Separation of surface and deep geological structures by application of band pass filter and statistical comparison with other methods

Hiva Rokhzadi
Young researcher club, Department of Geophysics, Islamic Azad University, Hamedan Branch, Hamedan, Iran
(hrokhzady@gmail.com)

Abstract: The observed gravity field's Fourier power spectrum is modeled with two equivalent-source layers, one for the shallower (residual field) geologic sources, and other one deeper (regional field) geologic sources. The depths and average physical property contrasts of the two of them are determined by fitting the observed gravity field's Fourier power spectrum Cordell (1985) with a two-layer spectral model. Each equivalent layer is simulated by a horizontal thin plate with spread randomly varying and distributed point density sources through it Cordell (1992). Adopting such a theoretical model for the Fourier power spectrum yields a stable and well-behaved filter transfer function. Like all band-pass filtering, the method is ineffective in the case of insufficient vertical separation between the shallow and deep geologic sources that gravity anomalies desired to separate. The key factor of this method is its iteration and repeatable, in dependent in result interpretation. More than a comparison between this method with polynomial one was conducted and the correlation coefficient was determined. The results of this study showed that increase of polynomial degree correlation has a straight relationship with Wiener filter one.
[Hiva Rokhzadi. **Separation of surface and deep geological structures by application of band pass filter and statistical comparison with other methods.** *Life Sci J* 2012;9(3):950-953]. (ISSN: 1097-8135). http://www.lifesciencesite.com. 136

Key word: Wiener band-pass filter, regional field, Fourier power spectrum

Introduction

The primary goal of studying detailed gravity data is to provide a better understanding of the subsurface geology Jacobsen (1987). The gravity method is a relatively cheap, non-invasive, non-destructive remote sensing method that has already been tested on the lunar surface.
Measurements of gravity provide information about densities of rocks underground. There is a wide range in density among rock types, and therefore geologists can make inferences about the distribution of strata. In the Taos Valley, we are attempting to map subsurface faults. Because faults commonly juxtapose rocks of differing densities, the gravity method is an excellent exploration choice Clark (1984).
Several methods such as second derivative for gravity separation methods are used for separation of other fields such as different geological structures such as layered and vertical structures.
Clark (1969) showed that the presence of noise can lead to divergences for downward continuation and differential maps and then Cordell (1985) modeled two layer sources by designing filter. The aim of this work is to design a band pass filter between different depths depending on the area and separation of local field from regional field, which is explained by Wiener (1949). The filter design process is simple and easily automated, being well-suited for modular implementation in a 'filter toolkit' applications program running on either a workstation or personal computer and yields repeatable, interpreter-independent results.
This study is an attempt to implement the new approach that can be stated in a separate layer structures.

Filter defining in layers

Gravity anomaly detection filter problem addressed by the gravitational field when the anomaly is created by the separation of power spectral Fourier gravity observations are obtained.
Get rid of unwanted frequencies, highlight signals of certain frequencies, identify harmonic signals in the data, correcting for phase or amplitude characteristics of instruments, prepare for down-sampling and avoid aliasing effects are the main reasons for filtering Gupta (1980). The power spectrum in the frequency of long distance and short-distance frequencies is done by increasing the depth of the source.
Observed gravity field, g, (gravitational vertical component) is often described as a combination of deep and shallow geologic parameters (Pawlowski, 1993) as:

$$\mathbf{g_o = g_s + g_d} \quad (1)$$

The gravitational field is defined by the sum of observed regional and residual gravity fields and Fourier power spectrum for two layers with different depths and average physical properties can be modeled, which the second layer belongs to deep sources.
Each layer is a thin horizontal density distribution of random sources which are considered to be transient. The average spectrum of the gravitational potential for a point source in a layer of depth, h, followed by Naidu,(1968) is modeled as follows:

$$\mathbf{<|G(f)^2|> = c <|\sigma^2|> \exp(-4\pi fh)} \quad (2)$$

Where:

- ✓ G(f) is the mean radial gravitational field Fourier of layer as a function of radial frequency (f).
- ✓ c, is a constant and σ is the constant density of point source (Cordell, 1979).

