# LAB 10
# 2D FILTERING

*Laplace* is a potential fields utilities package in matlab. It works with gridded data and generates filtered output (band-pass, low-pass or high-pass), first vertical derivative, second vertical derivative, upward and downward continued fields, and radial power spectra. Do *help Laplace.*

1) Use *PointMass.m* to generate a synthetic data set from a point source at 3 m depth and peak anomaly 3 mGal. The gridded area should be at least 50 m by 50 m. Call the gridded fields X,Y, g3 or something. Add noise of about .05 mGal to the noise-free grid with *randn,* and call this new grid g3n, for example. *Laplace* operates on the data files *x_in, y_in* and *z_in,* which must exist in your workspace when Laplace is called, so copy the grids created above to these variables. Execute *Laplace* and a mesh plot of the anomaly will be displayed. Select the radial frequency spectrum option. The graph of amplitude vs radial frequency should exhibit one prominent straight line segment, which you can define by clicking on the beginning and end points. The estimated source depth will be displayed on the spectrum. How well does this agree with the known source depth? You will be invited to continue defining straight line segments or quit. The radial frequency spectrum is also used to establish the cutoff between signal and noise. Make a note of this value for future reference.

2) After you quit the radial frequency spectrum, you can select another option from the main *Laplace* list. Try the low-pass option. The spectrum will be displayed in mesh form, and you will be prompted for cut-offs in x and y for the low-pass filter, and for the width of the ramp. Select the cutoffs on the basis of the radial frequency spectrum, and the mesh plot of the spectrum. A mesh of the filter will be displayed, and then the filter will be applied to the grid of data. If you exit *Laplace* at this point the low-passed data should be available for display as *z_out* . If you selected the filter cutoffs and ramp width wisely, this map should look like the noise-free version of the data. Try contouring the difference between the low-passed grid and the noise-free grid. Why is this result not uniformly zero? What is the standard deviation of the differences? Experiment with changing the cutoff frequency and ramp width to see if you can get the difference between the filtered and noise-free grids smaller.

3) Create a new data set with *PointMass.* This time have one source at 1 m depth (g1), and another at 10 m depth (g10)- they need not be at the same xy location, but can be of similar magnitude. Add the two together and name this $g110$, or something. Using the radial frequency option, check that the apparent source depths agree with the known depths and select a cutoff to isolate the shallower source from the deeper source. Now try the high-pass filter option of *Laplace.* Does the resulting grid look like the grid of the shallow source alone? Again, what are the problems and what are the limitations?

4) Take the original grid of the source at 1 m depth and upward continue it 2 m, using *Laplace.* Estimate the apparent source depth of the upward continued data from the radial frequency spectrum and from other methods. How closely does the upward continued grid look like the actual source at 3m depth? Is there any evidence of ringing?

5) Take the original grid of the source at 3 m depth and downward continue it 2 m. How well does the resulting map compare with the original for a source at 1 m? Is there any ringing?

6) Load the data from your detailed mag data and grid it. Execute *Laplace* and select the radial frequency option to estimate source depths and cut-offs. Perform a second vertical derivative on the data and examine the results. Single stations with anomalously high or low values should be apparent, and the known anomalies should be much more jagged in appearance. If there are any single station problems, try to trace these in the field notebook to see if you can figure out what went wrong.

7) The first vertical derivative, like the second vertical derivative, is used to enhance short horizontal scale features. The gain of the second vertical derivative increases as the square of the frequency, and the gain of the first vertical derivative increases as the first power of the frequency. Thus, the first vertical derivative has a more gentle gain function than the second vertical derivative. Observed potential fields nearly always have spectra that fall off in amplitude as the spatial frequency is increased, (as $f^{[-1 \text{ to } -2]}$), so the choice of first vertical vs second vertical derivative, would depend on what sort of spectrum the raw data has, and how 'flat' the interpreter wants the filtered spectrum to be. Try a first vertical derivative on your detailed grid and on laniganm.

8) Load the file called laniganm.dat into matlab. These are xy data from a mag survey conducted in the Lanigan Sk. area in 1989. The first column is the Line No, the

second column is the station No, and the third column is the total field in nT. The original flight lines were at 500 m spacing, with tie lines at 2000m and the samples along the flight lines were at about 11 m. These data were gridded onto a 51 m by 51 m grid, which comprise the lines and stations tabulated here. Grid these data and look at the second vertical derivative map, as well as radial frequency spectrum. Are there any single station problems? Are there any small scale features that you might want to look at more closely? Can you interpret distinct source depths, and the noise level?

9) saskgravr.txt is a subset of the Saskatchewan gravity data in the Saskatoon area, with our own composit field school added. Grid the free air, separate a residual and calculate the first vertical derivative. Since free air gravity has already been corrected for the free air effect, the gradient you have found is the extra contribution to the free air gradient from local mass anomalies, as well as from the attraction of the topography. If you were to actually measure the local free air gradient it would be the standard gradient $\sim -0.385 mgal/m$ plus the gradient you just calculated. Upward continue the free air gravity field 100m, 200m ... 2000m. You will need to run it through laplace each time. Get the upward continued value at (0,0), or somewhere in the center of the grid at each height and plot these values vs the height. One way of testing Newton's inverse r squared law would be to make measurements of gravity at the same heights and compare with your calculation. This of course has been done because there are some theoretical reasons for suspecting the law may not be exactly inverse r squared over 'geophysical' distances, that is 100's of m. The results have been inconclusive.