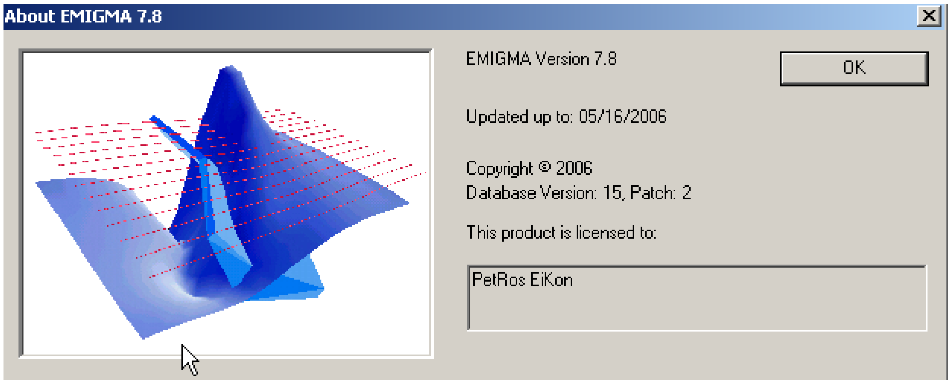
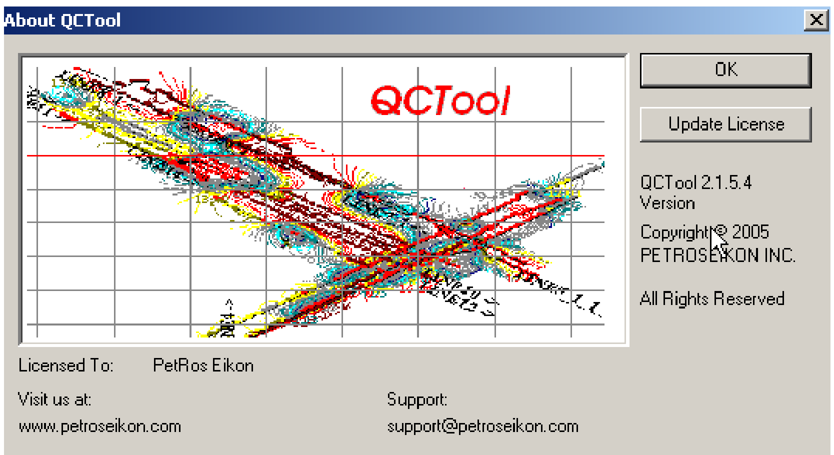
PetRos EiKon Inc



MAGNETOMETER COMPENSATION SOFTWARE



VERSION
2

PetRos EiKon Inc

PetRos EiKon inc, 10A Bram Ct, Unit 10, Brampton, Ontario Canada L6W 3R6
Tel: 905-796-0324 Fax: 905-796-5214 E-Mail: support@petroseikon.com
Web site: www.petroseikon.com

May 2006

CONTENTS

NOTICE TO USERS

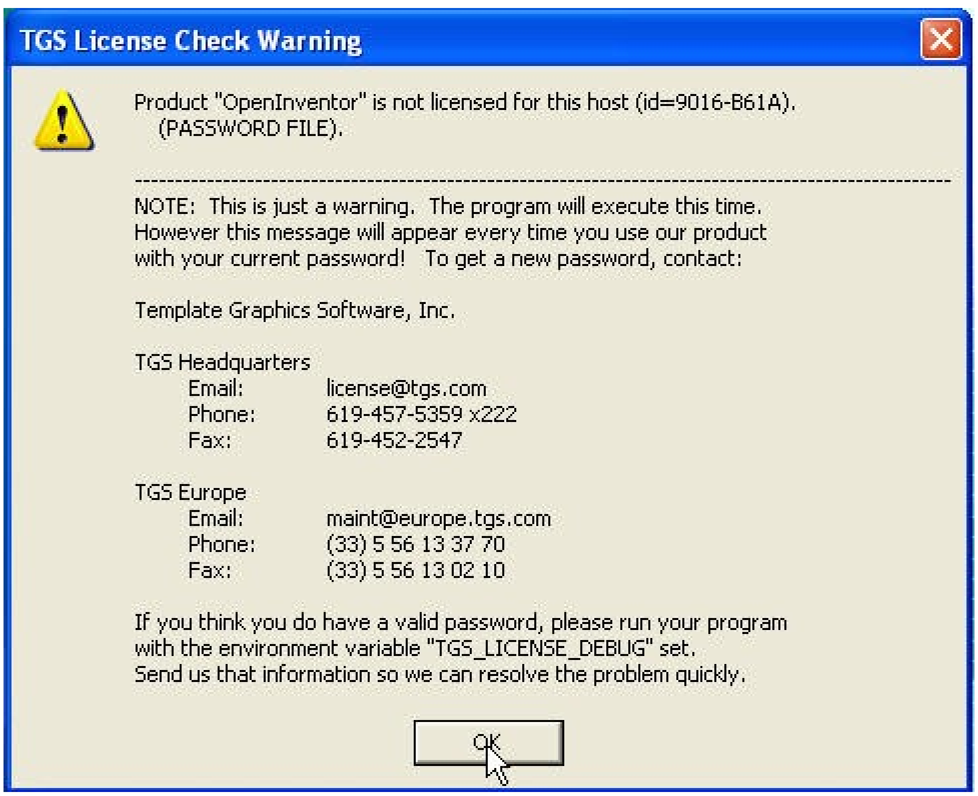
The magnetic compensation software routines are embedded within **EMIGMA V7.8 and QCTool**. Although the compensation is provided with a variety of additional tools from the EMIGMA package, the user need not be familiar with these other tools. For a basic introduction to the EMIGMA interpretation platform, please refer to the “Tutorials” directory either in the installed /EMIGMA directory or directly from the installation CD. In particular, please refer to the Powerpoint file, ***V78_Tutorial.ppt***. QCTool is provided with its own manual.

