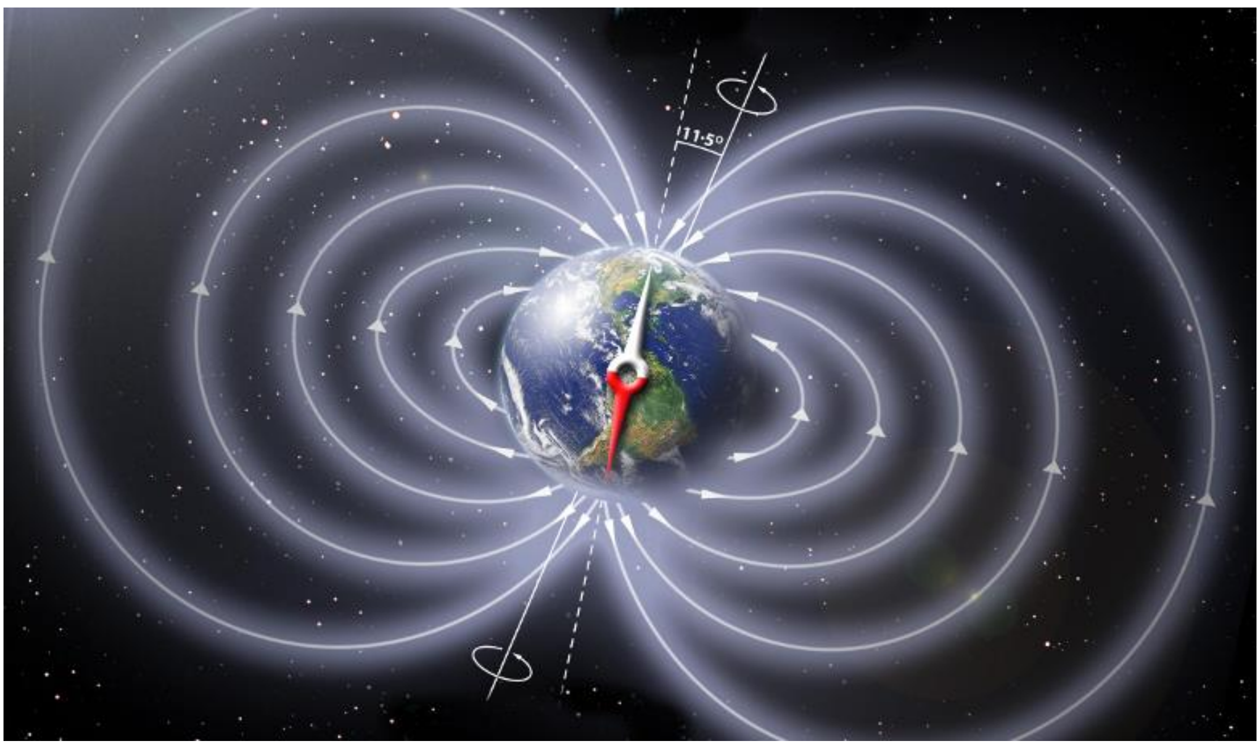
CALIBRATING THE MAGNETOMETER SENSOR



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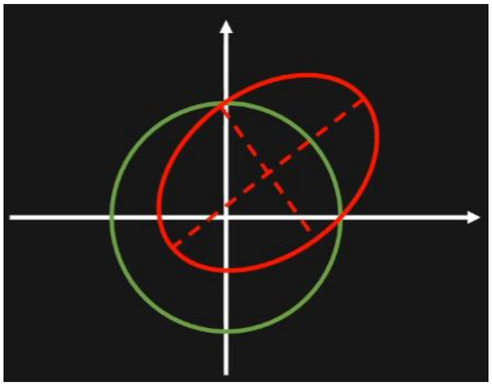
1. **What are the Magnetometers?**
   - Basic 3 compasses
   - 3 orthogonal magnets flux sensors, measures magnetic field vector
   - Earth's magnetic field – North – Compass heading
   - Drones, airplanes, satellites
2. **Error Modelling**



   a. **Error Modelling**

   In the Error Modelling, to get some of common errors in the mathematical model in a magnetometer and to describe them such as Scale Factor, Misalignment Error, Bias Error, Hard Iron Error, Soft Iron Error.

   b. **Scale Factor**

   Alright, this is not really an error due to noise, but we will require some form of scaling for the input in order to generate outputs that fall within our desired range.

