Matched Filtering with the USGS DOS Potential Field Software

At this point, you should be familiar with the various machinations you need to go through to run DOS programs, interact at the command line, and transform grids from Surfer to USGS and back. I appended the DOS help files to the end of this document – read 'em.

The DOS matched filtering sequence takes three different steps:

1. MFINIT.EXE computes the radial power spectrum of the total field anomaly you provide. MFINIT is reasonably interactive, start it at the command line and make sure you have it and the file in the same subdirectory.

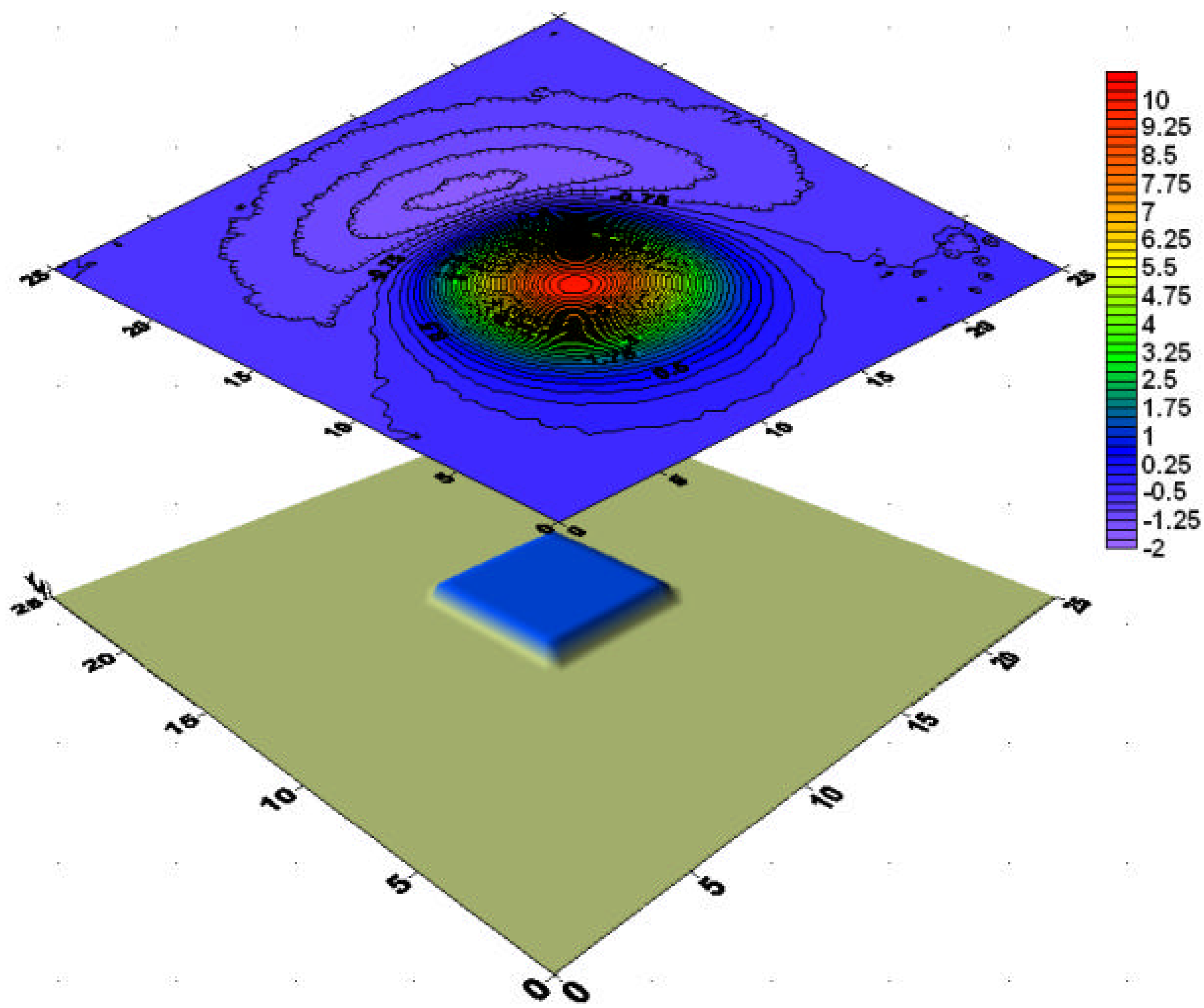
2. MFDESIGN.EXE performs interactive design of matched bandpass filters on the files created with MFINIT.EXE. It does so via full-screen DOS graphics (won't work with Windows Vista). MFDESIGN displays the radially averaged power spectrum, you provide the intercept numbers. Use a sheet of paper as a straight edge when you are fitting lines to the linear portions of the radial power spectrum.

