LAB 1: Using the Gravimeter and Measuring the Free-Air Effect

Due Tue, January 26

The purpose of this lab is to learn the proper use of our gravimeters, to get a feel for their accuracy, and to make our own estimate of the effects of elevation on gravity measurements. We will use two different gravimeters: the LaCoste & Romberg G93 and G1096.

The pull of gravity decreases with elevation because—as you know—gravity decreases as $1/r^2$ where r is the distance to the main body of mass that creates the Earth's field. This main body is the Earth as a sphere so r is the distance to the Earth's center. Elevation increases r and likewise decreases the pull of gravity. In gravity surveys where we are interested in isolating only the local geologic effects, we must therefore correct for this unwanted elevation effect, which is known as the "free-air" effect.

Design an experiment at the HIG building to measure how much gravity decreases with elevation. This will require 3-4 measurements at different heights but at the same geographic location.

1. a) A benchmark where absolute gravity has been measured is placed next to the HIG building. Near this location would be a great place to define your base or reference station.
   b) Record all measurements on the data sheet (datalog_gravity.xls) provided.
   c) Record the time as well as elevation of each measurement site above your base station.
   d) Make two measurements at your base station, one before and one after your other measurements. Doing so will allow you to correct for any changes in gravity with time due to tides or due to "instrument drift".

2. Convert your counter-dial readings into milligals using either "G1096_to_mGal.m", which uses "G1096_table.dat" or "G93_to_mgal.m", which uses "G93_table.dat". A summary of what these Matlab scripts do is given on the attached page.

3. Correct your readings for tidal variations/instrument drift. The rate change of measured gravity *dg/dt* can be computed by taking the difference in the two gravity readings at the HIG benchmark and dividing this number the time between the two readings. The amount that measured gravity changes between each measurement is approximately the product of *dg/dt* and the time between each measurement. Remove any temporal change in measured gravity from each of your measurements.

4. Make a plot showing your time-corrected gravity readings (in mGal) vs. elevation (in meters) and use the Matlab function "*polyfit*" (see "lab1_start.m") to find the line that best fits the trend. How does the slope of your line compare to that given in class for the free-air gravity correction? Describe your ideas for the real physical reason(s) that the two are different in the sense that they are.

5. Finally, calculate absolute gravity at each of your measurement points by using the absolute measurement of the benchmark.

OUTLINE OF OPERATING PROCEDURES FOR G&G GRAVIMETERS

HANDLING THE GRAVIMETERS

Gravimeters are very sensitive scientific instruments; they have a dynamic range of over 7000 mGal and a reading accuracy of 0.01 mGal. The replacement cost for each is ~$90,000, so please handle them with extreme care!

- Transport the gravimeters in their cases only. The cases should be closed an locked and should be carried, low to the ground, only by the handle on top.
- Always, always keep the gravimeter in the upright position.
- Hold the eyepiece fixture to move the gravimeter in and out of the case.

PREPARATION

- Always set up on rock or other solid surface. Avoid soil, sand, grass, etc.
- Check the batteries before going into the field.
- Always use the leveling dish.
- Let the instrument warm up for at least 5-10 minutes before the first measurement

MEASUREMENT PROCEDURE

1. Open the carry case. Check that the LOCK KNOB is locked (rotated fully clockwise).
2. Use the eyepiece fixture to lift the gravimeter out of the case. Never lift it using the dial!
3. Check the temperature reading (should be ~49.3^{o} for G93 and ~56.2^{o} for G1096).
4. Level the instrument.
5. Unlock the instrument by turning the lock knob fully counter-clockwise (until it stops).
6. Use the silver reading dial to center the needle. Rotate the dial in the direction you would like the needle to go. A proper reading is obtained when the swing of the needle is averaged. On the G93, 1 dial rotation = ~0.7 mgal. On the G1096, 1 dial rotation = ~1 mgal.
7. Read the counter then read the dial to obtain the measurement.
8. Lock the instrument (turn knob fully clockwise) and replace in case.

NOTES

- Wind, traffic, and other sources of ground "noise" can make it harder to make measurements.
- Instrument drift as well as tidal forces can produce a systematic offset in measurements conducted over time spans of several hours. This is one reason why a survey should always start and end at a known benchmark.

CONVERSION OF COUNTER READING TO MILLIGALS

The reading of the gravimeter is spring tension. Please refer to the calibration tables provided for each instrument to convert spring tension to milliGals. The value of gravity in milligals is given for each 100 units of the counter (the last digit on the counter indicates tenths). By using this table, and the corresponding factor, the value of gravity for any reading of the counter may be obtained in the following manner (as taken from the G93 manual):

1. Start with your gravimeter measurement.
   Example: **2654.36**

2. From the conversion table's COUNTER READING column, use the counter reading nearest the example reading (**2654.36**) but less than it. For this example the counter reading would be **2600**. Then, find the VALUE IN MGALS for a counter reading of 2600 which is **2731.10** mGals.

3. Obtain the difference in the original counter-dial reading and the counter reading chosen from the table.
   2654.36 – 2600 = **54.36**

4. Multiply this difference (54.36) by the interval factor given in the table for a counter reading of 2600.
   54.36 x **1.05239** = **57.21**

5. Add the above product to the milligals value. The sum thus obtained is the milligals value for the gravity station.
   2731.10 + 57.21 = **2788.31**

EXAMPLE CONVERSION TABLE VALUES:

COUNTER READING	VALUE IN MGAL	FACTOR FOR INTERVAL
2500	2625.88	1.05218
2600	2731.10	1.05239
2700	2836.34	1.05262