GPGN 303

Lab #4: Gravity Interpretation via Forward Modeling

Lab Date: Tuesday, September 16, 2014
DUE DATE: Monday, September 22, 2014 - by 5PM to the TA!

Task:

Quantitative interpretation of gravity data with varying data noise.

Objectives:

1. Familiarize with, and practice, the interpretation by trial-and-error forward modeling.
2. Understand the ambiguity between the recovered density, geometry and depth of a causative body during gravity interpretation when the data contain varying error levels.
3. Quantitatively interpret gravity data collected during previous lab over a possible utility-tunnel beneath CSM campus.

Programs:

(1) This lab exercise uses a simple MATLAB program, **polymod.m**, that allows rudimentary interactive input of a polygonal model for modeling a profile of gravity data. The program requires an input data file (e.g. **obs1.grv**) that specifies horizontal locations, the observed gravity data, and their standard deviation along a profile.

Upon initial execution, **polymod** will prompt for a data file and then display a graphic window. A pre-set initial model, its predicted gravity data, and the input gravity data will be displayed in the window.

There are also five control buttons:

(1) New Polygon: by pushing this button, you can input the vertices of a new polygonal body by clicking the *left* mouse button in the model section at the desired point. The input process is terminated when a point is entered by clicking the *right* mouse button. Be sure to input the vertices <u>*clockwise.*</u> Once the input is done, **polymod** will recalculate the gravity response and update the display.

Note: be sure not to input the last vertex that is the same as the first one.

(2) Density button: you can select a density value from a pre-set list of values here. When you choose a density value, the current polygon will take on this value and **polymod** will recalculate the gravity response and update the display.

(3) User Model: pushing this button will cause **polymod** to prompt for a user defined model file name. This allows the user to define a model by entering the coordinates of the vertices in the file.
(4) Save: this will cause **polymod** to display another graphics window without the control buttons so you can copy the result into a word document. **Polymod** will also save the current model to a file named '**polymod.mod**'. <u>You need to rename the file to save the result, otheriwse it will be overwritten by another save.</u>

Procedure:

The procedures are as follows:

1. Copy the supplied MATLAB program (**polymod.m**) and two data files (**obs1.grv** and **obs2.grv**) to your working directory.

2. Start the MATLAB.

3. Set the path to your working directory by clicking the Path Browser button (at the top center of MATLAB window) and select your working directory.

4. Run **polymod** by entering it in the MATLAB command window and follow the prompt.

5. Input the first data file (**'obs1.grv'**), examine the gravity data (shown in solid line with error bars). Based on what you have seen in previous lab sessions, what do you think is the causative body that produced the anomaly?

   Now begin the trial-and-error forward modeling by creating *three* new polygonal bodies that will reproduce the input data:

   (1) Find a dipping slab with four vertices and a density contrast of 1.0 g/cm^3.
   (2) Find a similar body with a density contrast of 0.6 g/cm^3 and a few more vertices. You can start from the model you generated in (1).
   (3) Find a model that has a density of 1.4 g/cm^3, and a flat top.

   A satisfactory fit between the observed and predicted data is achieved when (and only when) the predicted data are all within the error bars of the observed data.

   *Note: Make sure to rename the file "**polymod.mod**" to something different after each successful modeling so that you can include the result in the report*.

6. Restart the program **polymod** and input the second data file (**'obs2.grv'**). The data in **obs2.grv** have smaller errors.
   (1) Input each of the three models you just found and examine whether they are acceptable models for interpreting the new data set. Discuss why or why not.
   (2) Pick a case that is not acceptable, and find a new model that fits the data. Discuss the difference between the model derived in step-5 and the current model.

7. Restart the program **polymod** again, and input an observation data file that contains the field gravity data you collected over the supposed utility tunnel at CSM (from previous lab).
   (1) Using your own gravity data collected in the field, create an observation file similar to **obs1.grv** and **obs2.grv**, with the data location, gravity value and standard deviation. Remember that **polymod** works with gravity data in mGal units….convert if necessary!
   (2) Open your data file when prompted, and create a density model of the utility tunnel while fitting your field data within the error bars. You know the geometry of the tunnel overall and should have a good estimate of density.
   (3) Find a model that fits the data and is consistent with your prior information for the tunnel.
   (4) Discuss your ability to fit the data, and the quality of your recovered model in comparison to your previous knowledge of the tunnel(s).

Report:

Submit an electronic (pdf) report containing the following:

1. Your name, class, and lab number.
2. Description of the objectives of the lab.
3. Three plots corresponding to the tasks in step-5 outlined above and a brief description of each.
4. Three model files corresponding to the models in the plots.
5. Three plots showing how well the models in step-5 fit the data in obs2.dat (step-6), and brief description in each case.
6. The new model found in step-6 and the corresponding discussion.
7. The model of the utility tunnel(s) created in step 7 and the corresponding discussion.
8. Discussions:
   (1) How does the size of the model change as you decrease the assumed density contrast?
   (2) Based on the Gauss' law, can you predict how the product of the density contrast and the area of the polygon will change? Will the area increase, remain the same, or decrease as you increase the density contrast to fit a data set?
   (3) Can you uniquely determine the shape of the source that originally produced input data without the knowledge of the density contrast? How does the situation change if you know the density contrast?
   (4) How do the errors in data affect your interpretation?

Note: Please name your report following this convention:
GPGN303_Krahenbuhl_Li_G_Lab04.pdf
Number and caption the figures and refer to them by the figure number in the report.
List the names of both lab partners in the report.
You and your partner must submit identical reports.
Be sure to address everything in this handout!