Team TBL # 5: Hutchinson and Barta (2000) Geophysical Applications to Solid Waste Analysis Geonics

DUE: Wednesday, November 16, 2016

Overview

In this case history, EM-31 data are acquired over landfills. The data delineate the contaminated areas and are also used to estimate the depth extent of the waste. In your career, it is possible that someone will provide you with a document like this. Rather than accepting everything that is presented to you as scientifically sound, you have enough background to raise questions and decide for yourself what is reasonable and what is questionable. That is, by understanding the fundamentals, you are in a position to think critically.

Instructions

Answer the following questions within the context of the 7 step framework. Your answers should be brief, and point form can be used where appropriate.

- Discuss the case history amongst yourselves
- As a team, answer the following questions
- You will hand this in at the end of the class

Resources

- Hutchinson and Barta (2000)
- Response Function App
- GPG: Dual Loop Systems Geophysical Surveys: Electromagnetics

Investigating the Response Function

Q1. Use the Response Function App to answer the following questions.

a. Using the plots shown in the app, explain how the apparent conductivity is obtained. You may want to adjust the parameters h_1, σ_1, σ_2 and change the boom orientation.

b. Set the parameters to the following: $\sigma_1 = 0.01$, $\sigma_2 = 0.01$, $h_1 = 0.1$, $h_{boom} = 0$. What is the apparent conductivity for each of the boom orientations (horizontal and vertical)?

c. Next, set $\sigma_1 = 0.1$, and keep $\sigma_2 = 0.01$, $h_1 = 0.1$, $h_{boom} = 0$. What is the apparent conductivity for each of the boom orientations?

d. Now set $\sigma_1 = 0.01$, σ_2 0.1, and keep $h_1 = 0.1$, $h_{boom} = 0$. What are the apparent conductivities for each of the boom orientations?

e. Set $\sigma_1 = 0.01$, $\sigma_2 = 0.1$ and increase h_1 to 1.5. What are the apparent conductivities for each of the boom orientations?

f. For several of the above examples, we observe that the vertical and horizontal boom orientations give different apparent conductivities. How do you explain this?

g. Using the response function diagrams, and the answers above, which dipole orientation has greater depth of penetration? Which is more sensitive to near-surface layers? Justify your answer.

Q2. Set $\sigma_1 = 0.1$ S/m, $\sigma_2 = 0.01$ S/m, $h_1 = 0.1$. Now raise the boom height, h_{boom}. Start by looking at the vertical orientation, and repeat for the horizontal orientation. What happens to the response function? How does the apparent conductivity change?

Critically Analyzing the Paper

Q3. To generate Figure 3, the authors introduce a normalized data representation using the equation $L = cx \log_{10}(\sigma_{app}/\sigma_{arb})$. What do you think the terms in the equation are and what are their units? Given the information in the paper, how would you interpret L?

Q4. In the article, the authors state:

> "Further, we found that a linear relationship exists between the apparent terrain conductivity and depth of waste. The relationship is based upon the theory that a thick accumulation of field-saturated waste (i.e., greater mass) generates a stronger response than a thin deposit of waste. Consequently, a linear relationship exists between the apparent conductivity and waste thickness."

Using the app and your answers for question 1, how would you support or refute the statement that there is a linear relationship between apparent conductivity and waste thickness? Consider both boom orientations in your answer.

Q5. The authors carry out analysis to recover the lateral extent and depth of the waste. This allows them to compute the total volume of waste.

a. In Figure 2 in the paper, the caption reads "higher conductivity values (> 40 mS/m) represent areas of buried waste." If you were in charge of this survey, how would you attempt to determine this threshold value?

b. The authors did not explicitly show how they computed the estimated thickness of the waste based on apparent terrain conductivity (L). Assuming you have estimates of both the conductivity of the background and the conductivity of the waste, how would you approximate thickness of waste given an apparent conductivity measurements.

Mapping thickness of waste

Q6. You are tasked with determining the thickness of waste and estimating a total volume of waste using the apparent conductivity measurements in the map (page 8). The survey was conducted using an EM-31 on the surface of the earth ($h_{boom} = 0$). The transmitter-receiver separation is 4 m. At each measurement point, an apparent conductivity was recorded for the vertical boom orientation. You have some known data from collected samples:

- The blue diamond indicates where no waste was found, giving you a background conductivity of $\sigma_2 = 0.01$ S/m
- At the blue square, the waste thickness was determined to be 13 m
- The conductivity of the waste is $\sigma_1 = 0.1$ S/m

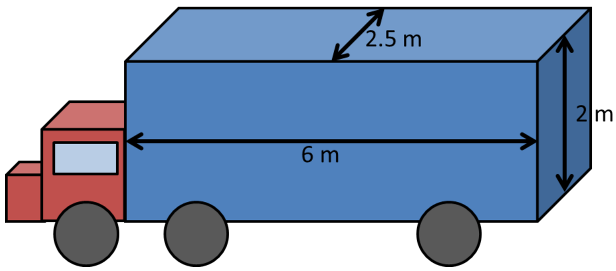
Note that waste thickness is equal to $4h_1$ where h_1 is the thickness of the first layer in the app!

