Geophysics 699 - Magnotellurics and Continental dynamics

Assignment 4

(1) Papers to read

Wu, F., The inverse problem of magnetotellurics, *Geophysics*, **33**, 972-979, 1968.

Constable, S., R.L. Parker and C. Constable, Occam's inversion: A practical algorithm for generating smooth models from EM sounding data, *Geophysics*, **52**, 289-300, 1987.

Smith, J.T., J.R. Booker, Rapid relaxation inversion of two- and three-dimensional magnetotelluric data, *J. Geophys. Res*., **96**, 3905-3922, 1991.

Rodi, W., R. Mackie, Nonlinear conjugate gradients algorithm for 2-D magnetotelluric inversion, *Geophysics*, **66**, 174-187, 2001.

Siripunvaraporn, W., G.D. Egbert, An efficient data-subspace inversion for two-dimensional magnetotelluric data, *Geophysics*, **65**, 791-803, 2000.

(2) Computation

In this question you will invert some synthetic MT data with the NLCG6 inversion of Rodi and Mackie (2001). This requires a USB dongle to run.

Test 2D model

A 2-D model has a conductive prism and a resistive prism (widths 2 km, depth extent 2 km, top at 2 km depth, resistivities 1 Ωm and 10000 Ωm respectively). The background resistivity = 100 Ωm. Centres of the prisms at offsets of 5 and 10 km.

The mesh should be appropriate for frequencies 1000-0.001 Hz. Use skin depth arguments to find:

(1) Total mesh size. This should be 3 skin depths at lowest frequency. Mesh should extend this distance in horizontal and vertical directions.

(2) Vertical spacing at surface. Should be 1/3 skin depth at the highest frequency.

(a) Create a new Winglink database (**prisms.wdb**). Generate model as described above. Add an MT profile from 0 –15 km, with a station every 500 m. Note that stations should be placed in the centre of the columns.

(b) Export files for external inversion.

(c) Using these exported files, run a forward calculation externally for TE, TM and T_{zy} and plot the model and pseudosections in MATLAB (**pmv17.m**).

This can be achieved with an inversion for 0 iterations. Dummy input files can be generated with MATLAB codes that I will supply (**dummy_dataTM.m, dummy_dataTE.m, dummy_dataHZ.m**).

In these MATLAB files you need to specify the number of stations, frequency band and number of frequencies per decade (4 is fine).

(d) Add Gaussian noise with the MATLAB script provided (**addnoiseTM.m** etc). Suggested levels are 5% in resistivity and phase and 0.02 in T_{zy} data.

(e) Invert the data using error floors that correspond to the level of noise added. Parameters to use include, $\tau = 10$, standard Laplacian (flag=2), 200 iterations, smooth model (flag=1), conjugate = no, statics =n).

(f) To make a starting model, copy your Winglink model to a new name and paint all cells to same value (100 Ωm). Then export as in (b), to a new folder.

(g) Try the following inversions. Make a separate folder for each inversion

TM, TE, T_{zy}, TE+TM, TE+TM+ T_{zy}

Comment on which model features each inversion recovers.

(h) Change the value of τ in the inversions (default is 10). Re-run the TE+TM+ T_{zy} inversions with τ = [0.1, 0.3, 1, 3, 10, 30, 100].

Plot a graph of roughness as a function of r.m.s. misfit. Comment on your results.

(i) Make a new folder and add a file *smooth.par*. This has the format:

```
1.0
0.0
1.0 1.0
```

Where the first number of the ratio of vertical to horizontal smoothing (α).

Re-run some inversions with $\alpha = 3$ and $\alpha = 0.3$. Comment on your answers.

MJU April 2009