GEOMETRICS INC.

**Magmap
User Guide**

24891-01 Rev. N

Magmap (24890-01)

MagMap

Magmap 4.0, User Guide

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Note to new G-858 Users.

This software replaces the DOS version of software also included with the G–858. In some cases, G–858 and G–856 magnetometers were shipped with an early MSDOS based version of MagMap. We strongly recommend that users upgrade to Windows 95, 98, , or NT in order to employ the full power and utility of Magmap. In keeping with the common naming conventions, this manual refers to Magmap and the newly released MagMap. New features will be added to the MagMap version in our continual pursuit to deliver the highest levels of support to our customers in their quest to "see beneath the surface of the earth".

1. What is Magmap?

Magmap is a post acquisition processing software used to analyze and process data from a number of different instruments. It allows the user to download data from the G−858, and modify the positions that were entered while doing a survey. It also supports other instruments such as the G−856, G−880, G−881, G-877 the Ohmmapper, MetalMapper and the EM-61. The resulting data grid is graphically displayed on the PC screen as a Quality Control measure and to assure coherence between the original acquisition parameters and the final locations. Editing functions include moving lines and positions, changing the direction of lines, rotating lines, and deleting parts of lines or entire lines. It also provides a means of performing diurnal corrections, plotting the acquired magnetic field values and filtering them for spikes, dropouts or leading errors. Vertical and horizontal (longitudinal and transverse) gradiometer data is supported. In cases where there is GPS data, MagMap has facilities to smooth this data and use these coordinates in place of mapped coordinates. Finally, the program will export data for surface plotting programs, such as Golden Software's Surfer and GeoSoft's suite of analysis plotting programs.

1.1. Program Flow Overview

The flow diagram below is provided for reference in the following discussions and will assist the user in understanding each step of the data processing procedure.
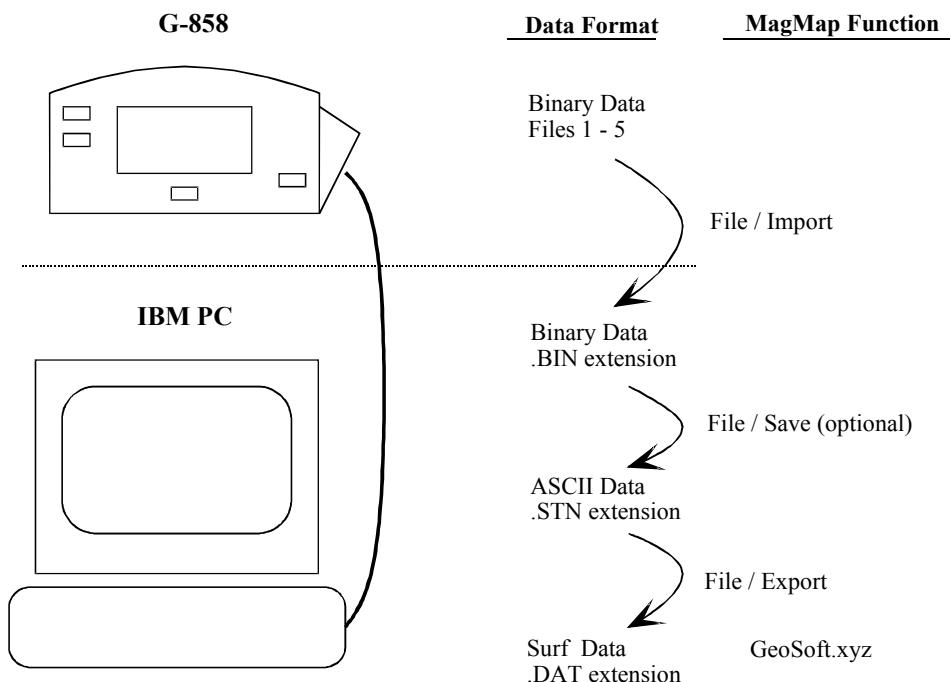
Data Flow for the Magmap program

1.1.1. Downloading Data from the G-858

The time, position and magnetic field data are stored in the G-858 console in one of 5 files numbered 1 through 5. The data are stored in a compressed binary format for maximum use of the available RAM. While the user may select ASCII download via RS-232 with a program of his choosing (i.e. Procom), this can take up to 20 times longer than downloading the compressed binary file with the Magmap Import program and is not recommended. Magmap Import provides an "Autospeed" function that will make RS-232 connections at up to 115 KBaud on compatible systems. EM-61 data is treated like Magnetometer data, OhmMapper data is processes within Magmap but is described in a separate manual, PN ------

1.1.2. PC File Formats

The transmitted binary data is stored in a binary file with the extension .BIN on your PC. This file requires about 100 KBytes of hard disk storage per hour of data collection (at 10 readings per second). The .STN file is an ASCII representation of the data. You can create this file at any point in your Magmap analysis and this can be viewed from an ASCII text editing program such as a spreadsheet. Most editing functions can be accomplished with the Magmap program. These files may be very large, typically 1MB per hour of data collection.

1.1.3. Accurately Positioning Data

After conversion, Magmap will interpolate readings between known position points called "marks".   When you have GPS data, each given position point will also count as a mark. You have great latitude in defining how the survey data was acquired and in editing the individual positions of the readings. Computation of the vertical or horizontal gradient from two sensor gradiometer files takes place at this stage. During the location process, the user may perform several corrections to the data including re-scaling, offsetting, and correcting for diurnal variations.

Finally, after positioning the data, Magmap will write an ASCII file suitable for input to a 3D surface plotting program, such as Surfer for Windows™ or Geosoft™ Analysis and Plotting Software. Such files consist of x and y coordinates, field values, difference between values (in the case of gradiometer data), and time and date for each magnetometer reading. <u>These files are typically about 3 MB per hour of data collected.</u>

After data corrections are applied, the corrected raw data may be stored in ASCII format with an .STN extension. This will be necessary if you have not completed all the editing you wish to do, and wish to continue at a later time.

1.2. Requirements

The G-858 can collect an enormous amount of data. Marine Mags create even larger files. Even modest size surveys will require large computer resources in terms of RAM and hard disk space. You will need a minimum of 16 MB of RAM

installed on your computer. Plenty of hard disk space will be necessary as well, if you want to store lots of data. Typical Windows95, Windows 98, Windows NT, and Windows installations will have enough resources.

Additionally, some of the larger surveys will be very time consuming. We recommend at least a Pentium system with 32 MB RAM, although Magmap will run on slower systems.

This program will not run under MS-Windows 3.1. It will run under Windows NT 3.51, but some of the dialog boxes and windows will not look as pictured in this document.

1.3.   Installation

1.   First, decide to which drive and directory you wish to install the Magmap program. It is prudent to keep it in the default directory.

        (C:\program_files\magmap2k)

2.   Insert the installation diskette into your floppy drive.

3.   Run the SETUP program found on that disk. There are several ways to do this. One is to double click on My Computer, double click on the floppy drive, then double click on SETUP. Or, click on START, then select RUN. Type A:\SETUP and press ENTER.

5.   Follow the directions on your screen.

1.4.   Usage

The three modes of operation of the G-858 correspond to different ways of manipulating the data inside the Magmap program:

1.4.1. Base Station

Magmap will download the base station data, plot it, and use it to correct the survey data for diurnal drifts.

You can determine that you have a valid base station file that overlaps with the field data by going to your export menu. If you do not have the message "*No valid base station file has been opened*" at the bottom of your export menu, this means you have a valid base station file.

1.4.2. Simple Survey

You must describe your survey to the Magmap program so that the program can properly locate the data points. You will manually input the starting line direction, the line and mark spacing and whether you took data bi-directionally.

1.4.3. Mapped Survey

Since you have already described your survey to the G-858, data will be located using the information you entered during the survey.

Note: You are able to edit and reposition data in both simple survey and mapped survey modes. Simple survey requires some positioning information to be entered. In mapped survey, the positioning information is entered in the field and you will most likely not need to edit any positions, or enter any further information.

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2.   How To Quickly Get Started

This is section is intended for the user who wishes to quickly start downloading and editing a G–856 or G–858 survey. Much more detail about the various functions is given in later sections. Please read those sections for more useful information about the capabilities of this program when you have time.

2.1.   How to download your surveys

Click the left mouse button on the toolbar button labeled "Import" or select "File" then "Import" in the menu. You will need to select whether you have a G–858 or G–856.

2.2.   How to edit positions

2.2.1.   Selecting and editing a single position

To edit a single position click the right mouse button ("right click") on the position symbol (small blue square). (You can select more than one position by pressing CTRL and clicking the left mouse button on each position you wish to select. Then right click to bring up the editing menu.)

- To move the position to a new location select "Move Position To".

- To shift the position by an X or Y offset select "Shift Position By".

- To delete a position select "Delete Position". **This will delete only the positions.** The locations of the nearby readings will then be re-interpolated using the positions that are left.

2.2.2.   Selecting and editing entire lines

To select a line click the right mouse button on the start of line symbol (big green square) or on the end of line symbol (big red square).

- To shift the line by an X or Y offset select "Shift Line By".

- To reverse the direction of a line select "Reverse Line".

- To correct a walking deviation error (for example you did not walk straight and end up at another line, select "Add Line Deviation".

- To rotate a line select "Rotate Line".

- To delete a line select "Delete Line". **This will delete the readings of an entire line.**

2.2.3. Selecting and editing segments

To select a segment click the right mouse button on the direction symbol (arrow) located between two positions. Segment operations are only available for continuous surveys.

- To shift the segment by an X or Y offset select "Shift Segment By".

- To reverse the direction of a segment select "Reverse Segment".

- To correct a walking deviation error (for example you did not walk straight between 2 positions and end up at another line, select "Add Segment Deviation".

- To rotate a segment select "Rotate Segment"

- To delete a segment select "Delete Segment". **(This will delete the readings between the two positions).**

2.2.4. Selecting and editing the survey grid

To select the grid click the right mouse button on the green area of the map.

- To shift the grid by an X or Y offset select "Shift Grid By".

- To reverse the direction of every line or every other line select "Reverse Grid".

- To rotate a grid select "Rotate Grid".

- To change the mark and line spacing select "Grid Setting".

2.2.5. Selecting and editing a group of positions

In order to move a several positions by a given amount, you may select them as a group and then move them.

2.2.5.1. SELECTING A GROUP OF POSITIONS

To select a group of positions click the left mouse button and draw a rectangle around the positions to edit. When you have finished drawing the rectangle, release the left button. Every position inside that rectangle will be selected (white square).

- To select more positions press the control key (CTRL) and repeat the previous operation.

- To select a single position press the CTRL key and click the left mouse button inside the corresponding position.

- If the positions were already selected they will be deselected, if they were not selected they will be selected (pressing the CTRL key toggles the selection.)

- To deselect all the positions left click the mouse button anywhere.

2.2.5.2. EDITING THE GROUP OF POSITIONS

Once you have finished selecting the positions, right click the mouse button on the green area of the map.

- To shift the selected positions by an X or Y offset select "Shift Selected Position (s) By".

- To delete the selected positions by an X or Y offset select "Delete Selected Position (s)". **(This will not delete any readings but will cause the data to be linearly interpolated between the remaining positions.)**

- To shift the selected segments by an X or Y offset select "Shift Selected Segment (s) By".

- To reverse the selected segments select "Reverse Selected Segment (s)".

- To reverse and shift the selected segments select "Reverse And Shift Selected Segment (s) by".

- To delete a segment select "Delete Segment **(This will delete the readings of every selected segment).**

2.3. How to line up positions along a slope

You can create a triangular back edge (useful e.g. if your survey is bounded by a road or a fence at an angle to the grid) by selecting the positions you want to move. Then, right click the mouse button, and choose "Line Up Selected Positions Along A Slope". Then, you will enter two coordinates. The positions will be moved to lie along the line you have defined.

2.4. How to undo the previous operation

Select "Edit" from the menu then "Undo". You can only undo the most recent operation.

2.5. How to view a profile of the readings

- To plot a profile of only the readings between two positions click the right mouse button on the direction symbol (arrow) located between the two positions, then select "Plot Mag Field".

- To plot a profile of only the readings for a specific line, right click the mouse button on the red or green square of the corresponding line, then select "Plot Mag Field".

- To plot a profile of the readings for the whole survey, right click the mouse button on the green area of the map, then select "Plot Mag Field". Individual anomalies may be flagged using the right mouse click. Select fag: dentifier flag will appear on position and contour maps.

2.6. How to create a 2D contour map of the readings

To plot a 2D contour map of the readings, position your cursor on the map and press the right mouse button. If you are trying to plot a contour map using GPS coordinates, you should right click on a starting or end point (green or red square). Then select "*Plot Mag Field in 2D contours*".

Note: The scale of the contour map is created by a technique called "Color Equalization". This technique represents each color as an equal amount on the map. As a result, it gives a good picture of anomalies when other linear scales would allow drop-outs and spikes to distort the map.

2.7. How to create a 3D map

To plot a 2D contour map of the readings, position your cursor on the map and press the right mouse button. If you are trying to plot this map using GPS coordinates, you should right click on a starting or end point (green or red square). Then select "*Plot Mag Field in 3D Surface*".

2.8. How to plot stack profiles on the map

This is only applicable for land-based surveys such as G–858 or G–856.

Position the cursor on one of the lines of the map and press your right mouse button. Select "*Plot Stack Profile on Top of Map*". Then select "*Plot Sensors Setup*" and choose which sensor you want to plot. You should then see a series of profiles appear over your lines. Plus Minus Keys control the amplitude of the stacked profiles.

You can zoom in and out by using the zoom buttons (a toolbar) located at the top of your screen. If they are grayed out, make sure that you have disabled "*Always Fit in Window*" from the *Scale* Menu.

2.9. How to filter the readings

Select "Filter" from the menu then "Despike" or "Linearly Interpolate Drop Outs".

Despike will only remove spike(s) above 1000 nT. (Use despike with caution in discrete survey mode, as the readings may change rapidly near an anomaly, and thus the anomaly may be interpreted as bad data and filtered out.).

2.10. How to export your survey to Surfer or Geosoft

First, open or download one or more base station files if a diurnal correction is desired. Then select "File" from the menu then "Export" or, right click the mouse button on the green area of the map then select "Export".

The diurnal correction will be done automatically if the time of any opened base station file matches the time of the survey.

3. Importing a survey

3.1. Downloading a survey from a G–856 or G–858 Magnetometer

3.1.1. Select import from the menu

Select "*File*" from the menu. Choose "*Import G–856 Data*" if you have a G–856 magnetometer or "*Import G–858 Data*" if you have a G–858 data.

The dialog box in Figure 1 should appear on the screen.
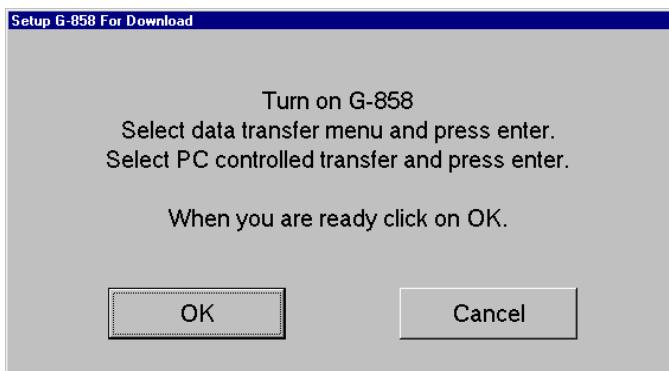
Figure 1

Note: Most of the following examples use the G–858 magnetometer but the procedure for downloading data from the G–856 magnetometer is the same.

3.1.2. Setting the G-858 magnetometer for upload

In the G-858 Initial Menu select "DATA TRANSFER" by moving the up or down arrow key.

Press the "Enter" key to go to the Data Transfer Menu.

In the Data Transfer Menu select "TRANSFER UNDER CONTROL OF PC" and press enter.

The G-858 is now ready to download the survey.

3.1.3. Setting the PC for downloading

Once your G-858 is ready for downloading, click the left mouse button on the OK button or CANCEL to abort.

The G-858 download setup dialog box should now appear on the PC screen as shown in Figure 2.

Figure 2

3.1.3.3 Selecting the data set

3.1.3.1 Setting the Communication port

3.1.3.2 Setting the baud rate

3.1.3.5 Setting "download only decompress later"

3.1.3.4 Setting "file name to save as"

3.1.3.6 Ready to download
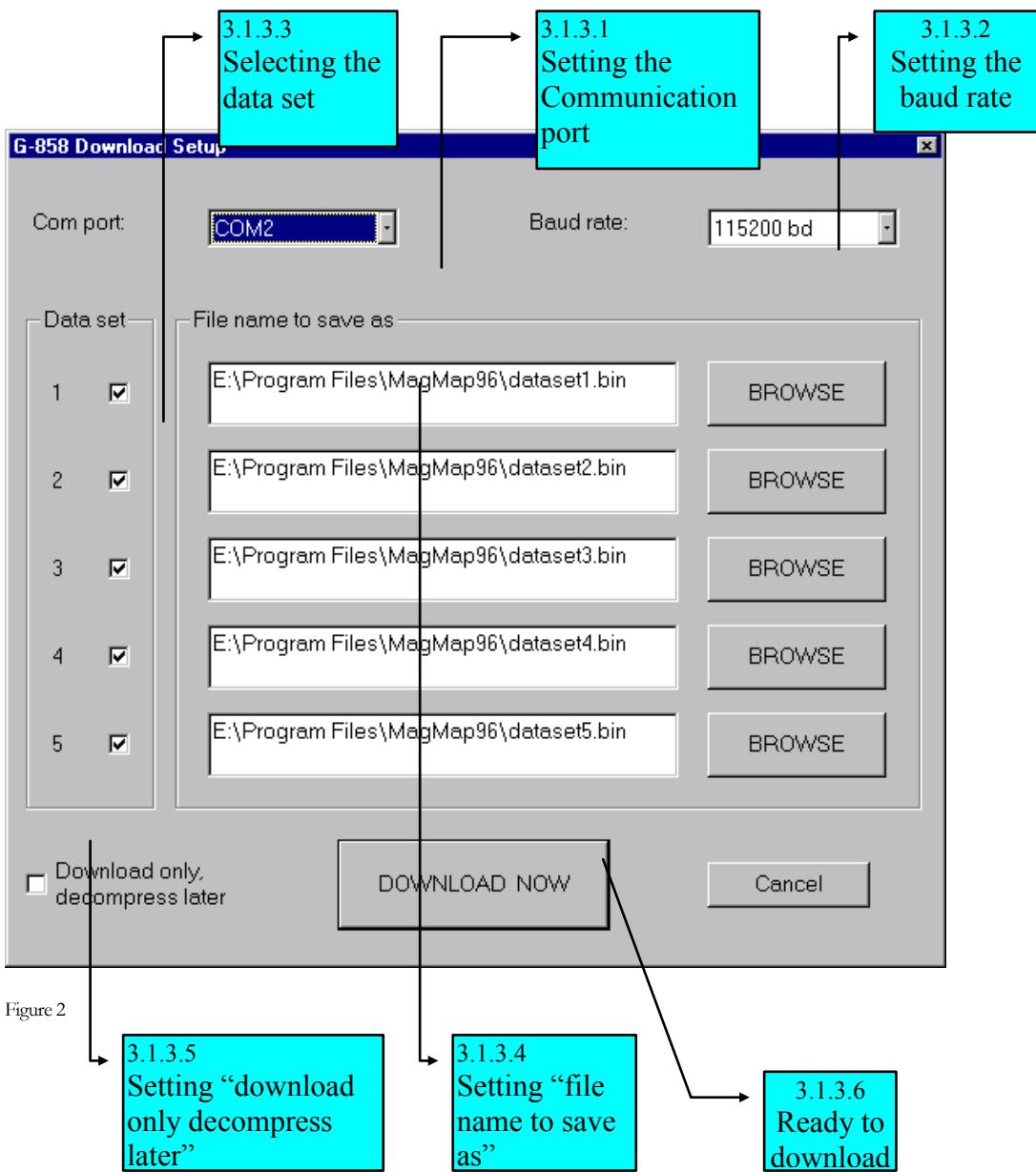
3.1.3.1. SETTING THE COMMUNICATION PORT

First setup the communication port that your G-858 is connected to. You can either select COM1 or COM2.

Make sure you did not select the communication port where the mouse or external modem is connected.

3.1.3.2. SETTING THE BAUD RATE

The G-858 supports different baud rates ranging from 1200 BD to 115 kBD and an auto mode "Auto Detect" where the PC will select the best baud rate. For most cases setting the Baud rate to 115kb should work just fine. If you are having problems downloading your survey at this baud rate with lots of retries, lower the value to "19200" or smaller.

Once you exit Magmap your settings will be saved. You do not need to set these values again, unless you connect the G-858 to a different port or are having problems at high baud rates.

3.1.3.3. SELECTING THE DATA SET

In the G-858 you cannot store more than 5 surveys at any time. Each survey is represented by a number from 1 to 5 that correspond to the data set number.

By default every data set is selected to be downloaded (check marks near the data set number). To prevent a data set from being downloaded click the left mouse button on the check mark of the data set you do not want to download. The check mark should now be removed and the "file name to save as" and "BROWSE" button of the corresponding data set grayed out.

Left clicking the mouse button again on the data set number will enable this data set to be downloaded.

3.1.3.4. SETTING "FILE NAME TO SAVE AS"

Next to the data set number you should type the drive, directory name and the name of the file you wish to save as on the PC.

By default data set number 1 will be saved on the PC as:

"C:\Program Files\Magmap\dataset1.bin".

Where:

C:	Is the drive letter.
\Program Files\Magmap	is the directory name.
Dataset1.bin	is the name of the file.

You can type any valid drive, directory and filename but you should try to use the extension **"*.bin"** for the filename. The extension **"*.bin"** indicates this is a binary compressed file downloaded from a G-858 and is what Magmap expects.

You will see later that you can save your survey as an ASCII (*.STN) file. In any case, you should always keep this binary file. You cannot edit this file. By caution, after downloading your survey, you should back up this binary file. Given the cost of your survey it is worth doing this extra step.

If you wish to browse your computer to select another drive or directory, left click the mouse button on the browse button. A standard Windows 95 "Save Dialog Box" will appear on the screen.

3.1.3.5. SETTING "DOWNLOAD ONLY DECOMPRESS LATER"

The data downloaded from the G-858 are in a compressed format. If you wish only to download your survey and not process the survey data now, you can keep your survey in the compressed

format to save some space on your hard drive. By default this feature is disabled. (Current hard drive sizes may make this unnecessary.)

3.1.3.6. READY TO DOWNLOAD

Once you have defined all the data sets you wish to download, click the left mouse button on the "DOWNLOAD NOW" button or "Cancel" to abort the download operation and close this dialog box.

You should see the following screen while the downloading is happening.
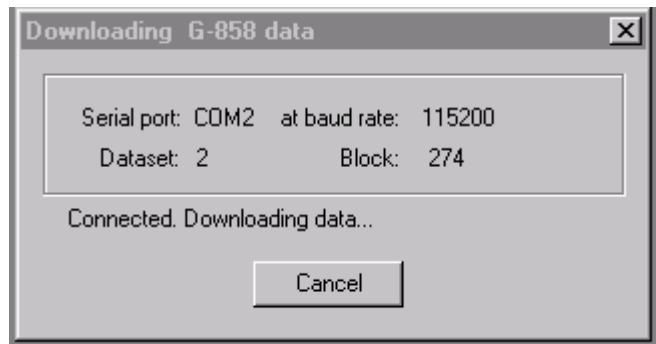
This screen allows you to see the status of the downloading (whether a connection has been established, etc.). You can also see the COM port selected and the baud rate.

- For every survey you download a new DOS window will appear on the screen reporting the status of the downloading process.

Once your survey has been downloaded, if the option "Decompress later" has not been set, your survey file will be opened automatically.

> Note: If your downloading does not work, you can have Magmap use the DOS utility, binxfer.exe. To enable this, you need to edit the Magmap.ini file by going to the Windows system directory and double clicking on "Magmap.ini". Find the string, "BINXFER = 0" and replace it with "BINXFER = 1". Magmap will now use the DOS utility to download.

If you do not need to open the file manually, you can skip the next paragraph that explains how to open an already downloaded file and go directly to paragraph 3.5, "Defining the grid (G-858 simple survey mode or G−856 only)".

3.2. Downloading ASCII data from 858 magnetometer and Ohmmapper.

This feature allows manual (not PC controlled) data transfer from G-858 console or similar devices. It is available from *"File / Import ASCII data"* menu and also via tool bar. To use this option the console should be connected to one of the PC serial ports and be ready for manual data transfer. Data transfer rate should be known and set identically on both sides (PC and console). Choose *"Import ASCII Data"*. The following dialog box is displayed:
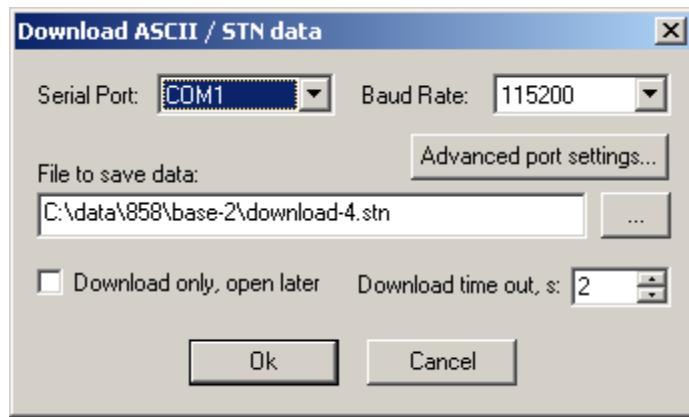
To activate download user should set the fields below:

1. **Serial Port:** Computer port where the console is connected. It's user responsibility to set correct port, program will not search all available ports.

2. **Baud Rate:** Set the same baud rate as on the console. Baud rate should be set correctly such that the baud rate on the console matches the baud rate set in MagMap. MagMap will not alter this baud rate during the data transfer.

3. **File to save data:** Select appropriate file name to store downloaded data. Use the "**…**" button on the right to invoke windows explorer and browser across the folders.

4. **Download only, open later.** Check this box to only store data in a file. Unless this box is checked MagMap tries to open data file immediately after download is complete.

5. **Download time out, s.** Time out in seconds used to determine if download is complete. If this value set to "0" no time out is used and user should terminate download by pressing "Cancel" button in the progress dialog (see below). Otherwise download is terminated automatically if no new data has arrived after the specified time out.

6. **Advanced port settings.** This button is used for devices other than G-858 console. It allows setting some advanced serial transmission parameters such as Data bits, Parity and Stop bits. If pressed the advanced serial port dialog is displayed:

In most of the cases uncheck "*Use advanced port settings below*" to set default transmission parameters.

After OK button is pressed, program shows download progress dialog:
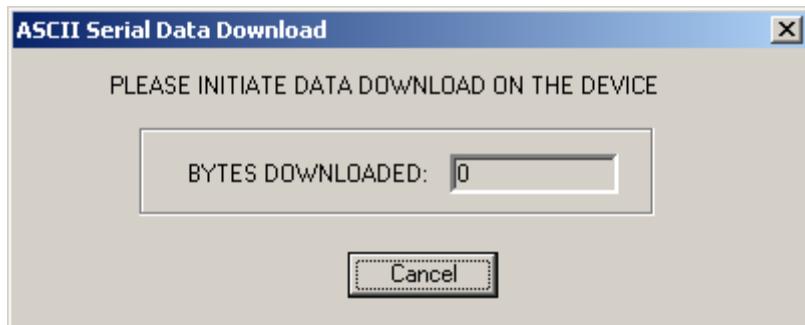
the "BYTES DOWNLOADED" shows bytes downloaded so far. Dialog stays on the screen indefinitely if user does not initiate manual data transfer on the console. If transfer is initiated then byte counter starts to run. When PC sees no new data longer than timeout specified above transfer is automatically terminated. Transfer can be terminated as well at any time by "Cancel" button. In this case user still can open downloaded data.

After download is complete program will try to open the file. In case of magnetometer STN file, the usual survey selection dialog (Simple, Mapped, Base station) could be displayed. In case of Ohmmapper STN file, the TRN file and additional data selection dialog is shown:
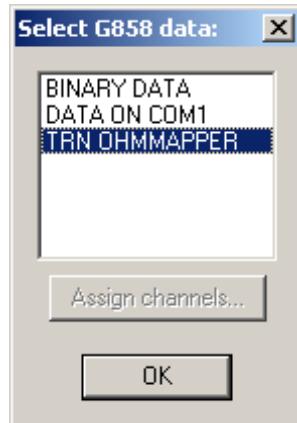
If Ohmmapper TRN system is used select "TRN OHMMAPPER". In this case serial messages in TRN file are treated as Ohmmapper data.

3.3. Opening a survey file

You can open several types of files that are already on your PC:

- G-858 binary compressed files.

- G-858 ASCII file (Simple Survey, Mapped Survey and Base Station).

- G-856 ASCII file (Survey and Base Station).

- Maglog airborne projects

- Individual Maglog Files (Maglog NT, Maglog-lite)

- Magsea projects

- Individual Magsea files

- MGS files (Marine Gradiometer Software)

- G-858 bin files with a .csv file that gives corrected GPS positions

- Surfer Fiber (*.dot) or XYZ files

 Note: Take care in selecting the proper category. The program acts differently for different types of projects.

And there are several ways to open these files.

3.3.1. Opening a file using the menu or the tool bar

There are several ways you can bring up the open dialog box (Figure 3).

- Select from the menu **File,** then **Open.**

- Or click the left mouse button on the open toolbar button.

- Or press the **CTRL** and **O** keys simultaneously.
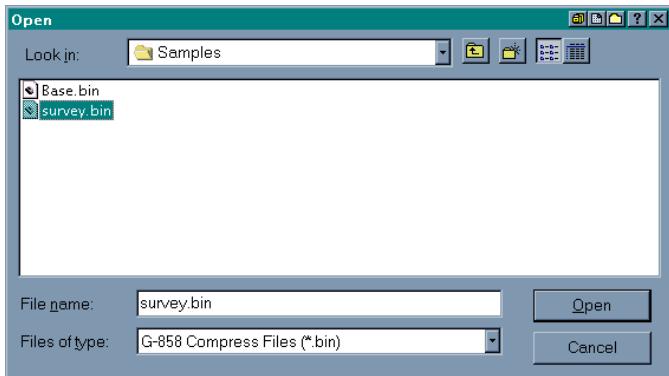
Figure 3

Once the open dialog box appears on the screen, select the desired file then click on the **Open** button.

3.3.2. Opening a file using Drag & Drop Windows Explorer

You can use Explorer to import several survey files.

Select every file you wish to import by pressing the CTRL key and the left mouse button. Then drag these files while pressing the left mouse button onto the MAGMAP window.

3.4.   Setting the type of survey

The "*Open*" dialog box has a list of several types of files that can be loaded. **It is very important to make sure that you correctly specify the type of file that you are using.** You can do this by selecting the "*Files of Type*" option in the "*Open*" dialog box and selecting the option which fits your survey. A sample is shown next:
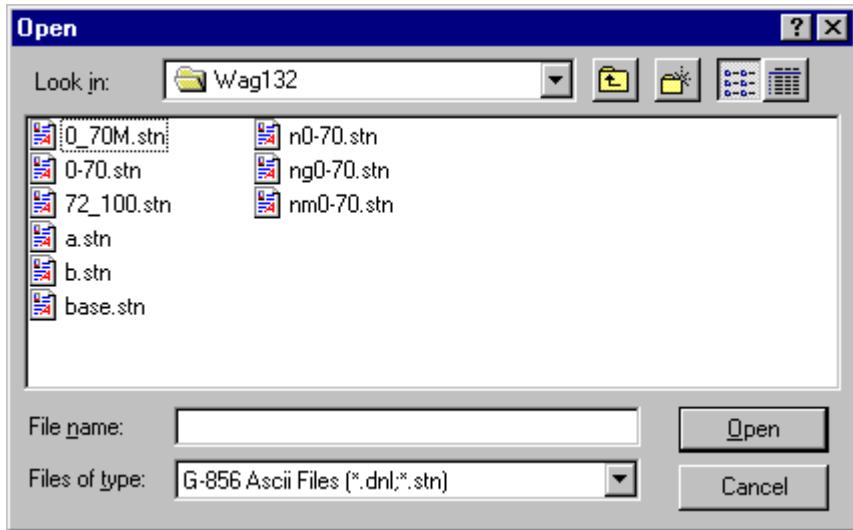
MagMap will sometimes recognize the type of file that is being loaded, but occasionally it will not. Each option in the "Open" dialog box is specifically designed for a particular type of file which will be discussed below.

3.4.1. G-858 Compressed files

This option will allow you to open 858 compressed files.

If you are opening a mapped G-858 binary compressed file you do not need to enter any survey information as it has been stored with your data in the file. Simple survey files require some information, such as, line spacing, covered in Section 3.4.

A dialog box indicating decompression and status information will be shown on the screen (Figure 4).
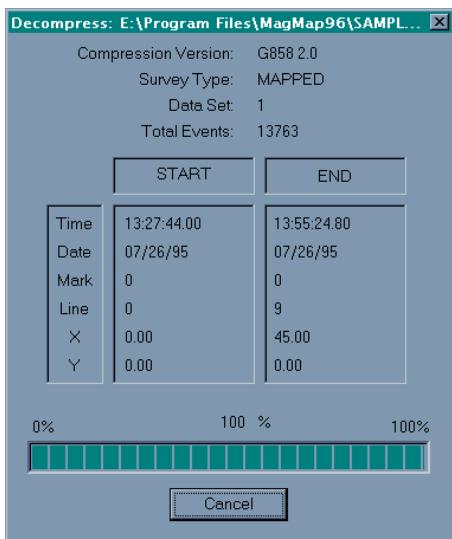
Figure 4

3.4.2. Opening a G-858 survey ASCII file

If you are opening a G-858 ASCII file that has been decompressed with the DOS version of MAGMAP you will need to select the type of survey you did as described in the following dialog box (Figure 5).

Otherwise if you are opening a G-858 ASCII file that has been decompressed using the windows version of MagMap called Magmap you will not be prompted for this dialog box as the survey information has been stored in the ASCII file.
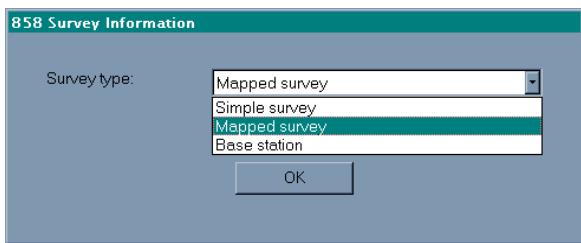
Figure 5

Once you have selected the type of survey you did, click the left mouse button on the "OK" button and your survey file will be read as shown on the next dialog box (Figure 6)
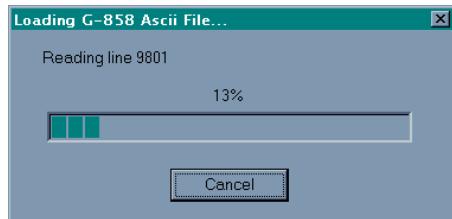
Figure 6

The line number of this dialog box indicates a count of lines of text of the file being read in and not the survey line number.

3.4.3. Opening a G-856 survey ASCII file

If you are opening a G-856 ASCII file you will need to select the type of survey you did (One sensor survey, Gradiometer survey or base station survey) as described in the following dialog box (Figure 7).

You will also need to set the year in which the survey was started. This is because the G−856 stores the date as the Julian day – e.g. Day 221 out of 365 is recorded as 221.

856 Survey Information

Survey type: One sensor survey

Which year was the survey started ? : 96

OK
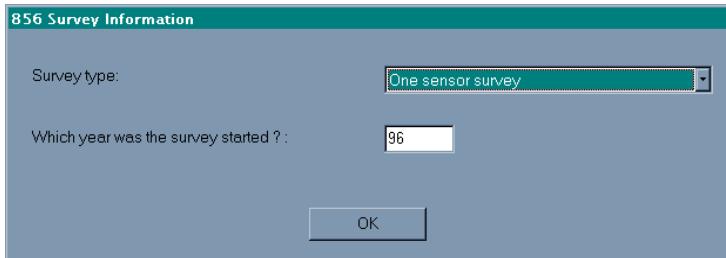
Figure 7

Once you have selected the type of survey you did, click the left mouse button on the "OK" button and your survey file will be read.

3.4.4. Opening a Maglog project file

The option "Maglog Projects (*.Survey) will give you the option of opening files with an extension "Survey". This option is useful if you have a set of Maglog files and you want the program to automatically open all files associated with the survey you did. After you have pressed "OK", it should automatically open all recognizable files types associated with the survey you took.

> Note: There are some files that Maglog NT produces that are not used in Magmap (e.g. comment files). Magmap will warn you that it cannot read these due to an unknown file type. In this case, it is safe to ignore this message.

3.4.5. Opening an individual Maglog file

You can open an individual Maglog file by selecting the file type: "Maglog Files (*.*)". You can then individually open each file associated with your project.

No user input is required when opening Maglog files except for Interpolator files using open as sufer.dat, etc.

3.4.6. Opening a G-856 MagMap for DOS file

This option will specify that the file you are opening is an old version of MagMap for DOS file.

3.4.7. Opening a Magsea project

This option is used when you have logged data from Magsea and have a series of files associated with your survey. This option will automatically load all pertinent files and normally does not require any additional input.

You may get a warning message such as the one below warning you of duplicate time stamps. You can choose to smooth the readings immediately by pressing "Yes" or you can leave the data as it is and correct it later.

3.4.8. Opening a Magsea individual file

You can use this option to individually open Magsea files. This option will show all files in your current directory – not just the files it can recognize. You should be able to open files with extensions such as *ref* and *D01*.

If you have readings with duplicate time stamps, you should get an error message such as described in the previous section.

3.4.9. Opening a MGS file (Marine Gradiometer Software)

This option will allow you to open a MGS file. If you have not purchased MGS Tools for Magmap, this will not apply to you. Otherwise, you should read the user manual on MGS tools for further discussions on these files.

3.4.10. Opening a G-858 bin file and corresponding .csv file

The option "G-858 bin files and .csv file" currently supports files that are created from Trimble's Pathfinder software. The ".csv" file is a file that has differentially corrected positions that were produced from the Pathfinder program. The 858 binary file should have GPGGA data strings recorded as serial data and there should be a one to one correspondence between readings in the .csv file and GPGGA strings in the binary file.

3.4.11. Opening SURFER™ dat file.

MagMap can read and display generic SURFER™ ACSII files in the same manner as MagLog NT (or MagLog Pro) surveys. This feature allows the user to load virtually any ASCII columnar data into MagMap for analysis. MagLog NT real time position interpolator files (extension INT) can also be loaded in this way.

Depending on the user selection, the following information can be loaded from a SURFER data file:

1. **Positions and Data**. In this case it is assumed that each reading in the SURFER file has an associated position.

2. **Positions ONLY**. In this mode the user loads only positions, i.e., the file is used in the same way as a GPS file in case of MagLog NT Survey files. Magnetic (or other) data should be loaded separately and may have a different sample interval than the position sample rate. Data can loaded as a SURFER file as well (see below) or as MagLog NT device file(s). While the user can load multiple data files, only one position file is allowed. Note that the Line Number file can also be loaded in this case.

3. **Data ONLY**. In this mode the user loads only data. Multiple SURFER files can be loaded in this mode. Positions and line numbers are loaded separately as MagLog NT GPS and Line Number file. Alternatively positions can be loaded as a SURFER file (see above).

4. **Use as a Base Station**. In addition, any file of the structure with magnetometer and time information can be used as a base station file for diurnal correction as long as the dates and times of the survey and base file intersect (base data must overlap rover data). This means that virtually any base station magnetometer can be used with MagMap to diurnally correct any other magnetometer data file.

Go to File/Open dialog and select SURFER *.dat files (Interpolator *.INT, Text *.txt) files as the file type. Then select your file of interest and press "Open". The program makes no assumptions about the possible file format and therefore a "Data file definition" dialog is required:
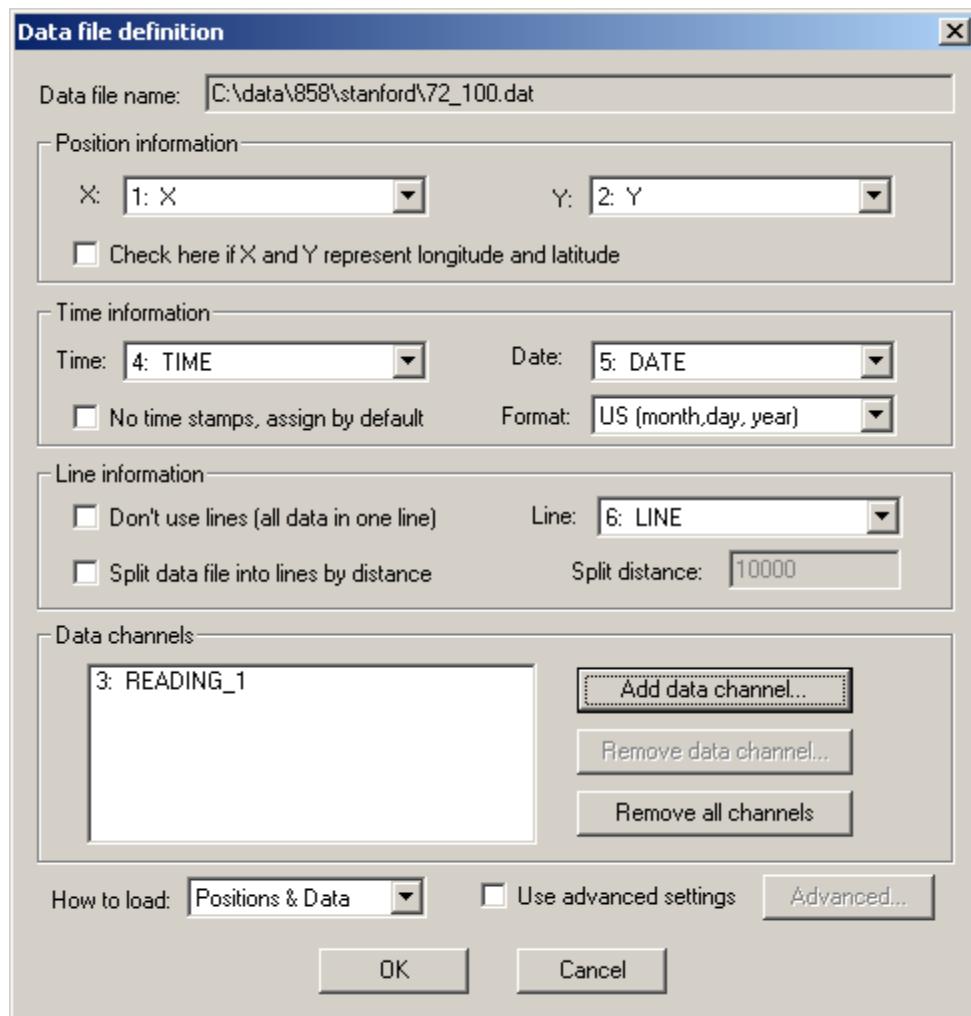
Use this dialog to specify the type of data provided in the separate file columns. MagMap uses the first file line (header) to name the data columns. If there is no header information, then the first line of data is used to define each column.

- **Position information**. Specify the columns with position information. For example, 1:Mag_X means that 1st column has name "mag_X" and is selected as X position. Y position is selected as "2:mag_Y". <u>For latitude and longitude data the check box below must be checked.</u> For UTM or local coordinate systems do not check this box.

  NOTE: If the data is Lat Long you MUST check the box or your resultant map will show no positions (green screen, one red and one green position box, nothing more.)

- **Time information**. To display data correctly MagMap needs time and date information. It is looking for key words "time" and "date" in the file header and will automatically select them. However you can always select other columns as appropriate. For a data file without time information, date and time values will be generated internally because MagMap needs these values to be able display the data in a linear fashion. Check "File has no time stamps, assign time by default" box to use default time stamps. Keep in mind that in this case the time displayed by MagMap is synthetic, and so no time related operations (like base station correction) can be used.

- **Time format**. MagMap can load dates in the following formats:

  o US time format as Month / Day / Year. Fields are typically separated by forward slash; year has short notation. (like 07 stands for 2007).

  o European time format. The same as US, but day goes first.

  o INTERMAGNET date format as YYYY-MM-DD. Here is four digit year is followed by dash and two digit month and then dash and two digit day. Example is "2007-09-11"

  Note that the user can use any characters to separate fields in the date string, except digits, commas, tabs, colons and spaces. For instance 10—12—1998 is perfectly correct time stamp. Year can be recorded as full year (as 2007) or as short year (07). Years less then fifty are to be considered of 21st century, years more than 50 belongs to 20th century. Examples: 07 is 2007, 77 is 1977.

- **Line information**. MagMap searches the file header for the word "line" to use that column as the line number. However you can always select a different column for line number as appropriate. If no line numbers are available, you can display the data as one line (check "Don't use lines") or you can automatically assign line numbers based on the distance between neighboring positions (check "Split data file into lines by distance" and enter "Split distance"). When distance between two sequential reading positions exceeds the "split distance" MagMap automatically starts a new line and increments the line number.

- **Data channels**. The last step is to specify which columns contain the magnetometer data. The "Data channels" list will list the columns selected for import. Press "Add data channel" and the following dialog box appears with all data columns listed:

Select the magnetometer data channels (for example could include magnetometer field data, signal strength, depth, altitude, etc.) and press "Ok". Hold the "Crtl" key to select multiple channels at once. The "Select channel to add" dialog box will be closed and the channels added to the data channels list. To remove an already selected channel, highlight it and press the "Remove" button. To remove all channels press the "Remove all channels" button.

- **How to load**. This dialog box controls and constrains the type of data that can be loaded into MagMap. Typically the user needs to load both data and positions; however it is possible to load disparate data from separate files, as it described at the beginning of this section. Select appropriate type here. Based on this selection, some input fields in the dialog are grayed out: for instance, if only positions are loaded the data section is disabled, if only data is to be loaded then the position section is disabled. Several "data only" and/or base station files can be opened simultaneously to over different time spans. This would normally be used when you have a multiple-day G-858 or MagLog survey with base station files that begin and stop each day. Then you would load the entire field survey and several base station files to apply diurnal correction on a day-to-day basis. Keep in mind however that multiple base stations which were positioned at different locations will have different base offsets and your final corrected data set under these conditions may need to be block leveled. Observing the base station data files concurrently on one plot will enable the user to insert an offset to the base station files to enable leveling of the data upon export.

- **Use Advanced Settings**. This selection allows tuning of the data import routines. This provides for removal of multi-string headers from a data files or use of a special character denoting comment lines which the program will not load. In addition you can scale the data while loading. (For instance in some systems a magnetic field value of 40000.000 nT could be recorded as 40000000). Note that all previous selections (such as the information denoting position and data columns, etc) are erased when this button is checked, and the "Advanced" button becomes available. When clicked, it shows the following dialog:
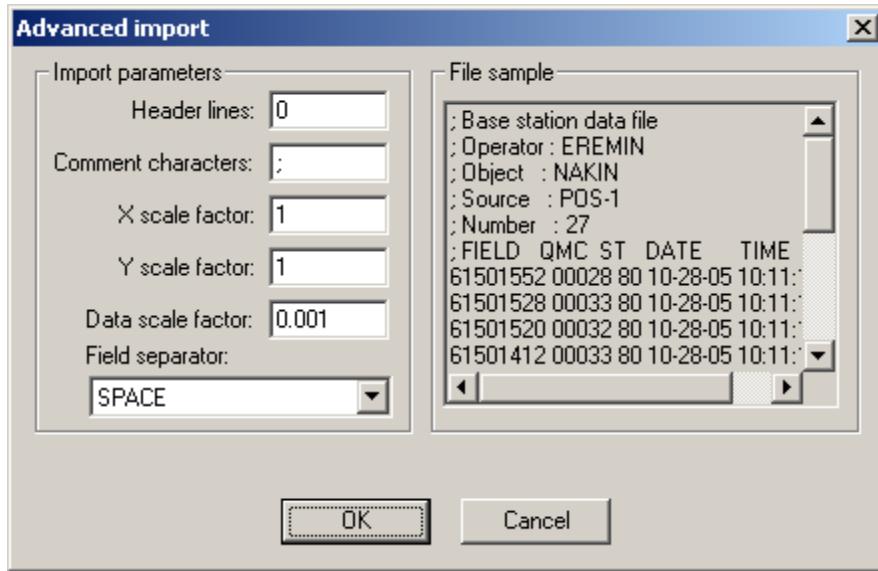
Here the following fields are available to the user:
- Header lines: Number of lines of text to skip from the beginning of the file.
- Comment characters: If strings begin with any of the characters in that field, it is assumed to be comment line and is omitted.
- X, Y scale factors: Multiply positions by these numbers while reading the data.
- Data scale factor: the same as above, but for data fields. All data fields are multiplied by this coefficient while reading from the files.
- Field separator: Describes how data columns are separated in the file. Possible values are "SPACE" and "COMMA or SPACE". In latter case either space or comma are considered to separate fields.

The beginning of the data file in shown in the right pane.

Here is an example how INTERMAGNET IAGA-2002[1] format can be loaded using the MagMap advanced features:

---

[1] International Real-time Magnetic Observatory Network (INTERMAGNET) data is available from **http://www.intermagnet.org/Welcom_e.html**; see "Conditions of use" on INTERMAGNET web site. Note that data is recorded in UTC time.
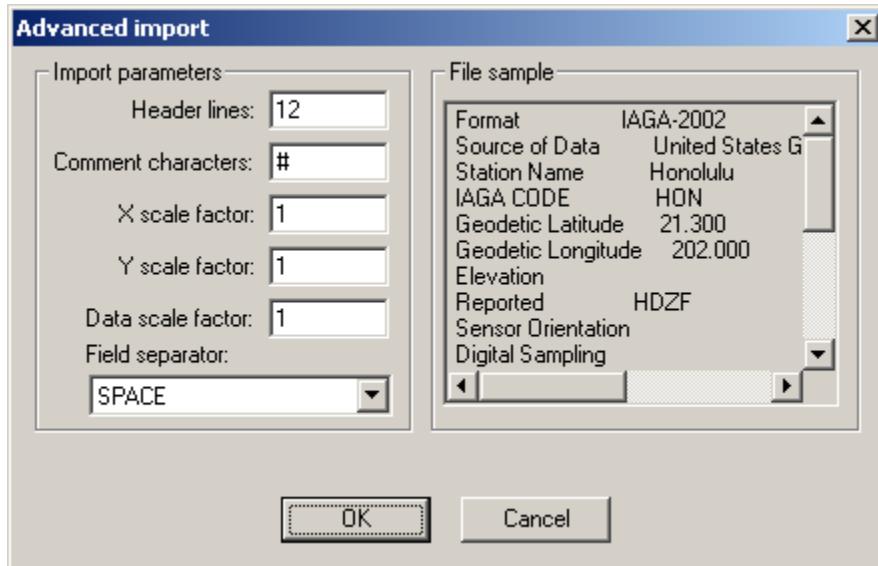
Here the program skips the first 12 lines; in addition, each line starting with "#" is considered to be a comment.

3.4.12. Showing all files (*.*)

This is the last option available but should not be used for opening individual files. Magmap has the ability to manipulate many different file types but it needs to know what type of file to expect. Since this option doesn't give Magmap any hint of the file type, the resulting behavior is unpredictable. It is more useful to use this option to see what is in your directory and then go to the appropriate file type selection to actually load your file.

3.5. Defining the grid (G-858 simple survey mode or G–856 only)

When you open a G–858 simple survey mode or G-856 file you will need to define the parameters of the grid. This does not apply to the G-858's mapped survey mode because the magnetometer has already stored the coordinates of the positions.

In the Grid Orientation dialog box (Figure 8) you will need to enter several parameters:

- **First position origin**: this is the origin of the survey's first position.

- **Mark spacing:** this is the distance between two positions.

- **Line spacing**: this is the distance between two lines.

- **Survey direction:** this is how you walked relative to the first position.

You cannot cancel the grid settings. The "Cancel" button is grayed out. You must set all the parameters to plot the map.

You will see later that you can change these parameters, and even use the grid setting for mapped survey mode.
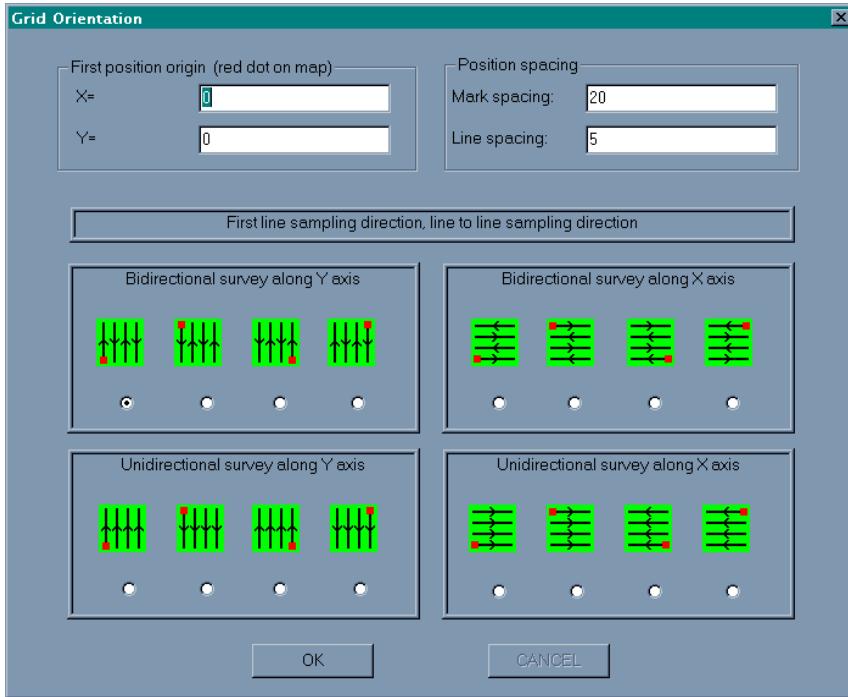
Figure 8

3.6.   Conclusion

Regardless of the way you import your data (by downloading your survey, or by using the open dialog box Figure 3, or using Explorer) the following window (Figure 9) will appear on the screen. Some surveys will only have the lower window (mapped) initially open.
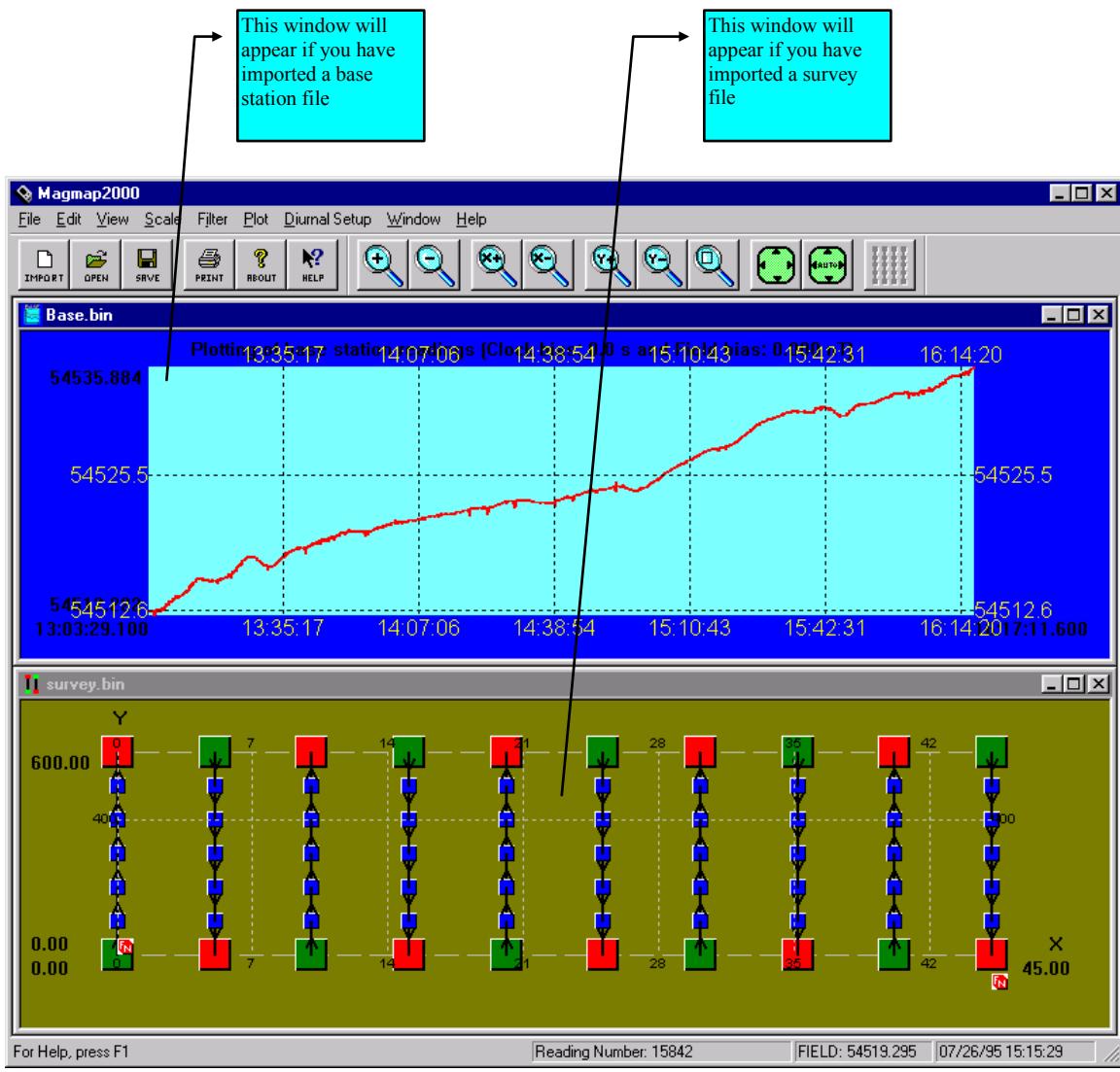
Figure 9

Note: If no profile is initially open, you can create one by right clicking on the mapped screen and selecting "*Plot Mag Field*". If you click on a position point, it will the profile of the line corresponding to the position point clicked. If you click on another part of the map, you will get a profile of all the data.

4. Editing of the map

4.1. Map user interface description and definitions

A **start of line** is the first position of a line and is represented by a green square (Figure 10).

An **end of line** is the last position of a line and is represented by a red square (Figure 10).

A **position** (called *Mark* in G-858 and *Station* in G-856) is represented by a blue square (Figure 10). GPS positions also show as Blue Squares.

Duplicate positions are positions acquired at the same location (same X and Y coordinates) with a different mark or line number. You get duplicate positions when you survey the same line or segment twice or when you shift a line or segment on top of another line or segment. They are represented by a double inlaid square.

A **selected position** is represented by a white square.

A **segment** is represented by an arrow, that also indicates the direction the user was walking between two positions (Figure 10).

A **grid** is represented by a white dotted rectangle (Figure 10). Gridlines can be configured using the *Scale* menu.

Every **magnetic reading** is represented by a black point (Figure 10). If there are many readings between two positions, it will look like a black line drawn between the two positions. By zooming in, every reading will be represented by a single point.

When the mouse cursor is placed on top of a position, the **status bar** will indicate information about the position such as time, mark, line, X and Y location.

The **scaling tool bar** contains 9 buttons:

- **Zoom in**: zoom in the map in the X and Y directions with the same zoom factor.

- **Zoom out**: zoom out the map in the X and Y directions with the same zoom factor.

- **Zoom in X**: zoom in the map in the X direction only. The scale in the Y direction remains unchanged.

- **Zoom out X**: zoom out the map in the X direction only. The scale in the Y direction remains unchanged.

- **Zoom in Y**: zoom in the map in the Y direction only. The scale in the X direction remains unchanged.

- **Zoom out Y**: zoom out the map in the Y direction only. The scale in the X direction remains unchanged.

- **Window Zoom**: zoom in map in the user selected window. To select zoom area, point mouse into one of the corners, click and drag mouse to the opposite corner. Zoom rectangle is shown with "rubber band" After releasing of mouse button selected rectangle is zoomed to extend s of the window. Areas outside of selected rectangle are not shown. To bring picture back to full extend press "Fit in window" button.

- **Fit in window**: the map is scaled to fit exactly inside the window. X and Y do not have the same scaling factor. If the window is resized, the map will not be scaled again to fit inside the window.

- **Always fit in window**: the map is scaled to always fit exactly inside the window. X and Y do not have the same scaling factor. If the window is resized, the map will be scaled again to fit inside the window.

- **True map coordinates**: X and Y have the same scaling factor.

When you zoom in a map, you can use the mouse or the arrow keys to scroll the window.

- Right key: Scroll to the right.

- Left key: Scroll to the left.

- Up key: Scroll to the top.

- Down key: Scroll to the bottom.

- Page Up key : Scroll one page up.

- Ctrl + Page Up key: Scroll one page to the left.

- Page Down key : Scroll one page down.

- Ctrl + Page Down key: Scroll one page to the right.

ZOOM IN X

ZOOM OUT X

MAP TOOL BAR

ZOOM OUT X and Y

FIT IN WINDOW

ZOOM IN Y

ZOOM IN X and Y

ZOOM OUT Y

ALWAYS FIT IN WINDOW

WINDOW ZOOM

TRUE MAP COORDINATES

END OF LINE
represented by a red square.
Mark 6   X=0
Line 0   Y=600

GRID
represented by a white rectangle

SEGMENT
represented by an arrow.

POSITION
represented by a blue square.
Mark 1   X=0
Line 0   Y=100
07/26/95 13:28:03

START OF LINE
represented by a green square.
Mark 0   X=0
Line 0   Y=0

MAG READINGS
represented by a black line or black dot.

DATE AND TIME
of position

STATUS BAR
indicating position information

X LOCATION
of position.

MARK NUMBER
of position.

LINE NUMBER
of position.

Y LOCATION
of position.

4.2. Selecting and editing a single position

To select a single position right click the mouse button on the position symbol (small blue square) (Figure 11).

A pop up menu should now appear on the screen.
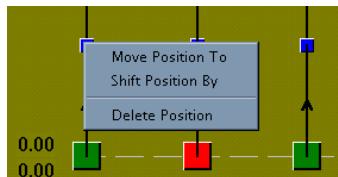
Figure 11

To perform the desired operation **"Move Position To"**, **"Shift Position By"** or **"Delete Position"** move the mouse cursor on top of the corresponding item, then left click the mouse button or use the keyboard arrow keys to select the item and press the "ENTER" Key.

- To move the position to a new location select "Move Position To".

- To shift the position by an X or Y offset select "Shift Position By".

- To delete a position select "Delete Position".

Once you have selected the operation to perform, one of the following dialog boxes will appear:

4.2.1. Moving a position to a new location
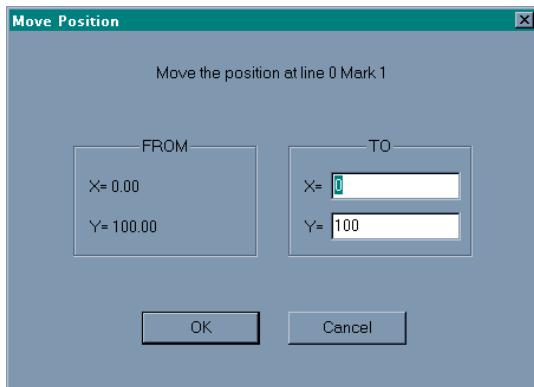
Figure 12

Type in the X and Y field the coordinates of the new location, then click the left mouse button on the "OK" button or pressed the "ENTER" key.

To cancel the operation left click on the CANCEL button or press the "ESC" key.

To switch between the X, Y, OK, and CANCEL controls, use the mouse or press the "TAB" key.

You can copy and paste values between every edit control.

The following commands are common to all edit controls in this program and Windows 95/98 and will not be described for the other dialog boxes:

When using the keyboard:

- To copy: press "CTRL" and "C" keys or "CTRL" and "INSERT" keys.

- To paste: press "CTRL" and "V" keys or "SHIFT" and "INSERT" keys.

- To undo press "CTRL" and "Z" keys or "ALT" and "BACKSPACE" keys.

- To redo press "CTRL" and "Z" keys or "ALT" and "BACKSPACE" keys.

- To cut press "CTRL" and "X" keys.

For example , in the survey plotted in Figure 10, if you move the position at MARK 1 LINE 0 from X=0 Y=100 to X=-2 Y=50 you will obtain the following picture (Figure 13).

When using the mouse:

- Click the right mouse button and a pop up menu will appear.
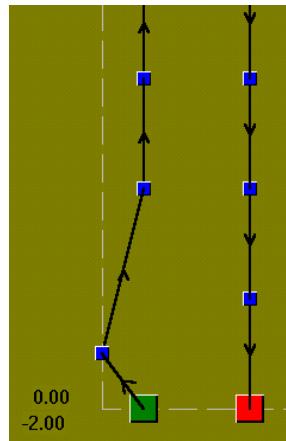
Figure 13

4.2.2. Shifting a position
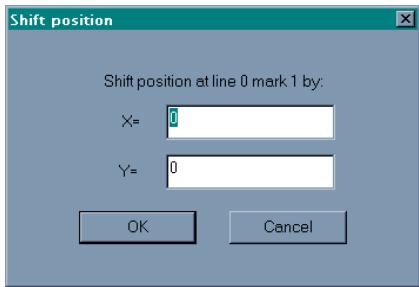
Figure 14

Type in the X and Y field the offset to the new location, then click the left mouse button on the "OK" button or pressed the "ENTER" key.

For example , in the survey plotted in Figure 10, if you shift by X=-2 and Y=-50 the position at MARK 1 LINE 0 located at X=0 Y=100 you will obtain the picture in Figure 13.

4.2.3. Deleting a position
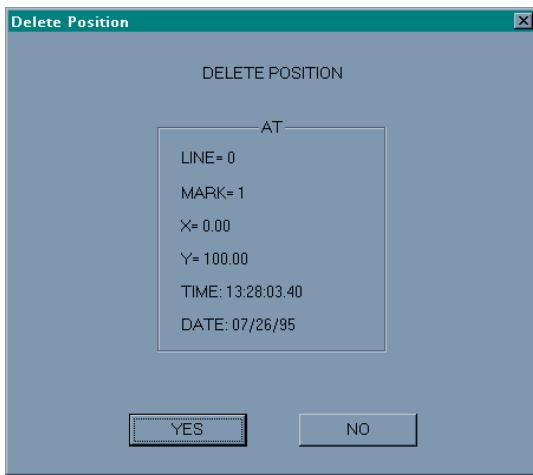
Figure 15

If the information reported by this dialog box confirms that this is the position you want to delete click on the "YES" button, otherwise click on the "NO" button to abort.

G-858 continuous survey mode:

Deleting a position **does not delete** the magnetic field readings acquired during the survey.

If a position is deleted, magnetic field readings are linearly interpolated between the previous and next position of the deleted position.

For example , in the survey plotted in Figure 10, if you delete the position at MARK 1 LINE 0 located at X=0 Y=100 you will obtain the picture in Figure 16.
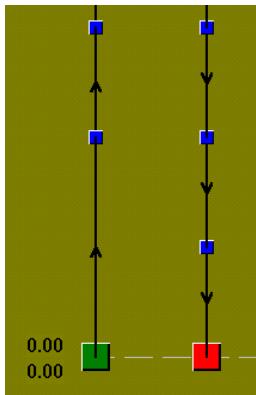
Figure 16

G-858 discrete mode or G-856:

Deleting a position **does delete** the position and the corresponding magnetic field acquired at that location.

4.3. Selecting and editing entire lines

To select a line right click the mouse button on the start of line symbol (big green square) or on the end of line symbol (big red square).

A pop up menu should now appear on the screen.
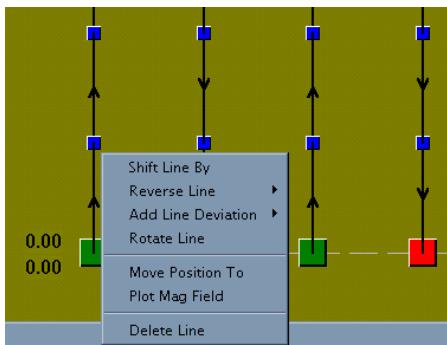
Figure 17

- To shift the line by an X or Y offset select "Shift Line By".

- To reverse the direction of a line select "Reverse Line".

- To correct a walking deviation error (for example you did not walk straight and end up at another line, select "Add Line Deviation".

- To rotate a line select "Rotate Line".

- To move only the start of line or end of line position, select "Move Position To".

- To plot every magnetic field reading of this line, select "Plot Mag Field".

- To delete a line select "Delete Line".

Once you have selected the operation to perform, one of the following dialog boxes or windows will appear:

4.3.1. Shifting a line
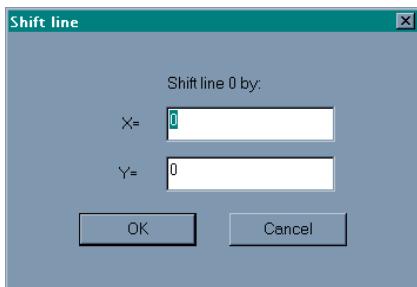

Figure 18

Type in the X and Y field the offset to the new location, then click the left mouse button on the "OK" button or pressed the "ENTER" key.

Every position of the corresponding line will be shifted by the X and Y offset.

For example , in the survey plotted in Figure 10, if you shift by X=2.5 and Y=-50 LINE 0 you will obtain the picture in Figure 19.
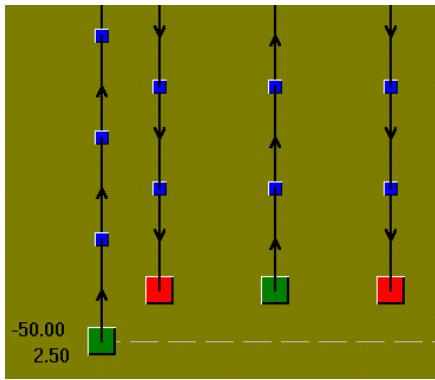
Figure 19

4.3.2. Reversing a line

There are three options for reversing a line:

A line can be reversed (mirrored) in the X and Y directions, in the X direction only or the Y direction only. The last two options should not be used for horizontal or vertical lines.

For most cases select "Reverse In Both Directions".
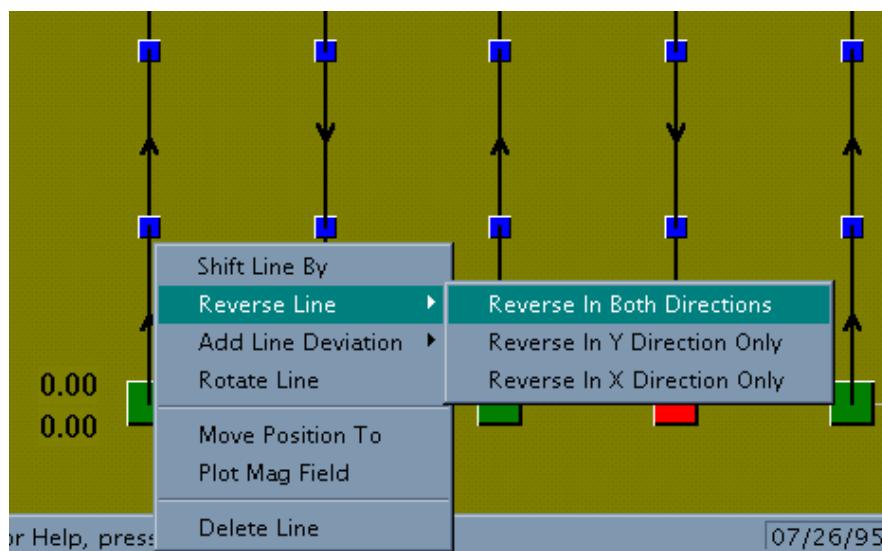
Figure 20

For example, in the survey plotted in Figure 10, if you reverse LINE 0 you will obtain the picture in Figure 21.
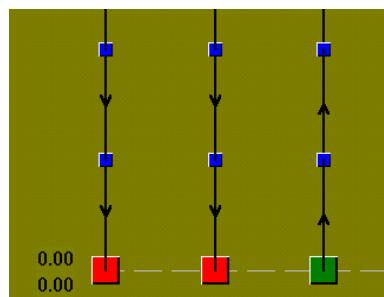
Figure 21

4.3.3. Correcting a walking deviation

There are two options for fixing a line deviation:

A line can be deviated in the X or Y direction.

If your line is vertical and you did not walk straight and end up off line at the end of the line, select "deviate in the X direction". If your line was horizontal, select "deviate in the Y direction".
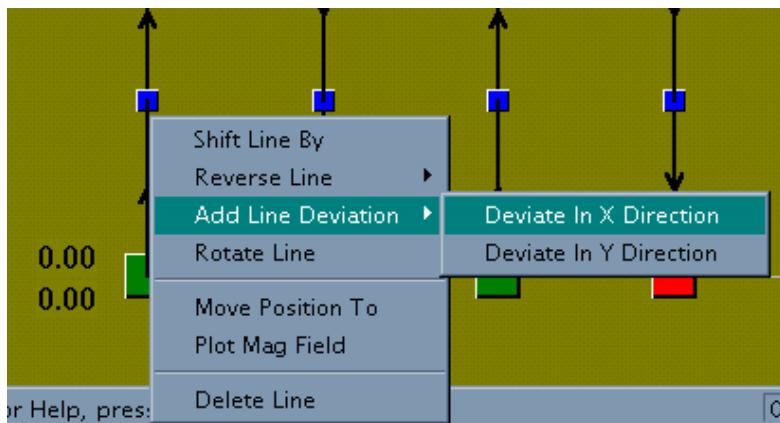
Figure 22

For example, let us assume that in Figure 10 you walk off line on LINE 0 and really end up at the end of line at X=2.5 and y=600. To fix this problem select "deviate in the X direction". When the following dialog box (Figure 23) appears on the screen type 2.5 and click on "OK".
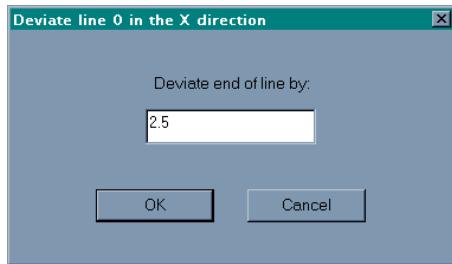
Figure 23

You should now have fixed your walking deviation as shown in Figure 24.
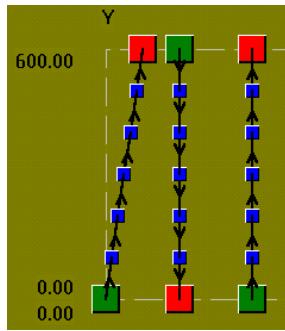
Figure 24

If by mistake you start line 0 at X=2.5 instead of X=0 and end up at X=0 and Y=600. First reverse the line, then deviate the line in the X direction by 2.5 and reverse the line again.

4.3.4. Rotating a line
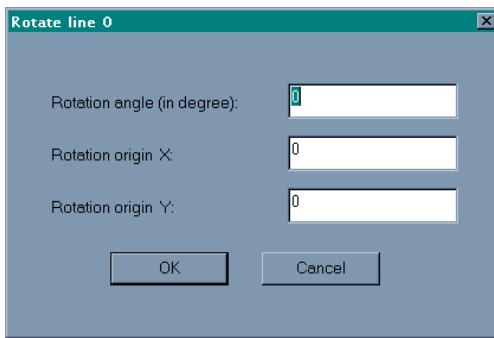
Figure 25

Type in the rotation field the angle of the rotation in degrees (from -360 to 360 degrees).

Type in the X and Y field the coordinates of the rotation origin. Once you enter all the fields, left click the mouse button on the "OK" button or pressed the "ENTER" key.

For example , in the survey plotted in Figure 10, if you rotate LINE 0 by 180 degrees at the origin X=0 and Y=0 you will obtain the picture in Figure 26.
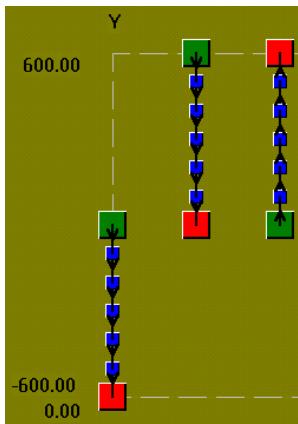
Figure 26

4.3.5. Moving the end or start of line position

This is the same as moving a normal position as described in paragraph 4.2.1, "Moving a position to a new location", page 42.

4.3.6. Deleting a line
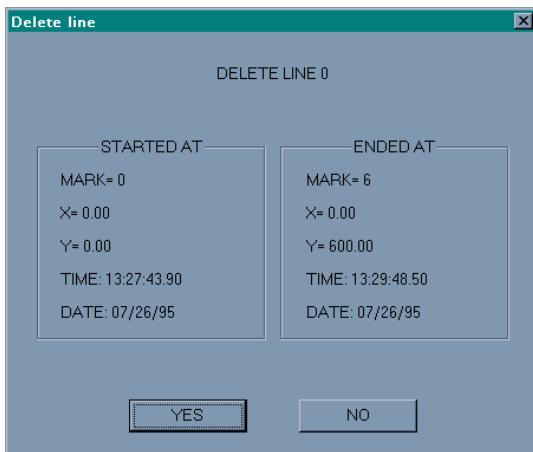

Figure 27

If the information reported by this dialog box confirms that this is the line you want to delete click on the "YES" button, otherwise click on the "NO" button to abort.

Deleting a line will delete all the positions and magnetic field readings acquired on this line.

For example , in the survey plotted in Figure 10, if you delete LINE 0, you will obtain the picture in Figure 28.
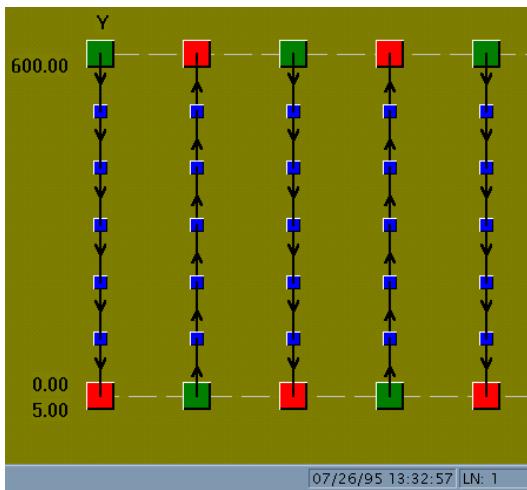
Figure 28

LINE 0 has been completely removed from the survey.

4.4.   Selecting and editing segments(continuous survey mode only)

A segment is defined as the set of readings between two positions.

In discrete survey mode there is only one reading per position and located at the position itself therefore there is no segment.

In continuous survey mode readings are acquired between positions and linearly interpolated between them.

To select a segment right click the mouse button between two positions on the direction symbol (arrow). Segment operations are only available for continuous survey.

A pop up menu should now appear on the screen.
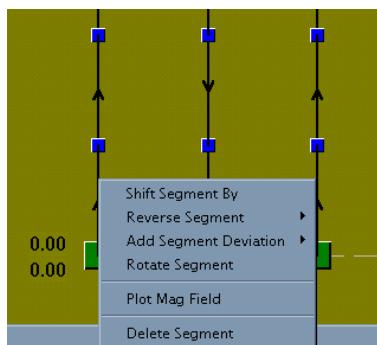
Figure 29

- To shift the segment by an X or Y offset select "Shift Segment By".

- To reverse the direction of a segment select "Reverse Segment".

- To correct a walking deviation error (for example you did not walk straight between 2 positions and end up at an other line, select "Add Segment Deviation".

- To rotate a segment select "Rotate Segment"

- To plot the magnetic field between 2 positions, select "Plot Mag Field".

- To delete a segment select "Delete Segment**". (This will delete the readings between the two positions).**

Every operation on a segment is basically the same as operating on a line. You can think of a segment as being a line with only two positions.

4.4.1. Shifting a segment
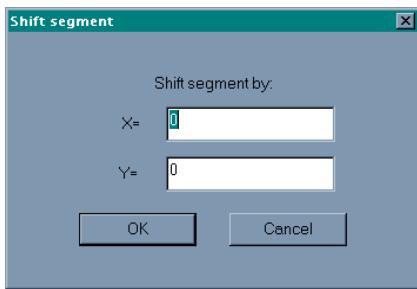
Figure 30

Type in the X and Y field the distance to the new location, then click the left mouse button on the "OK" button or pressed the "ENTER" key.

The two positions of the corresponding segment will be shifted by the X and Y offset and all the magnetic readings inside that segment will be linearly interpolated between the two new positions.

For example , in the survey plotted in Figure 10, if you shift by X=-2.5 and Y=-50 the second segment in line 0 you will obtain the picture in Figure 31.

Mark 1 and Mark2 have been duplicated.
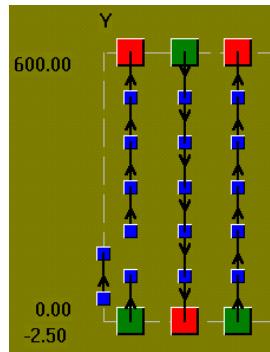
Figure 31

If you shift that segment again Mark 1 and Mark2 will not be duplicated.

4.4.2. Reversing a segment

There are three options for reversing a segment:

A segment can be reversed in X and Y direction, in X direction only and Y direction only. The last two options should not be used for horizontal or vertical segments.

For most cases select "Reverse In Both Directions".
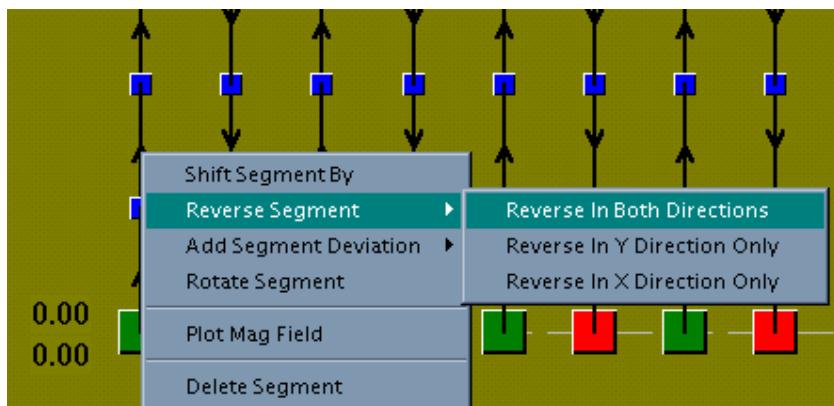
Figure 32

For example , in the survey plotted in Figure 10, if you reverse the second segment of line 0 you will obtain the picture in Figure 33.
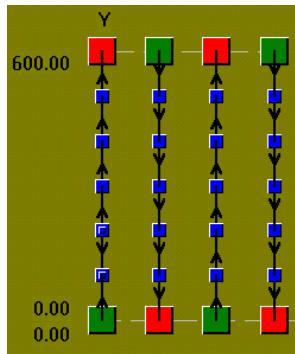
Figure 33

The positions at each end of the rotated segment have been duplicated in order to preserve the interpolation of the readings in the segments on either side of the rotated segment.

4.4.3. Correcting a walking deviation

There are two options for fixing a segment deviation:

A segment can be deviated in the X or Y direction.

If your segment is vertical and you did not walk straight and end up off line at the end of the segment, select "deviate in the X direction". If your segment was horizontal, select "deviate in the Y direction".
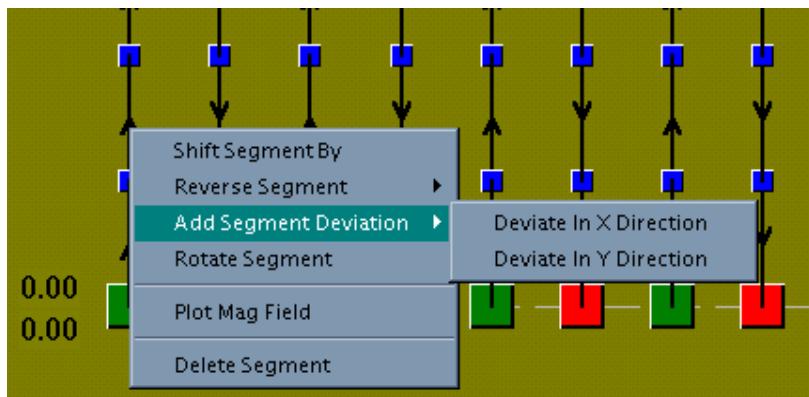
Figure 34

For example, let us assume that in Figure 10 you walk off segment on the second segment of line 0 and really end up at the end of the segment at X=2.5 and Y=200. To fix this problem select "deviate in the X direction". When the following dialog box (Figure 35) appears on the screen type 2.5 and click on "OK".
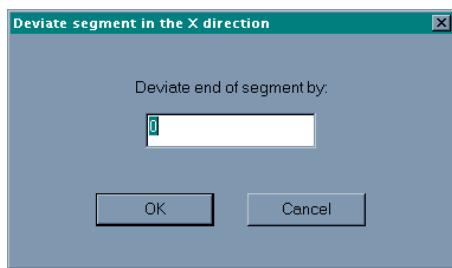

Figure 35

You should now have fixed your walking deviation as shown in Figure 36.
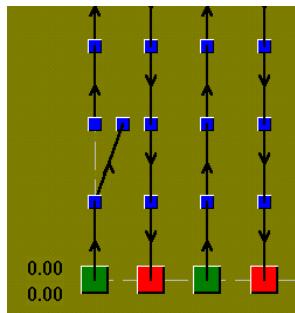
Figure 36

Mark2 has been duplicated.

4.4.4. Rotating a segment
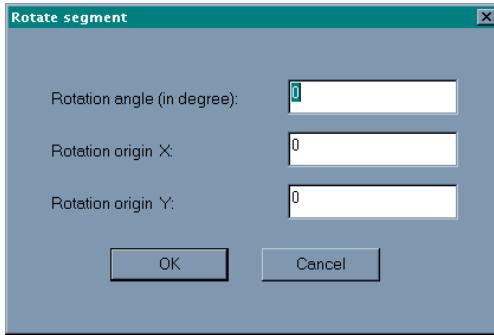
Figure 37

Type in the rotation field the angle of the rotation in degrees (from -360 to 360 degrees).

Type in the X and Y fields the coordinates of the rotation origin. Once you enter all the fields, left click the mouse button on the "OK" button or press the "ENTER" key.