   c. **Misalignment Error**

   When setting up the sensors on module, the 3 axis will most probably be somewhat misaligned because we can never position it perfectly. This causes the measurement axis to be skewed such that it is not exactly orthogonal.

   d. **Bias Error**

   The bias error is the error that shifts the measurement values away from the actual value by a fixed amount. If the mean of the actual measurement is 100, then having a bias of 10 would mean that the mean of the measurement reading will be 110.

   e. **Hard Iron Error**

   Hard iron errors appear due to the presence of permanent magnets and remanence of magnetized iron.

f. Soft Iron Error

Soft iron errors appear due to the presence of material that influences or distorts a magnetic field but does not necessarily generate a magnetic field itself.

3. Measurement Model

Using the mathematical model of the above errors, I can then summarize the measurement model

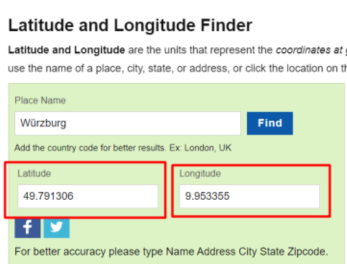
4. Calibration Model

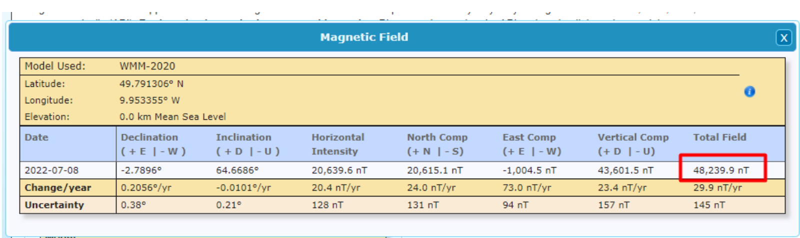
Using the Mathematical Model of the errors, we will get the measurement model of Magnetometer sensor. With the above measurement model, I can now manipulate the equation to make h the subject instead.

5. Calibration Code

For the Norm of Magnetic or Gravitational Field, you can go to this website (https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml#igrfwmm)

and you can put the latitude and longitude of your place and get the total field as nT.



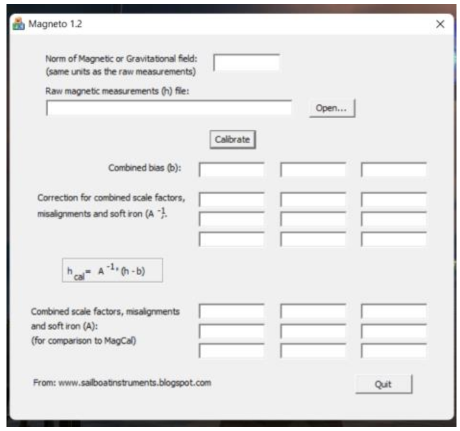


Magnetic Field

Model Used:	WMM-2020
Latitude:	49.791306° N
Longitude:	9.953355° W
Elevation:	0.0 km Mean Sea Level

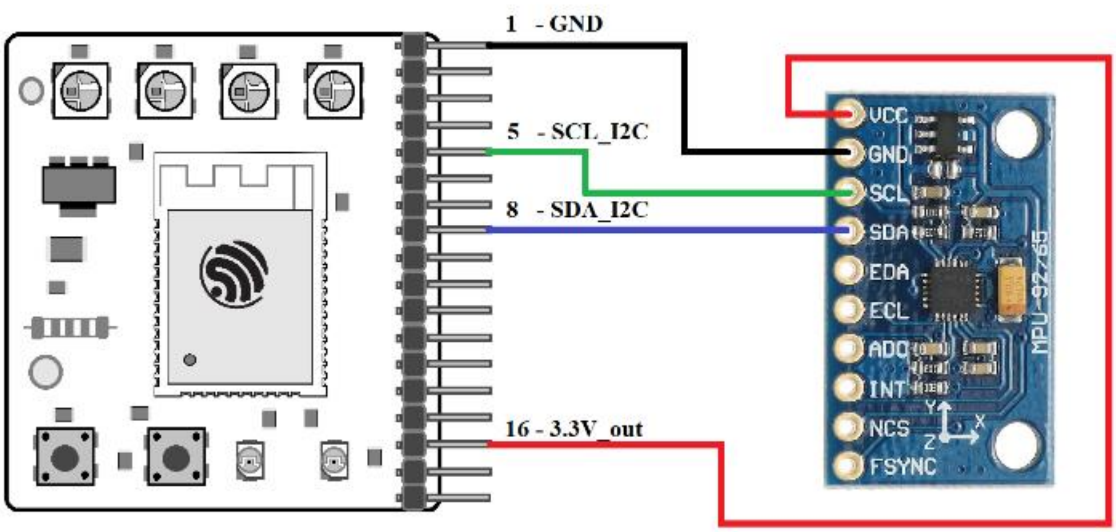
Date	Declination (+ E | - W)	Inclination (+ D | - U)	Horizontal Intensity	North Comp (+ N | - S)	East Comp (+ E | - W)	Vertical Comp (+ D | - U)	Total Field
2022-07-08	-2.7896°	64.6686°	20,639.6 nT	20,615.1 nT	-1,004.5 nT	43,601.5 nT	48,239.9 nT
Change/year	0.2056°/yr	-0.0101°/yr	20.4 nT/yr	24.0 nT/yr	73.0 nT/yr	23.4 nT/yr	29.9 nT/yr
Uncertainty	0.38°	0.21°	128 nT	131 nT	94 nT	157 nT	145 nT

