2-D Wavelet Application on Geophysics[1]

Serhat Şeker*, Osman N.Uçan**, Muhittin Albora*** and Atilla Özmen**

(*) Istanbul Technical University, Electrical & Electronics Engineering Faculty, 80626 Maslak, İstanbul, Turkey
e-mail: seker@elk.itu.edu.tr

(**) Istanbul University, Engineering Faculty, Electr.&Electron. Department, 34850, Avcılar, İstanbul; Turkey

(***) Istanbul University, Engineering Faculty, Geophysics Department, 34850, Avcılar, İstanbul

SUMMARY: One of the main purposes of geophysical mapping is the identification of units that can be related to the unknown geology. In literature some classical methods are proposed for the seperation of gravity maps. In classical approach, the regional field is estimated by least-squares fitting a low-order of the observed field. The other main approach applies a digital filters such as Wiener filtering to the observed. In this study, one of the very update 2-D image processing technique, Wavelet approach is applied to gravity anomaly map and satisfactory results are observed. Wavelets are with an effective algorithm for numerical image processing by an earlier discovered function that can vary in scale and can conserve energy when computing the functional energy. In between 1960 and 1980, mathematicians such as Grossman and Morlet defined wavelets in the context of quantum physics. Stephane Mallat gave a lift to digital signal processing by discovering pyramidal algorithms, and orthonormal wavelet bases. Later Daubechies used Mallat's work to construct a set of wavelet orthonormal basis functions that are the cornerstone of wavelet applications today. Since a major potential application of wavelets is in image processing, 2-D wavelet transform is a necessity. The subject, however, is still in an evolving stage and this section will discuss only the extention of 1-D wavelets to the 2-D case. The idea is to first form a 1-D sequence from the 2-D image row sequences, do a 1-D Multi-resolution. Analysis (MRA), restore the MRA outputs to a 2-D format and repeat another MRA to the 1-D column sequences. The two steps of restoring to a 2-D sequence and forming a 1-D column sequence can be combined efficiently by appropriately selecting the proper points directly from the 1-D MRA outputs (Figure 1). In the considered example (Table I) four spherical structures are used. For increasing regional effects on Bouguer

anomaly map (Figure 2), the big sphere with the biggest radius is replaced deeper than the others. Also to increase the residual effect, the other spheres are closer to the ground. At wavelet output, the residual map is extracted perfectly as shown in Figure 3. One of the main researches on gravity anomaly maps is to estimate the average depth of the buried objects resulting the anomaly. In interpretation of gravity anomalies by means of local power spectra, there are three main parameters to be considered. These are, depth , thickness and density of the disturbing bodies. In direct interpretation, the information such as the maximum depth at which the body could lie and depth estimates of the centre of the body are obtained directly from the gravity anomaly map. It is clear that infinite number of different configurations can result in identical gravity anomalies at the surface and in general, gravity modelling is ambigous. In indirect interpretation the simulation of the causative body of the gravity anomaly is computed by simulation. The variables defining the shape, location, density etc. of the body are altered until the computed anomaly closely matches the observed anomaly. As it is well known potential fields obey Laplace's equation which allows for the manipulation of the gravity in the wavenumber domain. Many scientists have used the calculation of the power spectrum from the Fourier coefficients to obtain the average depth to the disturbing surface or eqivalently the average depth to the top of the disturbing body. In this paper, we have estimated the spheres depths using power spectral approach with high accuracy as shown in Figures (4-5).

CONCLUSION

In this paper, 2-D Multi-Resolution Analysis (MRA) is used to perform Discrete-Parameter Wavelet Transform (DPWT) and applied to gravity anomaly separation problem. The advantages of this method are that it introduces little distortion to the shape of the original image and that it is not effected significantly by factors such as the overlap power spectra of regional and residual fields. The proposed method is tested using a synthetic example and perfect results have been found. Then average depth of the buried objects have been estimated by power spectrum analysis.

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Table 1 : Paramaters of Bouguer anomaly map of an Example

Parameters	sphere 1	sphere 2	Sphere 3	sphere 4
H	100	5	4	4
R	30	4	4	3
ρ (gr / cm^3)	1.8	1.2	1	1.3