It is assumed that the user of this software is familiar with running PC based programs and Microsoft Windows.

PASSWORD WARNING MESSAGE

As part of the security measures taken to ensure data security and to help eliminate software theft EMIGMA supports a software security device that is optionally implementable / available to the user. This security device uses a special password based on your computer specific information

This is an OPTIONAL provision only. If the license holder chooses not to implement this security protection it will in no way inhibit the use of the software as it relates to the compensation and all necessary tools for data analyses. A warning message screen (as shown below) will appear each time the software is started. **To continue using the software simply click on the OK button**



REQUIREMENT FOR MAGNETIC COMPENSATION

Modern magnetometers and signal processing boards for magnetic measurements now enable both high sensitivity and high sampling rates to be coupled with a broad bandwidth. The magnetic interference from the airframe and the sensor itself due to attitude changes are far greater than the inherent resolution of the system. Changing of magnetic parts and the use of coils and permalloy strips can only partially remove the interference effects. Proper magnetic compensation, either in real time or post processing is necessary to remove the aircraft's interference. The compensation must address all of the interference sources. Magnetic compensation is now the limiting factor in the overall useful sensitivity of airborne magnetic surveys.

It has been our philosophy to use very much a graphical approach to magnetic compensation so that the operators can always see down to the noise levels of the system. By this technique interference effects can often be seen immediately and cured before expensive airtime is wasted.

Additionally we recommend the use of wide bandwidth, which must be matched for the magnetometer and the compensating fluxgate. We recommend the use of 10 Hz sampling with a 2 Hz bandwidth to reduce the effects of aliasing.

The **PEI** method uses purely software techniques, without the use of varying currents and coils which can distort the field around the sensor. The **PEI** method records the compensated data and all of the required raw data necessary to re-compensate the magnetometer data in post processing.

SOURCES OF MAGNETIC INTERFERENCE

Magnetic interference in a geophysical aircraft environment comes from several sources. These include:-

A) **Permanent magnetism**, mainly from engines and other 'hard iron' magnetic components close to the sensor. This interference is proportional to the coupling with the magnetic field generated by the permanent magnetic materials on or inside the aircraft.

B) **Induced magnetism**, from 'soft iron' components close to the sensor. This interference is proportional to the coupling with the magnetic field and the magnitude of the magnetic field and is a function of the susceptibility and size of these components.

C) **Eddy current terms**, from rate of change of movement of conductive surfaces in a magnetic field. This interference is proportional to the coupling with the magnetic field, it's magnitude and the rate of change of attitude. Although, these causes are often considered to be the major contributions to "eddy current effects", there are, in principle, many other sources which are not well understood.

D) **Heading effects** of the magnetometer sensor itself.

E) **Altitude changes** in a vertical magnetic gradient.

F) Additional effects come from **moving surfaces** and materials, such as trim surfaces and push rods, and distortions of the airframe through flexing.

G) **Electrical and mechanical interference** in the pass band of the system.

The order of magnitude of these interference effects varies greatly from installation to installation. Typically permanent terms could bring 10 nT of magnetic interference, the induced terms 5 nT and eddy current terms 2 nT. The heading effects of modern magnetometers can be as much as 0.5 nT while the vertical magnetic gradient at 3000 m. above ground is of the order or 30 pT/m or 10 pT/ft.

On a fairly clean magnetic installation moving surface and electrical and mechanical interference should be better than 1 nT. These can be tested on the ground in a quiet location with the sensor held in a rigid position. As these interference sources are not measured they will affect the residual compensation and should be minimised. In fact the cleaner the installation, with respect to these unmeasured interference effects, the poorer is the overall improvement by this compensation.

The main differences in these terms can be seen in their magnitude and phase relative to a sinusoidal motion.

The permanent interference effect would be in phase with this motion.

The induced component is again in phase with the coupling but with only an increasing effect of the measured field, maximum along the north and south directions where coupling with the magnetic field is greatest.

The eddy current term has a magnitude proportional to the absolute value of the magnetic field coupling and to the rate of change of coupling.