To Calibrate magnetometer on ESPrtk using Magneto 1.2, Magnetic measurements will be subjected to distortion. These distortions are considered to fall in one of two categories: hard or soft iron.

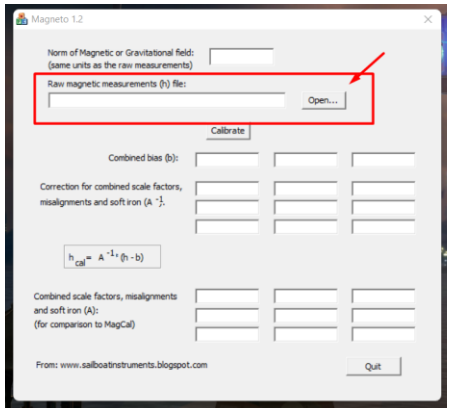


To inside the "Magnetic Field" of the Magneto 1.2 program, the program provides the combined bias(b) as World Magnetic Model (WMM).

While running the log-mag-reading.py file in the terminal, it should be connected to the computer as Arduino Board, then you can rotate the Arduino board differently orientations to collect the data that obtained magnetometer date.



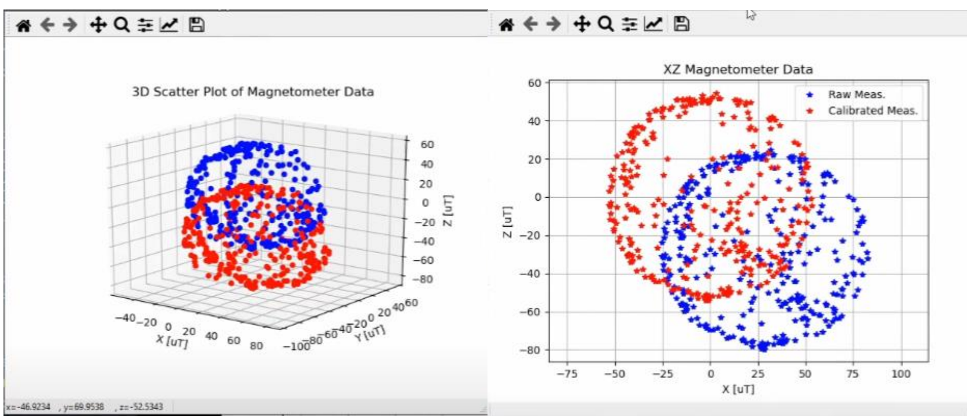
After that, you have got the .txt file date as magnetometer sphere.



The .txt file imports the programming directly from you, and click " calibrate " and The .txt file will be provided to combines bias and correction for combined scale factors misalignment and soft Iron. That parameters data, you can put A and b array inside the plot-calibration-data.py file.

6. Result and Conclusion

As a result, depending on the place's latitude and longitude, to provide the magnetic field and in order to log-mag-reading.py file, you can rotate different orientational of Arduino Board to collect the data of magnetometer sensor.



With these datas, to run the plot-calibration-data.py file, the python code will be obtained the 3D scatter plot of magnetometer date plot that shows two different shapes, as blues is uncalibrated sphere and red is calibrated measurements in the different axis(x,y,z).