For example , in the survey plotted in Figure 10, if you rotate the second segment of line 0 by 90 degrees at the origin X=0 and Y=100 you will obtain the picture in Figure 38.
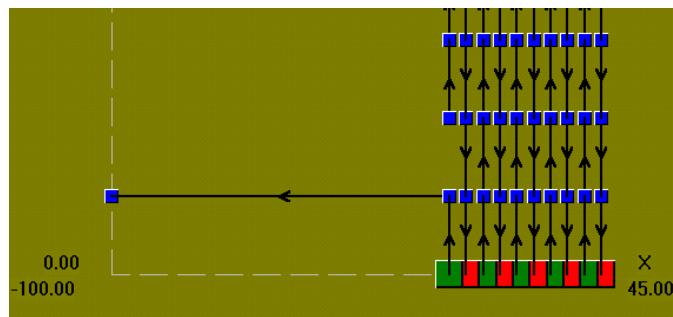
Figure 38

Mark2 has been duplicated.

(Note: Aspect ratio of x and y coordinates not identical)

4.4.5. Plotting magnetic field readings of the entire segment

For example if you plot all the readings of the second segment of line 0 as shown in Figure 10, you will get the following picture:
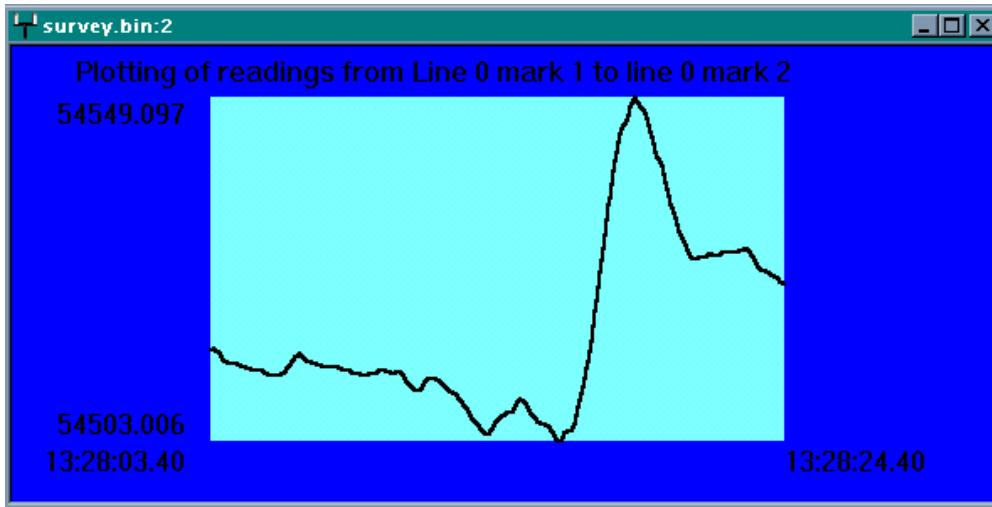
Figure 39

For more information on this window, see the section about plotting readings (section 0 page 106). Readings are not shown in their correct linear position, only in the sequence that they were taken.

This plot is used as a quality control device to insure that the data is free from excessive noise and dropouts. It is very important to immediately remove any zero values or spikes from the data (see section 7). After applying various filters, the data should be re-plotted for confirmation of results.

4.4.6. Deleting a segment
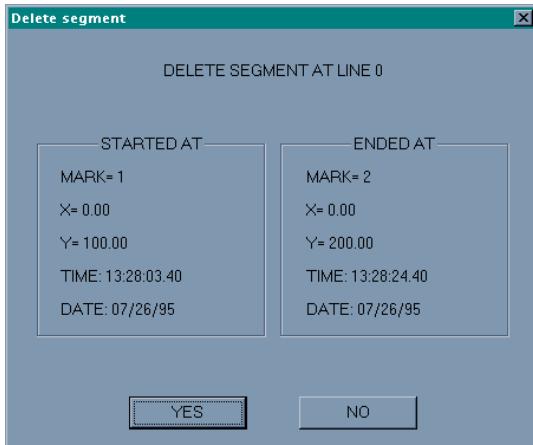
Figure 40

If the information reported by this dialog box confirms that this is the segment you want to delete click on the "YES" button, otherwise click on the "NO" button to abort.

Deleting a segment will delete all the magnetic field readings acquired for this segment. It may also delete the end positions if there are no other readings attached to these positions.

For example , in the survey plotted in Figure 10, if you delete the second segment in line 0, you will obtain the picture in Figure 41.
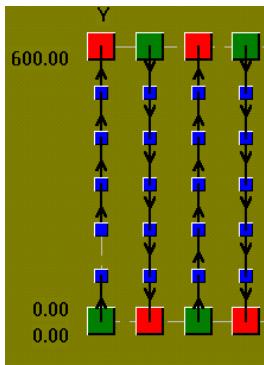
Figure 41

4.5.   Selecting and editing a groups of positions

4.5.1. Selecting a group of positions

- To select a group of positions click the left mouse button and draw a rectangle around the positions to select (Figure 42). When you have finished drawing the rectangle, release the left button. Every position inside that rectangle will be selected (indicated by a white square) as shown in Figure 43.
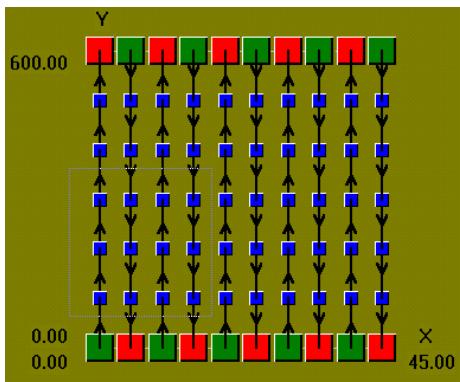
Figure 42
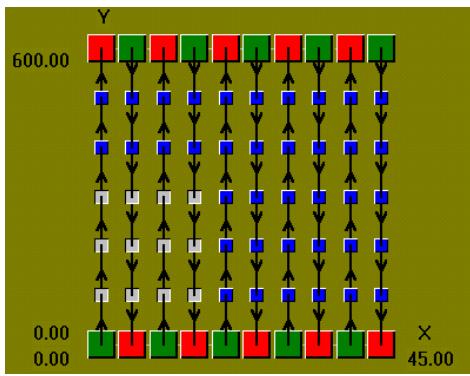
Figure 43

- To select more positions press the control key (CTRL) and repeat previous operation (Figure 44 and Figure 45).
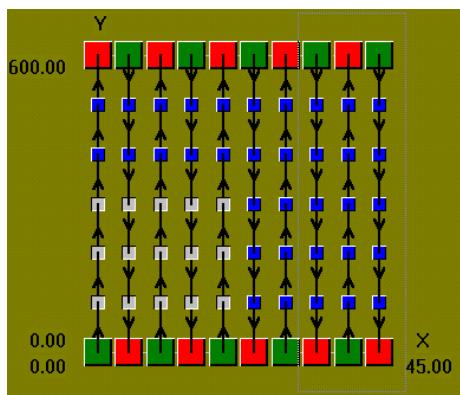
Figure 44
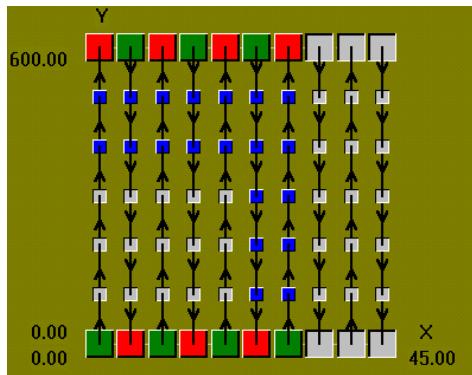
Figure 45

- To select a single position press the CTRL key and click the left mouse button inside the corresponding position.

- When you select positions, if the positions were already selected they will be deselected (Figure 46 and Figure 47). If they were not selected they will be selected (pressing the CTRL key toggles the selection.)
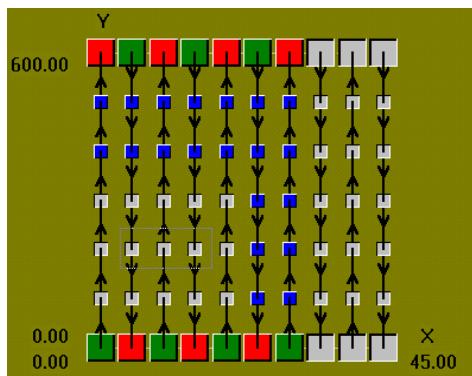
Figure 46
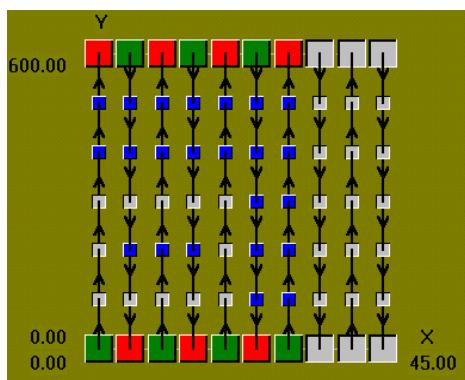
Figure 47

- To deselect all the positions click the left mouse button anywhere.

4.5.2. Editing a group of positions

Once you have finished selecting the positions click the right mouse button on the green area of the map.

A pop up menu should now appear on the screen.
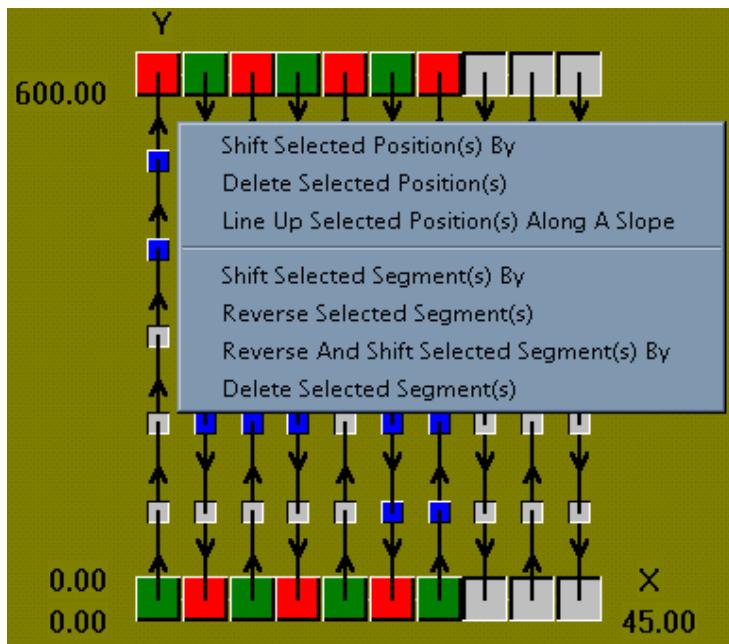
Figure 48

- To shift the selected positions by an X or Y offset select "Shift Selected Position(s) By".

- To delete the selected positions select "Delete Selected Position(s)".

- To line up the selected positions along a slope select "Line Up Selected Positions Along A Slope".

The following segment operations are only available for continuous surveys.

- To shift the selected segments by an X or Y offset select "Shift Selected Segment(s) By".

- To reverse the selected segments select "Reverse Selected Segment (s)".

- To reverse and shift the selected segments select "Reverse And Shift Selected Segment(s) by".

- To delete a segment select "Delete Segment". (This will delete the readings of every selected segment).

Once you have selected the operation to perform, one of the following dialog boxes will appear.
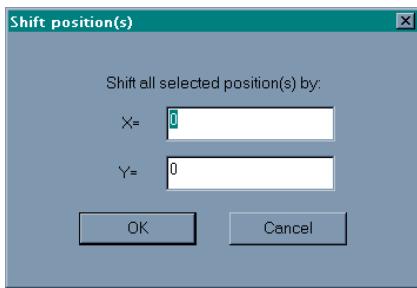
Figure 49

Type in the X and Y fields the distance for every position to the new location, then click the left mouse button on the "OK" button or pressed the "ENTER" key.

For example , in the survey plotted in Figure 50, if you shift by X=10 and Y=0 all the selected positions you will obtain the picture in Figure 51.
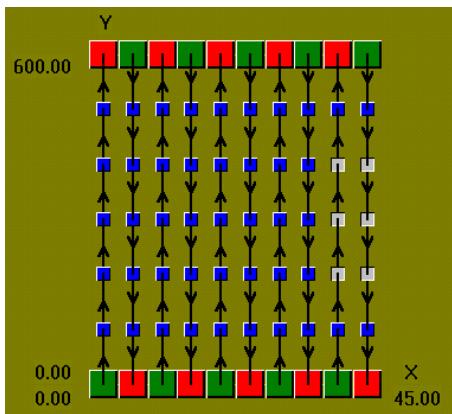
Figure 50
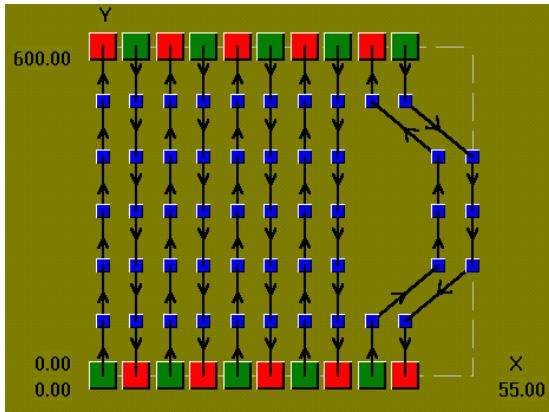
Figure 51

4.5.2.2. DELETING A GROUP OF POSITIONS

For example , in the survey plotted in Figure 50, if you deleted every selected position you will obtain the picture in Figure 52.
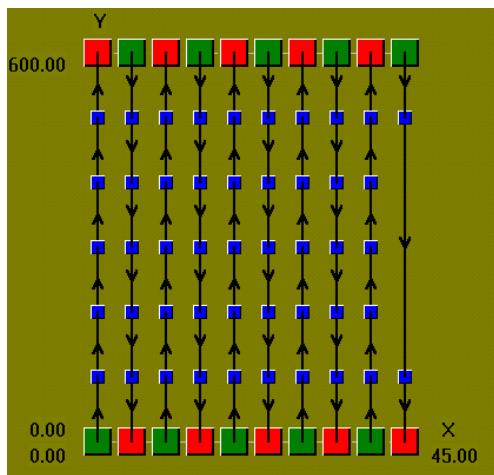
Figure 52

The behavior of the program differs depending upon whether you have performed a continuous or discrete survey.

G-858 continuous survey mode:

Deleting a group of positions **does not delete** any magnetic field readings acquired during the survey.

If a group of positions is deleted, magnetic field readings are linearly interpolated between the previous and next positions outside of the selected group of positions.

End of Line and Start of Line positions can not be deleted.

G-858 discrete mode or G-856:

Deleting a group of positions **does delete** every position and the corresponding magnetic field acquired at their location.

End of Line and Start of Line positions can be deleted.

4.5.2.3. LINING UP A GROUP OF POSITIONS ALONG A SLOPE

For example, suppose that the back edge of the map plotted in Figure 42 should be sloped in the following manner:

- Top left corner of the map is at X=0 Y=600.

- Top right corner of the map is at X=45 Y=650.

First select all the positions at X=600 as shown in Figure 53.
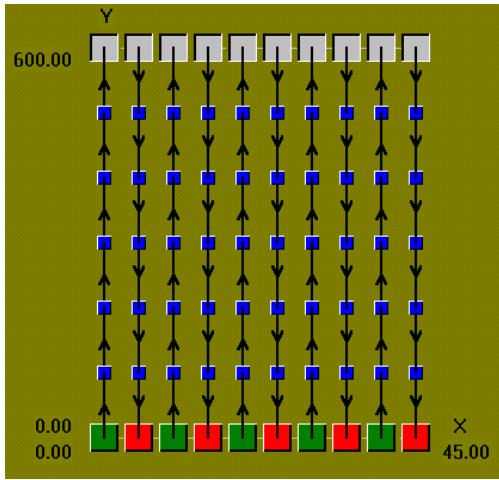
Figure 53

Click the right mouse button and select "Line Up Selected Positions) Along A Slope" from the pop up menu.

The dialog box as shown in Figure 54 should now appear on the screen.
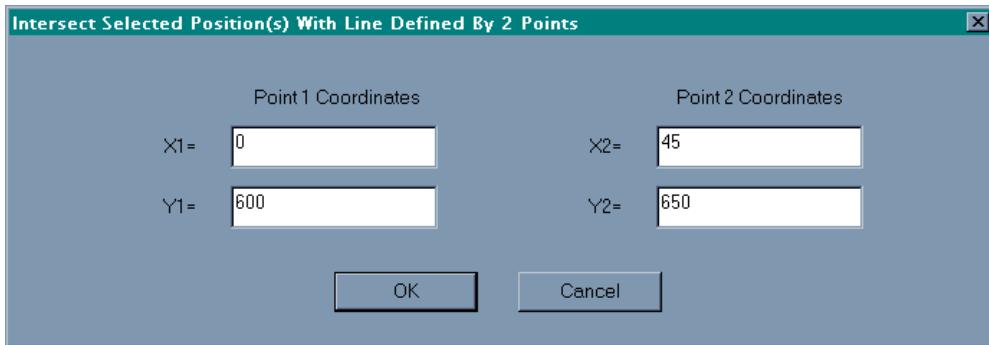
Figure 54

Type the coordinate of the top left corner of the map in the "point 1 coordinates" field.

Type the coordinate of the top right corner of the map in the "point 2 coordinates" field.

Then left click the mouse on the "OK" button.

You should now get the right shape of the map as shown below in Figure 55.
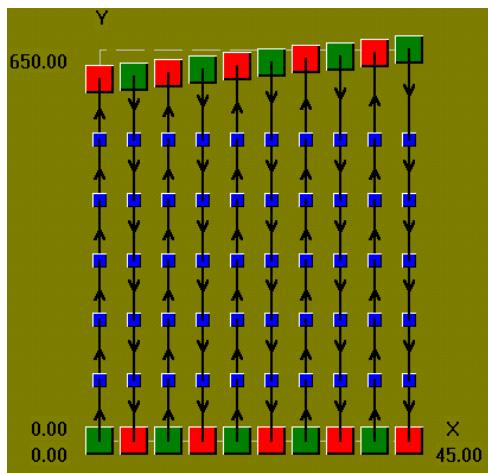
Figure 55

4.5.2.4. SHIFTING A GROUP OF SEGMENTS (CONTINUOUS SURVEY MODE ONLY)

You can shift a group of segments the same way as a single segment (see paragraph 4.4.1 "Shifting a segment" page 52).

4.5.2.5. REVERSING A GROUP OF SEGMENTS (CONTINUOUS SURVEY MODE ONLY)

You can reverse a group of segments the same way as a single segment (see paragraph 4.4.2 "Reversing a segment", page 52).

4.5.2.6. REVERSING AND SHIFTING A GROUP OF SEGMENTS (CONTINUOUS SURVEY MODE ONLY)

You can perform a reverse and shift operation on a group of segments all at once.

4.5.2.7. DELETING A GROUP OF SEGMENTS (CONTINUOUS SURVEY MODE ONLY)

You can delete a group of segments the same way as a single segment (see paragraph 4.4.6 "Deleting a segment" page 56).

4.6. Selecting and editing the survey grid

To select the grid right click the mouse button on the green area of the map.

A pop up menu should now appear on the screen.
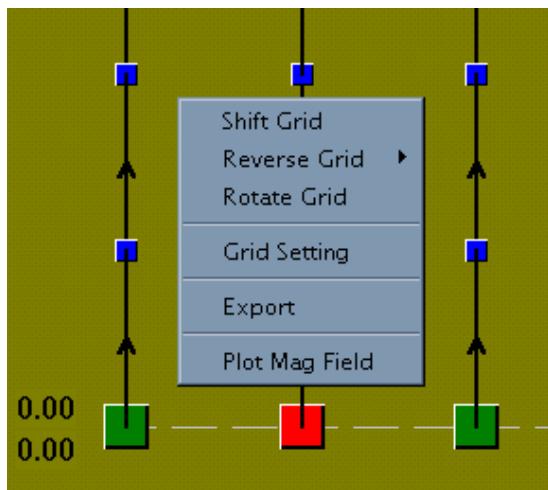
Figure 56

- To shift the grid by an X or Y offset select "Shift Grid By".

- To reverse the direction of every line or every other line select "Reverse Grid".

- To rotate a grid select "Rotate Grid".

- To change the mark and line spacing select "Grid Setting".

- To export your survey to Surfer or Geosoft Analysis and Plotting Software select "Export".

- To plot every magnetic field reading of the survey, select "Plot Mag Field".

Once you have selected the operation to perform, one of the following dialog boxes or windows will appear:

4.6.1. Shifting a grid
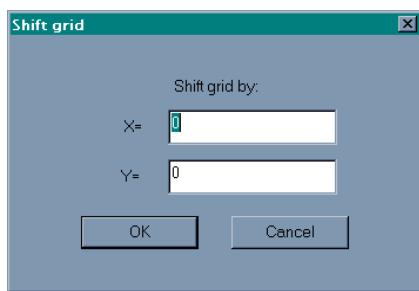
Figure 57

Type in the X and Y fields the offset to the new location, then click the left mouse button on the "OK" button or pressed the "ENTER" key.

Every position of the survey will be shifted by the X and Y offset.

For example , in the survey plotted in Figure 10, if you shift the grid by X=5 and Y=100 you will obtain the picture in Figure 58.
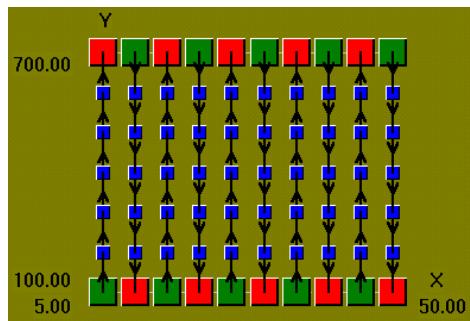
Figure 58

4.6.2. Reversing a grid

There are several options for reversing a grid:

To reverse every line of the survey select "Reverse Every Line" and "Reverse In Both Directions".

To reverse every even line of the survey select "Reverse Every Even Line" and "Reverse In Both Directions". Every other line, starting with the first line acquired in the survey, will be reversed.

To reverse every odd line of the survey select "Reverse Every Odd Line" and "Reverse In Both Directions". Every other line, starting with the second line acquired in the survey, will be reversed.
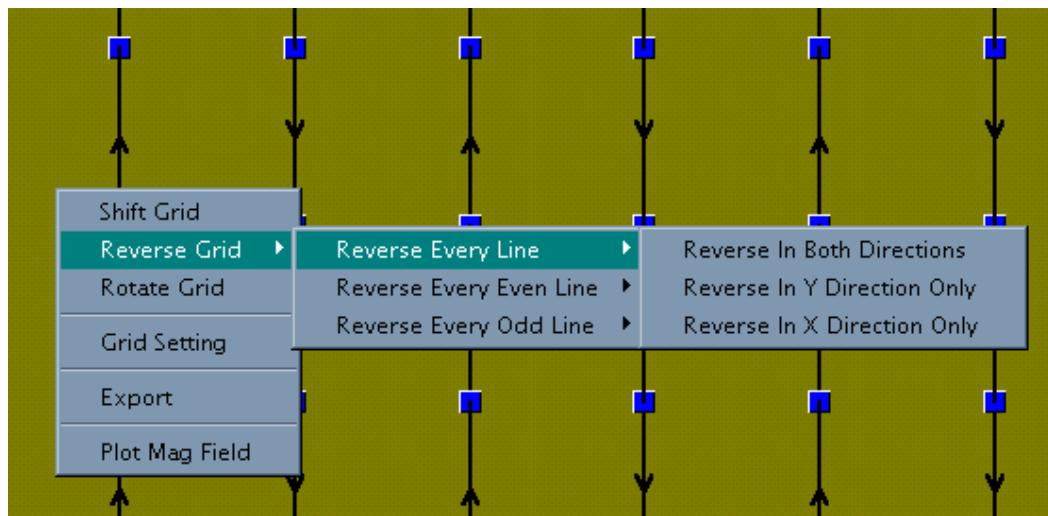
Figure 59

For example, in the survey plotted in Figure 10, if you reverse every line in **both directions** you will obtain the picture in Figure 60.
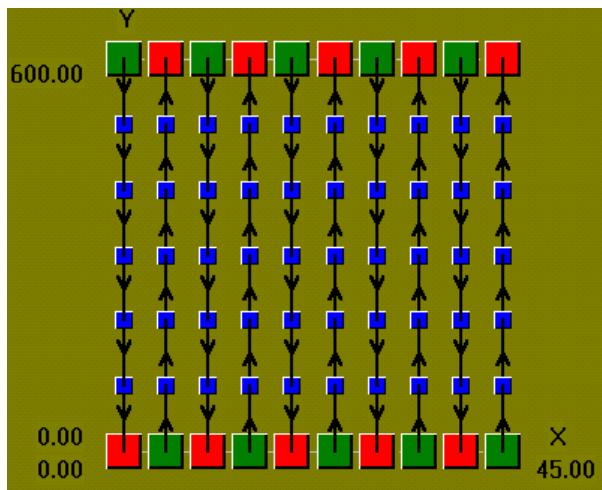
Figure 60

4.6.3. Rotating a grid
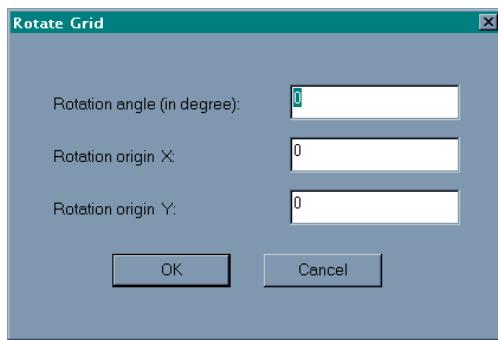
Figure 61

Type in the rotation field the angle of the rotation in degrees (from -360 to 360 degree).

Type in the X and Y field the coordinates of the rotation origin. Once you enter all the fields, click the left mouse button on the "OK" button or press the "ENTER" key.

For example , in the survey plotted in Figure 10, if you rotate the grid by 90 degrees at the origin X=0 and Y=0 you will obtain the picture in Figure 62.
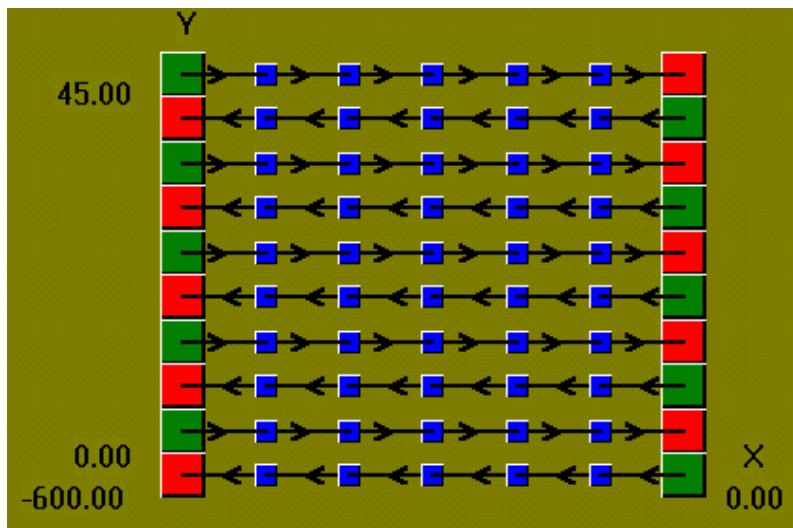
Figure 62

4.6.4. Grid settings

You can change the grid parameters that you already defined as described in paragraph 3.5, Defining the grid (G-858 simple survey mode or G–856 only), page 36.

In the case of mapped survey mode, you can redefine your grid. This will change the coordinates of every position acquired in your survey. You should only use this feature if you set up invalid grid information in the G-858 magnetometer before doing your survey, such as invalid line or mark spacings. **Potentially, every position in the survey may be changed.**

4.6.5. Exporting the survey to Geosoft or Surfer

See section 12.

4.6.6. Plotting magnetic field readings of the entire survey

For example if you plot all the readings of the survey in Figure 10, you will get the following picture:
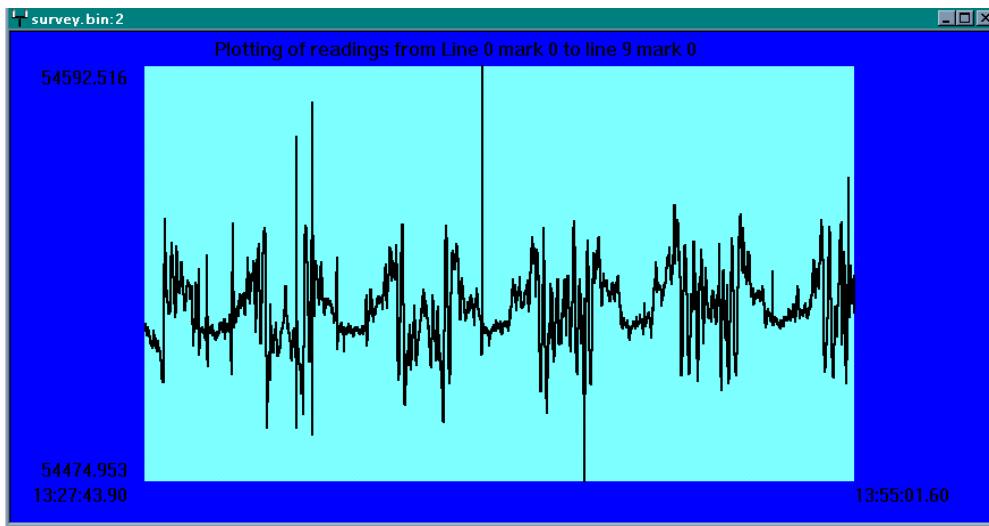
Figure 63

For more information on this window, see the section about plotting readings (Section 0 page 106). Readings are not shown in their correct linear position, only in the sequence that they were taken.

4.7. MagMap Coordinate Transformations

This chapter discusses how MagMap can transform a 858 local or GPS coordinate system into a different coordinate system using Pseudo Affine transformation and triangulation.

There are two problems to be considered here:

- How do we transform local 858 coordinates into State Plane coordinates or some other coordinate system? If both coordinate systems were defined completely without errors it would be sufficient to measure only two corresponding points in each system.

- How do we take into account possible irregularities in the 858 coordinate system such as non-parallel lines, curved lines or irregular mark spacing along the line? In this case it is not enough to define the transform using only two points. It could be that a new coordinate for every positional "mark" would be required.

Keep in mind that methods described below also can be used for direct transformation between Latitude / Longitude pairs, State Plane coordinates and vise versa.

The transform functions will typically be of most value where the survey is conducted without GPS but the final map product requires GPS positioning. The process is as follows: After the survey is completed the positions of the four corners of the survey area are measured with the geodetic grade GPS, and coordinates are recorded as Latitude Longitude or State Plane coordinates. (Alternatively, the positions of all survey marks (including end of line marks) could be measured with the GPS). Note: State Plane coordinates can be easily obtained with from Lat/Lon pairs using CORPSCON software program which is freely

available from the Army Corps of Engineers at:
(http://crunch.tec.army.mil/software/corpscon/corpscon.html).

Here is how MagMap solves the transform problem.

Example 1: Point for Point Mark replacement. You have State Plane positions for all survey "marks" (including end of the lines), you want the survey grid in Latitude/Longitude or State Plane coordinates.

The following file must be manually generated:

XGLOBAL	YGLOBAL	XLOCAL	YLOCAL	LINE	MARK
7606142.127	7252837.023	1300	0	39	26
7606092.261	7252834.938	1250	0	39	25
7606042.396	7252832.853	1200	0	39	24
7605992.530	7252830.768	1150	0	39	23
7605942.664	7252828.683	1100	0	39	22
7605892.799	7252826.598	1050	0	39	21

....

The first string is the header and is not used. The second line has two columns labeled XGlobal and YGlobal, which contain State Plane (UTM or Lon/Lat) coordinates, two columns with local (X-Y 858 coordinates) and columns for the line and mark numbers. The program actually uses only the State Plane and Line Mark pairs. All marks must be present in the file; omitted pairs are removed from the data in memory (a warning message is displayed). Integer numbers must be used for Line/Mark pairs.

Note: When data is exported, magnetometer data is interpolated between existing marks.

To perform the transformation, load the G-858 STN or BIN file and select "Survey Setup / Replace positions" from the menu:
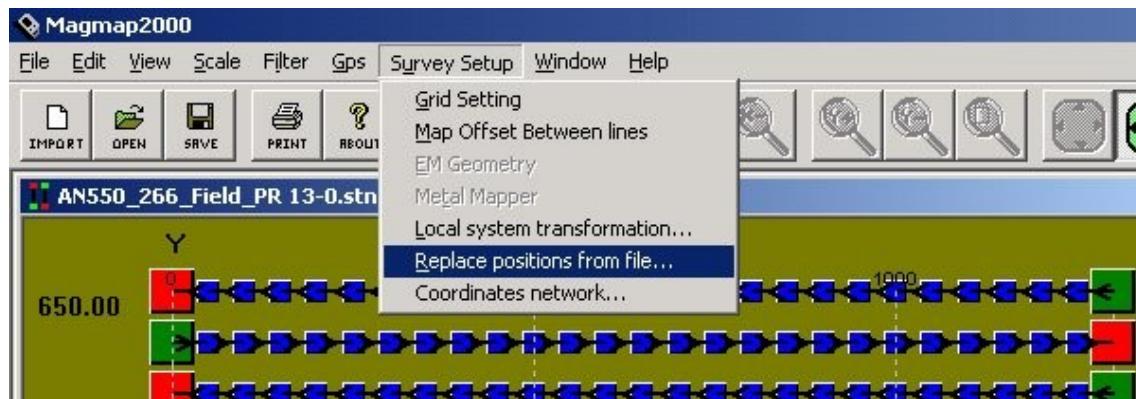
The warning will appear:

Click Yes and a dialog box opens for you to specify the replacement file name. Make sure you check the "New coordinates are Longitude and Latitude" box at the bottom of the dialog if you want to output position data in Lat/Lon, i.e., this box should be checked only if the new coordinates are to be geographical.

 When you click Open, the transformation routine will run.
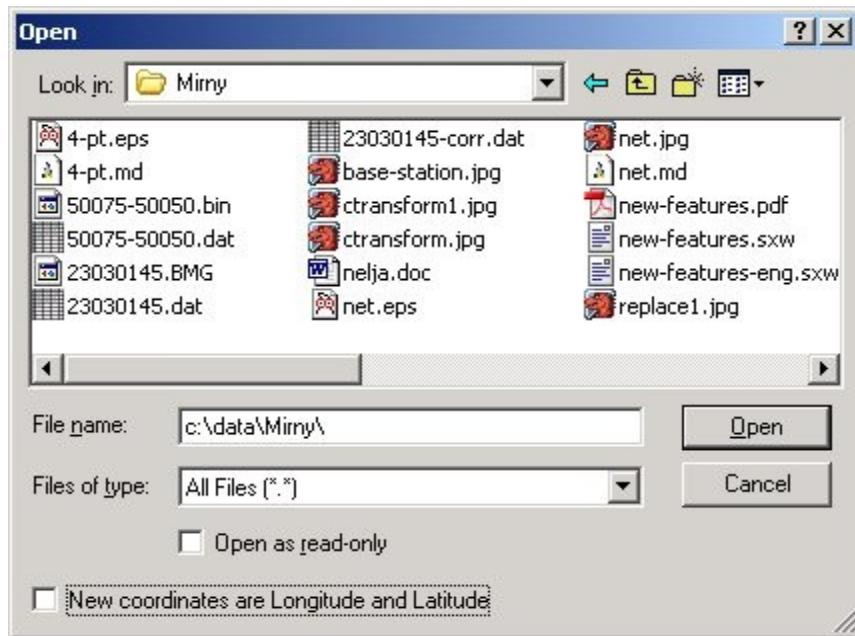
The position screen will now be updated with the new positions and may look like this:

If there is an obvious misplacement, use "Undo" to return to the previous position data display.

In this example all data positions are now in State Plane coordinate system.

Example 2: Local 858 X-Y positions and Global State Plane or GPS coordinates are known for 4 or more corresponding points.

This is a more common case where the corners of the area are measured with GPS. Then the new data position coordinates are simply recomputed from one coordinate system to another. The program does not try to account for any 858 system positioning irregularities.

Four points known in both coordinate systems are sufficient to derive the transformation. The new points need not necessarily coincide with any of 858 survey marks. The requirements are that no more then two points can be connected with a straight line (we are defining a new surface).

A Pseudo Affine transformation is defined in the formulas below :

$$X = a_1 xy + a_2 x + a_3 y + a_4$$
$$Y = a_5 xy + a_6 x + a_7 y + a_8$$

For example X, Y would be Global State Plane (or UTM, or new Lat/Lon positions) and x, y would be in the local 858 X-Y coordinate system. If both coordinate systems are accurately defined, a_1 a_5 are equal to zero and a_2 a_7 are equal to one. Coefficients a_2 a_7 describe scaling transformation; a_6 a_3 describe rotation transformation and a_4 a_8 describe

translation transformation between two coordinate systems. Non-linear terms a_1 a_5 describe inconsistencies in the application of the model after the transformations have been computed. For instance, if user defines local coordinate grid as 10 x 10 meter, and wants to transfer it into State Plane, which is defined in feet, a_2 a_7 would be 3.28 (scale coefficient between meters and feet). If he or she converts to UTM (defined in meters) then a_2 a_7 would be 1. Furthermore, if in reality 10 x 10 meter grid defined by the user is not square and for example is 9.6 x 10.2 meters, other terms in the equation for *X, Y* may also be used.

MagMap can use any number of points to compute this transformation. The recipe is to use well-defined points with minimal positional errors. For instance in the picture below you would not use points 1,2,3,4 if you know that point 3 is misplaced.
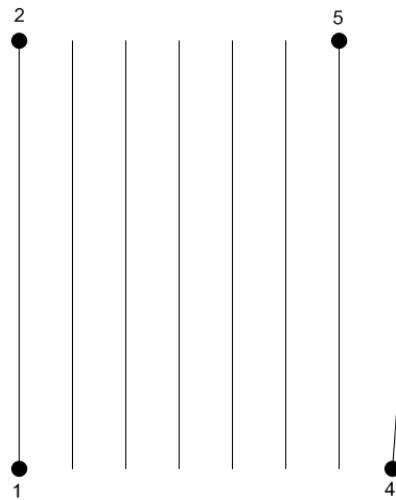
The local coordinates of point 3 (in x,y) will not show this misplacement. The correct solution would be to use points 1,2,4,5. Point 3will still be misplaced after transformation, and although nothing can be done here to correct its position, the rest of the grid will be correctly located.

If the quality of reference points is not known, you can use some number of them to obtain a least squares fit solution to minimize the errors. The fitting process is done automatically when more than 4 points are used in the solution.

MagMap allows user interactive solution computing as shown below:
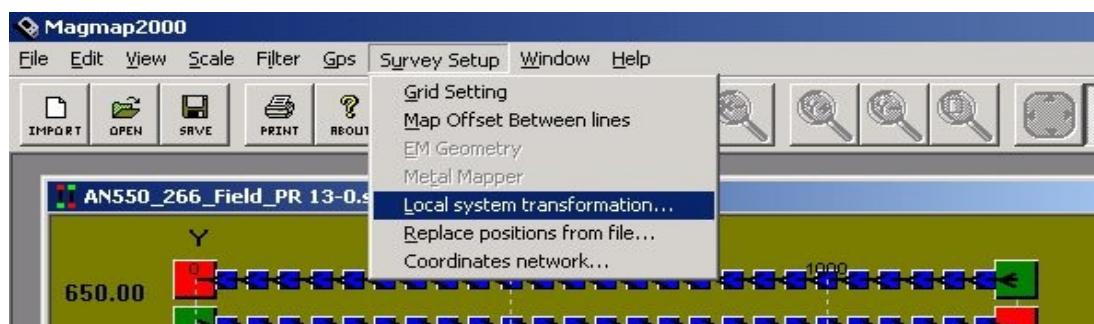
As before, open the Survey Setup and select Local System Transformation. The following dialog is displayed:
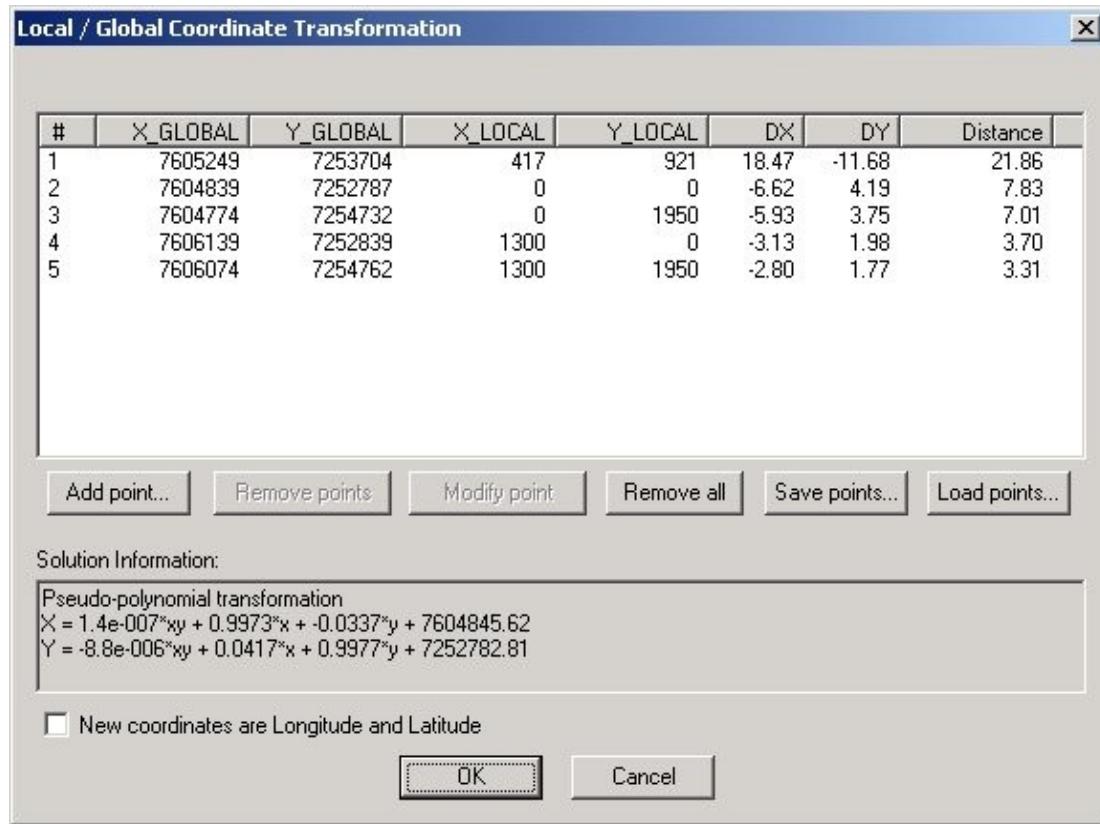
At the beginning, this dialog box will be blank. To add points interactively, press the "Add point…" button and fill in fields in the New Reference Point dialog:
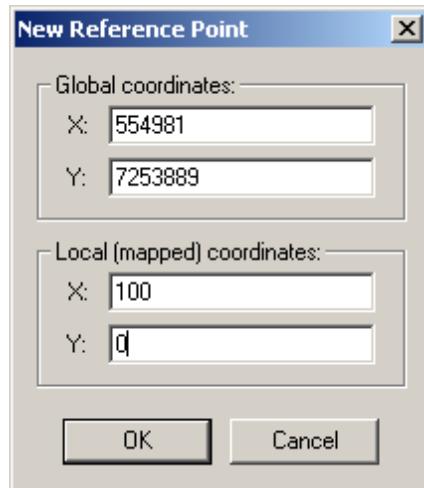
In the Global section type geographical (State plane, UTM, etc) coordinates in the first two fields. Type the local X-Y coordinates below in the Local dialog box. Press Ok. As soon as four or more points are added, the program computes a solution. Solution coefficients are displayed in the dialog box shown on previous page, along with computed errors (DX, DY

and Distance). Note that point 1 in the dialog box has a Distance mismatch of 21.86 m. Clearly this point will cause an incorrect repositioning of other points and should be removed from the computation. Points in the list can be deleted or modified by selecting the appropriate strings and pressing, "Delete" or "Edit" buttons.

The program treats the entered positions in differing manners depending on whether the "New coordinates are Longitude and Latitude" box is checked or not. If this box is left unchecked, the values DX, DY, Distance are computed as simple Cartesian distances between points in whatever units (feet or meters) the Global system employed. If the box is checked, the program uses an ellipsoidal approximation and computes distances in meters using Lat/Lon pairs. It is the user responsibility to select correct type of coordinates. Selecting "Lat/Lon" when the actual data is in UTM or State Plane would result in huge DX., DY and Distance error values.

If there are only four points, all errors are zero. Each time you add a point, modify or remove a point, the transformation coefficients are recomputed, new solution coefficients are displayed and DX, DY and Distance are updated. It is advisable to save this table into a file, (use Save Points button) for future reference. File format is shown below:

```
# X_GLOBAL   Y_GLOBAL   X_LOCAL   Y_LOCAL
  7605249      7253704      417      921
  7604839      7252787      0        0
...
```

The first line of the record is the header and is omitted. Note that the file format is compatible with the format used to replace all the marks (Example 1). These two files are interchangeable.

After the transformation is completed press "Ok" and the transformation information is read into MagMap. All points on the screen are replaced with new positions. If there is an obvious error, use "Undo" to revert to the earlier screen.

The general recipe in this case is that if a few points are known to have accurate positions, use them. If you are not sure of the accuracy of your positions, use as many points as you can to minimize errors through least square fit. Note that irregularities in 858 coordinates cannot be removed with this method.

Example 3: You have a known net of reference points

In this case there is a net of points where both local 858 and State Plane coordinates are known. Reference points may or may not coincide with Line / marks. See example below:

Reference points

········· 858 lines
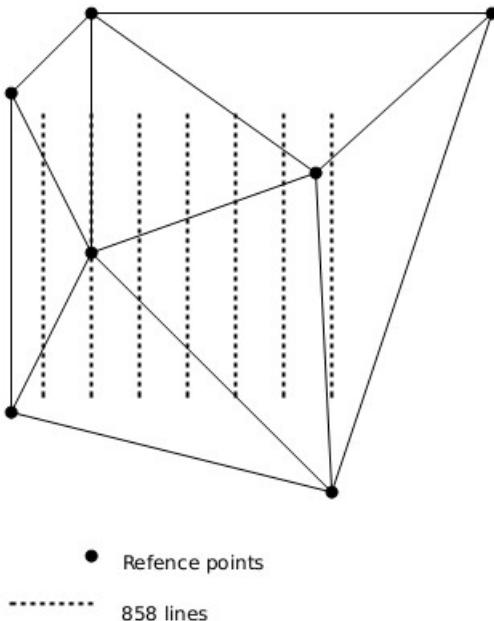
The program computes the Affine Transform in each of the triangles:

$$X = a_1 x + a_2 y + a_3$$
$$Y = a_4 x + a_5 y + a_6$$

Because the triangle defines a plane surface, the corners of the triangle (reference points above) will be computed with zero error. However note that if the reference net is sparse then the curvature of the survey lines will not be taken into account. If there are errors in the reference points the survey lines could be curved.

If the State plane coordinates are known for each start and stop mark of each line, it is possible to obtain the transformation by defining only a few reference points. Here is an example:
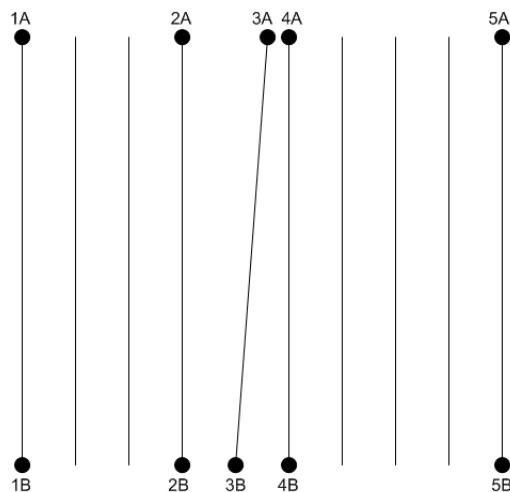
If it is known that line 3 positions are suspect, you can use points 1A-1B, 2A-2B, 3B, 4A-4B, 5A-5A. A good result will not be achieved using points 1A-1B, 3A-3B, 5A-5B.

MagMap implements this function the same way as in "replacement of all marks".
Select "Survey Setup / Coordinates Network"

If some of the marks are outside of the polygon defined by the triangle mesh, they will be removed.

If the transformation appears to be miscomputed, use the "Undo" button to restore original positions in case of error and check your reference point file for errors.

5.   Other views of Readings

Magmap has the ability to display readings in different ways, depending upon what kind of survey you have.

3-D plotting capability is included in Magmap. The purpose of the 3D displays is to give a quick overview at the data. They are not intended for in depth data analysis or presentation but can be printed.

5.1.   2D contour and 3D surface plots for magnetic field readings

5.1.1.   Creating a 2D or 3D plot

When right clicking the mouse button to edit the grid, two new options, "Plot Mag Field in 2D Contours" and "Plot Mag Field in 3D Surface", are included in the menu as follows:

> Note: "*Plot Stack Profile On Top Of Map*" may not be available for some types of surveys, specifically GPS surveys.

Selecting "*Plot Mag Field in 2D Contours*" and "*Plot Mag Field in 3D Surface*" will give a 2D contour plot and 3D surface plot, respectively. If this is done from the survey map, both plots use the current number of lines as X grids and a fixed 100 Y grids to create the mesh points. If this is done from the GPS map, both plots create a fixed 100 x 100 mesh points. The grid value (Z) is interpolated by two magnetic field readings that are closest to the grid point. The following pictures are the 2D/3D examples for the survey on Stanford Test site:

Plotting Mag Field in 2D Contours for Sensor 1

(red)	50200
	50155
	50109
(yellow)	50064
	50018
	49973
(green)	49927
	49882
(cyan)	49836
	49791
(blue)	49745
	49700

2D Contour Plot:

Plotting Mag Field in 3D Surface for Sensor 1

(red)	50848
	50567
	50287
(yellow)	50006
	49726
	49446
(green)	49165
	48885
(cyan)	48604
	48324
(blue)	48044
	47763
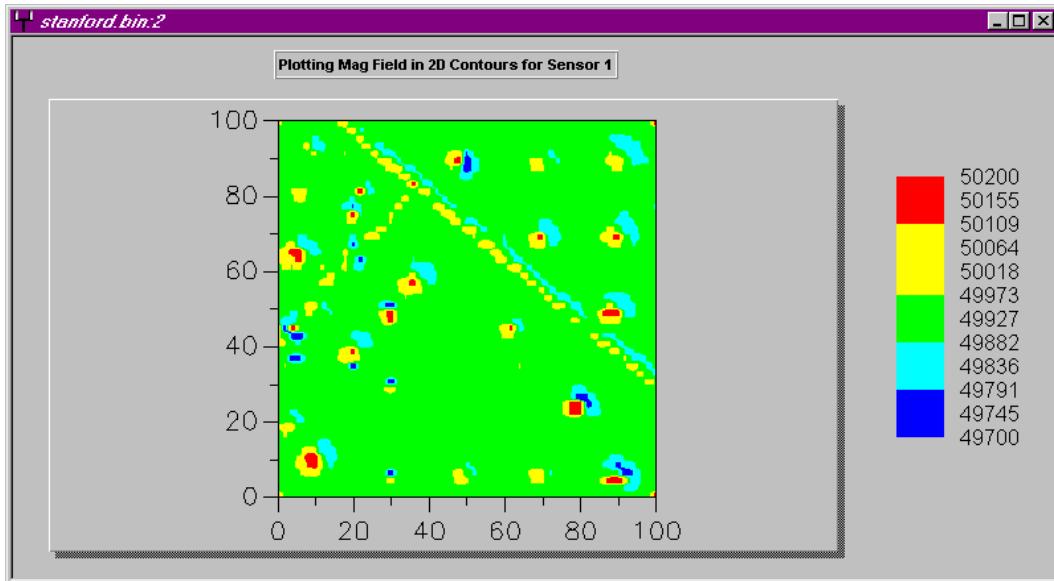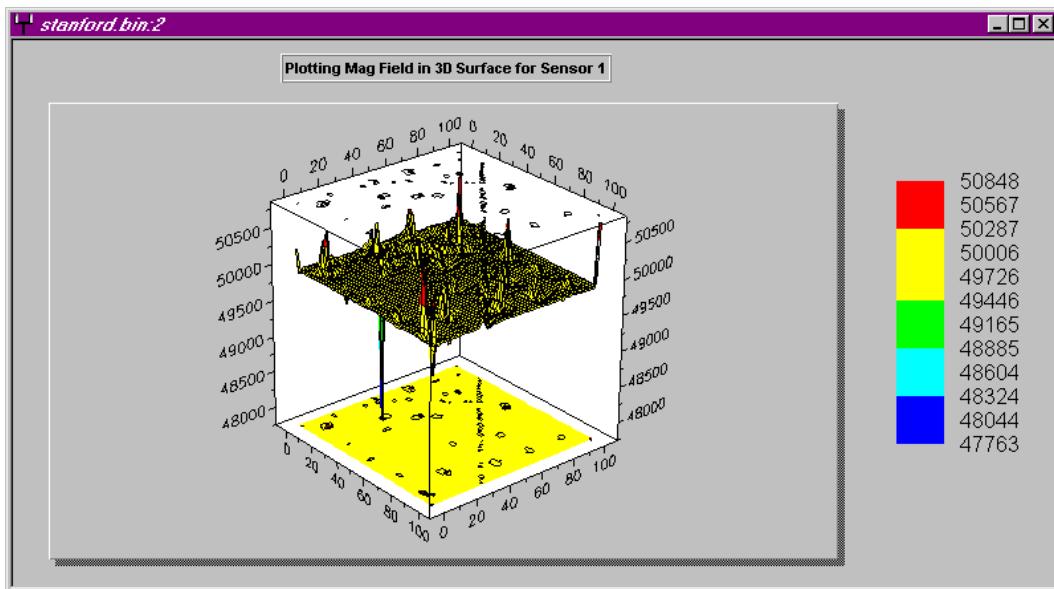
3D Surface Plot:

By default, it will create 10 contour levels using maximum and minimum grid values. The value and color represented at each level are listed to the right.

These plots use non-offset (GPS antenna to sensor) coordinates. In order to get a plot that takes offsets, heading error removal, or de-striping operations into account, you will need to export the file and then either view the output in a plotting program such as Surfer or reload the file as a Surfer (*.dot) file into Magmap .

Note: You can choose to plot any sensor (or pseudo gradient if available) by right clicking on the map and selecting the option: "*Plot sensors setup*". You can then choose the sensor you wish to plot.

5.1.2. 'Equalizing colors' technique for contour plot

As a recent addition to the program, the contour algorithm uses a technique where the colors shown are equalized. This is best explained by looking at the plot below, which does not employ this technique.
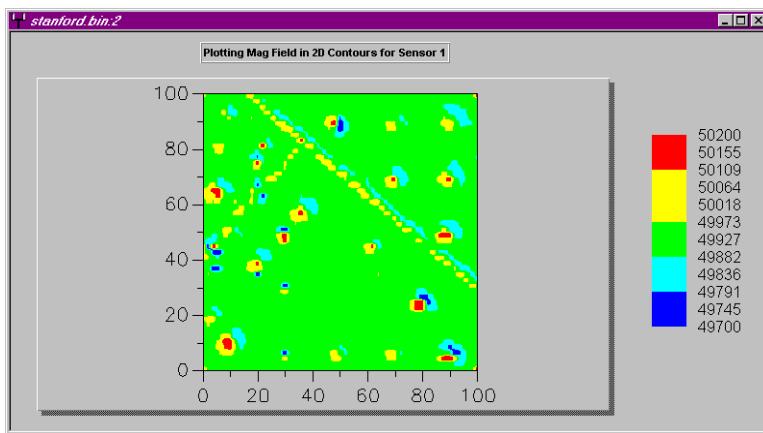
As it can be seen, most of this graph is dominated by one color. The other colors are sparingly represented and this occurs because each color represents a roughly equal part of the total magnetometer range. Since the range is divided up into equal parts, this technique will show a bad contour plot if a drop-out exists, or some small noise exists, because then the range is a lot larger and each color must span a much larger range. For instance, if we graphed the above and had one drop-out in the data (that we didn't filter), we would probably see an entirely red graph because blue would represent a range of about $0 - 10000$, green a range of about $0 - 30000$, and red, most of the valid data taken.

We can solve this problem by using a technique of equalizing colors. This means that each color is represented in the contour plot the same amount. In the graph below, we see this at work:
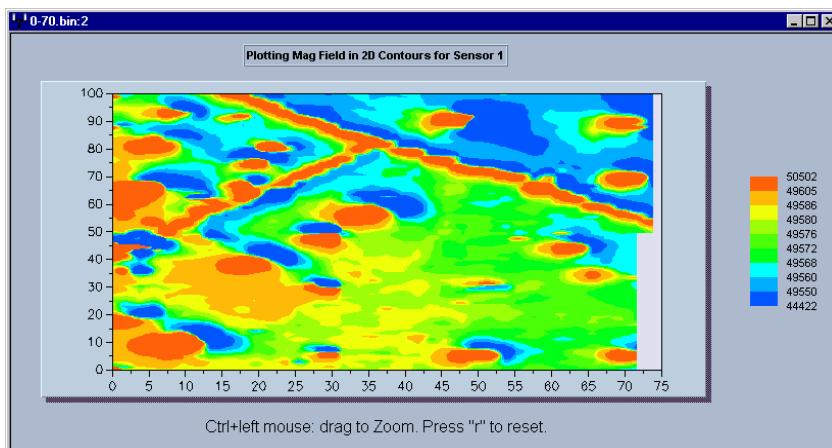
Note: The aspect ratio has not been adjusted.

This contour plot was done before any data was filtered or drop-outs removed. Thus, using conventional techniques, this plot should have been entirely one color using the number of colors available (for the same reason as discussed earlier). However, in this plot, blue spans about 400 nT whereas green spans about 8 nT – still, each color appears about the same amount on the graph.

Thus, the technique can be summarized as: the range for each color is picked in such a way that each color is represented the same amount on the graph.

5.1.3. Plot options for 2D/3D plot

5.1.3.1. SET MIN/MAX FIELD

Right clicking the mouse button inside the window will bring up the following context menu:

Plot Sensors Setup
Plot All Sensors

Set Min and Max Field
Set Grids (2D/3D Plot Only)

Selecting "Set Min and Max Field" will allow the user to change the maximum and minimum Z axis scaling. Type in the range of values you are interested in and press OK button when done. This will repaint the window using the new defined maximum and minimum fields. The legend to the right will be updated at the same time. Clicking on "Restore Default" button will reset maximum and minimum fields to be default values.

Set Vertical Scaling

Maximum field: 50847.6484375

Minimum field: 47763.3164063

Restore Default

OK   Cancel
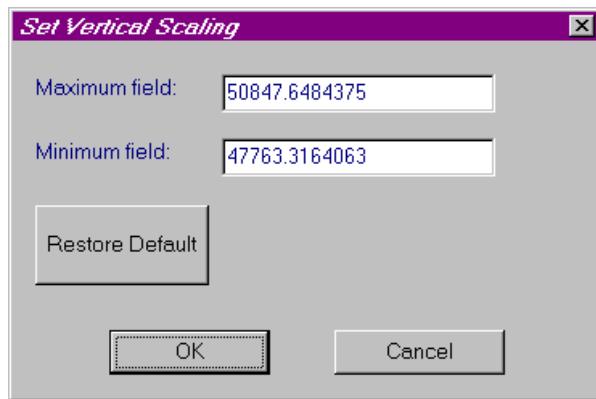
Selecting "Plot Sensors Setup" will let user select the readings for a specific sensor to be plotted. For the 2D/3D plot, it only allows one sensor to be plotted at a time. "Plot All Sensors" option is inactive for the same reason. After selecting the new sensor and clicking on OK button, it will repaint the window using readings from selected sensor. However, if user accesses "Plot Sensors Setup" from Profile Plot Mag Field Plot, it allows multiple sensors selection. To do this, hold down the CTRL key, and then click each sensor you want to select.

5.1.3.2. SET GRID SIZE

You can also set the number of gridding points used by clicking on the "*Set Grids*" option on the menu (obtained by right clicking on the contour plot).

This should then bring up the following dialog box:
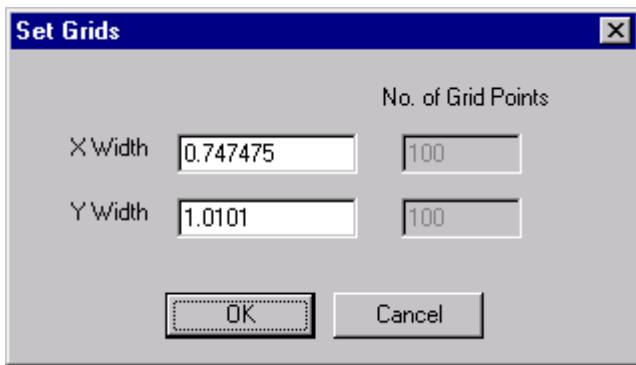
In this case, 100 grid points are used to define X and Y. (This is the default).

The X and Y width are calculated by taking the total X and Y distance (respectively), and dividing by the number of grid points desired. Hence, if you want to have a different width, the number of grid points will change accordingly. There is a maximum of 300 grid points in a given direction.

One important tip to remember is that it will take longer to generate the graph if you select more grid points. However, the resolution might be better if you have more grid points in the direction you took your measurements. Faster computers are always better for tasks such as these.

5.1.4. User Interactions for 2D/3D plot

In 2D/3D plot, user can rotate, translate, scale, and zoom the graph . The procedure for each operation is explained as follows:

- Rotation (3D only)

    ◊ Hold down BOTH mouse buttons and either:

    ◊ Move mouse counterclockwise to rotate view clockwise   or

    ◊ Press x, y, z, or e to select an axis, and then move mouse perpendicular to axis

Note: Some mouse drivers interfere with these dual button controls.

- Translation (2D/3D)

    ◊ Press SHIFT and hold down BOTH mouse buttons

    ◊ Move mouse to shift the chart

- Scaling (2D/3D)

    ◊ Press CTRL and hold down BOTH mouse buttons

    ◊ Move mouse down to zoom in or move mouse up to zoom out

- Zooming (2D/3D)

    ◊ Press CTRL and hold down LEFT mouse button

    ◊ Move mouse to select the area to zoom into

- Return to Default (2D/3D)

    ◊ Press "r"

    ◊ All scaling, translation, and zooming removed

Moving mouse cursor insider the contour/surface map will display the line number (LN), mark number (MK), x and y coordinates, representative date/time, grid value (FIELD), and representative reading number of the closest grid point at status bar.

5.2. Shaded Relief plot

The shaded relief plot is used to give a different view of the data, similar to what you might get via a contour plot, but more customizable. It is produced by assuming there is a light source above a 3-D topographical map of the data. The location of the light source is user defined, and the resulting shadows are graphed on a 2-D plot. You can decrease the effects that huge spikes have in your graphed data by using scaling factors that work to reduce the influence of the spike. You can also adjust the viewpoint by changing the relative location of the light source.

To produce a shaded relief plot, you need to first obtain a contour map. (See the section on contour maps for instructions on how to do this). From here, right click on the mouse as shown below.
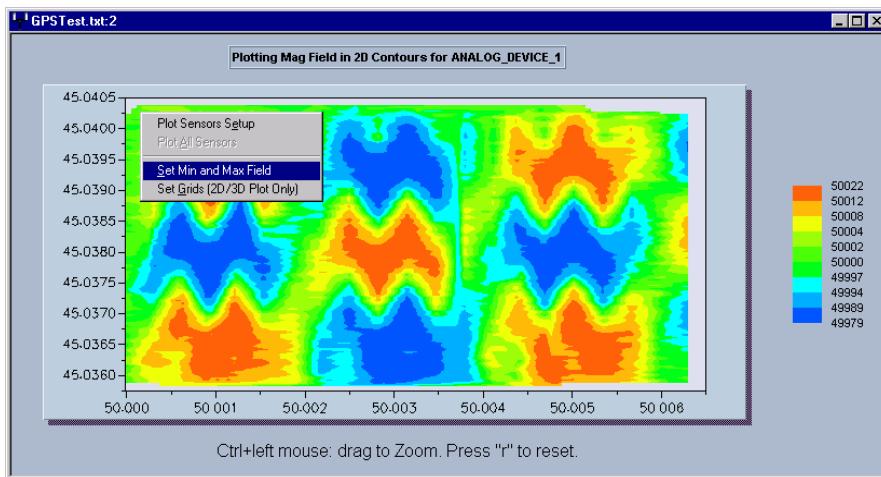
After you select "*Set Min and Max Field*", you should obtain the following dialog.
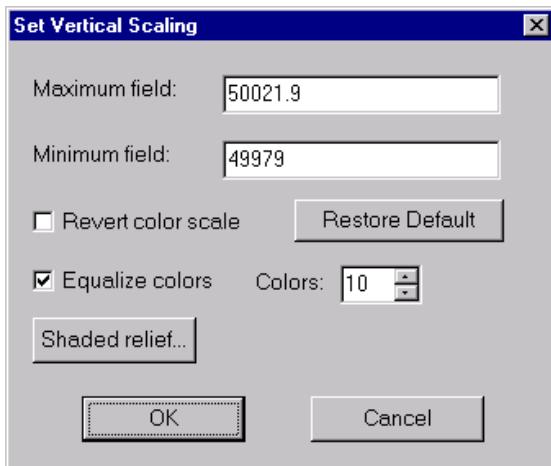
From here, press the "*Shaded Relief*" button to get a dialog that will let you set the parameters for your shaded relief plot.
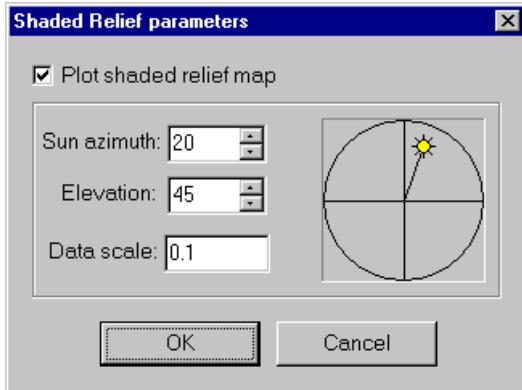
You need to select the option "*Plot shaded relief map*" to plot the map. Your map will be plotted after you press "OK" and exit out of the 'Vertical Scaling' dialog.

The **sun azimuth** and **elevation** parameters allow you to set the position of the light source in relation to the topographical map. The **data scale** setting allows you to vary the height differences of the different parts of the topographical map. A larger value of the data scale will favor large peaks, whereas smaller values will allow you to see smaller variations better.

An example of a shaded relief plot is shown below. Note, this is obtained from the same data that produced the contour map shown earlier in this shaded relief discussion.
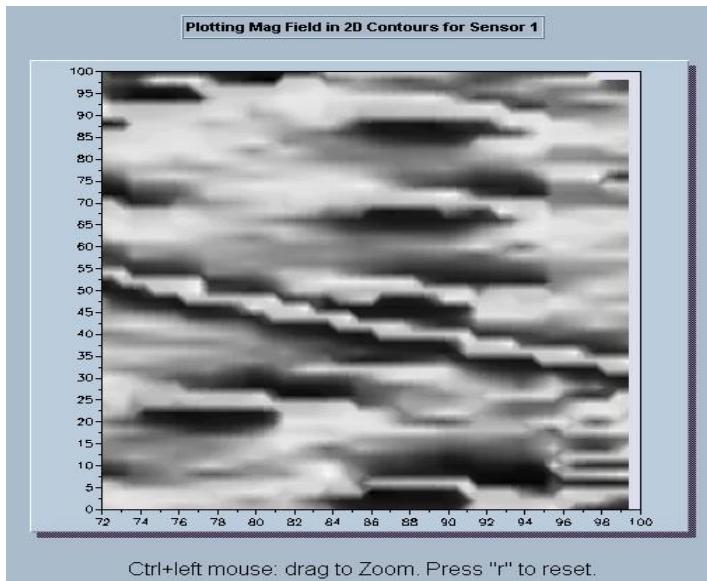
5.3.   Stack profile plot

5.3.1. What is a Stack profile?

For certain surveys, it is useful to view the magnetometer data of different lines at the same time in order to look for trends that occur between different lines. Since an anomaly

usually can be seen from adjacent lines, we can distinguish anomalies from noise by looking at several lines. We can also locate objects such as pipelines that extend over many lines.

Magmap's stack profile presents a way of looking at the magnetometer data of several lines at the same time.

It scales the magnetometer data over each individual mapped survey line as seen in the example below:
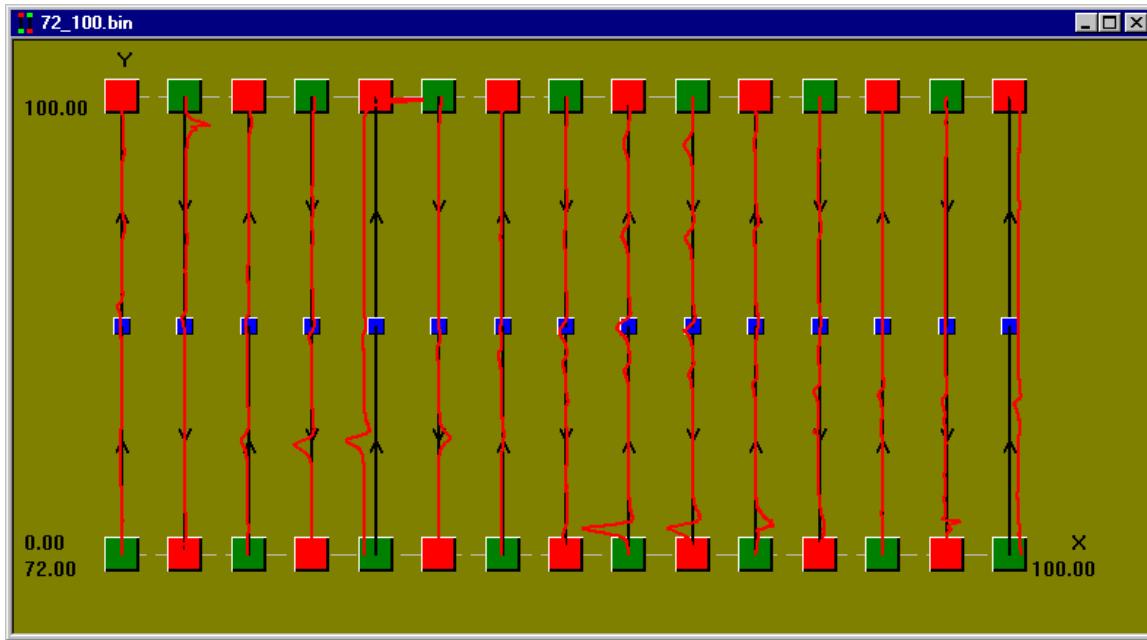
Stack Profile for an G-858 survey

Note the similarity of the second line (X = 74) to the plot of our magnetometer readings:
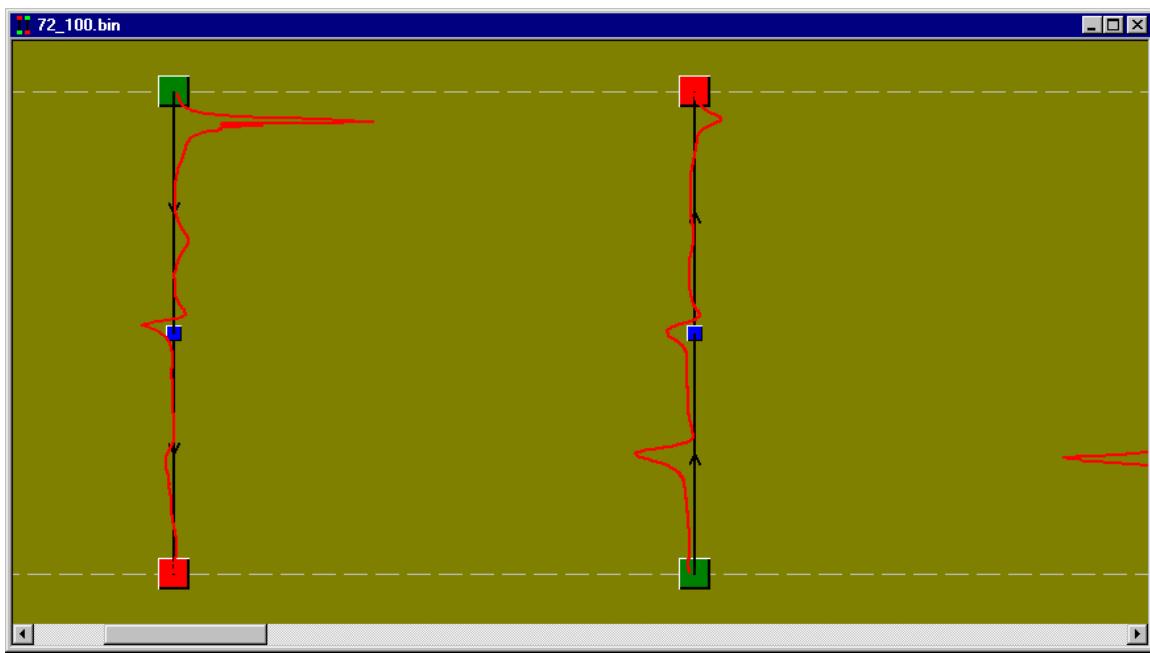
We have zoomed in on the left line (X = 74) so that we can compare it with the magnetometer readings below.
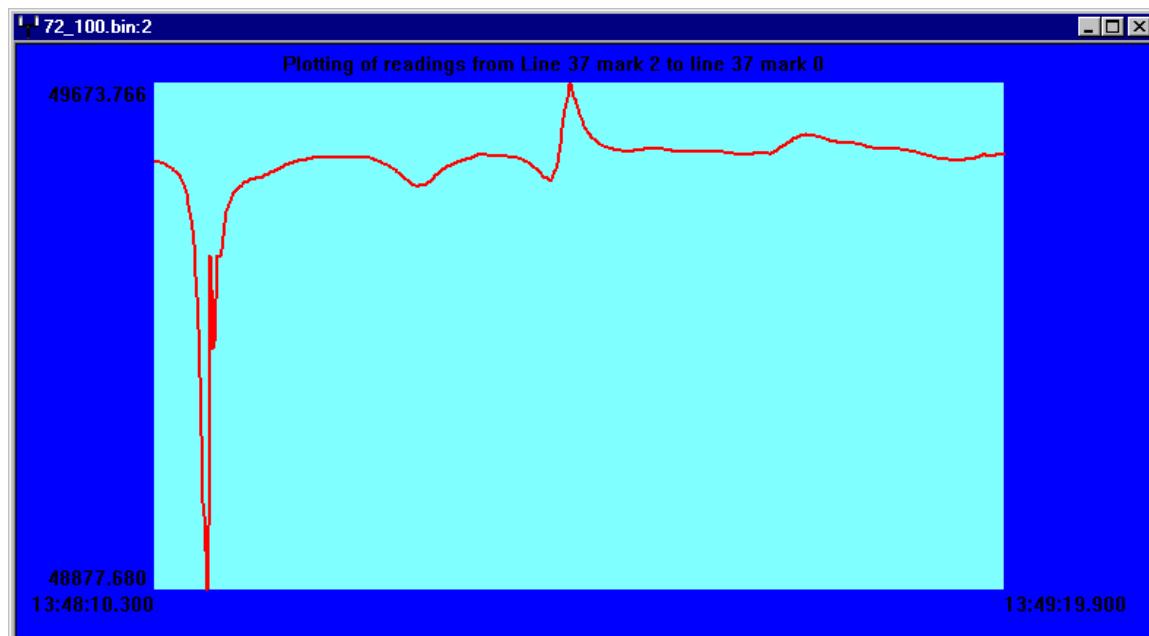
Magnetometer Readings for X=74

We can see that this early peak also appears above on the stack profile.

Currently Magmap supports handheld land-based surveys such as surveys done with the G-856 and G-858 magnetometers.

Note: Stacked Profile is not available for GPS date.

5.3.2. How to plot a stack profile

To plot a stack profile, you need to start from the mapped screen.
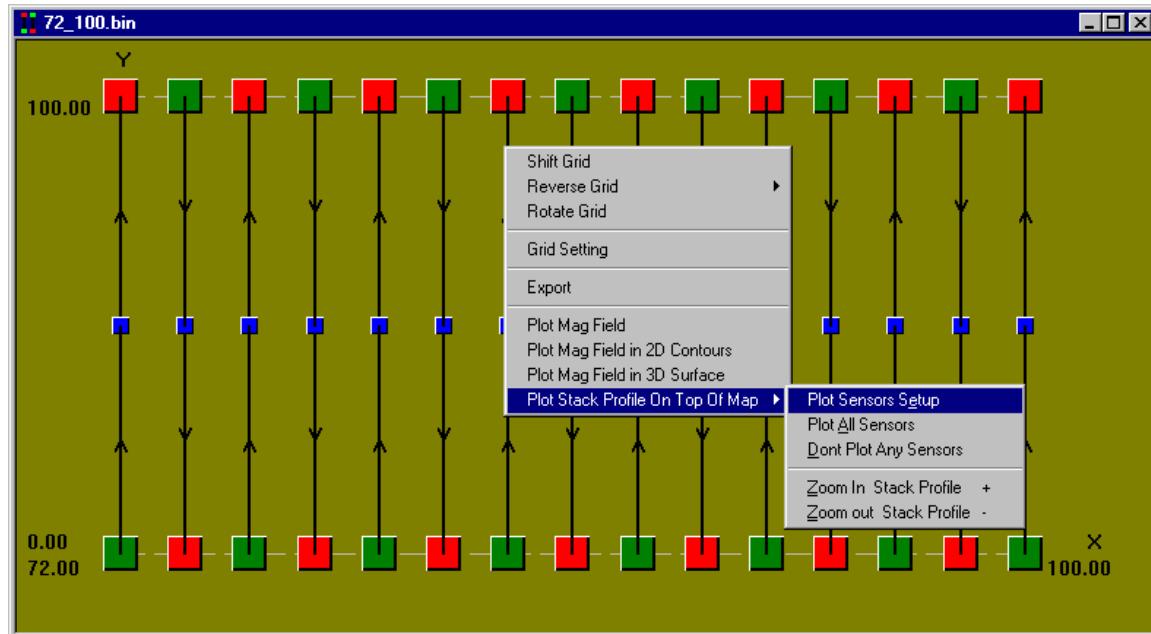
From your mapped screen, right click on your mouse and select: "Plot Stack profile".

From here, you have several options:

- Plot sensors setup – allows you to choose which sensor(s) you would like to plot, including the pseudo gradient, if available.
- Plot All Sensors – will automatically plot all sensors
- Don't plot any Sensors – will remove all stack plots from the screen (good for getting rid of your plotted profile).
- Zoom in Stack Profile – allows you to increase the scale of the magnetometer readings (the positions will remain the same but the variations in the readings will be easier to see). You can also press the "+" key to do this.
- Zoom out Stack Profile – allows you to decrease the scale of the magnetometer readings. You can also press the "–" key to zoom out.

In the case of the above survey, there is one sensor, so we choose "*Plot Sensors Setup*". We need to select the single sensor.
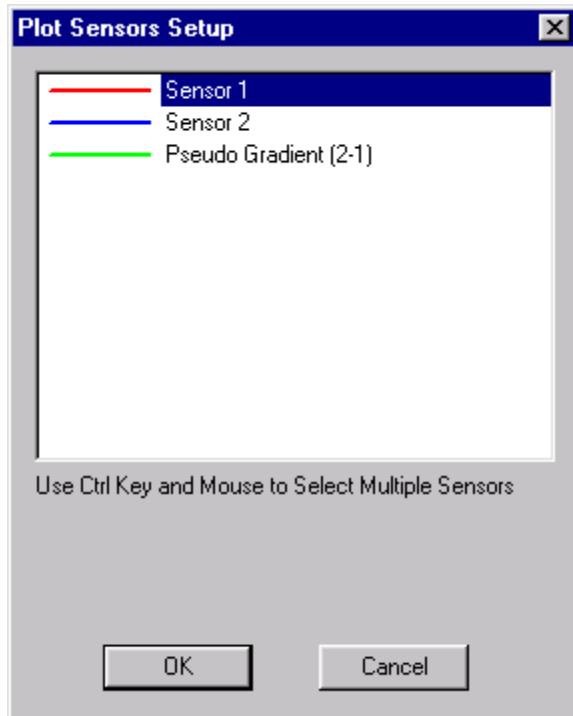
"Plot Sensors Setup" menu with single sensor selected

If we instead choose the option "*Plot All sensors*", Magmap will attempt to graph all the sensor readings on a single scale (e.g. the first sensor has readings averaging around 50000 gamma, whereas the second (non-existent) sensor has readings that are 0.) As a result, it will be difficult to see any small features on the stack profile since there is now a scale that has to span 50000 gammas compared to 5000 gammas when only one sensor is graphed.

Note: Due to the above, it is useful to de-spike the data and remove drop-outs from the data before you try to create a stacked profile. Otherwise it will be difficult to make out small features in your profile.

Your final result should look similar to the stack profile below:
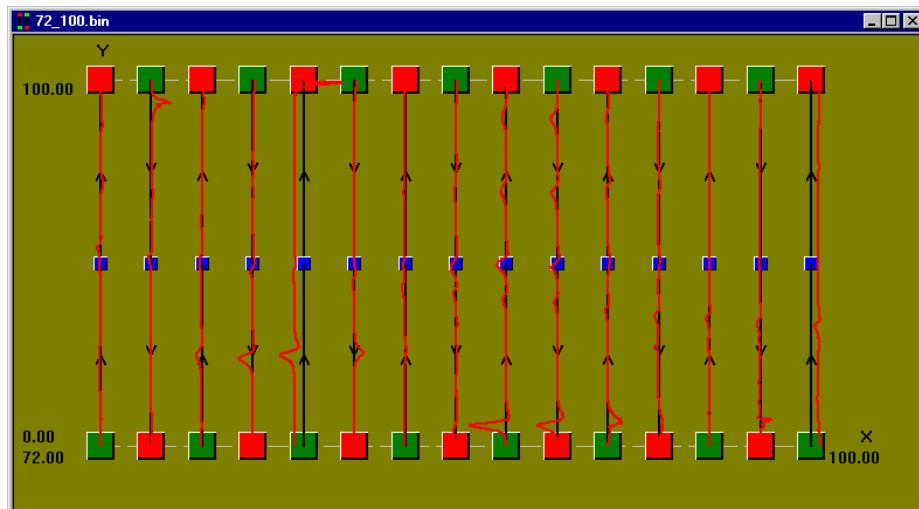
5.3.3. Scaling a stacked profile

The scaling for a stacked profile works the same as for all windows. This will be discussed in more detail in the following section.

5.3.4. How to turn "Auto-scaling" off

By default, Magmap chooses scaling that will allow all the data to fit in one window. In order to disable this (and hence, use the scaling buttons at the top of your Magmap screen), you need to go to your "Scale" menu and deselect "*Always fit in window*".

You will then have the option of zooming in and out.

5.4. Basic scaling operations

You can scale the map a few different ways:

1) Use the menu

2) Use the mouse and toolbar

The menu options that will immediately change the scale are

- Zoom in X and Y

- Zoom Out X and Y

- Zoom in X

- Zoom in Y

- Zoom out X

- Zoom out Y

- Window zoom. zoom in graph in the user selected window. To select zoom area, point mouse into one of the corners, click and drag mouse to the opposite corner. Zoom rectangle is shown with "rubber band" After releasing of mouse button selected rectangle is zoomed to extend s of the window. Areas outside of selected rectangle are not shown. To bring picture back to full extend press "Fit in window" button.

These are fairly self explanatory.

Once you select one of these menu options, your cursor will change to reflect the type of zooming operation you are doing. You can then zoom in on a specific point by pressing the left mouse button. This zooming feature will remain turned on until you select the menu option again, or deselect it from the toolbar.

You can go back to a view of the full map by selecting "*Fit In Window*".

You can also get rid of all scaling permanently by selecting "*Always fit in Window*".

You can also zoom by using the toolbar buttons (pictured below)

From left to right, they are:

- Zoom in X and Y

- Zoom out X and Y

- Zoom in X

- Zoom out X

- Zoom in Y

- Zoom out Y

- **Window Zoom**: zoom in graph in the user selected window. To select zoom area, point mouse into one of the corners, click and drag mouse to the opposite corner. Zoom rectangle is shown with "rubber band" After releasing of mouse button selected rectangle is zoomed to extend s of the window. Areas outside of selected rectangle are not shown. To bring picture back to full extend press "Fit in window" button.

- Fit full map in window (but keep scaling options enabled)

- Always fit full map in window

- Use true map coordinates.

5.5. True map coordinates

Usually, when you select "*Fit full map in window"*, Magmap will show you your entire map and use the full window to show it. This means that if you have a rectangular grid, Magmap will stretch or shrink a certain coordinate axis so that it is all visible. (E.g. in the case of a grid that is 100 x 1000, Magmap will graph the X axis from 0 to 100, and will graph the Y axis from 0 to 1000.) In order to make it all visible, Magmap might display one inch per 10 meters in the X direction and one inch per 100 meters in the Y direction.

