# Lab 3: Magnetics Part II

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Due: Before your next lab session

## Overview

Magnetic surveys are useful when trying to identify a target, which has a significant contrast in magnetic susceptibility with the background material. Some examples include unexploded ordinance (UXO) detection, locating steel infrastructure, and mineral exploration. Last week, you collected data over re-bar buried on the beach. This week, we will process and interpret those data.

Given all of the datasets collected by your lab session your task is to now formulate an interpretation, which is consistent with the data. Some of the difficulties that you may encounter during this process include: inconsistencies between data collected by different groups, noise-contaminated data, outliers, and data ambiguities resulting from incomplete field notes.

Some of the questions require calculation and plotting. You can choose your preferred methods to do the work (software, calculator, screenshot or by hand).

## Raw data (Q1 – Q3)

Q1: The provided spreadsheet contains the raw data from both lab sessions. Analyze the data from your lab session and identify the data points that you consider to be outliers. Highlight those outliers which you are excluded from processing in red.

Q2: In both tables, calculate the mean value and the standard deviation of data for each location. Complete the column "Mean" and "Std. dev.".

Q3: In the two tables, circle or cross out the standard deviations that your consider are unacceptably large. Depending on your tolerance, the mean values with a large standard deviation may need to be excluded for quality control purposes. The tolerance that you choose for the standard deviation is _____.

## Base station correction

The profile data contains the anomaly caused by the re-bar and an unknown variation in the background field during the survey. In order to isolate the anomaly, a base station was established to measure the fluctuation of the background field, which will be subtracted from the profile data. Ideally there would be a separate magnetometer set up at the base station location to automatically measure variations in the background field every second or so. This detailed time series could then be used to remove what are known as diurnal variations from the profile measurements. Since we only have start and finish base station measurements for each group we might have to assume that the variations between these measurements is linear and interpolate to calculate a correction value.

Q4: In the spreadsheet provided calculate the group drift which provides a measure of how much the base station readings varied from a group's starting to ending base station measurement. Also calculate group shift values to determine how much of a change in base station measurements is recorded between the end of one group and the beginning of the following group. What are two factors that could cause variations in base station measurements between groups? Be sure to print and include the completed spreadsheet and accompanying graphs with your lab report.

Q5: Looking at the plot of the base station measurements as a function of time and the group drift and shift measurements what is the range of variation in the base correction values. Do you believe that these variations are significant or negligible? Why?

## Interpretation

Q6: Since the profile cuts the re-bar perpendicularly, let's assume the anomaly was caused by an induced magnetic dipole in the cross section of the re-bar. In the space provided below create a sketch of this induced magnetic dipole response and plot the profile of expected total field measurements. In the sketch be sure to include vectors showing the direction of the inducing field ($B_o$) and the direction of magnetization in the susceptible target. Draw magnetic field lines radiating outwards from the target to help visualize the strength and orientation of the induced anomalous response. Be sure to label north and south on both the sketch and plot.