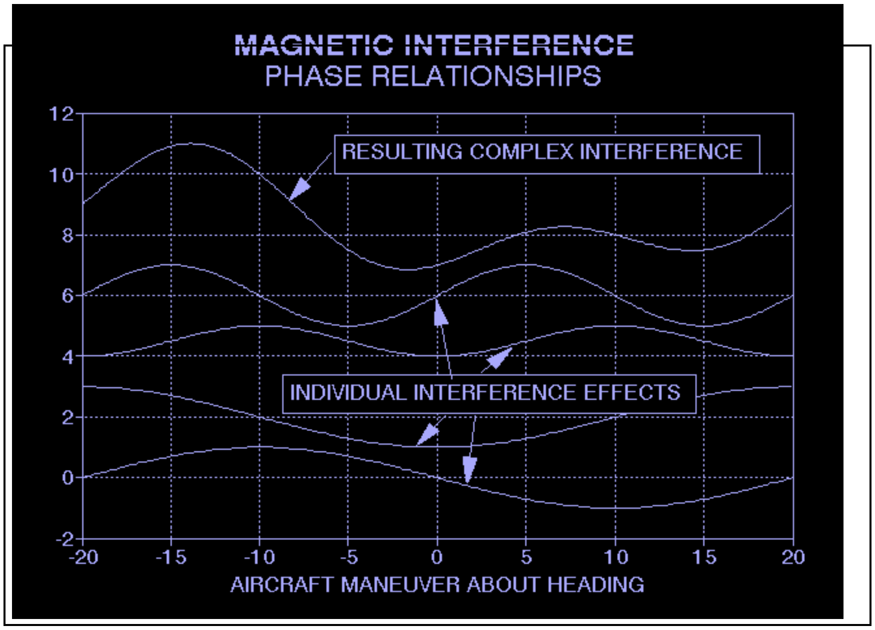


Figure 1

Above we show individual interference effects for a sinusoidal motion. They can be at the frequency of the motion, both in phase and 90 degree phase shifted. They can also have a frequency twice that of the motion, again in or 90 degree phase shifted. The resulting magnetic interference is the vector sum. This can have a complex shape, depending on the magnitudes of the interference.

REALITY IN COMPENSATING A REAL AIRCRAFT

The residual magnetic interference is somewhat more complex that a simple sine wave manoeuvre. In reality the magnetic interference is in three dimensions, longitudinal, transverse and vertical. Additionally the components in each dimension have different interference effects from pitch, roll and yaw motions. Similar phase shifted responses exist for rolls and pitches. The summed interference is much more complex as the three dimensional attitude and rate of change of attitude of a real aircraft is inter-related.

In a real environment the aircraft is also moving through a changing magnetic field. Even high above ground level there still exists long wavelength gradients and curvature in the magnetic field. By carrying out a box manoeuvre the background magnetic gradient changes at the same time as the heading effect of the aircraft. This makes it extremely difficult to separate the two effects.

BASES OF COMPENSATION

The basis of our compensation is the reduction of motion induced noise on the selected magnetic elements. These can be individual sensor or various gradient configurations. This motion noise comes from the complex three-dimensional magnetic signature of the airframe as it changes attitude with respect to the magnetic field vector. The noise comes from permanent, induced and eddy effects of the airframe plus additional heading effects of the individual Cs sensors.

Due to the background magnetic changes experienced in real flying conditions, long wavelength geological interference, it is felt that it is not easy to obtain adequate compensation coefficients which can be used on all survey headings. Only in extremely low gradient areas would this technique give reasonable results. This is due to the fact that these background changes alter with the heading and have the same high frequency components. They are, therefore, indistinguishable from heading effects due to the airframe alone. Attempts to use 1 set of coefficients for all headings average these background errors into the compensation coefficients and produce inferior results during compensation. Additionally, the coupling of the earth's magnetic field with the susceptible and conducting materials on the aircraft changes with heading and thus the net effect on the individual sensors varies with aircraft heading and thus this would imply the necessity of heading dependent coefficients.

Our approach has been to use four individual sets of coefficients, one each for the four cardinal headings. These are assigned to be nominally 'N', 'S', 'E' and 'W'. On survey the changes from the nominal line are small, typically within +-20 degrees for pitch, roll and yaw. Note: You may also use diagonal paths in the box data. Be sure, in all cases, when calculating the coefficients to split the box flight into its different flight directions as "lines" or "profiles". This is easily done within EMIGMA prior to caculating the coefficients.

We define 4 cardinal headings for each survey, even if only 2 are used for surveying. Of course, the other 2 cardinal headings may be used for tie lines. These cardinal headings are normally, but not necessarily, orthogonal. The Main Cardinal Heading is defined as the grid value of the cardinal heading closest to grid north. For example, the main survey direction is on a heading of 100 degrees east of grid north then the cardinal headings are 10, 100, 190 and 280 degrees with the Main Cardinal Heading 10. We then define our 10 degree east heading as 'NORTH'. Similarly the 100 degree heading is defined 'EAST', the 190 deg heading as 'SOUTH' and the 280 degree heading as 'WEST'. This convention will be carried through from the SURVEY program to post-processing.

The magnetic compensation is carried out in software without the use of active distorting magnetic fields. A magnetic interference model has been constructed with three orthogonal sets of components. This assumes a magnetically rigid magnetic interference model.

A three axis fluxgate is used to measure the coupling of the three axes with the background magnetic field. This sensor is very sensitive to attitude changes and is used to accurately monitor the aircraft reference frame. The frequency response and sample rate of the **acquistion system**dused to measure the fluxgate signals should be the same as that of the **magnetometer acquistion system**. This means that there is no phase distortion of these synchronised measurements. This leads to improved compensation throughout the pass band of the system.

A series of pitch, roll and yaw motions are carried out on each survey direction to vary this coupling and gather fluxgate, barometric and measured magnetic field data. This data is processed using generally either an SVD or a Ridge-Regression technique to find a stable set of coefficients for the model. When the compensation algorithm is run using the model and coefficients, either in real-time or post-processing, a magnetically compensated data set is generated.

We have tried to make this software as production orientated as possible, to supply the operator with real-time compensated data to view, confirming that it meets company specifications, and continue flying.

The programs supplied should enable the user to achieve software magnetic compensation for total field data. This can be carried out in real-time using previously calculated compensation coefficients or in post-processing using a selection of compensation coefficients.

