# 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 following two tables contain the raw data from one of the lab sessions. In the tables, identify the data points that you consider are outliers (circle or cross out in the tables). Those outliers which you are excluded from the processing.

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 ______________.

## Table 1: Magnetic data along the profile across the re-bar

| Group | Time | Location | 1 | 2 | 3 | 4 | 5 | Mean | Std. dev. | Correction | Corrected |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3:12 | 0 | 54030 | 54322 | 54319 | 54320 | | | | | |
| | 3:13 | 4 | 54320 | 54319 | 53094 | 54316 | 54318 | | | | |
| | 3:14 | 8 | 54319 | 54320 | 54317 | | | | | | |
| | 3:15 | 12 | 54342 | 54337 | 54336 | 54336 | | | | | |
| | 3:16 | 16 | 54410 | 54409 | 54411 | 54407 | 54409 | | | | |
| | 3:17 | 20 | 54332 | 54333 | 54331 | 54330 | | | | | |
| 2 | 3:28 | 2 | 54318 | 54318 | 54318 | | | | | | |
| | 3:29 | 6 | 54319 | 54322 | 54317 | 54318 | 54320 | | | | |
| | 3:29 | 10 | 54321 | 54319 | 54322 | 54323 | 54321 | | | | |
| | 3:30 | 14 | 54568 | 54574 | 54576 | 54580 | 54576 | | | | |
| | 3:31 | 18 | 54340 | 54337 | 54340 | 54340 | 54340 | | | | |
| 3 | 3:37 | 1 | 54317 | 54316 | 54314 | 54315 | | | | | |
| | 3:38 | 3 | 54315 | 54316 | 54313 | 54312 | | | | | |
| | 3:38 | 5 | 54317 | 54315 | 54316 | 54313 | | | | | |
| | 3:39 | 15 | 54536 | 54531 | 54531 | 54533 | | | | | |
| | 3:40 | 17 | 54354 | 54356 | 54354 | 54353 | | | | | |
| 4 | 3:47 | 4 | 54320 | 54317 | 54316 | 54321 | 54319 | | | | |
| | 3:52 | 13 | 53507 | 53509 | 53629 | 53469 | 53506 | | | | |
| | 3:55 | 13.5 | 54477 | 54480 | 54479 | 54476 | 54476 | | | | |
| | 3:59 | 13.25 | 54441 | 54441 | 54437 | 54438 | 54435 | | | | |
| 5 | 4:18 | 13 | 54399 | 54257 | 54403 | 54406 | 54407 | | | | |
| | 4:20 | 14.75 | 54579 | 54575 | 54581 | 54576 | | | | | |
| | 4:21 | 13.8 | 54530 | 54532 | 54535 | 54534 | | | | | |
| | 4:22 | 14.5 | 54348 | 54414 | 54394 | 54382 | | | | | |
| | 4:23 | 12.5 | | 54379 | 54523 | 54310 | 54302 | | | | |
| | 4:29 | 14.5 | 54580 | 54552 | 54553 | 54579 | 54583 | | | | |

## Table 2: Magnetic data at the base station

| Group | Time | 1 | 2 | 3 | 4 | 5 | Mean | Std. dev. | Correction |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3:11 | 54309 | 54309 | | | | | | 0 |
| | 3:19 | 53042 | 54117 | 52785 | | | | | |
| 2 | 3:26 | 54310 | 54313 | 54311 | 54313 | | | | |
| | 3:31 | 54309 | 54310 | 54307 | 54309 | | | | |
| 3 | 3:36 | 54313 | 54311 | 54312 | 54313 | | | | |
| | 3:41 | 54304 | 54307 | 54310 | 54312 | | | | |
| 4 | 3:47 | 54312 | 54317 | 54312 | 54315 | 54316 | | | |
| | 3:59 | 54310 | 54308 | 54311 | 54306 | 54312 | | | |
| 5 | 4:16 | 54322 | 54325 | 54324 | 54321 | | | | |
| | 4:28 | 54312 | 54312 | 54314 | 54312 | | | | |