Air

Earth

Total Field

Along Line
Location
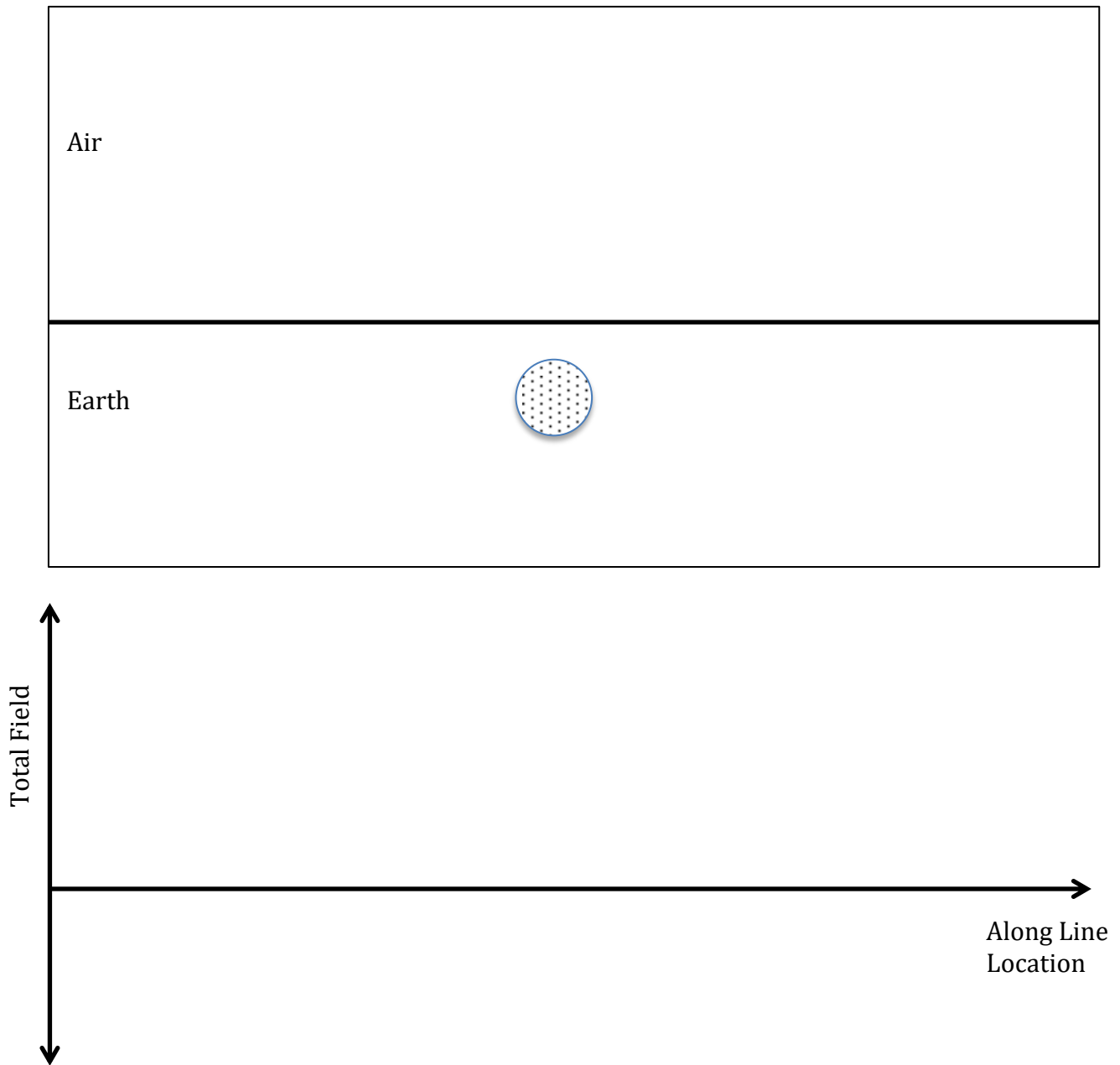
Q7: Using the plot of your profile measurements we will now attempt to estimate
the depth of burial of the re-bar. On the plot, measure the half-width of the anomaly
and use it to estimate the vertical distance between the magnetometer and the re-
bar. Draw a dot just beneath the x-axis of the plot to mark your estimate of the along
line location of the re-bar.

An illustration of the half-width of an anomaly. For a monopole the depth of burial is 0.5 $x_{1/2}$. For a dipole the depth of burial is $x_{1/2}$.
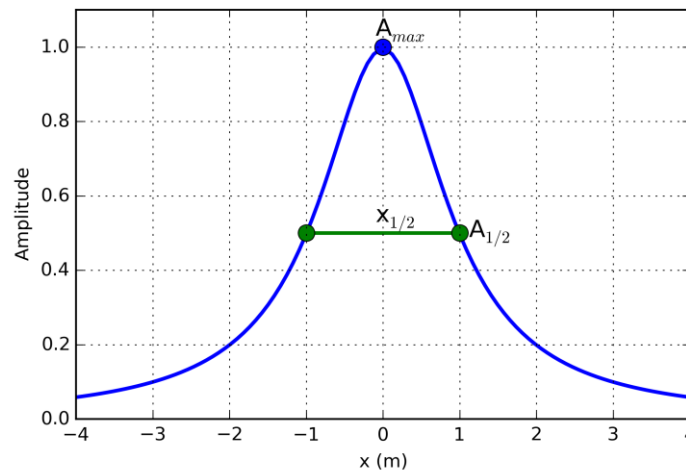