NOTE on Box Maneouvers: The coefficient calculation is such that no specific flight maneouvers need be made BUT sufficient maneouvers must be made to characterize the effect of the aircraft and the sensors with regard to attitude. Both, slow moving maneouvers and high frequency manoeuvers should be made in all directions during the box.

STAGES OF COMPENSATION

The compensation takes four stages:-

A) Acquisition of motion test data.

B) Reduction of this data to produce compensation coefficients.

C) Production use of these coefficients in real time to supply compensated magnetic elements.

D) Post processing, if desired, of the raw data with other sets of compensation coefficients for improved results, if valid.

ACQUISITION of Motion Test data (*Box data*)

The acquisition of motion test data should take approximately 20 minutes. Let us consider that we want to fly N-S traverses and E-W tie lines. The test should consist of the following:-

1) Have all equipment in normal operating conditions. The sample rate should be that of the survey. 10 Hz sampling with a 2 Hz bandwidth is recommended for all surveys. All the equipment that would normally be “ON” during a survey flight should on. If the aircraft is equipped with an auto-pilot it should be turned off and the aircraft flown manually. Aircraft systems that consume large amounts of power such as air conditioning should be either turned off and left off or placed in a mode where the compressor and fan systems are continually on and do not cycle. It should be noted that whatever aircraft systems are on during the compensation test flight must be “ON” for all surveys flights. Failure to observe this practice will result in poor compensation results during survey data acquisition.

2) The pilot(s) should be consulted to ensure they understand the following, often somewhat conflicting, ideal requirements.

The compensation test should be carried out in a magnetically quiet area at high altitude, away from ground effect, at least 8,000 feet above ground. The normal data acquisition program should be run with the sample rate the same as that to be used in the survey. During each of the four lines the aircraft should perform three each complete pitch, roll and yaw motions. These should be smooth and as symmetrical as is possible, of typically 5-10 second period. In addition, if flying any diagonal lines during the survey, diagonal lines should be flown in the motion o box test.

The motions should be consistent with normal aircraft motion experienced during survey data acquisition. Roll manoeuvres should be +/-10 degrees peak to peak, pitch manoeuvres should be +/-5 degrees peak to peak and altitude changes should also be minimised, 50 m. or less if possible, and yaw manoeuvres should be +/- 5 degrees peak to peak. Only the aircraft surfaces that are used on line to alter the aircraft attitude should be used, e.g. do not use rudder excessively if this is not normally used as magnetic push rods may complicate the compensation. The order of motions is not critical. It is, however, good procedure and enables us to view the replot in a more meaningful way. The line should be closed, the aircraft set on a new heading, e.g. west, and the same motions carried out. The motions should then be carried out again on the remaining south and east headings. IN order to assist in data analysis the operator should note on the flight log the start and end fiducials for each of the 12 manoeuvres

The operator may have several files, one for each direction or one file for the entire flight. The software can manage with either of these cases.

The reduction of the data to calculate the coefficients can be carried out on the aircraft but is easier to do it the ground, either on the aircraft system or a similar PC computer. It is recommended that a plot is carried out of the data at the fastest sample rate to view the fluxgate and the magnetometer signals to ensure that there are no glitches or other problems with the data. The user should also select the fid ranges to use for each heading. There should be from 800 to 2000 data samples for each line.

It is recommended that this test procedure should be carried out at the beginning of each survey and every two weeks or whenever any major magnetic component is changed.

REDUCTION WITH EMIGMA/QCTool

EMIGMA's tool "Magnetic Compensation" calculates the regression of the magnetometer readings individually against the fluxgate signals.

THE SOFTWARE DONGLE

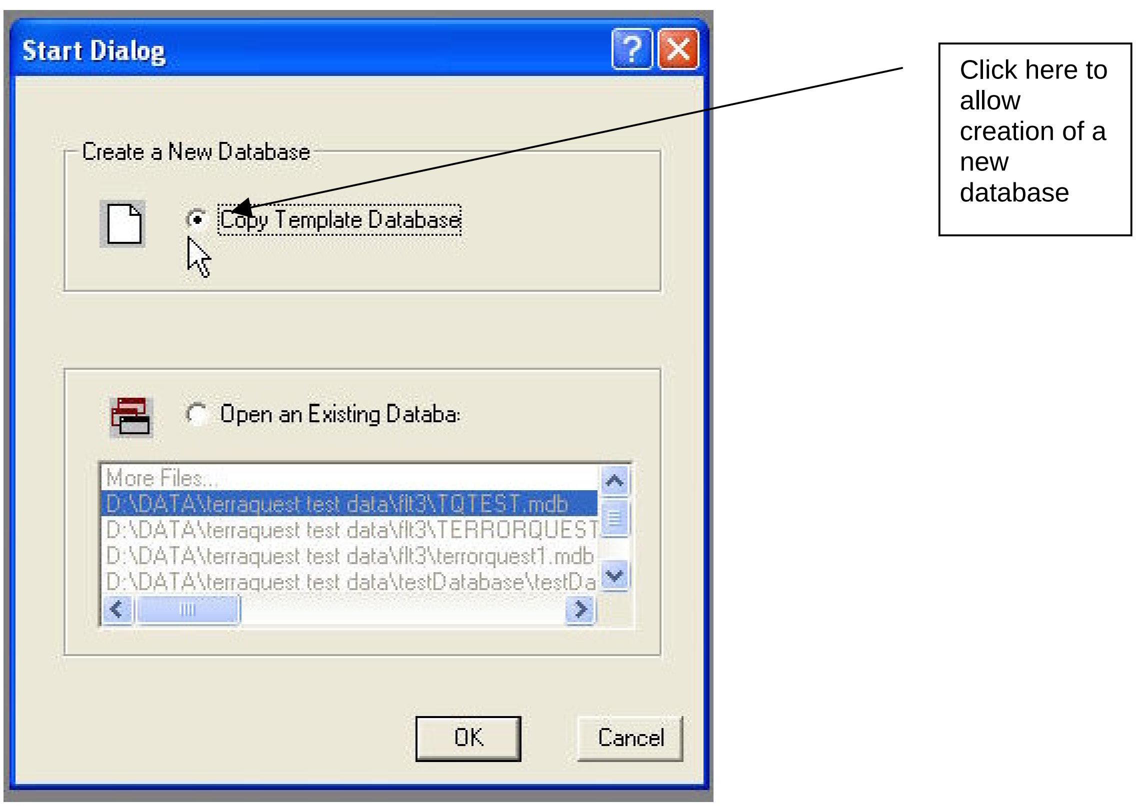
If you are running ***EMIGMA*** in a WINDOWS-based systems, a software dongle will be necessary. The software dongle contains different codes which control the availability of various aspects of EMIGMA. The dongle is read on start-up, and ***EMIGMA*** is configured in accordance with the contents of the dongle. In this way, it is possible to customize ***EMIGMA*** to particular individual requirements.