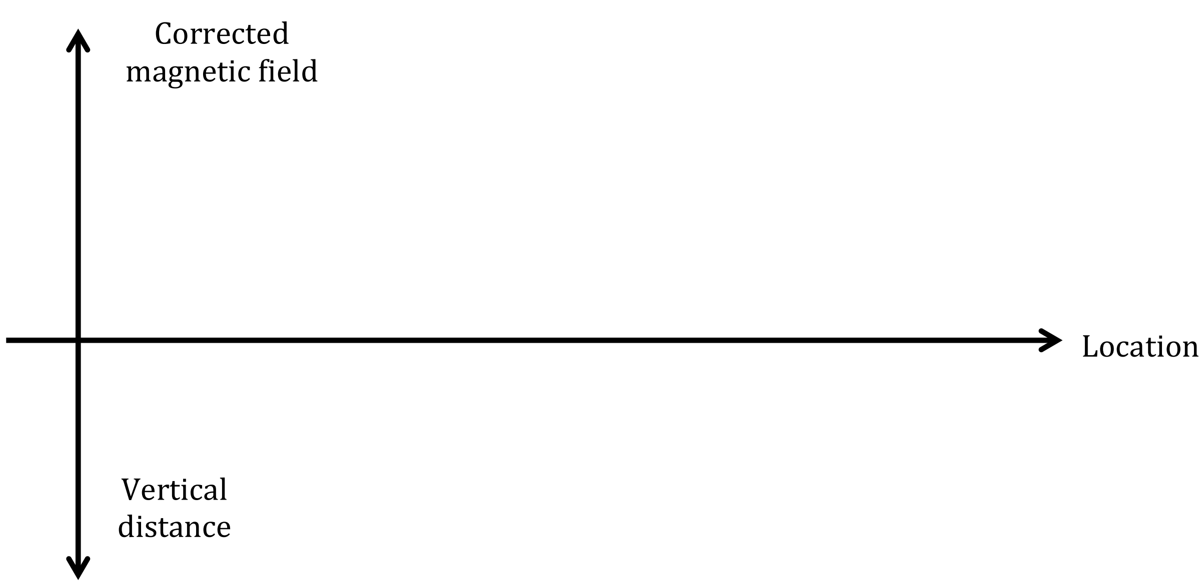
## Base station correction

Q4: 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. Now you need to calculate the values that will be used for correcting the profile data. For convenience, let's set the fluctuation to be 0 at the first base station measurement (3:11PM). Then use the mean values at the base station to calculate the "Correction" (Table 2) at a sequence of time. Next, use a linear interpolation in time to predict the base station correction values in Table 1. Finally, calculate the "Corrected" data in Table 1.

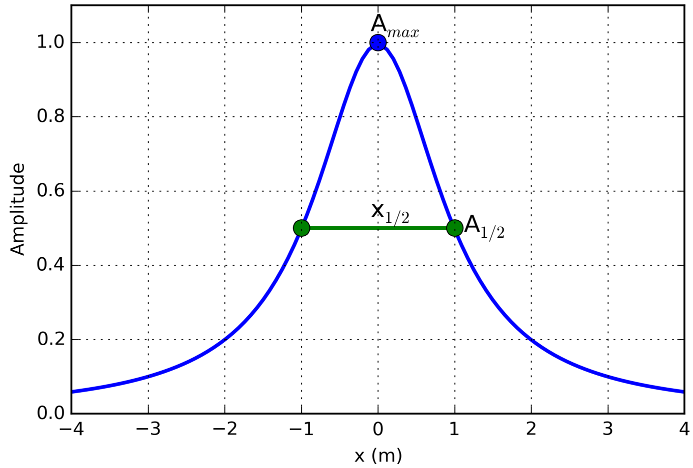
Q5: What is the range of variation in the base correction values? Do you think it is significant or negligible? Why?

## Interpretation

Q6: Create an appropriate grid using the given axes and plot "Corrected" in Table 1 using "Location" as the x-axis. Because 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. On the plot, draw the half-width anomaly and use it to estimate the vertical distance between the magnetometer and the re-bar. Use the x-axis of the anomaly plot as the level of measurement, and draw the estimated location of the re-bar on the cross section. Once the location of the re-bar is determined, draw the magnetic field lines due to the induced dipole and check whether the field data matches the expected shape of anomaly. Note: the magnetic inclination is about 70 degree in Vancouver and the profile goes from north to south.



An illustration of half-width 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 155 cm 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 in "Location" and "Corrected" in Table 1 to a plain text file in csv format "rebar.csv"; keep column headers. For example, the first few lines can look like

```
Location,Corrected
1,54301
2,54312
3,54324
...
```

Save or upload "rebar.csv" to the folder where "Mag_FitProfile.ipynb" is located. Open 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, changing "x0" to the peak location. In the last section, set "Binc" to 70, "Bigrf" to 54310. 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 contains 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 Monday lab. Nobody found it with shovel on Tuesday and Wednesday. After all lab sessions were finished, the TA's surveyed the entire area using the magnetometer. The data are provided as following.