Typically, you will fit the uppermost layer with a magnetic dipole (choice 0) and the next layers with choice (1) for a magnetic layer. Sometimes the first two layers are best modeled with dipole layers – experiment and think about what might be causing the shallow anomalies.

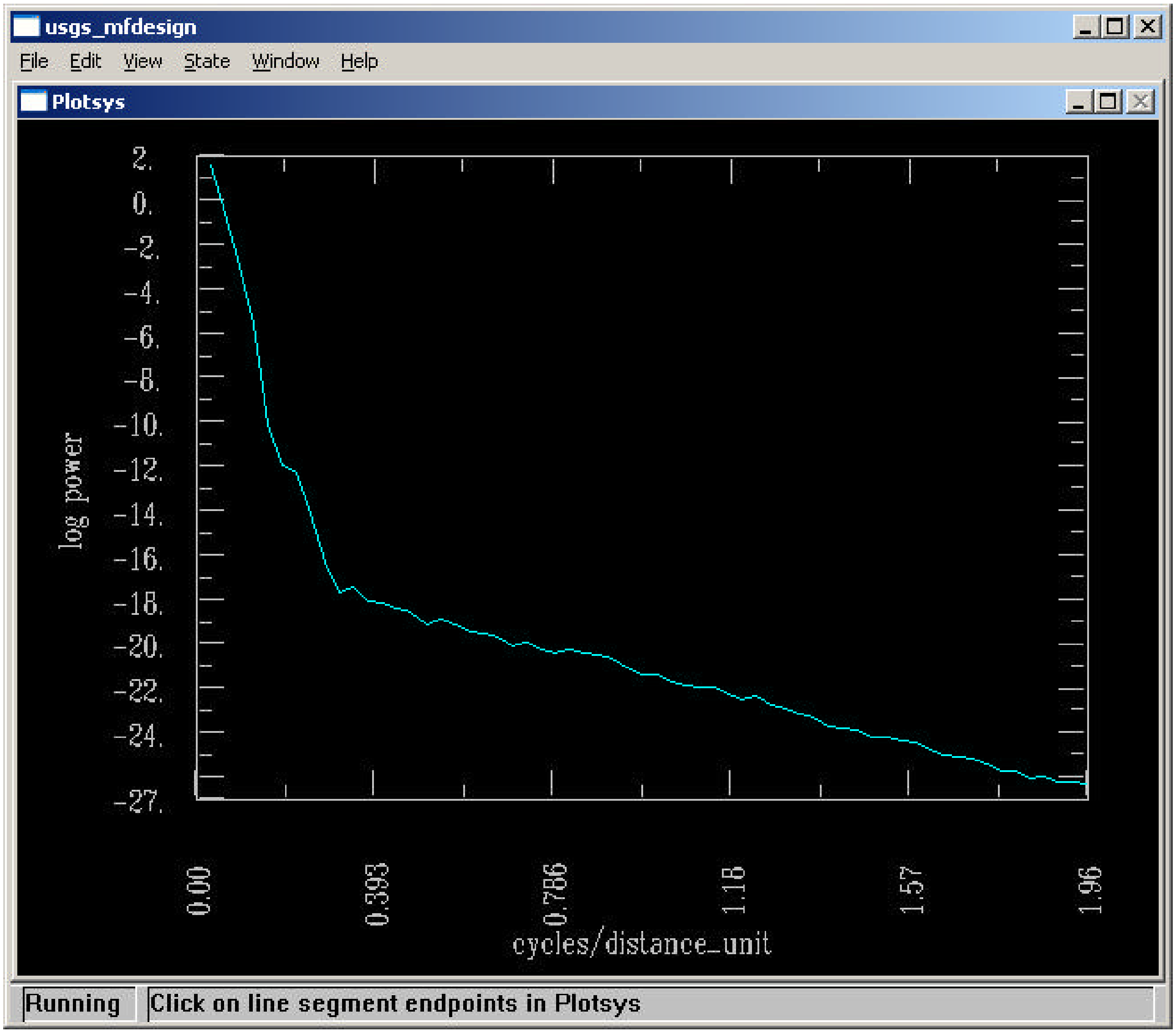
3. MFFILTER.EXE performs the bandpass filtering on the total field anomaly. It also allows azimuthal filtering in case you have some "herringbone". Once you are done with your choices, MFFILTER provides the option to perform nonlinear least squares adjustment to get a better fit.