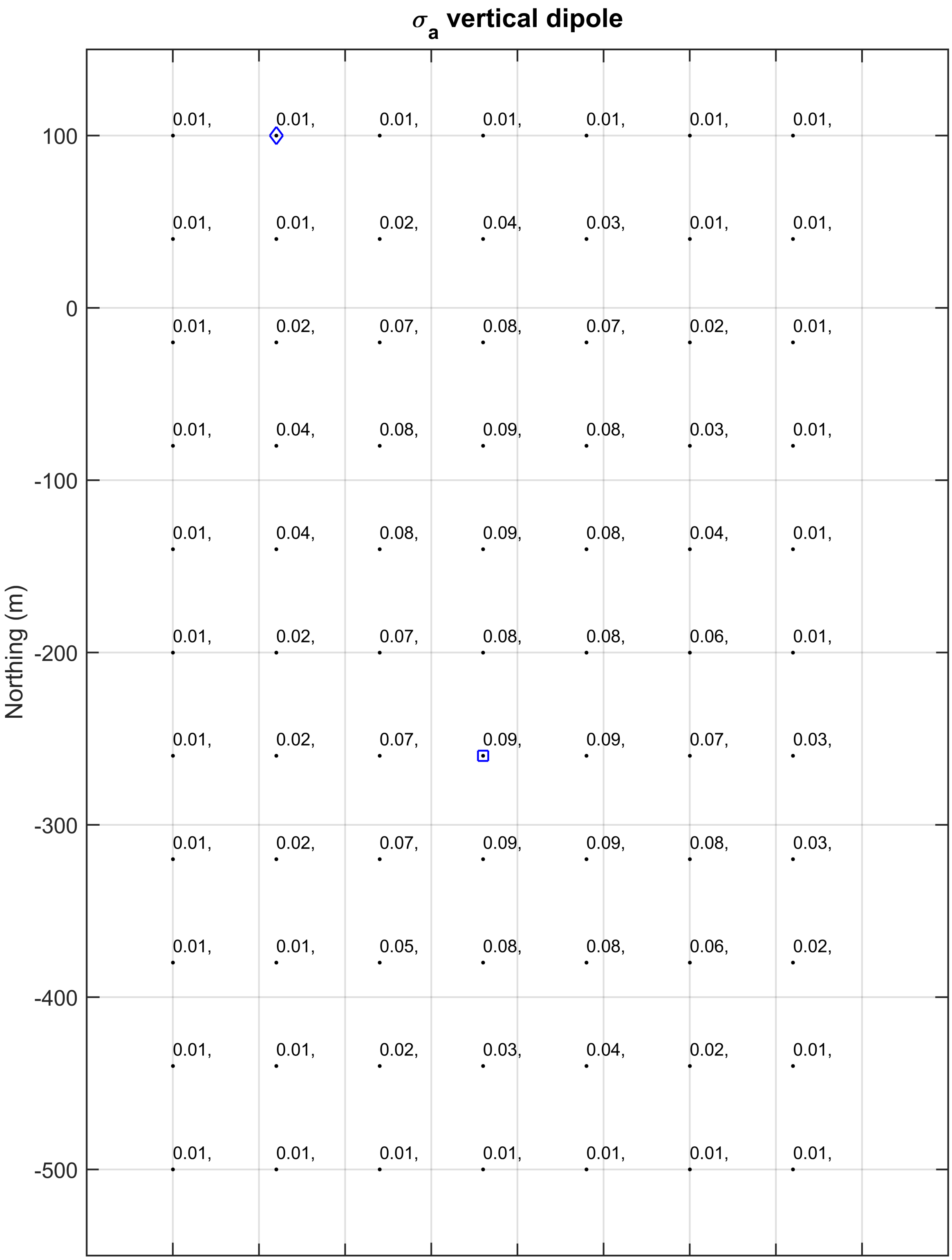
a. Convert the apparent conductivities to determine the waste-thickness.

b. Draw contours of the waste thickness on the map. Use 2 m contour spacing.

c. Estimate a total volume of waste

d. Bonus: Assuming you have trucks, like the one shown below, how many trucks do you need to remove all the waste at this site?




σa vertical dipole
Northing (m)
100
0
-100
-200
-300
-400
-500
0.01, 0.01, 0.01, 0.01, 0.01, 0.01, 0.01,
0.01, 0.01, 0.02, 0.04, 0.03, 0.01, 0.01,
0.01, 0.02, 0.07, 0.08, 0.07, 0.02, 0.01,
0.01, 0.04, 0.08, 0.09, 0.08, 0.03, 0.01,
0.01, 0.04, 0.08, 0.09, 0.08, 0.04, 0.01,
0.01, 0.02, 0.07, 0.08, 0.08, 0.06, 0.01,
0.01, 0.02, 0.07, 0.09, 0.09, 0.07, 0.03,
0.01, 0.02, 0.07, 0.09, 0.09, 0.08, 0.03,
0.01, 0.01, 0.05, 0.08, 0.08, 0.06, 0.02,
0.01, 0.01, 0.02, 0.03, 0.04, 0.02, 0.01,
0.01, 0.01, 0.01, 0.01, 0.01, 0.01, 0.01,