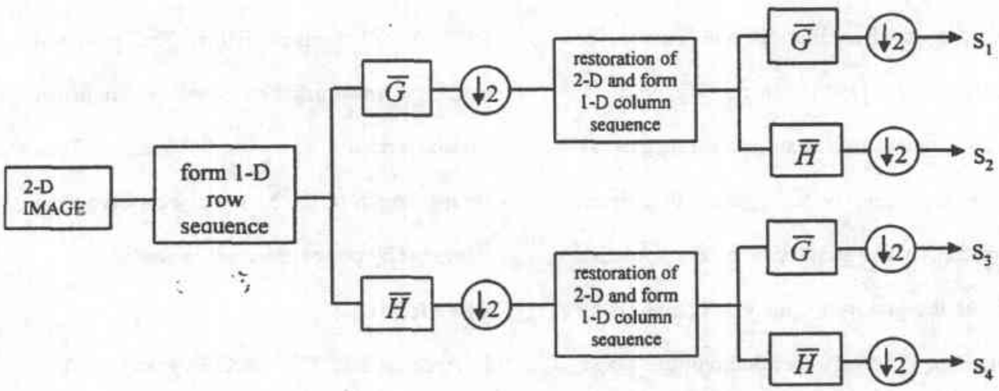


Figure 1. 2-D Multi-resolution Analysis (MRA) decomposition

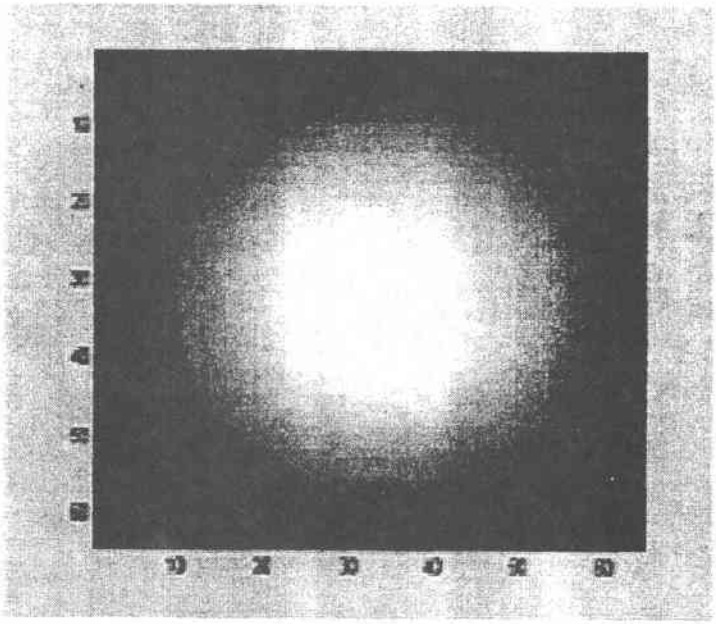


Figure 2. Bouguer Anomaly of four spheres with parameters as in Table I

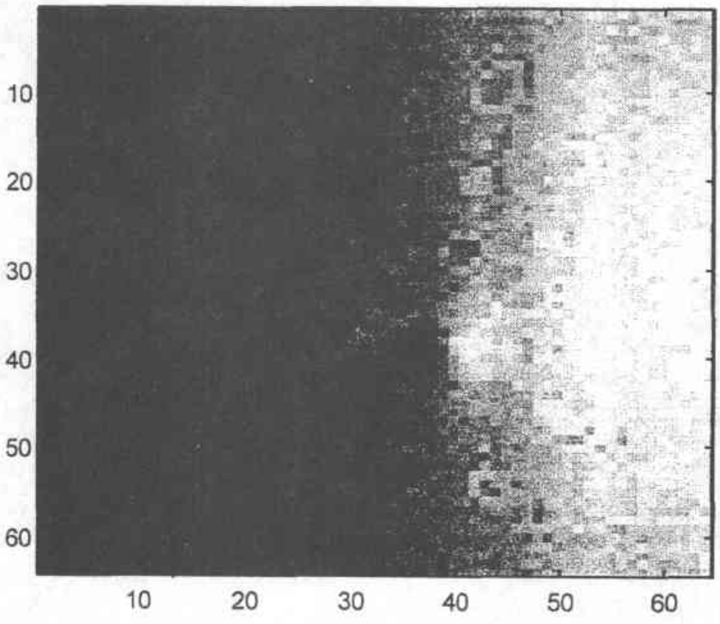
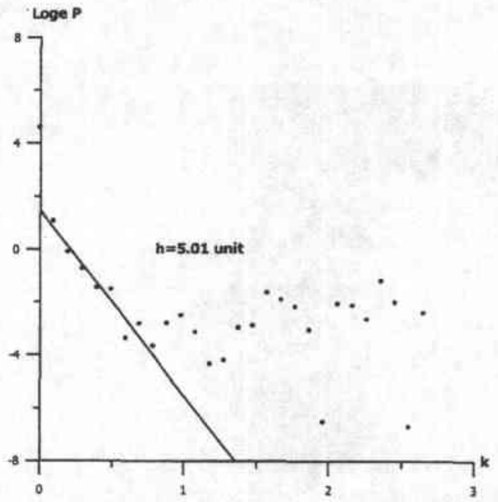


Figure 3. 2-D Wavelet output of the Bouguer Anomaly given in Figure 2



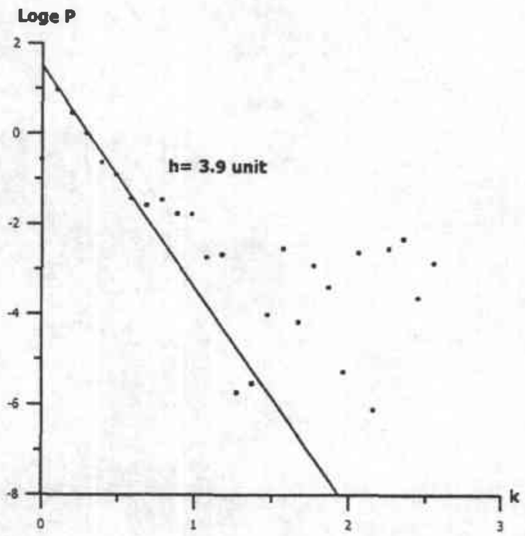


Figure 4. Power Spectral Density of the sphere-2 and sphere-3 in Table I.

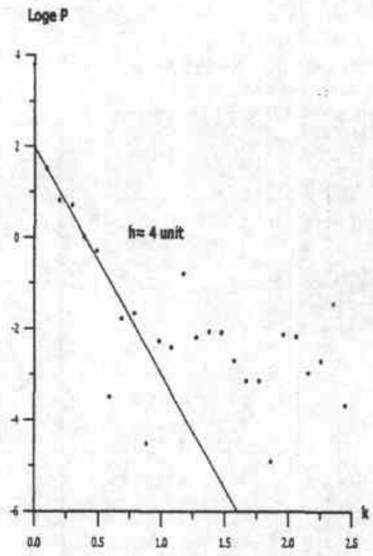


Figure 5. Power Spectral Density of the sphere-4 in Table I