If you want the scaling of X and Y to be the same, you can select the option: "*Use true map coordinates*". In this case, our original grid that was 30 x 100 would appear like the grid below:
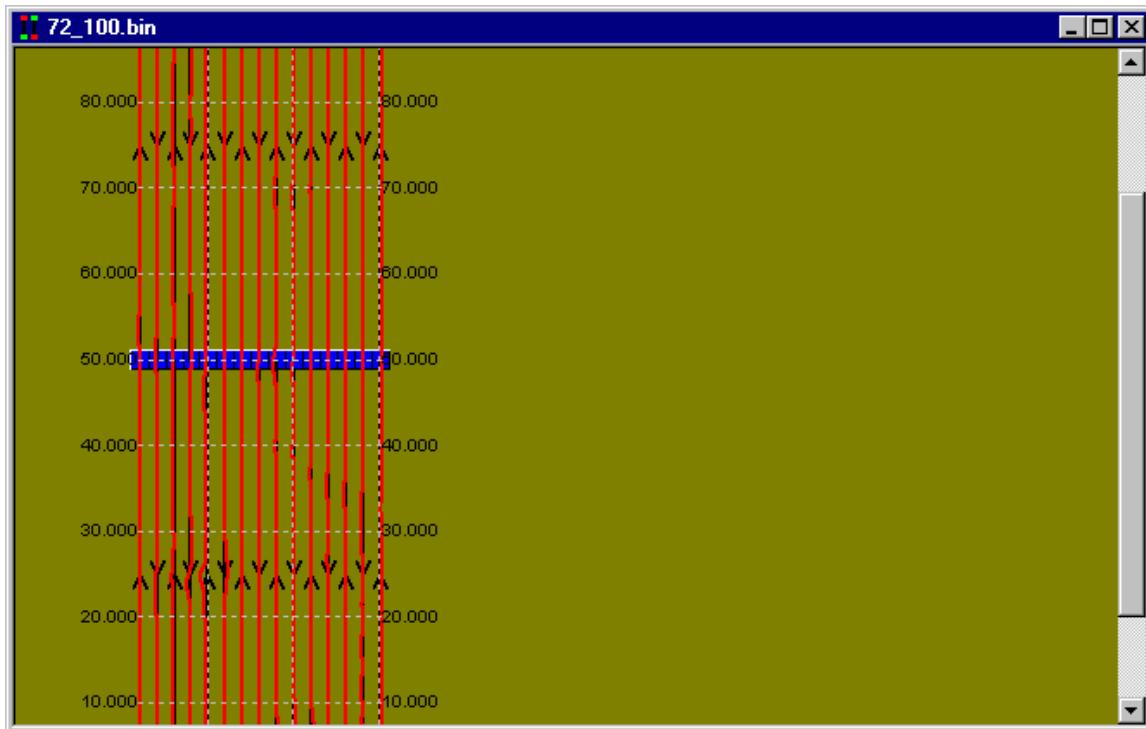
You can use the scroll bar to get to the bottom.

5.6. Using grid lines

When you are zooming closely in at regions of the graph, grid lines will be very useful in determining positions and magnitudes. These grid lines are available for both coordinate plots, and time series plots.

You can enable grid lines by choosing "*Grid Lines*" from the "*Scale*" menu. By default, these are not enabled.   It should bring up the following dialog box:
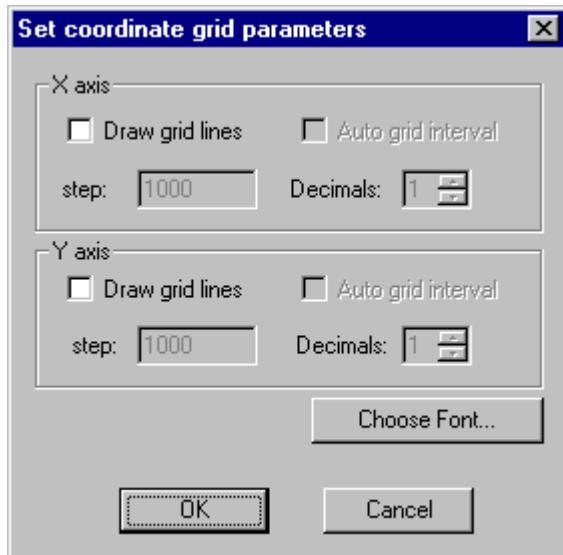
Dialog box for "Grid Lines" menu option (coordinate plot)
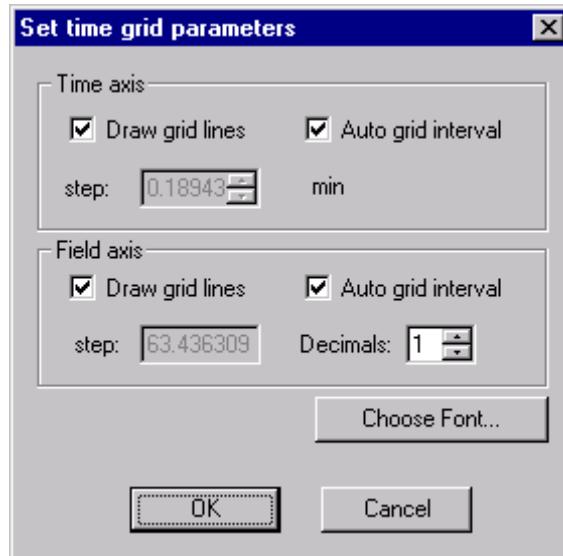
Dialog box for "Grid lines" menu option (time series plot)

Both dialog boxes behave in a similar fashion so we will discuss the first dialog box -- this dialog box allows you to set grid lines for X and Y and choose the scaling method. The two methods available are:

- Auto grid interval (automatic scaling) -- This assumes you want a fixed number of grid lines and will pick the scaling between each grid line so that you always see the same number of lines on your grid, no matter how much you zoom.

- Manual interval – you pick a step that you want.   The grid lines will remain the same through all zoom factors. (e.g. the distance between them will scale so that they always represent a constant value.)

There are also options to:
- Choose Font – You can select the font and color that the grid line numbers will be written in.

- Decimals – specifies the amount of precision displayed in the gridline numbers (number of numbers after the decimal point).

Note: The time series plot mesh step is set in minutes. The time axis can also have an irregular mesh because different survey lines were taken at different times (you may not have a continuous set of readings over the entire time).

Due to this, you may see irregularities in time labels.

Here are examples that illustrate the two different types of scaling:

In each example, we show the initial graph, and then zoom in on the lower left hand corner (corresponding to the coordinate 0,0). Both examples show the initial shot and two additional shots corresponding to two successive zooms.

The first example deals with automatic scaling. When you look at all three shots, notice that the number of scale lines never changes.
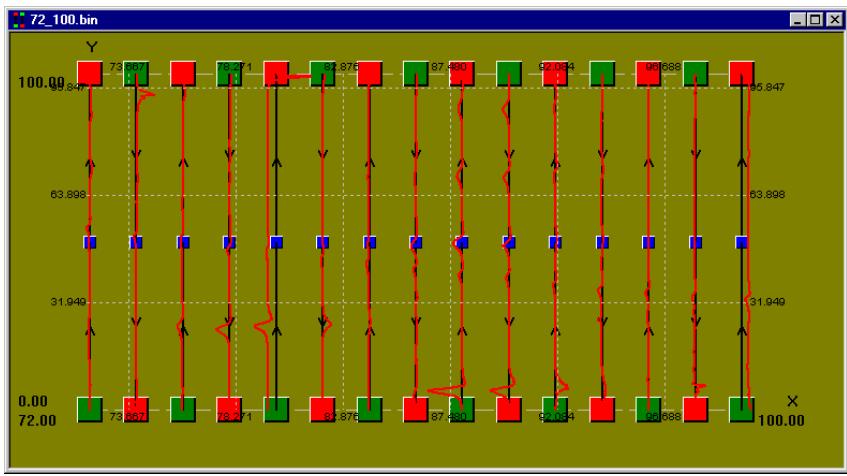
Initial map with "Auto scale grid lines" selected.

Same map, zooming in on (0,0) once.
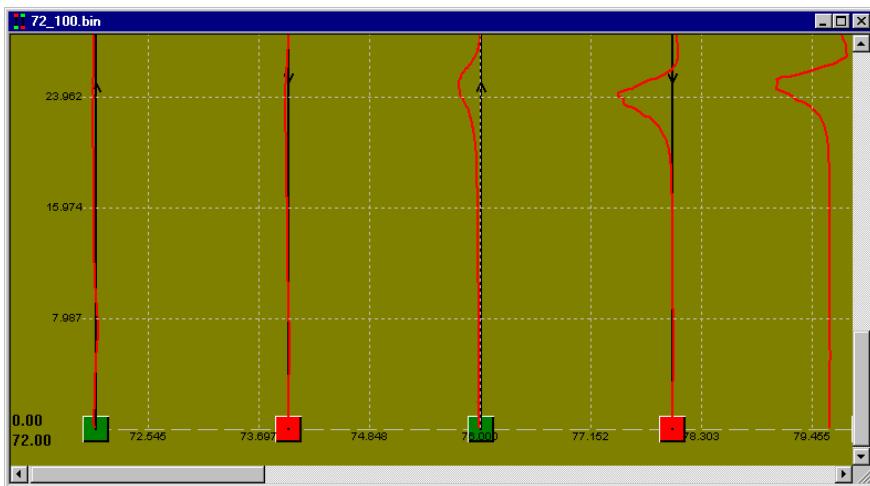
Same map zooming in on (0,0) twice

From here, we can observe that the number of white grid lines always remains the same, no matter how many times we zoom. The spacing between the grid lines does change.

This is different when we manually scale. The parameters are shown below:
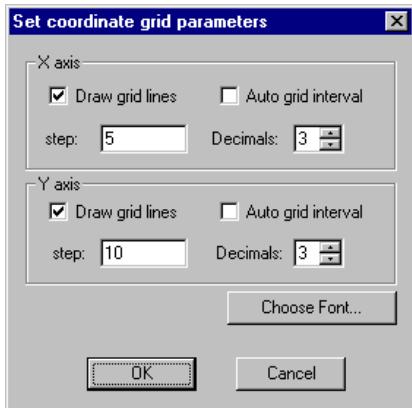
The initial graph we obtain follows:
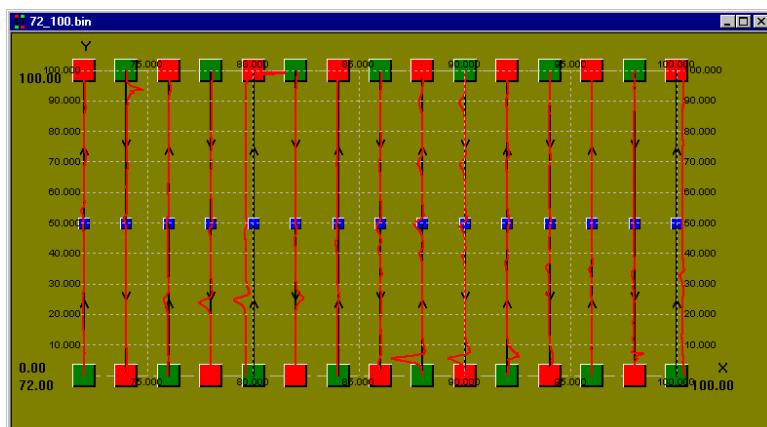
Initial graph using manual grid lines
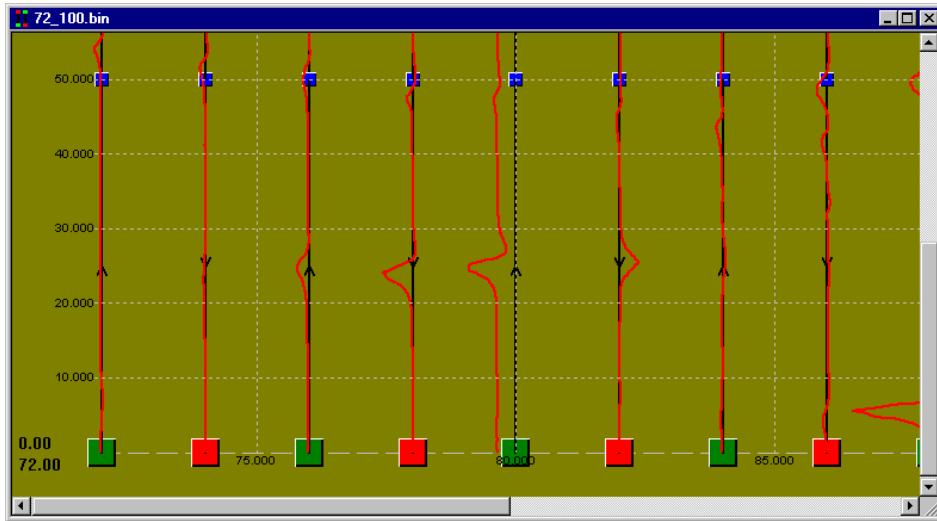
Graph obtained from zooming in on (0,0). (green starting square)

If we zoom in again, we see the lines again change:

Graph obtained from zooming in on (0,0) twice.

Note: As one can see, the total number of lines always remains the same when there is a manual scale (grid is fixed) and the number of lines shown on a given view remains the same when there is an automatic scale.

It is recommended that you use grid lines before printing. Note that the appearance on the paper greatly differs from what you see on the screen.

5.7. Marking anomalies for further study

In the course of a typical Magmap analysis, you usually will use at least two windows – one showing the positions involved in your survey, and the second showing a profile of the readings over time. It is often useful to be able to correlate an interesting feature seen on the reading profile with the positions given in another window. This can be done by the use of flags.

The flags placed on the profile will simultaneously appear on the position map and on the contour map, allowing the user to place the cursor on the flag on the map, for instance, and easily identify the anomaly's position. This feature works in either X,Y or Lat/Long spatial mapping configurations.

5.7.1. Setting a flag

To set a flag, you need to have an X,Y map (default screen for G-858 surveys), or a map with GPS positions. From here, you may click in an empty area (but inside the survey grid area) and select "*Plot Mag Field*".
This will bring up a profile plot of the readings.

Once you have the profile plot, you may right click on part of the map that shows the reading that you would like to locate on the position map.
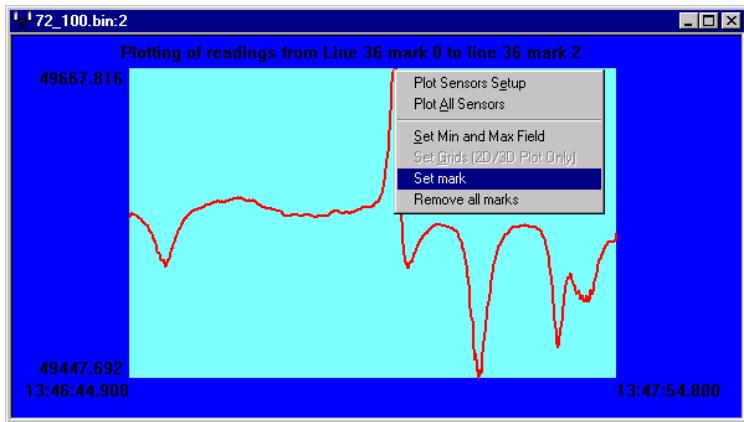
Figure 1 – Drop down menu shown on profile plot

The above screen shows the selection of the flag using the menu obtained by right clicking on the spot where you would like to place the flag. Once you have placed a flag, you should see the following.
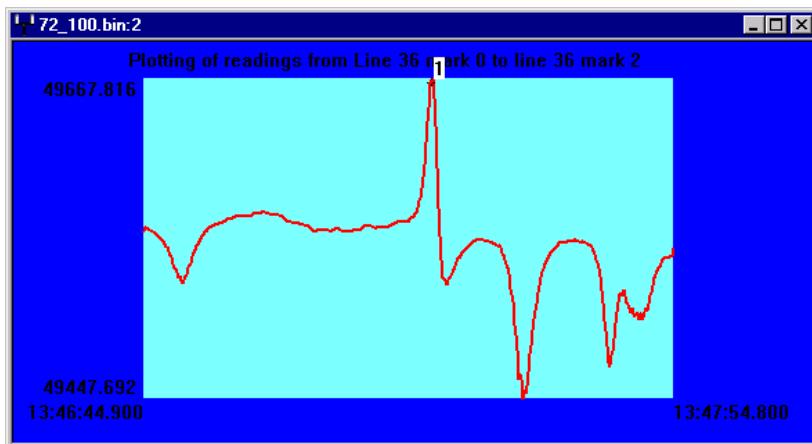
Figure 2 – magnetic profile after flags have been added
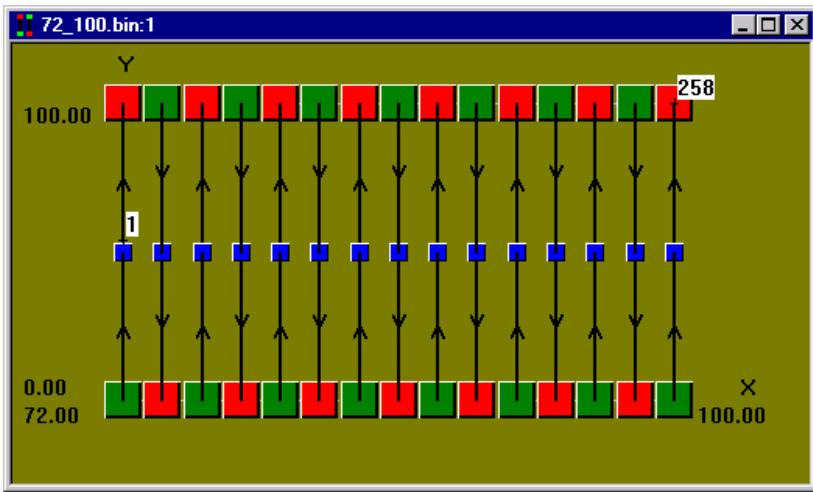
Figure 3 – position map with corresponding flag

Note that the '1' shown on the magnetic profile corresponds to the '1' shown on the position plot.

If you want to make a flag on the GPS plot, you need to bring up a magnetic profile corresponding to the GPS map. In the above example, we do this by selecting the *GPS* menu and then selecting "*Draw new map using GPS data and the features of a Maglog NT survey*". You should then see a GPS map and the corresponding magnetometer data.
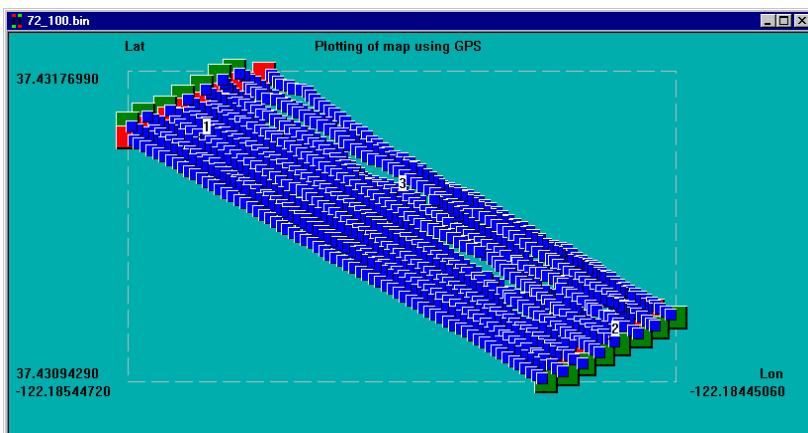
Figure 4 – GPS map with multiple flags

Note: The magnetometer data associated with the GPS positions is treated differently than the magnetometer data associated with the G-858 flags and positions. Thus, you need to choose the appropriate magnetic profile that corresponds to the map you want to flag (if you want to use the G-858 map, then click on that map to get the appropriate data, and if you want to use the GPS map, use the data associated with that map). This also applies to any

data editing operations – if you edit magnetometer data associated with the standard G-858 position map, you will need to repeat the editing operations if you wish to use the GPS map with the data. Since most users only use one type of map, this shouldn't cause any problems.

You can have as many flags as you wish. The flags should also be visible on any contour plots you generate. It is necessary to close a contour plot and reopen it to see the added flags.

Future additions to this program may include a table output of the anomaly positions

5.7.2. Removing a flag

You can remove flags from your map by right clicking on a portion of the magnetic profile and selecting the menu option, "*Remove all flags*".

5.7.3. Locating a position

You can locate a position by moving your cursor onto the part of a contour map or GPS grid whose position you would like to know. The position will be shown on the lower right hand corner of the static bar at the bottom of the screen.

6.   Base station and survey readings

The Earth's magnetic field varies over time periods on the order of seconds to hours, similar to survey periods. The variations are caused by internal changes in the Earth's magnetic field and the distorting effects of the solar wind. The distortions result in micropulsations and magnetic storms that occur at any time, and during the daylight hours, there are diurnal or daily magnetic field changes.

Diurnal and micropulsation variations may be corrected by collecting repeated magnetic field measurements at a fixed sensor location and orientation over the time span of a survey. The base station is placed close enough to the survey area so that the variation in field with respect to distance is assumed negligible. Less then a few miles is good. During analysis, we can then remove these short term-variations in field by subtracting time correlated base station readings from the magnetometer readings.   Due to the potential for high-gradients and significant variation in the magnetic field during magnetic storms, surveys are usually not conducted at these times. (Year is an eleven year solar sunspot maximum.)

This section describes the MagMap procedure for making diurnal and micropulsation corrections to data collected with the Geometrics G-858 or G-856AX magnetometers, with either of the same magnetometers set-up as the base station (all combinations are acceptable).

The plotting of readings for a segment, line, or grid is similar to the plotting of base station readings. Therefore, only the base station case will be described in the following paragraphs.

6.1.   MagMap's use of base station data

In order to do diurnal corrections, MagMap needs a series of base station readings with clearly marked time stamps that correspond with the roving magnetometer data.

From these readings, MagMap will determine which readings it can use. In the best case, the base station takes readings at the same rate as the magnetometer. This means that there will be a base station reading that corresponds to every roving magnetometer reading. In this case, the diurnally corrected reading can be calculated by the following formula:

DiurnalReading(t) = RovingMag(t) – BaseStation(t)

Where each reading is taken at a given time t.

In other cases where fewer base station readings are taken, Magmap will linearly time interpolate between known readings for the intermediate readings. The diurnally corrected reading will then be calculated in much the same way as above.

Note: In cases where the two magnetometers are not set to the same time, you can add a given time to the base station clock to make it correspond to the roving magnetometer clock.

If you do not have a proper base station file open, Magmap will inform you of this at export time. You will see the message: "*No valid base station files are open…*" This message will not appear if you have a valid base station file open – e.g. a base station file where the roving magnetometer and base station times overlap.

The quality of the correction may be degraded by a mismatch in times between the base station and survey data, a time mismatch combined with highly variable base station data, and noisy or spiky base station data. Although it is optimal to synchronize the instrument clocks and place the base station in a magnetically quiet location for the survey, this is not always logistically feasible. MagMap provides methods to deal with of these potential problems – see the following section.

6.2. Setting diurnal parameters (base station only)

You can access the screen that will allow you to set diurnal parameters by selecting the menu option "*Diurnal setup*" and then the menu item "*Diurnal Parameters*".

The resulting screen allows you to adjust the base station's clock to correspond with the magnetometer clock. Additionally you can choose to add a constant value to each outputted reading.
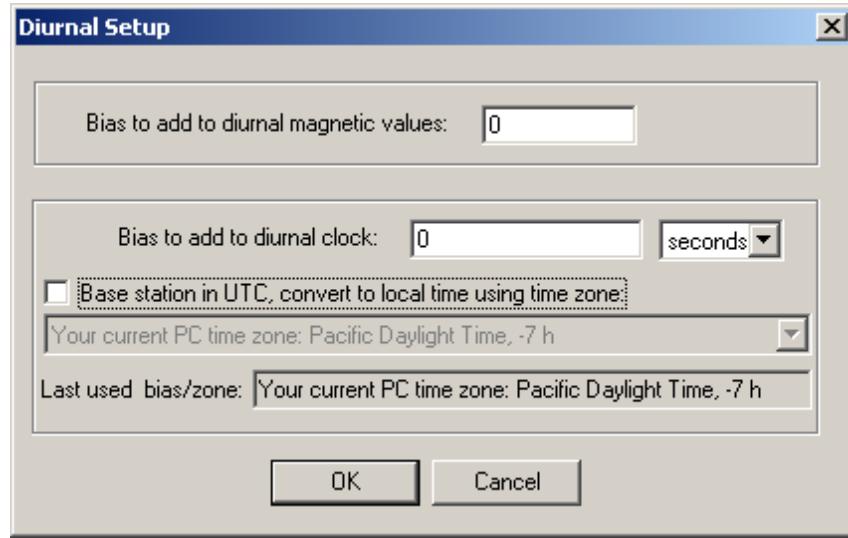
Figure 64

6.2.1. Adding a bias to diurnal magnetic values

You can add or subtract to all the base station magnetic readings a constant magnetic field.

In the "bias to add to diurnal magnetic values" just type any positive or negative value you want to add to every base station magnetic field.

The "Diurnal" column in the XYZ file consists of the difference between the sensor reading and the base station reading, plus the offset entered in this dialog box. This is in case you wish the diurnal values to be in the 50,000 nT range, rather than relatively small positive and negative values.

6.2.2. Adding a bias to diurnal clock values

A time mismatch between the base station and survey data will cause misalignment of the data values and cause subtraction of the wrong base station value during the correction. One can imagine that, if the base station data curve has large variations, a mismatch would yield even larger magnitude inaccuracies than if a smoothly varying curve was used. In turn, if the base station data curve is essentially flat (constant) during the survey period, there would be little concern about the effects of a time mismatch.

One may use the bias shift option to apply the shift needed to match the start times of the base station and survey data. The period of the base station data file should be equal to or greater than that of the survey data.

In the "bias to add to diurnal clock" just type any positive or negative value in seconds that you want to <u>add</u> to the time of all acquired magnetic field readings of the base station. This will allow for you to correct for errors due to the clock of the base station being different from the clock of the magnetometer.

Starting with version 4.96 MagMap offers more robust specification of base station time bias. User can specify units as seconds, minutes, hours, days. In addition it is possible to use a set of pre-defined time zones, acceptable from the drop list. This is typically used with base station data available from intermagnet network, http://intermagnet.org. These stations are always recorded in UTC time and conversion is needed to adjust to the magnetometer time, typically local time. To use this option please check "Base station in UTC, convert to local time using time zone" and select appropriate zone from the list. The first selection is always local PC clock time zone. For instance, if magnetometer survey data was recorded in local time, PC processing compute also set up in local time, but base station data is in UTC time, simply check "Base station in UTC" box and use the first selection "Your current PC time zone" from the box. It also takes care about daylight savings time, if applicable. Other course of action would be to pick one of the pre-defined time zones in the list.

It's important to understand that **MagMap does not store base station clock bias.** Whenever new data is loaded zero bias is applied by default, but last used time offset is shown in the dialog as a reminder. Clock bias also always applied to the original data. The typical example for instance if user entered -7 hours offset; but then he or she decided that this was wrong and the correct offset needs to be -8 hours. This new value (-8) should be entered into the dialog, but *not* -1. In other words old offset (if any) is not taken into account when new value is entered.

6.2.3. Performing Diurnal Correction

Diurnal correction is done automatically upon export of the edited file to Surfer or Geosoft format. Both the Base station and Survey files must be currently open, and be synchronized in day and time.   You must also select the "diurnal" column in the export settings when exporting the Surfer or Geosoft file. Note that an exported file in *.dat or *.xyz file format can be reloaded into Magmap for viewing or further editing.

6.2.4. Despiking base station data

We despike base station data in the same way that we despike magnetometer data. Please see the following chapter for a description on how to do this.

6.2.5. Smoothing base station data with a spline filter

It is possible in some cases for the base station data to have more noise than the field magnetometer. A typical example would be the use of the proton G-856 magnetometer as a base station and the cesium G-858 magnetometer as the field sensor. The G-856 has a typical noise envelope of about 0.25 nT and G-858 has a typical peak-to-peak noise of 0.1 nT.   Thus applying base station correction in this case can reduce the final precision of the corrected field data.

Smoothing of the base station data with third degree spline filter before applying the diurnal correction routine can alleviate this problem. Replacing the original base station readings with their continuous equivalent effectively moves the noise into a very low frequency domain. In this manner local magnetic anomalies are not distorted with noisy base station readings. It is recommended that the user despike the data prior to using the spline-smoothing filter.

This option is available under Filter / Smooth base station readings menu:
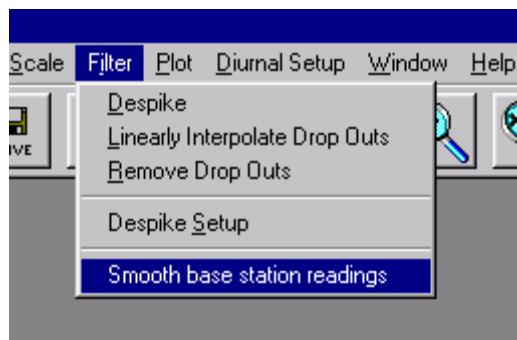
After this option is selected, the following dialog appears on the screen:
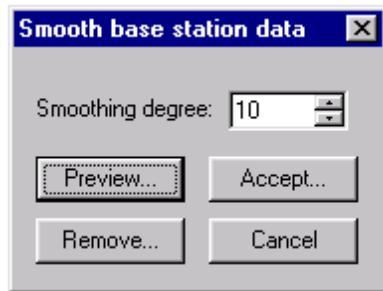
A larger "smoothing degree" value provides more smoothing. The user should try different values by pressing the Preview button and examining the results as it is shown on example below:
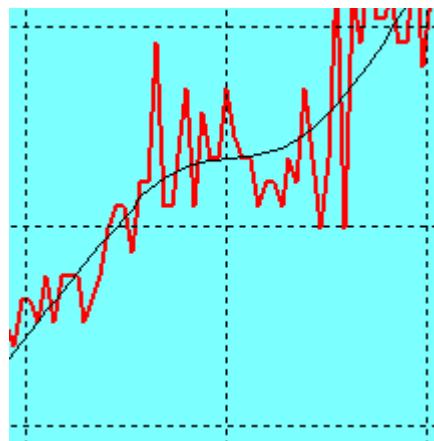
The black line represents a preview of the smoothed values. Note that the minimum amount of smoothing that gives a reasonable result should be used. Employing too high a smoothing factor will tend to remove small micropulsations and other rapid field variations that may be real. Some experimentation will be required to get a good result, but in general a spline degree setting of 5 to 10 will be sufficient.

After a satisfactory result has been reached, the "Smooth base station data" dialog box should be recalled and the Accept button clicked. The original base station readings are then replaced with the smoothed values:
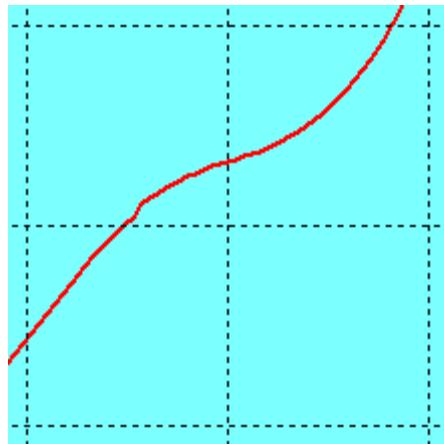
Now the user can proceed with the field reading export as usual. Smoothed base station data is used instead of original base station readings to perform diurnal correction.

"Remove" button erases results of smoothing from the plot without accepting them.

6.3. Base station user interface description and symbols' definition
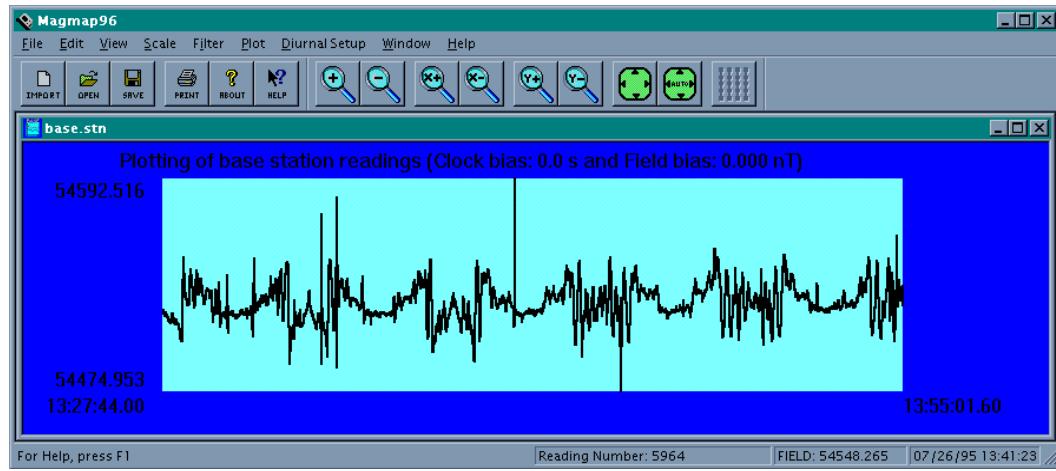
Figure 65

In the previous graph (Figure 65), the Y axis represents the amplitude of the magnetic field in nT and the X axis the reading number.

The time of the first and last reading is shown on the X axes.

When you move the mouse cursor in this window additional information will be shown on the status bar.

The first item shows the magnetic field amplitude, the second item is the reading number in the survey, and the last one is the time of the reading.

The base station scale tool bar is similar to the map scale tool bar described in paragraph 4.1, page 39 except for the last button, "True map coordinates," which is not available and grayed out.

6.4. Setting plotting parameters

When you click the right mouse button in the plotting window you will see a pop up menu as shown in Figure 66.
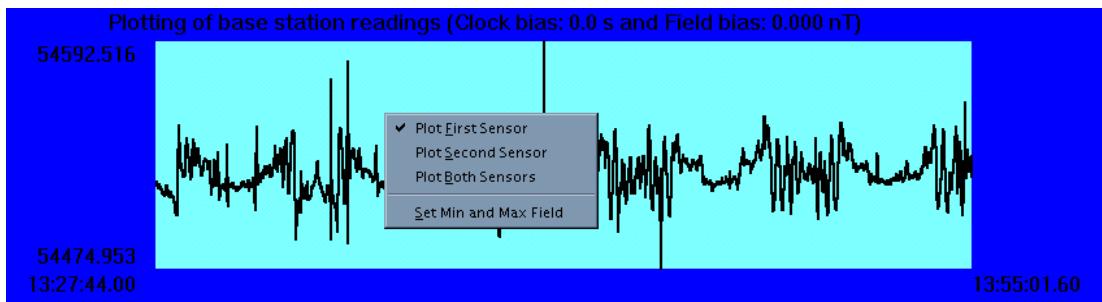
Figure 66

By default, only the readings for the first sensor are plotted. You can plot if you wish the readings of the second sensors or simultaneously the readings of both sensors.

You can also change the scaling parameters by selecting "Set Min and Max" as shown below in Figure 67.
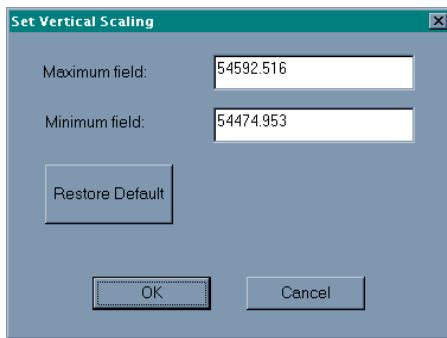
Figure 67

You can set the maximum and minimum magnetic field value to be plotted in the first two items of the dialog box.

You can restore the default value by clicking the left mouse button on "Restore Default".

6.5. Base station file formats

The base station file may have any name with the `.BIN` extension for a binary file and a `.STN` extension for an ASCII file. The `.BIN` file is a raw data dump and not stored in a user-readable format; do not modify files of this type. Depending on the magnetometer used for the base station, the .STN data formats would appear as follows.

G-856A/AX: 1 281 122347   6 535040

The values are line number, Julian day, time, station number, and magnetic field reading to one-tenth (decimal not shown).

G-858:   0 53504.000   0.000 13:59:00.000 07/06/99 0

The values are an internal tag number indicating type of data, first magnetic field reading, second magnetic field reading (zero unless using a second sensor), time, date, and a second internal tag number.

The base station data file time period must be equal to or greater than that of the survey data file. At a minimum, the file must contain two data points at times equal to or greater than the start and stop times of the survey data file.

It is possible to use SURFER ™ file for base station readings. File should consist of at least three columns: readings, date and time.

6.6.   Remote Base Station (RBS) data handling

6.6.1. Downloading data from RBS USB stick

MagMap software provides RBS data download interface consistent with G-856 / G-858 / G-859 data download. The difference is that in case of RBS data is simply copied from the RBS USB stick onto host computer, and new file name is assigned based on UTC data of RBS data set.

To download RBS data make sure that RBS data stick is plugged in the available USB port and recognized by the PC, and press "Import" button from MagMap tool bar.

Program display import dialog with RBS data selection at the bottom:
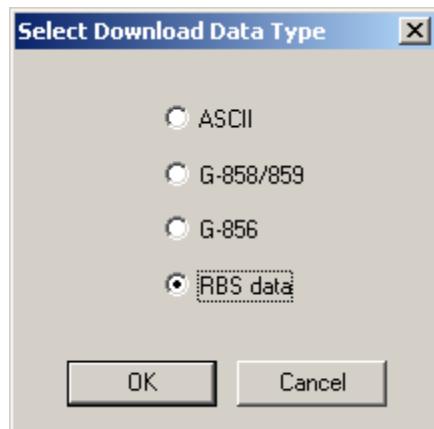
Select "RBS data" from dialog above.

Alternatively user can select "File / Import RBS data" from the main menu.

After selection is made, MagMag searches removable media for RBS field log file. If file is not found the error message is displayed:
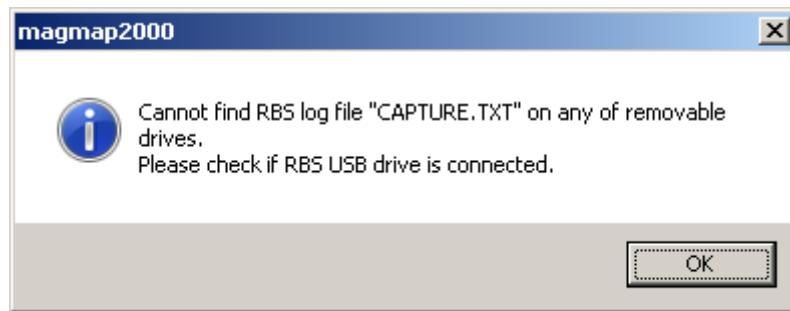
If MagMap detects RBS log file, it suggests new name based of log UTC time and opens "Save file" dialog:
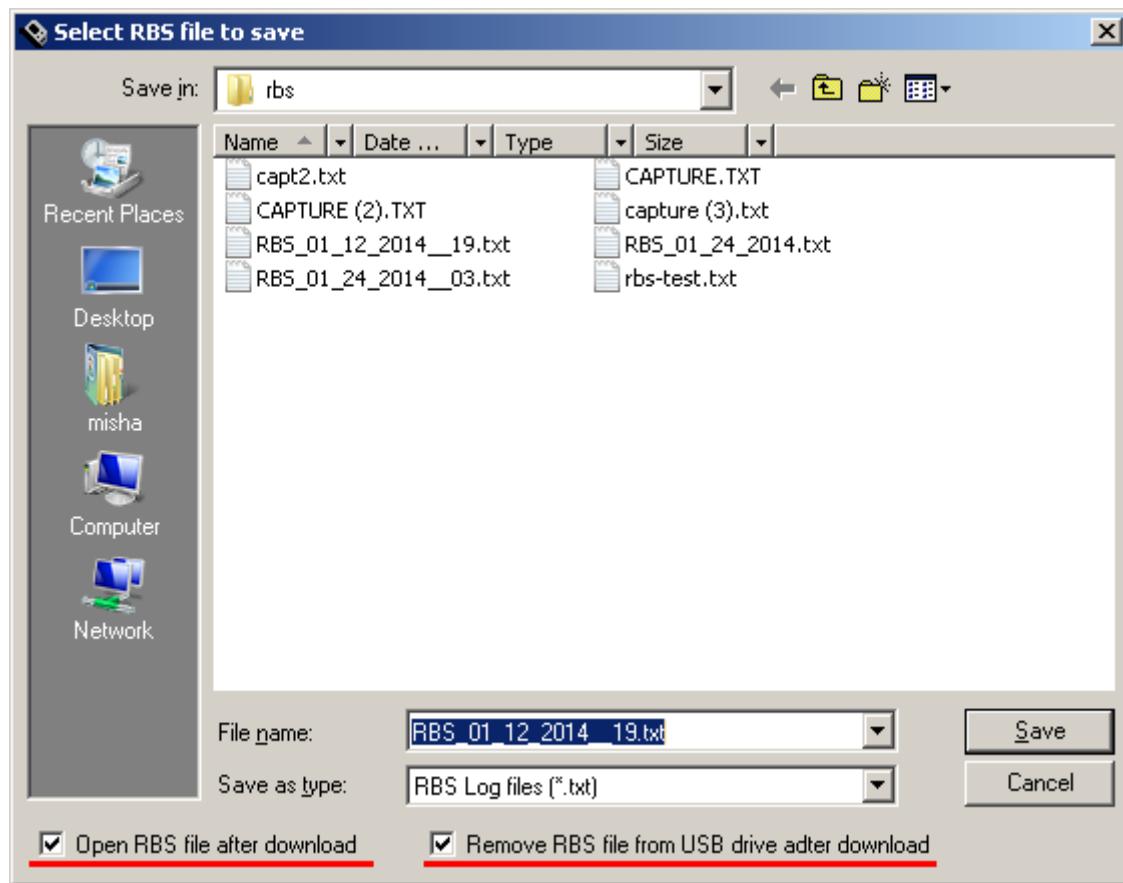
Note two check boxes at the bottom of the dialog:

1. **Open RBS file after download.** If this box is checked MagMap will try to open RBS field data file after it is saved to the host computer. If box is not checked file will be simply copied to the host PC.

2. **Remove RBS file from USB drive after download.** If this box is checked MagMag removes RBS field file from the USB drive after it is copied into PC, to free space for new data. Additional confirmation dialog is displayed before file is actually removed.

After user presses "Save" button MagMap copies field from USB stick to host PC under selected name, opens it if requested and removes from USB storage. Section 1.2 explains in details how the RBS file is loaded.

To read already saved RBS files use "File / Open" dialog as explained below.

6.7. Read RBS data into MagMap.

Geometrics Remote Base Station data is presented with file with extension .txt. The file holds mixture of raw GPS messages, such as RMC and magnetometer readings, accurately time stamped with the UTC time using GPS serial and PPS (pulse per second) output. Thus data is already has UTC time stamp. The typical example of RBS data is presented below:

```
$ 42204.989,1277,03:07:16.955,01/16/14,00
$GPRMC,030716,A,3724.0098,N,12153.3513,W,000.0,000.0,160114,013.7,E*62
$ 42205.009,1277,03:07:17.055,01/16/14,00
$ 42204.947,1274,03:07:17.155,01/16/14,00
$ 42205.028,1277,03:07:17.255,01/16/14,00
$ 42204.894,1274,03:07:17.355,01/16/14,00
$ 42204.894,1274,03:07:17.455,01/16/14,00
$ 42205.161,1274,03:07:17.555,01/16/14,00
$ 42204.932,1277,03:07:17.655,01/16/14,00
$ 42204.627,1274,03:07:17.755,01/16/14,00
$ 42204.970,1277,03:07:17.855,01/16/14,00
$ 42204.928,1277,03:07:17.955,01/16/14,00
$GPRMC,030717,A,3724.0098,N,12153.3514,W,000.0,000.0,160114,013.7,E*64
$ 42204.970,1277,03:07:18.055,01/16/14,00
```

   The magnetometer readings start with "$" and consist of total magnetic field, signal strength, UTC time and date, and hexadecimal status flag. All fields are comma separated. The status flag is zero if no errors were detected.

RBS file can be treated as Base Station data; in this case GPS raw messages are not used, and MagMap opens one standard base station data. Data can be also treated as rover; in this case MagMap parses raw GPS messages to extract positions. In latter case it opens two windows: readings view and GPS view, similar to data loaded as SURFER or airborne magnetometer. Please do not close any of these windows while working on the data. MagMap does not allow opening of multiple RBS or GPS data in rover mode, but data from another RBS file from stationary magnetometer could be open as base station.

Note that RBS data is complementary in case of Base Station mode. Other rover data such as airborne, marine or land should be loaded before or after RBS base data is loaded.

RBS rover mode is self-sufficient, assuming RBS was moved to perform magnetometer survey. In this case data can be exported into SURFER or Geosoft formats for further processing.

To open RBS file select File / Open from MagMap main menu and select filter settings as Remote Base Station (RBS) data as it is shown on the picture below, and select file to open.
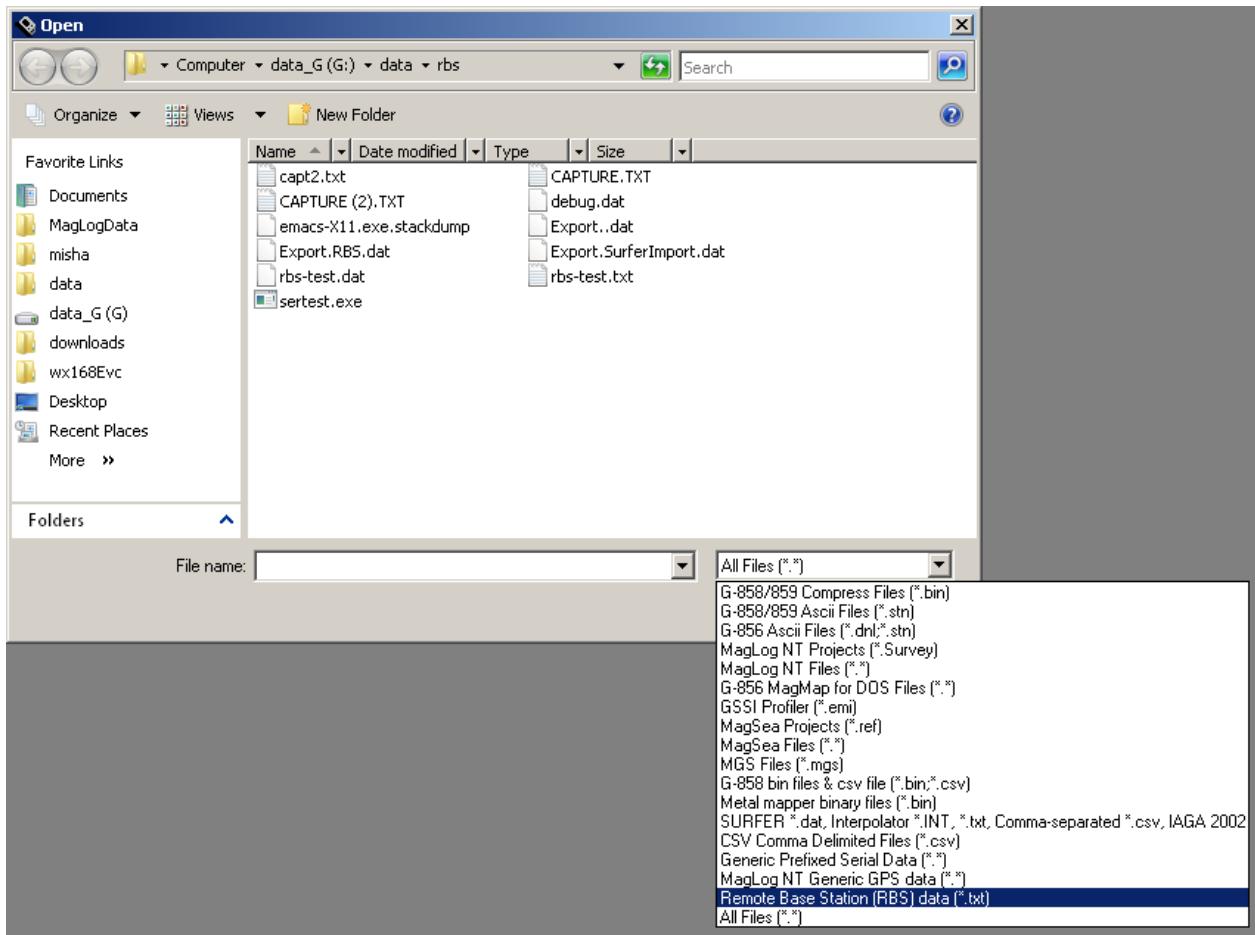
Program starts reading RBS file as shown below:
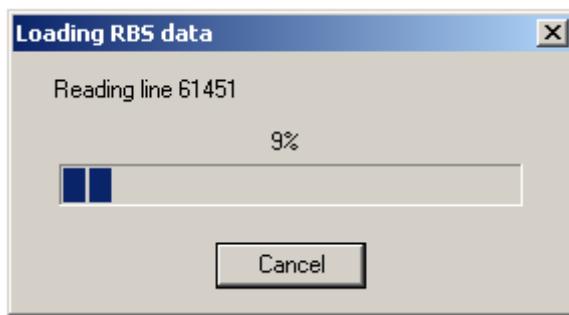
After reading is completed, RBS status dialog is displayed:
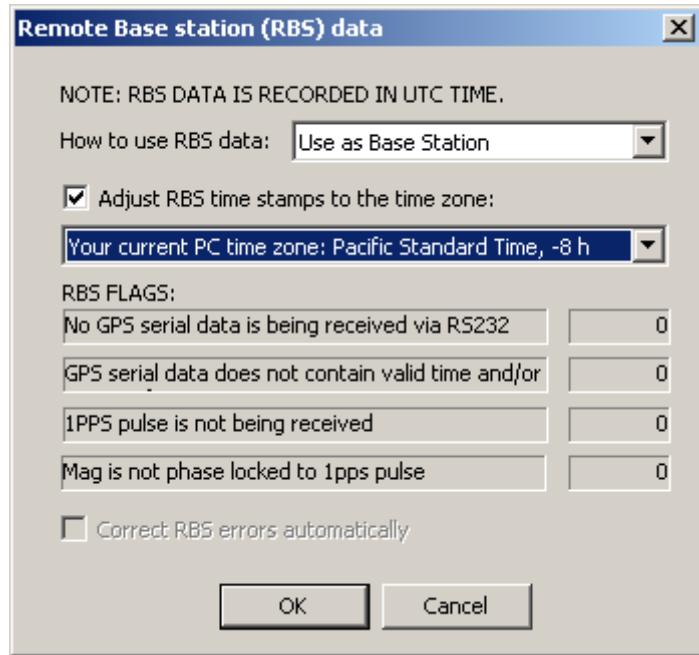
The following controls are available:

1. **How to use RBS data**. Possible selections are "Use as Base Station" or "Use as Rover (GPS+data)" In first case program opens base station window, in second case two windows (similar to airborne or SURFER data) with magnetometer readings and positions.

2. **Adjust RBS time stamps to the time zone**: RBS data always recorded in UTC time. Therefore it could be desirable to adjust then to the local time zone. Checking this box enables time zone selection below. In case of rover mode both magnetometer and GPS positions times are adjusted to local time zone.

3. **RBS flags**. Reports number of readings with specific flags set. These indicate problems with RBS and/or GPS. For the normal operation all flags should be 0.

4. **Correct RBS errors automatically**. This check box is enabled only if some of the RBS flags is not zero. Program will try to restore missing time stamps in this case.

After "Ok" button is clicked program creates one or two windows, depending on the mode selection.

7.   Processing magnetic field readings

7.1.   Introduction

Despiking is a technique used for removing readings known to be incorrect. These spikes are usually identified because they differ significantly from the adjacent readings. They can be caused by operating the sensor near the dead zone, under high tension lines, and or over sites where there is a high accumulation of small magnetic surface clutter and the operator is carrying the sensor just a few inches above the ground surface.

However, often, anomalies can be mistaken for spikes, so we need to develop a scheme that allows us to distinguish anomalies from spikes.

One criterion that we can use to distinguish multi-point spikes from anomalies is the number of points they span. It is reasonable that we will not see a 10000 gamma anomaly for .1 seconds (e.g. about one point for a magnetometer taking readings at a rate of ten times per second). However, if we saw this jump last for a long time (hundreds of readings), we would probably believe that it is an anomaly rather than an incidental spike. A lot of this is also dependent on the speed of the operator.

We can also use the height of the anomaly to characterize an anomaly. A jump of one gamma might be considered to be noise, whereas a jump of 5000 gamma might be an anomaly or a spike.

7.2.   A typical despiking session

A typical despiking session usually involves two activities:

- removing drop-outs (zero readings)

- identifying and removing spikes (non zero anomalous readings over a short duration)

When we remove drop-outs, we try to remove the effects due to being near a dead-zone or near a very large ferrous mass. These are zero readings that can show up in the data for short to long periods of time – usually showing that the magnetometer was operating under conditions where good readings were not possible.

Since these readings are not valid in our data and can overwhelm our efforts to see smaller anomalies, we remove them. We can choose between linearly interpolating between bad readings and removing the readings from the file without linearly interpolating them. Because most gridding programs will grid over the missing data, we recommend removing them. For more information, please see the following discussion on removing drop-outs.

To identify spikes, we suggest zooming in on potential anomalies and then counting the number of readings to see if they are really anomalies. To zoom in on a section of the map, de-select the "AUTO" button and click on the "X+" tool-bar button to allow zooming in the X direction. Once you are at a scale that allows you to distinguish the anomaly, place the cursor on the left and right at the beginning and end of the anomaly and note the reading numbers on the information bar at the bottom of the plot display. You can get the number of readings involved in the anomaly by subtracting the two numbers. In general, we would think that any anomaly greater than one second (10 readings or less at 0.1 second per

reading) or perhaps less than one second depending on walking or traverse speeds, would be determined to be a real magnetic field shift and not some artifact of the survey process.

Once a true "spike" is identified, it becomes necessary to define the limits of the spike editing process such that actual data is not modified in any way. We do this by setting the spike edit parameters by clicking on *Filter* and then *Despike Setup*. Default values are 5000 nT and 1 reading – a spike by anyone's definition!

Depending upon the type of spike identified, some iterative trial and error process may be required to remove the data spikes. Using the number of readings identified in the first part of the investigation process above, and using the maximum amplitude of the spike are good values with which to start. If the application of the spike filter has no effect on the profile plot, then a larger number of readings and/or a lower maximum anomaly level may have to be applied. Just click *UNDO* to remove the last spike edit process and then apply the new parameters.

When spike editing, keep in mind that all data will be edited that meet the criteria, not just the anomaly you are investigating. Sometimes removing the largest, very sharp anomalies can enhance your ability to see smaller objects in the survey area. The process of removing spikes is discussed in more detail later this chapter.

7.3. Removing drop-outs

Drop outs occur when the magnetometer is in a dead zone or near a very large iron or steel object like a car. They show up as zero readings in the data stream. They can be removed by selecting "*Remove Drop-outs*" or "*Linearly Interpolate Drop-outs*" from the *Filter* menu. This should always be the first operation erformed on new data. The process can be reversed by selecting, for example EDIT, undo removal of drop-outs.

"*Remove Drop Outs*" will automatically delete those readings with exactly zero value and adjacent readings around those zero values (+/- one reading). This will cause no 1D plotting for those readings and no output for them when exporting.

The difference between "Linearly Interpolate Drop Outs" and "Remove Drop Outs" is "Linearly Interpolate Drop Outs" will interpolate those zero readings by good adjacent readings. In other words, those zero readings and adjacent +/- one reading are replaced by interpolated values. Therefore, those readings will still be plotted or exported by the new values after filtering. "Remove Drop Outs" is usually the preferred method because most gridding programs simply grid over the missing data.

Please note that "Linear Interpolate Drop Outs" cannot be run if "Remove Drop Outs" has been run first because there is no meaning to do so.

7.4. Removing spikes

Magmap allows the user to define the maximum number of readings allowed in a spike and the height of the spike.

We can despike the data by selecting the Filter menu:

Despike
Linearly Interpolate Drop Outs
Remove Drop Outs

Despike Setup

Clicking "*Despike Setup*" will display the following dialog box:

Despike Setup   ☒

    Peak Threshold   5000

    Maximum Spike Readings   5   ▾

        Apply   Undo   Close
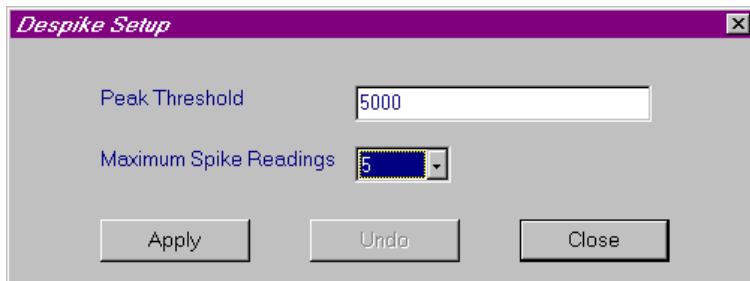
This allows the user to enter the peak threshold and select the maximum number of readings (width of an anomaly, in other words) which could be considered to represent a spike. When done, clicking on the Apply button will automatically find those spikes that match the criteria and filter them out. If the reading window is open, it will update the display automatically. Therefore, the user can easily check how well the despike filter works using the current settings. If the effect was not what was desired, the user can click on the Undo button to reverse the filtering. Clicking on the Close button will close this setup dialog box with the new settings saved in memory. Therefore, next time user selects "Despike" from Filter menu, it will always use the current despike setting to filter readings. The default value for peak threshold is 5000 and maximum spike readings is 1.

Use "despiking" carefully for (non-continuous) discrete surveys. Readings may have been acquired far apart and therefore may look like spikes to the algorithm.

Note: High amplitude noise variations usually occur over a very short time span. Thus, if you have an anomalous set (more than ten) readings, there is a good chance that this is not noise.

7.5. Destriping

7.5.1. Introduction

Destriping is a new feature offered in MagMap which offers the user the ability to remove coherent heading error offsets from data collected in parallel line mode. In addition, the program can perform a "smart" high frequency filter along the line to remove the small sinusoidal noise associated with "stride" or quantization processes inherent in the collection of the data.

We define heading errors as errors that are dependent on the direction of travel. When a survey is performed as a series of bi-directional parallel lines, these errors can be very noticeable and significant. Heading errors can be created by any number of sources, but the primary sources are heading error of the sensing system itself (often in the 1 to 2 nT range), offsets due to carrying some ferromagnetic object on the operator, or from the logging console or some other sensor device such as a GPS receiver or antenna being too close to the sensor. Only since the advent of very high sensitivity optically pumped Cesium vapor magnetometers have these errors been visible and the necessity to remove them become apparent.

Heading errors are traditionally removed by using a technique that attempts to find constant magnetic offsets for each line traveled. Since the causes of heading errors are usually magnetic objects that change orientation as the user changes orientation, in cases of heading error, there should be a constant magnetic field offset added to or subtracted from the magnetic field for each direction of the user. Thus, we attempt to find a technique that removes this constant magnetic field offset from each line. The line-to-line offset minimization uses a local min/max technique that searches down every line for local minima (or maxima) and seeks through an iterative process to minimize this offset on a line-to-line basis. The technique we use therefore has a minimum distortion effect on large anomalies while performing quite well in the flat areas of the field where heading error offsets are most apparent. It assumes that the lines are run straight and parallel.

7.5.2. Use of the Destriping data wizard

The input to the Destiping program is the *.dat file exported from MagMap after all filtering and data positioning edits have been made. The output of Destriping is a *.dat file and therefore can be called back into MagMap for viewing. However, better visual results will result if the data is gridded and displayed in third party program like Surfer or Geosoft. When the routine runs, it gives diagnostic data about the destriping process which will give the user important information about the success of the process and whether an additional iteration or varied parameter is required.

7.5.2.1. FILE PARAMETERS DIALOG

Destriping like GPS Interpolator (for large marine or airborne files), is accessed through the File menu selection. Click on File, then Destripe Data to access a dialogue box (shown below). The pertinent parts are:

- Name of input file. This is probably a dat file that was created using Magmap previously. It should have space separated columns with X, Y, and field values (at minimum). Additionally lines numbers are useful, but not mandatory.
- Name of output file. The default name is output.dat, so it is advised to select a new name that is more related to the name of your file.
- Name for statistics file – this is enabled if you have selected the option, "*Output Statistics File*".   The statistics file will report the statistical variance and the maximum offsets of the destriping process.
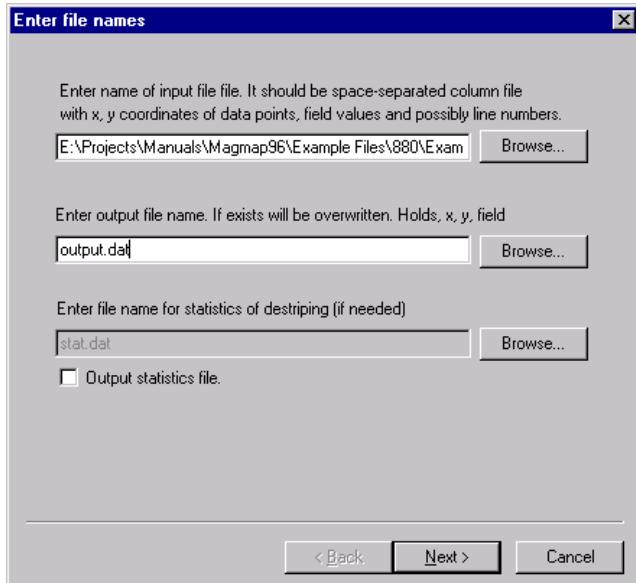
File name dialog box

7.5.2.2. INPUT FILE PARAMETERS DIALOG

This screen allows you to specify how to read the input file. Since destriping uses a columnar approach to interpreting the data format, you need to tell the program which columns hold the pertinent data. Usually the X and Y columns are listed, as well as one of the magnetometer or other data file columns, and the line number column. If you have collected multiple sensor data, then you will have the option of destriping either sensor or the gradient columns.
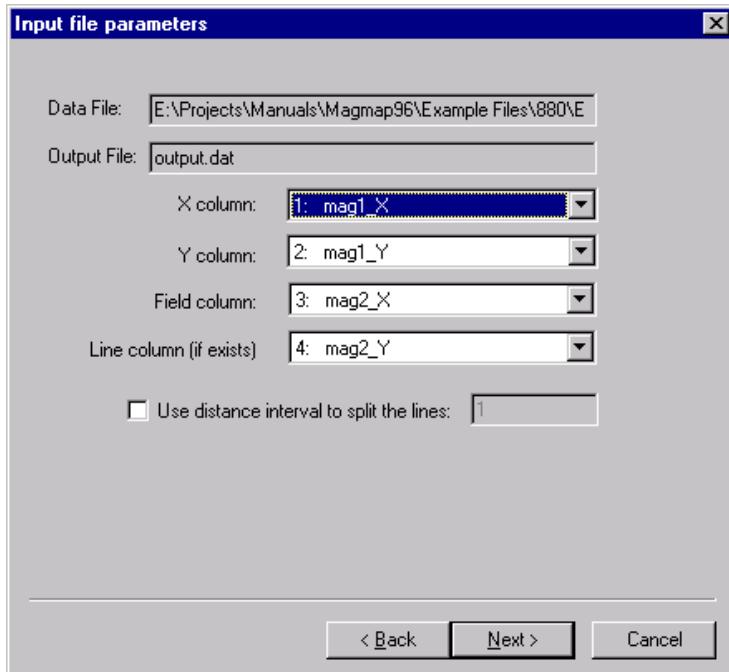
Input file parameters screen

By default, the X, Y, Field, and line columns are set to the first four columns present in the file. You will probably need to change the settings to reflect the correct columns used. Click on the down arrow to select the proper data column.
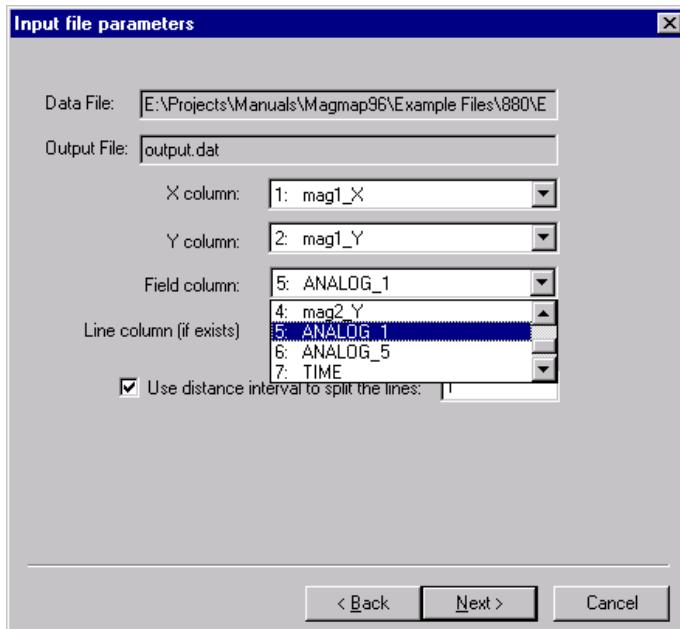
Selection of line column

A few options to be aware of are:

- Line column - Destriping uses the line number column to determine which lines it is working on. Select the proper column for the line number. If the output file does not have a line number included, you will need to select the option, "*Use distance interval to split the lines*".
- 'Use Distance Interval to split the lines' checkbox – This is used when there is no line number stored in the input file. In this case, you need to specify a **distance interval** to specify when a new line is started. This distance interval is defined as the maximum distance between the positions of two adjacent readings. E.g., if you do a land survey and have line spacings of 5 meters, it is probably safe to put a value of 2 or higher for this reading. If the value is too large, it will not notice when you have shifted lines, and if the value is too small, it may assume you have started a new line, when in fact you have just walked a little faster, or had a GPS error that made the distance larger.
-

7.5.2.3. DESTRIPING PARAMETERS DIALOG

Next, Magmap will bring the data into the destriping program and report the statistical findings. You should see a screen such as the one below:
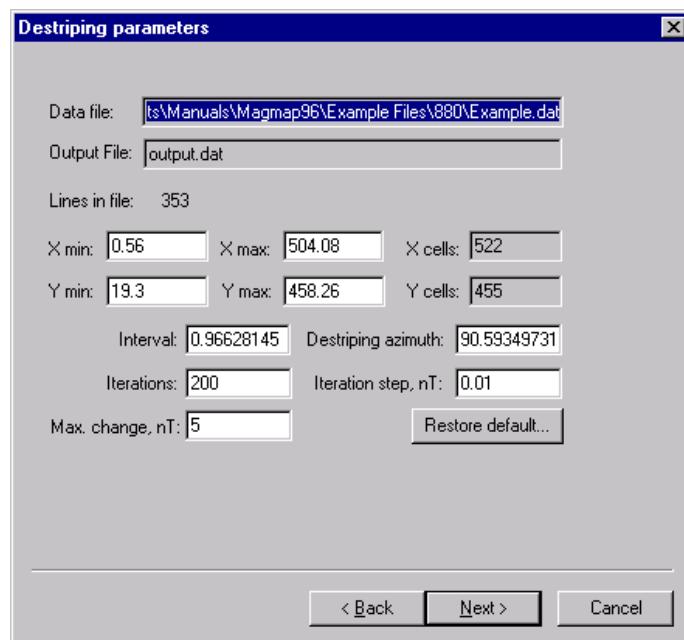
Here, you will get a report of the data.

- X min, X max, Y min, Y max – These are respectively, the minimum and maximum X and Y values found during a search of the file
- X cells, Y cells – these are the number of gridding cells calculated based on the **interval** specified below.
- Interval – this should approximate the average distance between adjacent points. For a series of data points equidistant, there should be no performance or accuracy gain by specifying a smaller interval. However, for points which are not equidistant, a smaller interval may help with accuracy. Usually the default value works well for most situations.
- Destriping azimuth: This is the angle between 'north' in your gridding system, and a line drawn perpendicular to your line. Usually the default works well in this case.

- Iterations: This is the number of times the program will increase/decrease the iteration step.
- Iteration step: this is amount the program will try to vary the field for a particular line on a given iteration.
- Max change: This is the maximum magnetic field amount that a line will be changed.

The two parameters, 'iterations' and 'iteration step' are best explained by understanding the method by which the destriping routine works. During the destriping process, we compare the readings across a number of lines that are taken perpendicular to the direction of travel. If we compare all the magnetic readings across a given perpendicular line, there will be a point on a survey line at which a minimum value occurs, and a point on a survey line at which a maximum value occurs. For each survey line, we make a total of all the minimums and maximums occurring on a perpendicular line. In destriping, usually one or more lines will have an abnormal amount of maximums, and another one will have an abnormal amount of minimums. By changing the field values of each line by a small constant value, we try to have an even distribution of maximums and minimums for each line, and hence destripe the data. We take small steps (iteration steps) because we don't want to overshoot – (e.g. add too much to a minimum or subtract too much from a maximum) but we also need to take enough steps to make a difference (iterations). Hence, a good result involves picking a small enough iteration step to not overshoot the correct value, and additionally doing enough iterations.

7.5.2.4. LINE SMOOTHING PARAMETERS DIALOG

This dialog is used to help us smooth the data to remove high frequency noise ("stride noise"). Typically, stride noise is very small (on the order of 0.2nt) and we do not wish to effect any actual anomaly data, so we allow an upper limit on what we will consider stride noise. The default for this parameter is 1nT. We consider any anomaly of greater than 1nT *that is coherent* to be real and we do not want to remove it. We recommend initially leaving this setting at 1nT. If for instance the stride noise is larger due to some magnetic object on the survey personnel, then this value should be increased.   This dialog box is shown below.
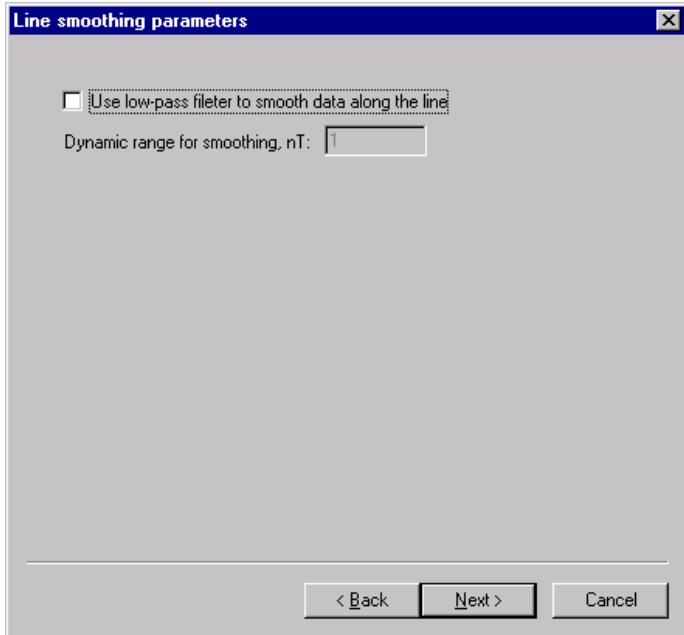
A low pass filter is used to filter the stride noise. Additionally, to keep from filtering out actual anomalies, we use a setting "*Dynamic range for smoothing*". This setting is used as a guideline when trying to distinguish anomalies from noise.

7.5.2.5. 'RUN DESTRIPING' DIALOG

The 'Run Destriping' dialog box gives us to options -- either running Destriping in a test mode or to actually apply the filters and write out the files. Clicking on "*Run Destriping*" will run the program without writing out the file so that the users can see the results of the parameter selection. In particular, we want to see the maximum offsets corrected and the average and maximum disbalance after the line-to-line balancing is applied. If the values are still too high, then you are given the option to go back to the earlier screens to select different parameters. Typically we like to see less than 5 nT maximum correction and a maximum disbalance after destriping of perhaps 5%. When you are happy with the results, press *Finish* and the actual destriping process with file output will occur.

Run destriping

Maximum correction, nT:

Maximum disbalance, % :

Average disbalance, % :

[Run destriping]   [Stop]

[< Back]   [Finish]   [Cancel]
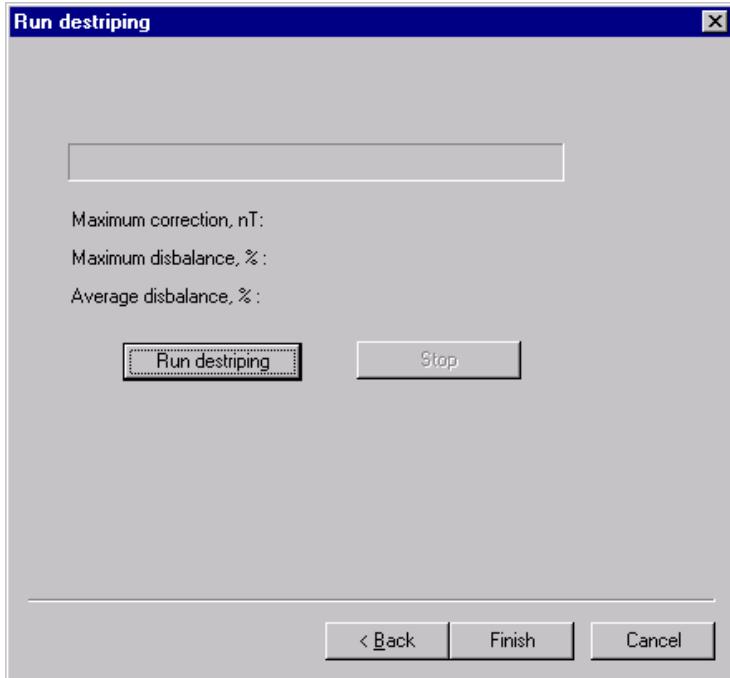
Bring the resultant file into Surfer or Geosoft and grid and display the data (we recommend shaded relief for maximum contrast and dynamic range display) and observe the results compared to the original *.dat file. If the results are insufficient, *we recommend running the previous destriping output file through the process a second time*. This often generates a smoother result with the downside of removing more of the high frequency content of the data file.

We believe that judicious use of the spike editing and destriping routines in MagMap will afford the user powerful data correction capabilities. Some experimentation will be necessary to get optimum results.

7.5.3. Results of destriping

Shown below is data taken and mapped without the destriping routine and with the destriping routine run once.   Note that the stripes on the original data are much more pronounced.

Shown below is data taken after destriping has been done twice.
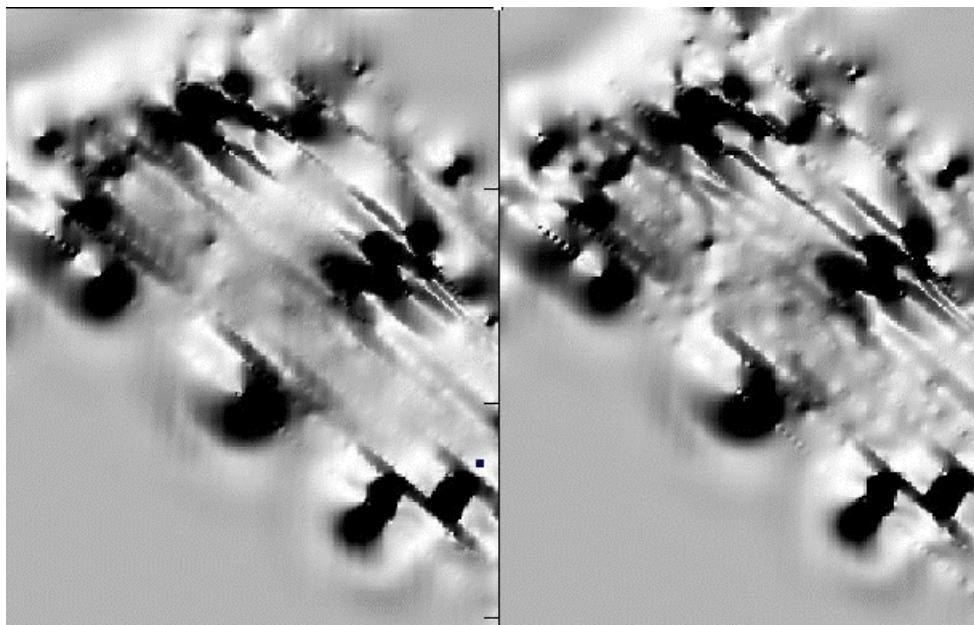
Shaded relief after one pass Destriping higher amplitude   *Original Data at higher amplitude*
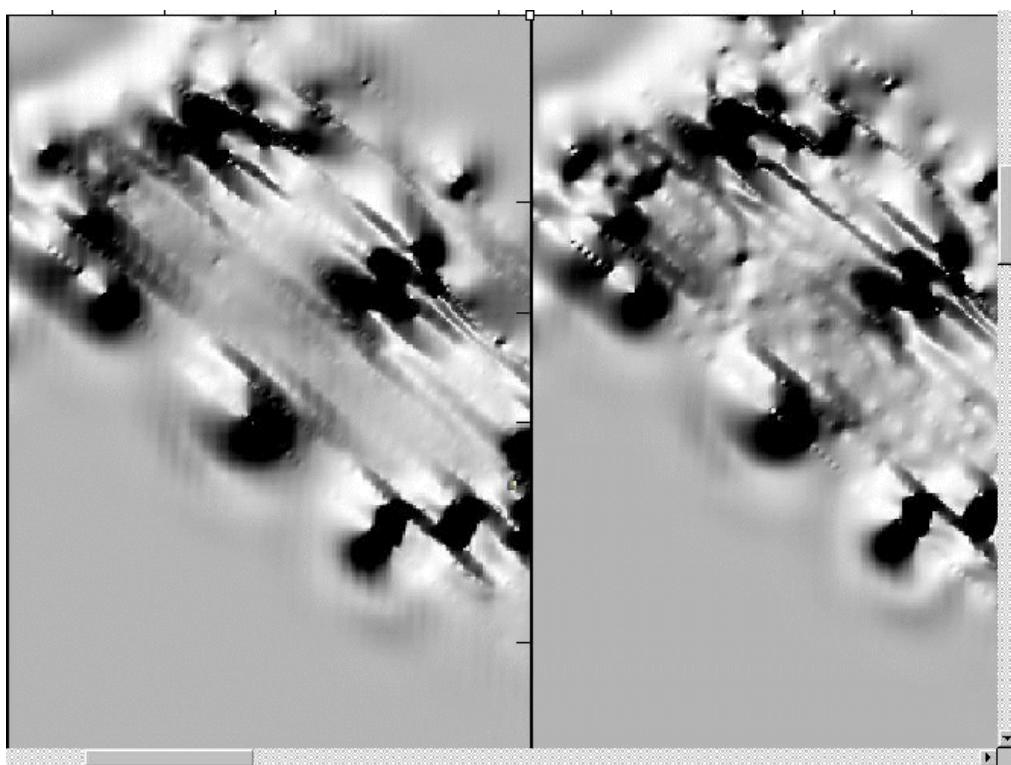
Data twice destriped with higher amplitude settings   *Original data at higher amplitude*

7.6. Pseudo gradient

During loading of G-858 compressed or ASCII files, Magmap computes a psuedo gradient – the difference between sensors one and two. This appears in the program as a third sensor (e.g. a G-858 magnetometer would appear to have three sensors as opposed to two). All kinds of processing available for total magnetic field are therefore available for the pseudo gradient, including 2D and 3D maps, line graphs, and stack profiles. For example, the plot selection plot sensors setup dialog looks like the following:
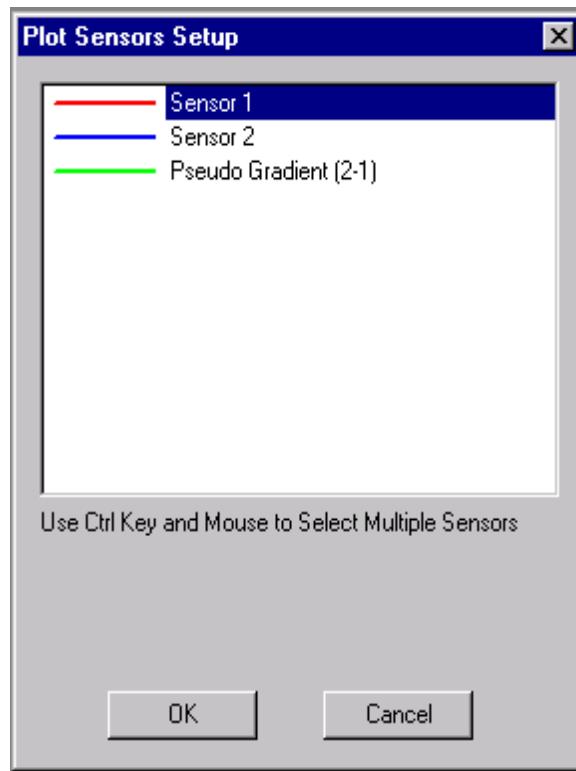
This 'pseudo gradient' option is also available when selecting what to plot for the contour plot and the 3D plot.

7.7. Setting time offset for readings

This section does not apply to land style G-858 documents. It apples to MagLog NT, SURFER and other documents where data and positions are represented by two or more separate windows, neither of them could be closed.

The function is similar to base station time offset setup, but apples to the survey readings and possibly to the matching position at the same time. It is available from *Bias Setup / Time Bias setup* menu. The following dialog is displayed when function is called:
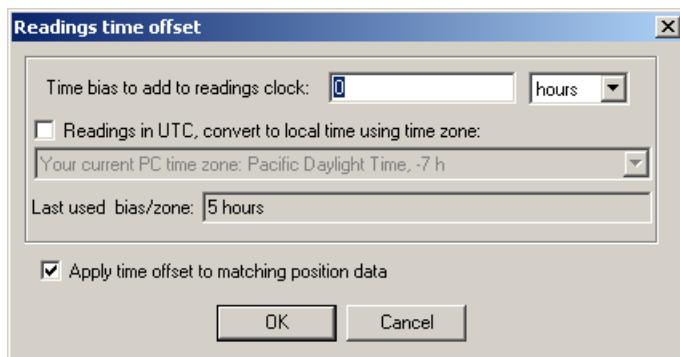
This screen allows you to adjust the survey clock to correspond base station or other time system clock.

There are two main modes of operation:

- Add bias in appropriate uinits, such as seconds, minutes, hours or days. This is a default mode.

- Assuming readings are in UTC time, apply time shift using set of pre-defined time zones selectable from the list. Check "*Readings in UTC*" button and use droplist below to select approriate time zone. First selection is always local PC time zone, based on time settings for your computer.

The dialog shows last used time bias or zone as a reminder.

The button "*Apply time offset to matching position data*" applies the same time shift to the GPS or other positions loaded into separate window. **Without this button checked data will not overlap in time after time bias is applied, which makes export impossible**. The user can however activate GPS window and apply the same offset to GPS time directly.

It's important to understand that **MagMap does not store clock bias.** Whenever new data is loaded zero bias is applied by default, but last used time offset is shown in the dialog as a reminder. Clock bias also always applied to the original data. The typical example for instance if user entered -7 hours offset; but then he or she decided that this was wrong and the correct offset needs to be -8 hours. This new value (-8) should be entered into the dialog, but *not* -1. In other words old offset (if any) is not taken into account when new value is entered.

While time bias functions offer great flixibility, the caution should be excersised to avoid data getting out of sync between themselves and / or positions.

8. GPS

8.1. Overview

Magmap will only import GPS data that has been stored with the following format: **NMEA output message format with a GGA message type**.

Magmap has facilities to change from geographical coordinates to UTM coordinates, smooth your GPS data, and add additional positions to be calculated relative to the GPS.

8.2. Loading your GPS data

If you used the 858 MagMapper or DataMapper console to store GPS data, you will see two menu items enabled. These items are

- Draw new map using GPS and the features of a regular 858 survey

- Draw new map using GPS and the features of an airborne survey

If you select either item, a new map will be drawn (as shown in Figure 69) using only GPS information. Each flag is a GPS position fix.

Every latitude and longitude in the data stream is converted from degrees, minutes, seconds to decimal degrees within a range of values from -180.00000 degrees to 180.00000 degrees.

> Note: If you earlier enabled UTM coordinates to be used in the program, the map will be drawn using UTM coordinates and the parameters you selected. You can change this later if needed.

When you export your survey to Surfer or Geosoft Analysis and Plotting Software, magnetic readings will be linearly interpolated between GPS locations in latitude and longitude decimal degrees. UTM conversion to meters is optional see section 8.3..

The user interface for a GPS map window is about the same as the regular map window using flag locations. Many of the editing functions that change the coordinates of a location are not available for a GPS map. You may move a (presumably bad) GPS position to a new location. You also can delete bad GPS positions, delete readings and plot readings.

> Note: Version 7 of Surfer for Windows now offers double precision numbers. This allows nine to fourteen digit decimal degrees to be faithfully represented in the Surfer map grid annotation (in previous versions you need to use UTM coordinates to get accurate positioning).
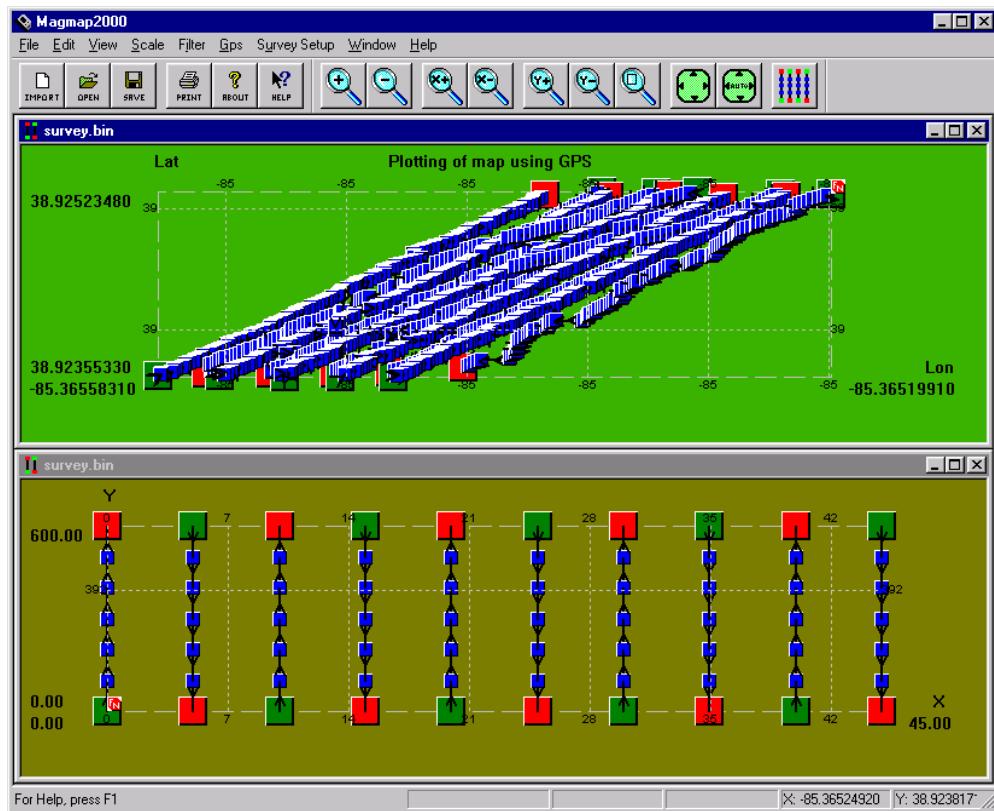
Figure 68

There are small differences in the way the program will behave depending upon with which option you choose to plot the GPS window. You should choose the first option ("*Draw new map using GPS and the features of a regular 858 survey*") if you don't need to specify additional offset (antenna to sensor) position points to be calculated. It also has an export menu that is simpler to use. The second option ("*Draw new map using GPS and the features of an airborne survey*") will allow you to specify extra positions relative to the GPS antenna to be calculated. Calculating additional positions will be discussed later in this chapter.

8.3. Planar Projected Coordinate Systems and Datum transformations in MagMap

Prior to version 4.99 05/09/2014 MagMap only supported standard Universe Transverse Mercator (UTM) projection. This allowed conversion from Latitude and Longitude measured in degrees to planar coordinate system expressed in meters. It was user's responsibility to match projection ellipsoid to the datum of the recorded GPS data as well as selecting appropriate UTM parameters such as central meridian, scale factor and false Easting and Northing, thus MagaMap was providing reasonable defaults based on the data.