It is important to note that modeling of layer density distribution on base of random distribution of point sources is constant.
From equations (1) and (2) the mean radial Fourier spectrum the observed gravity field is modeled as follows:

$$|G_o(f)^2| \propto \langle|G_o(f)^2|\rangle = c\,[\langle|\sigma_d^2|\rangle \exp(-4\pi f h_d) + 2\,\langle|\sigma_d^2||\sigma_s^2|\cos(\theta_d[f] - \theta_s[f])\rangle \times \exp(-2\pi f h_d) \times \exp(-2\pi f h_s) + \langle|\sigma_s^2|\rangle \exp(-4\pi f h_s)] \quad (3)$$

Detection of local gravity filtered through the modeling was done between 5 to 25 km depth, be in the best fit with the observed values. To determine the resolution of selected method in the present work, the following simplified algorithm was performed (Cordell, 1991).

1. Conducted a guess for (h_d) and (h_s) to test in the studied area between depths of 5 to 25 km from the surface of the earth.
2. By increasing the h_s and h_d, can find a proven straight relation between h_d, with depths increasing, and can resolve the equation by putting $\langle|\sigma_s|\rangle$ and $\langle|\sigma_d|\rangle$.
3. Repetitions the previous step while the h_d cover the full range (25 km).
4. Increasing the h_s for any 5 km in each calculation.
5. Repeat steps 2 to 4 to cover all of the area.

According to mentioned steps, figures 1 and 2 shows the designing band pass filter and radial fitted average power spectrum of observed gravity. These figures are indicating the two source layers modeled and drawing by regional field.

By application of the second equation, the coefficients are determined for of the first and second degree polynomials are shown in figure3 and 4.

$$g_R = a0 + a_1x + a_2y + a_3 \Rightarrow g_R = 0.001 + 0.0007x + 0.0041y + 1.9xy \quad (4)$$

$$g_R = b_0 + b_1x + b_2y + b_3xy + b_4x^2 + b_5y^2 + b_6x^2 \Rightarrow g_R = 0.125x - 0.0918y + 0.0793x^2 \quad (5)$$

