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 collected by students on September 16th, 2019. It also contains raw data collected by the TAs on another tab. Analyze both datasets and identify the data points that you consider to be outliers. Highlight those outliers which you are excluded from processing in red.

Q2: For both datasets, calculate the mean value and the standard deviation of the data for each location. Complete the column "Mean" and "Std. dev.". Remember not to include measurements that you have identified as outliers.

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 was ______________.

Base station correction

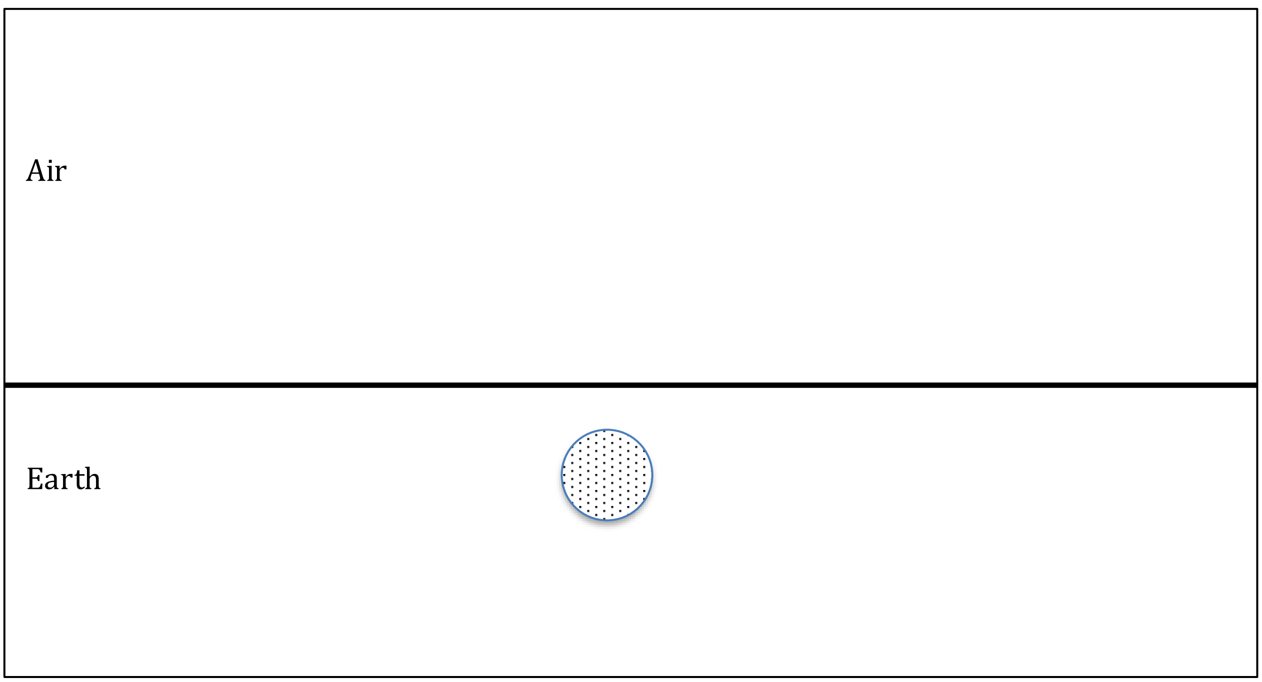
The profile data contains the anomaly caused by the re-bar and an unknown variation in the background field during the survey. In order to isolate the anomaly, a base station was established to measure the fluctuation of the background field, which will be subtracted from the profile data. Ideally there 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?

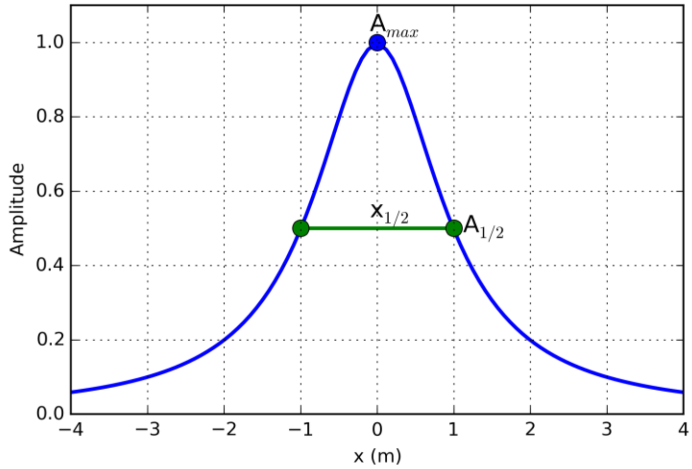
Interpretation

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.



Q7: From field collected data, we will now attempt to estimate the depth of burial of the re-bar. We will use the TA dataset for this because it is higher quality. Use the half-width approimation to estimate the burial depth of the re-bar. Remember that this magnetometer sensor is 190 cm above the ground.