Beginning with version 4.99 05/09/2014 MagMap is compiled with the public domain PROJ library freely available from its website http://trac.osgeo.org/proj/. The following license is applicable for users who utilize functions in this library:

```
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OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE
USE OR OTHER DEALINGS IN THE SOFTWARE.
```

MagMap still retains original UTM transformation code, which is not covered by PROJ license.

8.3.1. Input GPS Datum

Any geographical positioning data is related to the certain model of Earth, called a datum. The datum consists of ellipsoid, typically defined by its major axis and inverse flattening, and its orientation in space. The latter is typically defined by relative shifts, rotations and scaling to the reference datum, typically WGS84. The WGS84 datum is defined by its orientation relatively to remote stars; the discussion of this issue is beyond scape of this document.

 All modern GPS receivers use WGS84 by default, unless they are configured otherwise by the operator. Therefore it is safe in most cases to assume that recorded latitude and longitude are expressed in WGS84. Nevertheless there could be situations when user has configured his or her GPS receiver to use a different datum. To facilitate these cases MagMap has a GPS setup menu which is available under *File / Options*, tab GPS DATUM:
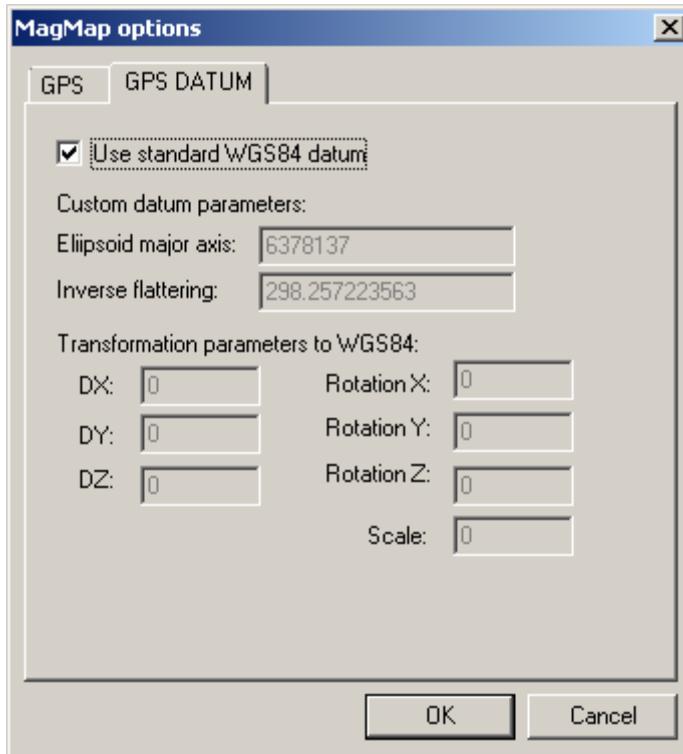
In most cases the user does not need to change anything in this dialog, just make sure that "Use standard WGS84 datum" box is checked. However if a different datum is used, this mark has to be unchecked and ellipsoid parameters to be entered. If 3-parameter transformation is available, enter only DX, DY, DZ and leave the rest as zeroes. If 7-paramater transformation is available enter all 7 parameters. Shifts DX, DY, DZ are in meters; rotation angles are in degrees and scale in parts-per-million. These units are typically used when a datum is described.

> Note: PROJ library uses the American convention for rotation angles. It means that if you obtained datum description in European convention you have to reverse rotation signs.

For instance for NAD 1927 datum used in California and some other states user need to enter major ellipsoid axis 6378206.4 m, inverse flattening 294.9786982 (Clarke 1866 ellipsoid) and enter DX=-8, DY=159, DZ=175 leaving the rest as zero.

The datum parameters should be set in advance of data processing and kept constant for all the data.

8.3.2. Applying standard UTM to the data

This facility is applicable to land, marine, and airborne magnetometer data, as well as OhmMapper data, under GPS window menu *GPS / UTM or other coordinate system setup*. By default only standard UTM projection is available, the same way as in previous versions of MagMap. When first called, the UTM dialog looks like the following:
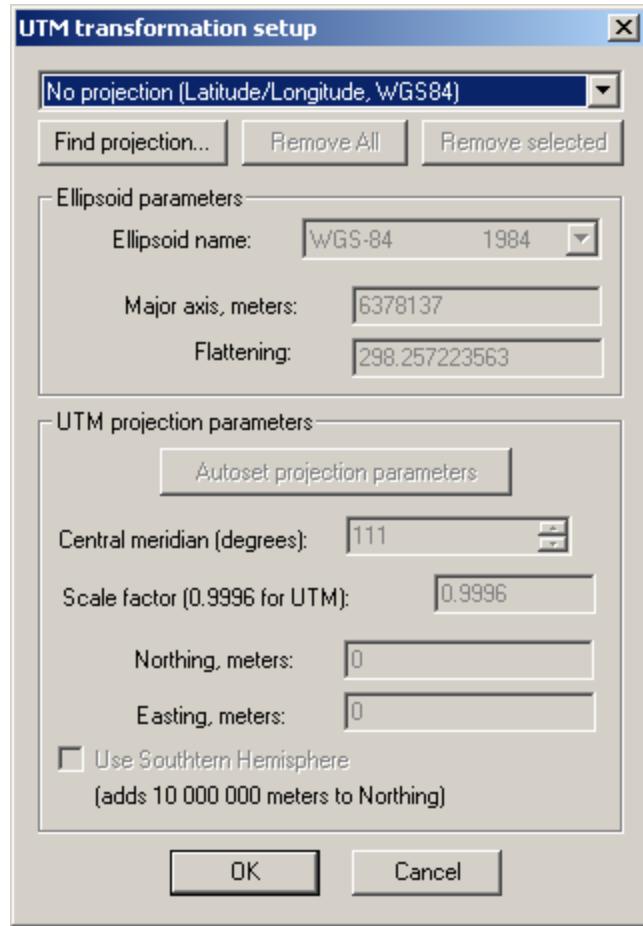
The drop box at the bottom of the dialog has only two selections:

1. No projection (Latitude / Longitude, WGS84)[2]. This selection does not apply any coordinate transformation to the data, and used to fall back to the original Latitude / Longitude coordinates if needed. If it is selected by when dialog first called, nothing happens with the data. Note that all bottom sections of the dialog are disabled in this case.

2. Standard UTM WGS84, meters. Applies standard UTM projection to the data. The bottom of the dialog becomes available and looks like:

---

[2] In datum other than WGS84 is used this text says "Your Datum" as a reminder. The same applies to the second selection, build-in UTM projection.
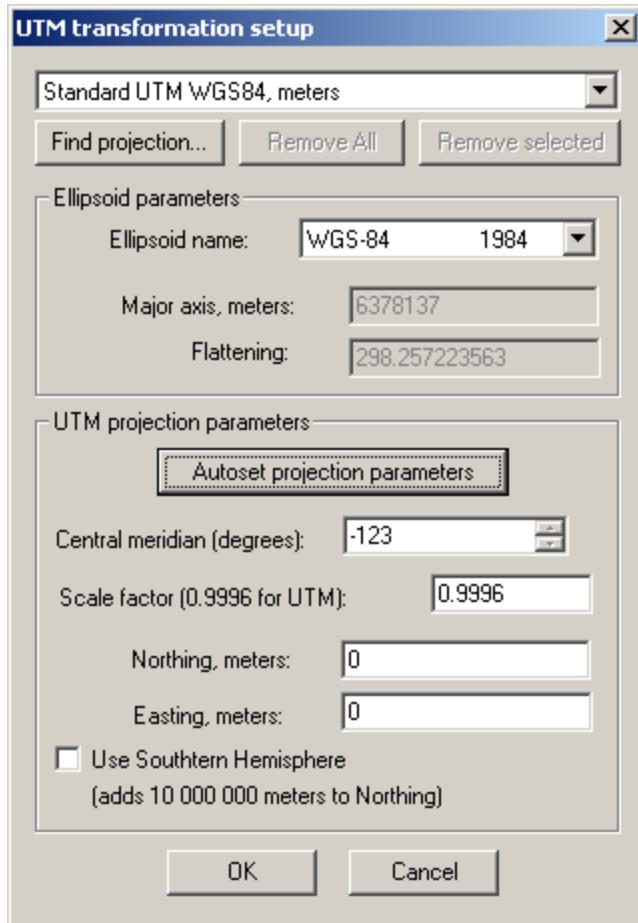
- **Ellipsoid name**: This is the type of ellipsoid you use to approximate the earth. Since the earth is not a perfect sphere some ellipses may better approximate the region you are surveying than others.

- **Autoset projection parameters:** This is useful when you don't know what the prime meridian you are using is, or when you data where your prime meridian may change. This will set the prime meridian and scale factor automatically for you, and also set Southern Hemisphere flag is data is in south of the equator.

- **Prime Meridian:** If you don't press "Autoset projection parameters", you should fill this in. This value has a large impact on the UTM coordinates generated due to the non-uniformity of an ellipse. It can be quickly estimated as the value of the longitude but you should look it up in the table below for a better calculation of your positions.

The Universal Transverse Mercator (UTM) Coordinate System uses zone codes instead of specific projection parameters. The table that follows lists UTM zone codes as used by GCTPc Projection Transformation Package.

Zone	C.M.	Range	Zone	C.M.	Range
01	177W	180W-174W	31	003E	000E-006E
02	171W	174W-168W	32	009E	006E-012E
03	165W	168W-162W	33	015E	012E-018E
04	159W	162W-156W	34	021E	018E-024E
05	153W	156W-150W	35	027E	024E-030E
06	147W	150W-144W	36	033E	030E-036E
07	141W	144W-138W	37	039E	036E-042E
08	135W	138W-132W	38	045E	042E-048E
09	129W	132W-126W	39	051E	048E-054E
10	123W	126W-120W	40	057E	054E-060E
11	117W	120W-114W	41	063E	060E-066E
12	111W	114W-108W	42	069E	066E-072E
13	105W	108W-102W	43	075E	072E-078E
14	099W	102W-096W	44	081E	078E-084E
15	093W	096W-090W	45	087E	084E-090E
16	087W	090W-084W	46	093E	090E-096E
17	081W	084W-078W	47	099E	096E-102E
18	075W	078W-072W	48	105E	102E-108E
19	069W	072W-066W	49	111E	108E-114E
20	063W	066W-060W	50	117E	114E-120E
21	057W	060W-054W	51	123E	120E-126E
22	051W	054W-048W	52	129E	126E-132E
23	045W	048W-042W	53	135E	132E-138E
24	039W	042W-036W	54	141E	138E-144E
25	033W	036W-030W	55	147E	144E-150E
26	027W	030W-024W	56	153E	150E-156E
27	021W	024W-018W	57	159E	156E-162E
28	015W	018W-012W	58	165E	162E-168E
29	009W	012W-006W	59	171E	168E-174E
30	003W	006W-000E	60	177E	174E-180W

Obtained from Software Documentation for GCTP General Cartographic Transformation Package: National Mapping Program Technical Instructions, U.S. Geological Survey, National Mapping Division, Oct 1990,

- **Scale factor:** Input .9996 for UTM coordinates.
- **Northing / Easting:** To retain standard UTM coordinates, set to 0. These are constant values that are added to your UTM coordinates. UTM coordinates are usually large numbers on the order of a million

meters but your survey may only be looking at thousands of meters. This allows you to simplify your final numbers by adding or subtracting a large offset.

- **Use Southern Hemisphere.** UTM coordinates in Southern hemisphere differ by 10,000,000 m in Northing. If this flag is set MagMap applies this additional shift automatically.

If selected UTM parameters does not comply with the specification the following dialog is displayed:
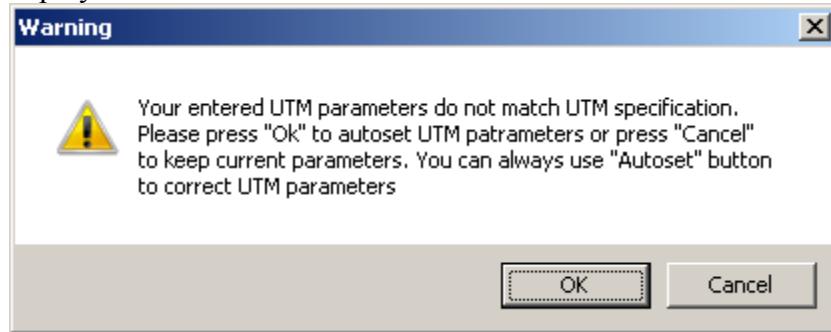
In most cases, it is a good idea to have the program automatically set the UTM parameters unless there are a special considerations (i.e. being at the edge of UTM zone).

8.3.3. Using planar (Cartesian) Coordinate Systems

With adopting PROJ library MagMap covers hundreds of coordinate systems, including US State Plane coordinates, Gauss-Kruger projections in different countries, national grids, etc.[3]. To use any of these coordinate transformations should be located in the PROJ data base or added to it and enabled in the projection dialog described in the previous section. The following is check list for enabling new projection:

- Make sure you know the area and / or name of the coordinate system (CS) you are going to use. The useful resource is European Petroleum Survey Group (EPSG) Geodetic Parameter Registry available online at http://www.epsg-registry.org/. In this registry each CS has its own unique code. User can search registry online to find out what CS are used in his and her area.

- Based on the above, it's user's responsibility to select CS applicable to the data. MagMap does not check fitness of the particular CS to the data.

- If datum transformation involved, obtain 3 or 7 parameters values to reduce CS to WGS84

---

[3] In fact, standard UTM is also covered by PROJ; this way it is double-covered by MagMap

- Obtain a test point where Latitude and Longitude and projected and transformed values are known. For the US State Planes Corpscon program by US Army Corps of Engineers is an excellent source of reference data. It is available online at http://www.tec.army/mil (note that Corpscon uses positive values for longitude because it is designed for US only).

Below we will proceed with an data sample "stanford.bin" available as part of the MagMap installation. We will use California zone 3 NAD27 coordinate system, assuming recorded data are in WGS84. Below are step by step instructions to accomplish this task.

After data is loaded in MagMap and GPS window is created, go to *GPS / UTM or other coordinate system setup* menu. The UTM /CS transformation dialog appears on the screen. Press *Find projection…* button. The selection dialog appears on the screen. It is initially blank as shown below:
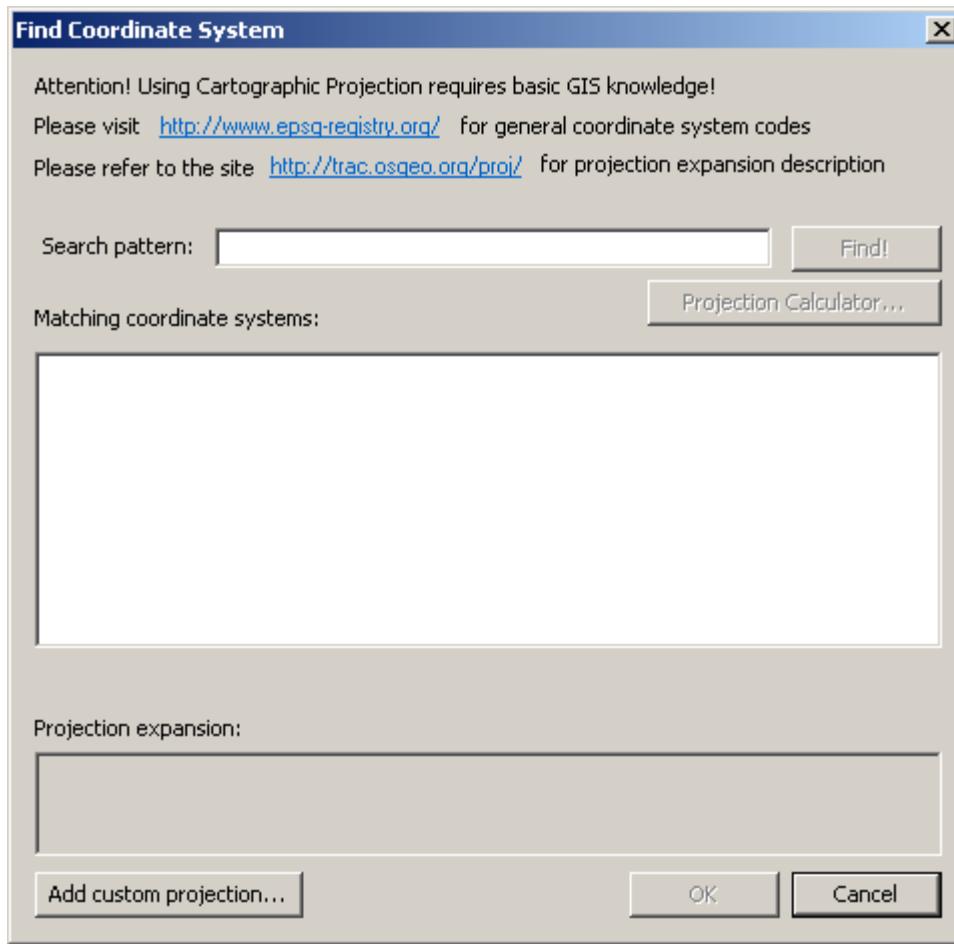
Now in the *Search pattern* field type "california" (case does not make difference, you can also type only part of the word such as "calif") and press "*Find!*" button or just press Enter. The dialog changes as below:

Find Coordinate System

Attention! Using Cartographic Projection requires basic GIS knowledge!

Please visit   http://www.epsq-registry.org/   for general coordinate system codes

Please refer to the site   http://trac.osgeo.org/proj/   for projection expansion description

Search pattern: california   Find!

                                        Projection Calculator...

Matching coordinate systems:

```
epsg:3497  NAD83(NSRS2007) / California zone 5
epsg:3498  NAD83(NSRS2007) / California zone 5 (ftUS)
epsg:3499  NAD83(NSRS2007) / California zone 6
epsg:3500  NAD83(NSRS2007) / California zone 6 (ftUS)
epsg:26741  NAD27 / California zone I
epsg:26742  NAD27 / California zone II
epsg:26743  NAD27 / California zone III
epsg:26744  NAD27 / California zone IV
epsg:26745  NAD27 / California zone V
epsg:26746  NAD27 / California zone VI
epsg:26747  NAD27 / California zone VII (deprecated)
```

Projection expansion:

Add custom projection...   OK   Cancel

The program showed all available descriptions which match the pattern. The first value in each string is file:code pair which uniquely describes the coordinate system by name of the institution (also the file name in PROJ MagMap subfolder) and its code. At the moment nothing else is selected; scroll down and select epsg:26743 NAD27 / California zone III. The dialog will change as below:
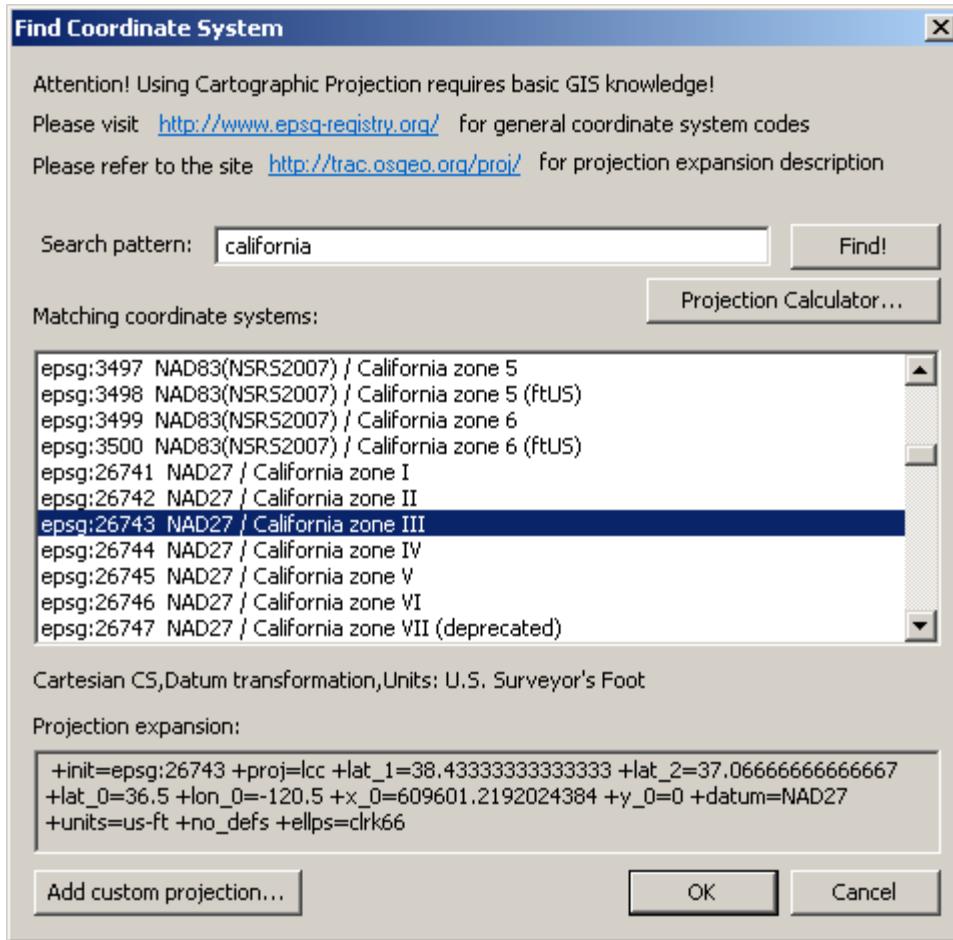
Now the projection is fully defined. MagMap shows brief information below selection list as *"Cartesian CS, Datum transformation, Units: U.S. Surveyor's Foot"*. This indicates that Latitude / Longitude pairs are to be reduced to the planar feet coordinates. The complete projection expansion in terms of the PROJ parameters is shown at the bottom; please see http://trac.osgeo.org/proj/ for explanation of parameters.

Now it's time to check the transformation. We obtain test point at 121W, 37.4N (WGS84) using Corpscon:

```
                INPUT                              OUTPUT
          Geographic, NAD83                   State Plane, NAD27
                                          0403 - California 3, U.S. Feet

        Accuracies of conversions from NAD 83 to NAD 27 are typically 12 to 18 cm.
────────────────────────────────────────────────────────────────────────────
                    Test Point                        1/1
          Latitude:  37.4                  Easting/X: 1855059.282
          Longitude: 121                    Northing/Y: 328100.376

                                          Convergence: -0 18 19.72430
                                          Scale Factor: 0.999947837


          Datum Shift (m.):  Delta Lat. = 7.116, Delta Lon = -92.132
────────────────────────────────────────────────────────────────────────────
  Remark:
                  Corpscon v6.0.1, U.S. Army Corps of Engineers
```

To verify transformation press *Projection Calculator* button and enter -121, 37.4 then press *Convert*:

```
┌─────────────────────────────────────────┐
│ Projection calculator              [X]   │
├─────────────────────────────────────────┤
│  Input coordinates:                      │
│     Longitude:  │ -121              │    │
│      Latitude:  │ 37.4              │    │
│              ┌─────────────────────┐     │
│              │      Convert         │     │
│              └─────────────────────┘     │
│  Output coordinates:                     │
│          X:  │ 1855059.282        │      │
│          Y:  │ 328100.389         │      │
│              ┌─────────────┐             │
│              │    Close     │             │
│              └─────────────┘             │
└─────────────────────────────────────────┘
```
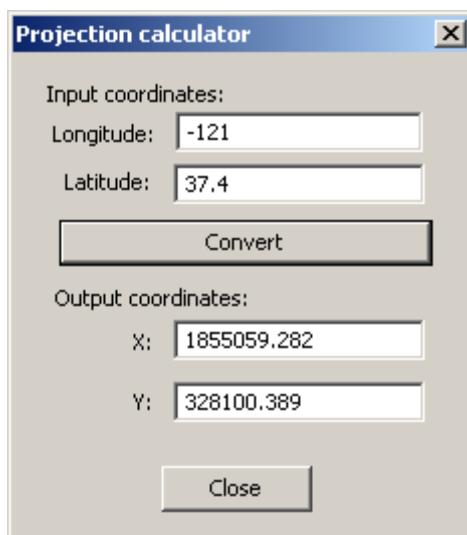
Comparing values we can see that there is 0.013 ft (4 mm) difference in Y, which is acceptable.

Next step after CS has been verified is to accept it as one of the CS available in the UTM / CS dialog. Just select epsg:26743 NAD27 / California zone III in the list and press "Ok". Note that additional selection appears as shown below:

```
┌─────────────────────────────────────────────────────┐
│ UTM transformation setup                      [X]    │
├─────────────────────────────────────────────────────┤
│ │ epsg:26743  NAD27 / California zone III      │ ▼ │ │
│ │ No projection (Latitude/Longitude, WGS84)          │
│ │ Standard UTM WGS84  meters                         │
│ │ epsg:26743  NAD27 / California zone III      │     │
│                                                       │
│    Ellipsoid name:   │ WGS-84        1984  │ ▼       │
└─────────────────────────────────────────────────────┘
```
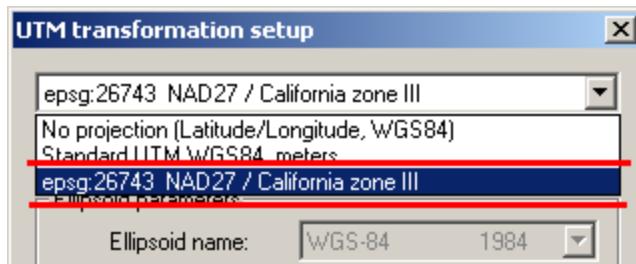
Next time MagMap is started and this CS is used there is no need to search the data base; it is readily available from the drop box selection.

There are two more buttons in the dialog: *Remove All* and *Remove Selected*. The first button resets drop box to its original state; all choices except two first choices (No projection and standard UTM). The second removes currently selected item.

Note that after CS is applied left bottom corner changes from 37.43050070, -122.18604560 to 343218.56, 1510768.62. The second pair is Northing and Easting in feet. If GPS offset is used in this mode it is also should be specified in feet.

When UTM /CS setup dialog called again and "No projection" is selected data is reduced back to the original Lat/Lon WGS84.

If dialog is called again and standard UTM (or other CS) is used the following happens:

1. Program converts position back from CS(1) back to original Lat / Lon.

2. Program converts Lat /Lon data to new coordinate system CS(2).

This makes look as seamless conversion from CS(1) to CS(2); however important that transformations are not cumulative. For instance one cannot convert from Lat/Lon WGS84 -> Lat/Lon NAD27 -> UTM NAD27 in two passes. Instead one needs to derive simple transformation Lat/Lon WGS84 -> UTM NAD27 and convert in single pass.

8.3.4. Datum to Datum transformations in Latitude / Longitude

This type of transformation does not change units of the data (i.e still decimal degrees) but changes reference datum. As an example consider the same data set ("stanford.bin") and convert it from WGS84 to NAD27 Lat/Lon. First find NAD27 projection using "NAD27" pattern as it is shown here:
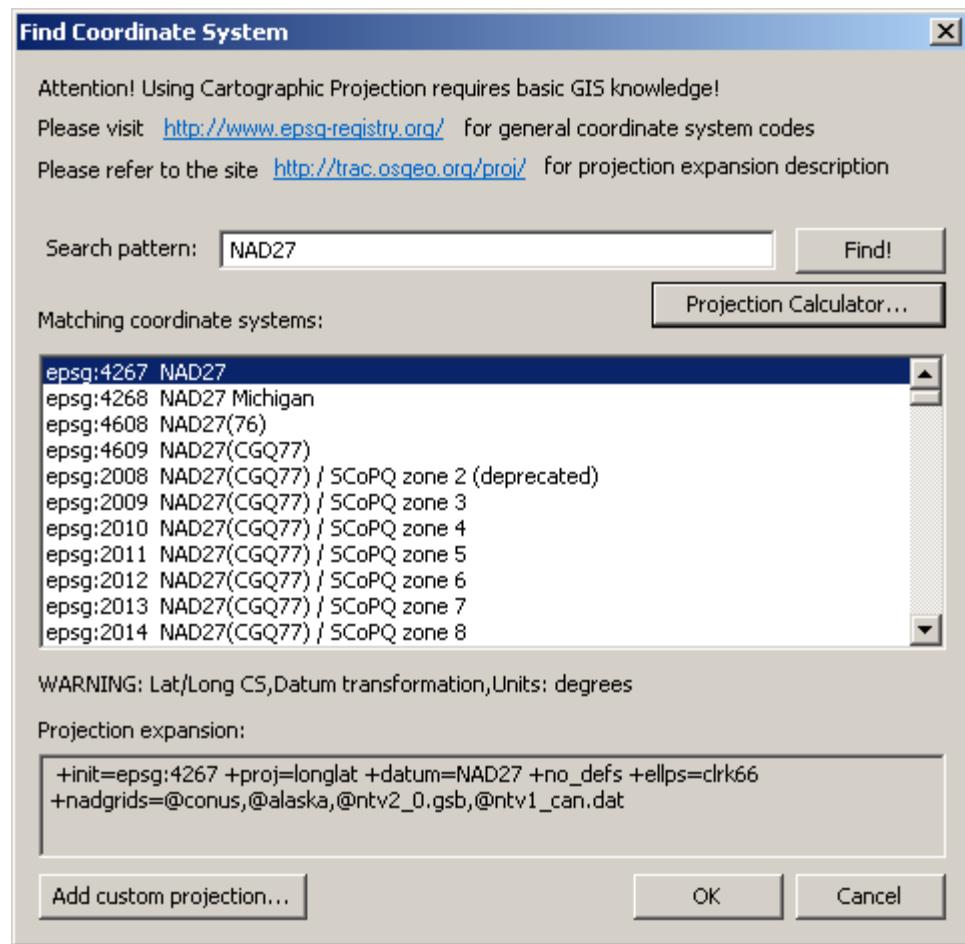
Note that MagMap reports "Warning: Lat/Long CS, Datum transformation, Units: degrees". Projection expansion line (+nadgrids=@conus,@alaska,@ntv2_0.gsb,@ntv1_can.dat) suggests that PROJ uses special grid files and not 3 or 7 parameters to perform the transformation. Finally projection calculator yields
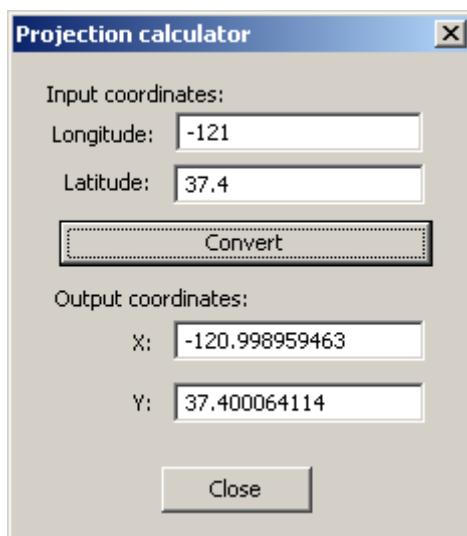
Finally check with "Corpscon" produces:

INPUT	OUTPUT
Geographic, NAD83	Geographic, NAD27

Accuracies of conversions from NAD 83 to NAD 27 are typically 12 to 18 cm.

Test Point   1/1

Latitude: 37.4	**Latitude:** 37.400064114
Longitude: 121	**Longitude:** 120.998959463

Datum Shift (m.): Delta Lat. = 7.116, Delta Lon = -92.132

Remark:

Corpscon v6.0.1, U.S. Army Corps of Engineers

Which is exactly result produced by MagMap.

Now we can add this CS to the selection drop list and use it as standard. Note however that to produce NAD27 UTM we need to derive transformation from WGS84, which is the original datum.

After datum transformation is applied left bottom corner changes from 37.43050070, -122.18604560 to 37.43056170, -122.18496940[4]

8.3.5. Adding custom user coordinate systems

MagMap allows defining of s new CS suing PROJ command language. These definitions are saved in the file "custom" located in the PROJ folder of MagMap installation and can be used the same way as standard PROJ data base files. To add custom CS use *Add custom projection* button in the *Find coordinate system* dialog. If some of the existing CS is selected it can be used as a base for new custom CS.

The dialog will look like below:

Define cusom Coordinate System

Free-format one-string CS description (NOT blank):

My custom NAD 27 CS

Your new projection code (no spaces): 1

CS definition in PROJ options (do not use +init option):

+init=epsg:4267 +proj=longlat +datum=NAD27 +no_defs +ellps=clrk66 +nadgrids=@conus,@alaska,@ntv2_0.gsb,@ntv1_can.dat

☐ Remove all old custom projections

OK   Cancel

---
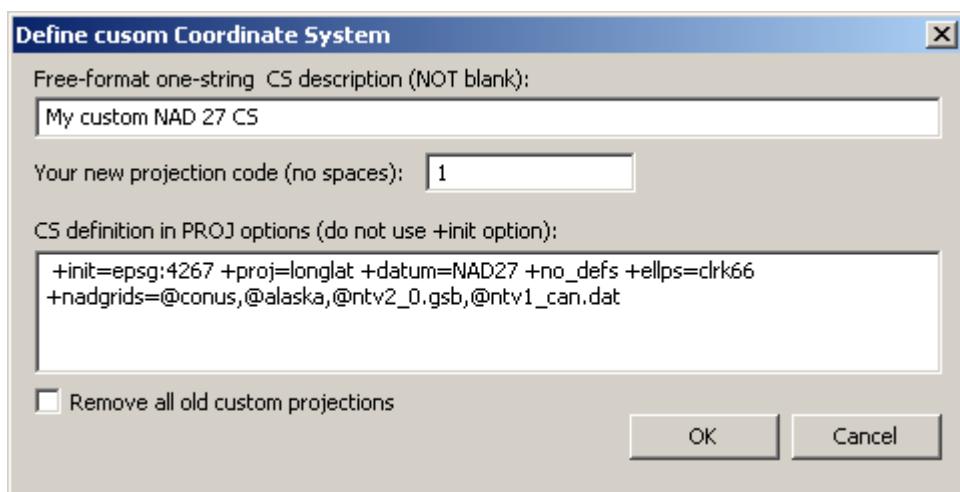
[4] Using multiple needless back and force datum to datum transformations can reduce accuracy of computations.

Here the following needs to be filled in:

- New CS description. This is free format one string description of the CS; keywords from that description can be used to locate CS in the "Find" dialog. It cannot be blank.

- Projection code. This is no space single word, could be a number. It should be unique across the custom projections. The new CS can be referred by id "custom:code"

- CS definition. Please use PROJ manual on parameters details. The definition must be valid, MagMap checks the validity after user presses "Ok" button.

- If *Remove all old custom projections* is checked, program will erase all already existing custom CS and keep only current one. This is done to avoid cluttering the data base.

  After OK is pressed custom CS is added to general data base. Now user can find it using *Find* button (easiest is to search for pattern "custom") and use calculator to verify the result. After this CS is permanently added to MagMap installation; future program upgrades will not erase it. It can be used the same was as already pre-defined CS.

8.4. GPS Offset

The GPS offset feature is available for data repositioning when the "*Draw new map using GPS data and the features of an airborne survey*" was selected during GPS conversion. This allows you to specify one or more offsets in relation to the GPS antenna position and calculate the new lat/long sensor positions. In the case of a handheld magnetometer (G–858) survey, the GPS antenna is always a fixed offset away from the magnetometer sensor. In the case of a marine magnetometer (G-882), the sensor is towed on a deployed cable of fixed length. In order to produce a final data set without positional errors, distance offsets from the GPS antenna to the sensor must be calculated. These values are then used to recalculate the actual sensor position.

Note that the position points that you specify in the offset screen will only be calculated when you export your data, not in real time. The recalculated sensor positions can be viewed in Magmap after the data is exported and read back in.

You can set offsets by pressing "GPS Offset". This will bring up the following dialog box:
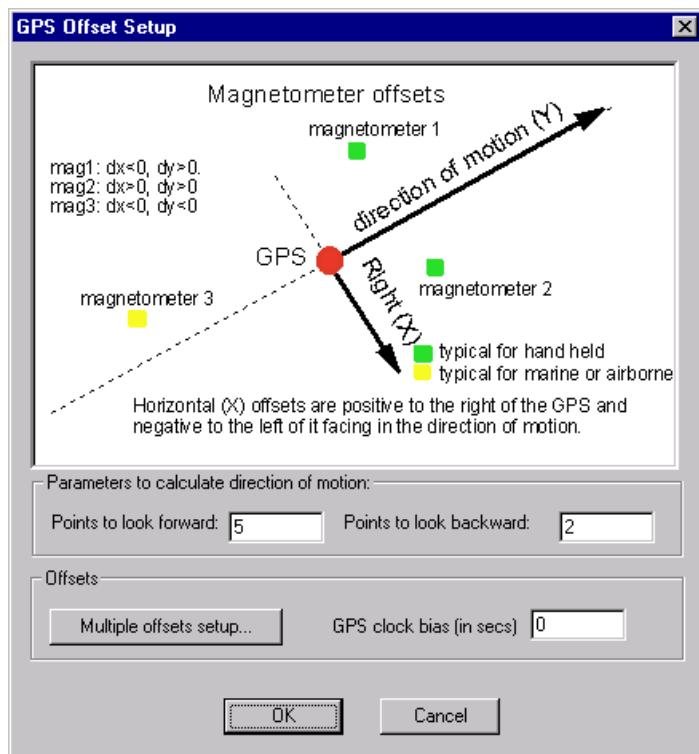
The picture shows how the coordinate system is defined.

Other parameters that you can change are:

- **Points to look forward**: MagMap needs to establish the direction the ship or person is travelling. This tells it how many points forward from the current point it should use to establish the direction of travel.

- **Points to look backward**: This tells MagMap how many points backward it should use to establish the direction of travel.

Note: The number of points you use to calculate the heading can be very important. We recommend that you choose between 2 and 5 points for both options. If you are moving in a straight line, more points will tend to give a better answer. If you are doing marine survey and making a lot of turns, it is better to choose a small number of points.

- **GPS clock bias**: This is the number of seconds to add or subtract from the PC (or 858/859) time stamp of the GPS position information. Note that this is not the GPS time as transmitted from the GPS receiver (e.g., UTC time). Using this feature it is possible to compensate for GPS system latency. For instance, if you have determined that the GPS system you are using has a latency of 0.5 seconds (that is to say, the actual position is reported and stamped in the PC approximately 500ms after the position is actually fixed in the GPS), you may apply this offset to more accurately tie the position to the magnetometer data. This feature can be used in conjunction with the multiple offsets setup described below.

- **Multiple Offsets setup**: This button allows you to setup offset position points which represent sensor positions relative to a tow point or to the GPS antenna position. The dialog box is shown below:
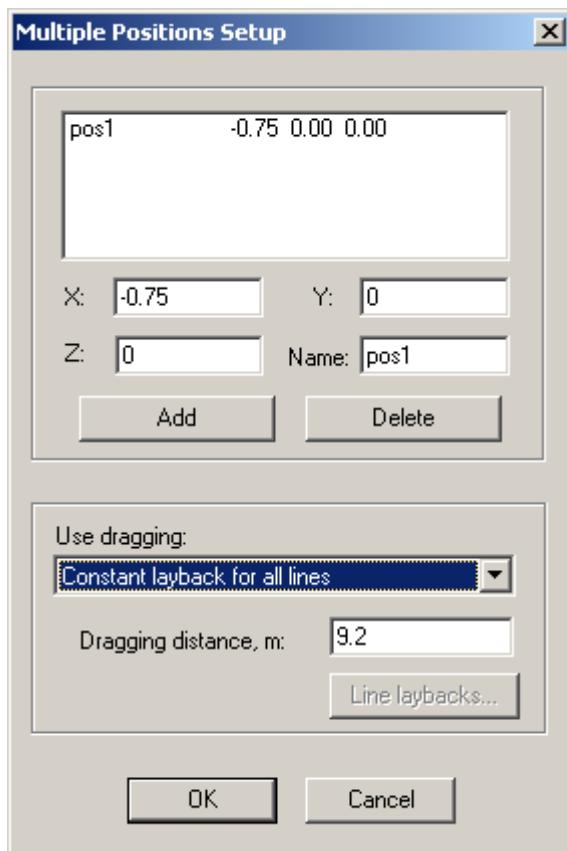
From this dialog box, you can add and delete additional position points to be calculated. You can also specify whether or not to use the dragging algorithm (used in marine tow operation) to calculate positions .

- X: This is the horizontal offset in meters (see diagram in "GPS Offset Setup") of the new position relative to your GPS antenna. Assume the GPS is at the coordinates (0,0). Then, from here you need to specify how far right (positive X) or left (negative X) your position is from the GPS. Assume that you are facing in your direction of travel.

- Y: This is the offset in meters parallel to the direction of travel of your position from the GPS. If your position is in front of the GPS, this will be represented by a positive Y. If it is located behind the GPS, this offset should be negative.

- Z: This is the vertical offset in meters of your position from the GPS. If the GPS is above the position point you would like MagMap to calculate, this offset should be negative. If it is below the point you would like to calculate, this offset should be positive.

Note: GPS of vertical positions are typically two or three times less accurate than X, Y accuracies.

- Name: This is an identifier by which this position will be known. When you are exporting, you can choose to export the position by selecting this name. Additionally, this name will be printed in the heading of the export file.

- "*Use Dragging*": This is used for marine surveys to give better position calculations. If this option is selected use positive values in meters, Magmap will calculate the position you specify using previous positions of the boat to give more accurate boat positions. Typically this is not used in land or airborne surveys. Three selections available: *Do not use dragging*, *Constant layback for all lines*, and *Individual layback for each line*. If the second option is selected you can enter the layback values (in meters, always positive). If last option is selected, you can inspect and modify separate layback values for each line using the *Line laybacks* button.

- If you select the dragging option, make sure that you don't include your cable length when you specify you're the "Y" distance. That is to say, if you have a single 882 magnetometer that you are towing with fifty meters of cable, you should specify a dragging distance of **50** and a Y offset of **0**, assuming that the GPS is located at your tow point at the rear of the vessel. If your GPS is not at the same position as the tow point, you would enter the Y offset for the GPS with respect to the tow point.

- Add: This will add a position point to the list. It will use the current parameters filled in under *X, Y, Z*, and *Name*.

- Delete: This will delete the selected position point from the list.

Note: You cannot edit a position point once it has been created. If you want to modify an existing position point, select it, delete it, and type in your correct offsets. Then press "Add".

8.5. Uisng different layback values for different lines[5].

Starting with version 4.88 MagMap supports Line Number files with recorded magnetometer offset (layback) for each line. This function operates on files created by MagLog version 3.28 or higher. The cable length is recorded by MagLog regardless of the real time position interpolation. It is assumed that layback value is constant during each survey line but can vary between the lines. A typical Line Number file looks like this:

```
START LINE 0 50.00  06/26/09 15:38:17.855
STOP  LINE 0 50.00  06/26/09 15:38:51.615
START LINE 1 25.00  06/26/09 15:39:47.954
STOP  LINE 1 25.00  06/26/09 15:40:21.558
START LINE 2 30.00  06/26/09 15:40:24.051
STOP  LINE 2 30.00  06/26/09 15:40:54.689
```

---

[5] This feature is only available for surveys recorded with MagLog software.

with layback values, in meters, recorded in the 4th column.

For surveys recorded with previous versions of MagLog, layback values are assumed to be zero, and can be entered by modifying Line Number file by hand or by using MagMap dialogs as described below.

- **Entering / modifying layback values on the map.** Right click on the beginning or end of the line (large green or red square) and select *Line layback* from content menu. The following dialog with selected line number and current value is displayed:
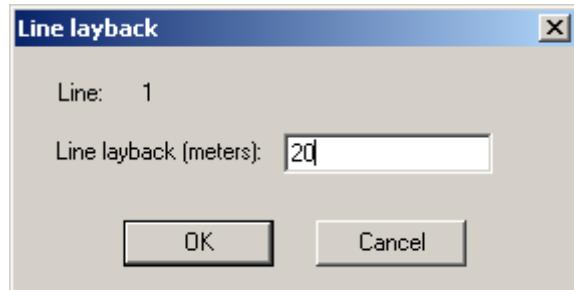

  Check or enter new value (always in meters).
- **Line / layback dialog.** From within GPS window select *Survey setup / Individual line laybacks* as shown below:
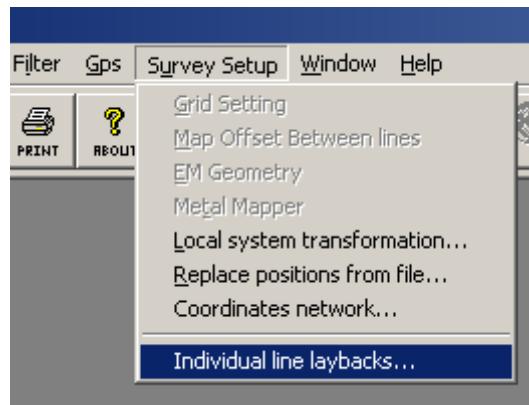
A list of all available line and layback values is shown:
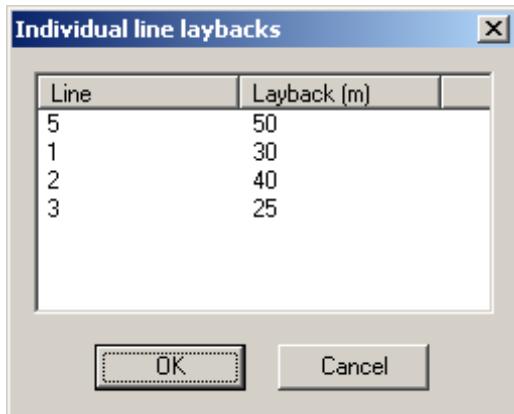
Edit layback values directly in the dialog by clicking on the line number and using keyboard to modify the value.

Note: All layback modification inside MagMap remain valid during a MagMap session, including data export into Surfer or Geosoft formats. They are not saved and will be removed after the survey file is closed. If the layback value (constant or variable) is used it is added to the export file as separate column.

8.1. Setting time offset for GPS / Position window

This section does not apply to land style G-858 documents. It apples to MagLog NT, SURFER and other documents where data and positions are represented by two or more separate windows, neither of them could be closed.

The function is similar to base station time offset setup, but apples to the positions. The function is available from GPS window under *GPS / GPS Time Bias Setup* menu.
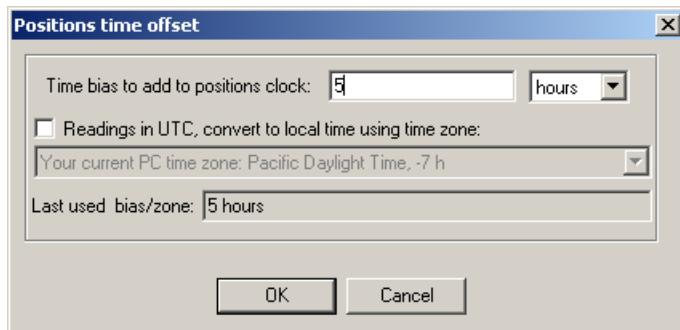
This screen allows you to adjust the position clock to correspond base station or other data clock.

There are two main modes of operation:

- Add bias in appropriate uinits, such as seconds, minutes, hours or days. This is a default mode.

- Assuming positions are in UTC time, apply time shift using set of pre-defined time zones selectable from the list. Check "*Readings in UTC*" button and use droplist below to select approriate time zone. First selection is always local PC time zone, based on time settings for your computer.

The dialog shows last used time bias or zone as a reminder.

Note: Time bias applies to positions ONLY. If readings were originally recorded with the same clock, the same bias needs to be applied to them using data window.

It's important to understand that **MagMap does not store clock bias.** Whenever new data is loaded zero bias is applied by default, but last used time offset is shown in the dialog as a reminder. Clock bias also always applied to the original data. The typical example for instance if user entered -7 hours offset; but then he or she decided that this was wrong and the correct offset needs to be -8 hours. This new value (-8) should be entered into the dialog, but *not* -1. In other words old offset (if any) is not taken into account when new value is entered.

8.2. Smoothing positions

Magmap uses a smoothing spline of the third degree to smooth data.

This feature allows you to smooth your GPS data and get rid of spikes in your position. After selecting the menu option : "*Smooth positions*", you should see a menu such as the one below that lists all of the lines you have in your survey. You will also see series of parameters you can set to manipulate the magnitude and type of smoothing.

We will start with the sample GPS screen below:
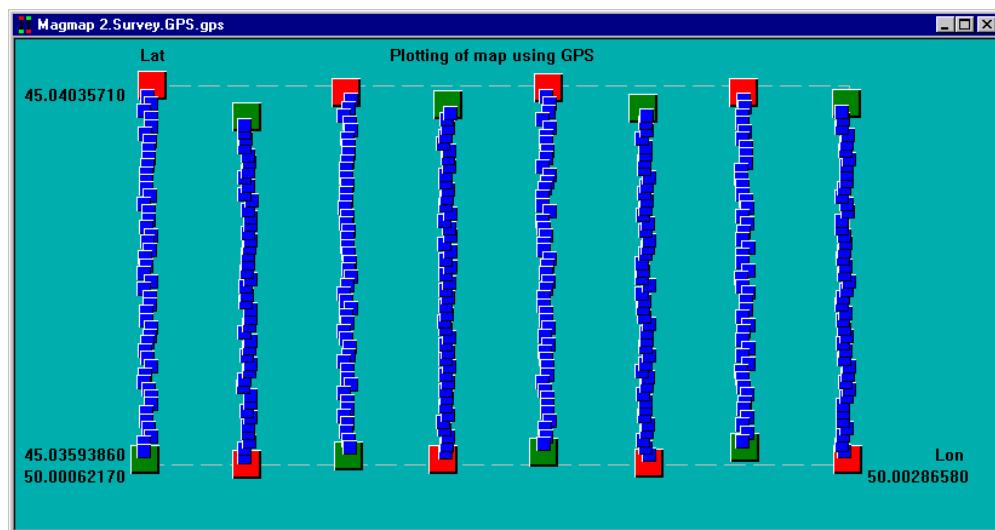
When we pull up the smoothing menu, we get the following:

Line smoothing parameters setup

Line #	Spl.smooth I	Parameter	Despike	Jump,m	Spl.smooth II	Parameter
Line# 0	Yes	4	No	10 m	No	2
Line# 1	Yes	4	No	10 m	No	2
Line# 2	Yes	4	No	10 m	No	2
Line# 3	Yes	4	No	10 m	No	2
Line# 4	Yes	4	No	10 m	No	2
Line# 5	Yes	4	No	10 m	No	2
Line# 6	Yes	4	No	10 m	No	2
Line# 7	Yes	4	No	10 m	No	2

[Change line parameters...]   [Smooth]   [Close]   [Close and apply...]
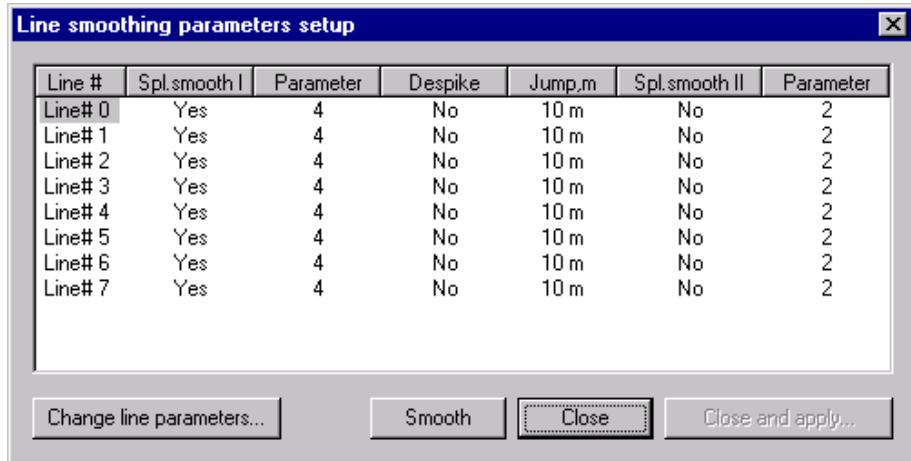
This dialog box gives us a lot of information. It lists all of the lines Magmap has identified and allows you to set individual smoothing parameters for each line.

You can click on any of the parameters (except for "Line #") and change the value. The parameters are:

- **Line #** -- this is the number of the line you will be smoothing.

- **Spl. Smooth 1**: This gives you the option of turning smoothing on or off for a given line.

- **Parameter**: This controls the degree of smoothing.

- **Despike**: This allows you to choose whether you would like to despike before smoothing or not.

- **Jump**: This controls the distance that is considered a "spike".   The program will calculate a smoothing curve. It will then calculate the distance between these smoothed points and your original points. If any of these distances are greater than the distance you specified in "jump", the point will be replaced by the point on the smoothed curve. All other points falling within the "jump" distance of the smoothed curve will be left alone.

Note: It is usually recommended to do a second smoothing after using "jump" to despike because the curve is not actually smoothed. Instead, the first smoothing spline is used only in calculating whether a given point is a spike. If you do smoothing a second time, it will smooth the despiked data.

- **Spl. Smooth II**: This allows you to turn on a second degree of smoothing that will be done after your first despiking and smoothing have occurred.

- **Parameter**: This controls the degree of smoothing for the second smoothing.

Note: You apply any change in parameters (except Line Number) by right clicking on the gray heading buttons. E.g. to change the Despike option, we would press "*Despike*". This will then give a menu that will allow you to change the value and apply the option to all lines.

You can also change the parameters for an individual line by selecting the line and pressing "*Change Line Parameters*". Below we have chosen to edit the parameters for line 4.
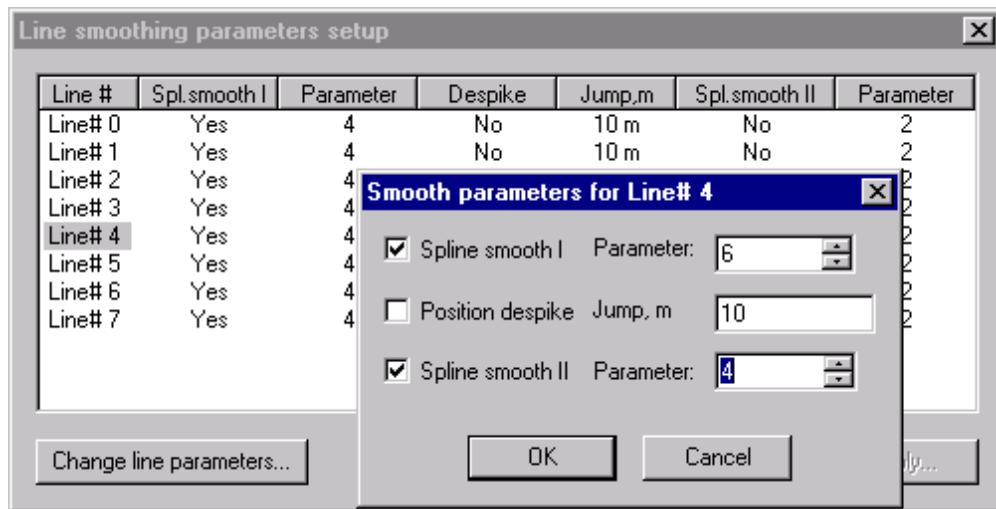

We have changed the first smoothing parameter from four to six (higher degree of smoothing) and turned the second smoothing with the parameter to four. After pressing "*OK*", the changes are reflected in the dialog box.

To smooth the data, we press "*Smooth*". This should draw a series of yellow lines that will show what your smoothed data will look like if you apply the changes.

Note: No changes will be applied until you press "*Close and Apply*". If you don't like the results of your smoothing, you can exit the screen by pressing "*Close*", or you can change the smoothing parameters and press "*Smooth*" again.

For the example data shown before, pressing "*Smooth*" results in the following screen:
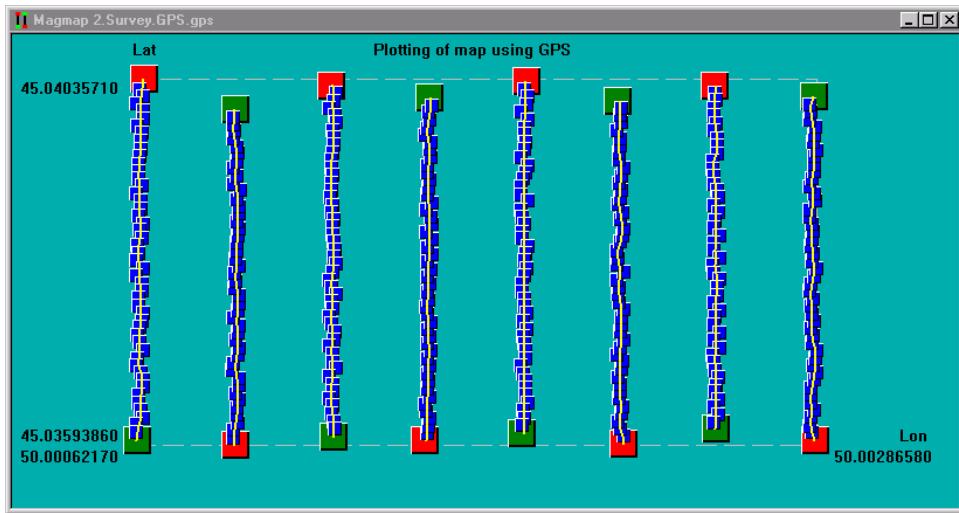
As you can see, line four (fifth from left) appears straighter than the other lines because it has a higher smoothing parameter and the second degree of smoothing is turned on.

If we press "*Close and Apply*", the changes are permanently applied.

Once applied, these changes cannot be undone. You will have to reload your file if you want to undo your changes.

The smoothed data is shown below:
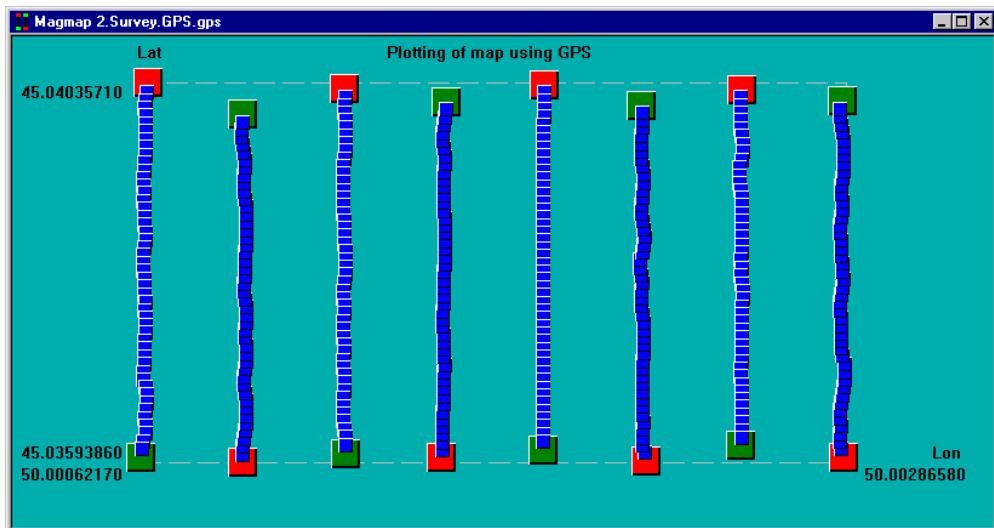
8.2.1. Recommended Smoothing Procedure

We recommend the following for optimum results:

1) Turn off despiking and your second smoothing. Figure out your first smoothing parameter by trying lower numbers first, and higher numbers later. You want your smoothing to be strong enough to minimize any effects of spikes. From here, there are two things you need to think about:

   a) Your data has obvious spikes that you would like to take out.

   - In this case, it is okay if your curve doesn't approximate most of the actual data. You should aim to get a curve that takes out the effects of the spike. The data that falls within the acceptable "jump" limits will not be changed. This data will only be changed on the second smoothing. Go to step 2.

   b) Your data has random error but no obvious spikes.

   - Here you should try to make your smoothed curve approximate your data as much as you can. Try to determine what is due to error and what is true positional reporting, and use small smoothing parameters to make your final path look reasonable. You probably won't need to do any additional despiking or smoothing (e.g. ignore Steps 2 and 3 if you get a reasonable curve).

2) Despike your data: After you have your first smoothed curve, choose a "jump" parameter that will remove the spikes.

3) Smooth your data a second time: If your path still doesn't look acceptable, apply smoothing a second time … probably to a smaller degree than the first. In most cases you will be doing this after despiking so you will want to use a smaller degree of smoothing because your first smoothing had to take out the effects of the spike.

4) If your final path looks acceptable, press "*Close and Apply*".

8.2.2. Warnings about smoothing

Some paths are easier to smooth than others. If you have data with many spikes, or if you have spikes that consist of several points far away from other points, it may be difficult to smooth your data.

If the technique described above doesn't work, experiment with the parameters and see if you can get a path that looks reasonable.

If all else fails, you can always manually delete certain problem points and proceed from there.

8.2.3. References on splines

For more information about splines, you can refer to the following:

<u>The Theory of Splines and their Applications:</u> Ahlberg, J.H., E.N.Nilson, Walsh, J.L, Academic Press, New York, 1967

- This book is out of print but can be found in some online used book stores (e.g. BarnesAndNoble.Com)

8.3. Troubleshooting

8.3.1. Map appears incorrect when using geographical coordinates.

Occasionally there is a problem where an offset was put into the UTM setup, UTM was disabled, but the offset still remains. Sometimes this will affect the map that is created. The easiest way to get rid of this problem is to select UTM, set both offsets to zero and select "OK". This will redraw the map in UTM coordinates. You can then go back into the UTM setup and deselect this item and the map should be redrawn correctly. If this doesn't work, try exiting the program and reloading your file.

8.3.2. Map appears incorrect when using UTM coordinates.

This could happen if you are using the wrong prime meridian. Refer to the section on setting UTM parameters for a better description of solutions. To see how the prime meridian affects the generated graph, you could try setting different prime meridians and seeing how your map changes.

8.3.3. Cannot get origin of grid to correspond to (0,0).

This could happen if you start with non-zero offsets. The easiest way to make the bottom left hand corner of your screen correspond to the point (0,0) is to

In UTM setup, set your northing and easting offsets to 0. Press "OK".

On your GPS map, look for the two numbers on the bottom left of your screen and write them down.

e.g. 500000.00, 6000000.00

Then go into your UTM setup again and input the negative of the first number for your "northing" parameter, and enter the negative of the second number for your "easting" parameter. In the above case, I would use northing = -500000, easting = -6000000. Press "OK" to accept the changes.

Your data should now be drawn correctly.

9.   Other devices

9.1.   Metal Mapper

The metal mapper is a device which can be connected to a G-858 console instead of the magnetic sensor. From a technical point of view, there is no difference between data collected with a true magnetic sensor, and data collected with an EM device – this means that Magmap will not be able to distinguish between the two different types of data and it is up to the user to tell the program what to do.

However, this data should be treated differently.

9.1.1.   Opening a Metal mapper data file

To tell Magmap how to correctly interpret the metal mapper file, the following procedure should be used when opening a file:

1) Download data from the G-858 console as it is described for the magnetometer. However, check the button "*Download only, decompress later.*" The result will be a binary file on your hard disk.

2) Go to "Open" (on the file menu). Select "Metal mapper binary files" in the dialog box. If you do not do it, Magmap will assume that your file is a magnetometer file.

3) Load the file as usual. Note that the menu item, "*Metal mapper*" under "*Survey setup*" is available.

Like the magnetometer, the metal mapper has two sensors, but it does not have a pseudo gradient. As soon as you have worked once with metal mapper files, binary files that are in your history list are treated as metal mapper files. This changes after you work with the magnetometer again.

9.1.2.   Treatment of Metal mapper data

The recommended treatment of Metal mapper data is as follows:

1) For each line, calculate the median value for each sensor and subtract this from the data.

2) Create a set of new readings by summing the absolute values of both metal mapper channels. These new values will replace the readings for sensor one and the readings for sensor two will be equal to 0.

3) Plot or map this new synthetic field.

To do these transformations, go to "*Survey setup / Metal mapper*". The following dialog should appear on the screen:
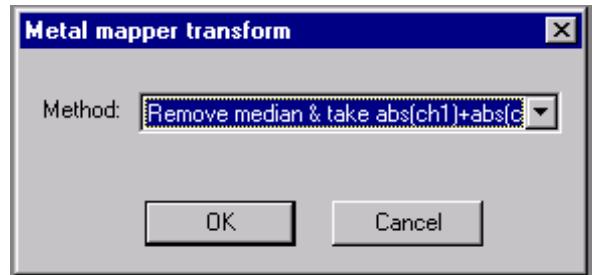
Choose "*Remove median & abs(ch1) + abs(ch2)*" and press OK. The data will be transformed and all of your views will be updated accordingly. If you save your data now, the transformed data will be saved.

If you want to undo this action, go to "*Survey setup*" and choose "*Original Readings (intact)*" as shown in the dialog box below:
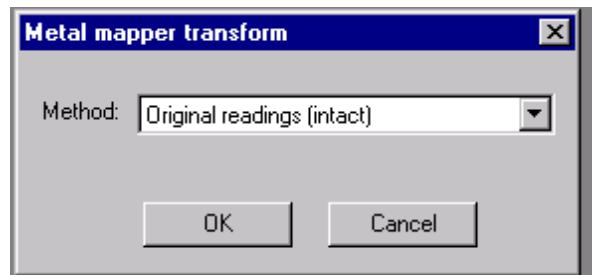
After you have pressed OK, all data will be restored and views updated.

Note: This option is not available if you load an ASCII *.stn* file. Hence, you will not be able to reverse any changes once you save to a .stn file, and then load this file.

---

10. Using Multi-Telegram messages with MagMap

Some devices used during marine or airborne surveys can produce multi-telegram messages. Most common example is the GPS with its variety of NMEA strings. Depending on GPS model and configuration, it can produce GGA, VTG, GLL, etc messages.

These messages could not be used with MagMap in the past. However newest software version allows handling of such devices. Here we provide and example how GPS stream can be used to extract VTG messages and include results in the MagMap200 export output file.

It's important to understand that MagMap uses prefix to select strings of interest. If beginning of data string matches to the user-provided prefix, data is accepted (or rejected, depending on policy). Then data is parsed the same way as for Generic Serial Device. Channel names can be assigned by default (in this case program counts all available channels) or can be defined by the user. In latter case some of the data channels could be omitted (for instance, only speed could be extracted from the VTG message and meaningful channel name can be assigned).

Below this kind of data is referred as "prefixed data". GPS VTG message is used below as an example, but procedure works the same way for any kind of prefixed data.

To use this feature (sequence of operation is not important) either of following conditions should be met:

- At least one GPS or SURFER file should be loaded. Those files should refer to the same time interval as prefixed data.

- MagLog Survey file should be loaded. This includes GPS, line number file, magnetometer (or other devices). After all this information is loaded, prefixed messages could be loaded from the same GPS file.

- Prefixed data should be acquired with MagLog program, or at least have time stamps at the end of the message. Time should sequentially increase.

As a result, user is able to export speed values with its positions, pretty much the same as it is done for magnetic field.

10.1. Example: using GPS VTG messages.

In this example we load speed values from GPS VTG messages in addition to all other information included by default into MagLog survey. Prefixed data could be loaded after or before main survey data.

To start loading prefixed data, go to *File / Open* menu and select file type as *Generic Prefixed Serial Data* as it is shown on the following screen shot:
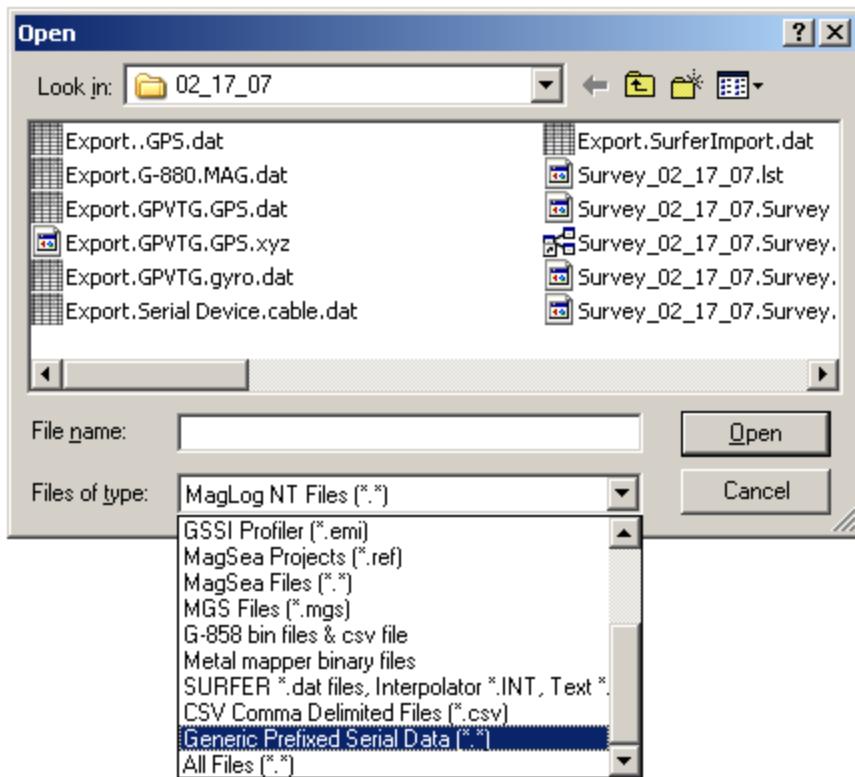
Then select file you wish to load, for instance GPS file (it also contains VTG messages). Program will show preview of the file (first 20 strings) and allow prefix definition as it shown here:
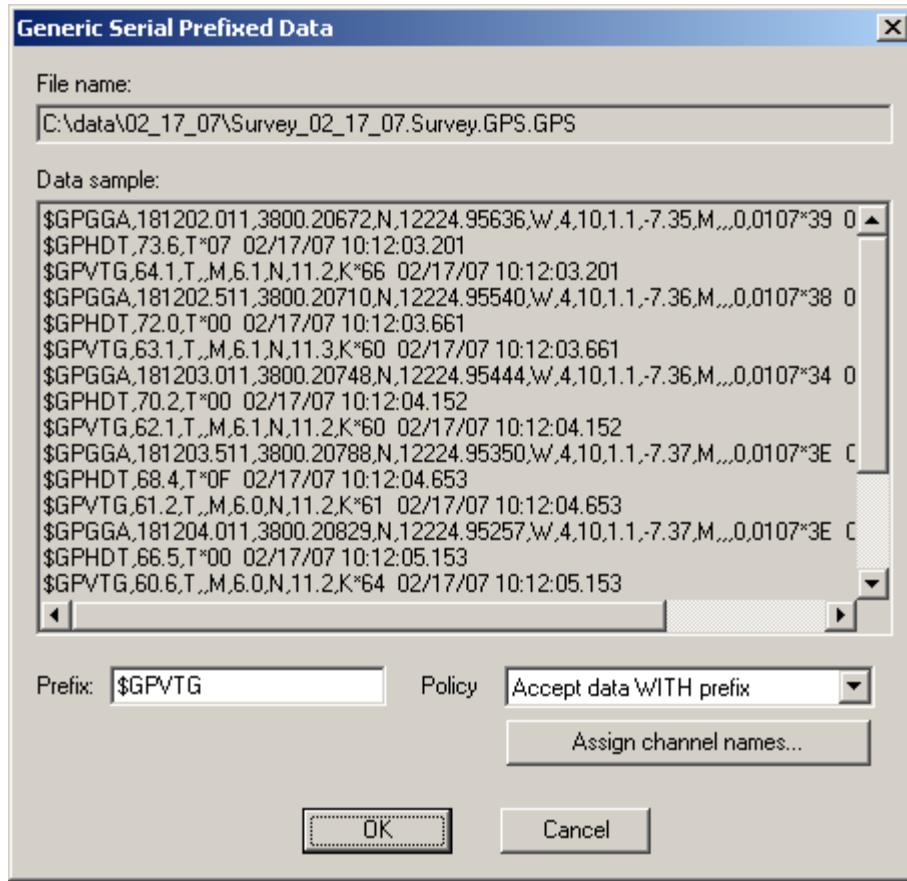
To define prefix, type "$GPVTG" and select *Policy* as *Accept data WITH prefix*. It means all other strings in the file are ignored.

As defined by NMEA VTG messages has the following type of information: heading (degrees from true or magnetic North) speed over the ground (knots), speed over the grounds (kilometers per hour). As an NMEA message, it also has checksum. It means by parsing this message program will produce for channels. Last channel (checksum) is meaningless. Be default channels have names CH1, CH2, CH3 etc.

Those default names can be re-assigned by pressing *Assign channel names* button. Assignment dialog is displayed as the following:
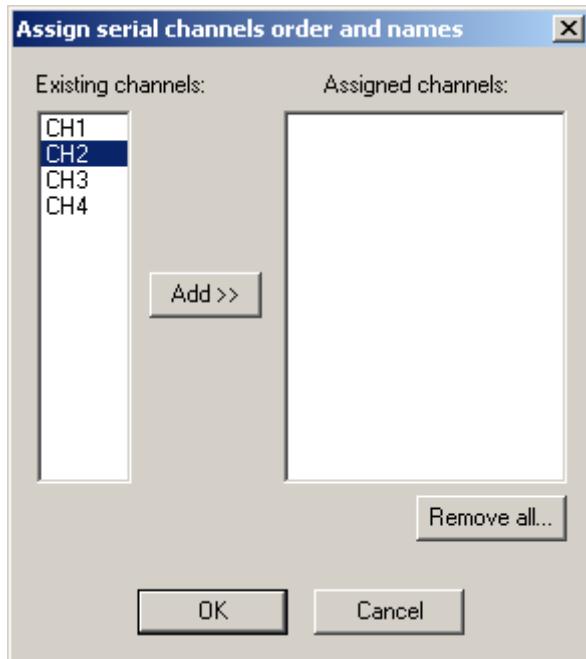
Use this dialog to re-assign channel order and names. If any of the assigned channels are defined (right pane of the dialog is not blank) they are used in place of defaults. In no channel is specifically assigned (right pane of this dialog blank) then default names from the left pane are used. In this example we only want to get speed in knots (channel #2) so select CH2 on the left and press *Add* button. Type desired name as shown (no spaces please):

Then press *Ok* button. Dialog displays the change:
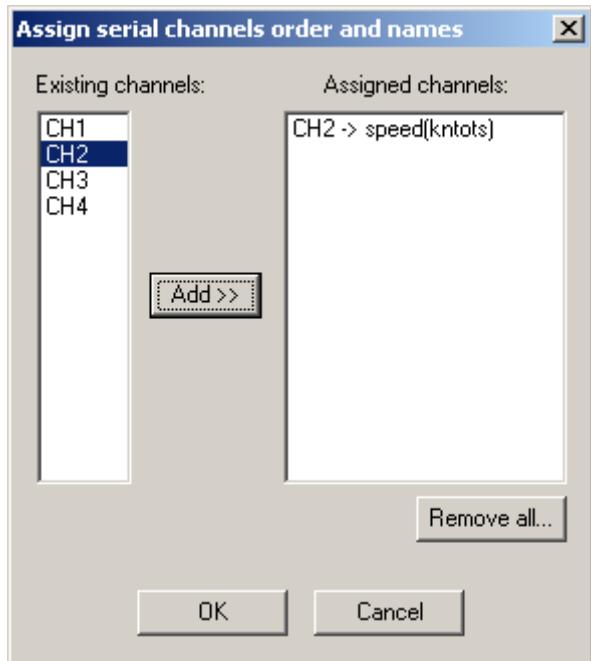
Press *OK* to complete assignment, and then press *OK* one more time to load actual file. Progress dialog is shown on the screen:
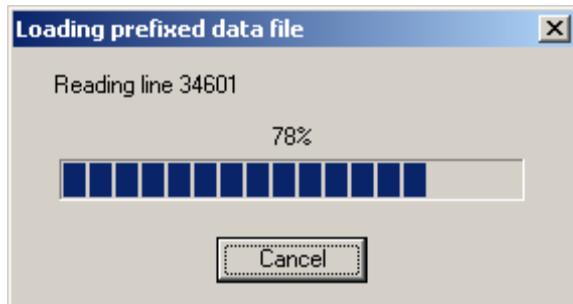
File is loaded the same way as MagLog NT *Generic serial device* file. When load is completed, graph window is shown on the screen (in addition to other data windows). Note that you should not close this window till you complete data processing. You can perform all kinds of operations with these data. The window is shown here:

Now, when all other data loaded and is ready for export, you can see speed in the export list:
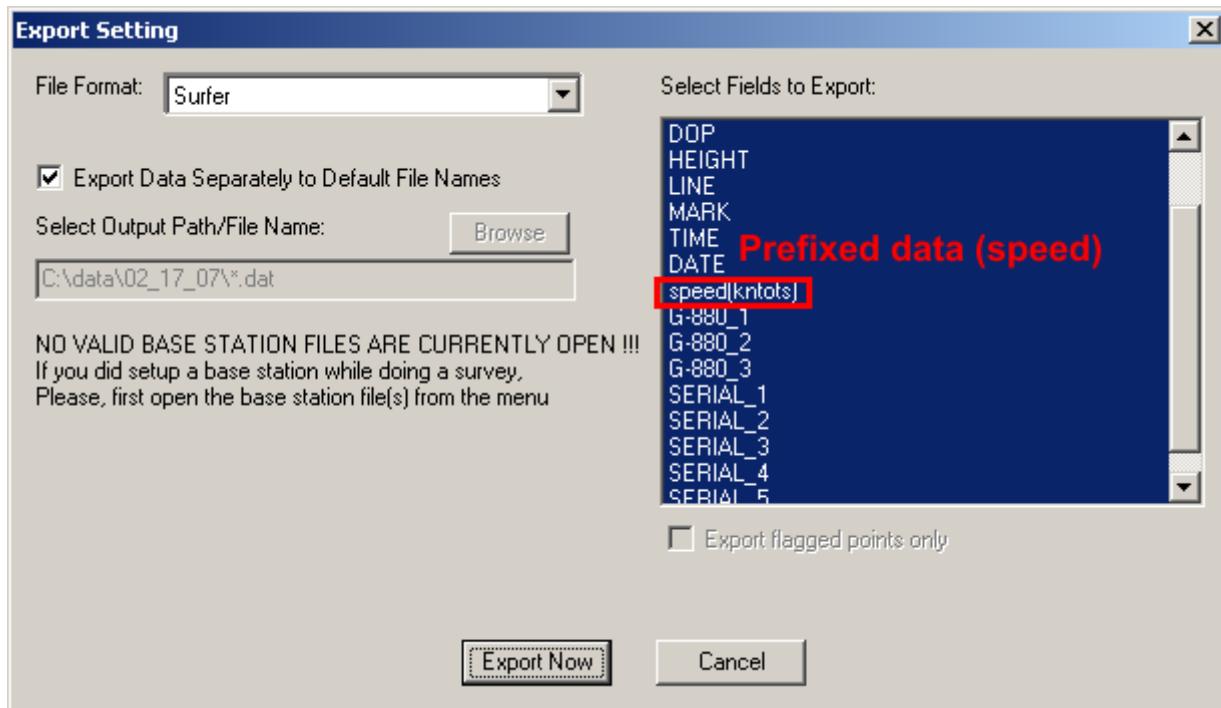
If data is exported into separate files with default file names, prefix is used as part of this filename (except non-alphabetical characters, such as "$" in this example).

This example (speed values) is mostly for QC purposes (for instance, one could check what was actual speed during the survey). More practical example would be to use height measurements from GGA message. Those are taken in already, but only if other data (such as magnetic field) is present. Let's assume

the survey where GPS is the only device, and the goal is to plot an elevation map. Loading GPS data into MagMap as usual, and then loading GPS again as prefixed data can achieve this.

> Note: This may not work as expected, if GPS during the survey loses some of the fields in its GGA message (for instance, due to poor satellite coverage). This will shift channels in the message and some other channel can substitute height, which is not desirable.

11. Other utilities

11.1. BintoAsc utility

G-858 files have a binary format and therefore it is impossible for the user to modify them. However, sometimes it is necessary to access the data directly (this might be due to a hardware problem), or if the user wants to do data manipulation outside of Magmap.

The *BintoASC* utility allows the user to convert the binary data file to an ASCII file and save it.

Note: If the user uses Magmap to save ASCII data, often data like GPS data or serial data logged onto the console will not be saved in the same file.

To use this feature, go to the *File* menu and select *Binary 858 ->ASCII*.   You should see the following dialog:
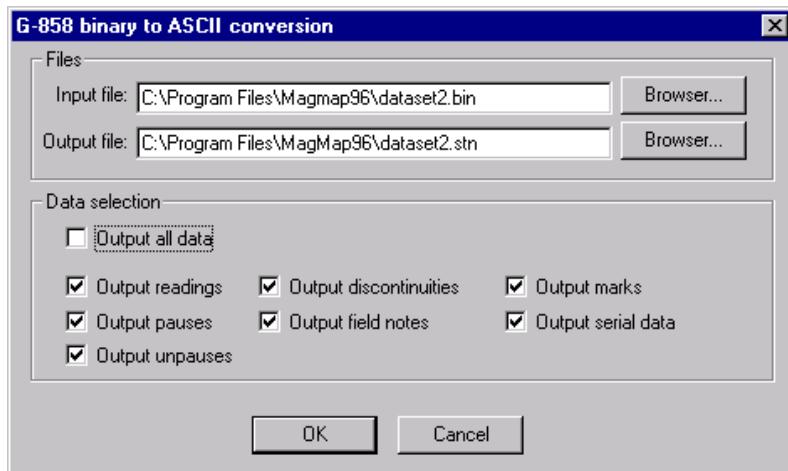
Here you can select the input and output file names. Additionally, you can select if you want to output all your data, or output specific types of readings.

When you press "*OK*", the program will run a conversion routine and create your output file. You are free to load this file into Magmap or use it for other purposes. Please see the G-858 manual for the description of the formats of the above types of entries.

11.2. GPS Interpolator

11.2.1. Introduction

This utility is used to assign locations to large marine or airborne Maglog NT data files using interpolation of GPS positions. Such large files are not well handled in MagMap and should therefore be processed in   Surfer or Geosoft type programs.

Features:

- Processes binary and text data files.
- Text data files can be processed as original, Surfer, or Geosoft, format.
- Original data files remain unchanged.
- Locations can be output as geographical or plane coordinates. A choice of 12 pre-defined ellipsoids or a user-defined ellipsoid can be applied to UTM conversions.
- UTM parameters can be stored to and read from a text response file.

Magmap provides a wizard to simplify use of this utility. It can be accessed by selecting the menu item "*Interpolate GPS wizard*" located in the *File* menu.

11.2.2. Select Input and Output Files

After you have selected "*Interpolate GPS wizard",* you should see the first panel of the wizard that allows selection of input files, input file format, output file, and output file format.
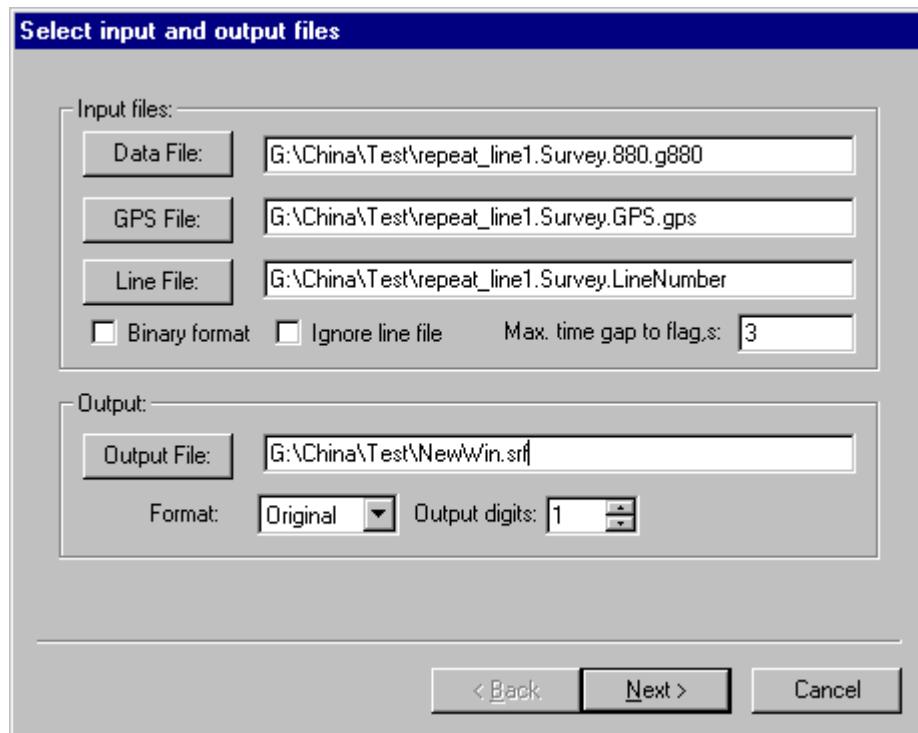
- Data file: name of the MagLog NT data file to be processed. Most of the data files are in ASCII (text) format. Data files from the GR-820 spectrometer are in binary format. These files will contain GR-820 as part of the filename. Data file records must end with a MagLog NT time stamp formatted as _MM/DD/YY_HH:MM:SS.sss.
- Gps_file: name of the MagLog NT location data file to be processed. This file will usually contain 'GPS' as part of the filename. GPS file records must contain NMEA $GPGGA data and end with a MagLog NT time stamp formatted as _MM/DD/YY_HH:MM:SS.sss. If GPS records contain '*', the GPS checksum will be verified.

A sample acceptable GPS reading is shown below:

$GPGGA,114804.00,1838.5075,N,11228.2062,E,1,8,01.0,+00058,M,+00052.9,M
08/10/99 09:05:02.530

- Line_file: name of the MagLog NT line file to be processed. This file will
  contain the line number as part of the filename.

  This file is created by Maglog NT and should list the times that each line
  starts and stops. A sample line file is shown below:

```
START LINE 0  08/10/99 09:05:02.251
STOP  LINE 0   08/10/99 09:05:20.440
START LINE 1  08/10/99 09:05:25.074
STOP  LINE 1   08/10/99 09:05:38.507
```


11.2.3. Interpolating Other Data Sets

It is possible to interpolate additional data sets to the magnetometer time using the MagMap GPS
Interpolator Wizard. This involves a simple linear interpolation based on time stamps in the data
files to be interpolated and a magnetometer data set with time stamps (time stamps means that
every reading has a time associated with it when it arrived at the computer). For example, one
could interpolate fluxgate magnetometer data acquired during an airborne survey to the main
cesium magnetometer times. This interpolated data set could then be used for Compensation
processing.

