



LAB 8

FORWARD MODELING USING DIPOLE SOURCES

Actually, pairs of Magnetic Monopoles

POTENTIAL FIELD METHODS

something like a magnetized rod, see file lab8-add.pdf

An **isolated magnetic source** often looks to first order like a dipole. So dipole modeling is a first step in modeling. It can give you a pretty good idea of depth, physical size (in terms of the dimension along the polarization and orientation.) *DipoleFieldGui*, *DipoleFieldScript* and *DipoleFieldProfile* can be used to familiarize yourself with how the shape of an anomaly changes as depth etc change. These are all below *local* in the directory structure I gave you, so make sure you set the path. Run *DipoleFieldGui* it call the other two and brings up an interactive graphic.

- 1) In particular, start with a vertical dipole and a vertical field, ie induced magnetization at the North pole, and progressively change the inclination of the dipole and the field in steps of 5° . Notice that for large values of inclination there are negative lows either side of the high, that is, one to the north and one to the south. At an inclination of about 80° (the inclination at Saskatoon is about 75°) the negative low to the south disappears. The negative low to the north increases in amplitude, until at an inclination of 0° , ie at the equator, the low and high are the same magnitude.
- 2) Set the inclination of the field and dipole polarization to 75° (similar to what it is at Saskatoon), the depth to 5, and the dipole length to 5. Now increase the depth in steps of 5 and note what happens to the general shape of the anomaly. What happens to the positions of the high and low, as the depth increases?
- 3) Set the inclination of the field and dipole polarization to 90° , the depth to 1, and the dipole length to 1. Now increase the dipole length in steps of 5. What happens to the general shape of the anomaly? Why is this?
- 4) The **matlab function *DipoleGrid*** is similar to *DipoleFieldGui*, except that it returns a 2D contour map, with 40 contour levels. The grid can be re-displayed with *mesh* or *surf* etc. The call is: $[X, Y, F] = \text{DipoleGrid}(\text{source}, \text{field}, \text{swne})$ where *source* is a vector whose 7 elements define the source parameters, *field* is a vector whose 2 elements define the parameters of the local field, and *swne* is a vector whose four elements define the sw and ne corners of a rectangular grid. The grid spacing is 1 m. Do help *DipoleGrid* for a description. If grids X and Y are substituted for the vector *swne*, then the output is calculated on these grids. X, Y, F are the arrays of x, y, and the total field anomaly F, which you can subsequently examine with *surf* etc. Experiment with this, until you feel confident that you understand how the various parameters interact to produce a given contour map. The contour map will have North at the top, East at the right. Use *surf(X, Y, F)*, *view*, *colormap* etc to plot different views of this. If you want to re-contour this with a fewer number of contour lines use;

$$\text{contour}(X(1, :), Y(:, 1), F, N)$$

where N is the number of contour lines you want.

- 5) Try to adjust the various parameters until you produce a contour map that looks similar to your field data from the detailed grid. The best way to do this is to grid your data to create $[X, Y, Z]$, then use $[X, Y]$ in *DipoleGrid* so you calculate model anomalies on the same grid as you observed. This is forward modeling, just as you did with GM-SYS, except you are only dealing with a dipole source, not a source of arbitrary shape. The xy positions of the maximum and minimum, the peak to peak amplitude, the extent of the anomaly (full width at half height), and the shape are important features to match. Once you develop some experience with this you should find that a few iterations are sufficient to get a reasonably good fit. *DipoleGrid* has no regional, so you must have a good regional residual separation on your data before you try the modeling.

The field school target is not a single dipole, so you will not get a perfect match, and the recovered parameters will only approximate the actual conditions. You could of course forward model a second source as well. How well can a 3D source be approximated by a single dipole? The best fitting dipole will most likely be approximately centered in the source, and contained within the source as well. So the length of the best-fitting dipole can be expected to approximate the dimension of the target in the direction of polarization, and the depth of the N and S poles should be an upper bound on the depth to top, and a lower bound on depth to bottom. In the case of a thin sheet, the polarization will lie within the plane of the sheet, so for this target, the declination of polarization should define the strike of the source quite well. The deeper the source is the better the dipole will fit the observed field, but in the field school the target is quite shallow, so you should not expect perfect agreement. Nevertheless, the recovered dipole does supply valuable information about the source, that can be used as an initial model in GM-SYS. You could improve this modeling by constructing a target from a sheet of dipoles (execute DipoleGrid many times to construct a sheet of dipoles and add the results together to form the response from a plane target).

Use *profilex.m* to extract profiles from the contour map. The call is $[x, XI, YI, Z1]=profilex(X, Y, sp, Z)$, where X, Y, Z are the usual grids, and sp is the spacing at which a profile will be extracted. x is distance along the profile from start to end, and XI, YI are the locations. A second version of the call is $[x, XI, YI, Zout1, Zout2, Zout3]=profilex(X, Y, sp, Z, Z1, Z2)$. Here $Z1$ and $Z2$ are other gridded values on $[X, Y]$, eg Z might be Free air gravity, $Z1$ topography and $Z2$ something else. **Profilex expects $[X, Y, Z]$ to be contoured in the current figure window when the call is made,** and you define a profile to extract by clicking on beginning and end points. When you do depth estimates from profiles, or modeling with GMSYS, it may be helpful to extract profiles that run across the strike of the target.