Q7: The magnetometer was 190cm above the surface. Using the vertical distance between the re-bar and the magnetometer in the previous plot, your best estimate of the burial depth is _____. Does your estimate match the true depth of 30 cm below the surface? If yes, explain why the half-width method works well. If not, list some possible reasons.

Q8: Next, we use simulation-based approaches to extract more information from the data. Compile the data from the "Location" and "Mean" columns into a plain text, csv file "rebar.csv"; keep column headers. Be sure to sort the data by location (smallest to largest). For example, the first few lines can look like

```
Location,Mean
1,54301
2,54312
3,54324
…
```

Save or upload "rebar.csv" to the folder where "Mag_FitProfile.ipynb" is located. Open the gpgLabs notebook "Mag_FitProfile.ipynb". Find the section labeled "#Input parameters". Change "filename" to 'rebar.csv', so the notebook will load the data file you just created. Run the notebook. Make a rebar model by changing "dx" and "dz" to 0.02, changing "dy" to 3, and changing "x0" to the peak location. In the last section, set "Binc" to 70, "Bigrf" to ~54210. Adjust "depth" and "susc" so that the simulated curve can fit the survey curve (comp=tf, irt=induced). Take a screenshot of your best data fit plot and report your values for "depth" and "susc".

Q9: The rebar may contain remanent magnetization that makes it difficult to fit the data using only the "induced" magnetization. Now switch to irt = total. Adjust "Q", "rinc" and "rdec" to see whether you can fit the data better. Take a screenshot of your best data fit plot and report your values for "Q", "rinc" and "rdec".

## The lost Re-bar

A re-bar used for the shovel search was lost after the first day of a previous year's lab. Nobody found it with the shovel on subsequent days, so after all lab sessions were finished, the TA's surveyed the entire area using the magnetometer. The table below contains the total field [nT] data that was collected.

| North | East = 0 | East = 1 | East = 2 | East = 3 | East = 4 | East = 5 | East = 6 |
|-------|----------|----------|----------|----------|----------|----------|----------|
| 0 | 54319 | 54317 | 54318 | 54312 | 54308 | 54307 | 54304 |
| 1 | 54314 | 54311 | 54314 | 54310 | 54307 | 54305 | 54299 |
| 2 | 54302 | 54295 | 54301 | 54308 | 54303 | 54300 | 54294 |
| 3 | 54296 | 54267 | 54289 | 54304 | 54303 | 54299 | 54288 |
| 4 | 54301 | 54284 | 54298 | 54307 | 54303 | 54299 | 54286 |
| 5 | 54310 | 54308 | 54311 | 54311 | 54305 | 54303 | 54298 |
| 6 | 54314 | 54317 | 54314 | 54312 | 54305 | 54304 | 54304 |
| 7 | 54316 | 54314 | 54315 | 54313 | 54305 | 54304 | 54305 |
| 8 | 54315 | 54315 | 54314 | 54313 | 54308 | 54304 | 54305 |
| 9 | 54314 | 54314 | 54312 | 54312 | 54306 | 54304 | 54307 |

Q10: On the total field magnetic data map below, circle the anomaly that you consider is responsible for the lost re-bar.

Q11: The anomaly of the re-bar looks like a **monopole / dipole** model (circle one).