This feature cannot be used for binary data.

Pressing the "Next" Button brings up the following screen:
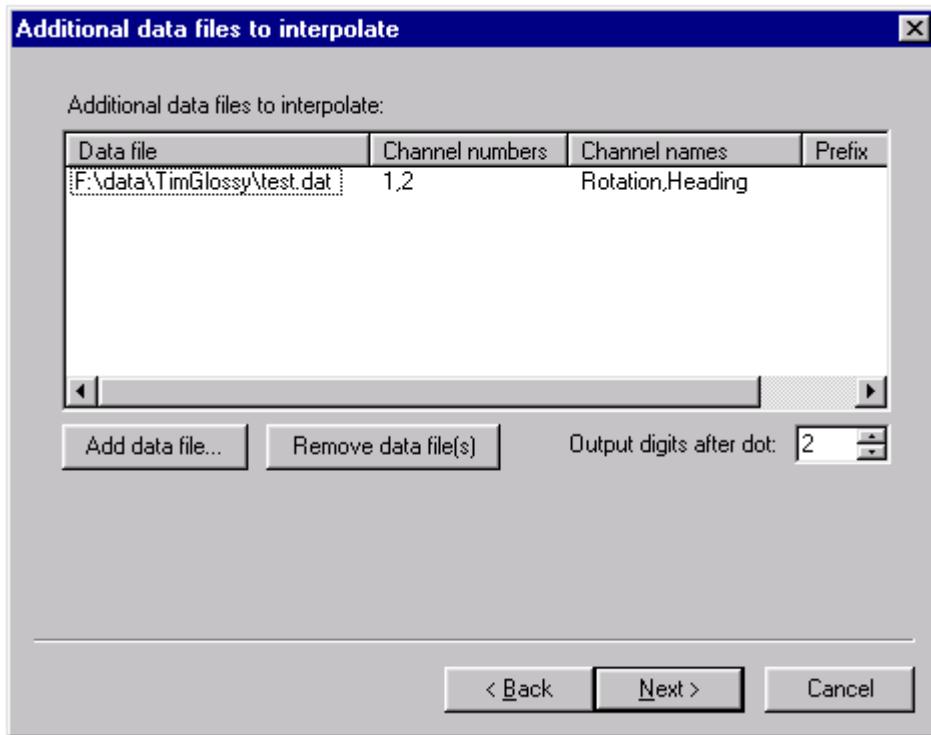
If there is no need to interpolate additional files, simply press "Next" to advance to the next screen.

The middle of the dialog box is initially blank. Files are added by clicking on "Add data file…" and removed by using the "Remove data file(s)…" button. Press "Add data file" button to add new data file to the list. First a standard "Open file" dialog appears where the name of an existing file will be selected. Then a second dialog box appears where

fields in the file will be specified.
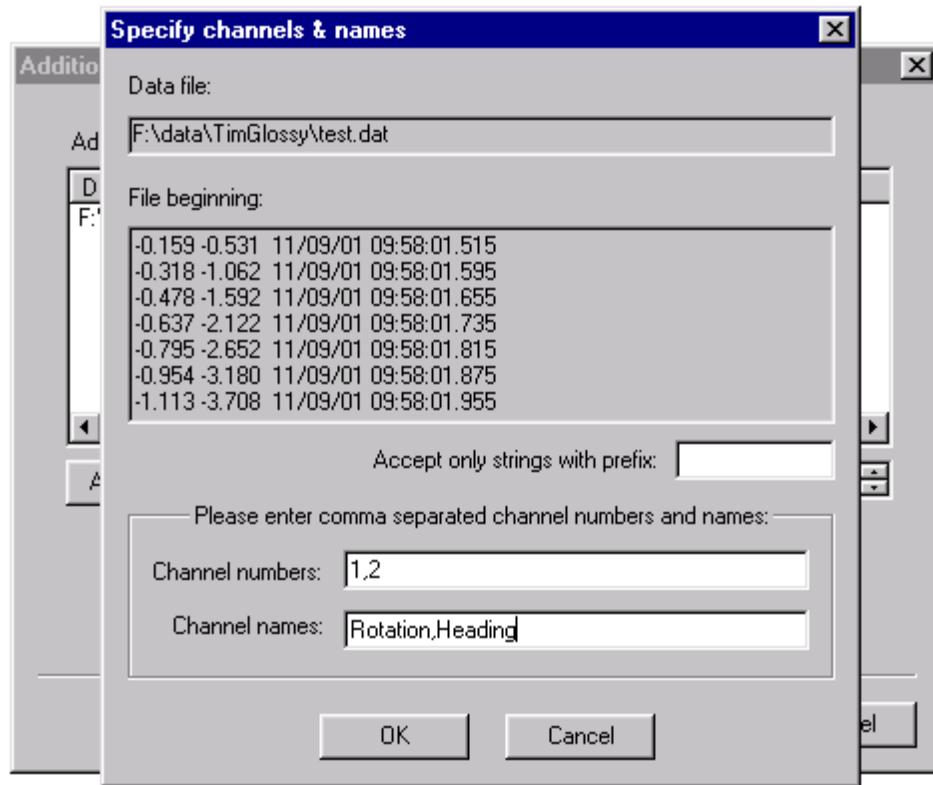
The data file name is listed in the upper box and the beginning of the file is listed in "File beginning" box so the user can make decisions about which parts of the messageto use for interpolation.

Use the <u>channel numbers</u> dialog box to specify which "channels" (columns) are to be interpolated. It is possible to specify more then one channel using a comma separated list. Magmap uses the same parsing rule as MagLogNT, i.e., any character that is not a digit, dot or sign is interpreted as field separator.

Names should be assigned to the channels using the <u>channel names</u> enter field. Use a comma-separated list to specify the names for more then one channel. No spaces are allowed in the channel name designator box. These names will appear in the headers of Surfer or GeoSoft interpolated output files.

The use of the <u>prefix</u> designator allows filtering of multi-message files. When the prefix is left blank, all strings in the file are used for interpolation. A prefix causes the program to accept only strings that start with the designated prefix.

<u>Example:</u> Typical GYRO compass file acquired during marine survey:

$HEHDT,180.3,T*25 06/23/01 09:12:24.730

$HEROT,17.5,A*18 06/23/01 09:12:24.746

The task is to have both fields (HEHDT and HEROT) interpolated to the magnetometer time and appear in the interpolated output file as two columns.

Procedure: Press "Add data file" on the Wizard's screen and select GYRO compass file. Enter prefix "$HEHDT" in the prefix field, enter the channel number as 1 and type the channel name as "Heading". Then press "Add data file" again and select the same file. Now use "$HEROT" as prefix, set the channel as 1 and the name as "Rotation". With this setup the program will read the input file twice: once taking only heading strings and a second time taking only rotation strings. Both these variables are interpolated to the magnetometer time and appear in the resultant file as two separate columns with the names "Heading" and "Rotation".

11.2.4. Select UTM transformation parameters

The second panel allows input of UTM translation parameters.
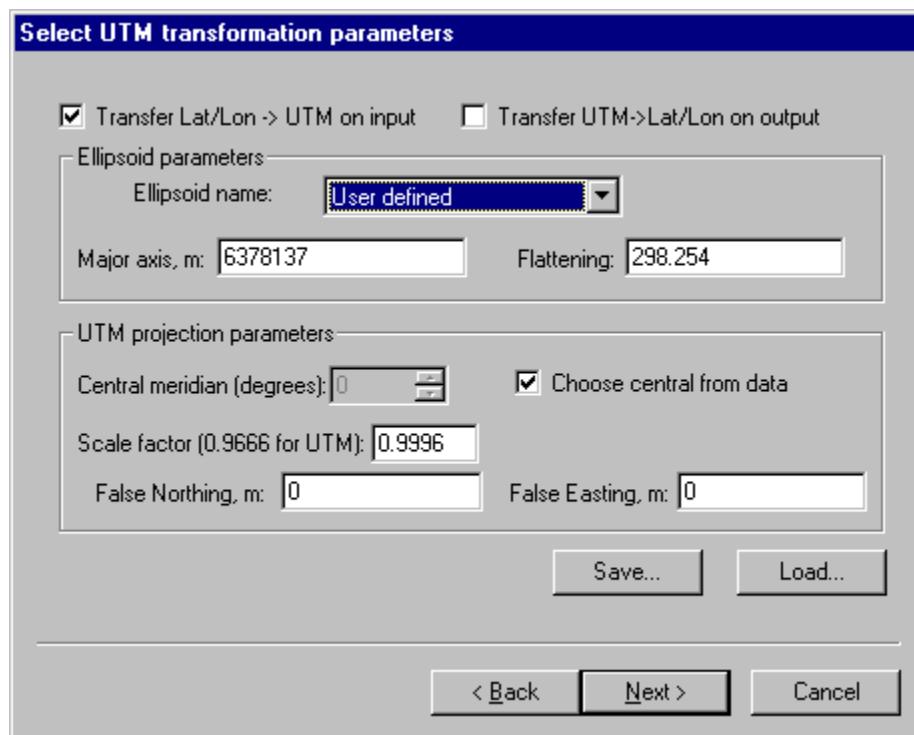
The 'Transfer Lat/Lon -> UTM on input' check box must be checked to enable the other items on this panel. If this box is not checked, GPS_Interpolator operates with unchanged geographical coordinates which results in less accurate positions.
The 'Transfer UTM -> Lat/Lon on output' check box us used to generate accurate interpolated locations in geographical coordinates.

Ellipsoid parameters section:

The '*Ellipsoid name*' list box allows choice of 12 pre-defined ellipsoids or a user defined ellipsoid. Pre-defined ellipsoids include WGS 84, GRS 80, WGS 72, Australian 1965, Krasovsky 1940, International 1924, Hayford 1909, Clarke 1880, Clarke 1866, Airy 1830, Bessel 1841, and Everest 1830.

'*Major axis*' and '*Flattening*' text edit boxes are enabled only for user defined ellipsoids.

UTM projection parameters section:

- Central meridian (degrees) - text edit box is used for manual entry of the Central meridian to be used for location conversion. This box is disabled when '*Choose central from data*' check box is checked.

- Choose central from data - causes GPS_Interpolator to automatically determine central meridian from the first GPS data file record. Automatically determined central meridians are chosen by UTM Zones on six degree centers.

- Scale factor - should usually be left at 0.9996. The text edit box is provided for the rare case where a different scale factor can be useful.

- False Northing, m, False Easting, m - allow entry of offsets to calculated *Northing* and *Easting* UTM coordinates.

- Save... - allows storage of UTM transformation parameters in a file.

- Load...- allows loading of UTM transformation parameters from a file.

For more discussion on individual UTM parameters, please refer to the UTM discussion in the Magmap manual.

11.2.5. Run Interpolation

The third panel is used to start the interpolation process using parameters set on the first two panels.
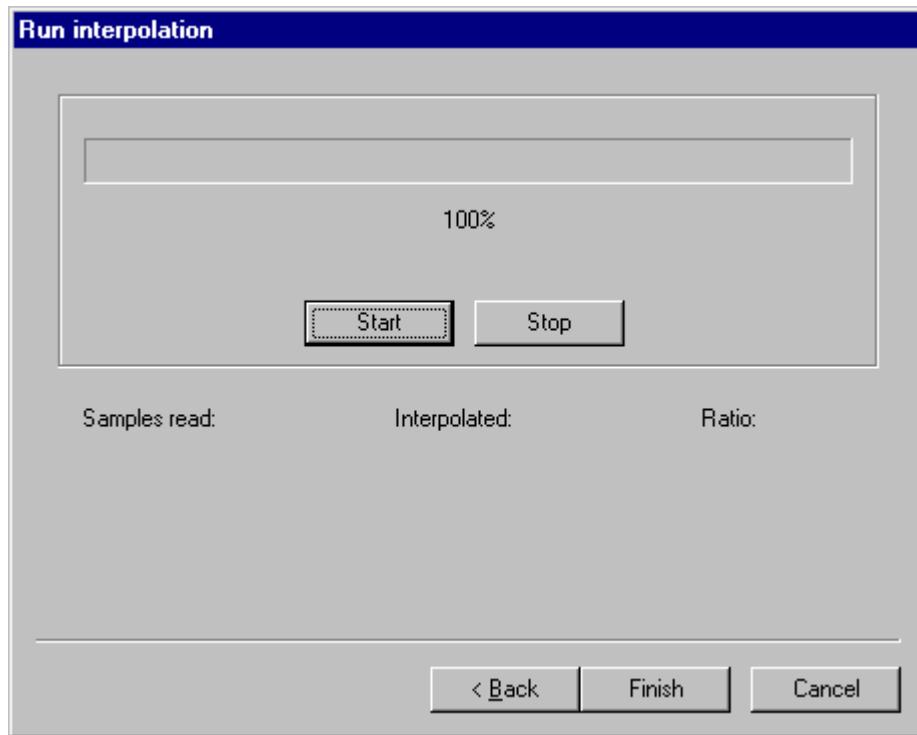
- Start - initiates the interpolation process. When the process is finished, GPS_Interpolator remains running and ready for additional work.
- Stop - interrupts a running interpolation.
- Samples read - the number of input data records.
- Interpolated - the number of interpolated output data records.
- Ratio - ratio of 'Interpolated' to 'Samples 'read'. Ratio should be close to 100% with a good data set.
- Finish - starts an interpolation process and closes GPS_Interpolator when the process is finished.

11.3.   G-860 STN Converter

The G-860 magnetometer records data in separate files similar to the way data is recorded with Geometrics' MagLog recording software. You must use STN format data when you wish to process data using internal coordinates rather than GPS coordinates. The G-860 STN Converter utility makes a copy of a recorded data set in

G-858 STN compatible format that includes Marks, Pauses, and End Lines. The converter can be accessed through *File->Utilities>-g-860 STN converter...* as shown below.
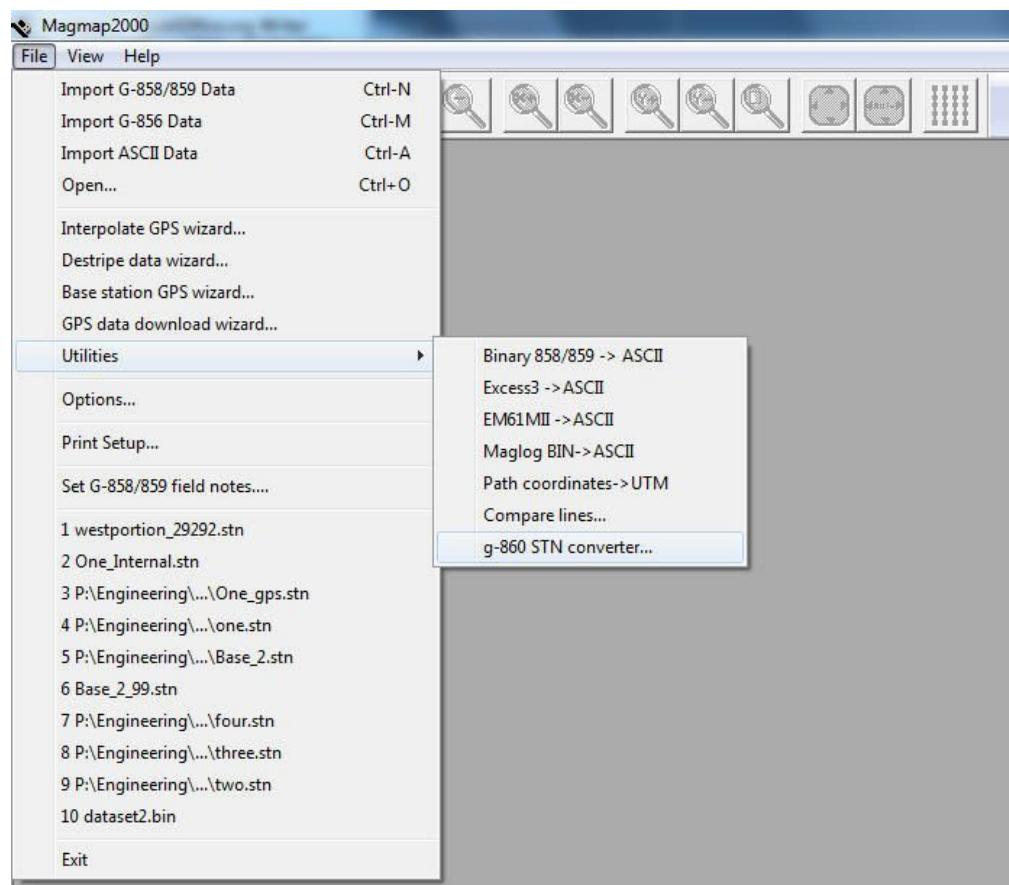
The STN converter dialog will appear. Click on the top Browse button, indicated by … to browse to the Survey file to be converted. Note that you must click on this button to select a file as typing in the Survey file: is not allowed.
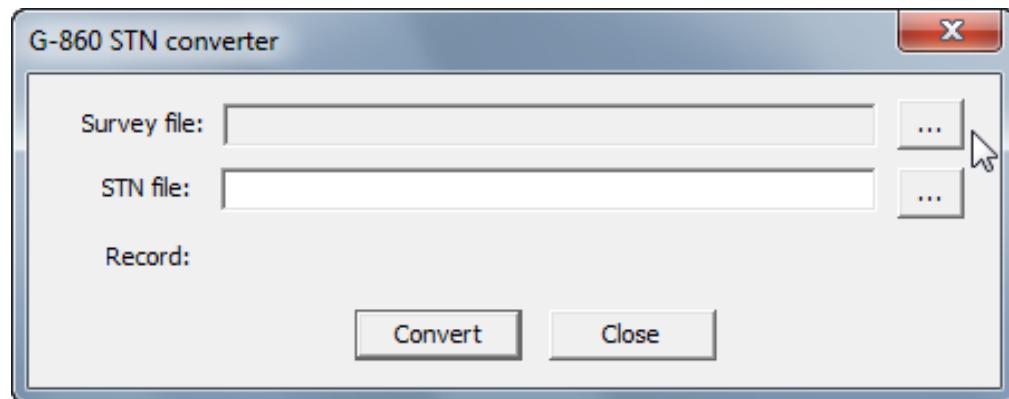
A browse window displaying available Survey files will open.
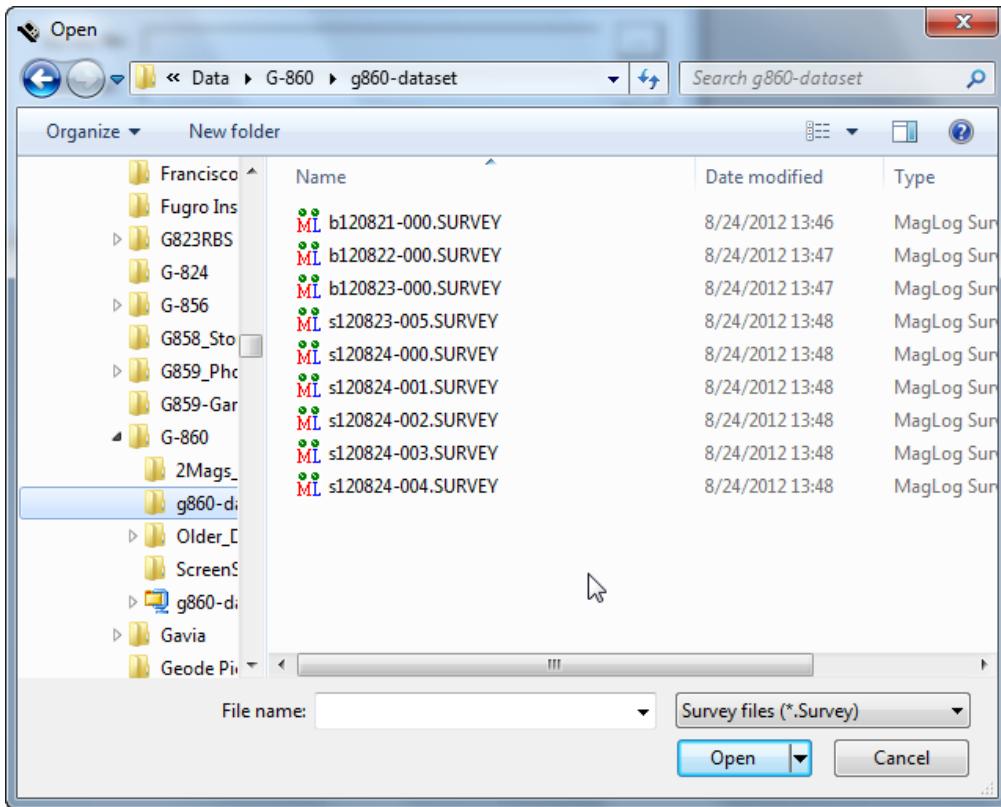
Files beginning with the letter, b, are base station files. Files beginning with the letter, s, are survey files. Choose a file and click the Open button to select.

Now you can click the STN file: browse button, indicated by … to browse to the location where you wish to place the converted file, and enter a file name. Note that the converted file does not have to be in the same folder as the Survey file.
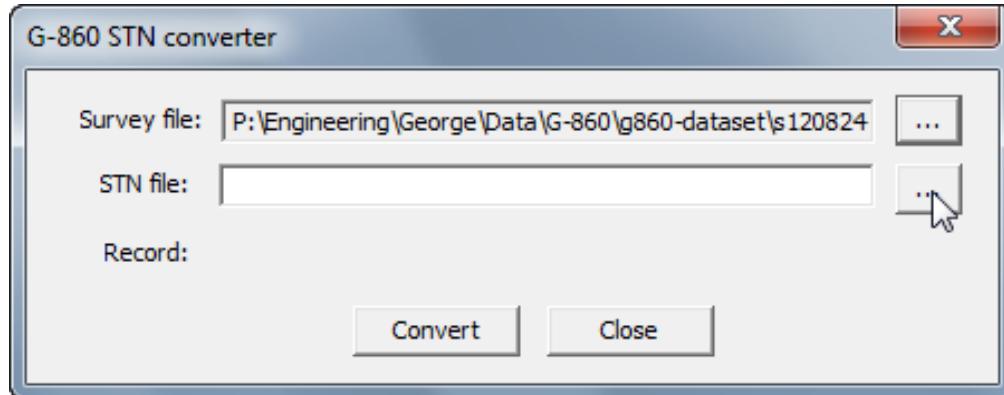
Click the OK button after browsing to a directory and entering a filename.
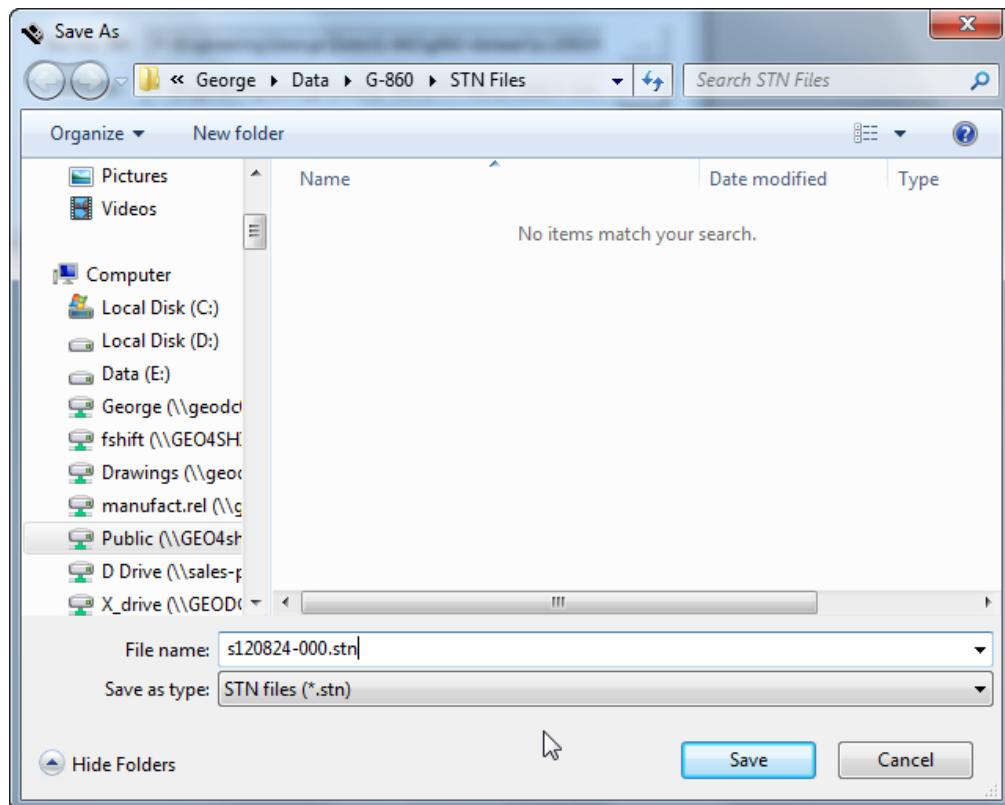
The G-860 STN converter dialog now has entries for both Survey file: and STN file:. Click Convert to finish the operation.
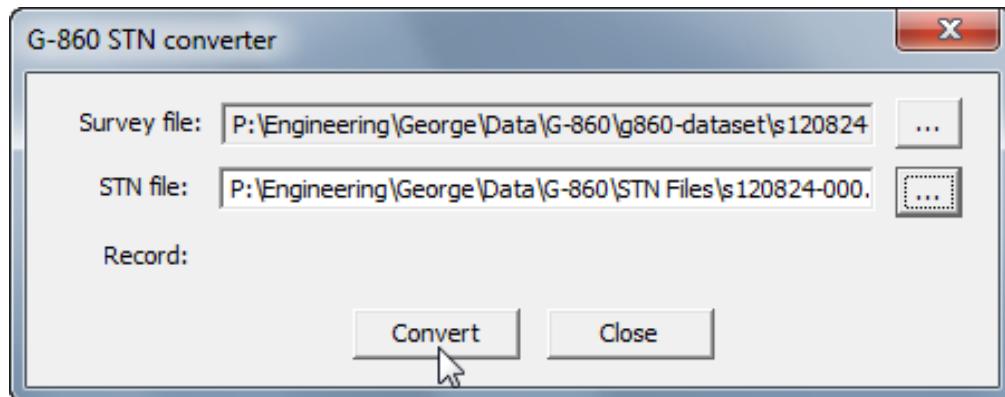
The G-860 STN converter dialog will stay open until you click the close button to simplify converting multiple files.

Once you have finished converting G-860 Survey files, you can use MagMap Open button on the tool bar to open an STN file for processing. STN files containing base station data will automatically open in a profile window. STN files containing survey data will cause the 858 Survey Information dialog to open.
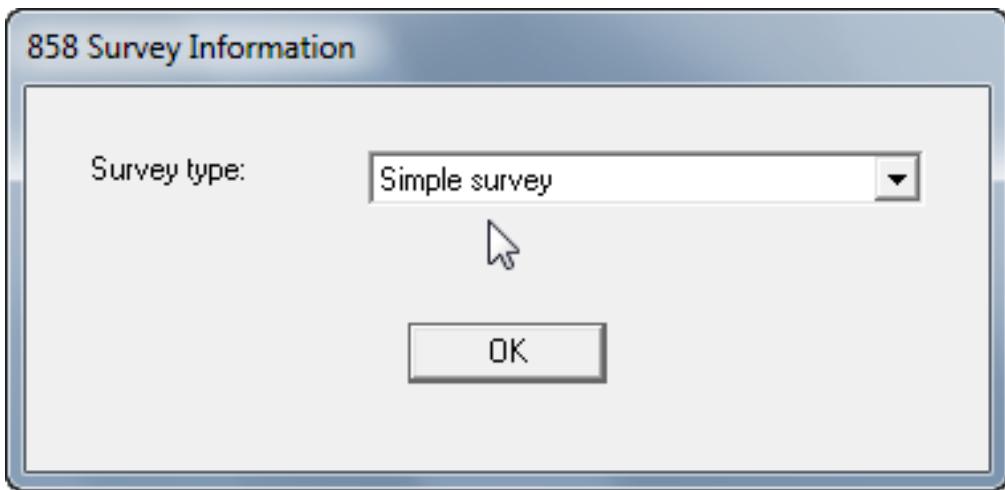
Choose Simple survey from the drop down list and click the OK button to
open the map window; then continue processing as normal.

12. Exporting to Geosoft or Surfer

Before you export, you should be aware of which type of survey you are dealing with. This is important because different options are available for different types of surveys and the export menus and procedures appear quite different.

Each of the following sections will define the type of surveys that are supported.

12.1. Exporting a land-based survey

This export procedure covers the export menu that you will see for land-based surveys:

This includes

- Surveys done without GPS (only mapped coordinates available)

- Surveys done with GPS where you drew the GPS map using the option "*Draw new GPS map using the features of a regular 858 survey*".

To export your survey to Geosoft Analysis and Plotting Software or Surfer, you must have an open survey file.

When several survey files are open, you must select the survey you want to export by selecting the window (just click the mouse button anywhere in the window).

If you used a base station and want to do a diurnal correction to your data, you must also open every base station file which covers the range of times desired.

Once you have an active survey, select "Export" from the File menu item or right click the mouse button inside the grid and select "Export" from the pop up menu.

The following export dialog box (Figure 69) will appear on the screen.
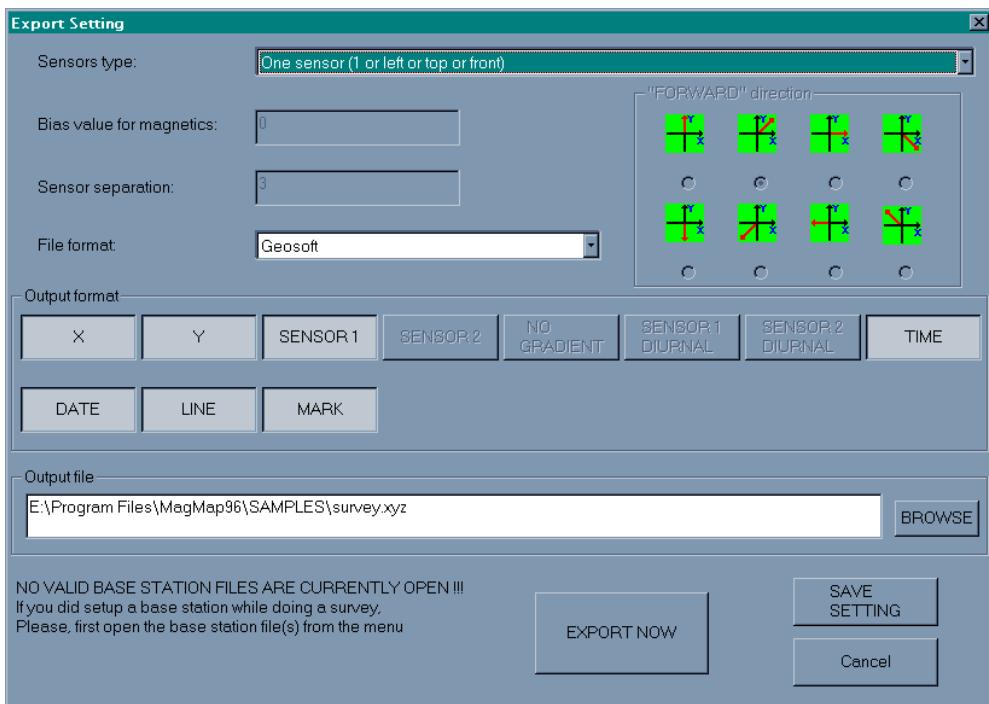
Figure 69

12.1.1. Setting the type of survey

You can change the grid parameters that you already entered as described in paragraph 3.5, page 36.

In the case of mapped survey mode, you can redefine your grid. This will change the coordinates of every position acquired in your survey. You should only use this feature if you set up invalid grid information in the G-858 magnetometer before doing your survey, such as invalid line or mark spacing.

In the "Sensor type" combo box choose the configuration of your sensor(s):

12.1.1.1. ONE SENSOR (1 OR LEFT OR TOP OR FRONT)

You had one sensor only, and it was connected to the first connector.

12.1.1.2. ONE SENSOR (2 OR RIGHT OR BOTTOM OR BACK)

You had one sensor only, and it was connected to the second connector.

12.1.1.3. HORIZONTAL GRADIENT (RIGHT - LEFT WHEN WALKING ACCORDING TO "FORWARD" DIRECTION)

You had two sensors (second sensor on the right of the first sensor).

You want the horizontal gradient with the **left** sensor magnetic field subtracted from the **right** sensor magnetic field when you walked according to the picture defined in "FORWARD DIRECTION".

For example, if you set the "FORWARD DIRECTION" to the first item (line going up in the increasing Y direction):

Every survey line going in that direction will have the gradient computed as the following: **right -left**.

Every survey line going in the opposite direction will have the gradient computed as the following: **left -right**.

12.1.1.4. HORIZONTAL GRADIENT (LEFT - RIGHT WHEN WALKING ACCORDING TO "FORWARD DIRECTION")

You had two sensors (second sensor on the right of the first sensor)

You want the horizontal gradient with the **right** sensor magnetic field subtracted from the **left** sensor magnetic field when you walked according to the picture defined in "FORWARD DIRECTION".

For example if you set the "FORWARD DIRECTION" to the first item (line going up in the increasing Y direction):

Every survey line going in that direction will have the gradient computed as the following: **left - right**.

Every survey line going in the opposite direction will have the gradient computed as the following: **right -left**.

12.1.1.5. VERTICAL GRADIENT (TOP - BOTTOM)

You had two sensors, one on top of the other.

You want the vertical gradient with the **bottom** sensor magnetic field subtracted from the **top** sensor magnetic field.

12.1.1.6. VERTICAL GRADIENT (BOTTOM - TOP)

You had two sensors, one on top of the other.

You want the vertical gradient with the **top** sensor magnetic field subtracted from the **bottom** sensor magnetic field.

12.1.1.7. LONGITUDINAL GRADIENT (REAR - FRONT WHEN WALKING ACCORDING TO "FORWARD DIRECTION")

You had two sensors, second sensor in front of the first sensor.

You want the longitudinal gradient with the **front** sensor magnetic field subtracted from the **rear** sensor magnetic field when you walked according to the picture defined in "FORWARD DIRECTION".

For example if you set the "FORWARD DIRECTION" to the first item (line going up in the increasing Y direction):

Every survey line going in that direction will have the gradient computed as the following: **rear - front**.

Every survey line going in the opposite direction will have the gradient computed as the following: **front -rear**.

12.1.1.8.LONGITUDINAL GRADIENT (FRONT - REAR WHEN WALKING ACCORDING TO "FORWARD DIRECTION")

You had two sensors, second sensor in front of the first sensor.

You want the longitudinal gradient with the **rear** sensor magnetic field subtracted from the **front** sensor magnetic field when you walked according to the picture defined in "FORWARD DIRECTION".

For example if you set the "FORWARD DIRECTION" to the first item (line going up in the increasing Y direction):

Every survey line going in that direction will have the gradient computed as the following: **front -rear**.

Every survey line going in the opposite direction will have the gradient computed as the following: **rear - front**.

12.1.1.9.2 SENSORS TO COVER 2 LINES

You had two sensors, with the second sensor on the right of the first sensor.

You do not want the horizontal gradient, but instead assume that each sensor covers one line (to get a better land surface coverage). Often used for archeology and UXO surveys.

12.1.2. Setting bias for magnetics

If you have selected a gradient survey you can add or subtract to the gradient a constant magnetic field.

In the "bias value for magnetics" just type any positive or negative value you want to <u>add</u> to the gradient.

12.1.3. Setting the sensor separation

If you have selected a survey with two sensors, type in this field the distance between the two sensors (this unit should be consistent with the survey position units).

12.1.4. File format

You can choose between Geosoft or Surfer output format.

12.1.5. Output format

You can individually select the output fields you want to export to Geosoft or Surfer by clicking the left mouse button on each item.

Outputs that are supported are:

- X: your X coordinate (or longitude)

- Y: your Y coordinate (or latitude)

- Sensor 1 reading

- Sensor 2 reading **

- Gradient between Sensor 1 and Sensor 2 **

- Diurnally corrected Sensor 1 reading: ***

    Base Station Reading – Sensor Reading

- Diurnally corrected Sensor 2 reading: **, ***

    Base Station Reading – Sensor 2 Reading

- Time, Date, Line, and Mark (all features in land-based surveys done with G-858 magnetometer)

*** These outputs are only available for surveys with 2 magnetomters*

*** *You need a base station file*

12.1.6. Output file

Type the file name of the new Geosoft Analysis and Plotting Software or Surfer file. By default the file name is the same as the survey file with the extension .xyz for Geosoft and .dat for Surfer. You can use the browse button to select another directory or drive.

12.1.7. Export Now, Cancel, Save Settings

If you are ready to export your survey click the left mouse button on the "Export now" button, otherwise you can cancel by clicking on the "Cancel" button or save your export settings by clicking on the "Save settings" button.

12.1.8. Base station

If no base station files are currently opened, a blinking warning message will remind you that if you wish to export your data with diurnal correction you must first open the base station file or files. If you have a proper base station file open, no message will be displayed and your data will be diurnally corrected.

12.1.9. Survey boundary consideration

In continuous survey mode, when you export your magnetic readings to Surfer or Geosoft Analysis and Plotting Software, the first reading coordinates will not necessarily have the same coordinates as the first position of a line and the last reading coordinates will not necessarily have the same coordinates as the last position of a line . When you press the mark key at a the beginning of a line and walk along the line you will get a reading after a delay defined by your cycle time.

For example, when you start a line at X=0 and Y=0 and end a line at X=0 and Y=100 and the magnetometer cycle time is set to one second, you will only get the reading only a second later and the magnetometer will automatically record readings every second. By definition when you press the end of line key, you stop recording, and therefore you may or may not record the last reading at exactly X=0 and Y=100.

12.2. Exporting a Maglog NT survey

This export procedure covers the export menu you will get from:

- Maglog NT sea survey (G-880, G-881)

- Airborne survey

- Land based survey where GPS was loaded using the option "*Draw new map using GPS and the features of a Maglog NT survey*".

12.2.1. Export Procedure

To export a survey, select "*Export*" from your "*File*" menu. You should see the following menu:
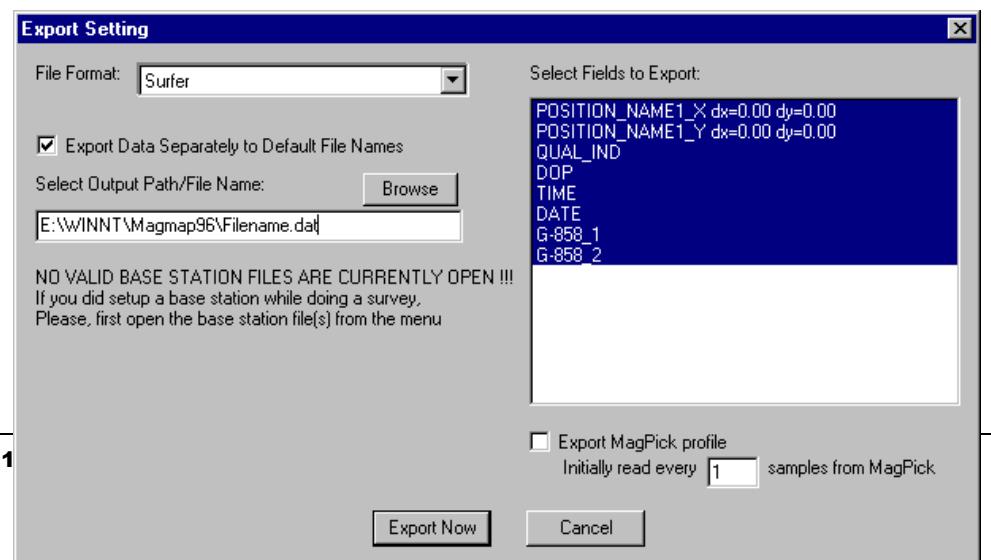
Export menu for Maglog NT survey

This menu is quite different from the one that was discussed in the previous section. One of the most noticeable changes is that you can output the additional positions specified in your GPS Offset menu.

The options you are given are:

- Export data separately to default filenames – This will export your data to separate files. You should get one file per device.

Be careful if you choose this option. This option will ignore any filename you type in!

- Select Output Path/Filename – choose any filename and path you wish to store your data in.

- Select Fields to Export – Highlight all fields you wish to export. The highlighted fields will be exported with a heading identifying each column. You can select more than one field by holding down your CTRL key and selecting objects with your left mouse button.

- Export MagPick profile – This will export a profile that you can use with the MagPick program.

12.2.2. Output Files

There are a few different file types you can export.

12.2.2.1. SURFER

This outputs a file in Surfer format. You can select any combination of fields to export and this will export them (with headings) in a format compatible with Surfer.

A typical Surfer file is shown below:

```
magnetometer_X magnetometer_Y         GPS_X        GPS_Y      G-858_1
 -122.1852905  37.4305114 -122.1852782  37.4305008 50199.07600
 -122.1852912  37.4305121 -122.1852790  37.4305015 50096.44800
 -122.1852920  37.4305129 -122.1852798  37.4305022 49944.51800
```

Here we chose five fields to output – two position pairs that we specified, and the first field reading.

Note: Surfer will only read data files with the extension ".dat", ".slk", ".csv" or ".txt".

This outputs a file in Geosoft format. A Geosoft Analysis and Plotting Software file has the extension ".xyz" and it has headings and a separate line that lists the line number. A typical Geosoft file is shown below:

```
mag1_X       mag1_Y        mag2_X        mag2_Y       G-858_1
LINE 0
 -122.1849910  37.4302225 -122.1849192   37.4301530 50199.07600
 -122.1849918  37.4302233 -122.1849200   37.4301537 50096.44800
 -122.1849926  37.4302240 -122.1849208   37.4301544 49944.51800
 -122.1849933  37.4302247 -122.1849215   37.4301552 49810.18600
```

Here, the fields outputted and the format look very similar to the Surfer file. The only noticeable difference is the separate line that lists the line number. This is updated later in the file.

12.2.2.3.TEXT (SPACE DELIMITED)

This outputs all the fields with one space between each reading.

12.2.2.4.SURFER – 3 COLUMN

This export procedure is particularly useful when you have two sensors with corrected positions for each sensor and you would like to export into one Surfer compatible file. Normally, the easiest thing to do would be to export a file two times – one file for the first set of readings and positions, and the second for the second set of readings and positions. You would then need to concatenate these two files. We tried to save some work by creating this file format. For each set of positions that you select, you may select one reading. This assumes that the first positions you specified will go with your first reading, and the second positions you specified will go with your second reading, etc.   If you don't have a position set to go with a reading, or vice versa, you will get an error message such as the one below:

In one case, we chose to fill out the output screen like the following:
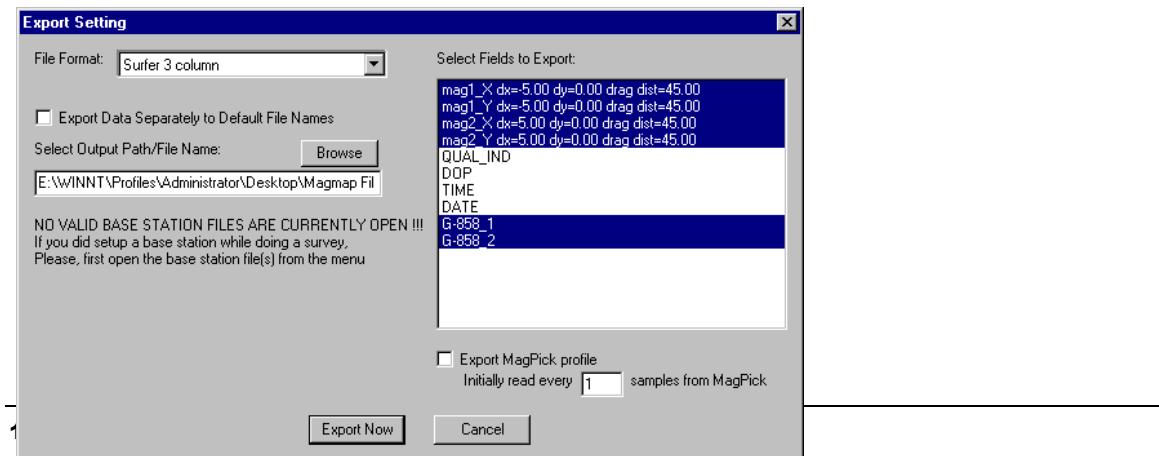
Here is a portion of the output file we obtained:

```
X                  Y              Data
-122.1849910 37.4302225 50199.07600
-122.1849192 37.4301530 0.00000
-122.1849918 37.4302233 50096.44800
-122.1849200 37.4301537 0.00000
```

Note: In this example, the first magnetometer had valid readings and the second had a series of "0" readings. This is evident when we look at the output file – one line corresponds to the first magnetometer and the second corresponds to the second magnetometer. Three fields are always outputted.

13. Saving your editing

Magmap allows you to save your editing only in the G-858 ASCII format, so can use your favorite editor or spreadsheet to view or edit your data.

The "Save" option is not available with any Maglog NT files. This applies to the following:

- Any Maglog NT survey files

- Any G-858 files that stored GPS data that was then opened as a Maglog NT file. If you want to view this file in its ASCII form, you need to use the program bintoasc.exe as described below.

To save a file, select "File" from the menu then "Save" or "Save as".

If you save a GPS map window, only GPS locations and magnetic readings will be saved. Positions, field notes, and pause events will not be saved.

If you save a regular map window (using mark location), only position locations and magnetic readings will be saved. GPS data, field notes, and pause events will not be saved.

You should never save a file with the same file name as your original file.

If you wish to process the data yourself or if you write a program that reads G-858 ASCII format you can use the DOS utility program "***bintoasc.exe"*** that is shipped with Magmap. It allows you to decompress a G-858 binary compressed file to G-858 ASCII format.

For more information type bintoasc.exe at the DOS prompt.

14.   Printing

Magmap allows you to print any Magmap window. There are also a few options available that will help you print.

- You can change the title of a plot by clicking on the middle of the title on a window. This is useful when you need to distinguish different plots.

- You can see a preview of your printing by choosing "*Print Preview*" from your file menu. It will immediately show you a preview of how your hard copy should differ from your screen layout. Namely, Magmap will set a white background and scale the picture to occupy most of the available space. This will allow you to have a reasonable layout, but it will prevent you from using exact scaling. Additionally, for contour maps, the coordinate mesh will be plotted.

Shown below is an example of the *Print Preview* screen.
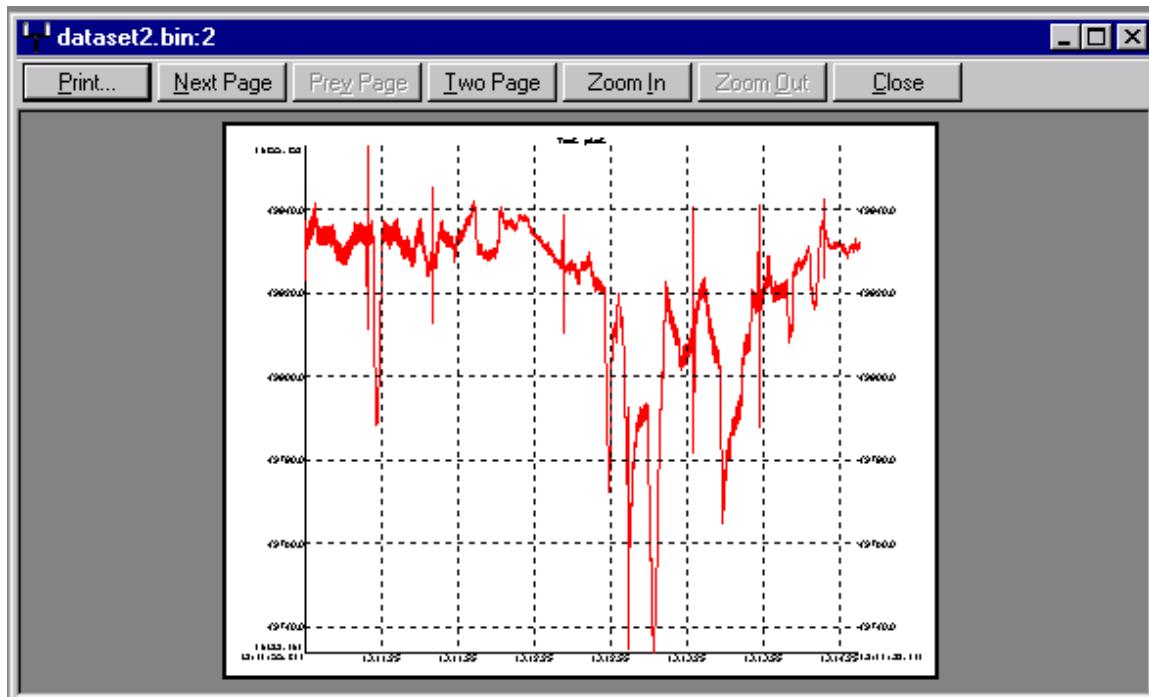
You can also choose the type of printer you want to use and the parameters by selecting "*Print setup*" from the file menu. We recommend that you use a landscape paper orientation. The printers available are set up using the standard Windows printer setup.

You can get your hard copy by pressing "*Print*".

15. Example : Manipulating a Survey with a .csv file

The option "G-858 bin files and .csv file" currently supports files that are created from Trimble's Pathfinder software. The ".csv" file is a file that has differentially corrected positions that were produced from the Pathfinder program. The 858 binary file should have GPGGA data strings recorded as serial data and there should be a one to one correspondence between readings in the .csv file and GPGGA strings in the binary file.

This section describes the operations you need to go through to load these files and some basic data operations you can do with this.

15.1. Load the files

To load the files, you need to select "Open". This should give you the following menu.
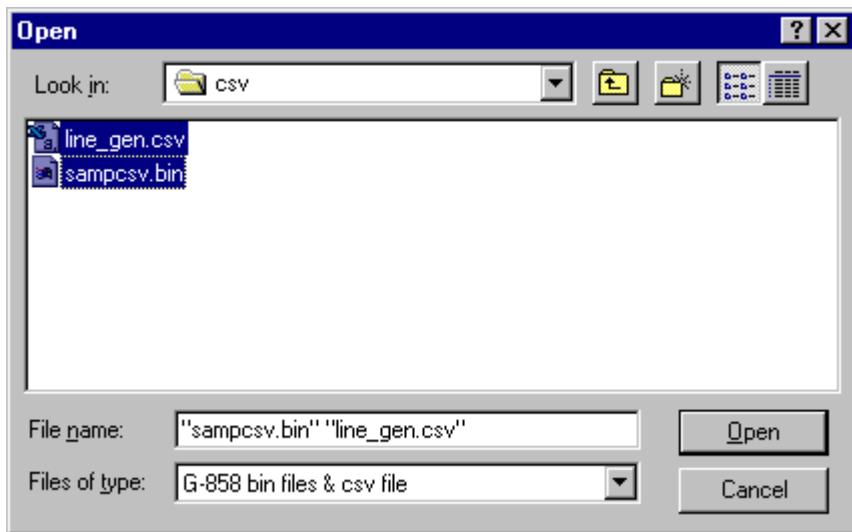
Make sure that: 1) You select files of type "*G-858 bin files & csv file*"

2) You select both files to be opened. You can do this by holding the "CTRL" button and left clicking on the applicable files.

After this, you should see your normal position screen without your GPS data. In this case, we got the following which reflected the manual position points we took.
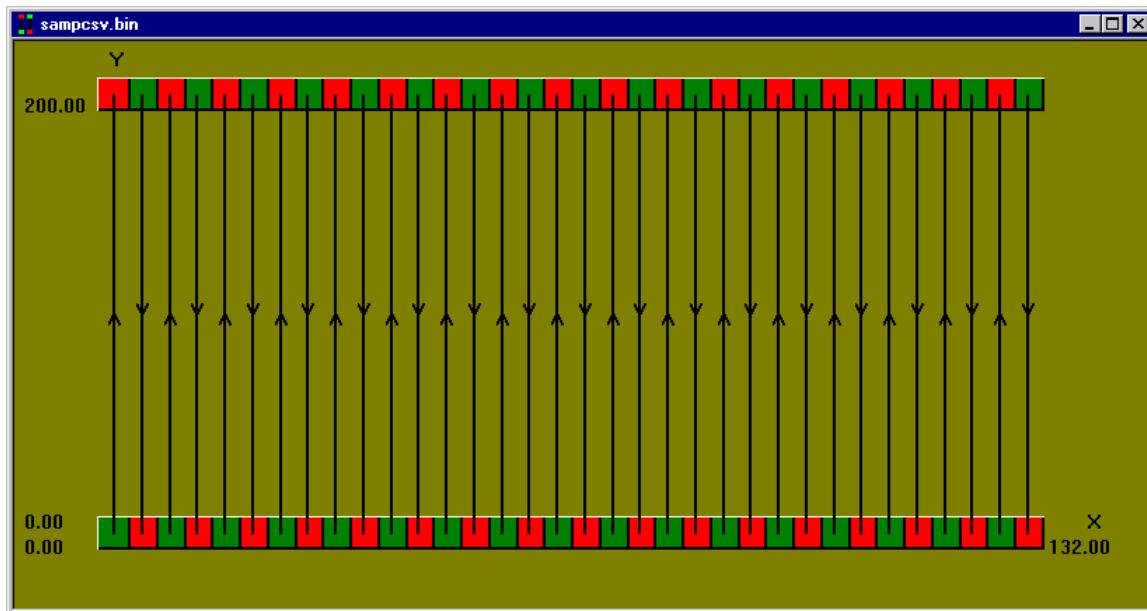
Opening screen after loading .csv files

15.2. Looking at the GPS data

15.2.1. Drawing it as an "858 Mapped Survey"

Next we will look at our GPS data. We can do this by selecting "*Draw new map using GPS and the feature of a regular 858 survey*" from our GPS menu.

We will be prompted to add some time corrections to the data. This allows us to correlate the time reported from the GPS (UTC) with the time that the correction file is given in (Greenwich time).

In our case, we use the following:
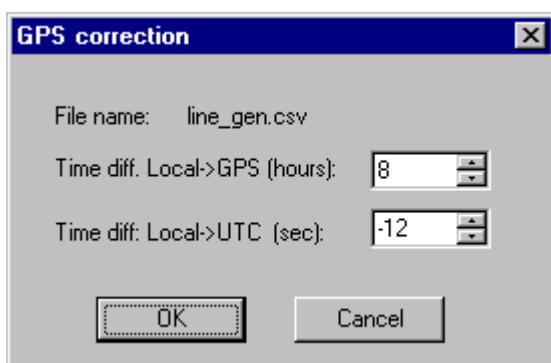
Our GPS data is shown below:
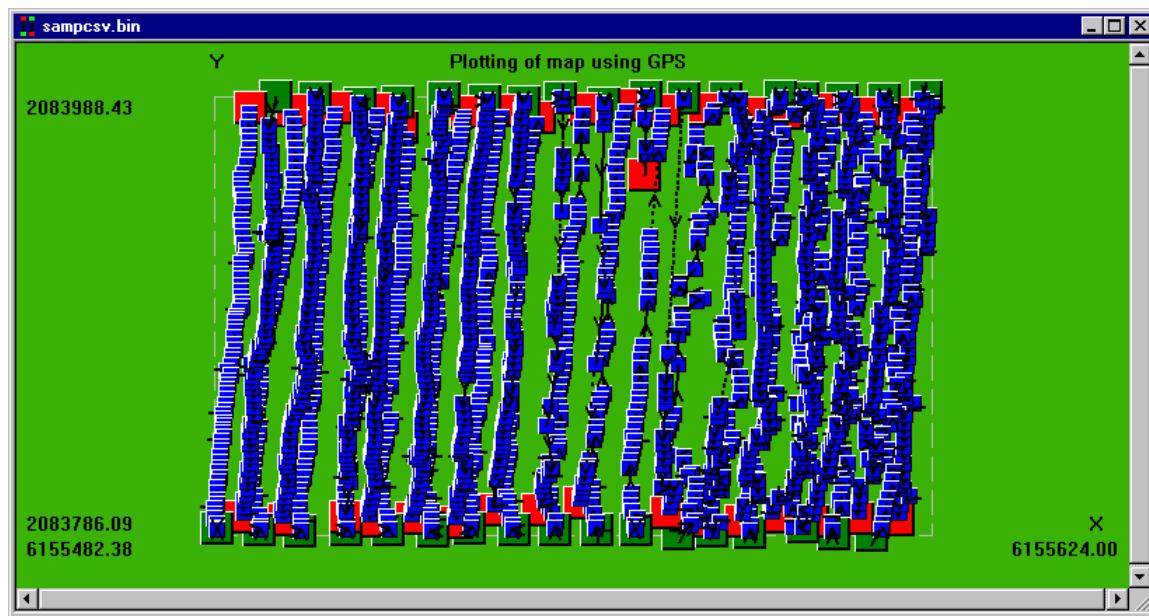
GPS Screen with correct time corrections

It is important to set these offsets correctly. If they are set wrong (e.g. we use 8 hours, -20 seconds instead of the above), we can get a dramatically different picture, such as the one shown below:
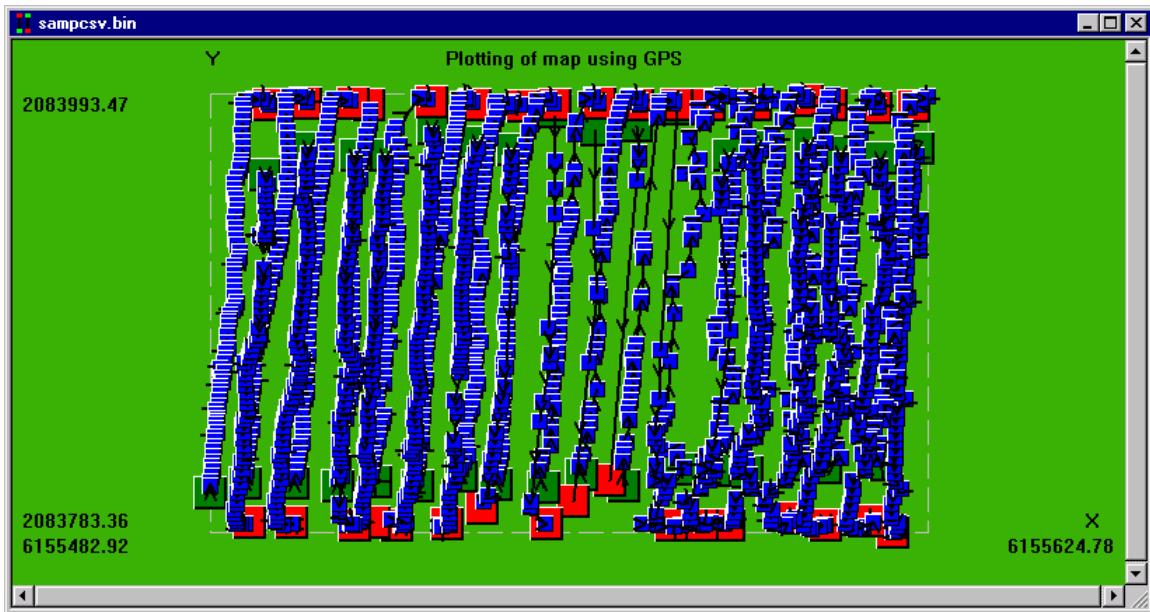
Map plotted using incorrect GPS time corrections

15.2.2. Drawing the data using the features of a Maglog survey

This survey type allows us to add offsets later if needed. The main difference between the two is that you will get three views: one of your GPS positions graphed on top of your marks and lines that you set, one of your magnetometer data, and one of the survey grid you set up.

From here, you can despike your data and do your normal GPS smoothing operations.

16. Sample Analysis from a Maglog File

This section discusses how to analyze data from Maglog NT files. It specifically covers operations that you might need to do, such as calculating additional magnetometer position points, smoothing GPS data, and removing spikes from your data.

16.1. Layout of Survey

This looks at the two sample files included: 880Test.txt, and GPSTest.txt.
These files were generated using a course with the following features:

- 500 x 500 meter grid.
- Survey is done in several bi-directional continuous lines
- Line spacing is 25 meters.
- Speed of the boat is 10 meters/second
- Ratio of Magnetometer to GPS readings is 10:1.

For the individual files:
- Small positional and magnetometer errors are introduced
- Some drop-outs and spikes also occur in magnetometer data
- Magnetometer gradiometer data is given – one magnetometer is assumed to be 40 meters behind the boat, and the second is assumed to be 50 meters behind the boat.
- There are two magnetometer sensors, each with depth and altitude channels (similar to a G-880).
- Coordinates are given in geographical format.

16.2. Importing the files

We can directly import the files into Magmap by loading the associated survey file or by directly loading the individual files, in this case.

You need to make sure that you use one of the two options available in the "open" dialog:

- Maglog projects (*.Survey) – this is used to load a survey and all associated files

- Maglog files (*.*) – this is used to load individual Maglog NT files.

After this is done, you should see your two files appear in Magmap as follows:
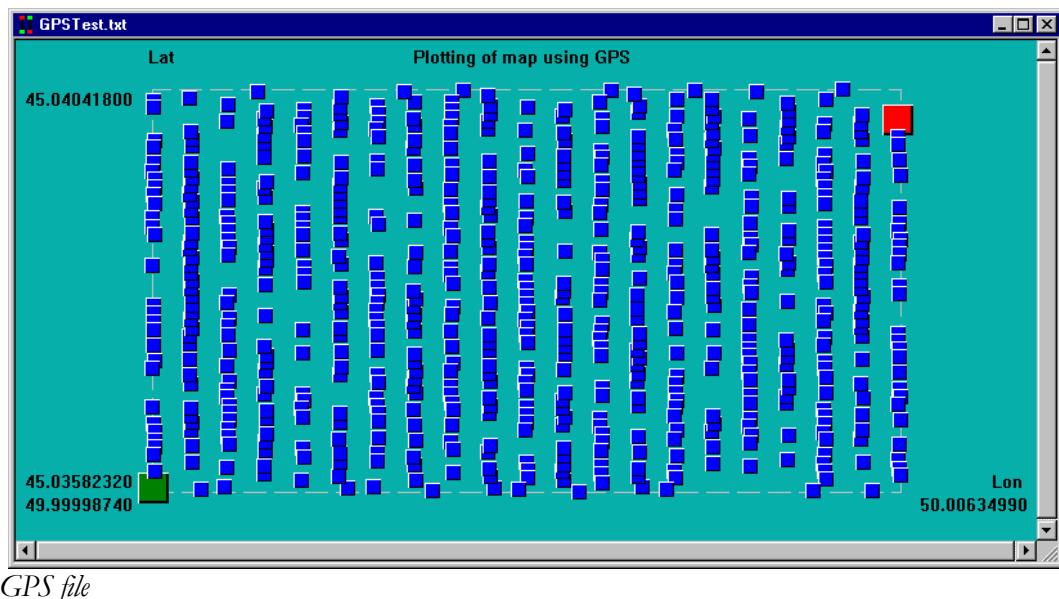
GPS file
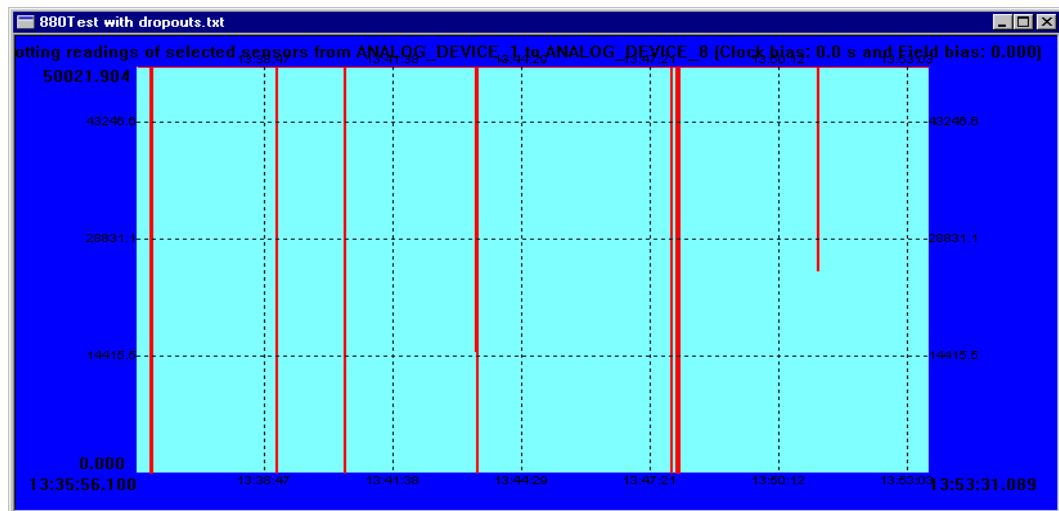
880 file with one sensor plotted.

16.3. Basic editing operations for 880 Data

As seen from the above 880 file, there are several dropouts and it will be difficult to look at the data while the dropouts remain. This section will discuss basic filtering techniques to remove the dropouts and display the data in a reasonable fashion.

16.3.1. Rescaling the data

We would first like to re-scale the data so that we can see the source and extent of the dropouts. We can re-scale by clicking on the right mouse button. This will bring up the following pop-up

menu:

From here, we should select "Set Min and Max Field". The following dialog box will then come up:
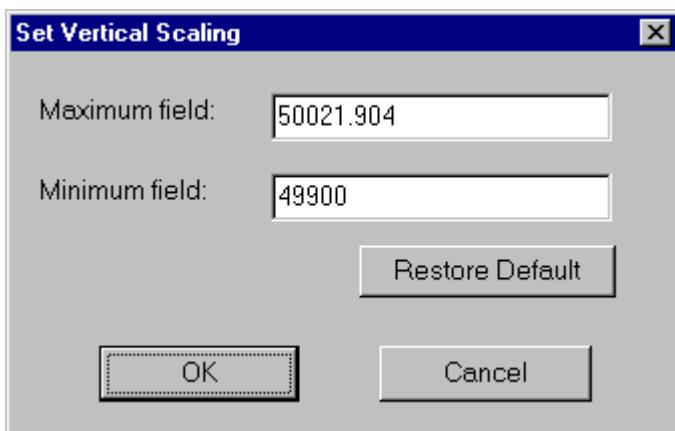
By default, the minimum field is set to the minimum reading received in the survey. Since the survey has dropouts, the minimum field will be set to 0. In this case, we need to change it to 49900 (or some other value that will allow us to see the data) so that we can see some features besides the dropouts. If we press "OK", our G-880 screen changes to reflect the scale change.
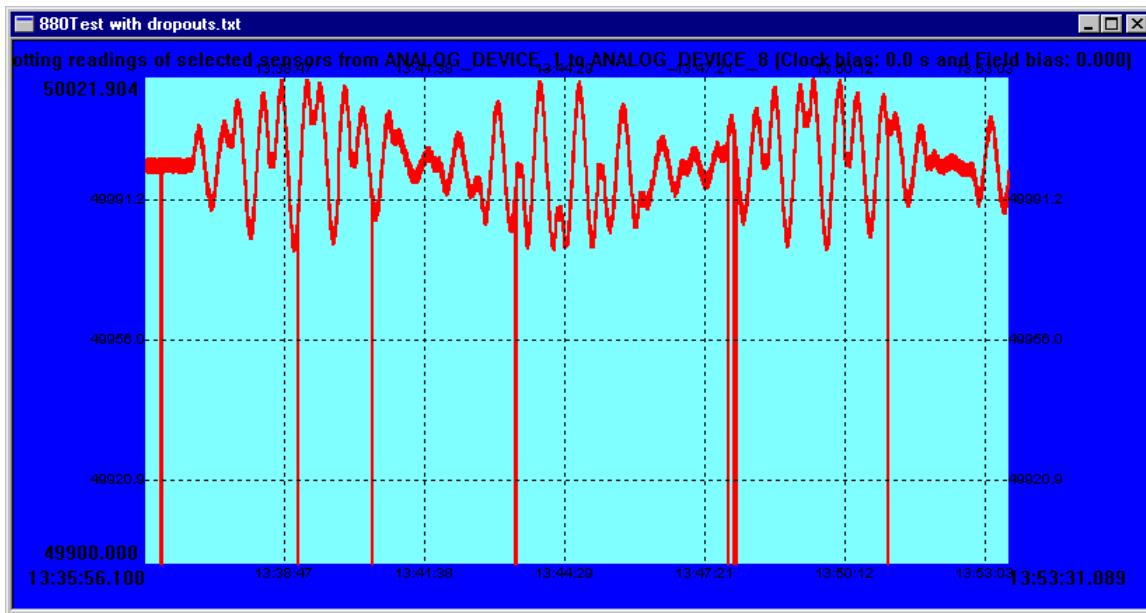
880 screen after scale change

16.3.2. Plotting second sensor

By default, only one sensor is plotted. Since we are interested in looking at the data from both sensors, we will need to plot this as well.

We can plot this by right clicking on the mouse while the magnetometer window is active. We will get the same pop-up menu that we saw before:

This time, we need to select "*Plot Sensors Setup*".

This should yield the following window:
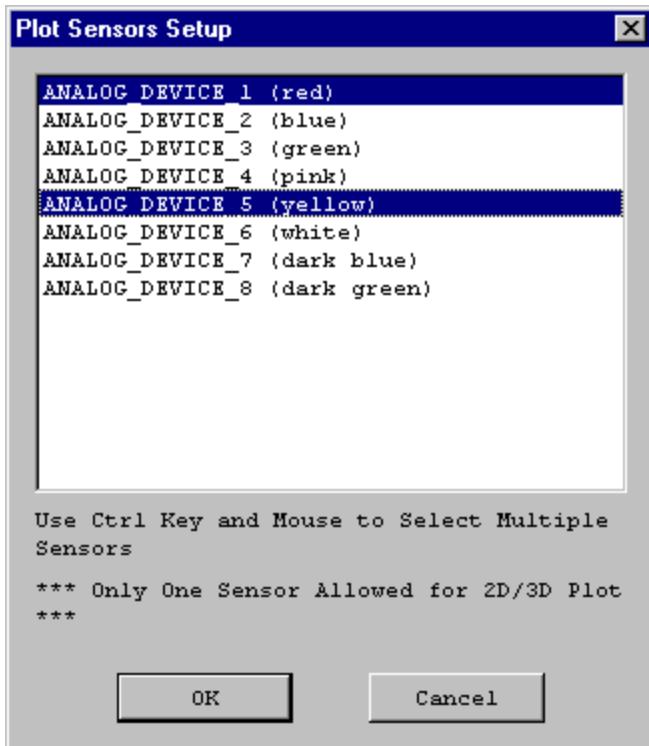
In this example, we choose the options "*Analog_Device_1*" and "*Analog_Device_5*" because we know that we have two 880 magnetometers, each with signal, depth, and altitude measurements. The data that is logged will appear as the following to Magmap:

- Field 1 – Analog Channel 1

- Signal 1 – Analog Channel 2

- Depth 1 – Analog Channel 3

- Altimeter 1 – Analog Channel 4

- Field 2 – Analog Channel 5

- Signal 2 – Analog Channel 6

- Depth 2 – Analog Channel 7

- Altimeter 2 – Analog Channel 8

Thus, if we wanted to graph the two signals instead, we would choose to display analog channels 2 and 6.

After we have pressed "OK", the magnetometer screen should look like the following:
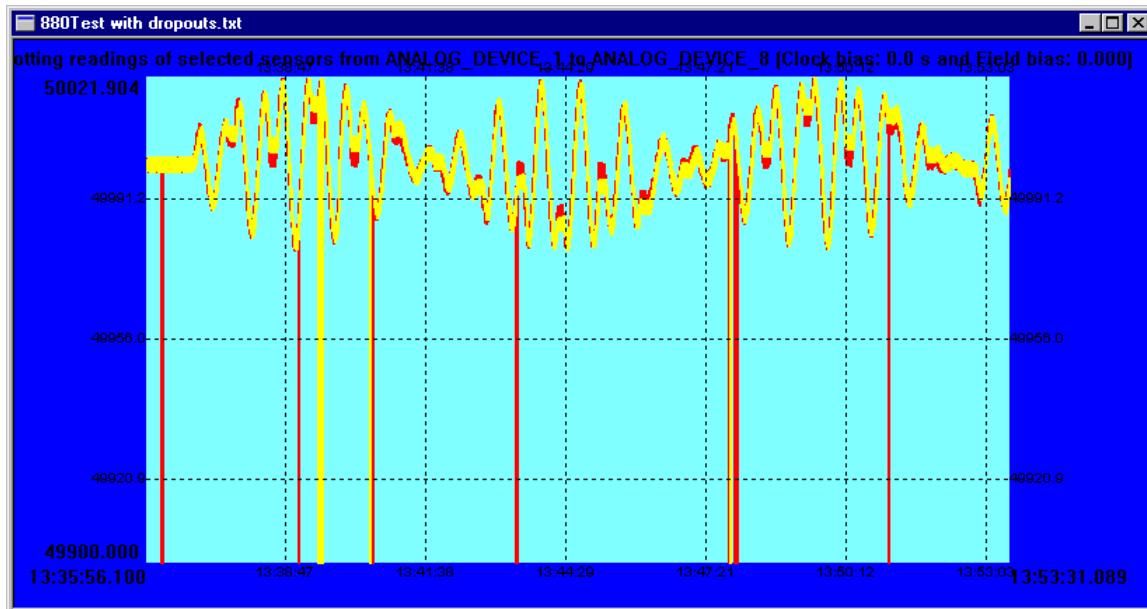
Scaled magnetometer data

16.3.3. Despiking the data

In the above case, there are spikes and drop-outs in the data. Magmap has facilities for removing both.

The generic option: "*Linearly Interpolate Drop-outs*" will remove drop-outs with varying numbers of points involved. It will replace the drop-outs points with valid points nearby. This doesn't involve much conscious effort on behalf of the user. If we select this option through the despike menu, we will get the following:
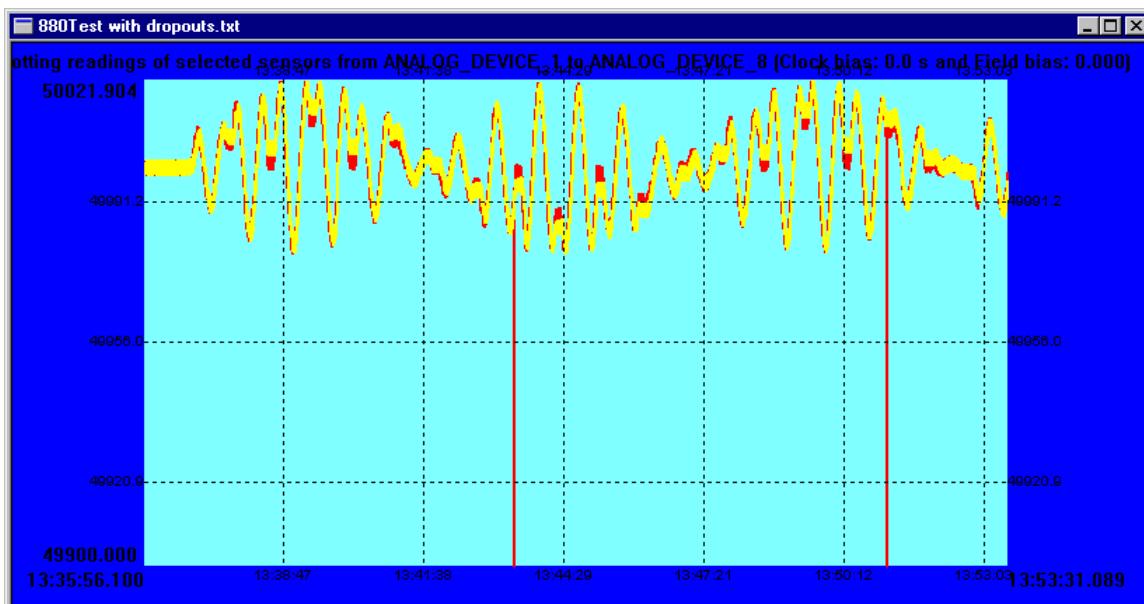
Scaled magnetometer data with dropouts linearly interpolated

In this case, the drop-outs have been removed. However, there are still spikes that need to be removed. The readings that are left after removing drop-outs are not zero readings – but they still are significantly different from normal readings to count as spikes.

We can remove spikes using the "*Despike Setup*" also available through the "*Filtering*" menu.
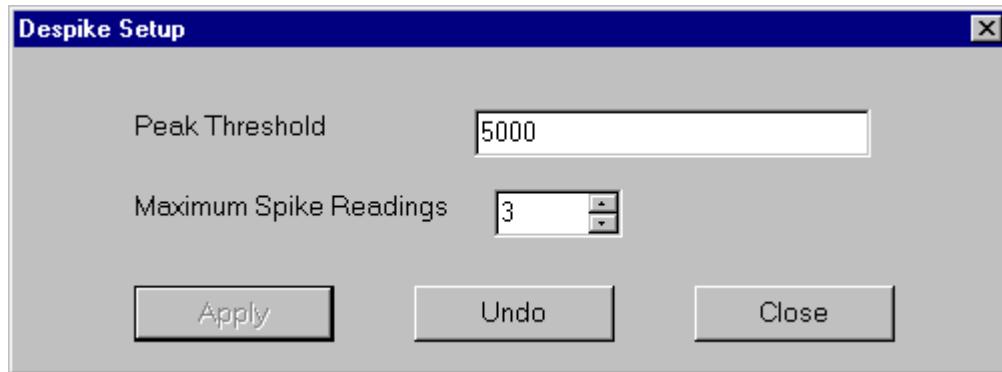
In this case, these options work well. If we used this to filter our drop-outs, we would need to use more than one point for our "*Maximum Spike Readings*". This is how the program determines it is dealing with a spike. Since spikes that are due to error tend to be short in duration (a few readings), if you have any more readings composing your spike than the "*Maximum Spike Readings*", Magmap will assume that this is not a spike and it will leave it alone.

After you are done with this, press "Apply".

> Note: Magmap keeps a history of the changes you have done to your data. If you don't like the changes you made, you can press "Undo" to get back your original data. In a few cases, (e.g. where you remove the drop-outs, or linearly interpolate them) you will not be able to undo your changes after your first despiking. Be careful and undo any changes you don't want to keep before despiking.

You should get the following:
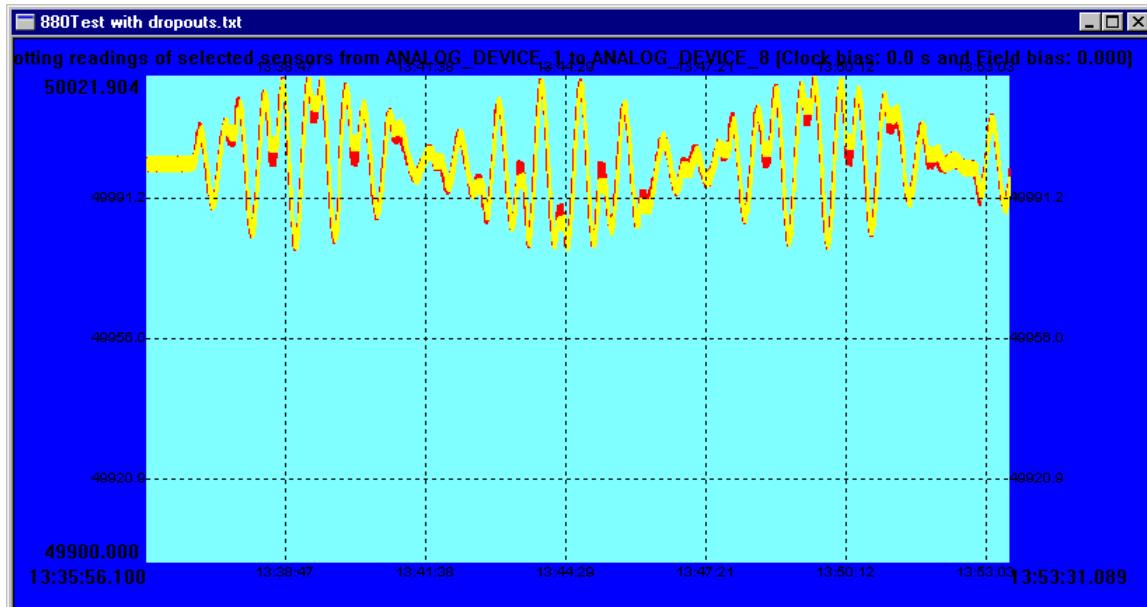
Scaled magnetometer data with drop-outs removed

If you want, you can re-scale this again to fit the bounds of the data.

You can also remove all your drop-outs by despiking, rather than by selecting "*Remove Drop-outs*". Be careful doing this though because some drop-outs that last for a long time may not get removed if they are longer than the maximum number of points involved allowed in a spike.

16.4. Manipulating the GPS file

Our starting GPS file is shown below:
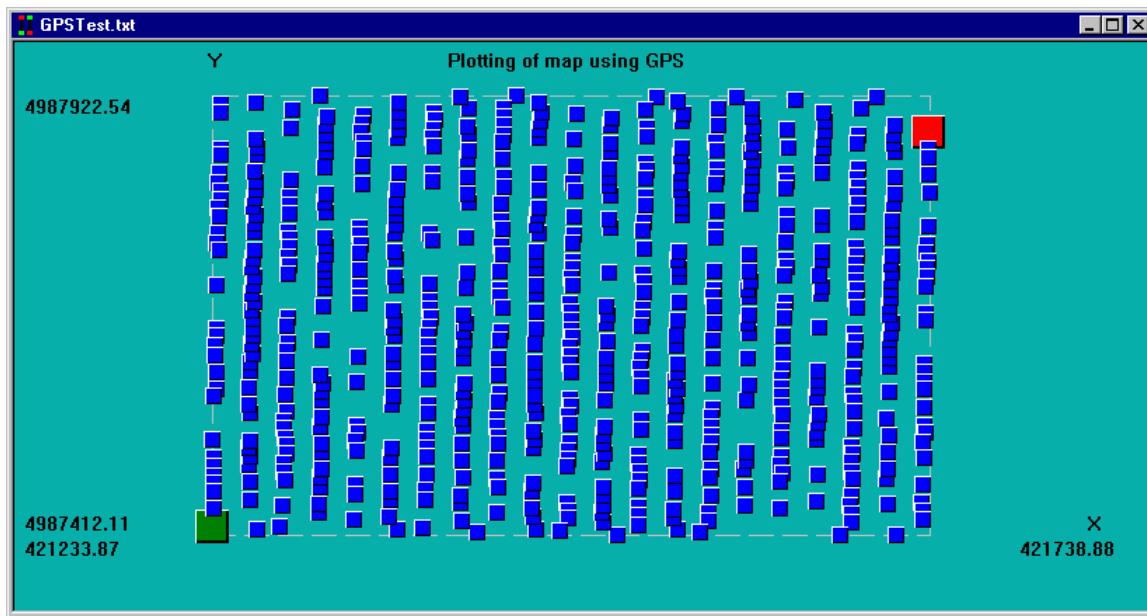
This section will show how to change from geographical to UTM coordinates, and how to smooth the data.

16.4.1. Using UTM coordinates

The data is originally given in geographical format. However, we would like to see UTM coordinates instead. We can do this by selecting "*UTM Setup*" from our "*GPS*" menu. We can then fill out the following:
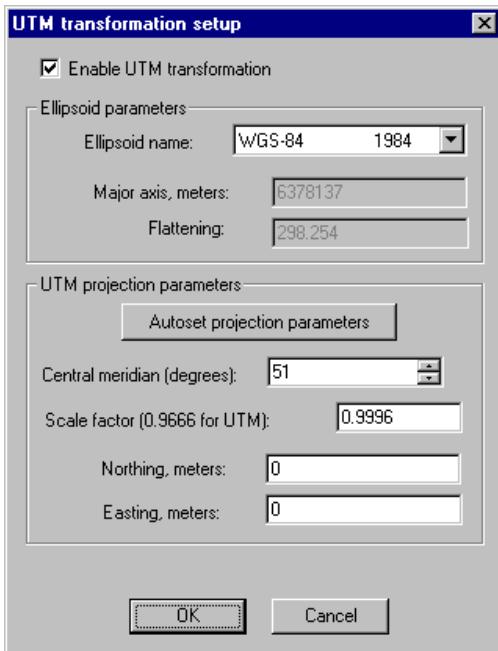
In this dialog box, we select **Enable UTM Transformation,** which will cause the coordinates to be output in UTM format. Additionally, we set the **Northing** and **Easting** parameters equal to 0. This will make it easier to add offsets later. We also allow the computer to choose the prime meridian.

The new GPS screen is shown below:
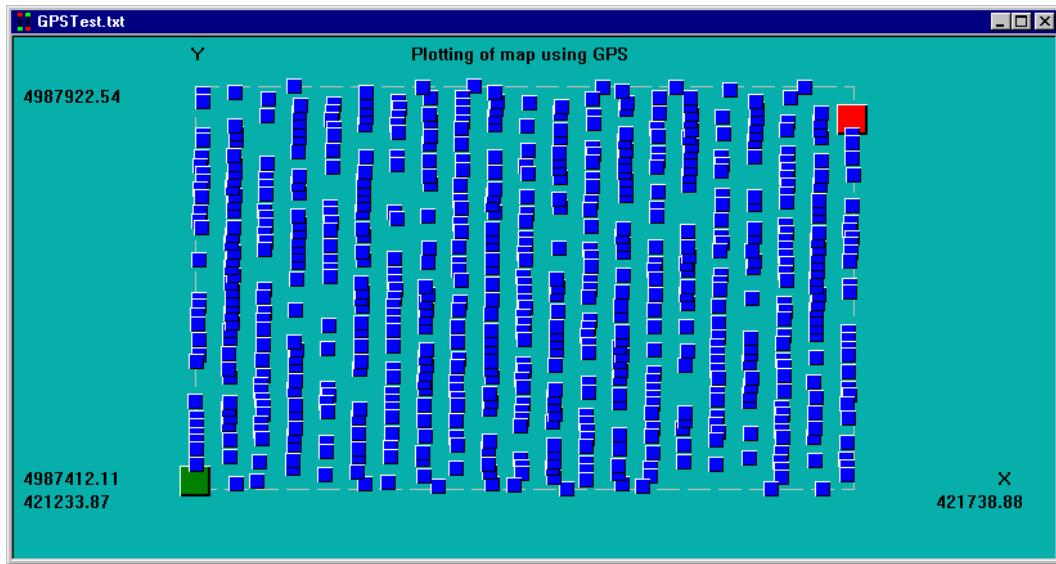
Now we would like to graph this in a local coordinate system – e.g. instead of using the huge numbers that are given from absolute UTM coordinates, we would like to shift all points by a given amount so that the final numbers are more manageable. To do this, we can set offsets.