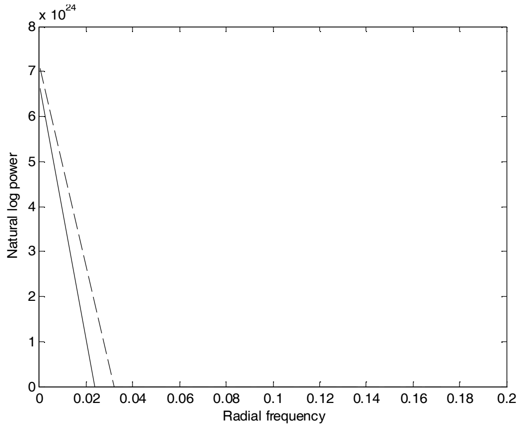


Figure1. Average radial power spectrum to estimate the depth

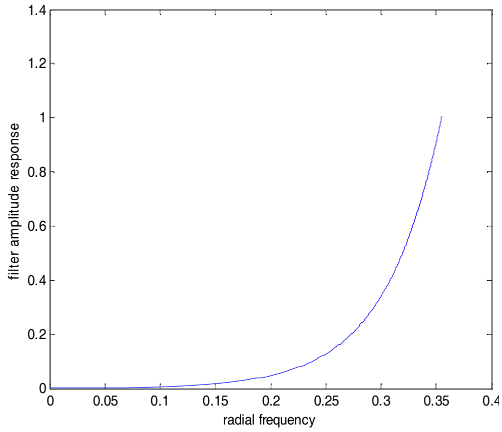


Figure2. Regional field based on band-pass Wiener filter design

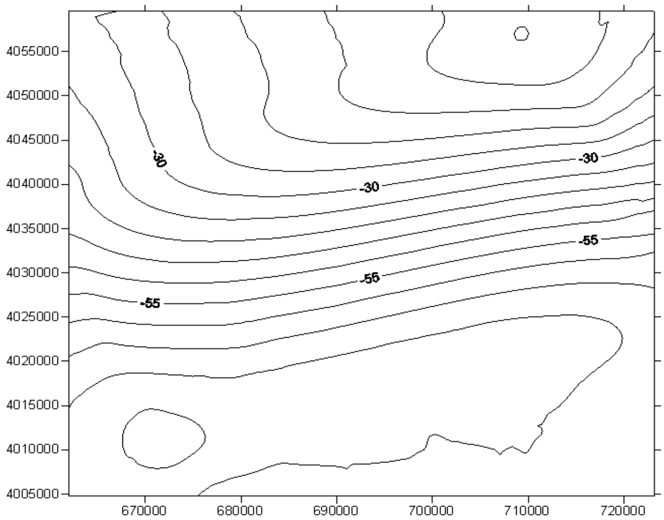


Figure3. Regional Median degree polynomial fitting method (first degree), with 5mgal contour lines

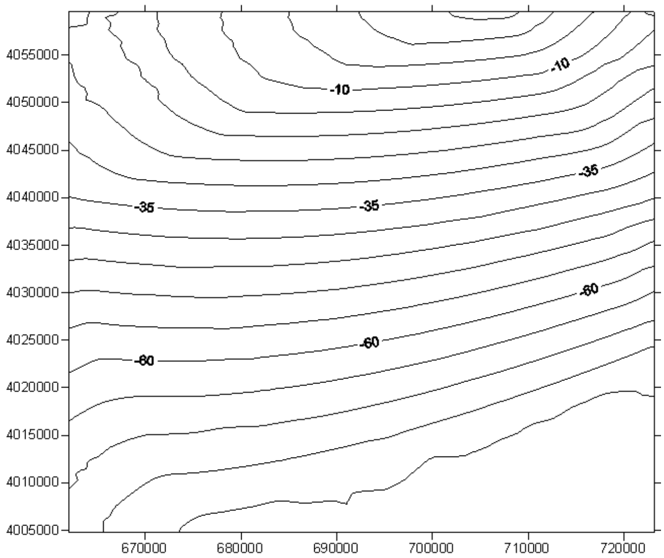


Figure4. Regional Median degree polynomial fitting method (second degree), with 5mgal contour lines

By defining the Band pass wiener as below, the figure5 can be obtained (Craig, 1996).

$$\widetilde{H}(f) = \frac{1}{1+\dfrac{G_s(f)1}{G_d(f)}} \qquad (6)$$

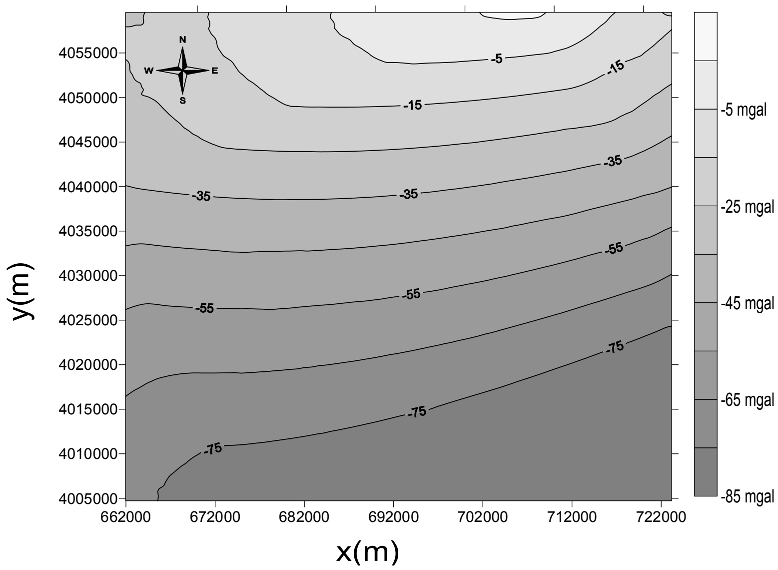
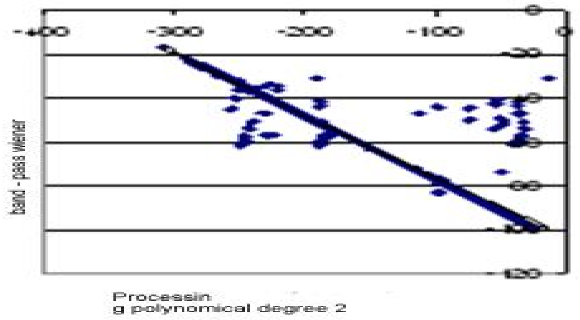


