

## Preparing Grids for MAGMAP FFT Processing

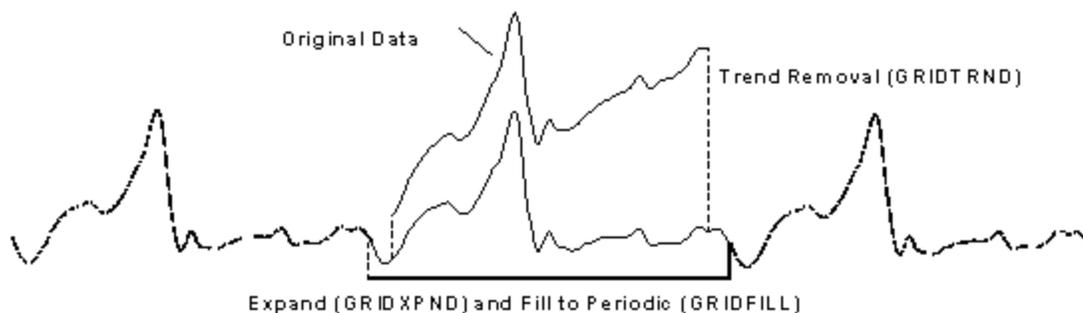
This *Preparing Grids for MAGMAP FFT Processing* lesson guide describes how to prepare your grids for the Fast Fourier Transform process, this preparation process includes.

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Grid preparation includes the following basic processes:

1. Removing a first order trend from the grid. The removed trend is stored in the user area of the grid header, and is filtered together with the zero wavenumber.
2. Expanding the grid dimensions by adding cells along all grid edges to produce a square grid. By default, the grid dimension is increased to the next Winograd special value that is at 10% larger than the current grid dimension (*Winograd, S. On Computing the Discrete Fourier Transform, Mathematics of Computation, Vol. 32, No. 141, pp. 175-199, Jan. 1978.*). Cells initially are not assigned values. The system uses the Winograd FFT algorithm for dimensions up to 2520 x 2520 cells. Beyond that, the algorithm switches to the power of 2, expansion and FFT algorithm.
3. The expanded rim is interpolated maintaining edge continuity, using one of the 2 available methods.

The following diagram illustrates the effect of the above processes in one dimension. Because the pre-processed grid must be periodic, it is important to remove a first order trend before expanding and filling.



If a significant trend is left in the data, the expansion and filling processes may introduce a large step to ensure periodicity. In the Fourier domain, this step function predominates, and might cause serious artefacts.

## Preparing Data for Processing

MAGMAP is designed to work on gridded data. This *How-To Guide* does not explicitly describe the procedures used for preparing your data. In practice, you will create the gridded data prior to using the MAGMAP Filtering system.

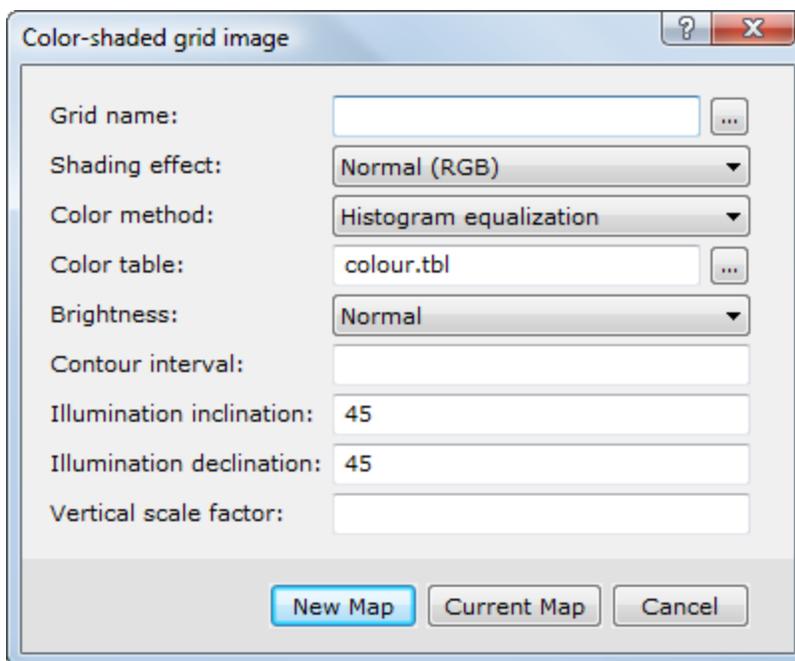
## Displaying Grids Prior to Processing and Analysis

Before starting, you may want to display the grid you have ready for processing.