Again, we go to the "*UTM Setup*" menu and fill in the offsets as follows:

UTM transformation setup

☑ Enable UTM transformation

Ellipsoid parameters

Ellipsoid name:	WGS-84 1984	▼

Major axis, meters: 6378137

Flattening: 298.254

UTM projection parameters

Autoset projection parameters

Central meridian (degrees): 51

Scale factor (0.9666 for UTM): 0.9996

Northing, meters: -4987412.11

Easting, meters: -421233.87

OK   Cancel
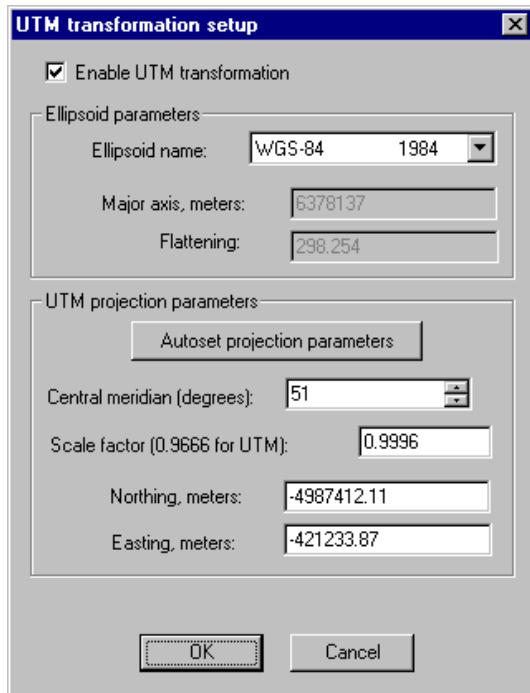
Note: Here we select the values for Northing and Easting by taking the negative of the two coordinates numbers in the bottom left corner of the GPS graph. (See graph).

When we press "OK" we get the following
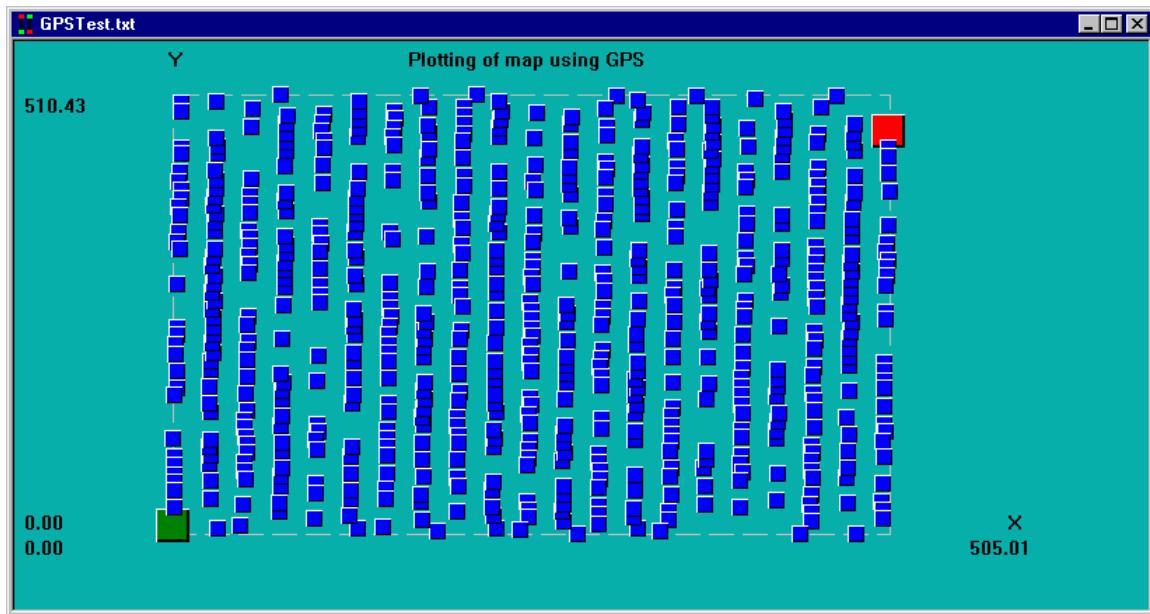
Note that the bottom left corner now corresponds to (0,0). If you export data, it will also be in this coordinate system (with the offsets you selected).

16.4.2. Smoothing GPS Data

We would now like to smooth the data. We can do this by selecting "*Smooth Position*" from the GPS menu.
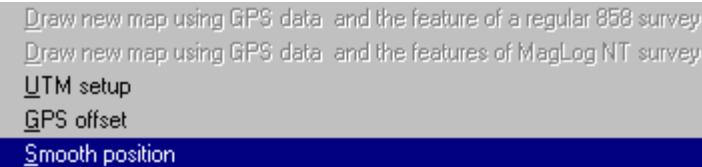
We then see the following dialog:

Line smoothing parameters setup

Line #	Spl.smooth I	Parameter	Despike	Jump,m	Spl.smooth II	Parameter
No line	Yes	4	No	10 m	No	2

[Change line parameters...]   [Smooth]   [Close]   [Close and apply...]
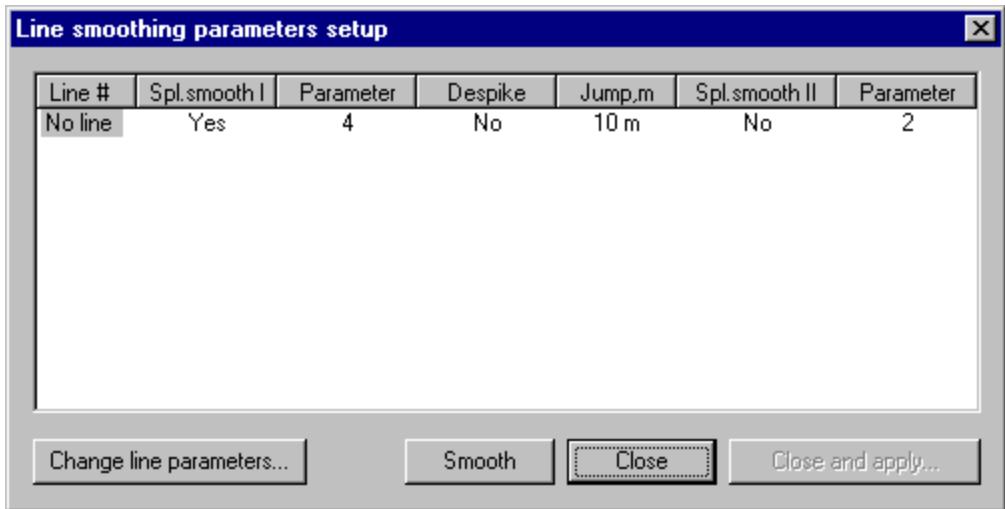
Since this data was done as one line, we only see one set of parameters we can change (this may be different for Maglog surveys taken using several lines!)

If we accept the parameters as shown, we get the following:

GPSTest.txt

Plotting of map using GPS

Y
510.43

0.00
0.00

X
505.01
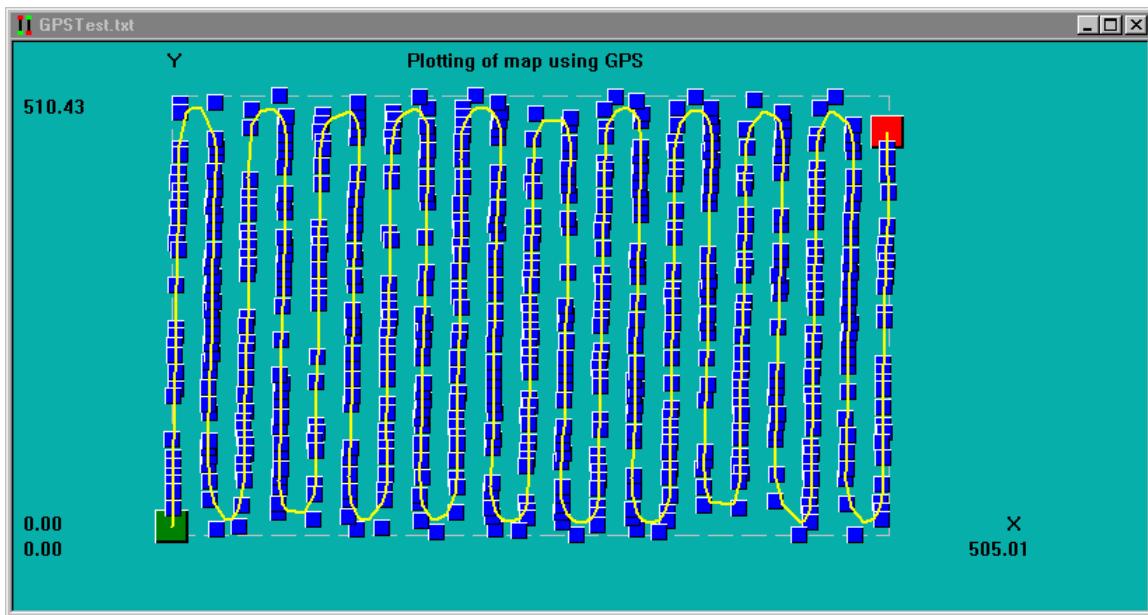
GPS data with smoothed path drawn

We accept this smoothing by pressing "*Close and Apply*". The final map shows our smoothed positions:
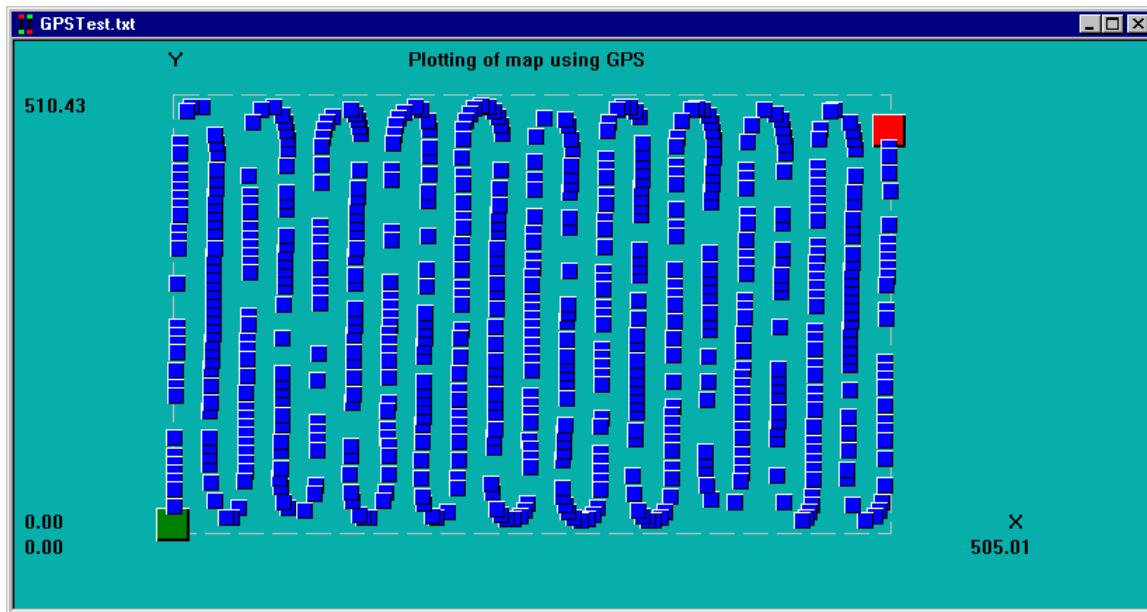
16.5. Other operations

16.5.1. Setting Offsets

In this survey (as in most surveys), the positions of your magnetometers will not be the same as the GPS positions reported. This can be easily seen by looking at a contour map generated by Magmap for the example data set.
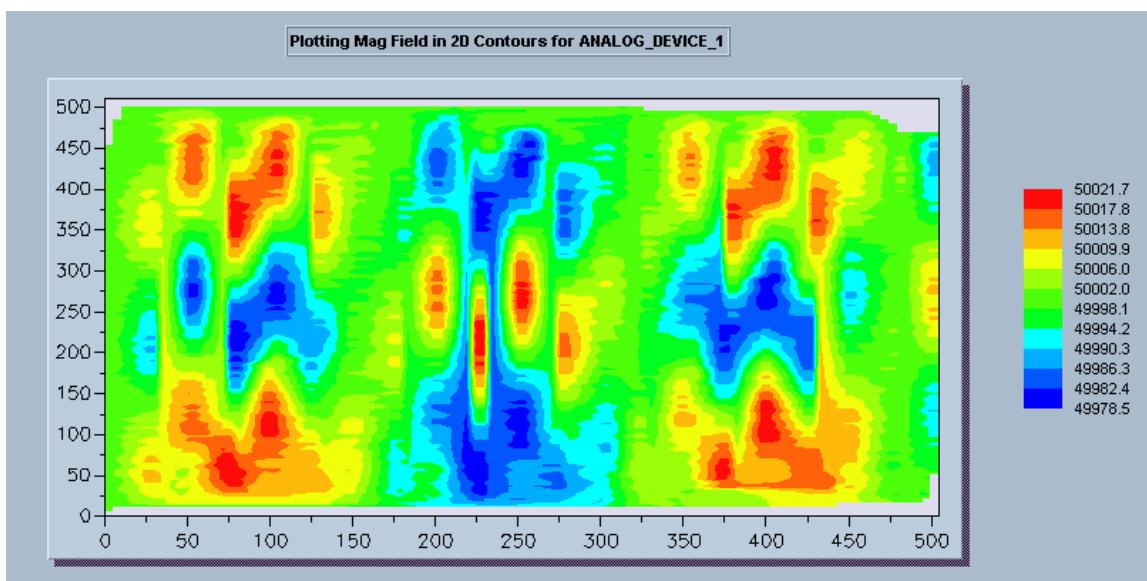
This should appear to be a grid of 9 circular anomalies. However, due to the difference between the GPS position and the magnetometer position, the actual map doesn't come out that way.

We can correct this by setting offsets. Select the "*GPS Offset*" menu option (under GPS).
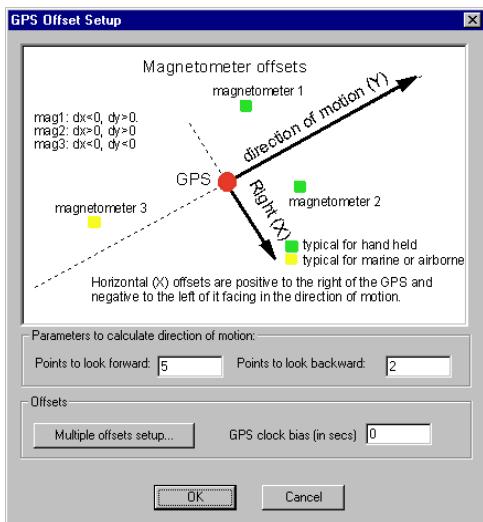
From here, press **Multiple offsets setup.**

This will give you the following menu:
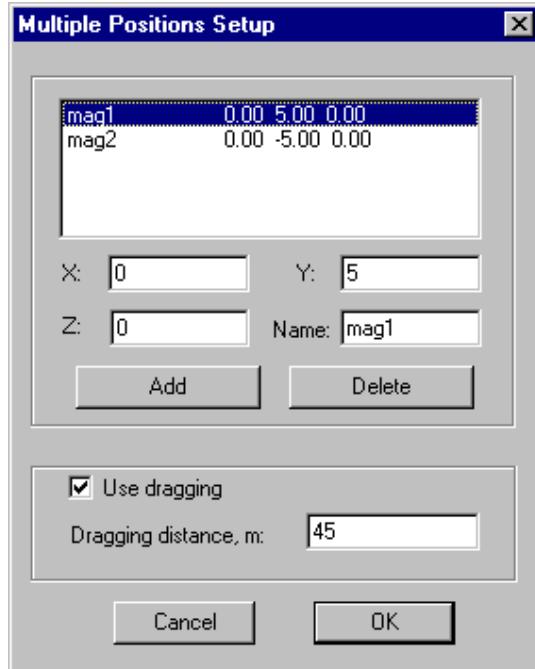
Recall that we have two magnetometers: one is dragged 40 meters behind the boat, and the second is dragged 50 meters behind the boat. In the above dialog box, we have specified a dragging distance between the two magnetometers (45 meters) and we have specified two positions we would like to calculate with relation to this dragging distance (mag1 and mag2).

You have the opportunity to export these positions and use them in gridding programs such as Surfer.

Note: These positions are calculated later. They are not available from within Magmap.

16.5.2. Exporting to a file

We have now smoothed and despiked our data. We would like to export it so that we can make a grid in a 3D plotting program such as Surfer.

To do this, select "Export". You should see the following dialog box:
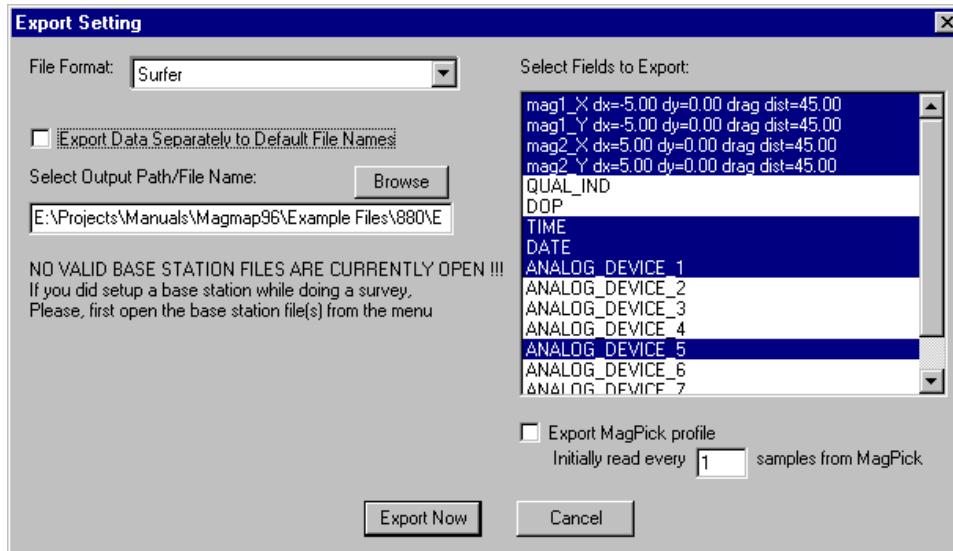
In this case, we have chosen to export this in Surfer format.

Additionally, we do not want to export data separately (this would keep the GPS and 880 data in separate files), so we have **unselected** "*Export Data Separately to Default Filenames*".

By default, all fields are highlighted and exported. If you don't want to export all of the fields, you can hold down the "*Ctrl*" key and select the fields you would like to export (as seen above).

The final file should look similar to the following:

```
mag1_X    mag1_Y     mag2_X      mag2_Y     ANALOG_1      ANALOG_5         TIME        DATE
-0.14   -30.11     -0.26     -40.11 49998.34700 50000.31700 13:35:57.000   12/12/98
-0.13   -29.09     -0.25     -39.09 49998.60500 49999.47400 13:35:57.100   12/12/98
-0.11   -28.07     -0.24     -38.07 50001.78000 49999.97900 13:35:57.200   12/12/98
-0.10   -27.06     -0.22     -37.06 49998.59200 50001.06000 13:35:57.300   12/12/98
```

```
-0.08   -26.04       -0.21       -36.04 49999.60500 50000.99200 13:35:57.400   12/12/98
-0.06   -25.03       -0.19       -35.03 50000.40500 50000.01800 13:35:57.500   12/12/98
-0.05   -24.01       -0.18       -34.01 49999.97800 49999.68100 13:35:57.600   12/12/98
```
Sample output file in Surfer format

Note: In the output format that we used in the example, we would have to look at the data separately (one magnetometer at a time) or work with it further to concatenate all the readings. You could instead choose to output the file in "*Surfer 3 Column*" format which would create three columns and would combine the readings for both magnetometers.

---

17. Analyzing an 858 Land Survey with GPS Positions

This section covers a sample analysis of an 858 land-based survey that has GPS input. In this survey, we will look at the results obtained using the GPS readings as position points, and also at the results obtained from doing a time interpolation between the endpoints of the lines.

This sample survey also has some common problems that might be encountered during a survey. We will need to delete certain lines, and de-spike the data. There is also base station data.

17.1. Survey layout

This survey had the following features:

- 100 x 100 meter grid

- Lines were 2 meters apart

- Each line is 100 meters

- Additional position points were obtained from an Trimble AG-132 non-magnetic GPS that was carried near the magnetic sensor

- A base station took data.

17.2. File features

We made three files during this survey:

- 0-70.bin -- This file has all measurements for the first 36 lines (up until X = 70).

  - At X = 52, one line was mistakenly repeated.

  - At X = 72, the battery went dead.

- 72-100.bin – This file has the conclusion of the survey (until X = 100)

- Base.bin – This file has the base station data.

- There are drop-outs at the beginning due to a the magnetometer warming up.

17.3. Analysis of magnetometer files

17.3.1. Loading the file

In this section we will manipulate the two magnetometer files to get the correct mapped information.

We begin by opening the file. The file type is "G-858 Binary File" as shown below:
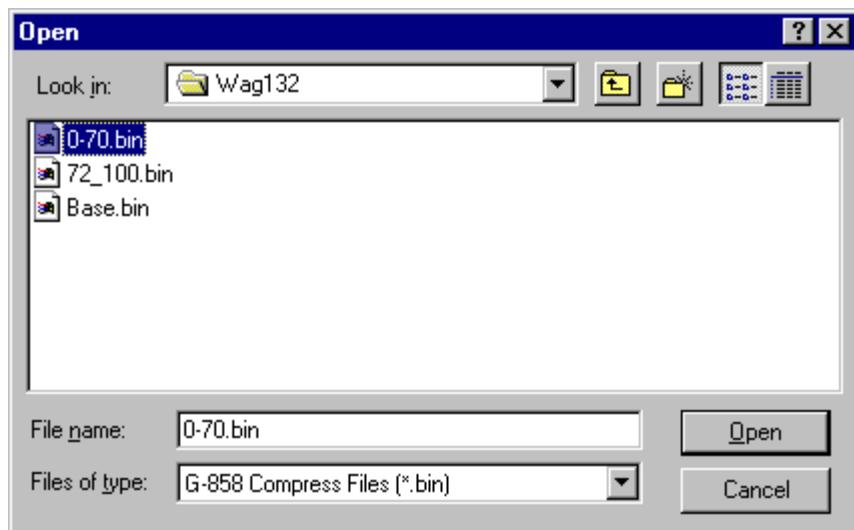
Note: This menu will default to the last file type you selected. If you do not select "G-858 Compress Files" as shown above, you will still get your data, but you might not get your survey map.

You should get the map shown below:
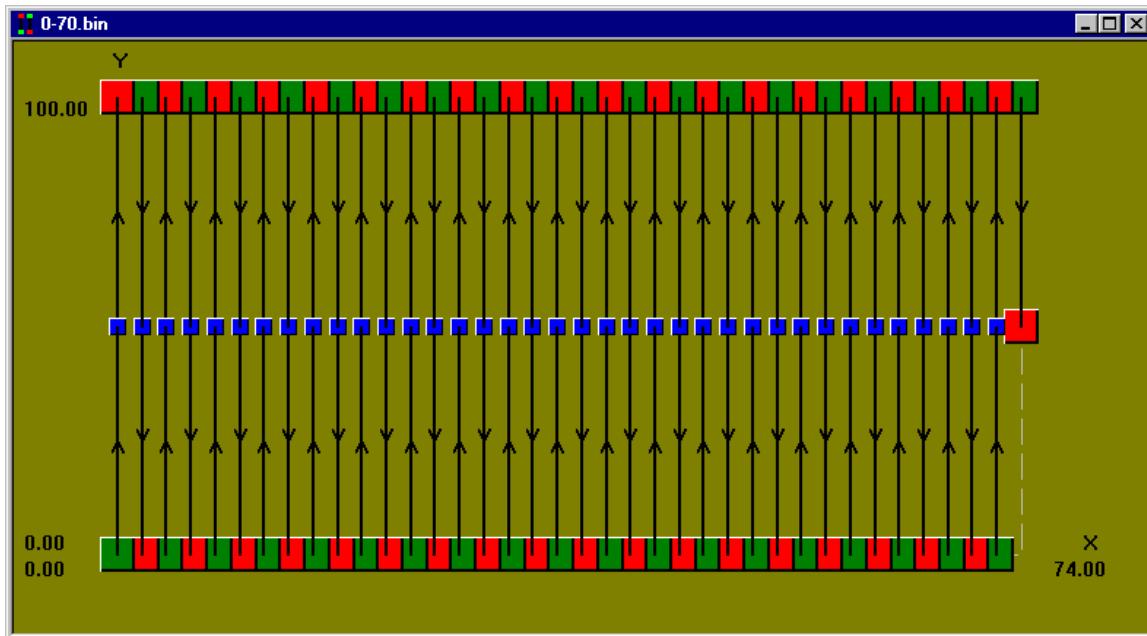
Initial map for first G-858 file

17.3.2. Manipulating the map

In this survey, we did have some problems with the map but we don't need to do anything to fix them. We will use GPS rather than the marks and end-of-line manual positions to do our final positioning so we need to edit the lines that will be associated with the GPS file.

If you wish to read more about editing the map, see the following chapter.

17.3.3. Drawing the GPS map

Now we would like to manipulate our GPS and magnetometer data. To do this, we need to make a GPS map. We can select the "*GPS*" menu item and then "*Draw new map using GPS data and the features of a Maglog NT survey*".
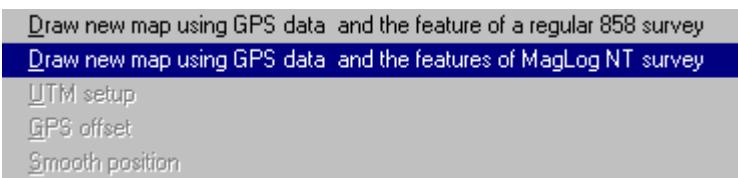
We picked this option because we will need to add a position offset to our data (our GPS and magnetometer are not located in the same place). This option will allow us to do this.

We should then have the following two files:

Lat   Plotting of map using GPS

37.43161330

37.43050080   Lon
-122.18604560   -122.18470140

GPS data

Plotting readings of selected sensors from G-858_3 to G-858_4 [Clock bias: 0.0 s and Field bias: 0.000]
50510.357

0.000
11:26:36.800   13:04:57.000
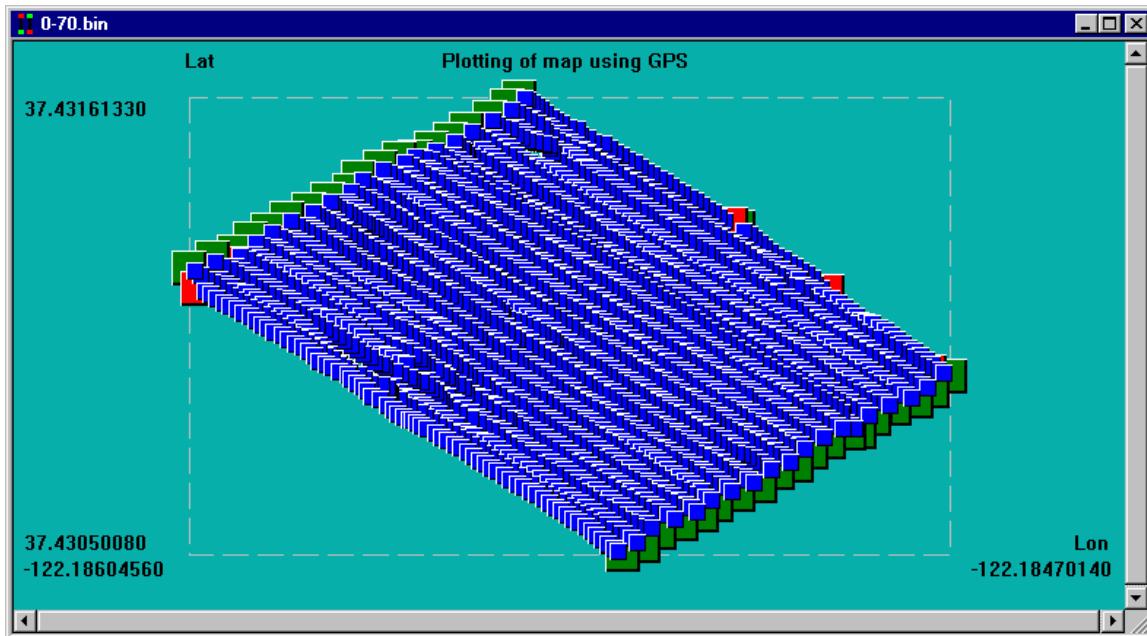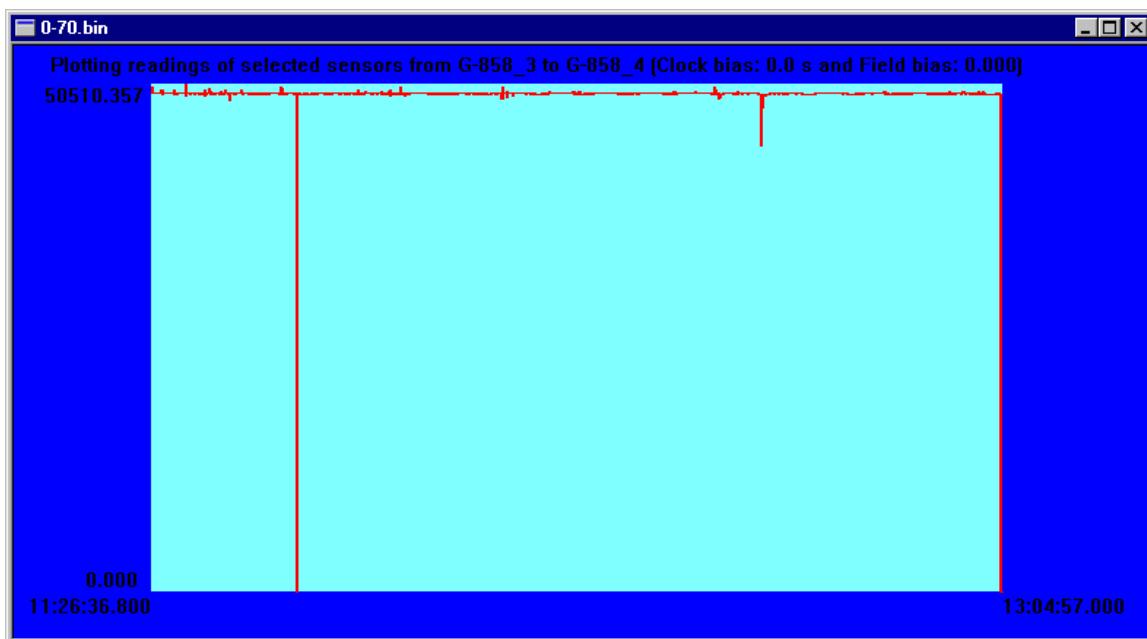
Magnetometer data

17.3.4. Editing the GPS data

We now want to edit the GPS data. Recall that the mapped file had some lines we needed to delete. We know that the last line definitely has bad data. We also know that there was one line that was done twice.

Additionally, we will want to add a position offset to account for the magnetometer being located 1.6 meters in front of the GPS. We would also like our final map to be in UTM coordinates.

17.3.4.1. DELETING A GPS LINE

In this file, we can safely ignore the line that was done twice because the position data is still okay. For the GPS data, if a line was done twice, the GPS will report the same positions twice and this should not affect any attempts to graph the data.

However, we still need to delete the last part of the line where the data could be bad due to the loss of battery power.

To do this, we select the end of the line and then right click on the mouse as shown below:
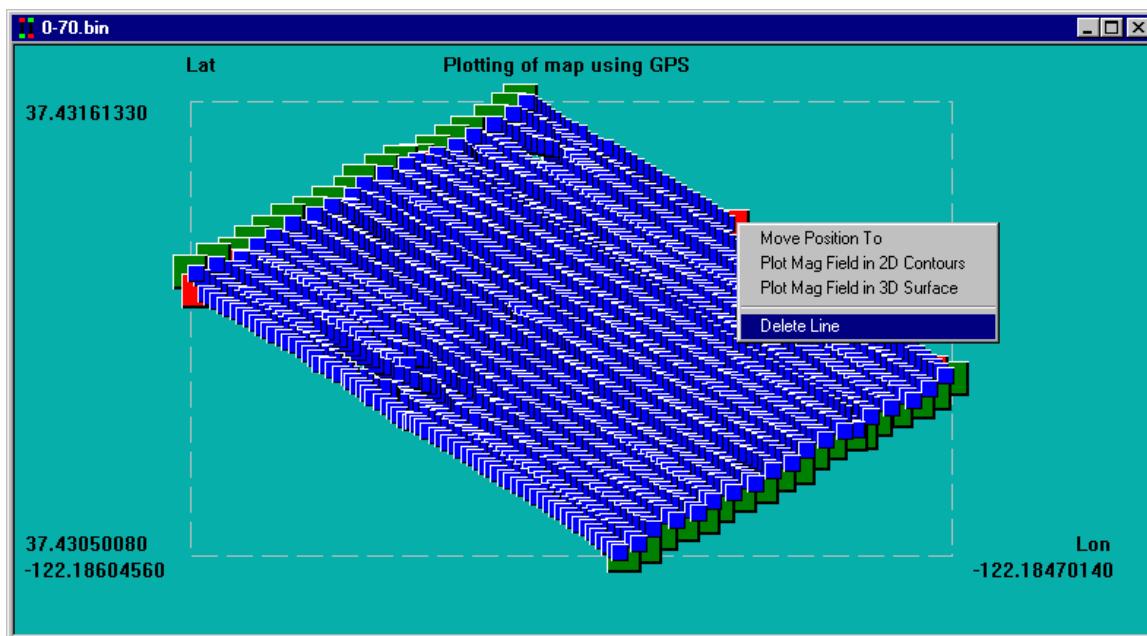
In this case, there are two bad segments to delete. When you have finished deleting the bad segments, your final map should look like the following:

> Note: The sample file, 0-70.bin was improperly terminated and can cause problems during export. If you have problems exporting this file, reload the GPS file and don't delete the lines above.
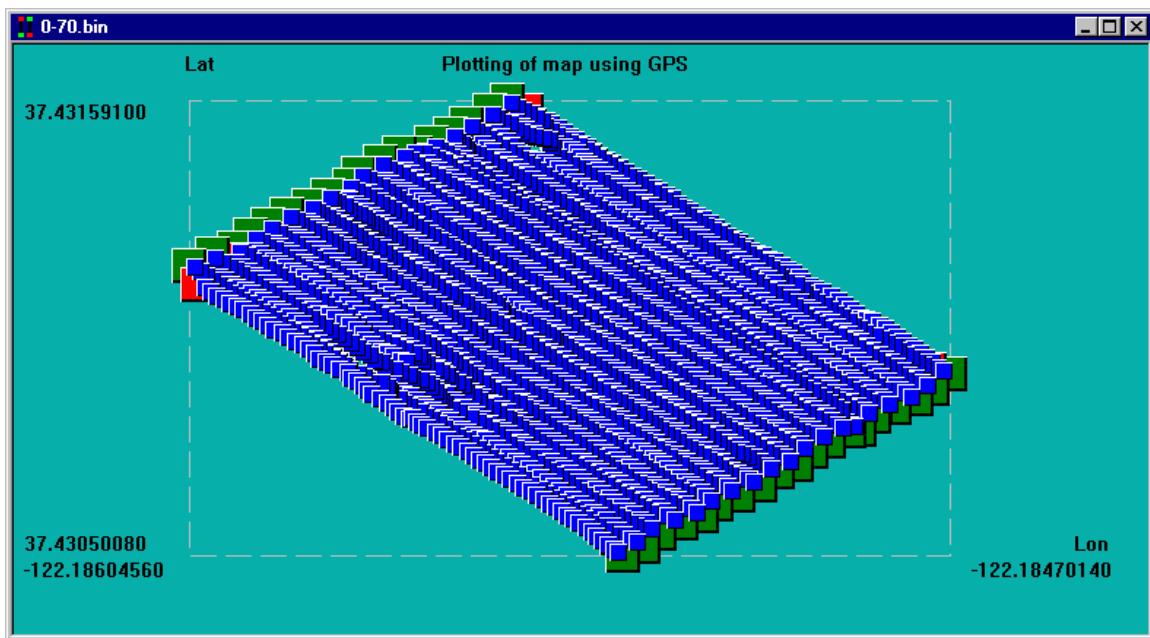
GPS map with segments deleted

17.3.4.2. CHANGING TO UTM COORDINATES

We intend to later import this data into Surfer so it would be helpful to have the coordinate system in a more manageable format (UTM).

To do this, we need to first display the UTM coordinates with no offsets, and then change it into a local grid that has some more manageable numbers.

We can change to UTM by selecting our GPS menu. Make sure that your GPS screen is the active one – otherwise you will not be able to find this menu.

From here, select "UTM Setup"
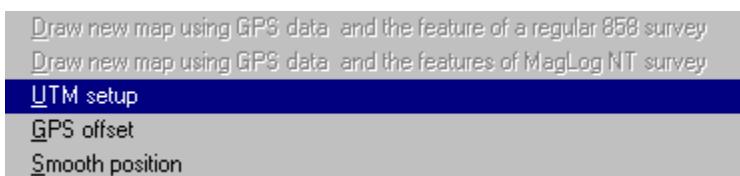
Then, fill out the parameters in the *UTM* screen as follows:

UTM transformation setup

☑ Enable UTM transformation

Ellipsoid parameters

Ellipsoid name: WGS-84 1984

Major axis, meters: 6378137

Flattening: 298.254

UTM projection parameters

Autoset projection parameters

Central meridian (degrees): -123

Scale factor (0.9666 for UTM): 0.9996

Northing, meters: 0

Easting, meters: 0

OK   Cancel
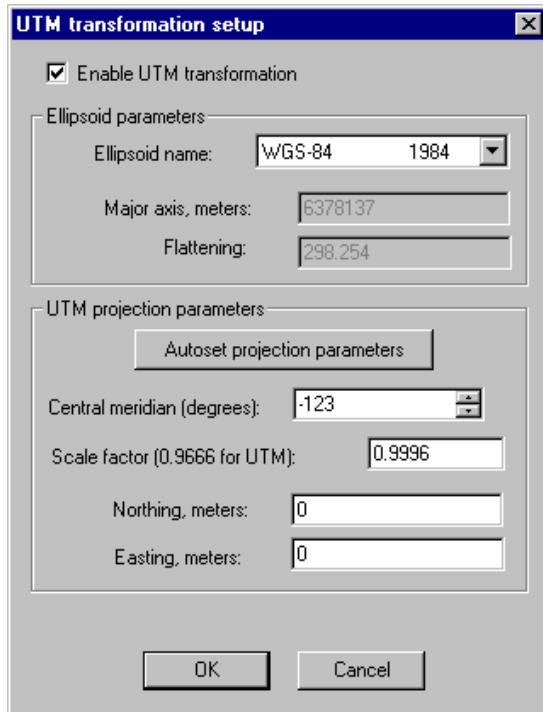
Note: Here we let Magmap automatically set the central meridian.

After we are done and press "OK", we should get the following map:
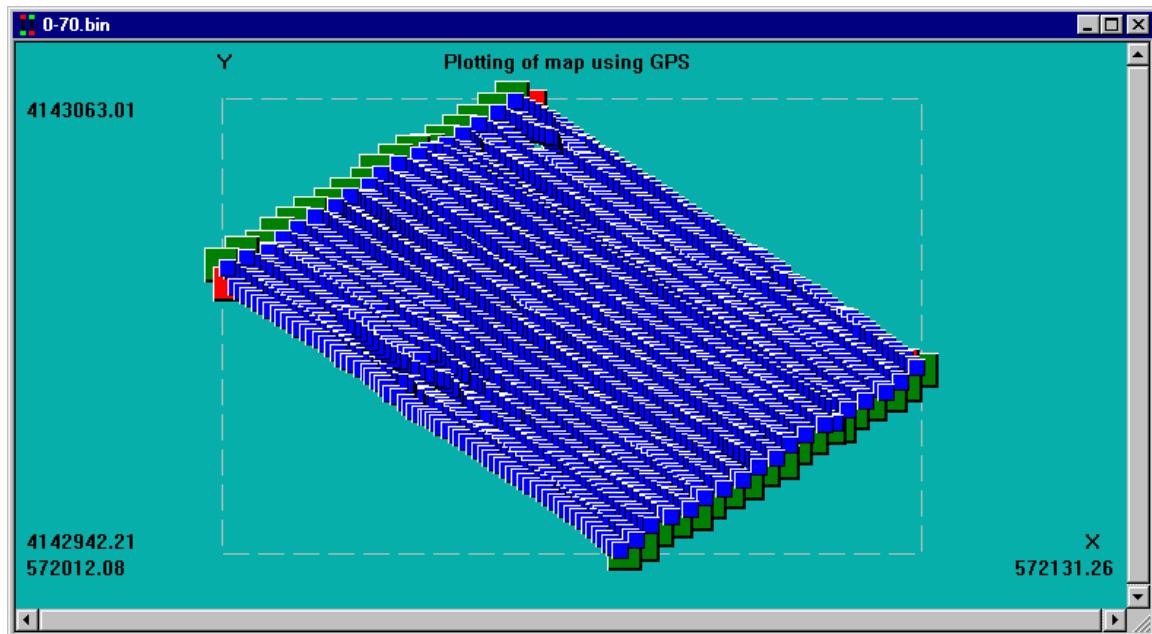
GPS map with UTM coordinates (no offsets)

As can be seen, this map is in UTM coordinates but they are quite large and difficult to deal with. We would like to have this in a local coordinate system, where the bottom left-hand corner corresponds to the coordinates (0,0). To do this, we need to add offsets.

We need to look at the GPS screen in UTM coordinates to get these offset values. In the above case, we need to have a northing offset of –4142942.21 and an easting offset of –572012.08 (we took the negative of the numbers located in the bottom left hand screen). – Remember that we can find our offsets by using the formula:

- Value + Offset = NewValue

- Offset = NewValue – Value   ** if NewValue is 0, then Offset = -Value.

Here, "Value" (for northing) was 4142942.21 and NewValue was the value we wanted to have – namely 0.

After we have set these offsets, our map should appear as follows:
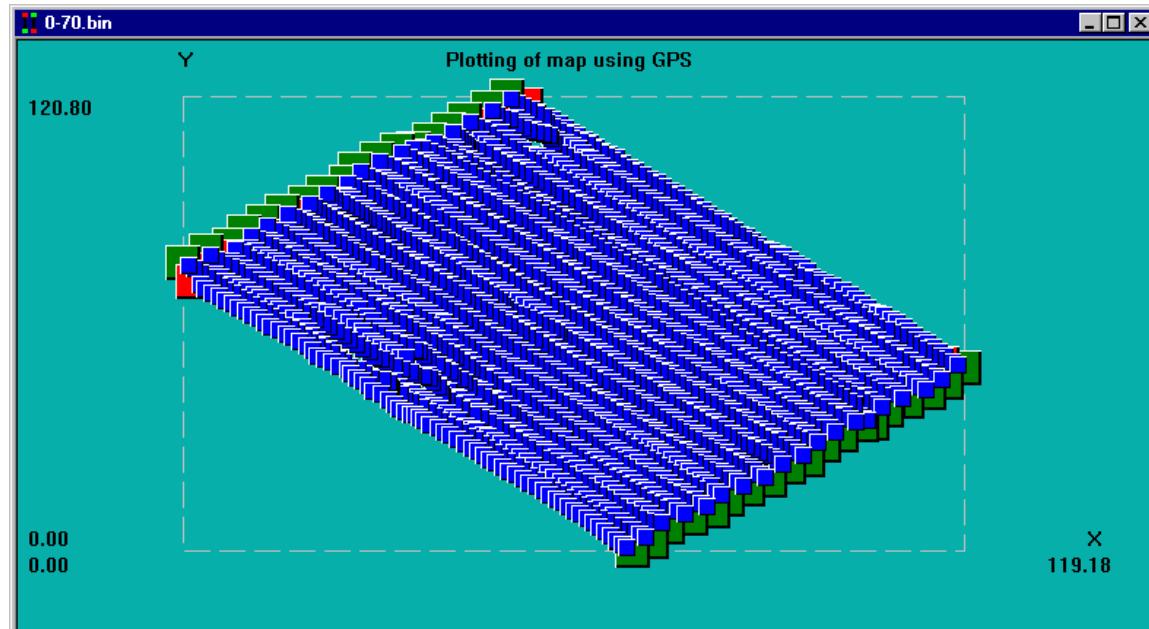
GPS map in local coordinate system

17.3.4.3. COMPUTING ADDITIONAL POSITIONS

Now we need to add a position point for the magnetometer. As said before, the GPS is located about 1.6 meters behind the magnetometer. As a result, if we were to graph the data, we would see many errors due to the fact that the GPS and magnetometer were not at the same place. These errors would also depend on what direction we were travelling while taking the data. In lines going "up", the magnetometer would appear to be ahead of the GPS and we would need to add 1.6 meters to each GPS position in order to make this appear correct. In lines going "down", we would need to subtract 1.6 meters from each GPS position in order to get the correct magnetometer position. A single anomaly would appear to be in different places from line to line.

Magmap can correct for this by outputting an extra position point. (See Chapter 7 for more discussion).

We would like to have two position points outputted – one labeled "GPS" and one labeled "Magnetometer". We can do this by selecting the "GPS" menu, and then selecting "GPS Offset".

From here, press "Multiple Offsets Setup". Then fill out the dialog box as follows:
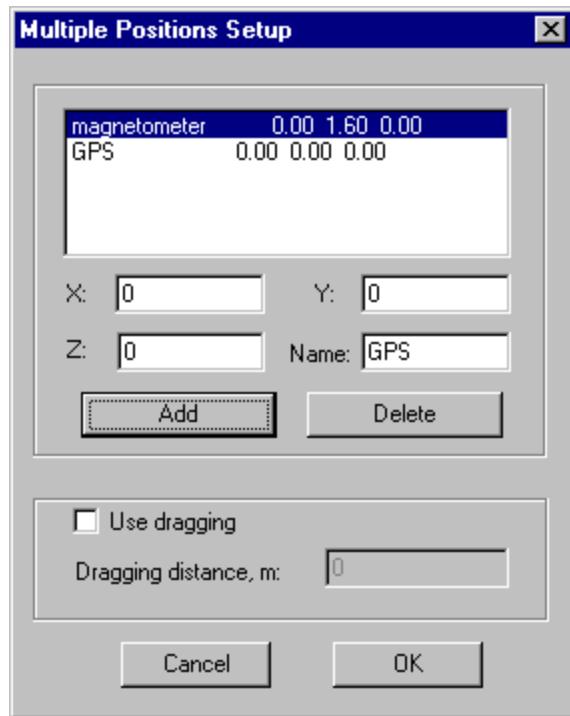
There are a few important points to make sure you do:

1) Make sure "*Use Dragging*" is disabled. This is mainly used in marine surveys where the distance can be variable.

2) Delete the initial position point (you cannot edit and existing position point).

3) Add the two position points labeled "*magnetometer*" and "*GPS*".

After you have finished, you are done with what you need to do with the GPS data for this file. It is useful to save your work.

Note: The GPS position is included so that we can output our original positions and compare the results later. It is not usually necessary to keep this position.

17.3.5. Editing Magnetometer data that goes with the GPS

We also need to edit our magnetometer data that will be used with the GPS. As seen earlier, we had data with drop-outs.
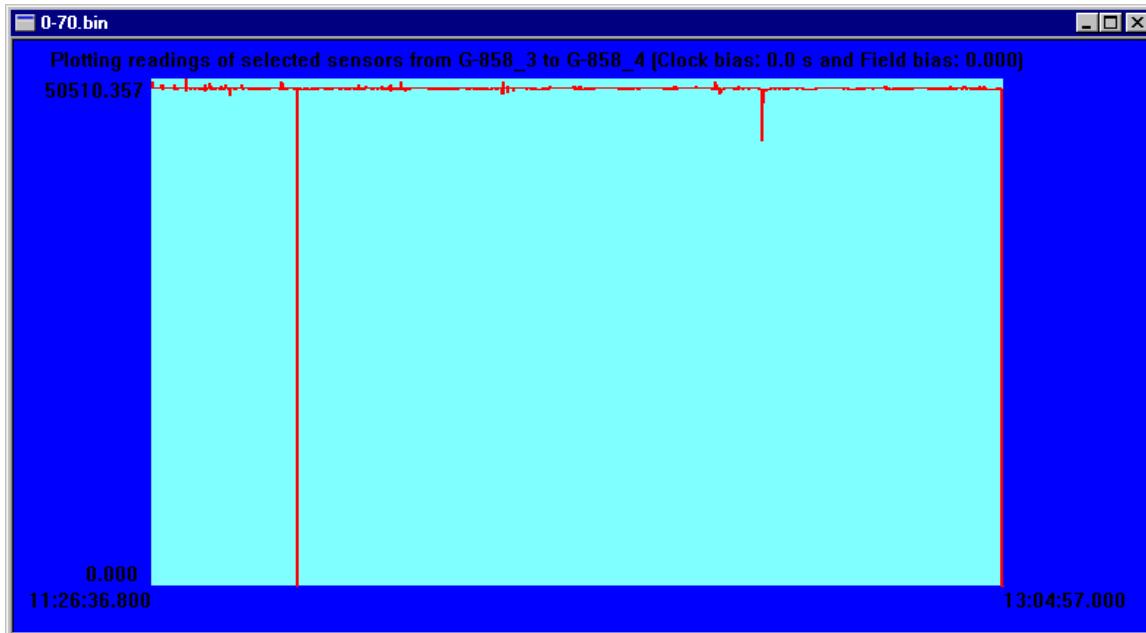
Initial magnetometer data

The first thing that we can do is to remove the drop-outs.   We will choose to linearly interpolate the drop-outs with good readings (see Chapter 6 for more of a discussion on filtering data).

To remove the drop-outs, make sure that the magnetometer screen is selected. Then, from your "*Filter*" menu, select "*Linearly Interpolate Drop Outs*".

Your new magnetometer screen should re-scale to reflect the filtered data.
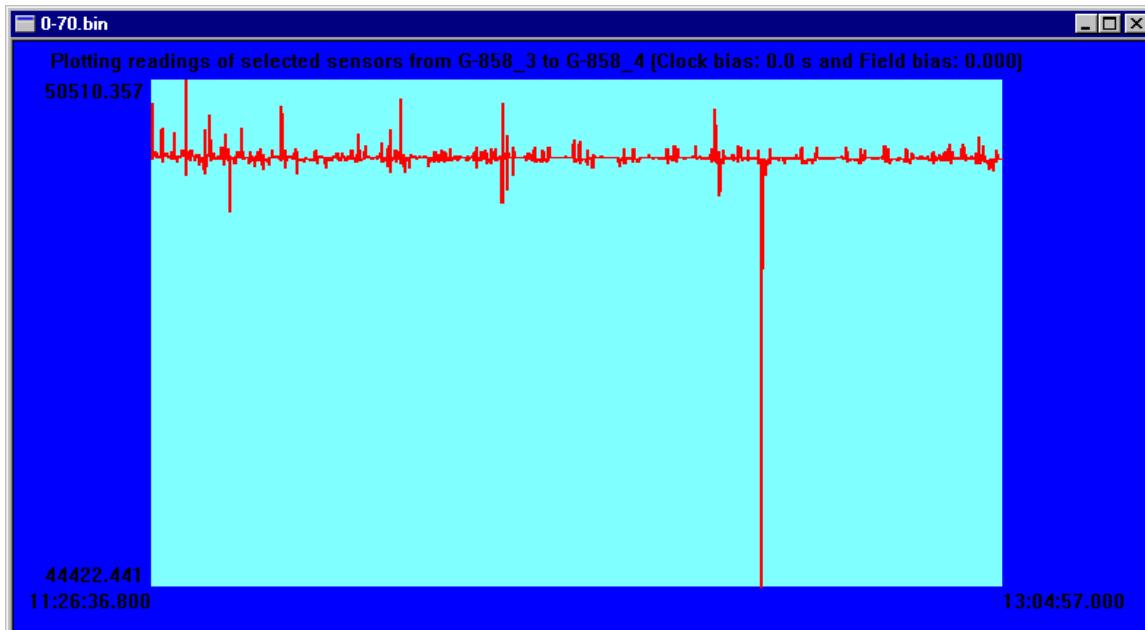
Magnetometer data with drop outs linearly interpolated

There is also a downward spike in the middle of the screen that appears suspect. We can choose to despike the data using a spike value of around 500 (spikes of 50 are common) but this won't do anything. If we look closer (e.g. run our cursor on the readings and see different values for different times), we notice that this "spike" actually consists of several changing readings – in other words, it is not a spike at all.

Thus, we are finished with our magnetometer data.

17.3.6. The base station file

This section describes some operations that we can do with the base station file. Normally this file requires very little attention – it is only used as a stationary reference to compare the magnetometer data to.

17.3.6.1. LOADING THE BASE STATION FILE

We can load the base station either as a binary file, or as an ASCII file (if you have already converted it). In this case, we will load the ASCII equivalent.

To open the file, you can select it as follows:
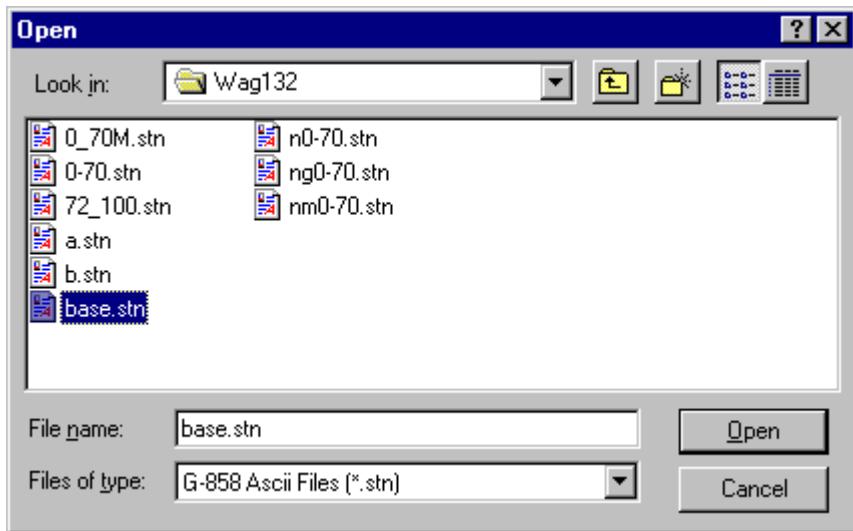
From here, you should see your base station data.

Base station data

17.3.6.2.CHECKING THE BASE STATION DATA

If we look at the file, it is difficult to see if the data is good or not. We see some drop outs which occurred when the magnetometer was warming up. However, it is difficult to see if the rest of the data was good. We don't need to set any bias for the time because we set the clocks to be the same at the beginning of our survey. Additionally, we don't want to add any magnetometer offsets to all the data.

We can re-scale the data by pressing the right mouse button. We fill out the following:
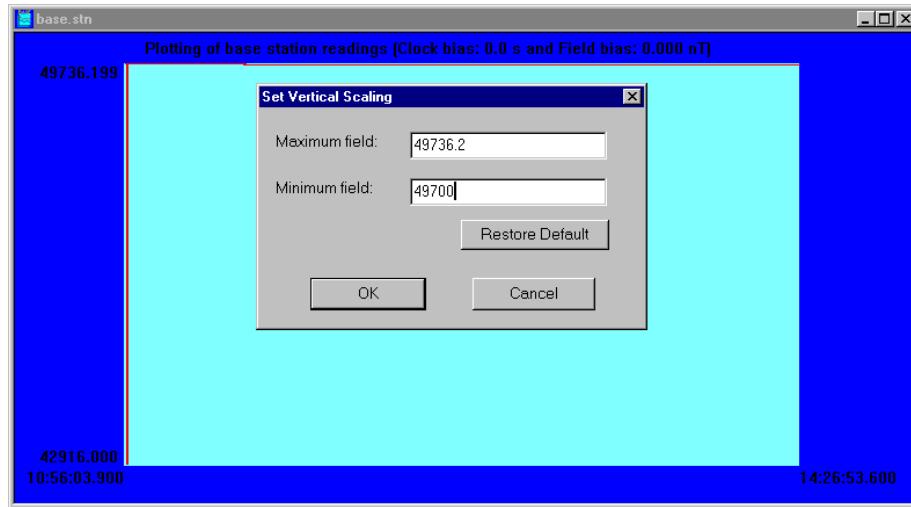
Our new map shows us that the data is okay, except for the very beginning.
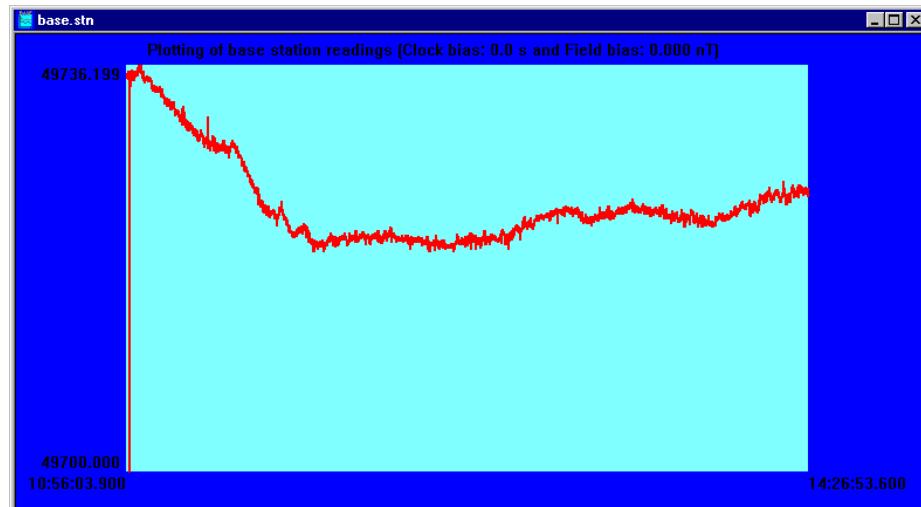
Re-scaled base station data

In this case, we don't need to do anything more to the data because these spikes occurred a long time before the survey began. Thus, we have done all we need to do with our base station file. (It is always a good idea to save it though).

17.4. Exporting the data

We have finished editing the GPS data and the magnetometer data. We need to export this data so we can further analyze it.

To export this data, we select the screen with the GPS data. This is important because certain export options are only available through the GPS screen.

We can then go to the file menu and select "*Export*". This should bring up the following menu:
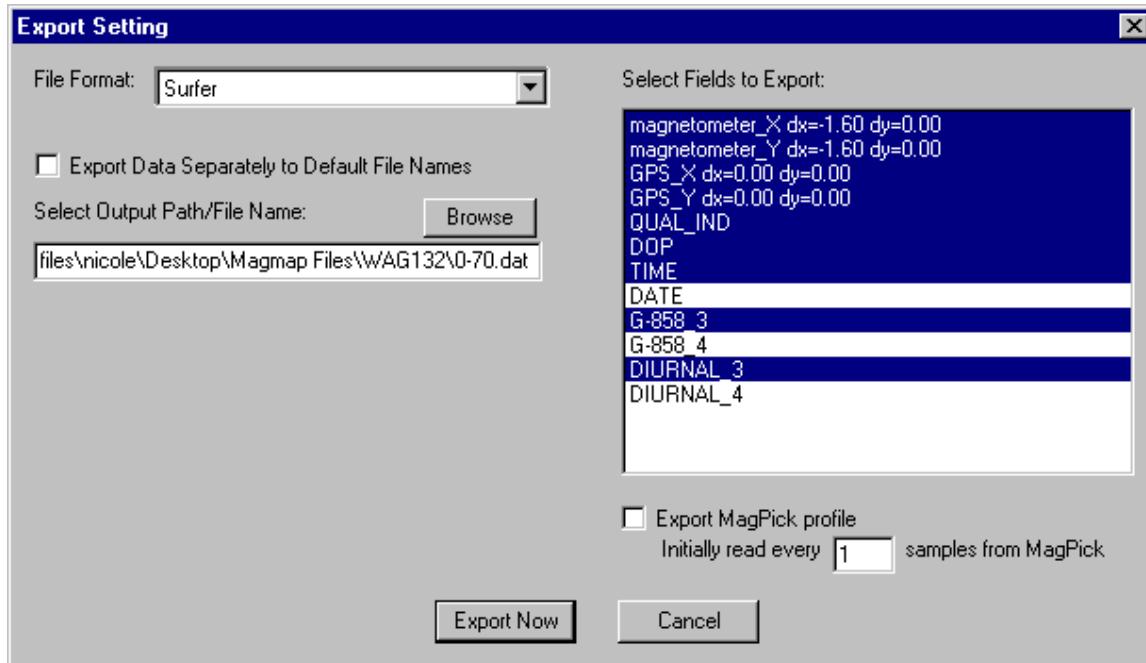
Export Setting dialog box

Here we have chosen to export a number of fields:

- magnetomer_X, magnetometer_Y – the two magnetometer shifted positions we specified

- GPS_X, GPS_Y – the non-shifted GPS positions we specified.

- QUAL_IND, DOP – two quality factors included in the GPS data.

- Time

- G-858_3 -- the first sensor reading (uncorrected)

- DIURNAL_3 – the diurnally corrected first sensor reading (Base Station Reading is subtracted from sensor reading)

Note: We have not selected G-858_4 and DIRURNAL_4 because we only had valid data on one sensor.

We also need to make sure that we pick a suitable name for our output file and uncheck "*Export Data Separately to Default File Names*".

When we are finished, we press "*Export Now*" and the data is exported. Some sample data from the output file appears below:

```
magnetometer_X magnetometer_Y     GPS_X     GPS_Y   QUAL_IND      DOP   G-858_3       DIURNAL_3
TIME
    67.48      1.17      68.57      0.01      2.00      1.00 50199.07600 -469.64900 11:26:36.900
    67.41      1.26      68.50      0.09      2.00      1.00 50096.44800 -367.06300 11:26:37.000
    67.34      1.34      68.43      0.16      2.00      1.00 49944.51800 -215.13900 11:26:37.100
    67.27      1.42      68.35      0.24      2.00      1.00 49810.18600  -80.81000 11:26:37.200
    67.20      1.50      68.28      0.31      2.00      1.00 49719.18700   10.18600 11:26:37.300
    67.13      1.58      68.21      0.39      2.00      1.00 49658.80000   70.56500
11:26:37.
```

As can be seen, we have exported all of the fields that we wanted into a Surfer compatible format.

Note: Some versions of Magmap have problems exporting this file. This is due to the fact that the file 0-70.bin was improperly terminated. If you get a message that prevents you from exporting such as: "*One of the lines is shorter than Look forward points + Look backward points. Export Aborted*", one work around is to not delete any lines on the GPS map. It should work fine then.

17.5. Further Data manipulation

17.5.1. Processing the second file

The second file also needs to be processed. This data has no noticeable spikes and the map is correct, so the processing should be easy (refer to previous sections for operations you might choose to do).

In this case, we loaded the file, drew a map using the GPS readings, and exported the data (no special manipulation required).

Make sure you select the same export fields as you did in the first file. You should also pick a new filename to export to. Make sure your base station file is open.

Note: Many of the settings you selected in the first file will be valid for the second. These settings remain (e.g. GPS offsets, UTM settings) until you change them.

If you have difficulty graphing the GPS data (e.g. the option is grayed out), make sure that you have closed the first file. **Magmap cannot have two GPS maps of the same type open at one time.** You should also check and make sure you have the map, rather than the base station file selected.

17.5.2. Concatenating two files

In this example, we took data in two files, and exported into two separate files. However, we still would like to look at all the data in one map.

We can choose to combine these files either in Surfer (refer to Surfer documentation), or do it through DOS. To do it through DOS, you need to do the following steps:

1) Remove the heading from your second file. This is important because Surfer recognizes headings only from the first line.

- You can do this easily from a text editor by deleting the first line.

2) Concatenate the two files with a command at the DOS prompt such as :

Copy a + b   c

- Here, "a" and "b" are your first and second files and "c" is the name of the new output file.

  In this case, we named our two output files 0-70.dat and 72-100.dat. We wanted to output to a file called 0-100.dat, so we typed:

  Copy 0-70.dat + 72-100.dat 0-100.dat

These two steps are all that is necessary to concatenate a file for use in Surfer.

17.6. Analysis in Surfer

This section assumes you are familiar with basic operations in Surfer.   If you are not, consult the Surfer manual for discussions on the plots used.

We find the shaded relief plot to provide the most useful view of our data. The contour plot doesn't work as well here because we have a large range of data, and some smaller anomalies will not show up when graphed.

If we do a shaded relief plot using the magnetometer data, we get:
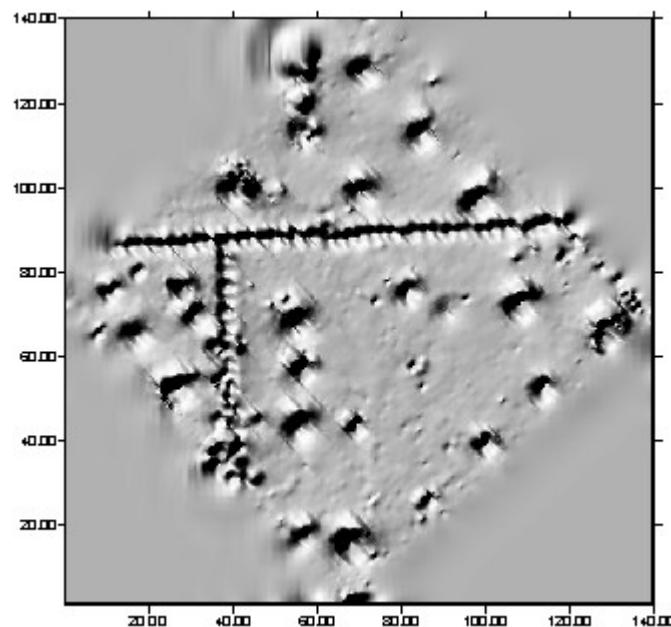
Surfer shaded relief plot of magnetometer data

Here, we used

- X = Mag_X

- Y = Mag_Y

- Z = DIURNAL_3

We can also see several anomalies from looking at the map. There is a long pipe that runs across the top of the screen, and another pipe that connects and runs parallel to the Y axis (X = 40). Also note that these coordinates are graphed using the offsets we specified in the UTM screen.

We can compare this plot with one we obtain using the non shifted positions (replace mag_X and

mag_Y with GPS_X and GPS_Y):
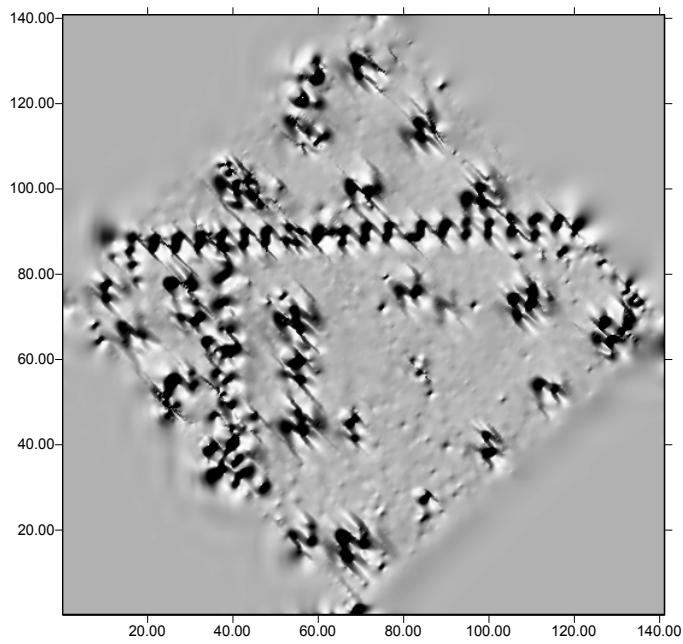
Surfer shaded relief plot with uncorrected positions

As you can see, here we can see errors introduced because the magnetometer and the GPS are not in the same place.

We can also look at the data that has not been diurnally corrected (but the positions have been corrected)
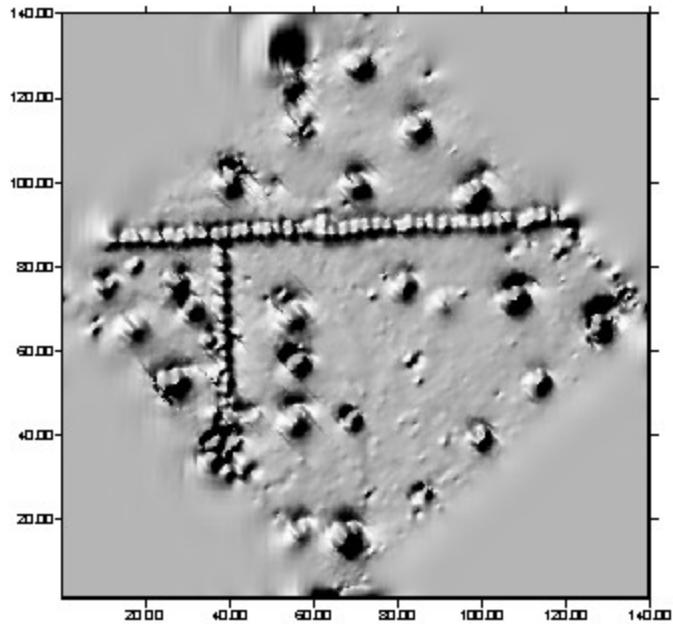
Data with no diurnal corrections

18. G-858 Survey with no GPS data

Magnetometer surveys were typically done using a pre-defined, measured grid that would allow the surveyor to establish a few position points, and time interpolate the rest. Recent developments have allowed the use of GPS positioning but there are still many surveys done without GPS positioning.

The sample survey discussed in Chapter 12 had GPS positioning but we also had a mapped survey setup. We will use the same files but will approach the analysis from a mapped survey perspective.

18.1.1. Loading the file

In this section we will manipulate the two magnetometer files to get the correct mapped information.

We begin by opening the file. The file type is "G-858 Binary File" as shown below:

> Note: This menu will default to the last file type you selected. If you do not select "G-858 Compress Files" as shown above, you will still get your data, but you might not get your survey map.

You should get the following map:
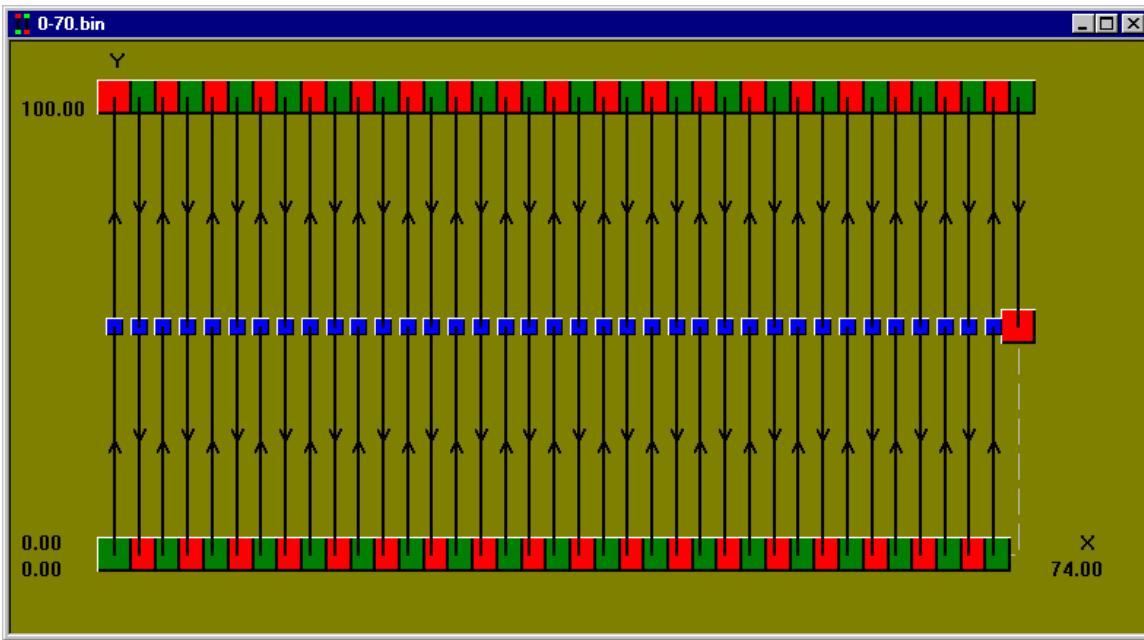
Initial map for first G-858 file

18.1.2. Manipulating the map

Now we need to do some editing operations on the map.

This map has a few problems that need to be addressed.

1) We need to take out a line at X=52.

2) The last line is bad because the magnetometer battery was drained. We need to delete this line.

We will start by deleting the line at X = 52. To do this, we need to select the three position segments, and then right click to select "*Delete Selected Segment(s)*" as shown below.

You can select more than one position point by holding down "CTRL"

Map with position points selected
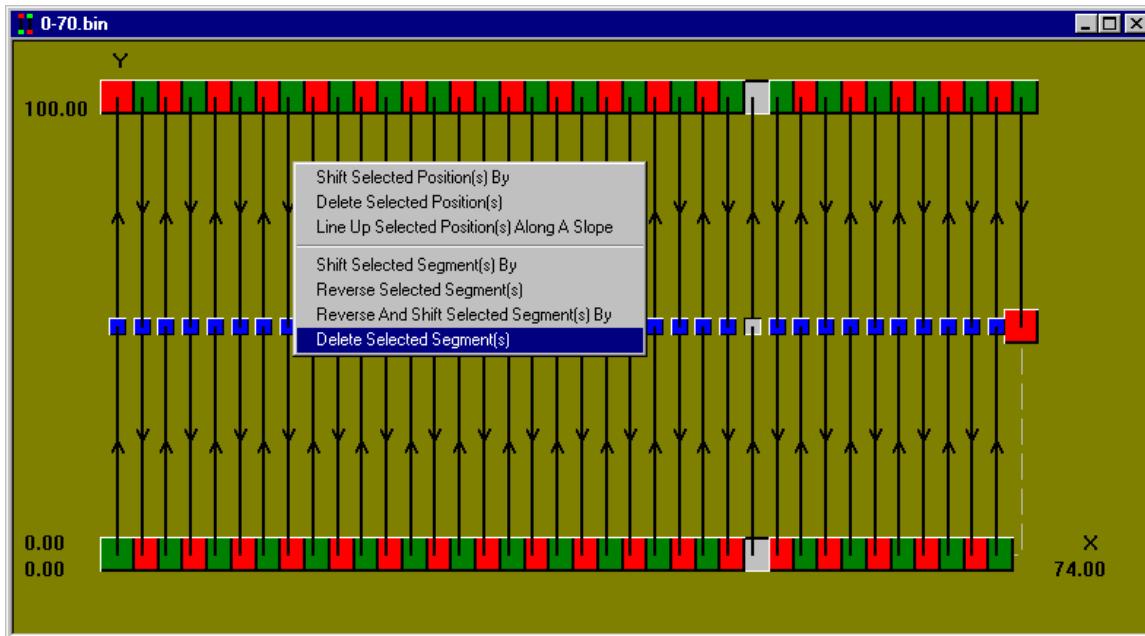
Here, we have selected the three position points (we can pick these out by looking at the statistics on the bottom of the screen. We search for X = 52, or Line = 26.

After we have deleted the line, the map should appear as follows:
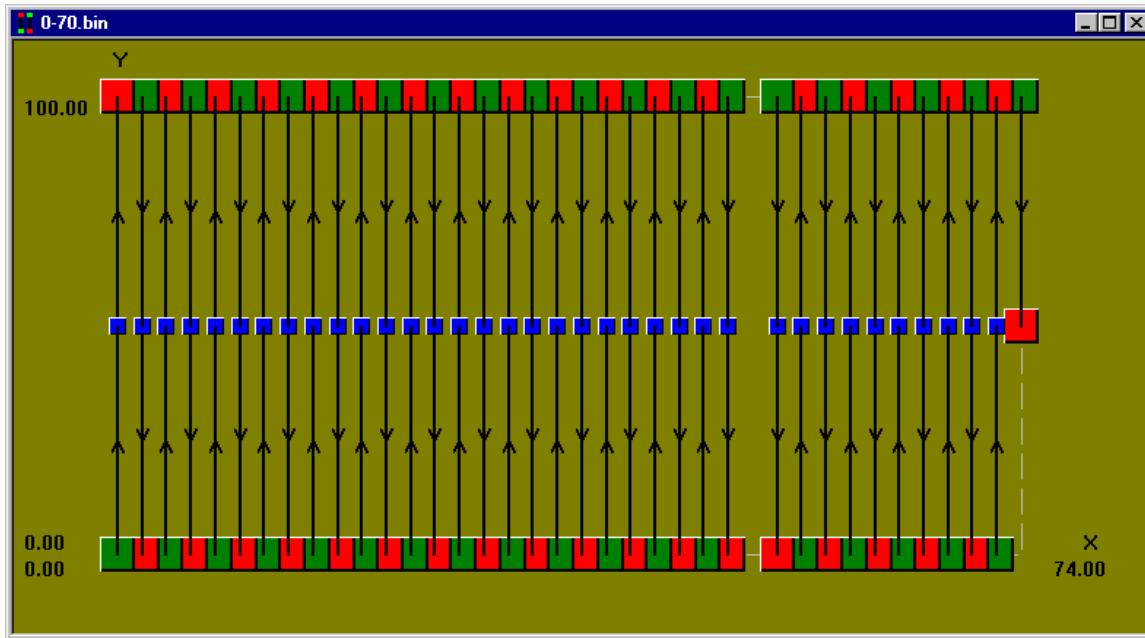
Map with a line deleted

We now need to shift all of the other segments over so that our other map coordinates will be correct. To do this, we need to select all the segments and then press the right mouse button to bring up the pop-up menu. From here we can select "*Shift Selected Segment(s) by*" as shown below:
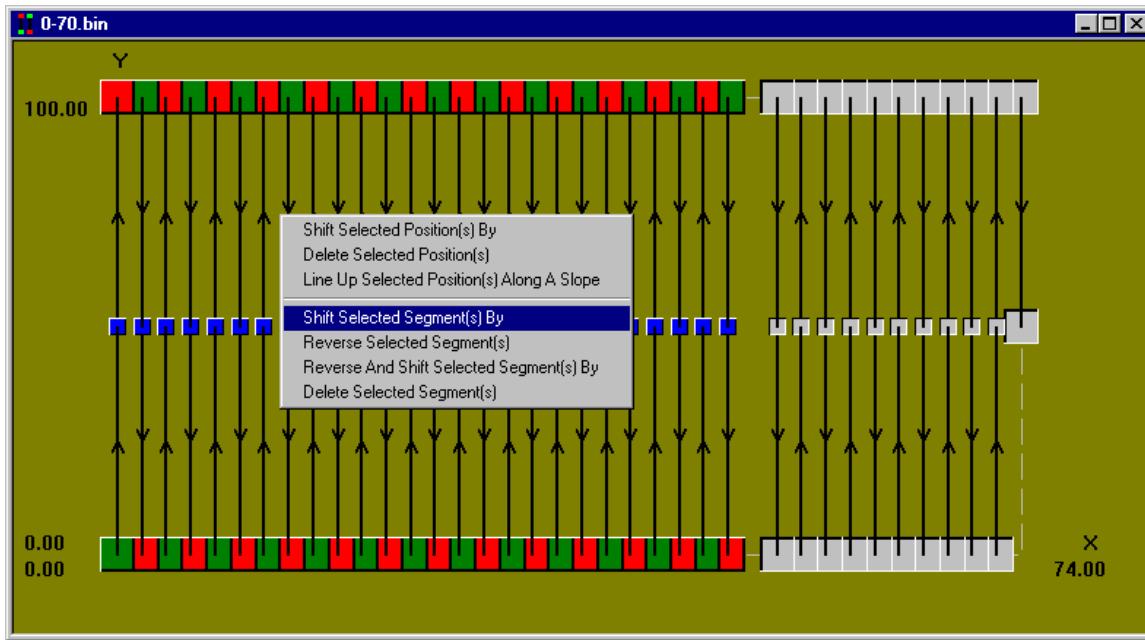
Since we want to move all of the segments 2 meters to the left and we don't want to change the Y offsets at all, we should use an X offset of –2 as shown below.
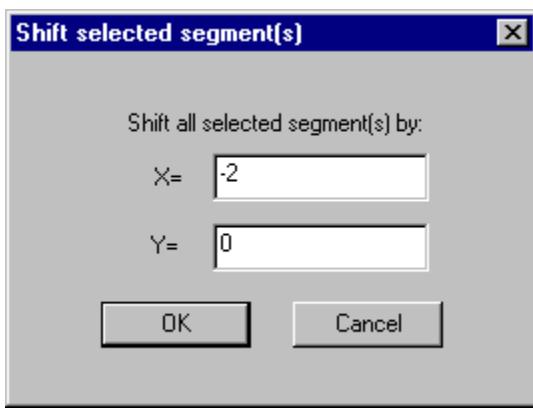
"Shift Selected Segment(s)" menu

In the new map, we see that the lines we selected have shifted over by 2 meters.
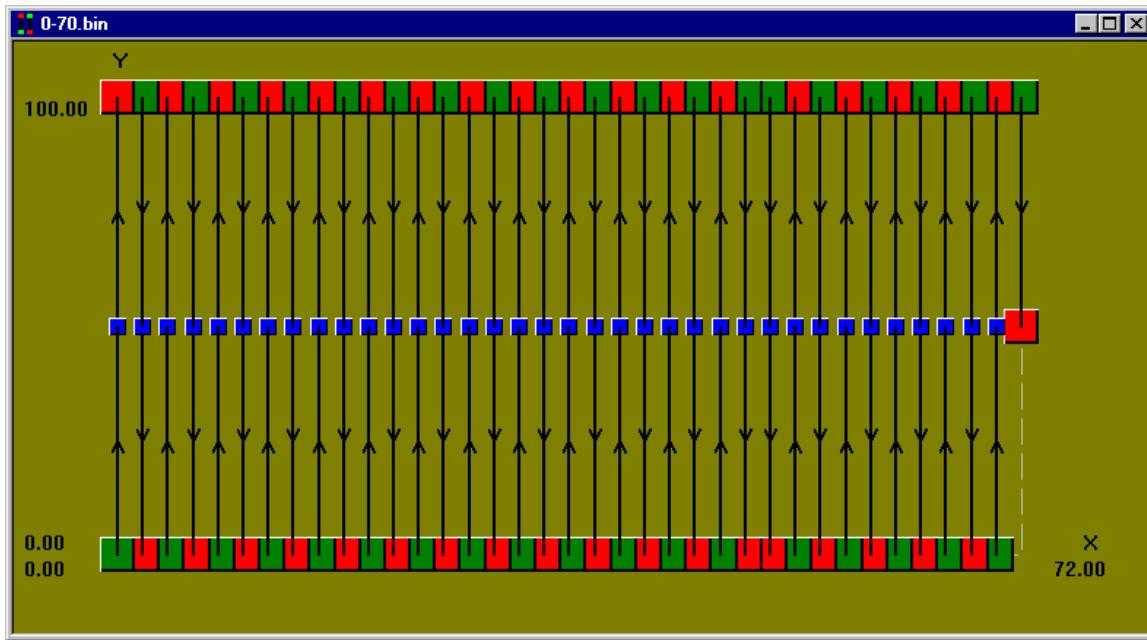
Map with segments shifted

Now we need to delete the last line where the battery went dead (X = 72). In order to do this, we do the same delete operation that we did earlier. We select the two position points and then delete the line.
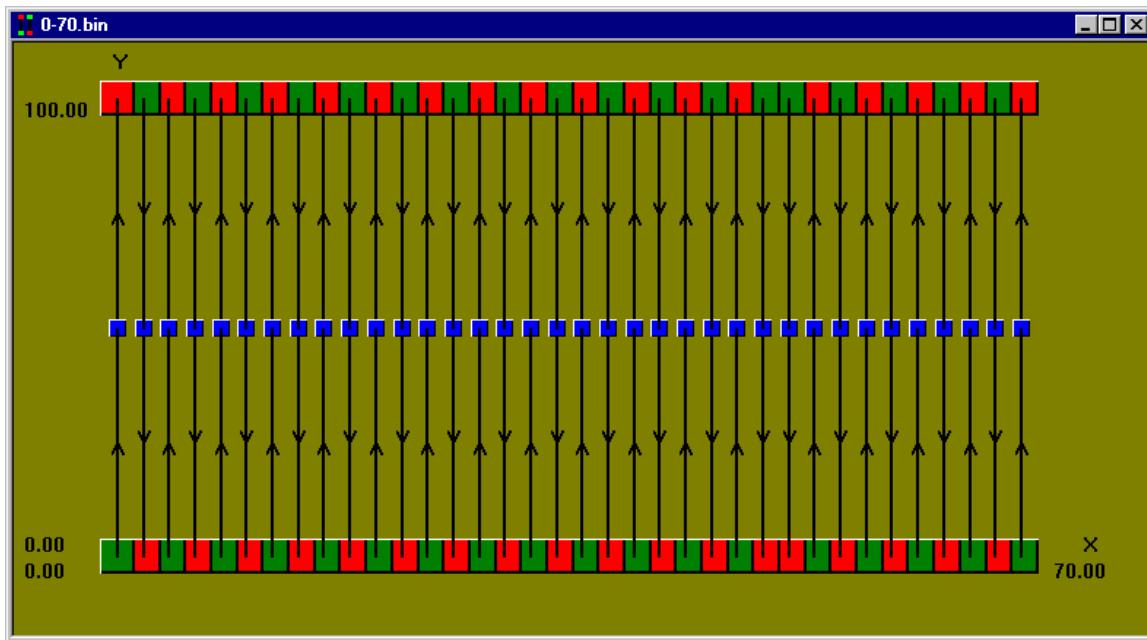
Final map for X=0 -> 70

18.1.3. Saving current work

At this point, it is advisable to save the current work in case there are changes to make in the future.