MFFILTER.EXE gives you the names of the output files as it progresses, typically mfilt.31, mfilt.32, and mfilt.33 for a three layer case. These are USGS grid files. Use PFDRIVER to transform them to Surfer grids.

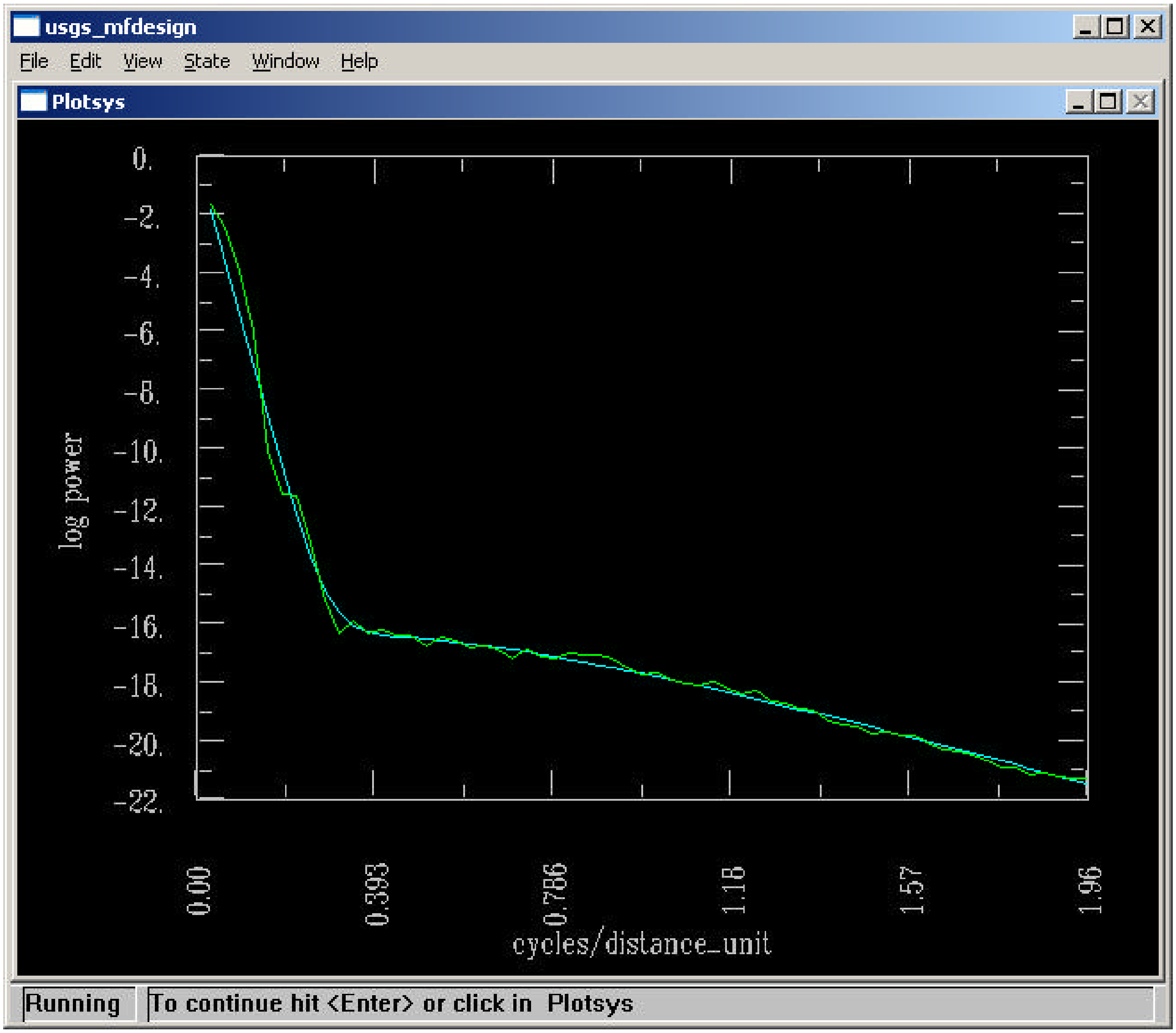
The images below are in sequence. They are from a different software package but the concepts are identical.



