10
Ø6.80
Ø2.80
Ø5.00
5.00
5.00
4.00
10.00
51.38
Ø7.20
Ø3.30
DRONE
WARRIORS
Ø5.00
10.00
43.20
158.00
60.98
4.00
Ø5.00
63.50
10.00
4.00
7.82
1.70
161.40
1.70
DRONE
WARRIORS

Future Works

- Get more densely-packed data using a drone
- Take runs with more high-end sensors and compare to initial runs
- Redesign instrument package to be more compact