To do this, press "*Save*". Since we have not specified a save file before for this, we will be prompted to type a file name.
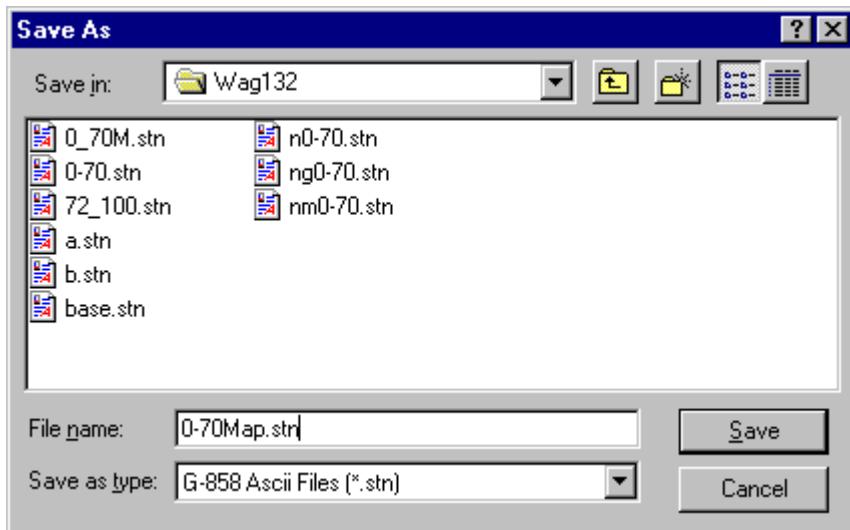
In the above example, there are several ".stn" files already present. It will be helpful to pick a naming convention so that we can easily identify the files associated with a given open file. In this case, we chose to add "Map" to the initial file name. We can save this by pressing "OK".

18.2. Manipulating the G-858 data

Now that we have edited the map, we should look at the data and check for drop-outs and spikes.

> Note: The magnetometer data associated with the GPS and the magnetometer data associated with the map are treated separately. Any changes (e.g. despiking, removing drop-outs) that are done to one data set are not applied to the other.

You can look at the G-858 data by positioning the cursor on a point that is not the endpoint of a line (e.g. in this case, we positioned it on one of the black lines with arrows). Right click on it and you should get the menu seen below:
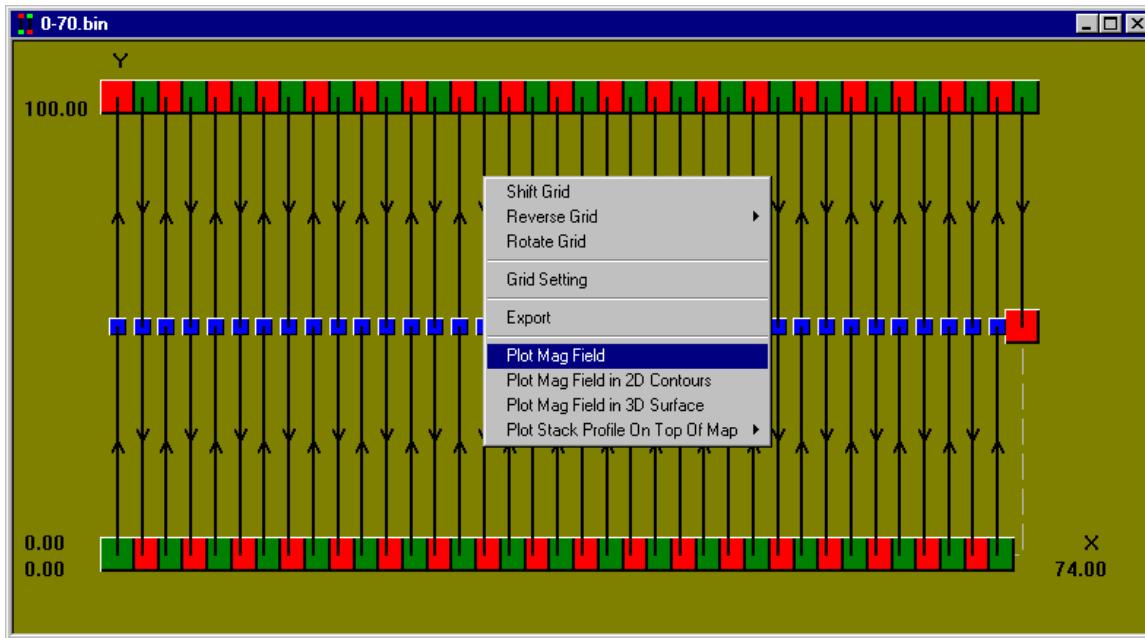
After selecting "*Plot Mag Field*", you should see the following magnetometer data.
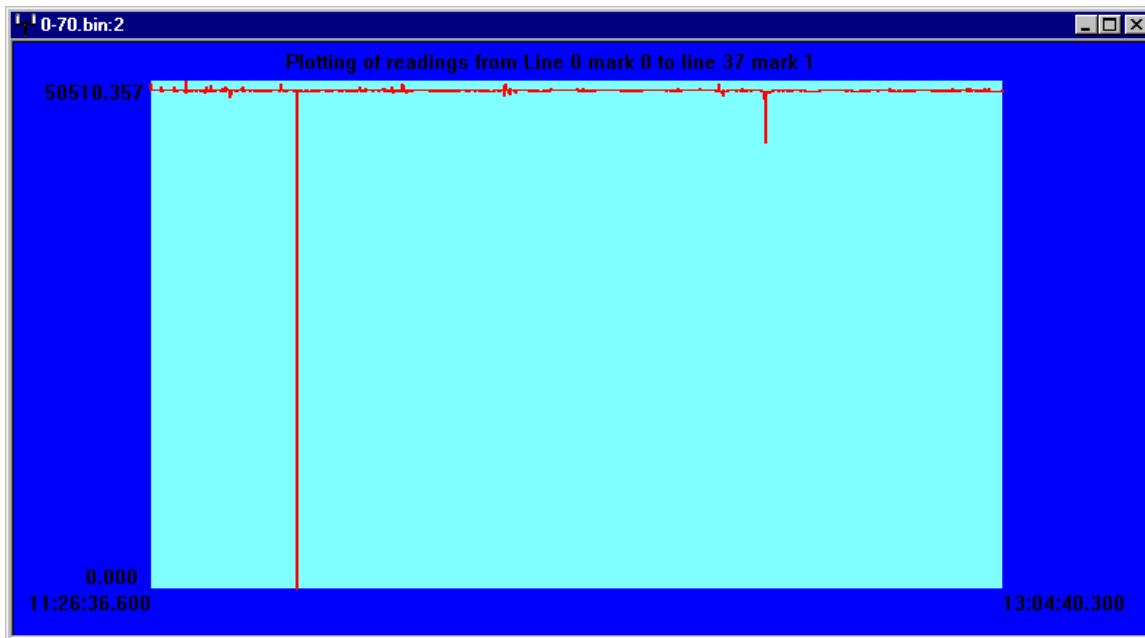
Magnetometer data

The discussion of how to remove drop-outs and despike this data is given in section 0 above.

18.3. The base station data

The base station data is treated the same as in the previous chapter – section 0 above

18.4. Analysis of G-858 data from within Magmap

This section describes some operations commonly used in analysis.

18.4.1. Setting a proper scale

We can use Magmap to gauge how large a particular anomaly is, and also where it occurs. To do this, we will need to set up a series of good grid lines and then use Magmap's zoom feature to look at pertinent features.

To turn on the grid lines, go to "*Scale*" and select "*Grid Lines*". You should get the following menu:
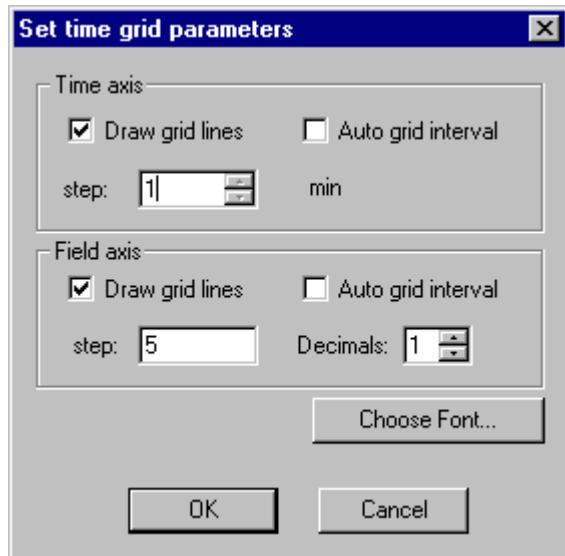
"Grid Lines" dialog box

Here we have chosen to manually specify our grid lines. We have chosen intervals that are pertinent to our survey – e.g. the survey is 100 meters wide, so it makes sense to scale and try to locate anomalies on the scale of 1-5 meters.

We have disabled Auto gridding because it is more difficult to find the values that will be assigned to the intervals.

When we press "OK", our grid appears as follows:
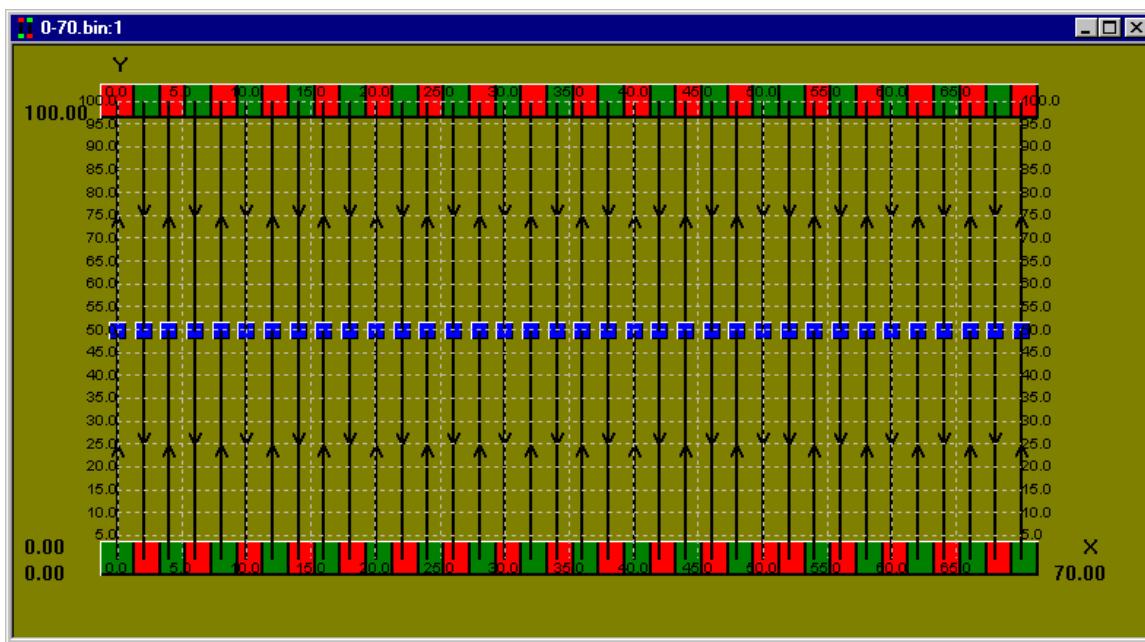
Map with grid

Note: Magmap will apply the grid options to the active window. Make sure that you have selected the window you want to grid.

18.4.2. Using the Stack profile

The stack profile is particularly useful in a survey such as this, where the lines are straight and parallel. We can plot a stack profile on our map by selecting an endpoint and right clicking to get the menu:
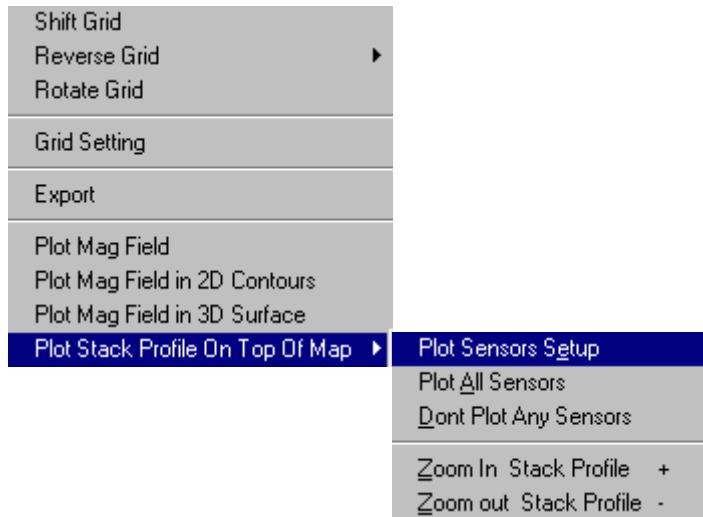
This should bring up a menu that will allow us to select the sensor we want to plot – Sensor 1.

Our stack profiles are shown below:
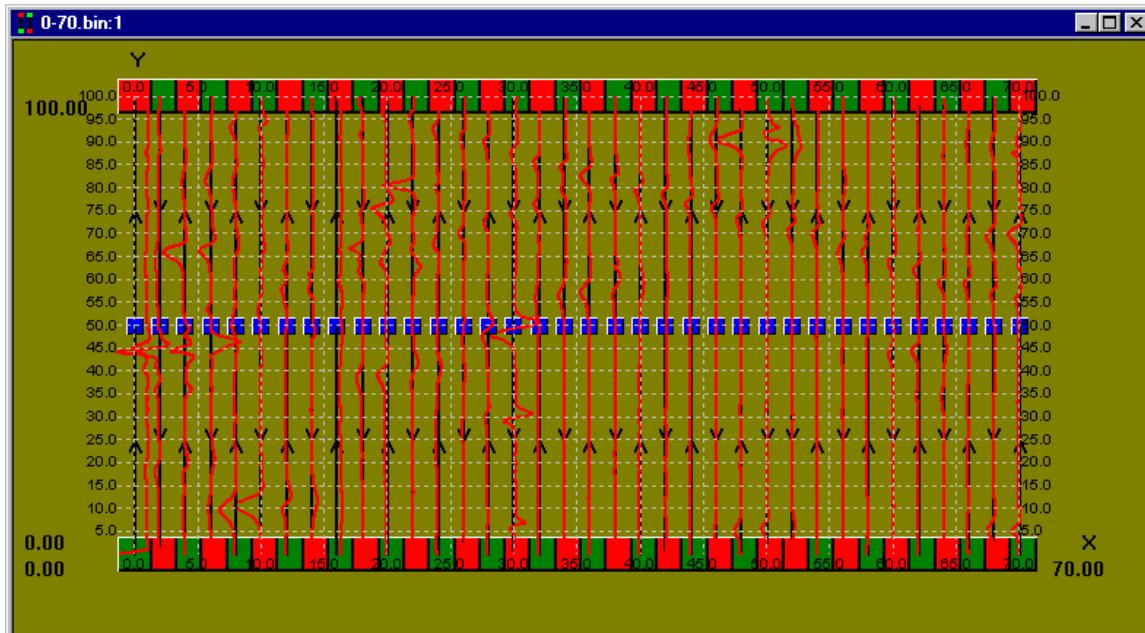
Map with stack profiles plotted

At this scale, we can see some anomalies but we would like to zoom in on them to characterize them more accurately.

We can right click on our map and select "Plot Stack Profile on Top of Map". From here, select "Zoom In Stack Profile" as shown below:
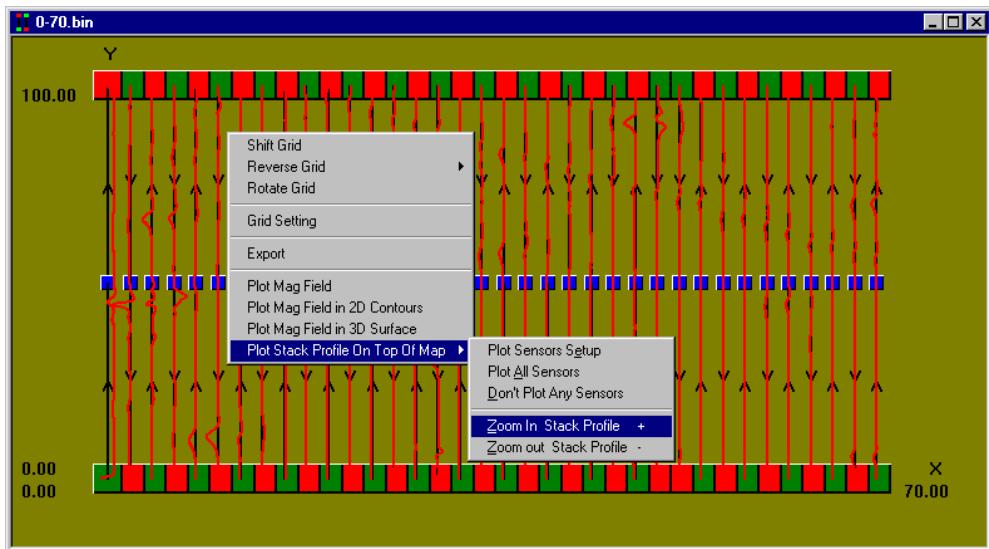
Note: We can also change the height of the stack profile peaks by using the "+" and "-" keys.

After zooming a few times, we get the stack profile shown below:
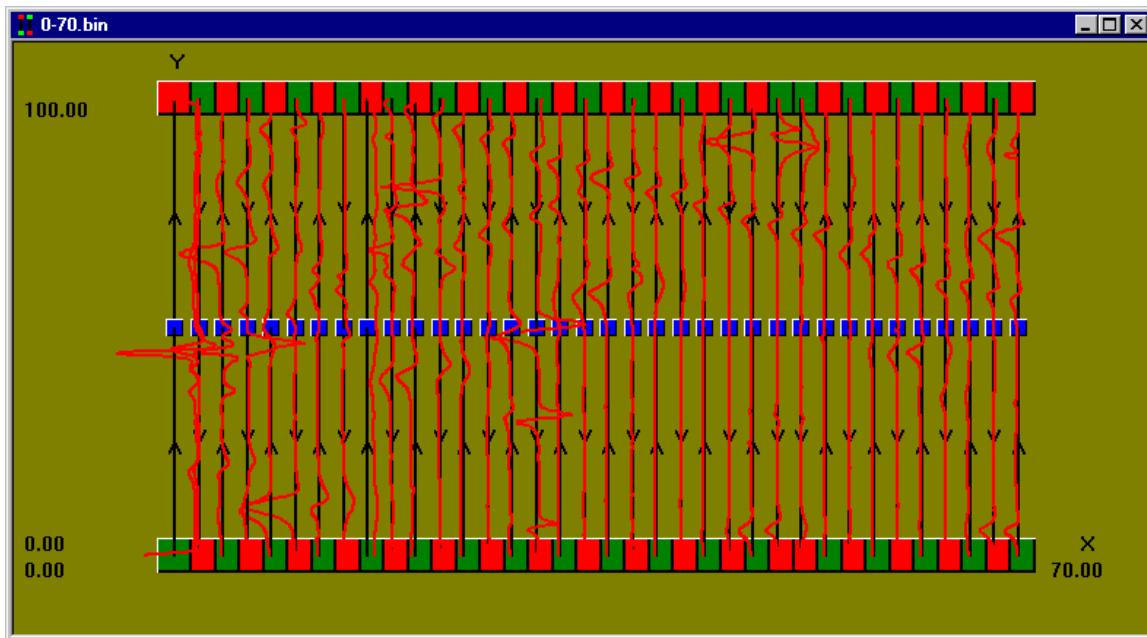
There are a few things we can immediately tell from looking at the stack profile. One thing is that we have a few objects that look linear.
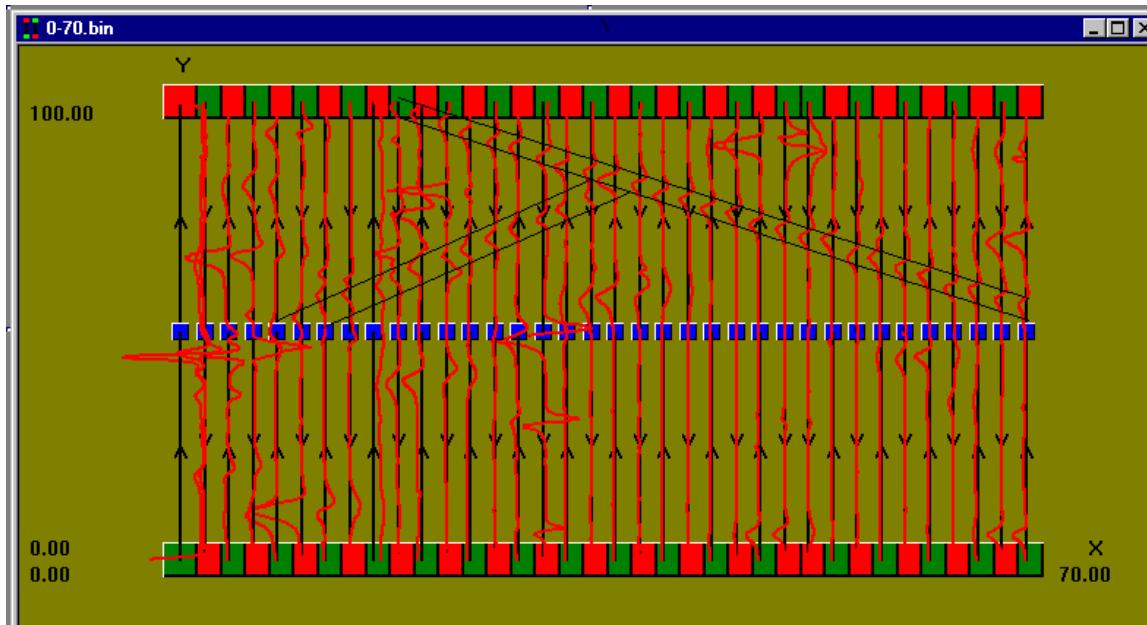
We can tell this because there are several anomalies on the stack profile that have about the same height and width and can be arranged in a line. This is characteristic of objects such as pipes. These particular anomalies came from a wooden pipe wrapped in steel wire that was buried at the survey site in the 1800s. The wood had long since rotted away but the steel wire surrounding it was picked up by the magnetometer.

You can also look at other anomalies and try to get some basic characterizations such as depth, X and Y coordinates, and width. You can even begin to guess what type of object it is. For more discussion, read "Applications Manual for Portable Magnetometers" by S. Breiner. A thorough discussion on interpretation of anomalies is given in Chapter 5.

18.5. Exporting the data

This data can now be exported for further analysis. The technique is a little different than the technique we saw in Chapter 17. For one thing, we have no GPS data to export.

We can export our data by selecting "Export" from the file menu.

We get the dialog box shown below:
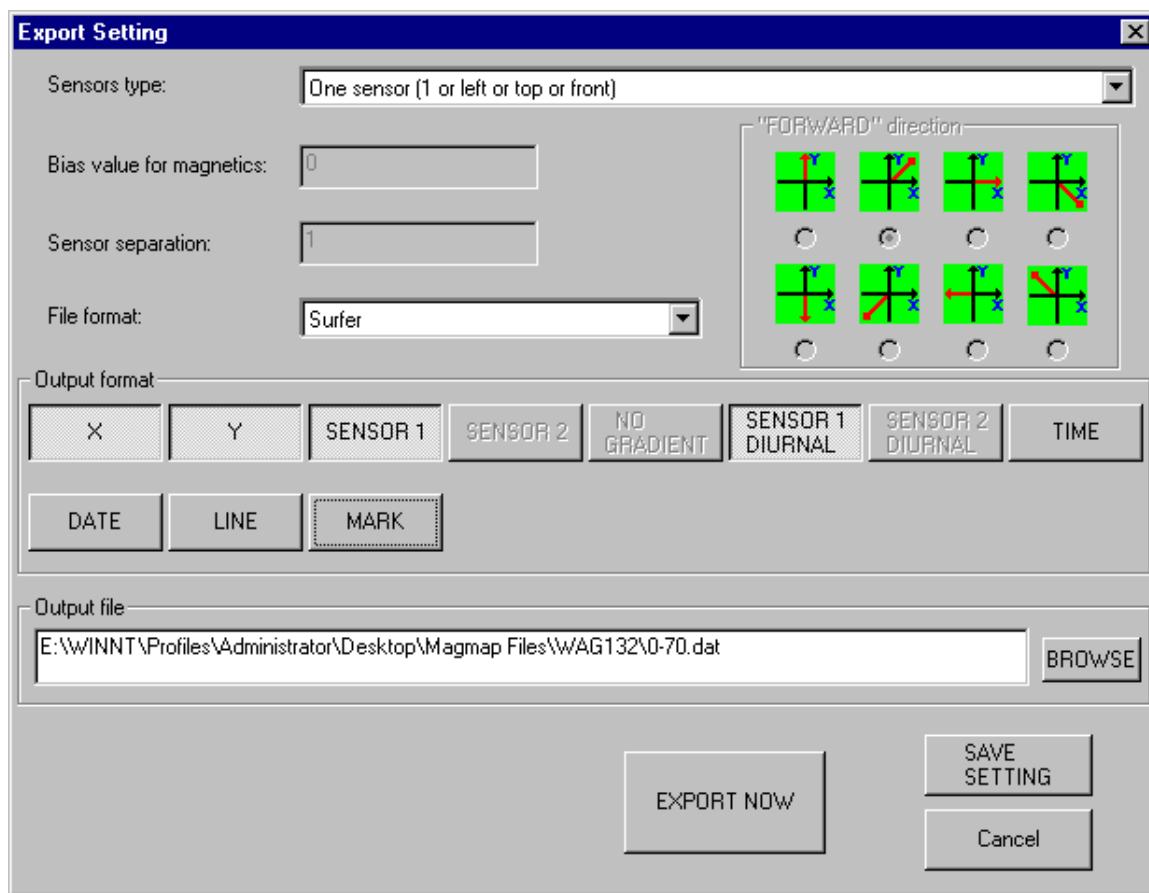
In this case, we have chosen to export the position, sensor reading, and diurnally corrected sensor position to a file named 0-70.dat.

We can export this by pressing "*Export Now*".

> Note: Even if there is GPS data present, it will be ignored in this case. You need to select an active GPS window in order to export GPS data. GPS and mapped data are always treated separately.

18.6. Further data manipulation

The second file is processed much like the first. There are no huge spikes in the data and the map is correct. Therefore, you should be able to easily load the base station file, load the data file and export without having to do anything else.

Make sure that you export this file with the same output parameters!

Refer to section 17.5.2 for information on how to concatenate the output files.

18.7. Analysis in Surfer

This section assumes you are familiar with basic operations in Surfer.   If you are not, consult the Surfer manual for discussions on the plots used.

18.7.1. Using the contour and shaded relief plots

As done in Chapter 17, we find the shaded relief plot to provide a useful view of our data. We get the result shown below:
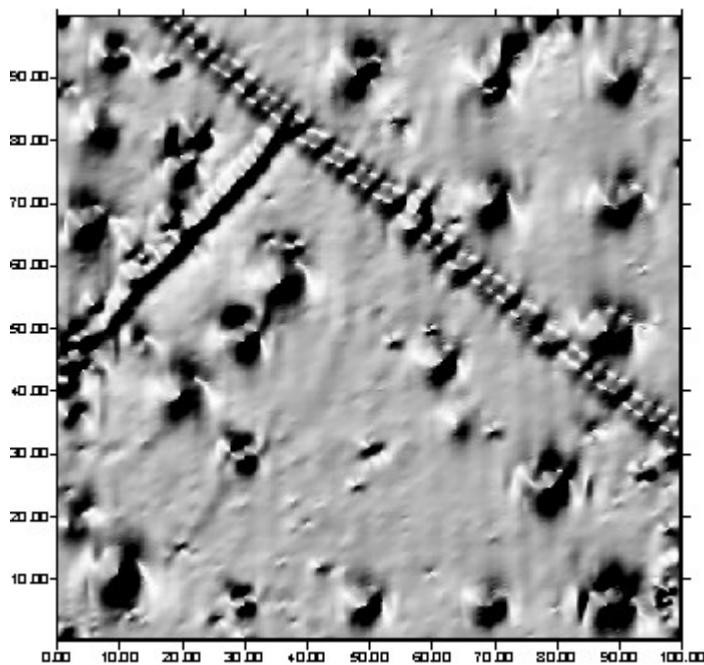
Shaded Relief plot with mapped data

We can easily make out the pipe features on this map. We can also see several other anomalies on the map.

This map is useful because we can get a good view of where all the anomalies are. We can also get a good idea of how deep they are by seeing how wide they are. A large peak (very dark spot on the contour graph or a large peak on the stack plot) can be indicative of a large object, or something near the surface. The width of the anomaly will distinguish this.   An object buried close to the surface will tend to have a high peak but narrow width, whereas the same object buried deeper will give a larger width and shorter peak.

This is discussed in more detail in the <u>Applications Manual for Portable Magnetometers</u> by S. Breiner.

You can also start to make a guess about the nature of the object by looking at the contour plot. Naturally, objects such as pipes that lie horizontally are quite prominent on the graph. You can make other general identifications by looking at whether the anomaly appears to be a magnetic monopole or a magnetic dipole. For instance, in the contour plot below, we can see a number of dipoles and a number of monopoles.
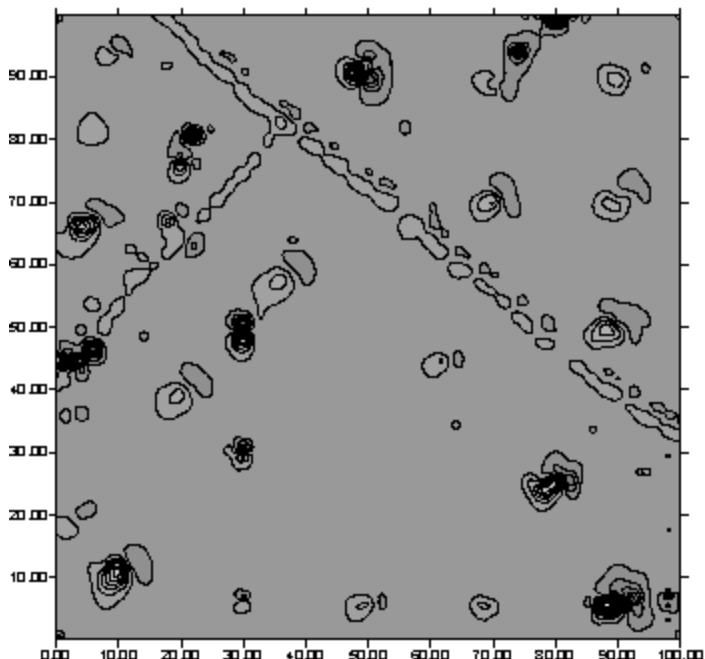
Contour map of data

We can zoom in on a few characteristic dipoles:
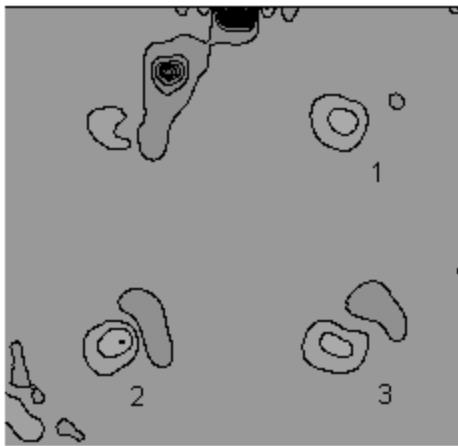
Selected dipoles from data

These anomalies are dipoles that were produced by buried drums lying horizontally. In each case, the number and orientation of the drums differed, as well as the depth. In the lower right hand anomaly (3), 3 drums were spread out and buried shallowly (about 1.8 meters). In the lower left hand dipole (2), two drums were buried at right angles at about 2.0 meters depth. One can see the slight differences in the shape of the dipoles.

The drums are buried in the same orientation in the upper right hand dipole (1), but they are deeper. You can see that the anomaly appears weaker and harder to see.

Additionally, since the magnetic field is induced, one can see that the dipoles point in a north-south direction. The drums themselves point along the Y axis of the plot but the induced dipole points in the direction of the magnetic field.

We can also see examples of magnetic monopoles here.

Example of magnetic monopole

This one is from a drum buried vertically, the top of it about 2.0 meters from the depth. Other monopoles are characterized by an object's long axis being perpendicular to the direction of the magnetic field. In this case, the magnetic field was equatorial (horizontal to the ground) and the long axis was vertical. Note the converse relation – a dipole is seen when the long axis is parallel

to the magnetic field, as in the case of long sheets of metal being buried parallel to the ground, or drums being buried parallel to the ground.

As you can see, we can start to make guesses about the orientation and depth of things from a basic understanding of the contour plot.

There is a more in depth discussion on estimating depth given in the <u>Applications Manual for Portable Magnetometers</u> —Chapter 5.

18.7.2. Getting a position of the anomaly from the contour plot

This is a general rule of thumb that helps you get the position of the object from knowing the minimum and maximum of the dipole.

We begin with a dipole that we previously looked at:
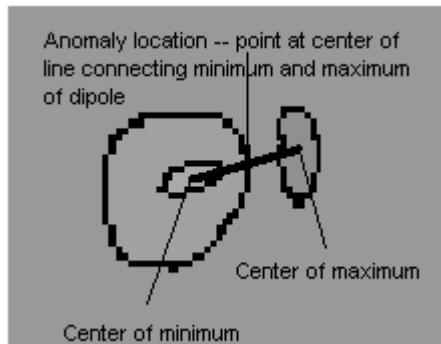
This figure shows how you can find the location of the anomaly by finding the minimum and maximum. Namely:

1)   Find the center of the minimum.

2)   Find the center of the maximum

3)   Draw a line connecting the two

4)   Find the center of this line.

5)   The location of the anomaly is at the center.

This is only a rule-of-thumb but it is useful when you have a large area and don't know where to start digging.

18.7.3. Additional Observations

You might also take the opportunity to compare the results from the mapped survey with those obtained from the same survey using the GPS. As surveys get larger and larger, it becomes more difficult and expensive to lay out accurate mapped surveys. Additionally, as there are fewer and fewer definite position points, the errors are greater because it is difficult to accurately time interpolate position points for each magnetometer reading. Even small changes in speed can make a large difference over a long line. However, with smaller surveys, the error of the GPS (usually around 1 – 2 meters) can be larger than the error received from time interpolation. We can attempt to reduce these errors by smoothing, but it always becomes a factor when doing a survey.

Keep these factors in mind when you are planning your survey.

19. Using GPS time to synchronize base station data.

A typical requirement for magnetometer survey is to record base station information using the GPS clock or to merge GPS and magnetometer time information after the survey. MagMap includes a "Base Station Wizard" available from the "File" menu to provide this functionality. The wizard operates independently from the rest of MagMap code so you do not use the standard data load command.

The following information is required for the Wizard to operate:

1. Magnetometer data with local (e.g., 858 console) time stamps.

2. GPS data with local time stamps and with embedded time information. The most convenient GPS time message is the NMEA ZDA string. It has both time and date information. The navigation message GGA has time information but lacks date information. If you use the GGA string you will be asked to specify the date.

3. PPS (pulse per second) information if available. Many GPS's output a PPS as well as the location information. Each PPS should be represented by a string in the log file and have local time stamps attached to it indicating when the pulse arrived. The PPS logging is optional but needed for high precision surveys (with time accuracy of 1-2 mS).

The input data can be presented in one file or from separate data files. The "One File" mode is typical for the 858 file in STN format and the separate files mode is typical of MagLog™ software when used as a base station logger.

19.1. Sequence of operation: 858 STN data.

A typical example is to use data logged with the Geometrics G-858 land magnetometer. After the data is downloaded to the computer as a binary dump (bin file), it should be converted into an ASCII STN file using the Binary 858 -> ASCII STN utility (available from MagMap "File" menu). Ideally the STN file should include magnetometer data, GPS data logged via one of the 858 serial ports and also the PPS data logged as a pulse input via the G-858 COM #4 serial port. Note that the order of the data is time reversed in the STN file and this order will be preserved in the output file.

To call the Base Station Wizard, use the "File / Base Station GPS Wizard" option:
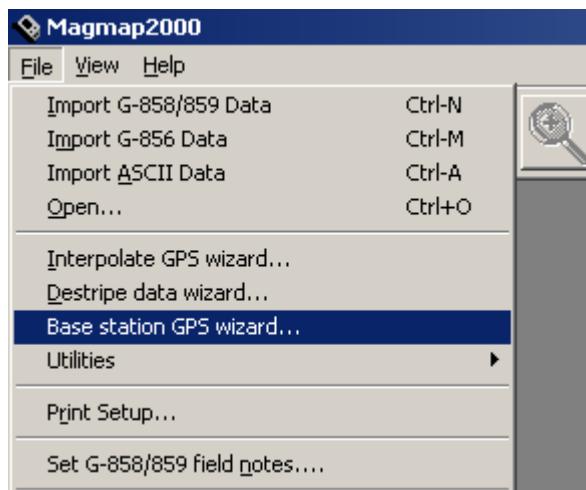
The first screen of Wizard is displayed:
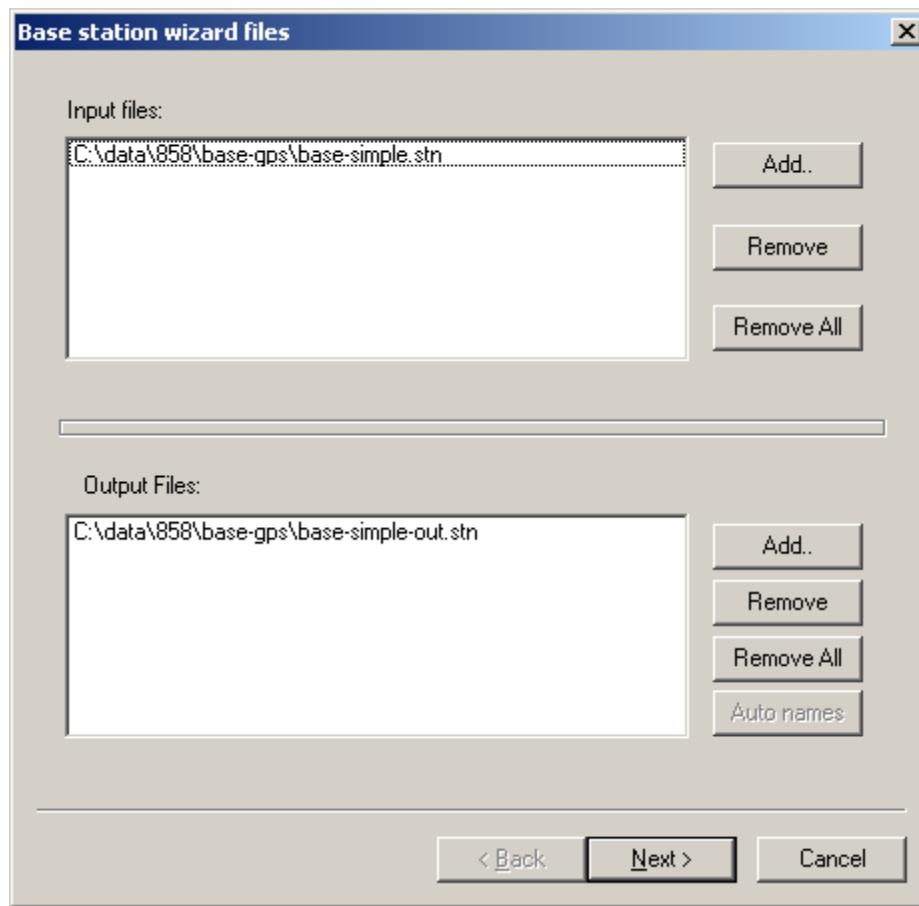
The input and output files must be specified. In the 858 STN case, all data messages are available inside one file, therefore only one input file is specified. The output file is a single file as well; it

has exactly the same information as input file but all the time stamps are replaced in accordance with GPS messages.

In general multiple input and output files can be used (see next section for how to use with MagLog files). However the following restriction is placed on the output file structure: the number must be equal to number of input files or equal to one. The "equal to one" case refers to the time stamp replacement operation.

After files are selected, press "Next" to proceed to the second and final screen of the wizard:
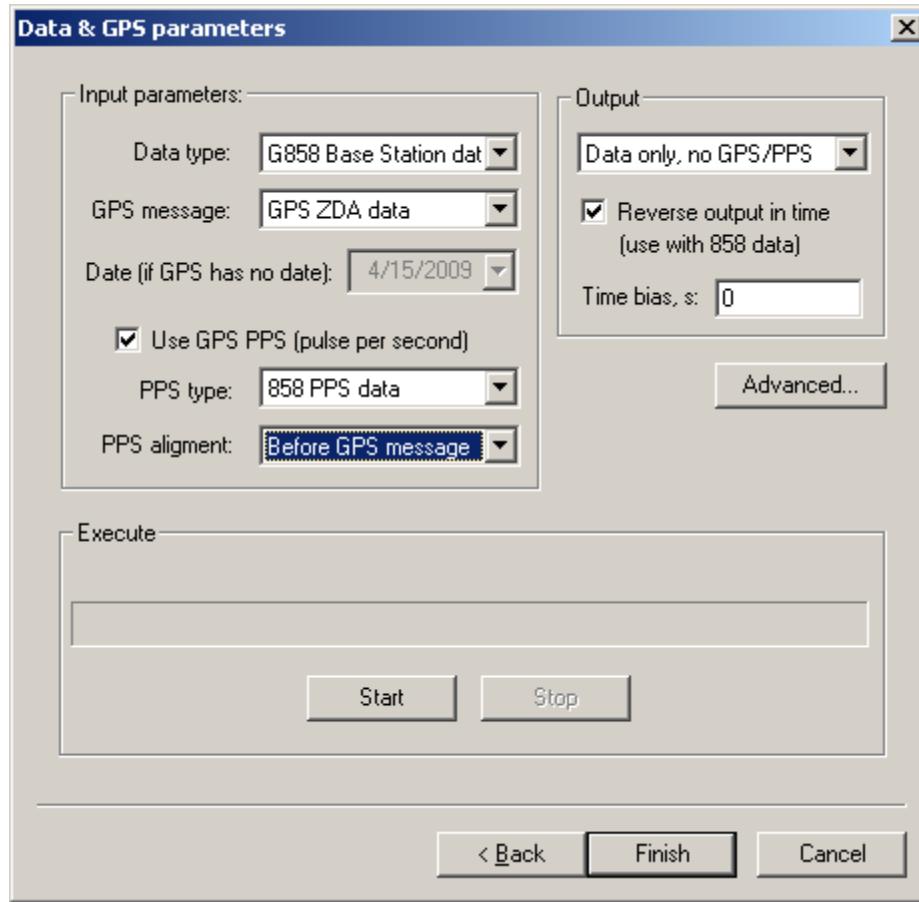
The input and output parameters should be carefully selected for proper program operation. Here we describe each dialog box:

1. **Data type.** This field describes uses "input type" to define the format of the local time in the file. For instance in the G-858 STN file the time information is first and the date information follows. For MagLog™ data the order is reversed. Note for the G-858 file case that local time for all three types of information (data, GPS and PPS) must be formatted identically.

2. **GPS message.** This field describes the GPS NMEA message used transmitted by the GPS. The GPS can usually be set up to send local or UTC time. Ideally both time and

date should be available which is why we recommend the ZDA message. Other messages such as GGA can also be used with some limitations.

3. **Date (if GPS has no date).** If the user selects a message with no recorded date such as GGA it must be manually specified here. Note that because of the reverse order of G-858 STN data, the date of the last reading must be specified here. For instance if the G-858 recording was made through 12:00 am (midnight), the date of the following (or last) day of the recording must be used here. For MagLog™ data please specify date of the beginning of the record. To avoid this confusion it is always best to use the complete GPS message (such as ZDA) with base station data.

4. **GPS PPS.** The G-858 console provides the ability to log incoming voltage pulses via COM port 4. Two wires should be connected to a DB-9 connector on pins 2 and 5 (signal and ground). In the G-858 STN file these data appear as blank lines with a tag 21. Date and time stamp follow. MagLog™ software has the ability to log the PPS via a special PPS to serial converter, which can be provided by Geometrics. In either case click this box to make use of PPS data. If the PPS data is present but this box is not checked the PPS pulses are treated as ordinary data.

5. **PPS type.** Select appropriate type of the PPS data. If the incorrect type is selected, the program does not recognize the PPS records.

6. **PPS Alignment.** This field describes how the PPS pulse is related to the RS-232 message. The possible choices are: "before" (PPS pulse first and then NMEA message with time and date) and "after" (NMEA message first, then PPS pulse follows).

7. **Output.** Select the appropriate type of output. If only one file is selected for output (G-858 or MagLog™ merge operation) it is possible to omit the GPS and PPS information and the local time stamps are simply replaced with the GPS times. This produces smaller and cleaner files, which are easy to load as a base station for diurnal correction. In the case of multiple output files all information is saved (the output control in disabled).

8. **Reverse output in time.** This option is required for G-858 base station data.

9. **Time bias.** Time bias, in seconds, to be added to the output time stamps. This makes it easy to change the time zone if needed (remember that 1 hour has 3600 seconds).

10. **Advanced.** This button controls the advanced settings of the program. It allows the user to add other data types and configure them for time stamp conversion as described in detail below. For general purposes we do not recommended the use of advanced settings.

After all Input and Output parameters are set press "Start" to execute. A progress indicator will be displayed; pressing the "Stop" button will cancel the operation and result in no output. If the operation is successful a "success" dialog box appears or if the operation failed due to improper parameters, the "failure" notice is shown. The typical reason for operation failure is improper settings in the advanced section of the program.

If the "Finish" button is pressed the program executes the computation again (if any parameters have been changed since last run) and stores the parameters for the next run. The "Cancel" button closes the dialog without storing any parameters.

After the operation is completed the local (console) time stamps in the data file have been replaced with GPS time stamps; the formatting in the rest of the file is preserved.

19.2. Sequence of operation: MagLogLite and MagLogPro data.

The data logged with MagLog™ software are stored in separate files, typically one file per device. For instance the GPS data is stored in the GPS file with .GPS extension, PPS data in another file, magnetometer data in a third file and so on. The GPS Base Station Wizard allows the user to process all data files at once[6]. In the first dialog box, the user should list all ASCII survey files (i.e., do not load the binary project file). It is possible to select multiple files in the file selection dialog as shown in the following example:
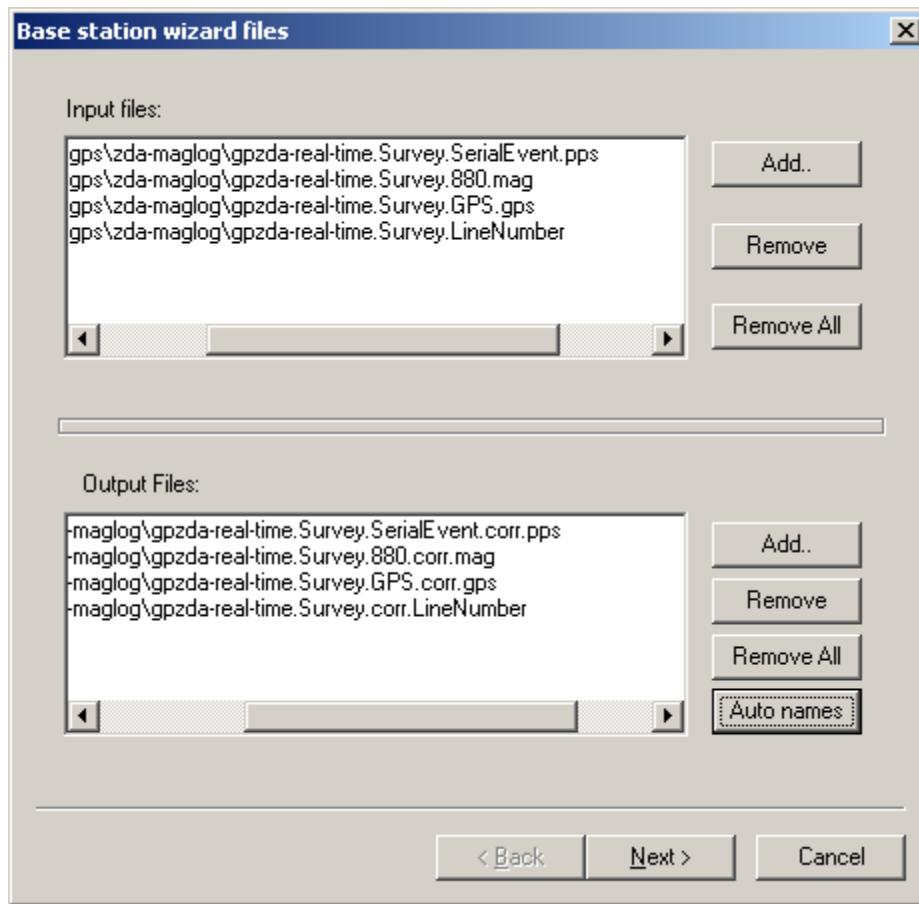
Using the "Auto names" button allows the creation of new names by inserting suffix ".corr.". Note that the number and order of the output files should be the same as number and order of input files. Alternatively, the user can create only one output file and merge all the information (this is useful for base

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[6] The GPS Base Station Wizard can be used for survey files as well as for generic data files.

station operation and subsequent diurnal correction routines in MagMap). If output files already exist a warning is posted when the "Next" button is pressed.

Select the appropriate parameters in the second wizard screen as shown below:
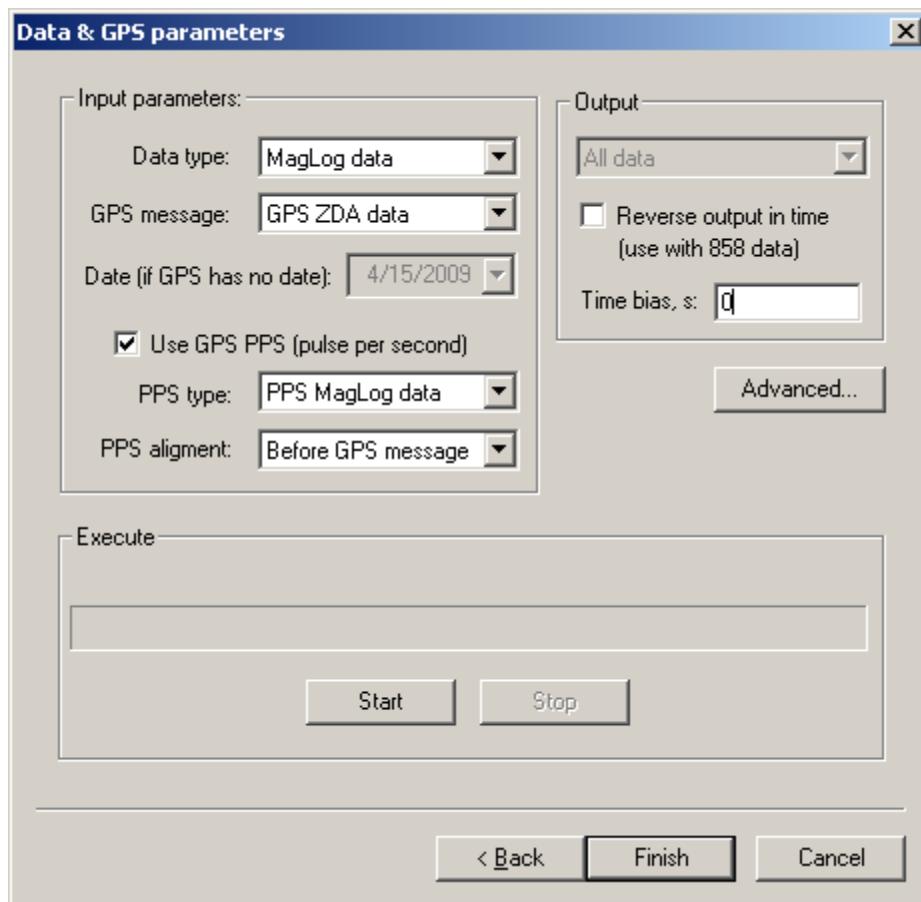
Enter the correct date if the GGA or other NMEA message with no date is selected. In contrast to the case of the G-858 data file, this date will be the date of the beginning of the survey.

The rest of the operation is identical to the G-858 case. If there are multiple output files, each output file will have exactly the same information, as the original file except the time stamps will be changed to GPS time.

19.3. Advanced operation.

GPS Base wizard uses the Perl Regular Expression library to parse GPS and magnetometer data. It allows the user to use virtually any input data if the data parsing instruction can be written as a Regular Expression. The syntax of Regular Expression is outside of the scope of this manual,

please see below for a reference to additional information[7]. Use the "Advanced" button to access the Regular Expression mechanism. A warning is displayed:
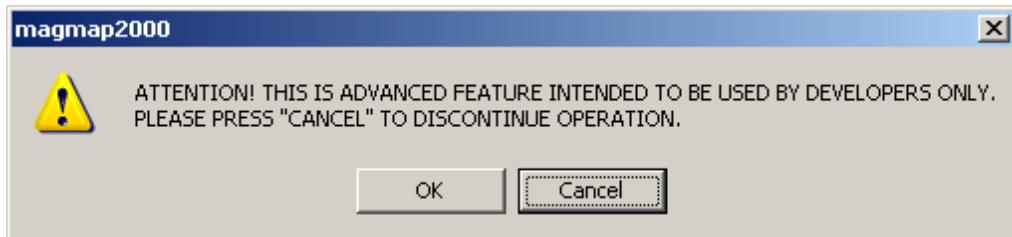
Press the "Ok" button to open a dialog box with all available parsing rules displayed:
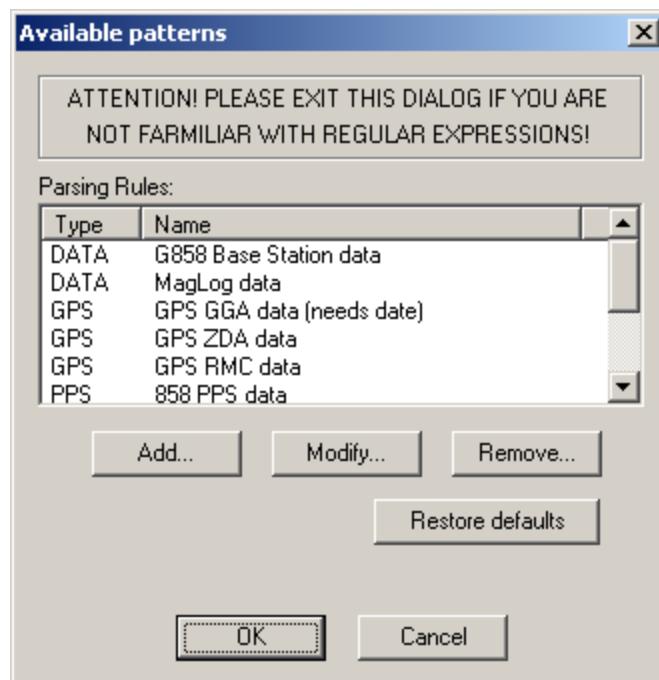
"Type" refers to the following:

1. DATA – to parse local time stamps in all messages.

2. GPS – to parse GPS time stamps in GPS messages.

3. PPS – to parse PPS time stamps in PPS messages.

The user can modify or add new data types by using "Modify…" and "Add…" buttons. "Restore defaults" button removes all custom rules and restores the built-in program default expressions. The Regular Expression modification dialog is shown below:

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[7] For more information, please see "Mastering Regular Expressions, 2nd Edition" by Jeffrey E. F. Friendl, O'Reilly, 2002.

Edit parsing pattern

ATTENTION! PLEASE EXIT THIS DIALOG IF YOU ARE
NOT FARMILIAR WITH REGULAR EXPRESSIONS!

Type: [GPS messag ▼]   Name: [GPS GGA data (needs date)]

Regular expression for parsing:

[GGA,(?<hh>\d\d)(?<mm>\d\d)(?<ss>\d\d)]

The following variables must be defined:
      hh - hour; mm - minute; ss - second.
      mt - month; dd - day; yy - year;

Example (MagLog time stamps):

[(?<mt>\d\d)/(?<dd>\d\d)/(?<yy>\d\d)[\t]+(?<hh>\d\d):(?<mm>]

[OK]   [Cancel]
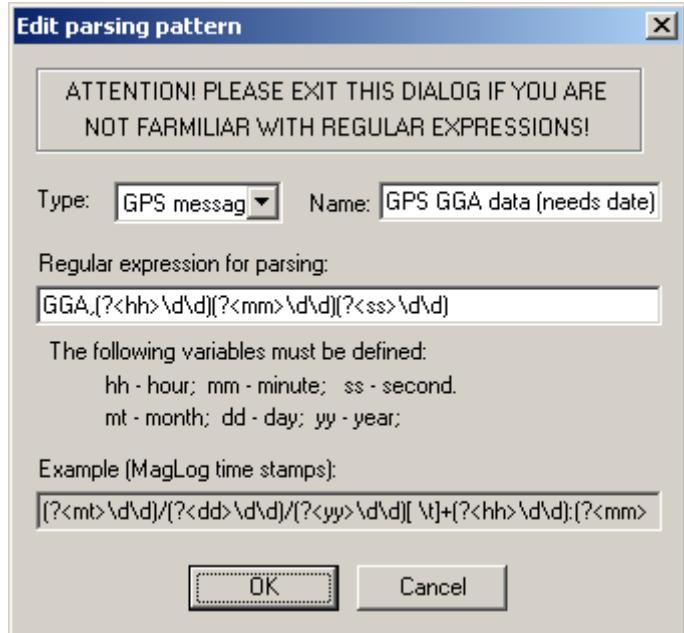
"Name" refers to a user defined text description of the dialog and can be any text (blank description is not recommended).

20. Using GPS devices or GPS exchange (GPX) files to position the data (GPS Data Download Wizard)

This is a brief description of how new MagMap features can be used to position data using an arbitrary GPS receiver with internal logging feature.

20.1. Requirements

1.   Arbitrary data source supported by MagMap. This could be 856, 858 or any other file or device we support. The time in the device console should match the GPS receiver time. The user is responsible for manually setting the console time to match the GPS time. After the survey is completed the data should be downloaded in MagMap as usual, and filtered or spike edited in the normal procedure. A base station correction could be applied at this time and the data exported as a time tagged SURFER data file. This file is necessary to perform re-positioning using external the GPS receiver.

2.   The GPS receiver must be supported by GPSBabel software. Please visit www.gpsbabel.org to download and install GPSbabel. Typically GPS devices have either one or both of two main modes to log the track information: internal memory or mass storage memory (memory card). In the first case the track information can be downloaded using an RS232 or USB protocol; in the second case the GPS device will appear as an external flash drive with a set of GPX files.

20.2. Operation

The GPS Data Download Wizard presents data in the same manner as for airborne or marine surveys. This means that only one GPS file can be opened at a time, so all MagMap windows should be closed prior starting the wizard. The wizard is available from File / GPS data download wizard menu. The first screen is shown below:
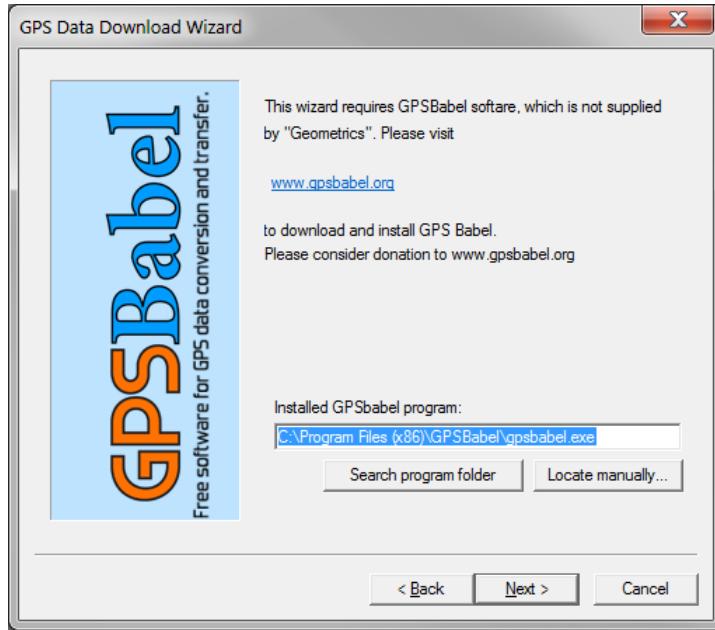
"Installed GPSbabel program" should point to the valid gpsbabel.exe file. If the program is not installed click on the link above and visit the GPSBabel web site. Then locate the program install folder manually or use "Search program folder" button. Then press "Next"

This is the next screen:
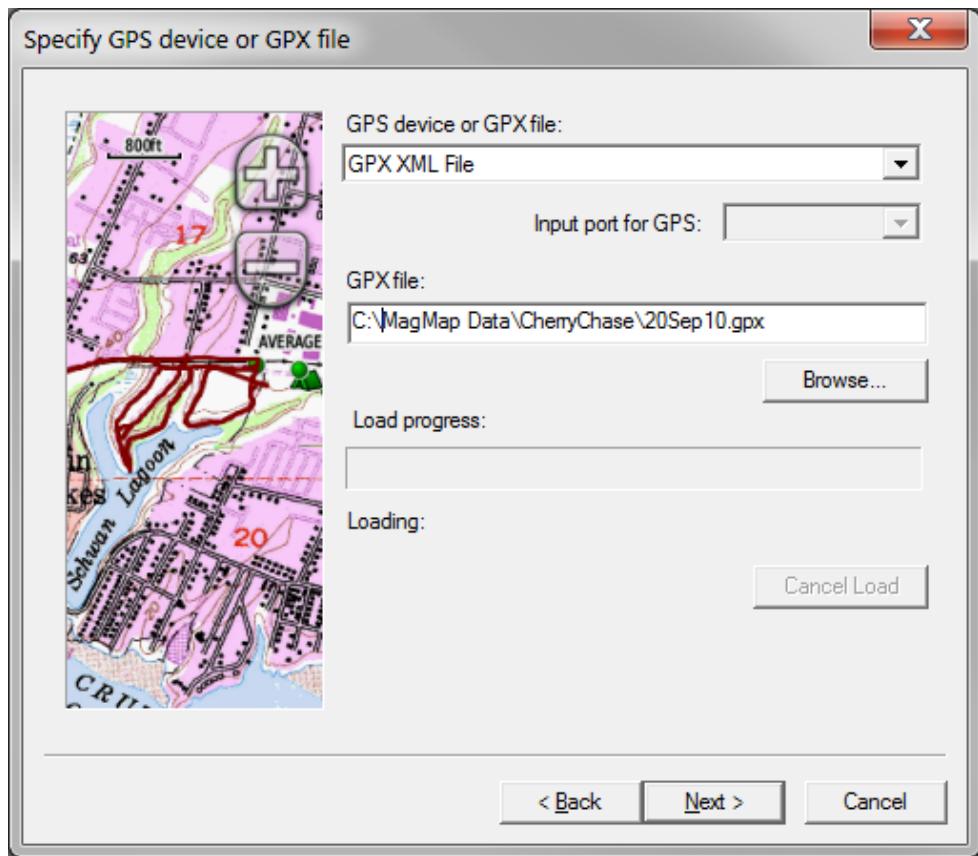
The purposes of this screen is to tell Magmap where and how obtain GPS data. There are two ways that data can be obtained: 1) Downloading data from the device or 2) reading the transferred GPX file.

In the first case the device should be properly connected with an appropriate cable (USB or serial). It should also be turned on and running. Device mode (USB or Serial Com port) should be selected in the appropriate fields. When the user presses "Next", MagMap will start gpsbabel.exe and then download and re-format the data.

In case number 2, the proper GPX file should be selected. When the "Next" button is pressed the GPX file is retrieved and re-formatted.

In both cases a progress window will be displayed and success or error messages appear on the screen. If the operation is successful the program advances to the next screen.
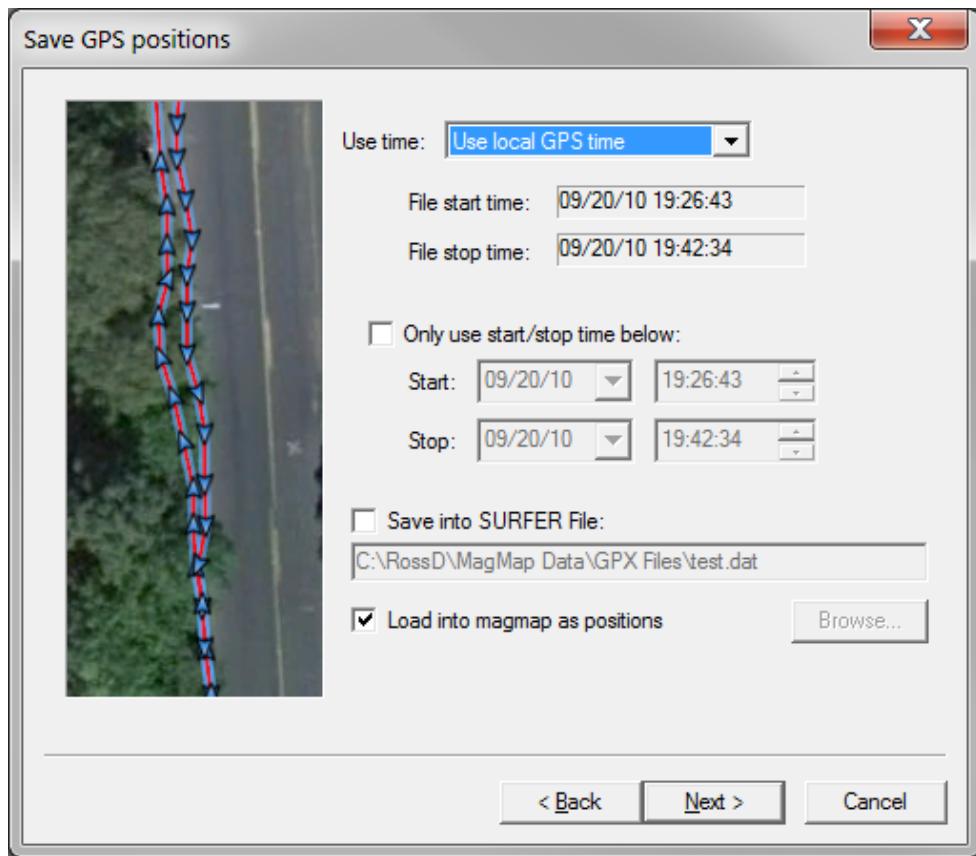
This screen presents a summary about the downloaded track information. The user has the following choices:

1.   Use GPS based local time or use UTC time.

2.   Select start / stop window for GPS data or use all data.

3.   Optionally save downloaded GPS data into SURFER file for future reference. The file has 4 columns: longitude, latitude, altitude (in meters), date and time. The last column is in local or UTC time depending on the selection in the dialog box. If the file is not saved, the GPS data is discarded after the wizard completes.

4.   Ability to load GPS information as soon as wizard is complete. If this is checked, MagMap reads the positions at the wizard completion and loads them into an airborne data type GPS window. If this button is checked MagMap advances to the next screen.
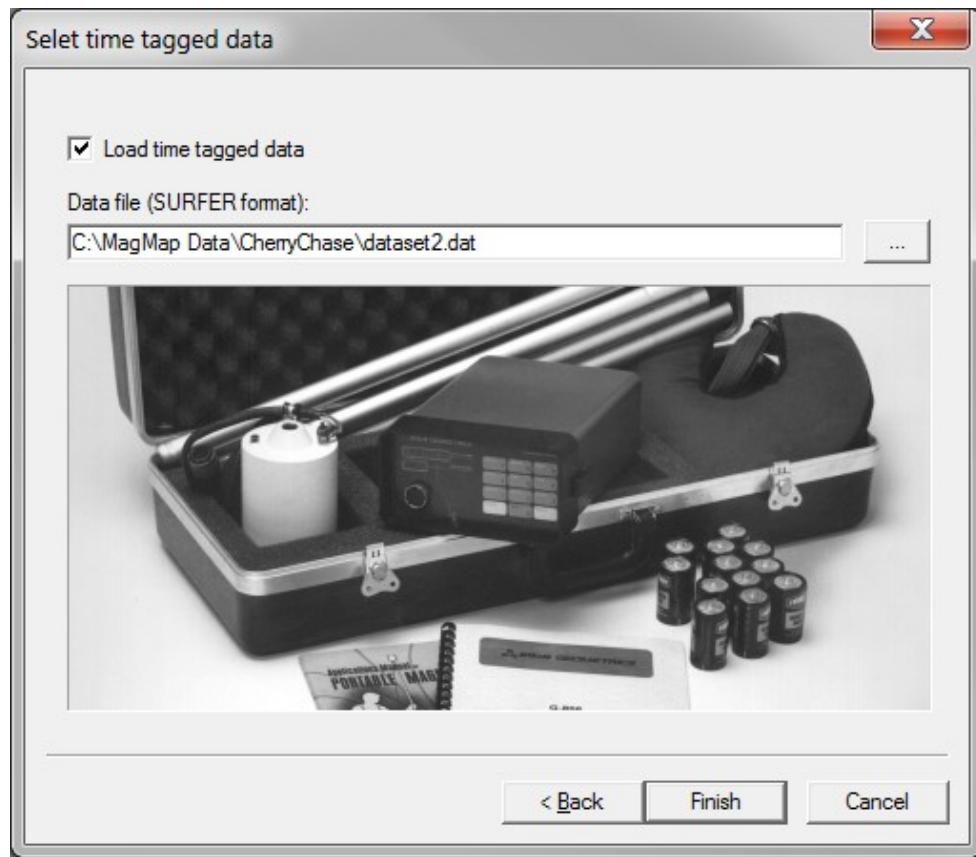
In this screen the user has an option to select his or her data file, as described in the requirements section above. MagMap will load this file along with the GPS position thus enabling a GPS position export. However the user must specify the data structure of the file. The following dialog is displayed after "Finish" button is pressed:

Data file definition ☒

Data file name: `C:\data\g-858\gpx\barnon395-time-shift.dat`

Position information

X: `1: X`   Y: `2: Y`

☐ Check here if X and Y represent longitude and latitude

Time information

Time: `5: TIME`   Date: `6: DATE`

☐ No time stamps, assign by default   Format: `US (month,day, year)`

Line information

☐ Don't use lines (all data in one line)   Line: `4: LINE`

☐ Split data file into lines by distance   Split distance: `10000`

Data channels

`3: READING_1`

Add data channel...

Remove data channel...

Remove all channels

How to load: `Data ONLY`   ☐ Use advanced settings   Advanced...

OK   Cancel

This is a typical MagMap SURFER file dialog import box with some limitations. The User can load "Data ONLY" and must select valid TIME and DATE fields. "X" and "Y" fields are not available. It is also recommended to use a LINE field if available. If the "line" field is selected, the program will remove all GPS data which does not belong to lines, thus cutting the survey to the actual grid. To complete the procedure at least one data channel should be added (typically Reading_1).

After the wizard is complete the GPS and data windows will be displayed on the screen. This is similar to the way done in the MagLog airborne survey mode. Note that the user can load his or her magnetometer data file after completing the GPS Download Wizard, i.e, it need not be loaded during GPS wizard processing. Thus there are different sequences of operation available and for instance generic prefixed serial data could be loaded in place of the SURFER *.dat file, etc.

21. Using GPS GPX wizard to create and upload survey routes into hand held Garmin GPS

GPX survey wizard creates file in GPS exchange format and optionally uploads it into GPS hand held receiver, or saves it into hard disk for future use. The function is designed to produce a group of parallel routes at certain separation to be used as a survey grid for field navigation. The operation is completely independent of the rest of MagMap functions and does not require any data to be loaded into MagMap.

21.1. Requirements

User must define *base route*. The route grid will be created as a number or routes (lines) parallel to the base route. The base route can be created by the following two methods:

1. By defining start and stop points in geographical coordinates. These values can be taken from user's GIS project, popular applications like Google Earth or Arc Info Explorer, or directly measured in the field with hand held GPS. In latter case user could use waypoint to mark start of the route, than walk to the end and mark end waypoint. The coordinates must be written down in either of decimal degrees, degrees and minutes or degree, minutes and seconds.

2. By defining start point of the base route, it length and geographical azimuth. The start point can be obtained by means described above; the length and azimuth can be obtained by using mapping application or by direct measurements. The length can be measured in meters, feet, kilometers, miles or nautical miles.

Given above information, user can proceed with creating survey grid.

21.2. Sequence of operation

MagMap GPS survey wizard can be called from File / GPS Survey wizard menu:
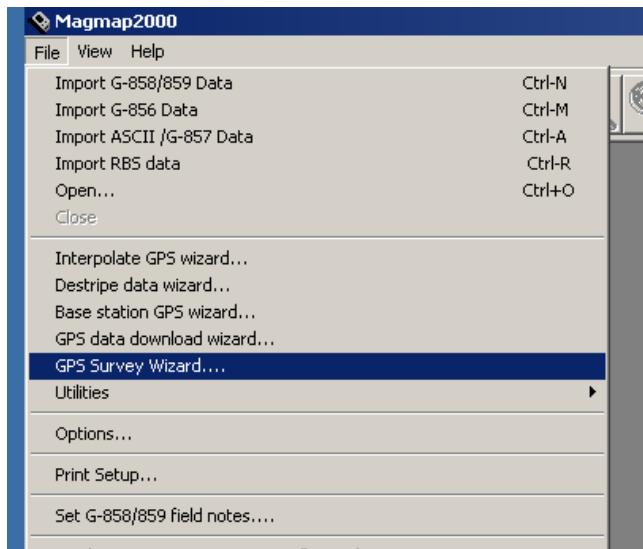
The first screen of the wizard appears as below:
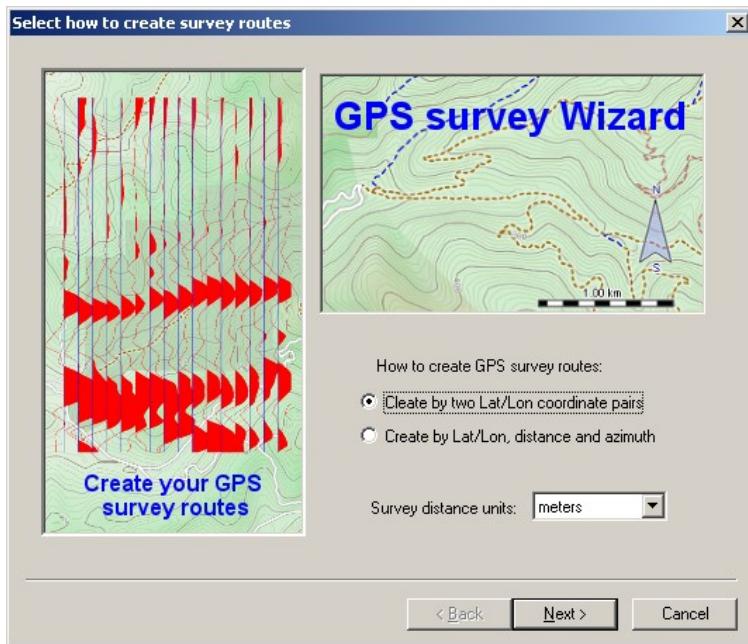
In this screen user should select the method to create grid: by two points, or by start point azimuth and distance, and also select distance units to be used to the end of the wizard. If first option is selected next dialog looks like following:
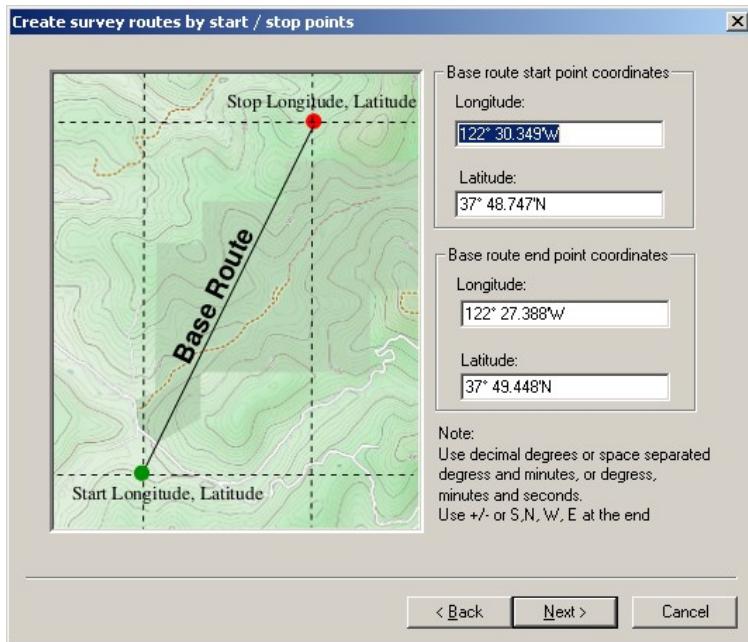
User should type or copy and paste coordinates of two points (total of 4 digits). MagMap accepts coordinates as decimal degrees (use negative values for Western and Southern hemispheres), degrees and minutes or degrees, minutes and seconds. In last two cases values must be separated by space or other non-digit symbol and might have suffixes as "W", "E","S","N" or just negative

first number. Use tooltip help which appeared while mouse hovering over the controls of the wizard for explanation.

In case of second option when start point, azimuth and distance is selected the wizard screen is different:
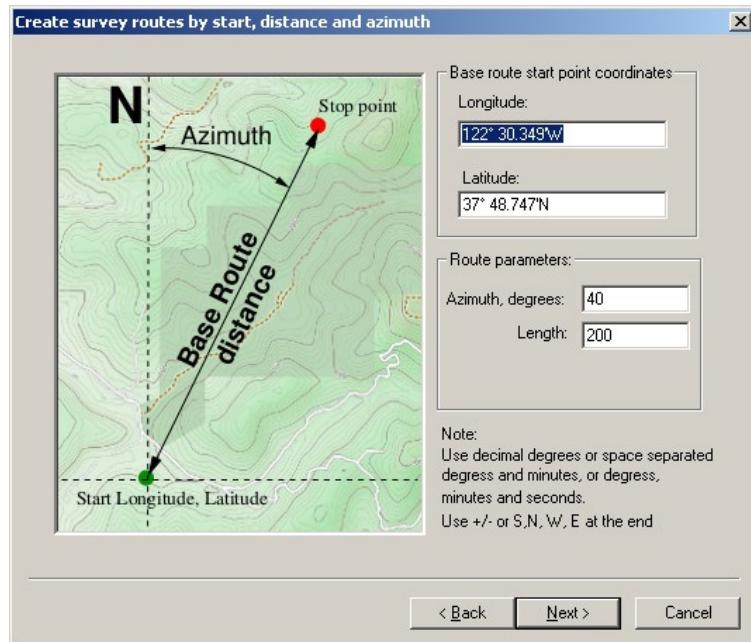
The latitude / longitude of the start point can be entered the same way as for two points method, azimuth is counted from true North and have to be entered in decimal degrees, the distance is defined in the selected units and must be positive.

Either of the dialogs fully defines base route and makes it possible to start with parallel routes definition, which is presented below.
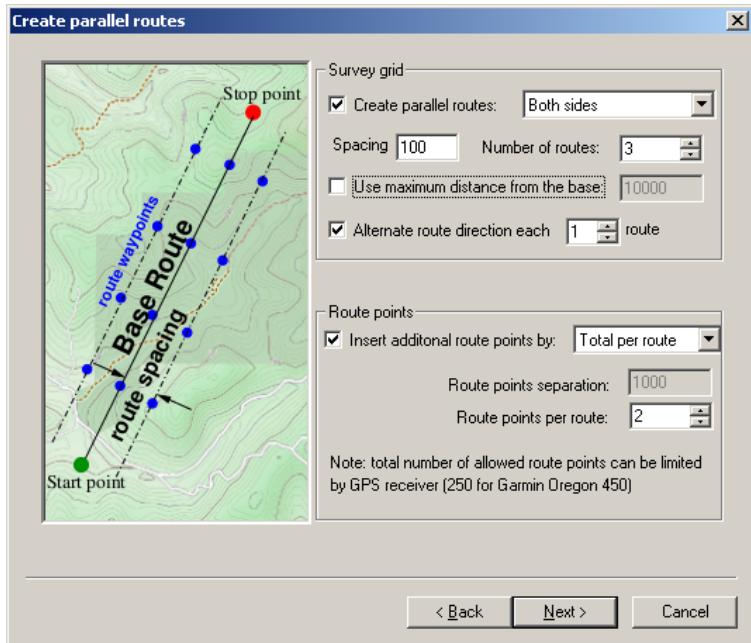
There are two main groups of parameters: *survey grid* and *route points*. First group defines routes parallel to the base and is most important, second group defines additional routes points per new route to aid GPS navigation. The following are controls in the first group:

1. **Create parallel routes**. This option enables routes parallel to the base. Note that if it is not checked only one base route is created, which is probably not what is needed, except special cases. Should be checked in almost all cases.

2. **Where to create routes**. Selectable from the drop box with possible choices: *left, right*, or *both* sides. In first case routes are created on the left of base route if looking from start to end, second on the right and last on both sides. Base route is created in any case. **Spacing**. Distance between parallel routes in units selected on the first screen.

3. **Number of routes** to be created in addition to the base route. Assuming this number is N, in case of left or right selection N+1 route is created. In case if both sides option is used then 2N+1 route is created. Routes are numbered left to right if looking from start to end.

4. **Use maximum distance from base.** This option is alternative to the "number or routes" option above. User can define maximum distance from the base route instead of defining number of routes. This would spare some manual computations. For instance if route separation is 100, and maximum separation is 500, program creates 5 additional routes.

5. **Alternate route direction.** Hand-held GPS receivers take direction of the route into account; therefore it is beneficial to make adjacent routs going into opposite direction. Use number on the right to define number or routes to switch direction. Using "1" changes direction for every route.

If route points are used GPS would guide user from point to point which might be easier than navigating to the line. *Note that number of route points is limited and defended by GPS model.* It's user responsibility not to exceed this value.

The following controls define route points:

1. **Insert additional route points**. Check this box to enable route point's insertion.

2. **Insert by**. There are two possible modes: insert by distance or insert by number. In case if "by distance" option is used route point's separation should be entered. Note that there could be some odd interval between last route point and the end of the route. The second selection is insertion by number. In this case specify total number of route points to be inserted between start and stop. Program computes interval automatically and inserts route points uniformly. Assuming there are N inserted points the total number of route points per route is 2+N, where "2" is counted for start and stop points.

3. **Route point separation** in units selected for the wizard, if "by distance" option is used.

4. **Route points per route**. Total number or inserted route points if option "by number" is used.

After dialog is completed program advance to the final wizard screen:
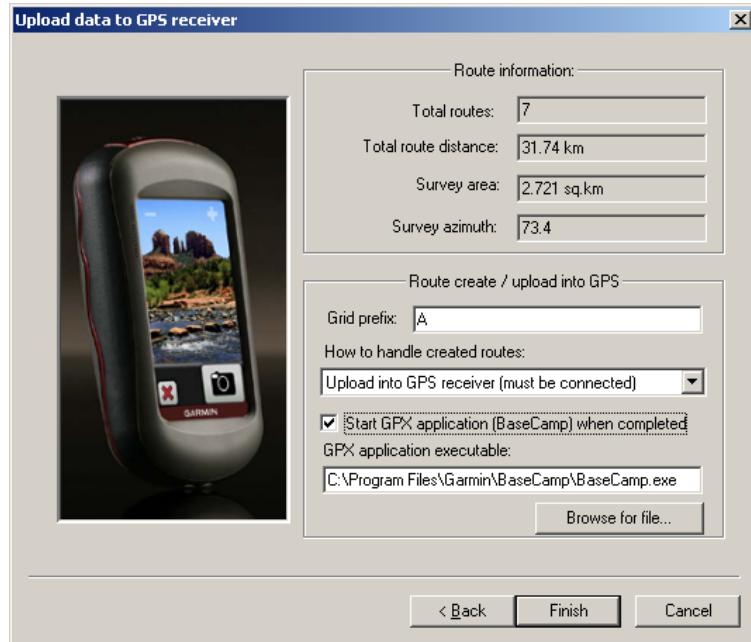
At this point GPS receiver could be connected and put into mass storage mode to upload routes.

The information part of the dialog shows some basic facts about created grid, such as total number of routes, total distance to travel for all routes, covered area and true main survey azimuth. The rest of the dialog controls where GPX file is going to be created:

1. **Grid prefix**. Enter few letters prefix to distinguish created grids while using GPS receiver. *This value cannot be blank*. If case if existing prefix is used there would be two grids under the same name available from GPS route menu, which is confusing.

2. **How to handle created routs**. There are two possible options: Upload into GPS receiver or save as GPSX file. In first case GPS receiver should be connected in mass storage mode. Program tries to find it searching for Garmin\GPX folder on the removable media and posting a message if it is not found. Second option allows user to select location into file system.

3. **Start GPX application (BaseCamp) when completed**. It could be useful to see and possibly modify created grid in the GPS applications, such as Garmin Base Camp. Select this option to start Base Camp automatically after GPX file is created, or load route data into running Base Camp application. Note that Google Earth also can be used to view survey grid; however Google Earth does not handle GPX files by default, therefore user should start it and load GPX file by hand.

4. **GPX Application executable**. Use this filed and button below to point program to Base Camp location. The path must be valid for the feature to work.

After *Finish* is pressed user is presented with file selection dialog. Please enter name of the newly created GPX file and press *Save* button. If Base Camp option above is used, application will start automatically; you may need to find new route grid in "My collection" folder and zoom to it. If data is uploaded into GPS you can safely remove GPS drives, turn on GPS and navigate to the "Routes" menu. All routes which belong to the same grid will have the same prefix.

21.3. GPS and Base Camp grid appearance

After routes are loaded into GPS receiver they appear as separate menu entities under "Where to Go / Routes" menu. Routes from the same survey grid are recognized by prefix. For instance assume prefix "A" was used and 7 routes created; GPS menu shows items A1 to A7. They may not be in order. To start survey with route 1 user should select "A1" and so on. Assuming there are total of 5 route points per route. First point is always route prefix and route number, such as "A1". Then route points have sequential numbers, so all points would be in the sequence: A1,.2,3,4,5. For route A3 points are A3,2,3,4,5. Note that route point's numbers are the same for each route, except first point. Garmin GPS uses default waypoint mark to show route points. No navigate the route user selects it from the menu and presses "Go" button.

Base Camp software does not allow duplicate route points names. Therefore route "A2" may have route points which looks like A2,21,31,41,51. The way how route points are re-numbered is internal to the Base Camp. Note that these new names are used if grid is uploaded to GPS receiver via Base Camp.

22. How to handle USBL data in MagMap

The purpose of this presentation is to show how USBL data can be used to interpolate magnetometer positions in post processing using MagMap software.

It is assumed that data was recorded using MagLog NT software with USBL data recorded by a Generic Serial device interface in MagLog.

The necessary files are:
1.   USBL data recorded as Generic Serial Device. The data should have $PTSAG messages with non-zero flags or $PIXSE,POSITI messages showing position of the acoustic beacon. In present it is not possible to distinguish between multiple beacons if they are used; therefore it is assumed that only one acoustic beacon is employed.
2.   MagLog NT interpolator file with magnetometer and calibrated depth and altitude information. It should be noted here that position information from interpolator file is not used.