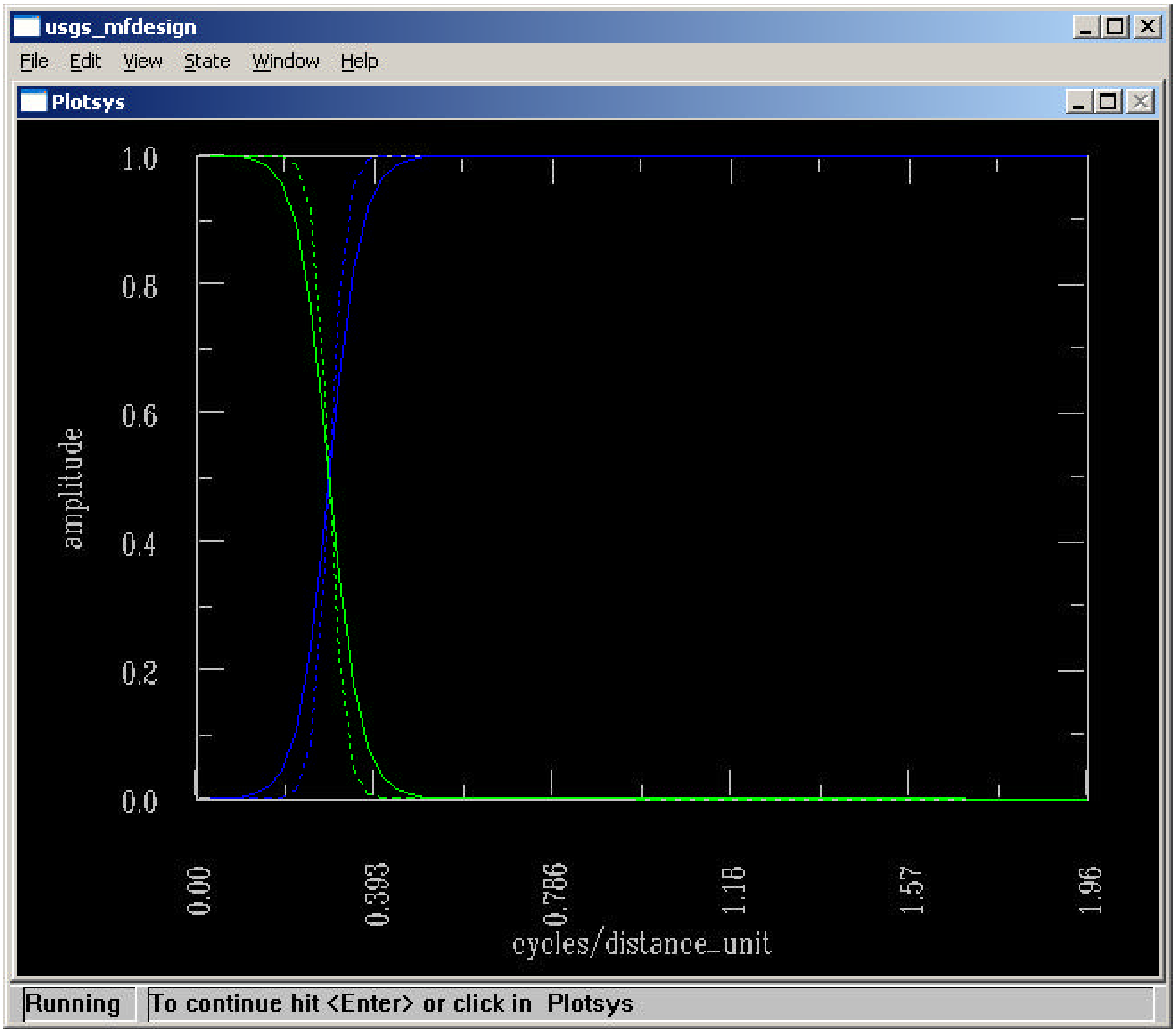
For the demo data, I modeled a vertical prism 4 kilometers below the surface and added a few percent noise to the resulting total field anomaly. The added noise is in the observations and represents observational error. I did that by using Surfer's Grid Node Editor to turn the grid to a .dat file. I then added a column of noise (use data transform and RANDn(average, StDev)) and added that to the observation column. I then regridded the data.