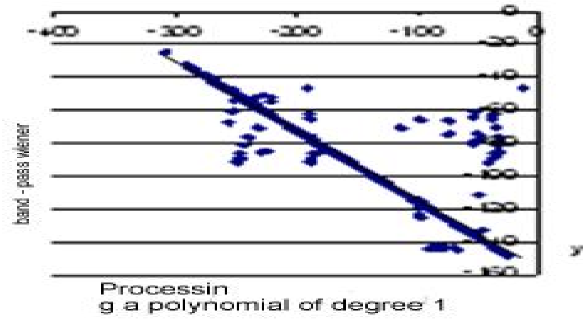
Figure5. Regional Median causeway Wiener filter method, with 10mgal contour lines

Conclusion:

In this thesis paper, Wiener filtering method can be used as a method to isolate the local fields and the remainder was introduced to evaluate the performance of the analytical method with polynomial fitting and compared both that Causeway Wiener filtering method and the square of the Pearson fitting a quadratic polynomial 1 is $R^2 = 0.9475$. Pearson Square causeway Wiener filtering method and the polynomial fit of degree 2, $R^2 = 0.9491$, respectively.



Graph2. Band pass Wiener filtering method and the correlation coefficient fit for second degree polynomials



Graph1. Band pass Wiener filtering method and the correlation coefficient fit for first degree polynomials

Reference

- Clarke, G. K. C., 1969, Optimum second-derivative and downward continuation filters, Geophysics, 34, 424-437.
- Clark, R. D., 1984, Lucien LaCoste, The Leading Edge, 3, 24-29.
- Cordell, L., 1979, Gravimetric expression of graben faulting in Santa Fe county and the Espanola Basin, New Mexico, in Ingersoll, R.V., ed., Guidebook to Santa Fe County, 30th Field Conference , 59-64, New Mexico Geological Society.
- Cordell, L., 1985, A stripping filter for potential-field data, 55th Ann Internal 218.
- Cordell, L., 1992, A scattered equivalent-source method for interpolation and gridding of potential-field data in three dimensions: Geophysics, 57, 629-636.
- Cordell, L., Zorin, Y.A., and Keller, G.R., 1991, The decompensative gravity anomaly and deep structure of the region of the Rio Grande rift: Journal of Geophysical Research, 96, 6557-6568.
- Gupta, V. K., and Ramani, N., 1980, Some aspects of regional residual separation of gravity anomalies in a Precambrian terrain Geophysics, 45, 1412-1426.
- Jacobsen, B. H., 1987, A case for upward continuation as a standard separation filter for potential-field maps: Geophysics, 52, 1138-1148.
- Craig, M., 1996, Analytic signals for multivariate data, Mathematical Geology, 28, no. 3, 315-329.
- Naidu, P., 1968, Spectrum of the potential field due to randomly distributed sources: Geophysics, 33, 337-345.
- Pawlowski, R. S., and Hansen, R. O., 1993, Gravity anomaly separation by Wiener filtering, Geophysics, 55, 539-548.
- Wiener, N., 1949, Extrapolation, interpolation, and smoothing o stationary time series, John Wiley and Sons, Inc.

11/10/2012