### To Display a Grid

1. From the *Grid and Image* menu, select *Display* and then select **Colour-Shaded Grid**.

The *Color-shaded grid image* dialog appears.



2. Use the *Browse* button to select an appropriate *Grid name*.
3. You can accept the default values for the remaining parameters and click the **New Map** button.
4. The system creates a colour-shaded image from the supplied grid file and places that image in a new map window. The map is given the name of the grid file, with a (\*.map) extension.



Click the *Help* button on the *Colour-shaded grid image* dialog for information about each parameter.

## Preparing Grids for Transformation

Before transforming a grid to the wavenumber domain (applying the forward FFT), the grid must be properly conditioned to conform with the fundamentals of Discrete Fourier Domain processing. This topic is extensively covered in the signal processing literature and is outside the scope of this Guide. In a nutshell, the conditioning helps minimize the processing artifacts.

In MAGMAP's Step-by-Step and Interactive approaches, the grid is preconditioned by executing the *Prepare Grids* menu item. In the 1-Step process, grid preparation is handled automatically in the background.

The basic grid preparation steps consist of:

- Enlarging the grid to a square of permissible dimensions \*\*. The FFT process only accepts specific dimensions. The expansion serves the secondary purpose of ensuring an adequate gap for establishing the periodicity.
- Optionally removing the regional trend. The intent is to minimize the introduction of long wavelength high amplitude behaviour in the expansion areas.
- Replacing all the dummies in the expanded grid with plausible values, while maintaining the power and frequency content in the data at about the same level.
- Ensuring periodicity along opposite edges.

### To Prepare a Grid for FFT Transformation

1. On the MAGMAP menu, click *Step-By-Step Filtering* and then select **Prepare Grid**.

The *FFT2 grid pre-processing* dialog appears.

The screenshot shows the "FFT2 grid pre-processing" dialog box. It contains the following fields and options:

- Name of Input (Original) Grid File: [Text box] ...
- Name of Output (Pre-processed) Grid File: [Text box] ...
- Type of trend surface to remove: [Dropdown menu] first order
- Trend based on: [Dropdown menu] edge points
- % expansion: [Text box] 10
- Square or rectangular expansion: [Dropdown menu] square
- Grid fill method: [Dropdown menu] multistep expansion
- Roll off to zero at distance of (cells): [Text box]
- Limit all amplitudes to be less than: [Text box]
- Edge amplitude limit: [Text box]

Buttons: Start, Cancel

2. Select the *Name of Input (Original) Grid File*.
3. Specify the *Name of Output (Pre-processed) Grid File*.
4. You can leave the remaining parameters to the intelligent default values, as shown above.
5. Click the **Start** button. The system prepares the grid and displays it in your current project as a temporary map file. You can come back later and visit the help content to find out about the effect of the individual parameters on the grid preparation process. For now, we will focus on the effect of filtering.

## Trend Removal Algorithm

The system first removes a first order trend from the data. Because the data is made periodic when filled, this procedure removes the amount of step function that may be required to connect the grid at opposite edges.

The trend surface is (by default) calculated using the edge points of the data, so that no strong anomalies within the grid affect the trend. The trend coefficients (first order only) are stored in the grid file header and, during filtering, anything applied to the zero wavenumber of the data is also applied to the trend coefficients.