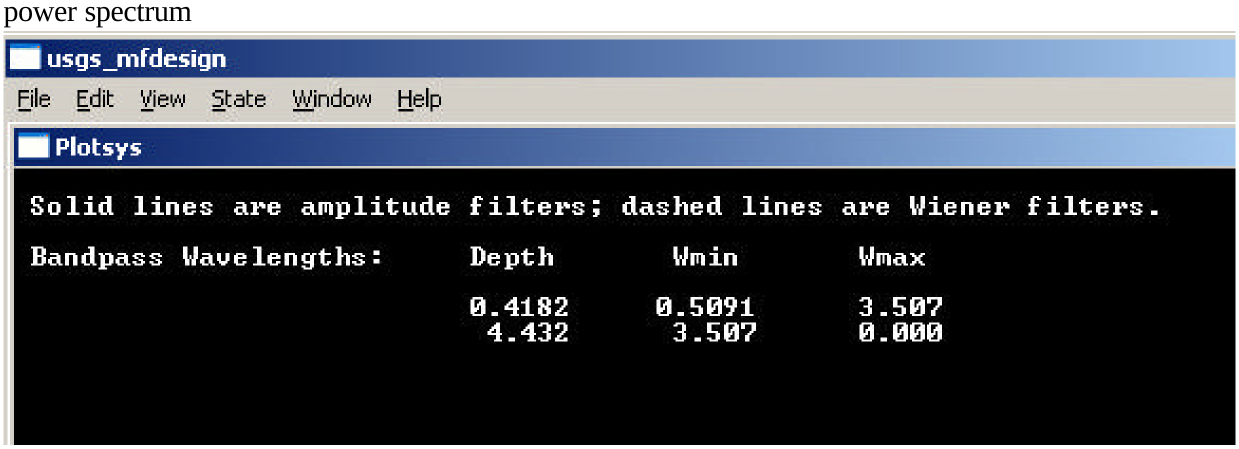
This is the radially averaged power spectrum for the noisy data above. Note that there are two distinct linear segments, representing shallow and deep equivalent sources. The low slope segment runs from a wavelength of about 2.5 kilometers to 0.5 kilometers.



This is MFDESIGN's fit to the power spectrum after iterative adjustment.