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



a) Should you use the monopole or dipole formula for depth from half-width?

b) What is you maximum amplitude for the anomaly and what is your half-width? Draw this on your Excel printout for the TA data set.

c) What is your estimation of the burial depth? Does this match the true depth of 30 cm? 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. We have compiled the location and average field measurements for TA collected data into a csv file. We will use the Jupyter notebook to load and interpret these data.

Open the gpgLabs notebook "Mag_FitProfile.ipynb". 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 the average measured value in the survey. 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

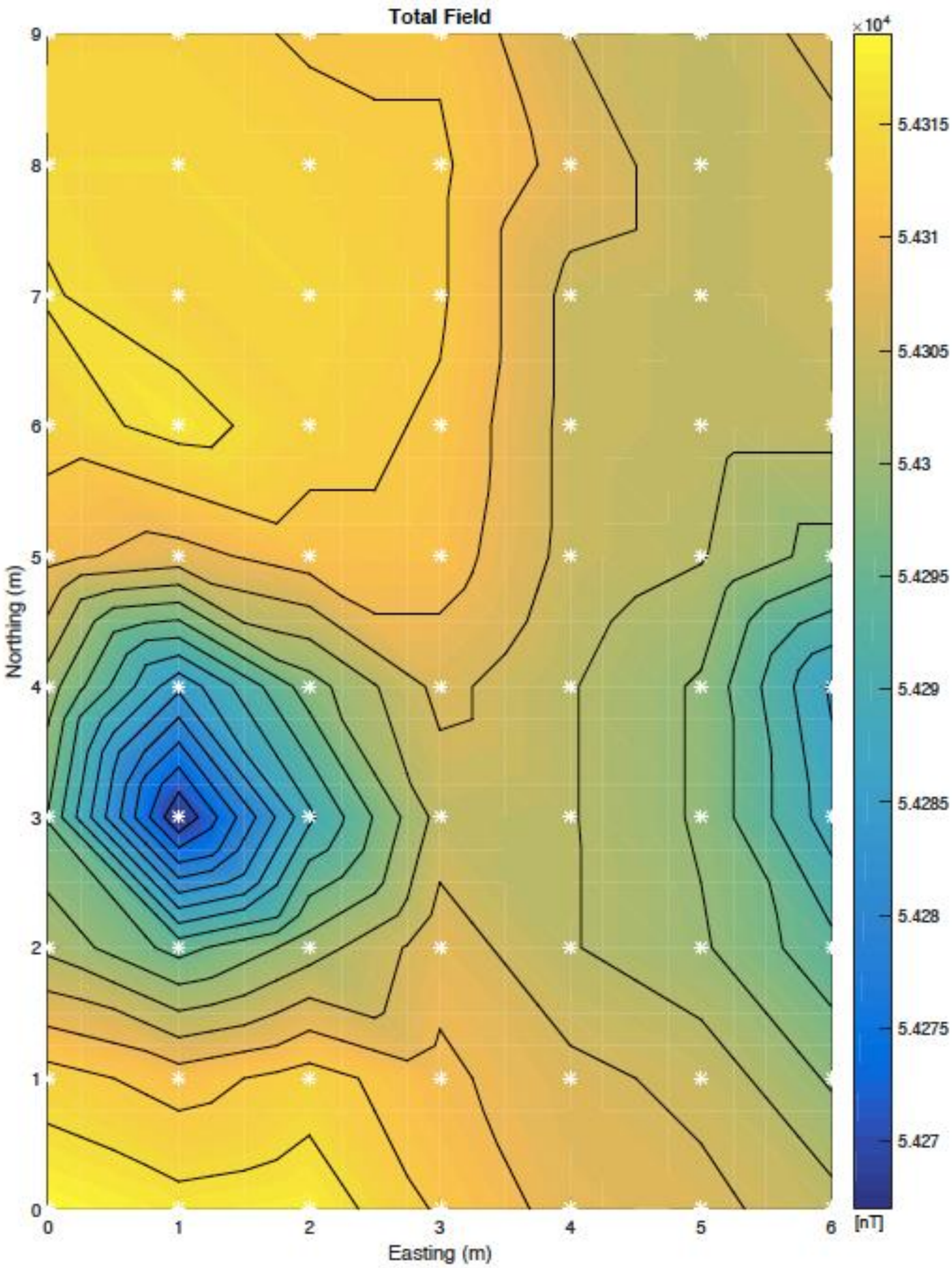
A re-bar used for the shovel search was lost after the first day of a previous year's lab. Nobody found it with the shovel on subsequent days, so after all lab sessions were finished, the TA's surveyed the entire area using the magnetometer. The table below contains the total field [nT] data that was 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: Most of the anomaly is due to **induced** / **remanent** magnetization (circle one). Explain why. (hint: it is negative anomaly, is it possible to have negative anomaly at Vancouver?)

Q12: The anomaly of the re-bar looks like a **monopole** / **dipole** model (circle one). (hint: target is a vertical rebar)



Total Field
Northing (m)
Easting (m)
0
1
2
3
4
5
6
7
8
9
$\times 10^4$
5.4315
5.431
5.4305
5.43
5.4295
5.429
5.4285
5.428
5.4275
5.427
[nT]