Q12: Most of the anomaly is due to **induced / remanent** magnetization (circle one). Explain why.
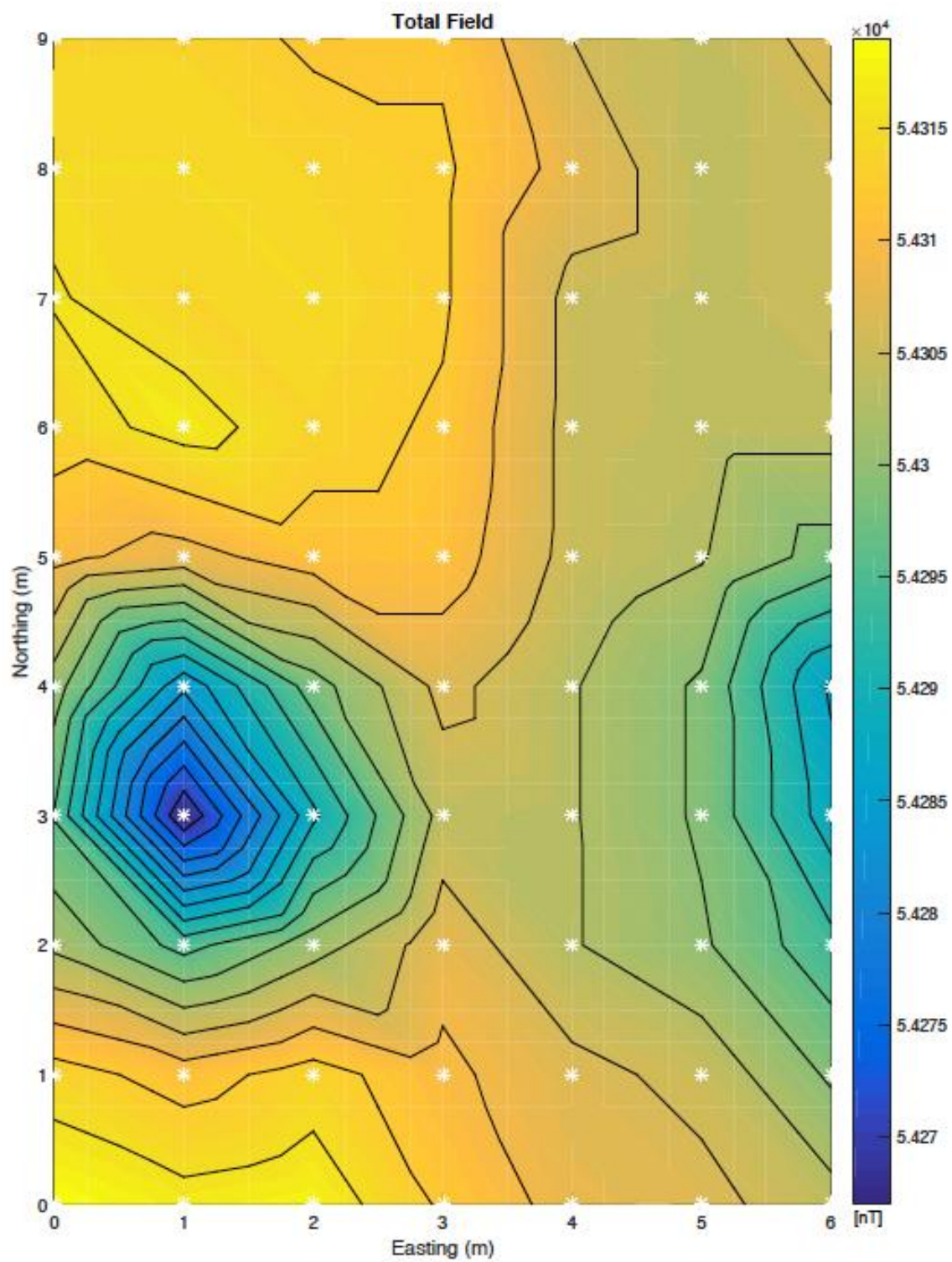
**Total Field**

Q13: Using the data in the table, plot a total field profile along a N-S line at Easting = 1 m. Be sure to include your plot in this report. Let's assume the inclination is 90 degree. Use the half-width method on the plot to determine the depth of the top of re-bar. Try the half-width method for both monopole and dipole models and discuss which one gives a more reliable result. Your estimated depth of burial is _____.