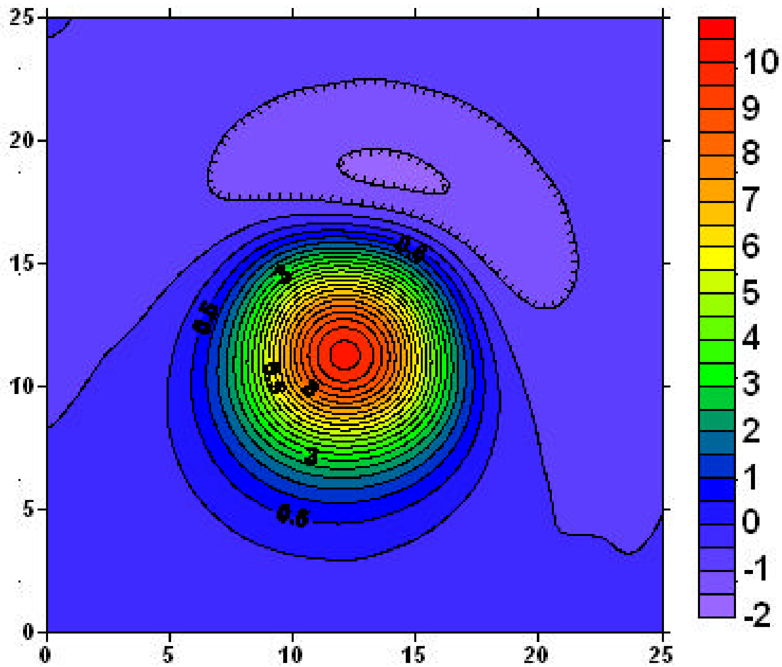


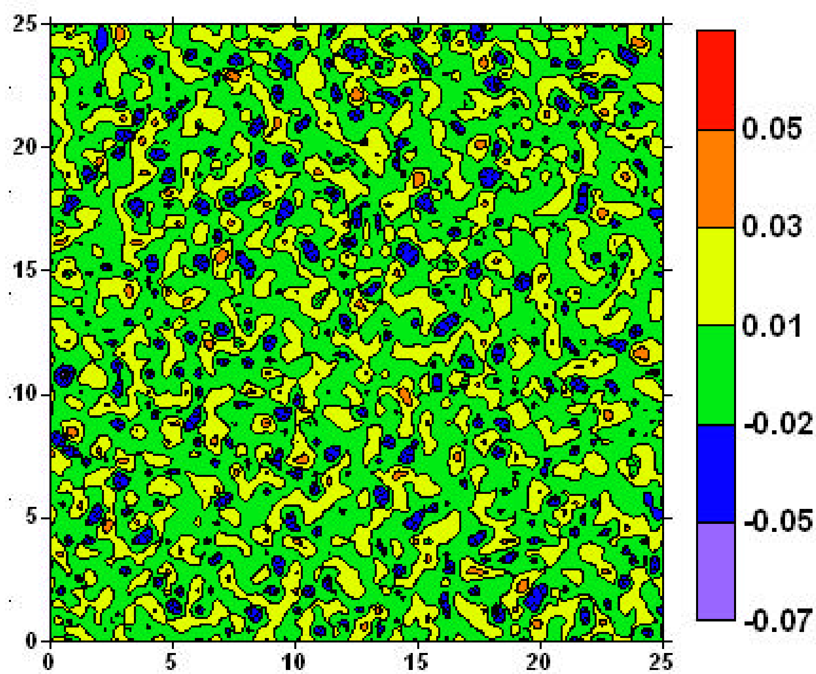
These are the low pass and high pass filters that represent the two linear segments in the radially average power spectrum



Bandpass Wavelengths:	Depth	Wmin	Wmax
	0.4182	0.5091	3.507
	4.432	3.507	0.000

This shows the depth of the equivalent layers isolated in the power spectrum





The upper map is the anomalous field from the long wavelength (low wavenumber) part of the spectrum. The lower map is from the high wavenumber (short wavelength) part of the spectrum. I generated the noise as a random function (RANDn(average, StDev) in a Surfer worksheet and added it to the original data. The lower map is a good characterization of random noise, the upper map an excellent representation of the field without the noise.

MFINIT

computes the radial power spectrum and the residual power spectrum of a standard gridded file. The input grid must be complete (no dvals), and its column dimension must be less than 2049.