The software dongle should be plugged into the parallel port of your computer before ***EMIGMA*** is started, and should remain in the port for the duration of the model run. The executable may be placed on a number of computers, but the dongle must be on the computer when executing. NOTE: If a parallel port is not available, a USB dongle can be provided. Some newer computers particularly Toshiba notebooks can come without the parallel port enabled. If the software indicates that it cannot find the dongle, the user should check the parallel port settings in the BIOS. We recommend the parallel port dongle due to its strength and reliability.

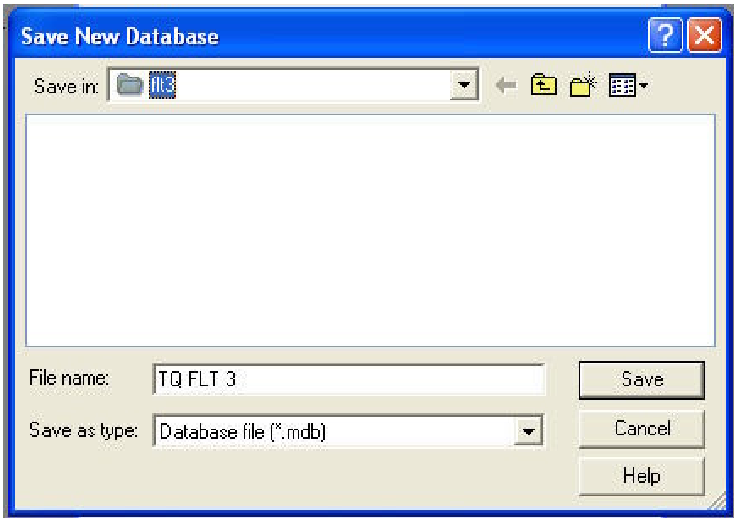
Getting Started in EMIGMA V7.8

Start -> Programs -> Emigma 7.8 -> Emigma V7.8

$ To **Create a New Database** - Select **Copy Template Database, OK**

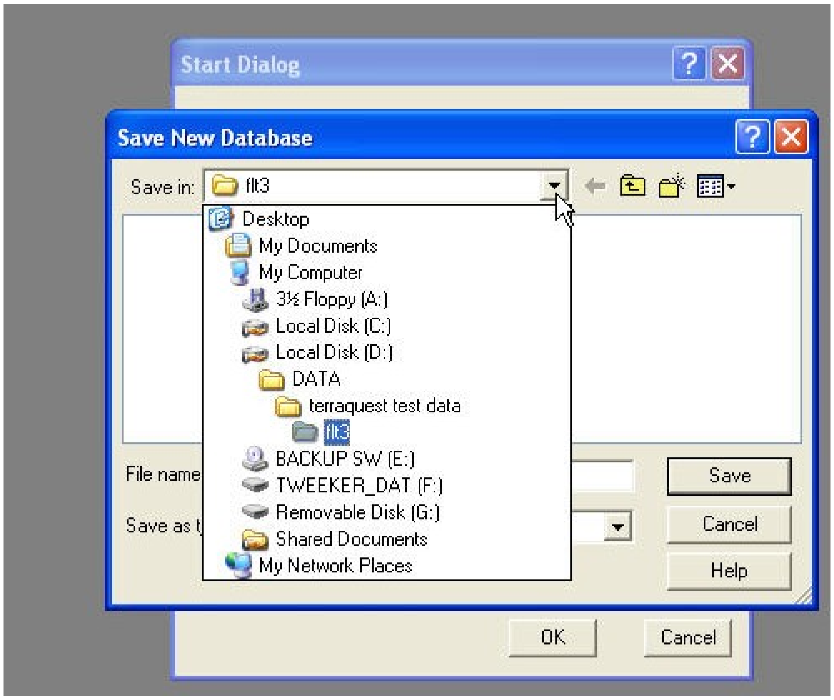


A new window will open as shown below. This window allows the user to create a new database name and store it in the directory of choice. This would usually be the main data processing directory or the directory containing the raw flight data**. It is recommended to place the database in a subdirectory of your processing directory.**