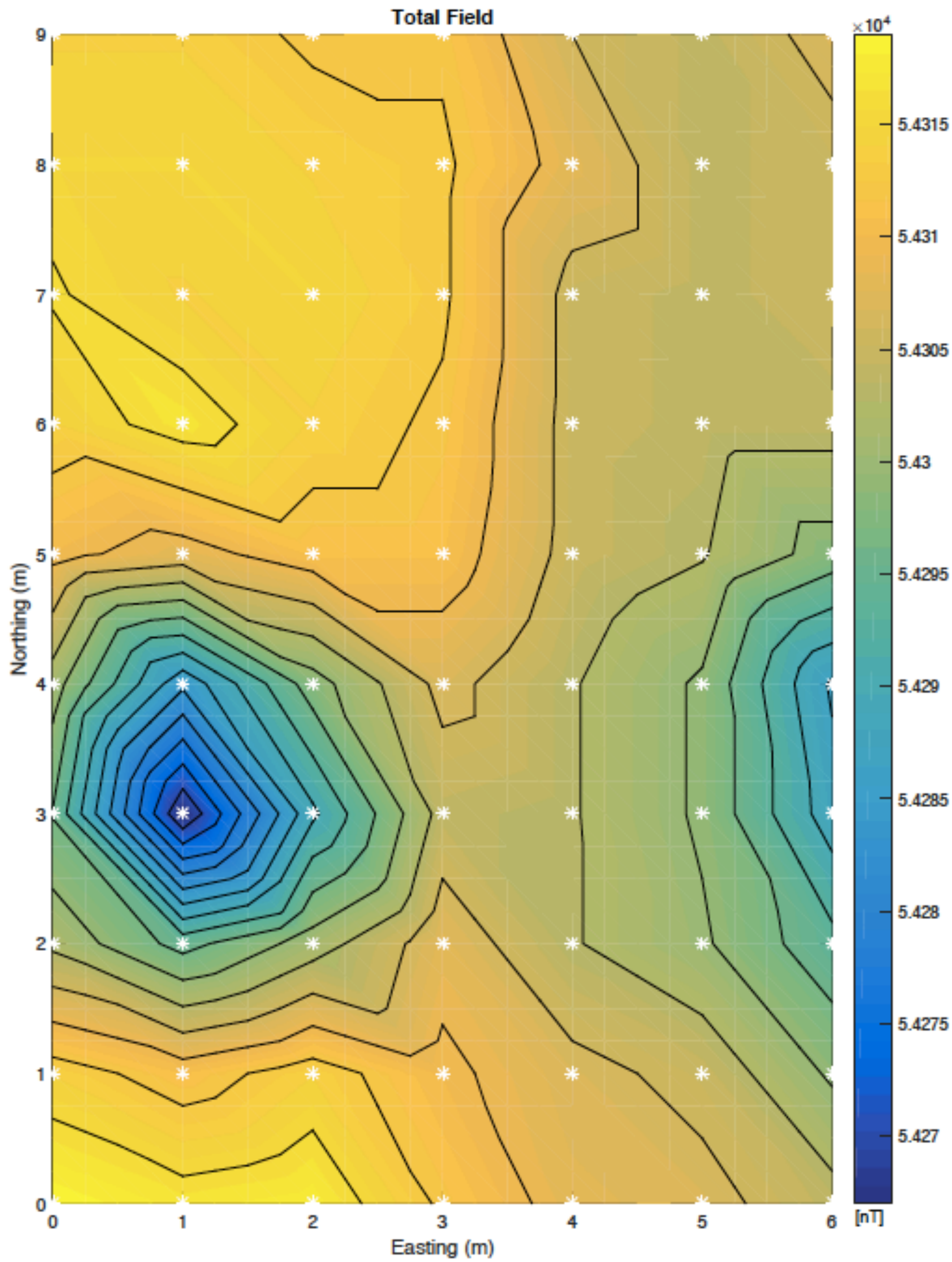
| North | East = 0 | East = 1 | East = 2 | East = 3 | East = 4 | East = 5 | East = 6 |
|---|---|---|---|---|---|---|---|
| 0 | 54319 | 54317 | 54318 | 54312 | 54308 | 54307 | 54304 |
| 1 | 54314 | 54311 | 54314 | 54310 | 54307 | 54305 | 54299 |
| 2 | 54302 | 54295 | 54301 | 54308 | 54303 | 54300 | 54294 |
| 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.

Q13: Using the data in the table, plot a total field profile along an E-W line at North = 3 m. Remember to remove a regional field if you think it is necessary. 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 ______________________.



Total Field
Northing (m)
Easting (m)
×10^4
5.4315
5.431
5.4305
5.43
5.4295
5.429
5.4285
5.428
5.4275
5.427
[nT]