22.1. Step 1: Configure MagMap to use only certain USBL messages

Start MagMap, go to File / Options menu and make sure that only relevant navigation messages are checked. For example if it is assumed that $PTSAG is going to be used make sure that GGA and

PIXSE USBL is not checked. "Option" dialog may look like as below:
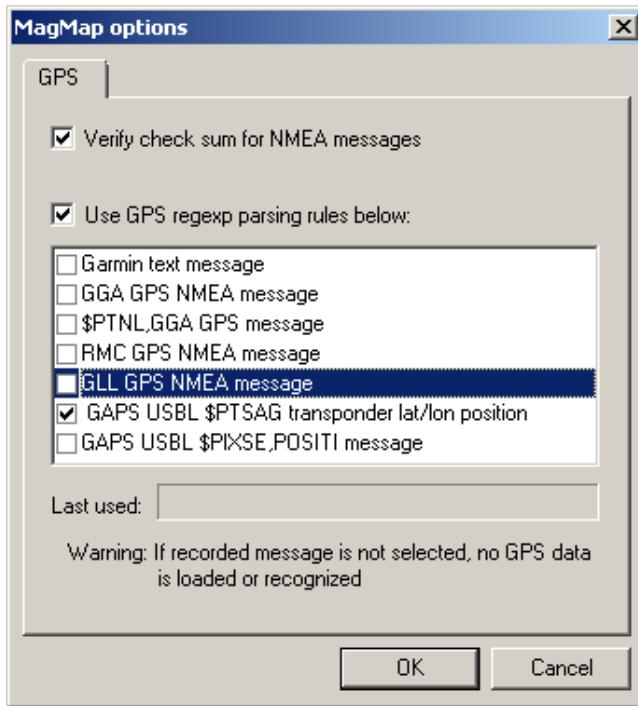
Even though Garmin text, GGL, and $PTNL,GGA are not transmitted by USBL system they could be disabled in MagMap to prevent accidental usage.

These settings are global to the program and are saved when MagMap exits.

22.2. Step 2: Load raw USBL data (all USBL messages are enabled)

Go to File / Open menu and select file type as MagLog NT generic GPS data as it is shown below:
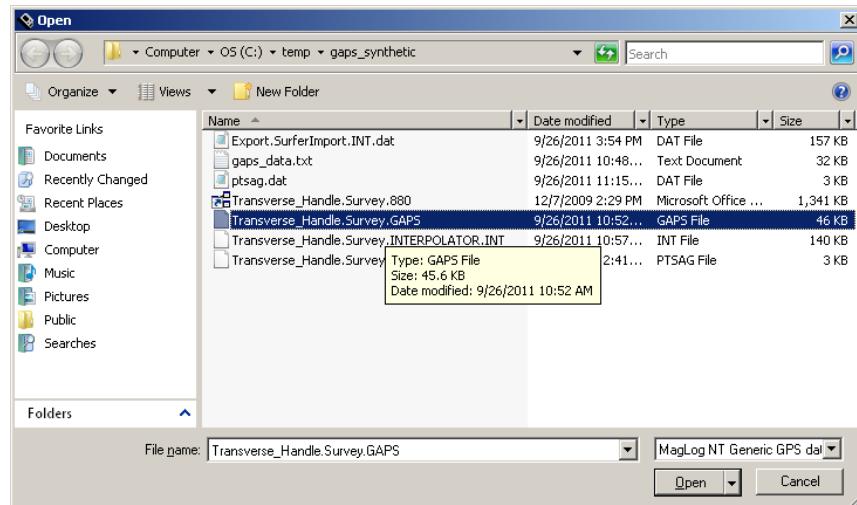
This selection tells MagMap to treat data as position data without trying to guess file type from its content.

Select the file logged by MagLog. Program creates a window which may look as shown below:
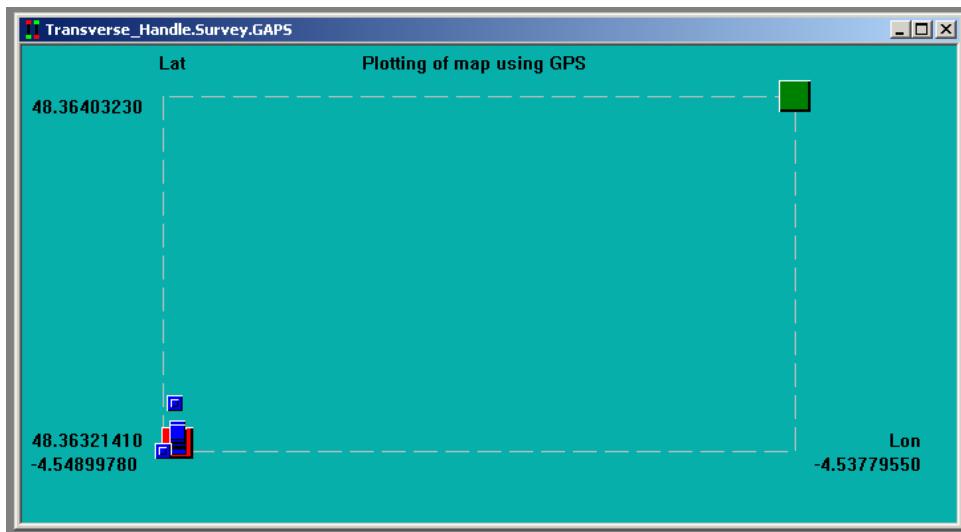
Please do not close this window till processing is complete. User can remove or smooth positions here if necessary.

22.3. Step 2a: Load filtered USBL position data

This step could be applied in place of (2) in case the MagLog survey uses serial port filtering for USBL generic serial device and only one kind of navigation message is logged (namely, $PTSAG or $PIXSE,POSITI but NOT both). In this case MagMap can automatically recognize the data format. There is also no need to disable messages in the "Options" dialog prior to operation, therefore step 1 can also be omitted.

Simply select File / Open dialog as shown below:
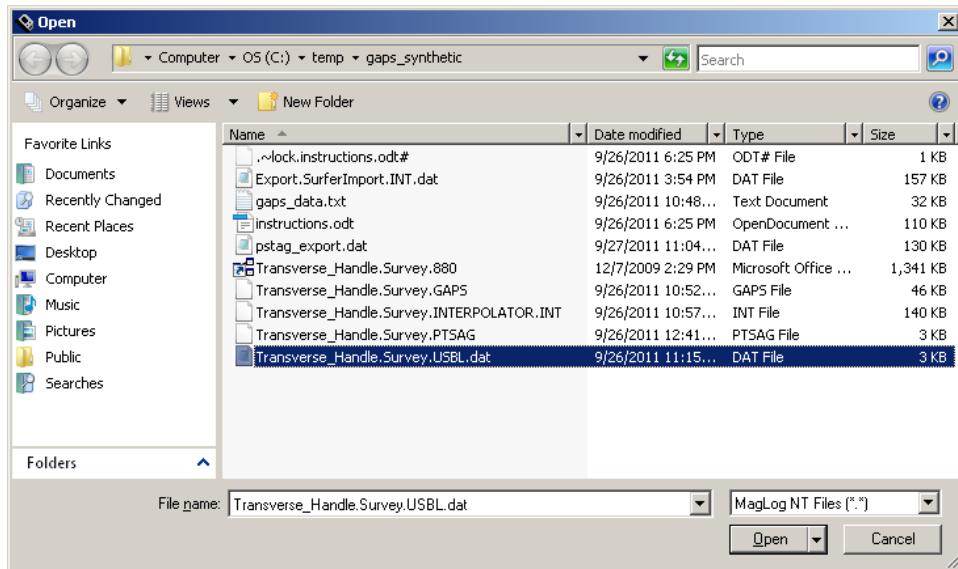
Make sure that "MagLog NT Files (*.*)" are selected as a filter in the lower right corner of the dialog. Select appropriate file and press "Ok". Result is the same as in step 2.

22.4. Step 3: Loading magnetometer data

With GPS (USBL) window open go to File / Open and select SURFER file type from the file type's selection drop list. The window should look similar to the one shown below:
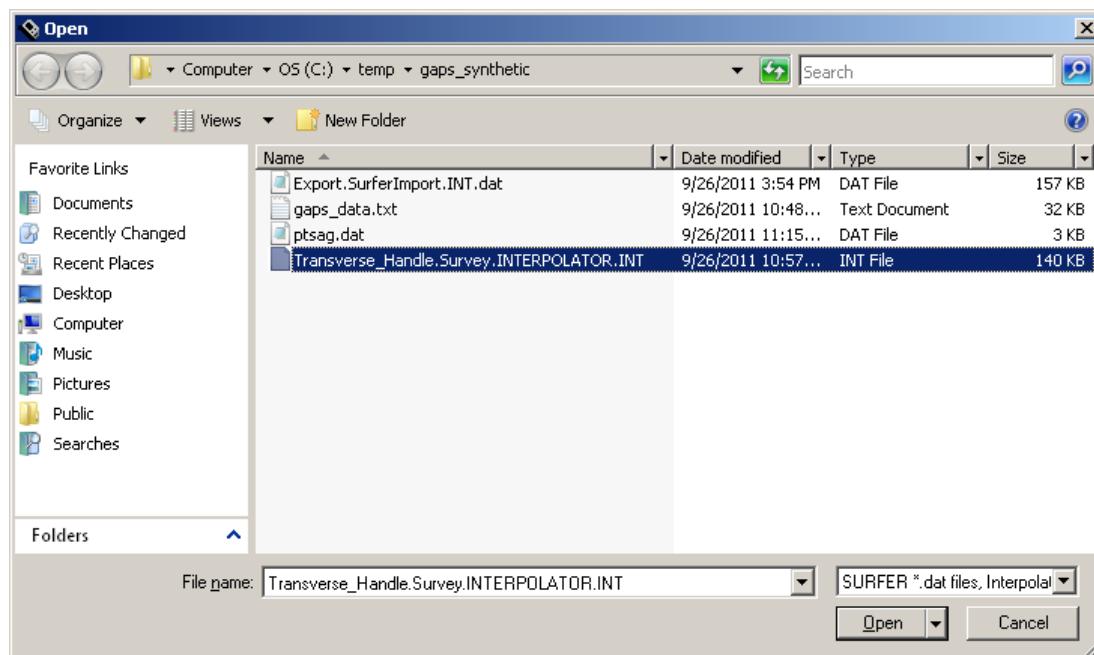
After user presses "Open" the following specification dialog is displayed:
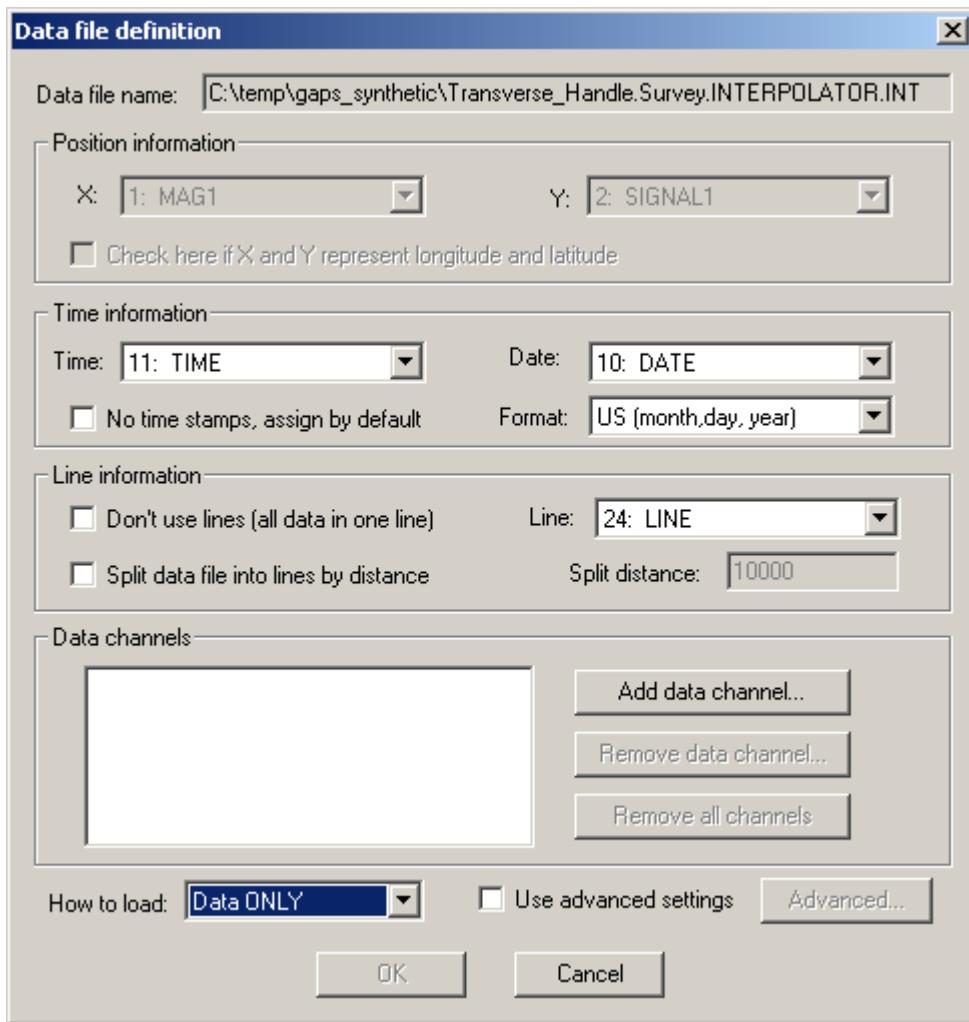
Make sure all of the following are set:

1.   At the bottom of the dialog - "How to load" - Data ONY. This instructs MagMap to disregard all position information from the file. "X" and "Y" fields at the top of the dialog are disabled in this case.

2.   Make sure that the check box, "No time stamps, assign by default", is NOT checked and "Time" and "Date" columns are properly selected. Make sure time format set to "US (month,day,year).

3.   Make sure that the check box, "Don't use lines (all data in one line)", is NOT checked and line field is selected. This tells MagMap to load line information from the interpolator file.

At this point press the "Add data channel" button and select data channels as the following dialog box:
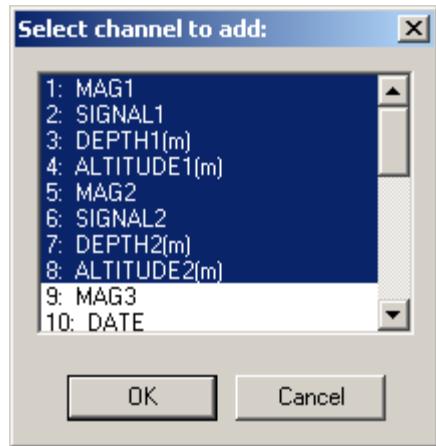
This selection ensures that all magnetometer information from the interpolator file is transferred to the combined magnetometer / USBL file.

Press "Ok" to load the data. This creates data graph window on the screen as shown below:
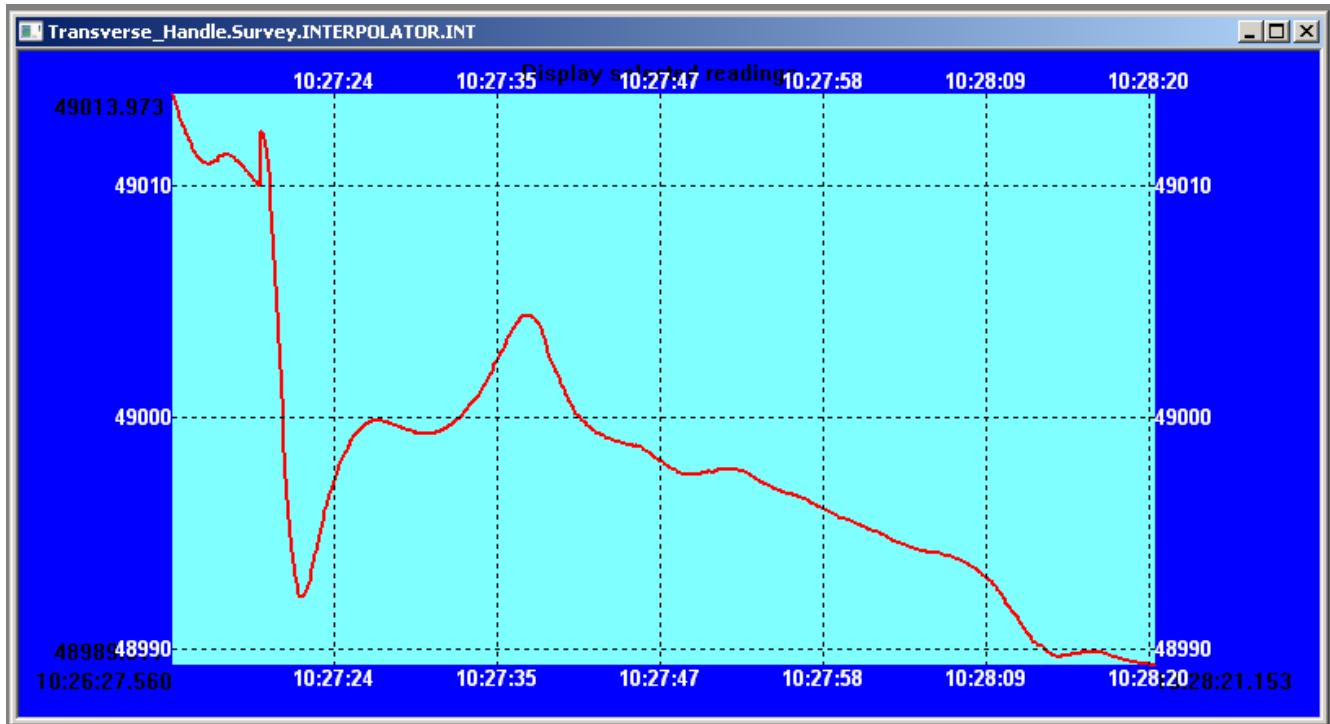
Please do not close this window till interpolation procedure is complete.

At this point you could apply some positioning / data cleaning operations if necessary. Please consult MagMap manual for details.

22.5. Step 4: Set sensors offsets and layback distance

After data is successfully loaded into MagMap user should set up offsets for individual sensors and proceed with data export, creating final XYZ file. It's important to understand that MagMap GPS window display GPS positions (in this case beacon positions) and offset calculations only take place during export.

In this example we consider a typical TVG with 1.5 m sensor separation, sensor #1 is on the port side, and acoustic beacon is attached 3.5 Meters in front of the TVG (this distance includes 1.8 m of cable and 1.7 m of TVG itself).

Activate GPS window and select GPS / GPS offset menu. The following dialog is
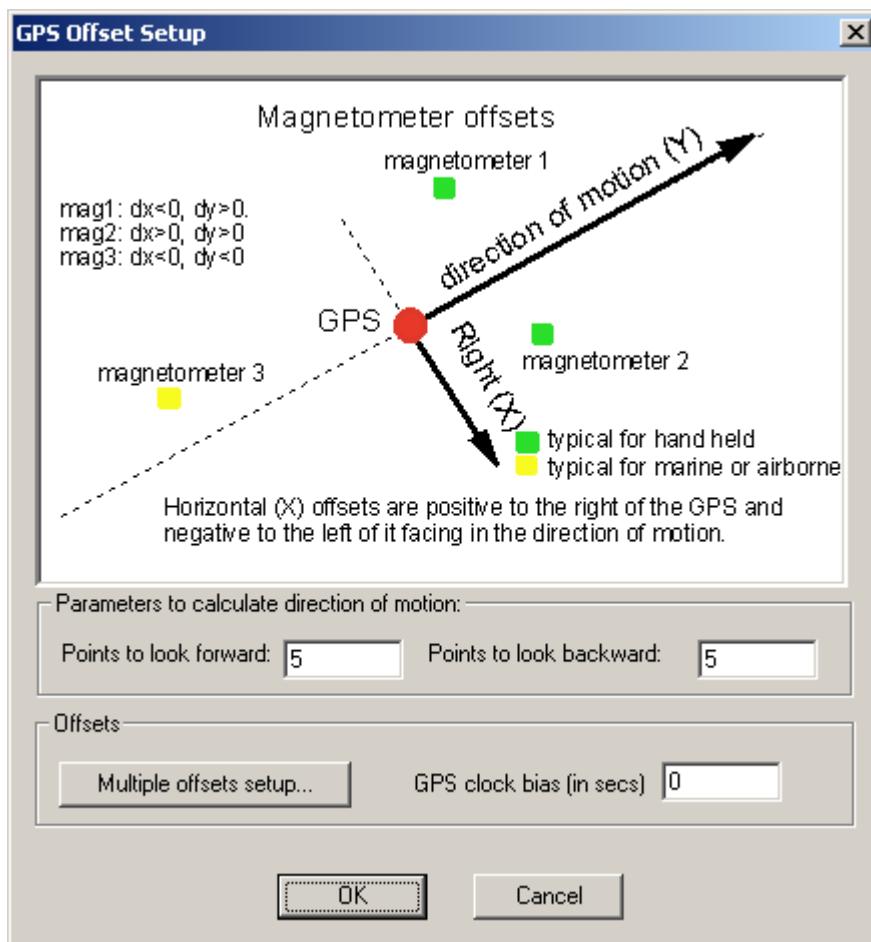
displayed:

Please use provided picture for reference. Press "Multiple offsets setup" button:
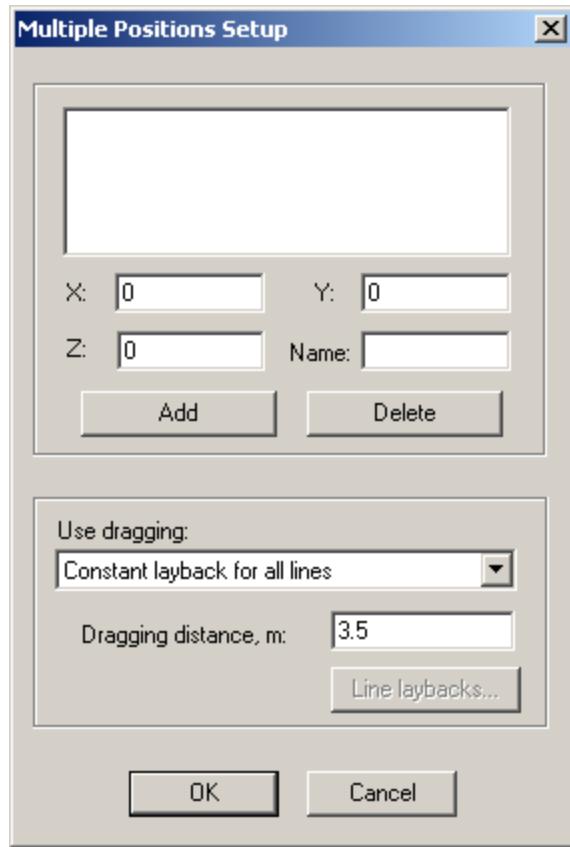
If there are any positions not matching your configuration are defined in the list box please delete them by selecting with a mouse and pressing "Delete" button. Then type: X: -0.75 Y: 0   Z: 0 and Name: "mag1". Press "Add" button. Change X: to 0.75 and name to "mag2" and press "Add" again. At the end dialog should look like the following:
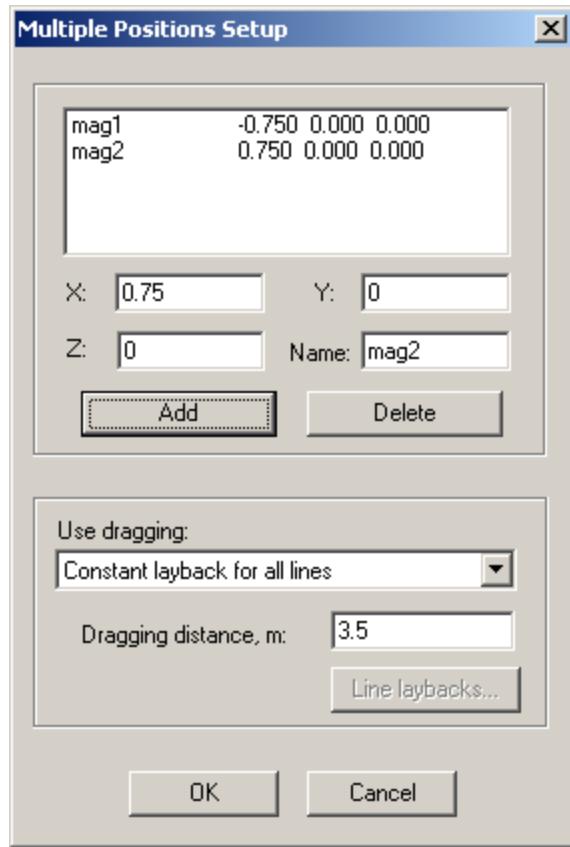
Make sure that "Use dragging" field reads "Constant layback for all lines" and dragging distance is entered correctly (3.5 m in this example). Press "Ok" to close this dialog and press "Ok" again to close main offsets dialog. Program is now ready to export the data.

If the GPS window has lost focus, activate it again. Right click on the GPS map and select "Export" from the context menu. Alternatively select File / Export from main menu. The "Export" dialog should look similar to the one below:
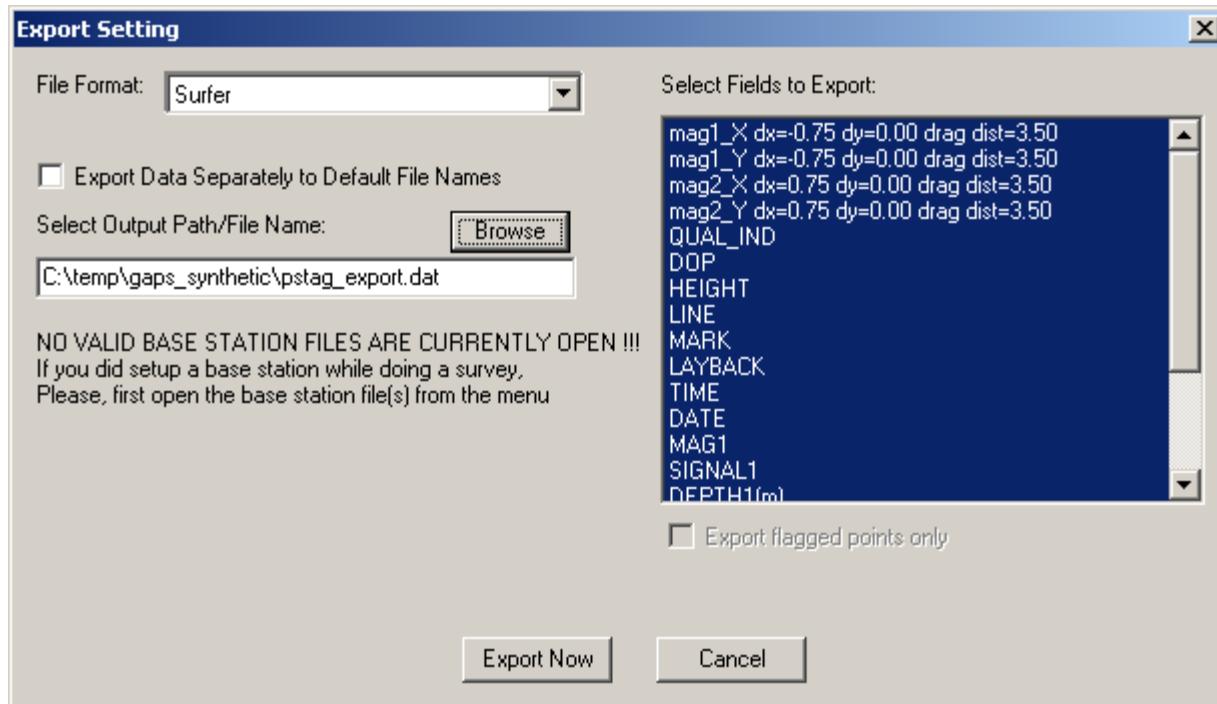
There is a choice to export into SURFER DAT or Geosoft XYZ format. It is also advisable to remove "Export Data Separately to Default file names" mark and press "Browse" button to select an appropriate new file with a meaningful name. The easiest waay is to select all items on the right side of the dialog. Some of them such as "height", "dop" and "qual_ind" are not applicable to USBL PSTAG message and might be not selected for export.

Press OK to export data into the file. The resulting data file contains the following columns:

1.   mag1_X , mag1_Y Longitude and Latitude of the first (port side in this example) sensor.

2.   mag2_X , mag2_Y Longitude and Latitude of the second (star side in this example) sensor.

3.   MAG1 – magnetic field reading for sensor #1

4.   SIGNAL1 – signal system reading for sensor #1

5.   DEPTH1(m) – calibrated, in meters, depth sensor reading for sensor #1

6.   ALTITUDE1(m) – calibrated, in meters, altitude reading. Note that in TVG systems altimeter could be connected to either of sensors. Therefore one of the altitude readings is dummy. Check your configuration to find out which altitude reading is valid.

7.   MAG2, SIGNAL2, DEPTH2(m), ALTITUDE2(m) – the same as above for sensor #2.

8.   LINE MagLog line number, interger value.

9.	MARK. Please disregard this field.

10.	TIME , DATE time and date of the reading.

User can proceed with further data processing using Geometrics "MagPick", Golden Software "Surfer"   Geosoft "Oasis Montaj" or other software.

23. Typical problems and solutions

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I. The Problem:

In the contour map generation routine, the Legend was always visible and if you made the map with many contour interval colors, the legend became bigger than the map!
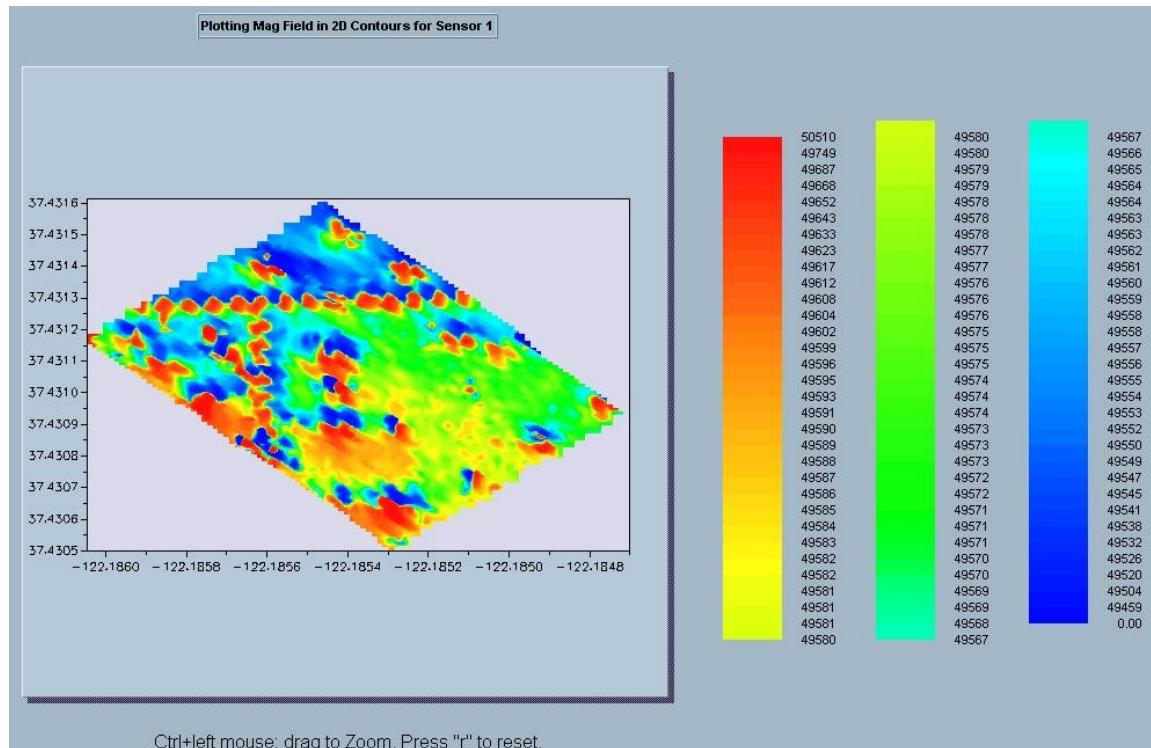
The Solution:
Now by right clicking on the map you can select "Plot Color Legend " box or not. If you turn it off, then you can get a larger picture of the map on the screen for zooming and further analysis. Remember that when in PLOT DATA display (profile display) you can select anomalies for flagging by right clicking on the profile and selecting SET FLAG. When you do that, the flag appears on the profile (number 1 below), on the position map and also on the color contour map showing the position of the anomaly. Put the cursor on the anomaly and read the X, Y or Latitude Longitude of the cursor on the info bar at the bottom

Plotting Mag Field in 2D Contours for Sensor 1

Ctrl+left mouse: drag to Zoom. Press "r" to reset.
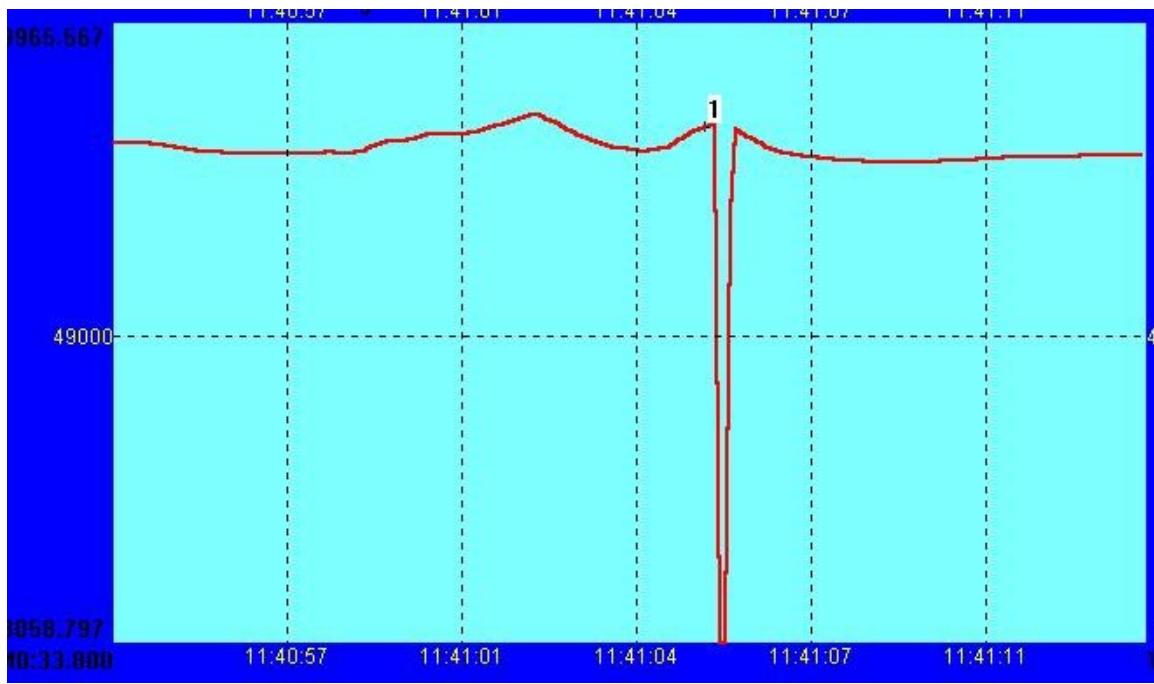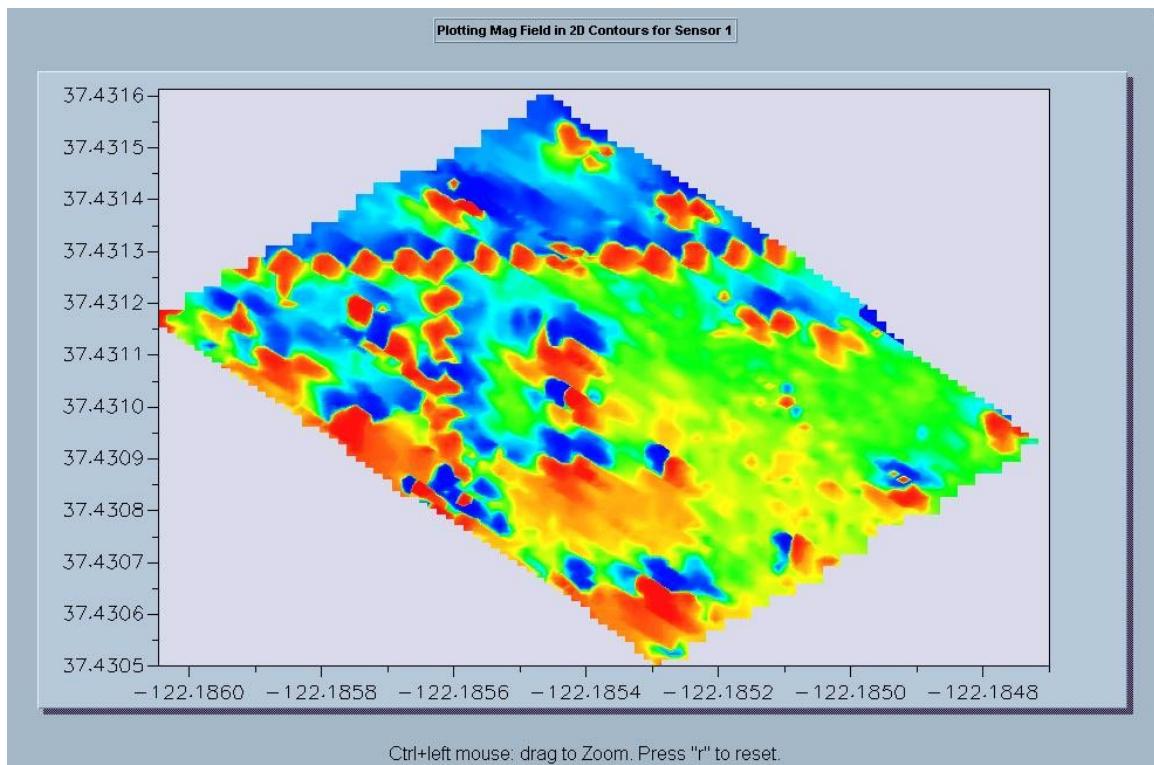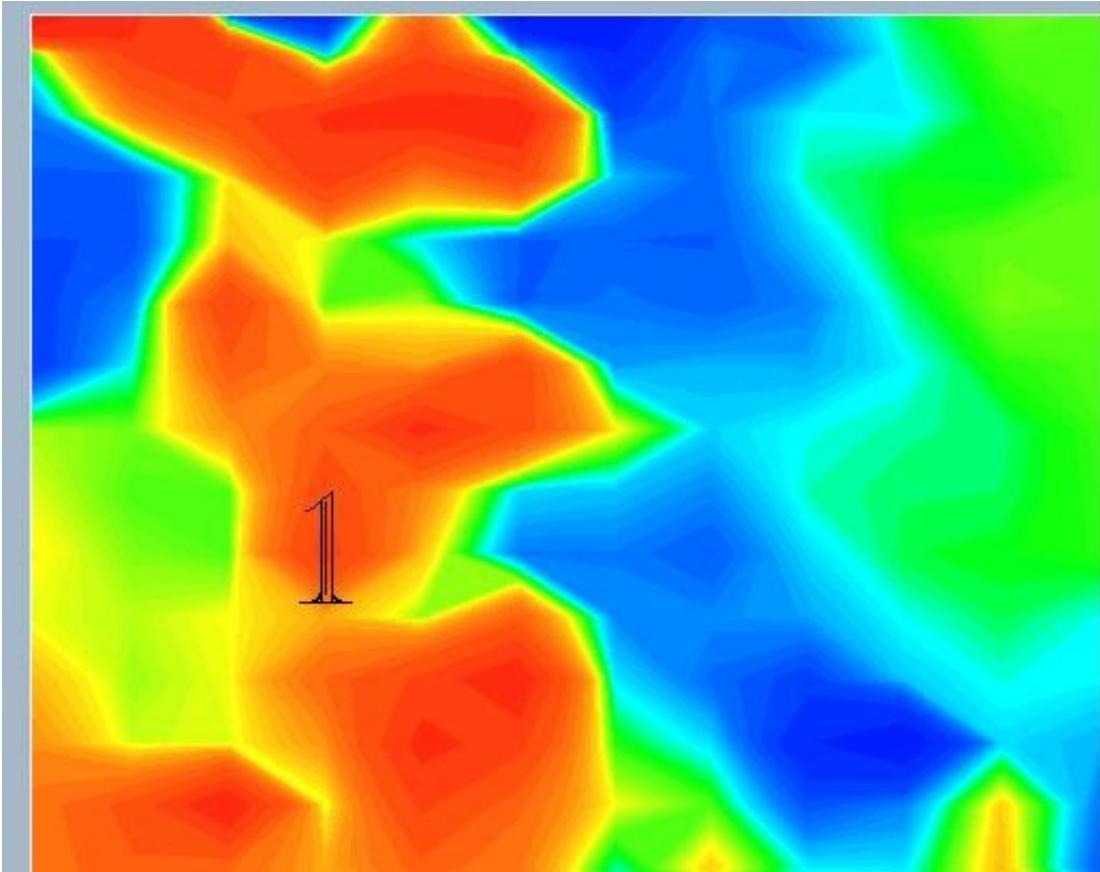
II. The Problem:

Sometimes there may be spikes in the data that are hard to filter using the Despike feature of MagMap. We have now added a much more powerful despike editor called the Range Despike editor.

The Solution:

With the profile plot on the screen, go to Filter then Range Despike. You will see an icon appear that will allow you to draw a box on the plot with your mouse. All data that exceeds the minimum or maximum boundaries of the box will be cut from the data set, but only with in the lateral boundaries of the box. This gives fine control as well and sweeping editing abilities to the user.
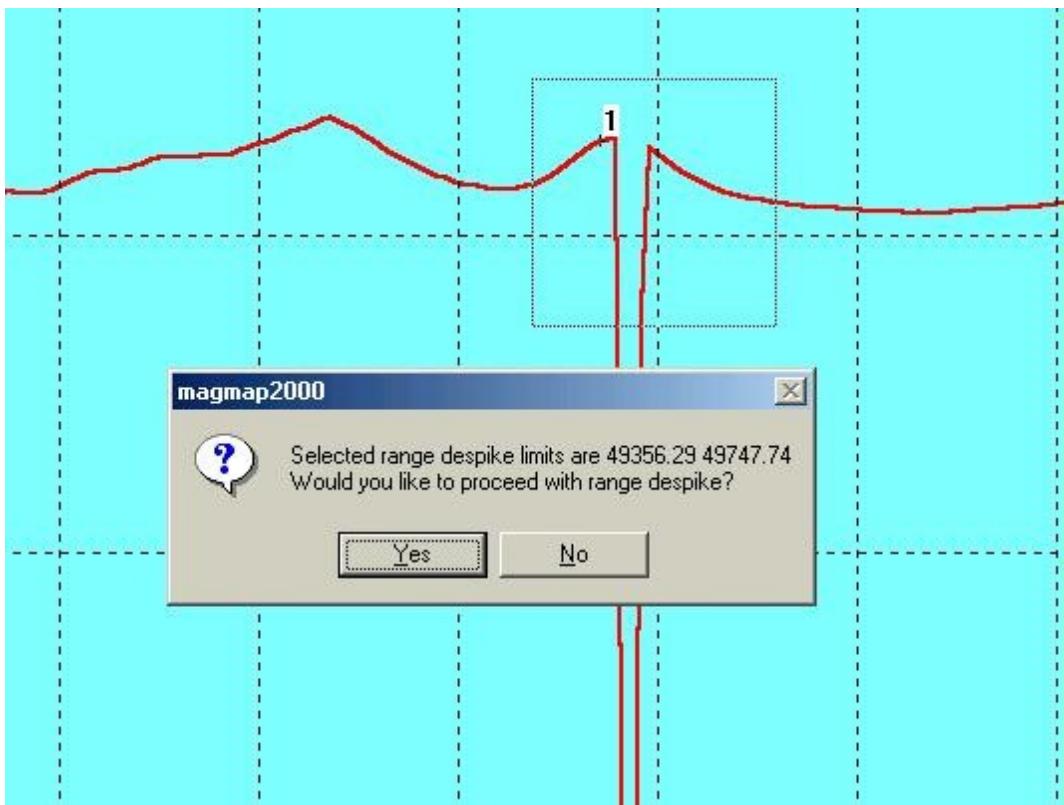
After Despike:
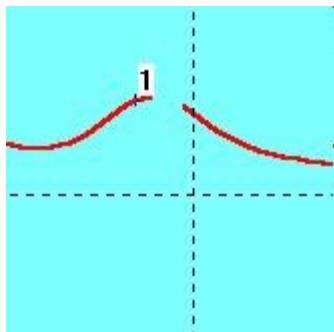
After the Range Despike editor has been applied the data is now modified and the results will be shown in the Contour Map and when the data is exported to Surfer, MagPick or Geosoft for additional processing. This is a quick and easy way to clean up the occasional spike or dropout.

III. The Problem:

Basestation data some times has noise that should be smoothed prior to applying diurnal correction. MagMap now offers a basestation smoothing routine which when combined with the Range Despike editor offers excellent noise reduction.

The Solution:

Bring in the basestation file and then go to Filter, Smooth Basestation Data. You can select a value from 1 to 10 for the smoothing, 10 being the highest filtering. Note that the filter curve is shown prior to your acceptance. If you go back to Filter and Smooth Basestation Data, you can choose Accept which will modify the data in memory. Then you can export it or plot it. Remember that your original data is never changed (*.bin files) but you can save a *.stn file over the original *.stn file.

Basestation data 4 hours

Basestation data, filter level 4 preview, zoomed in
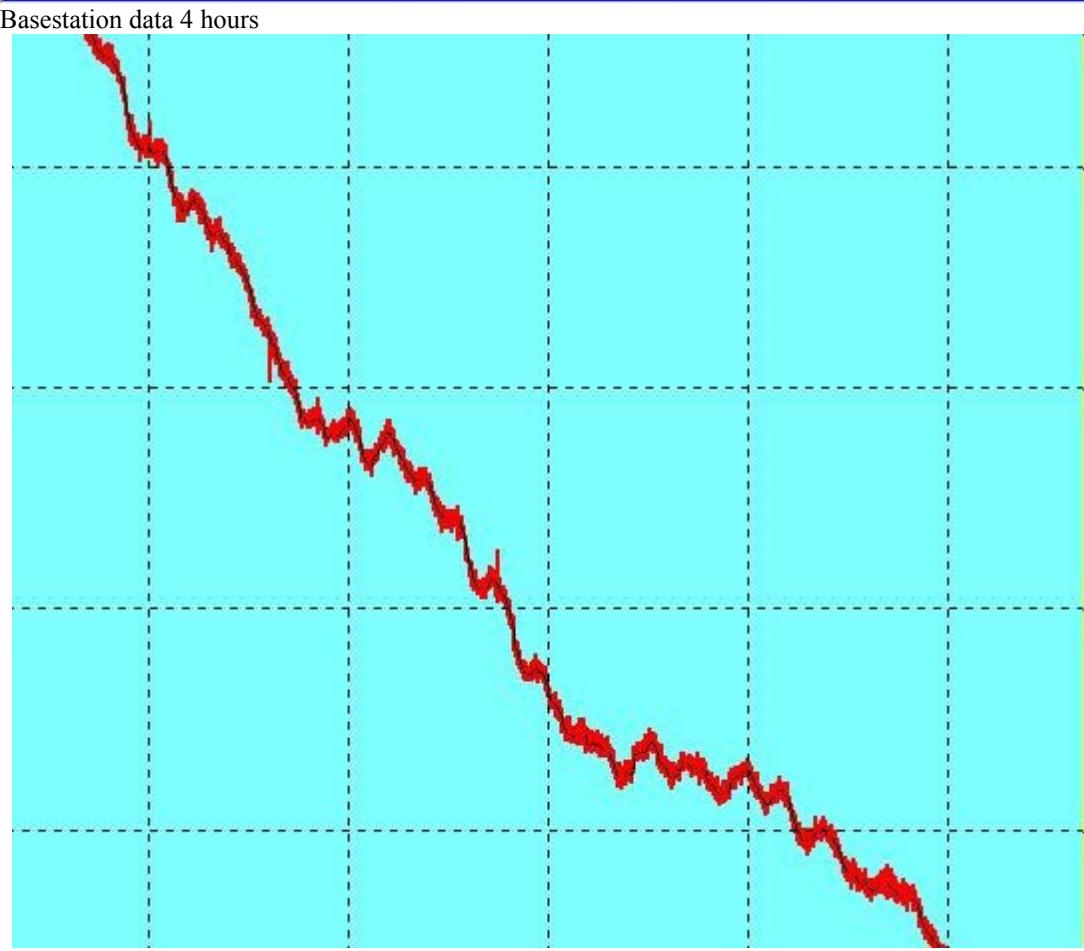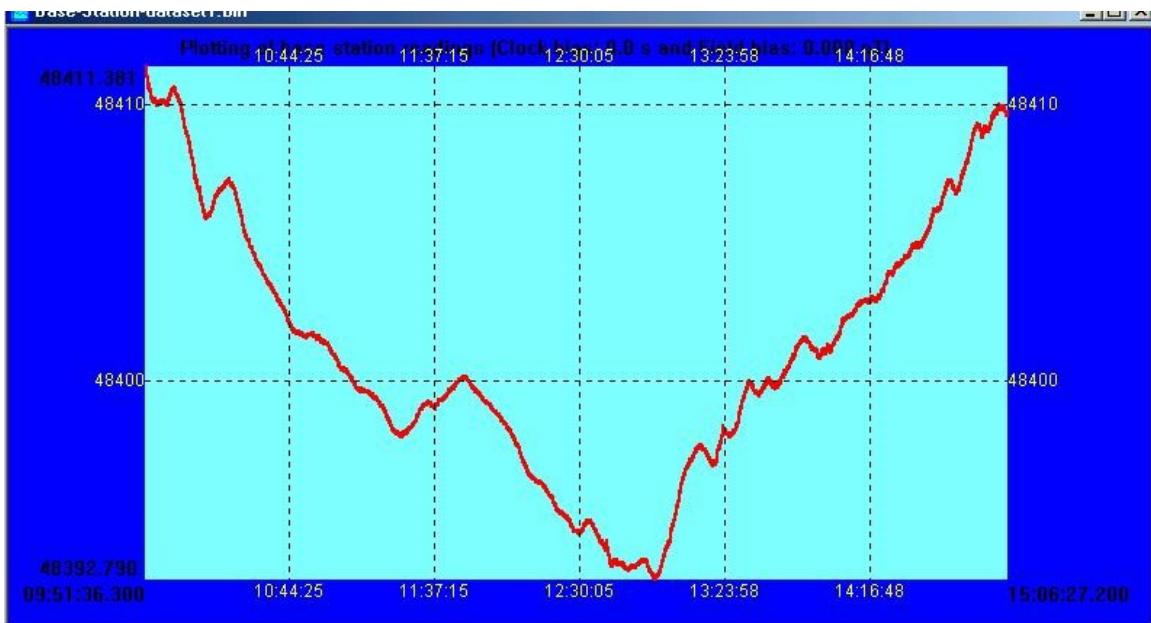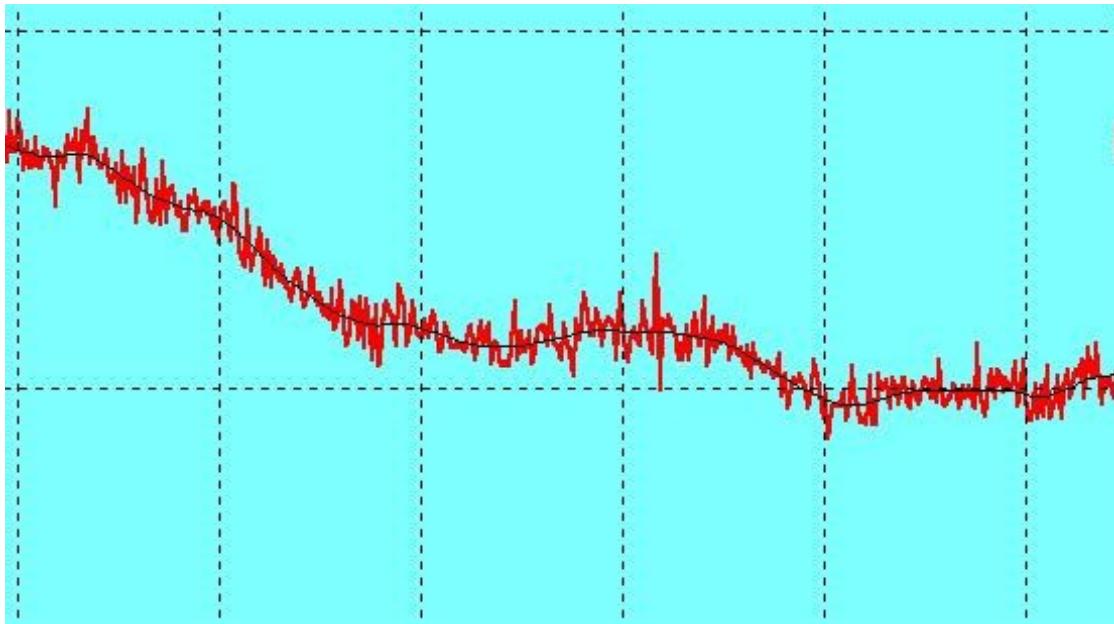
Basestation filter 4 preview, further zoom
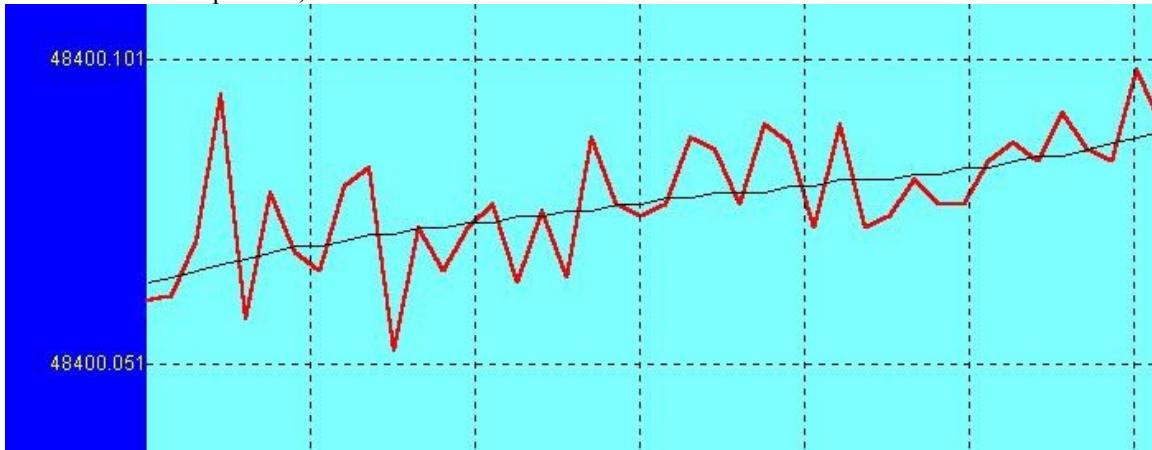
Basestation data, 0.05nT smoothed to 0.01 or better with filter level 4
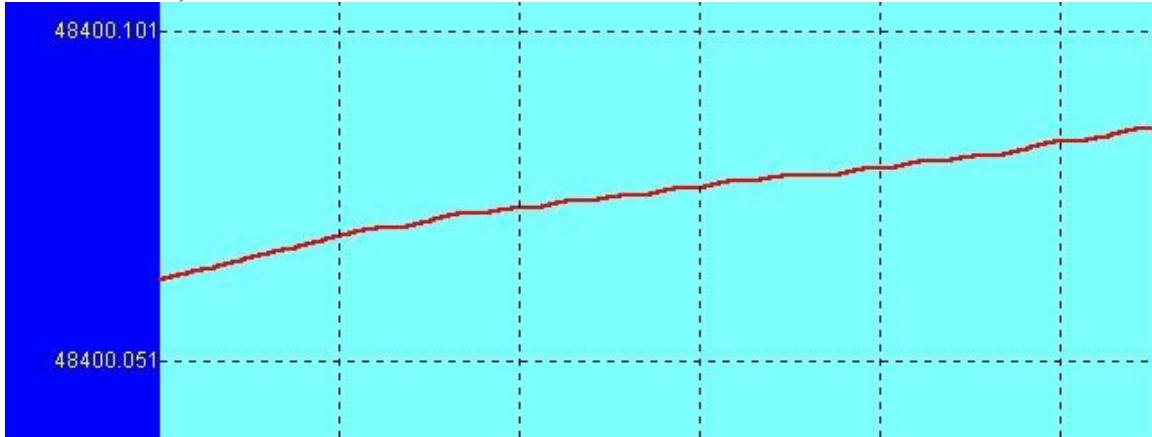
Basestation data accepted

NOTE: This feature will be implemented on regular data by November 2002. Then you can apply smoothing to both basestation and field data!

IV. The Problem

Zooming in to see the data had a maximum limit using the circle with a + in it (or an X+ or Y+)

The Solution:

Our programmers have come up with a magnifying glass zoom tool like those found in graphics programs. The Icon is a circle with a small box in it. Simply select this icon and then draw a box around the portion of data that you want to zoom.

Menu bar for Zoom Tool

When you have finished zooming and wish to return to the original coordinate display, simply click on the green icon with the arrows pointing outward .

V. The Problem

Sometimes we may want to apply a "frequency filter" to our data that becomes a spatial frequency, i.e., we are looking for something specific, a source of a given size. Or we may want to eliminate a certain high or low frequency component in the data so that we can more clearly see the "targets" of interest.

The Solution:

For instance, let us say that we are interested in the geological signal because we are looking for magnetite concentrations associated with placer gold deposits. However, there are also magnetic materials right on the surface due to weathering of the host rock. We can raise the sensor to "look" deeper (essentially applying a low pass distance filter), but we can also filter out the high frequencies in the following manner.

Bring in data with low and high frequency components and contour
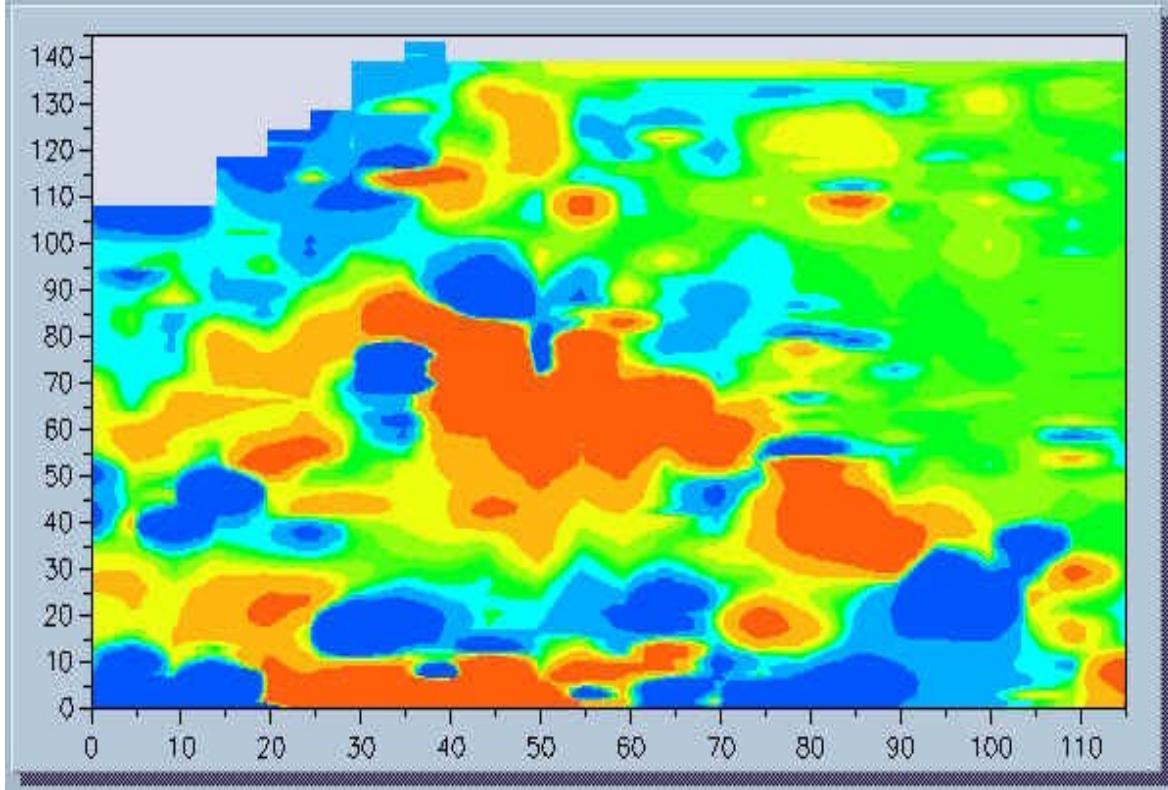
Now look at the data plot and apply a factor 7 spline to it, press review
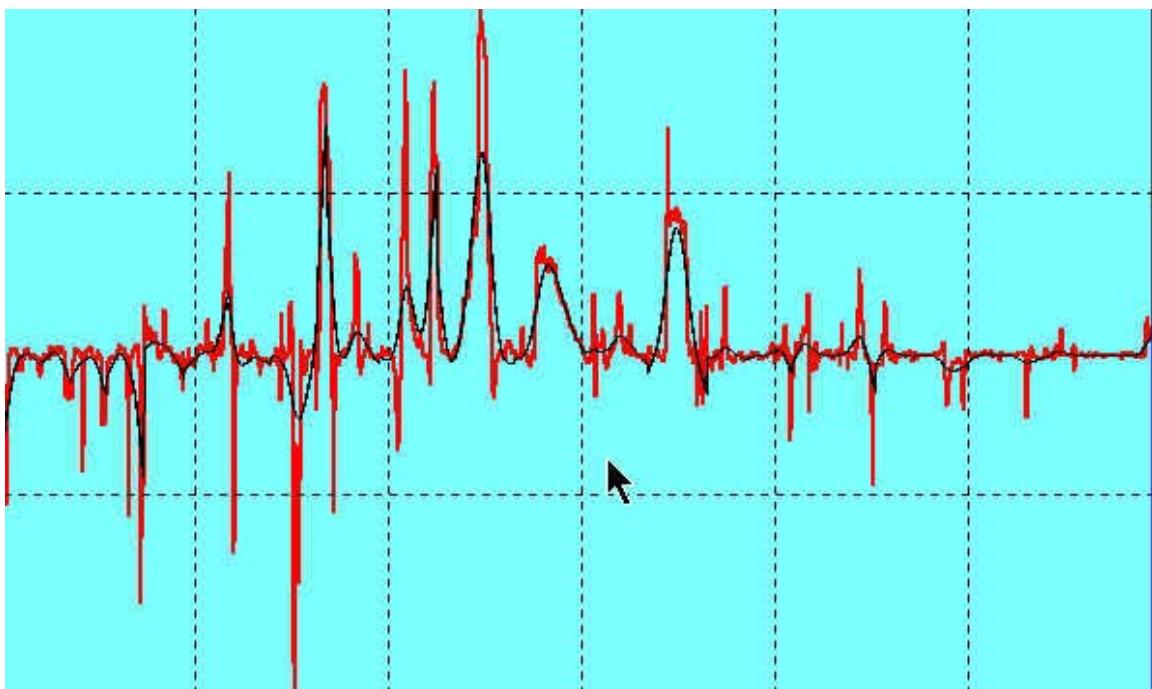
If it looks sufficiently "low passed" then accept the data and generate a contour map. Compare with the raw data contour map above.
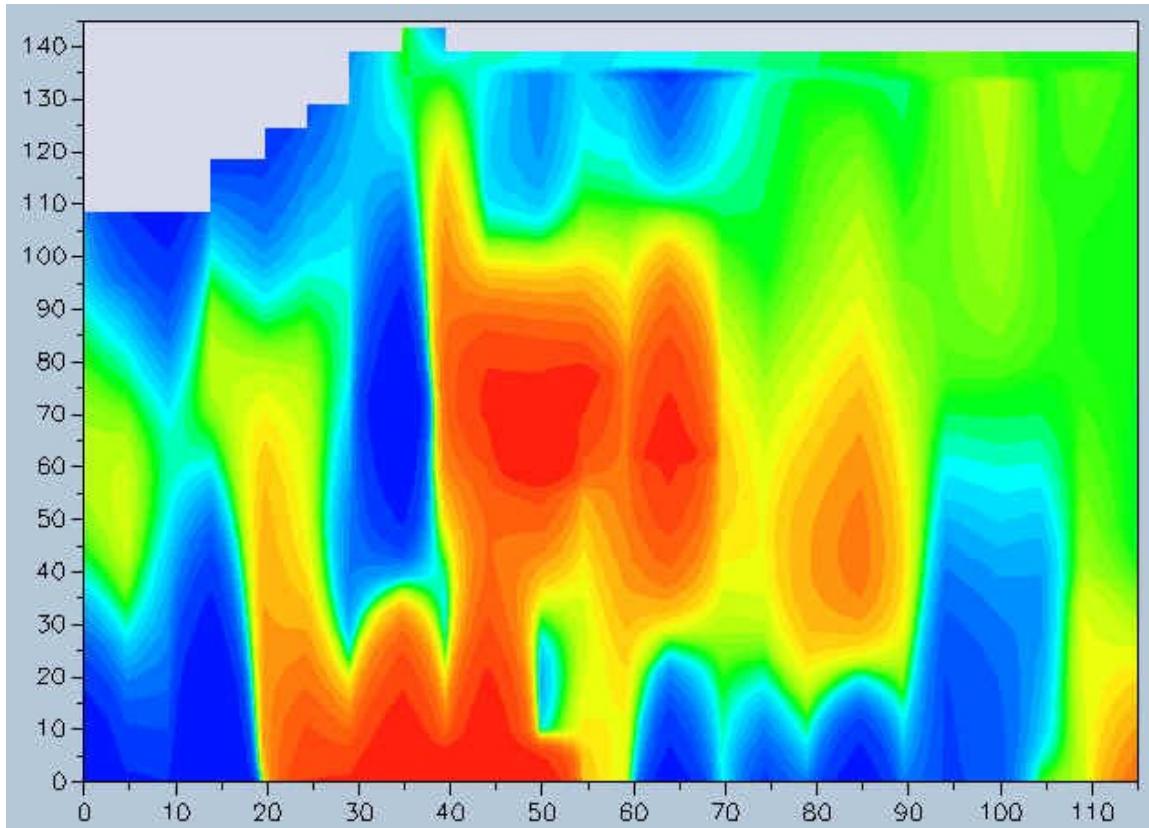
Or one can "look" even deep with higher spline factors.

What if we want to look at only the surface features, for instance if we are doing an archeological or UXO survey, we may want to accentuate the higher frequencies and remove the deeper geologic signal. In this case we apply a high order (high number) spline filter to the data and THEN CLICK THE DIFFERENCE button so that the data that is presented when we press review is the difference between the raw data and the splined data. Then in this fashion, only the higher data is saved into memory when we press the Accept button.
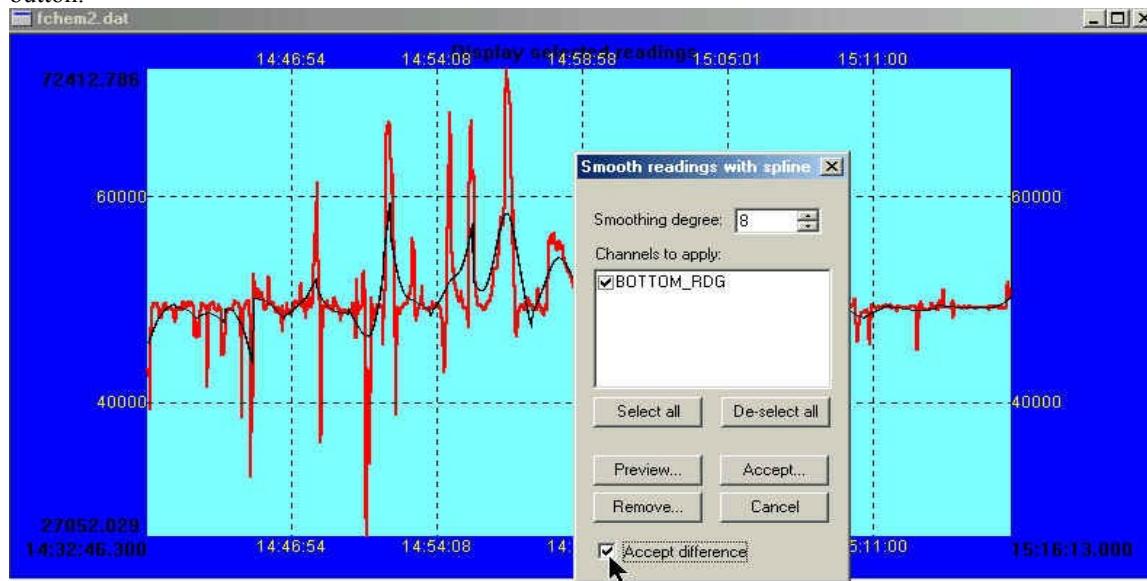
Then when we contour the data we get high frequency (small target) data display.
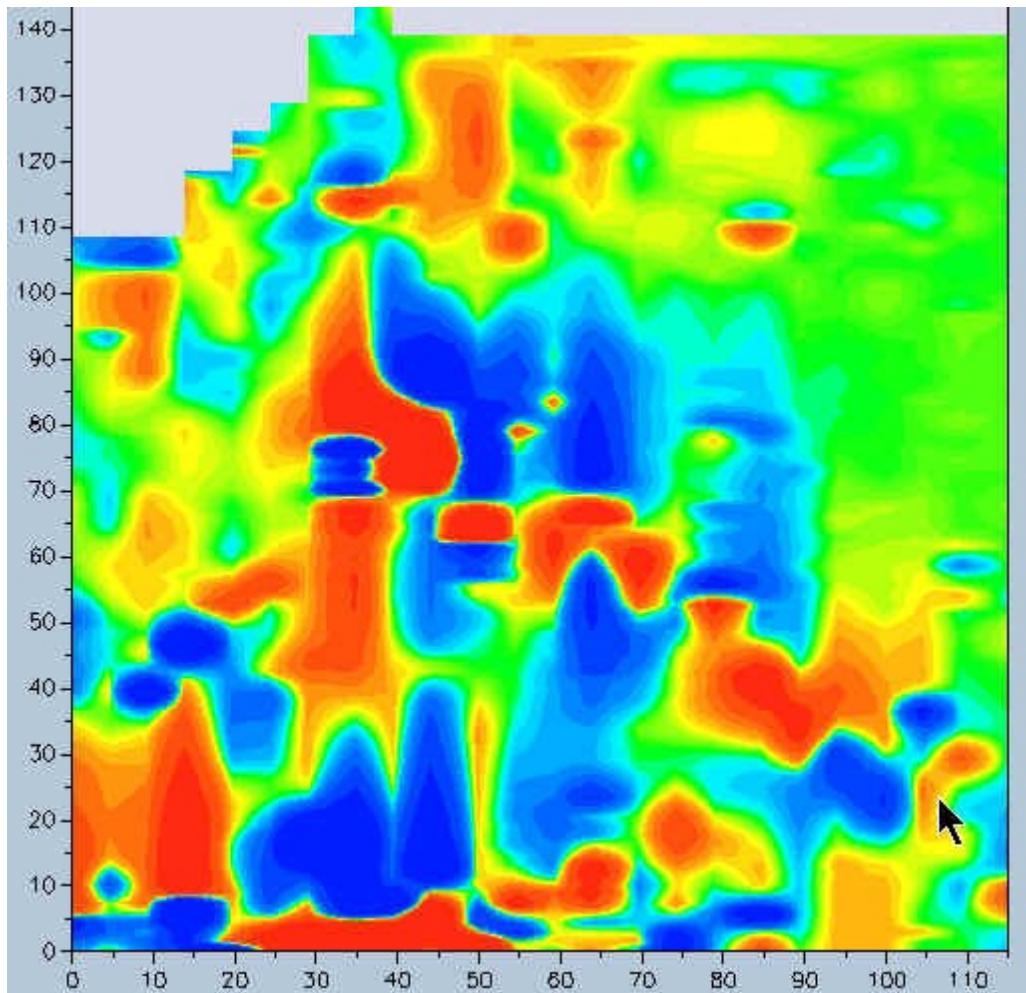
VI. The Problem

Noise spikes due to operation of the sensor close to the dead zone (see dead zone sensor orientation discussion in technical report MTR-120) can be troublesome to remove. However with our new range despike and spline filter modules, the data clean up is simple and quick.

The Solution:

Here is a sample of data corrupted by poor sensor orientation:
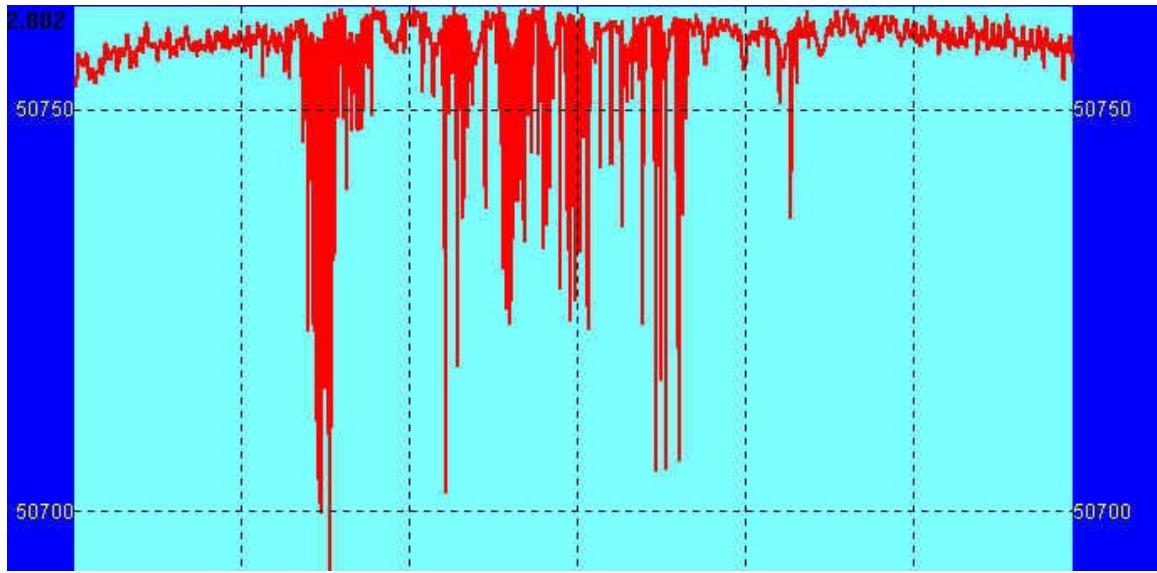
First we use the Range Despike tool to eliminate the obvious spikes:
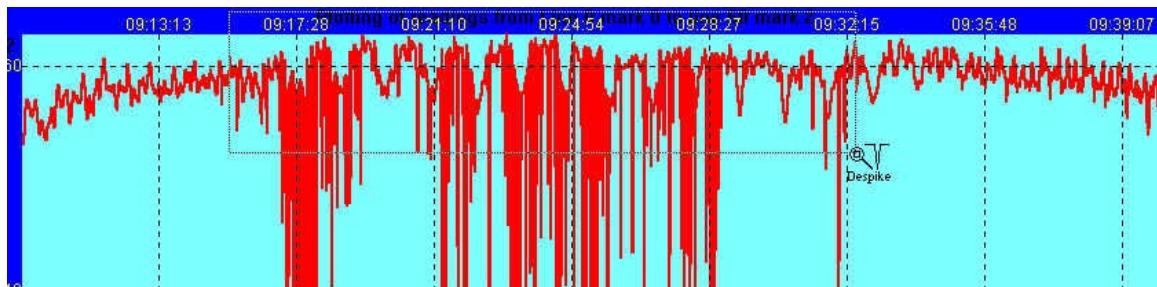

Now the data is rescaled:
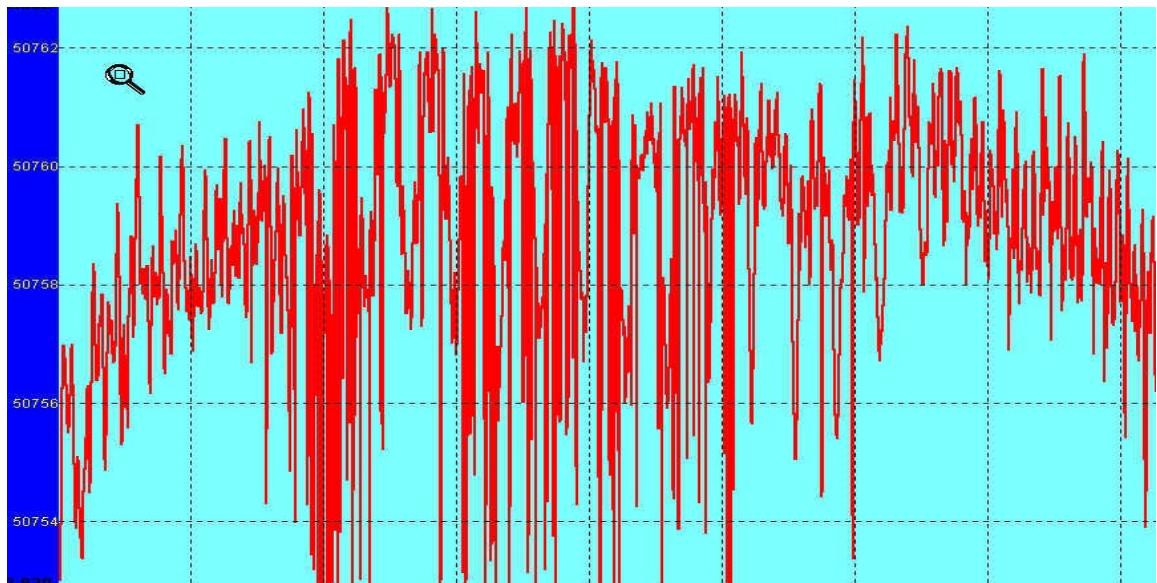
Next we can do a quick spline fit for REVIEW using the Smooth Readings dialog box under Filter. If we wish we can do some additional despiking <u>after</u> applying the filter to see the results:
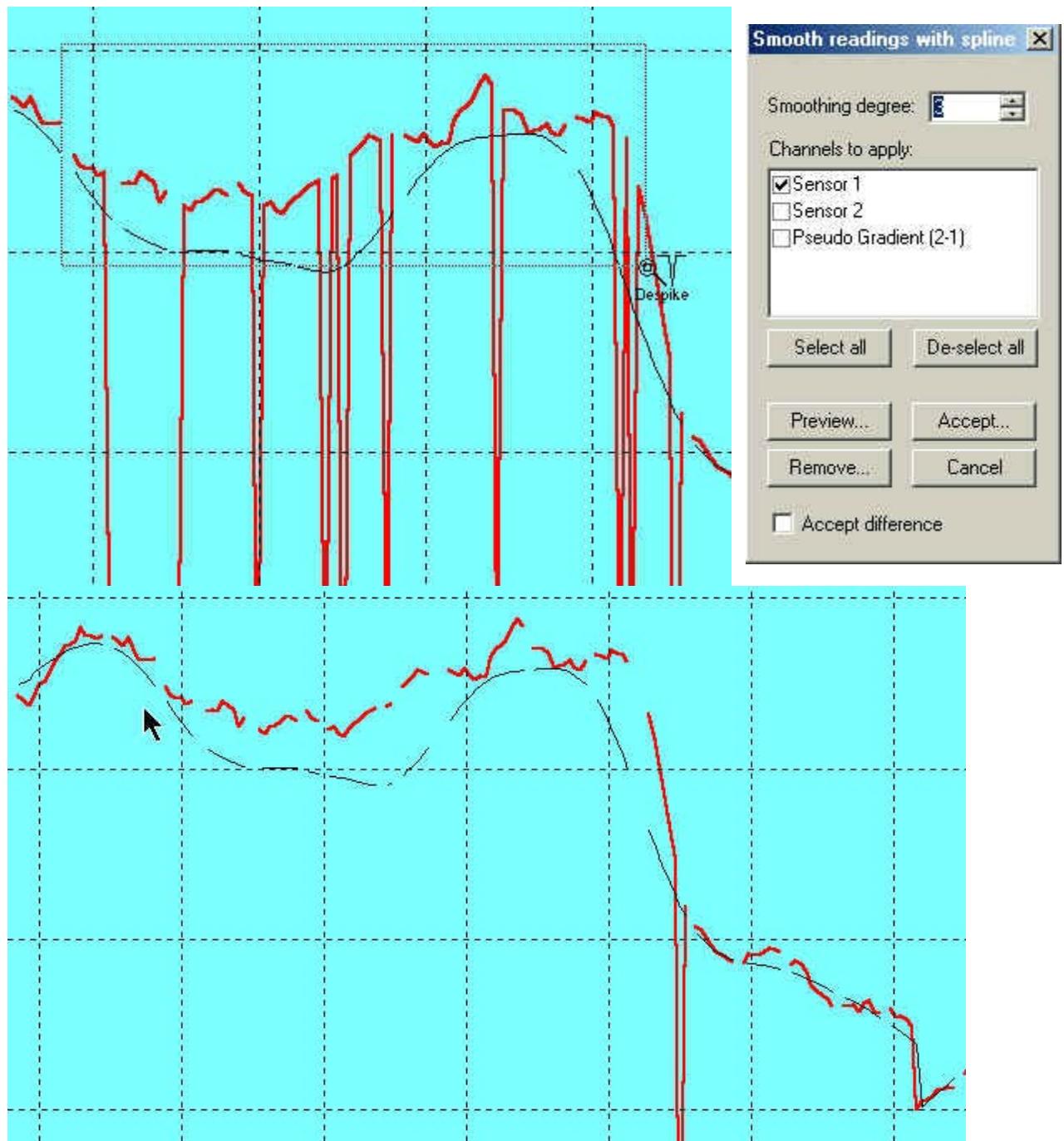
And now apply a factor 3 spline filter (Review) again from the Filter dialog and see results.
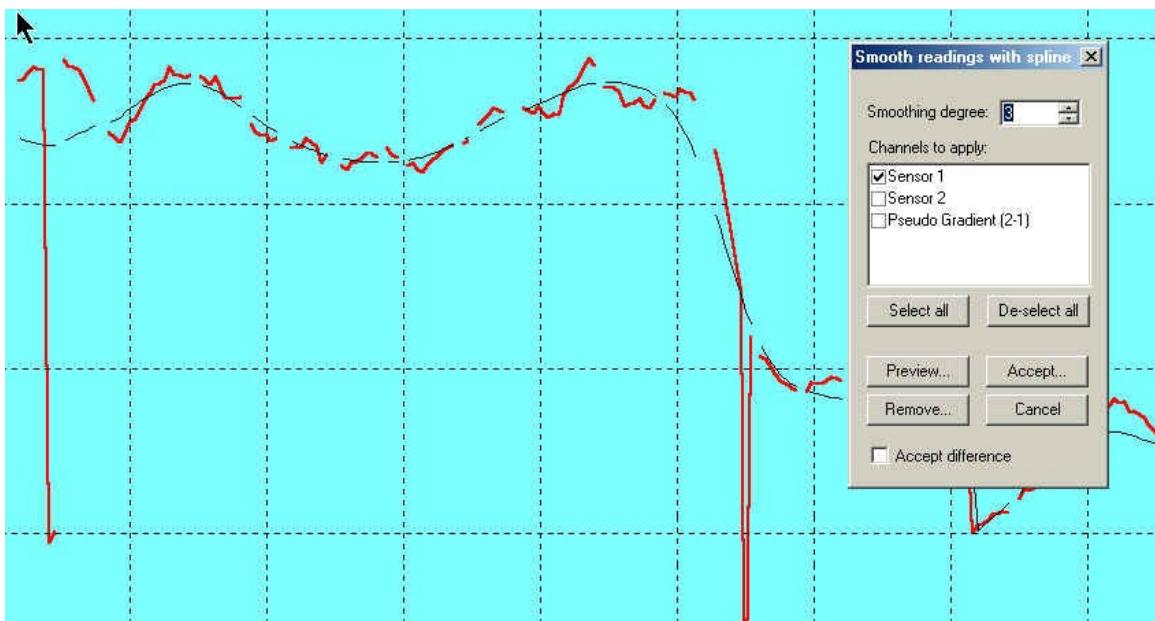
Now compare with and without despiking and filter
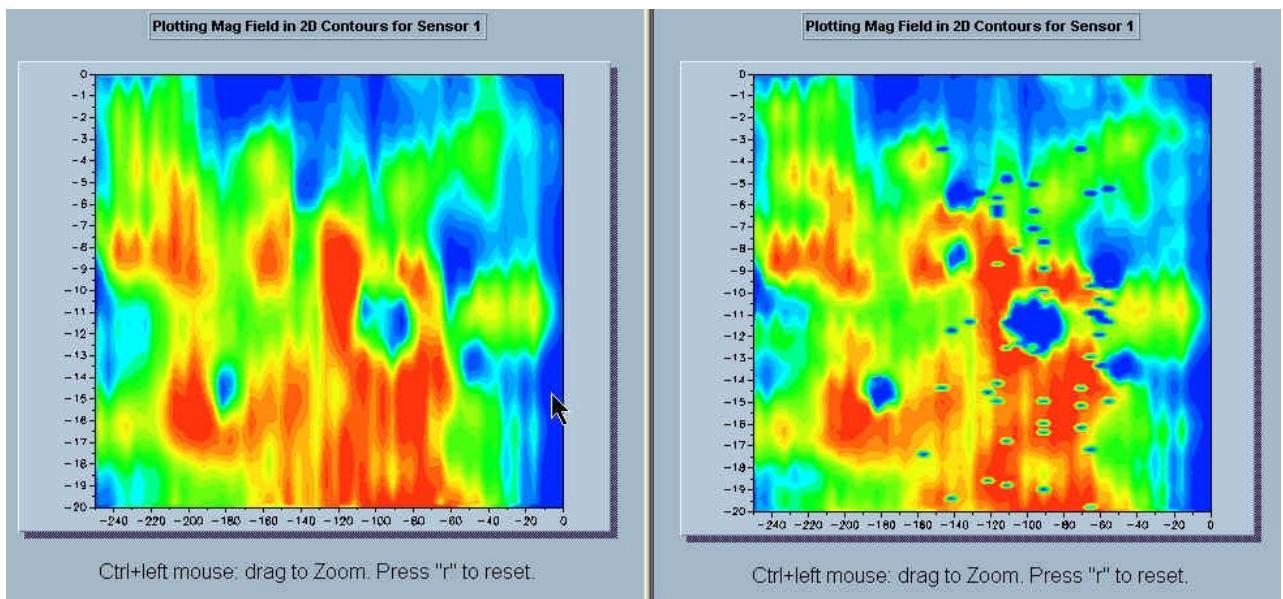
For more information, please refer to the manual and visit our website often for more updates.

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