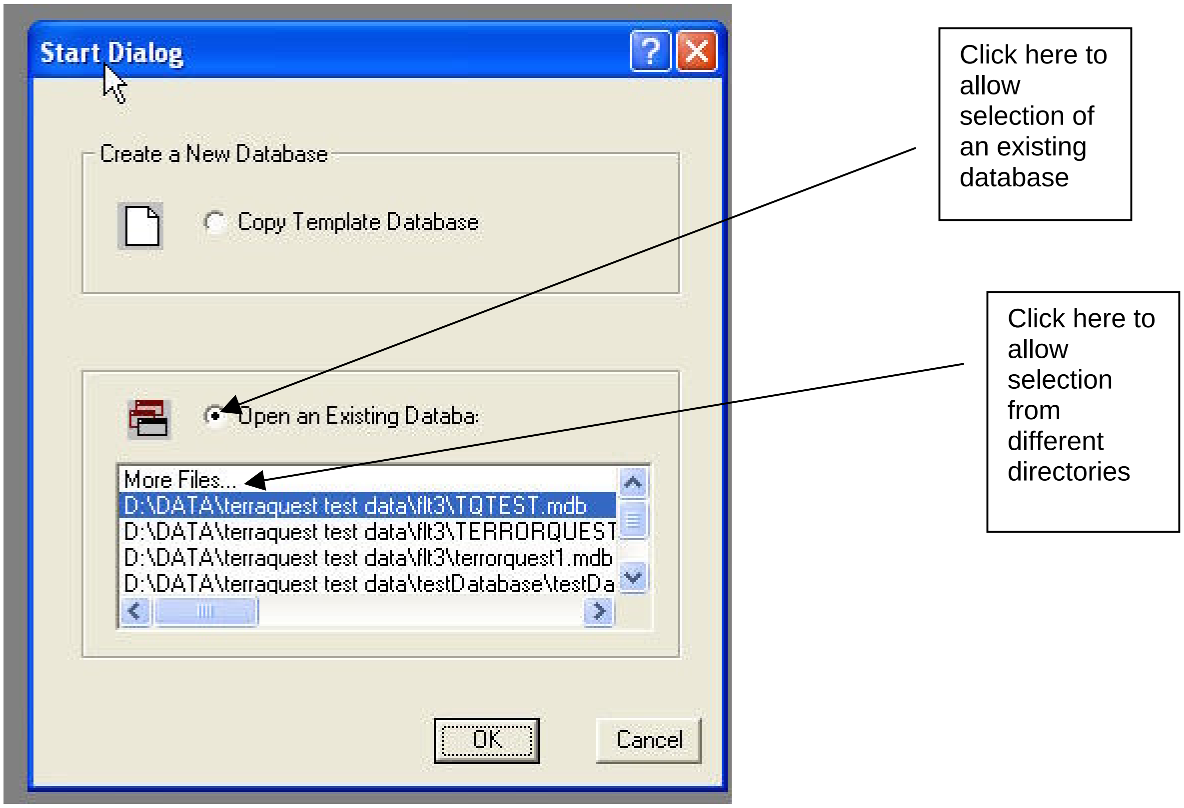


$ (If you need to Browse for the file template Database file: NewDatabase.mdb you will find it in c:\emigma\emigmav7.8\bin

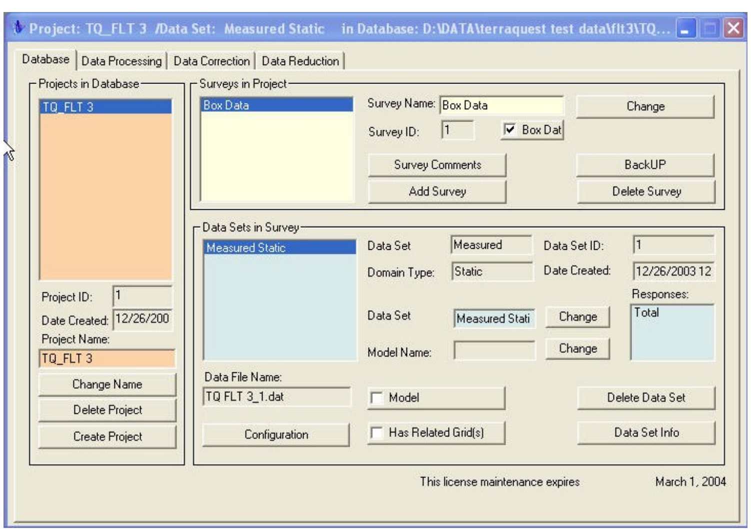
$ **Save New Database -** Browse for the path to save your new database file and give it a name.mdb as shown in the figure below

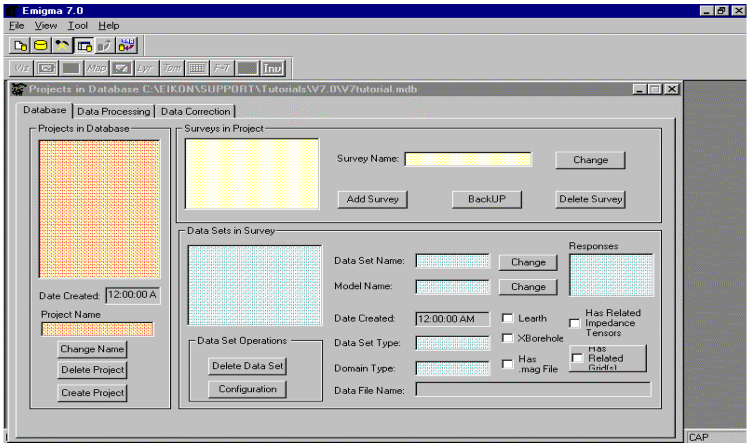


To open an Existing Database - Select **Open an Existing Database** and either chose your database from the list or browse for your data base file by selecting **More Files**….