## Grid Expansion Algorithm

The grid must be expanded in size to have dimensions that are acceptable to the FFT: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 24, 28, 30, 36, 40, 42, 48, 56, 60, 70, 72, 80, 84, 90, 112, 120, 126, 140, 144, 168, 180, 210, 240, 252, 280, 315, 336, 360, 420, 504, 560, 630, 720, 840, 1008, 1260, 1280, or 2520 cells. Also, the expansion provides an area for extending the grid to be smoothly periodic. Grid expansion simply pads the edges of the grid with dummy values.

The system enables you to specify a minimum percentage for expansion. The default is 10%, after which the next largest acceptable dimension is selected.

In most cases, the default size is acceptable. However, if the wavelength of the anomalies of interest is more than approximately two times the default padded size, you must increase the expanded size by increasing the expansion percentage. If the expansion is too small, any step in the expanded area can adversely affect the anomalies within the data.

## Grid Filling Algorithm

The system replaces all the dummy values within a grid with the interpolated values. It starts by interpolating the blank areas of the grid by:

1. Replacing dummies within each grid row so that the grid lines are periodic
2. Replacing dummies within each grid column so that the grid columns are periodic
3. Averaging the results from the row and column filling. The averaging procedure uses inverse distance weighting to the nearest data within each row and column. This procedure effectively fills holes in the data and accounts for irregular edges of the grid.

When filling, you must avoid introducing abrupt step functions in the filled grid. You can suspect a step problem if you observe “ringing” in a filtered output grid. Ringing is a symptom of Gibb's Phenomena, which is observed when you modify the Fourier Spectrum of a step function. Filters, by definition, must modify Fourier Spectrum; therefore, filtered maps are susceptible to Gibb's Phenomena if you are not careful when filling the grid.

Ringing can be identified as a wave pattern that extends away from, or around, a strong anomaly. The wavelength of the pattern is normally near the size of the strong feature in the data. Because the system interpolates data beyond the edges of the grid, it can introduce step functions that cause ringing to spread into a filtered grid.

## Minimizing "Ringing" from Grid Filling

MAGMAP provides the following parameters that can be set to minimize ringing problems when they occur. For a complete summary of the trend removal, grid expansion, and filling parameters, see the Setting Trend Removal, Grid Expansion, and Filling Parameters section at the end of this section.

### Applying Maximum Entropy Prediction

You can use Maximum Entropy Prediction (MEP) to interpolate the data. MEP samples the original data near the grid edges to determine its spectral content. It then predicts a data function that would have the same spectral signature as the original data and calculates the extrapolated data of a similar nature and the real data adjacent to it.

As a result, the predicted data will not significantly alter the energy spectrum that would result from the original data alone. This process works along lines in one direction then the other, and applied weighting along adjacent lines to eliminate line to line discrepancies.

### Effect of Elongated Rectangular Expanded Grids

For expanded grids with a X vs Y dimension exceeding 2, the disparity of the wave-number  $u$  and  $v$  increments affects the resolution of the output grid differently in the X and Y directions, and causes a directional bias.

### Controlling Edge Effects

Sometimes, the prediction function can produce large ridges that extend away from the edges of the data. If you suspect artefacts caused by an edge effect, closely inspect the pre-processed grid to identify if edge filling has produced strong ridges in the filled areas. This typically happens in the originally rectangular grids for which a large expansion is required in one direction in order to make the grid square.

If you suspect such an edge problem, you can set the distance at which to roll the data to zero. Ensure that the roll to zero distance is at least as large as the longest anomalies of interest along the edges of the data, otherwise the edge anomalies may be distorted.

### Limiting Strong Anomalies by Magnitude

Very strong anomalies within the original data area of a grid can also cause ringing problems in filtered maps. For example, iron formation anomalies in magnetic data can be many orders of magnitude greater than the surrounding anomalies. The magnitude of these anomalies is so great that they dominate the Fourier spectrum, and even small changes to the spectrum result in ringing. Such ringing appears as waves that surround the large anomaly.

If required, you can smoothly limit any anomalies that exceed a specified magnitude. Data less than half the limiting magnitude is not changed. Above half the limiting magnitude, data is smoothly attenuated so that it does not exceed the limit.

