Geophysics 424 , Assignment 2
Electromagnetic exploration techniques

Question 1 (12 points)

In this question, you will use a **MATLAB** program to interpret some MT data.

Two MT data files (**MTdata-TBT640.txt and MTdata-CXB02.txt**) and a sample model file are also available.

(a) For each MT data file decide the **minimum number of layers** needed to fit the data. Explain your answer.

(b) Generate a model with this number of layers, and adjust the resistivities and depths so that you can fit the MT data. The **MATLAB** script computes a root-mean-squared (r.m.s) misfit value. An acceptable r.m.s. misfit should be in the range 1 to 1.5

Different options are available for handling the error bars. Use the "*Constant*" option" in this assignment.

To fit the data, use the following steps

(1) Rename the data file to be analysed to **MTdata.txt**

(2) Rename model file as **MTmodel.txt**

(3) Start MT1Dfit_v2008 in **MATLAB**

(4) Open **MTmodel.txt** in an editor. Change the model as needed and then save the file.

(5) Click "**Change model**" button and the new response will be displayed. Note the r.m.s. misfit displayed in the **MATLAB** command window.

(6) When the fit is acceptable, click "**Quit and print**". A JPEG file of the model and fit is generated.

Include a copy of the figure showing the fit to data and resistivity model in your write up.

(c) TBT640 was collected in Northern Tibet. Can you think of a geological explanation for the resistivity models you obtained? Reading Unsworth et al., Journal of Geophysical Research, (2004) will give some ideas.

(d) CXB02 was collected in the Chicxulub Impact crater. Can you think of a geological explanation for the resistivity models you obtained? Reading Unsworth et al., Geophysical Research Letters, (2004) will give some ideas.

Question 2 (8 points)

A plane electromagnetic wave has a frequency *f* and is travelling in the Earth in the *z*-direction. The Earth has a conductivity (σ) and the electric field is polarized in the *x*-direction.

Starting with Maxwell's equations, derive the differential equation that governs the variation of E_x with z.

List **all the assumptions** that you make.

Solve this equation and show that the skin-depth (in metres) is given by

$$\delta = \frac{503}{\sqrt{\sigma f}}$$

Question 3 (7 points)

EM signals with a period of **11 years** are being studied for information about the conductivity structure of the mantle.

(a) If the average resistivity of the crust and mantle is 1 ohm-m, to what depth will the EM fields propagate?

(b) Which assumptions made in you answer may not be valid?

Question 4 (12 points)

MT data is being recorded at a single station with 5 channels. Each sample requires 16 bytes per channel to store in the memory of the instrument. Data can recorded in the following frequency bands.

Band 1 : Sample rate = 1000 Hz
Band 2 : Sample rate = 100 Hz
Band 3 : Sample rate = 10 Hz

The processing requires 20 cycles of a signal to get a good estimate of apparent resistivity.

(a) Initially only Band 1 is used for data collection.

With 24 hours data recording, what are the **maximum** and **minimum** frequencies that will be recorded?

How much **memory** is required to store the whole time series?

(b) In an effort to reduce memory requirements, Bands 1 and 2 are used. Band 2 is recorded for 24 hours. Then Band 1 is used to give the high frequency data.

How long should Band 1 be recorded for?

Hint : the lowest frequency estimated from Band 1, should be equal to the highest frequency estimated from Band 2.

What will be **the total memory** required?

(c) Repeat (b) when using Bands 1-3. Band 3 is recorded for 24 hours.

What are the relevant recording times for bands 1 and 2?

What will be the **total memory** required?

(d) Using 3 bands clearly reduces the memory requirements. In what ways could this compromise the data collection strategy? (i.e. getting good estimates over the whole frequency band?)

(e) What could be done to overcome this problem?

This assignment will be due at 5 pm on Monday November 13 2023