If the user elects to load an existing database the chosen data base will be loaded and the following screen will appear showing the particulars of the database.





Creation of a new Database

If the user has elected to create a new database from scratch the following screen will appear but will have no information listed in the various information boxes.

Importing Data to the Database

Import Data

Select the Import Data Icon

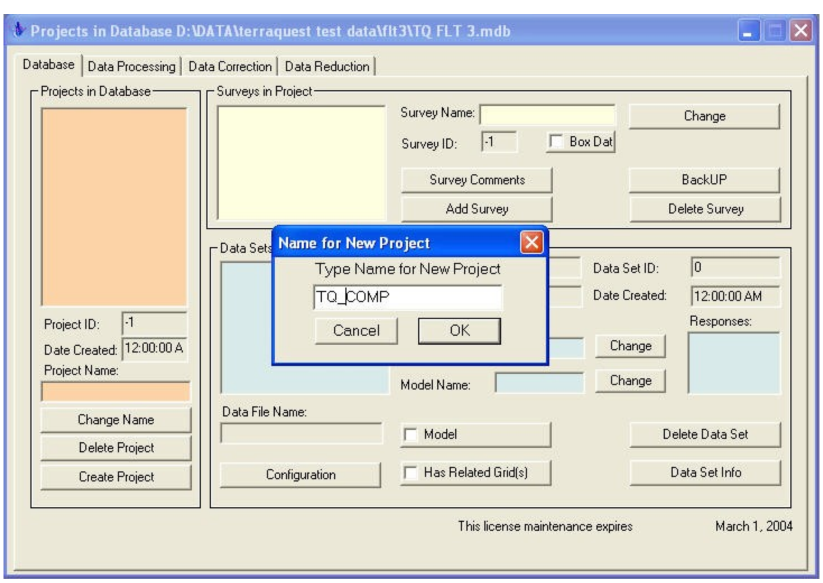
If you are creating a new database within an existing project:

You will be asked if you want to create a new Project.

Select **Yes** if you are starting a new database or a new project within a database. Select **No** if you want to import a data file into a preexisting project.

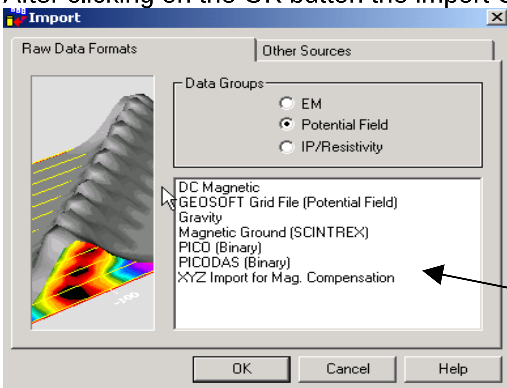
Type in the name of the New project. **OK**

If you are creating an entirely new project and data base the following screen will appear



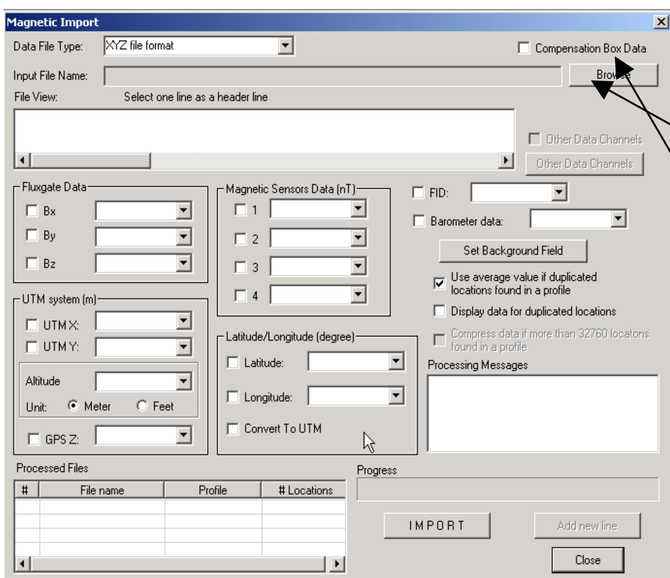
Enter in the name of the new project and click on the OK button. The user should ensure the project name is informative and represents the project at hand.