This is the first program in the matched filtering sequence. It is followed by MFDESIGN and MFFILTER.

input: a specified standard grid
output: mfilt.6 fourier transform parameters
mfilt.8 fourier transform
mfilt.9 log averaged radial power spectrum
mfilt.40 log residual power spectrum
mfilt.50 extended input grid

The program works fastest if the temporary files are written to a large RAM disk in extended memory. To set up a RAM disk drive on power-up or on rebooting, include a line like the following in your CONFIG.SYS file:

```
DEVICE=C:\DOS\RAMDRIVE.SYS 7680 512 /E
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written by Jeff Phillips

MFDESIGN

performs interactive design of matched bandpass filters for gridded potential field data.

This is the second program in the matched filtering sequence. It is preceedeed by MFINIT and followed by MFFILTER.

input: mfilt.9 log averaged radial power spectrum (from MFINIT)
output: mfilt.7 filter parameters for MFFILTER

The program will first ask the user to select a layer code corresponding to a shallow equivalent source model for fitting the high wavenumber end of the spectrum. This choice is arbitrary. Available codes and models are:

- 0 magnetic dipole layer
- 1 magnetic half-space or density layer
- 2 density half-space

The spectrum of a single magnetic dipole layer (layer code 0) will appear linear at high wavenumbers but become concave downward and achive a maximum at low wavenumbers. The log averaged radial power spectrum of a single magnetic half-space or density layer (layer code 1) will appear linear at all wavenumbers. The spectrum of a single density halfspace (LAYER CODE 2) will appear linear at high wavenumbers but become concave upward at low wavenumbers. A spectrum produced by multiple equivalent source layers may exhibit combinations of linear, concave upward, and concave downward behavior. Theoretically code 0 should only be used on magnetic data and code 2 should only be used on gravity data. In practice the high wavenumber end of the spectrum, which corresponds to the shallowest equivalent source layer, can usually be fit to any of the three models. If layer code 0 or 2 are selected, the power spectrum will be corrected to the form of layer code 1 before plotting.

The program will next plot the (corrected) log averaged radial power spectrum and ask the user for the left intercept and bottom intercept of a line fitting the high wavenumber end of the curve. It may help to hold a straightedge up to the screen, and read the intercepts directly. If the line has no bottom intercept, enter the left intercept and zero; the program will then prompt for a right intercept. The indicated line will be drawn on the plot. A beep will indicate that the plot is finished and the user must press the enter key.

The user will next be given the option of trying again using the same or a different model (layer codes 0, 1 or 2), or accepting the fit for this high wavenumber end of the spectrum and proceeding to model the adjacent lower wavenumber range of the spectrum using a deeper equivalent source layer (layer code -1 'next layer'). If layer code -1 is selected, the effects of the modeled equivalent source layer will be removed from the spectrum, and the residual spectrum will be plotted.

The program will next ask the user for a layer code corresponding to the equivalent source model to be used to fit the next lowest part of the spectrum. Proceed as before by selecting a layer code between 0 and 2 and fitting a line to this part of the spectrum. When the fit is acceptable enter a layer code of -1 to go on to the next deepest layer.

When the user has fit an acceptable line to the lowest wavenumber part of the spectrum, the model is completed by entering a layer code of 99. The observed and modeled spectra are then plotted, and the user is asked if iterative improvement of the model is desired. Iterative improvement can be performed a step at a time (step-by-step option) or recursively until the percent improvement becomes zero or negative (forever option). The improved model spectrum will be plotted and the model parameters listed. The user will be given a second chance to iterate on the model, and a chance to start completely over.

Once the model has been accepted, the program will plot the bandpass filters corresponding to the equivalent source layers, and list the crossover wavelengths of the filters. After MFDESIGN has completed, the current observed and model spectra and the current bandpass filters can be redisplayed by running the program MFPLOT. To apply the bandpass filters to the data grid, run the program MFFILTER.

MFFILTER

performs matched bandpass and azimuthal filtering on gridded potential field data.

This is the third and final program in the matched filtering sequence. It is preceeded by, and uses output from, the programs MFINIT and MFDESIGN.

input: mfilt.6 fourier transform parameters (from MFINIT)
mfilt.7 filter parameters (from MFDESIGN)
mfilt.8 fourier transform of original grid (from MFINIT)
mfilt.40 residual spectrum (from MFINIT)
output: mfilt.31-39 bandpass filtered grids
mfilt.41-49 azimuthally filtered grids
mfilt.51-59 downward continued grids

MFFILTER is self prompting. The azimuthal filtering options are experimental and may not produce desirable results in all cases.

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