If limited anomalies are wide, this can cause the attenuated anomalies to have flat tops, a fact that you should be aware of when interpreting the resulting filtered maps. If flat-topped anomalies are not wanted, another option is to clip high magnitude anomalies using Geosoft's Grid Windowing GX (for more information, contact your Geosoft representative). Clipped areas must be set to dummy values, and the resulting processed grids will have holes where the anomalies have been clipped.

### **Limiting Strong Anomalies Near Grid Edges**

Very strong anomalies that are truncated at the edge of a grid can cause problems in filling because their magnitude is extended into the filled borders of the grid. Step functions parallel to the grid edges result, and ringing can manifest itself as a streak in a filtered grid that extends away from the strong anomaly, or appears on the opposite side of the grid (remember that the grid is considered periodic, so an anomaly on one edge can effect the opposite edge of the grid).

If required, you can smoothly limit the magnitude of strong anomalies within a certain distance of the edge of a grid. You can specify the maximum edge magnitude and distance. All anomalies of greater magnitude than the edge limit will be smoothly attenuated starting at half the magnitude limit.

In extreme cases, it may be necessary to totally limit edge anomalies by specifying the maximum magnitude of 0. This is similar to applying the Hamming window to the grid, which is the more conventional approach used to handle the edges of data in the Fourier processing. However, this method produces a pronounced edge ring around most data grids, which is usually unacceptable.

### **Setting Trend Removal, Grid Expansion, and Filling Parameters**

Geosoft provides a variety of capabilities for preparing grids prior to applying the forward FFT. These capabilities are controlled through the *Prepare Grid* menu option. When you select this option, the system displays the FFT2 grid pre-processing dialog. The following table summarizes the parameters that can be set in this dialog and provides guidelines for setting them.

Trend Removal Parameters	
<b>Type of trend surface to remove</b>	Select order of trend to remove (the default is the first order). Options are: remove mean, first order, second order, third order.
<b>Trend based on</b>	Select or type either 'edge points' or 'all points'. The trend surface to remove can be calculated either by using all the valid points in the grid, or by using only the points along the valid edge of the grid. Using the edge points is often better, especially if there are any large-magnitude anomalies within the grid.
Grid Expansion Parameters	
<b>% Expansion</b>	Type the expansion size (grid is expanded in size by at least this distance as a percentage of the smallest grid dimension). The expansion must be about half the size of the broadest features of interest in the grid. If you are tapering the data to 0, the expansion need not be larger than the taper distance.
<b>Square or rectangular expansion</b>	Select or type either 'square' or 'rectangular'. If the grid is small, or if the wavenumbers of interest approaches the size of the grid, we recommend square expansion because it minimizes side effects that result from having different wavenumber samples in the X and Y directions. Rectangular grids can save significant processing time and disk space when working with large grids.
Grid Filling and Ringing Parameters	
<b>Grid fill method</b>	Select or type a fill method. When filling the dummy areas, the new values are determined by extrapolation from the nearest valid parts of the grid. This extrapolation may be based on inverse distance weighting, multi-step expansion or maximum entropy prediction. Maximum entropy is slower but it creates a filled area more similar in character to the actual data.
<b>Roll-off to zero at a distance of (cells)</b>	Specify the number of cells beyond the valid area at which to roll off to zero. By default, no roll-off is applied. For some grids, the prediction function can become unreasonable at large distances from the valid parts of the grid. In these cases, the data can be forced to zero at a specified distance. This option should only be used on trend-removed grids.
<b>Limit all magnitudes to be less than</b>	High-magnitude anomalies can cause problems in filtering systems such as MAGMAP. With this option, anomalies that exceed half the specified limit are smoothly attenuated. The attenuation is started at half the limit, with no values allowed to exceed the limit. This option must be used only on trend-removed grids.
<b>Edge magnitude limit</b>	High-magnitude anomalies on the edges of the valid area can produce oscillations in the extrapolated areas. With this option, a limit may be placed on anomalies along the edges of the grid.

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