After clicking on the OK button the import Utilities window will appear as seen below



Use this import application to import compensation box data or survey flight data

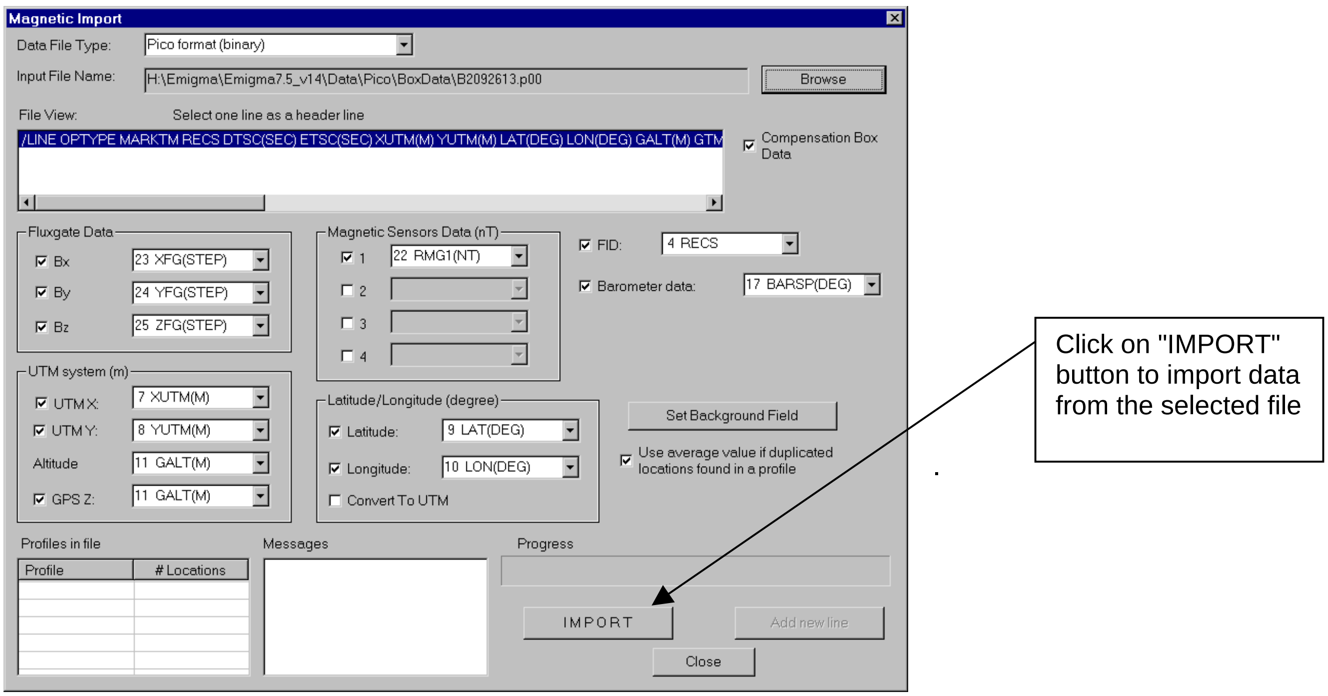
Select either XYZ Import for Mag Compensation, Picodas Bindary or PICO Import from the Import Utilities List by clicking on the desired line.



Click on "Browse" button to select data file you would like to import into the database

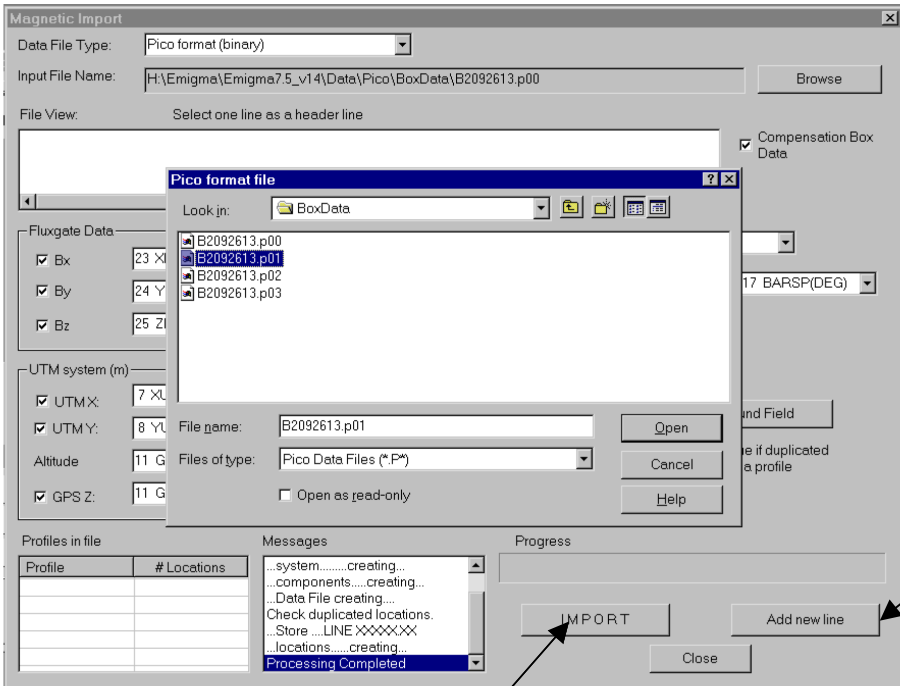
Select data type to be imported

If you import Compensation Box Data make sure that "Compensation Box Data" is checked. To import real magnetic flight data ensure this button does not have a check mark.



It should be noted that the compensation software treats compensation box data as a separate entity / database from actual flight data. If the user wishes to use the calculated coefficients to actually compensate the box data to determine its effectiveness then the data must be imported twice, once as “box data” and again as “flight” data.

Once the desired line to be imported has been selected click on the import button. The data from this line will be entered into the data base. To add additional lines click on the “Add New Line” button, select the appropriate line(s) and press click on the IMPORT button again. Repeat this procedure until all the lines from the compensation box have been entered into the data base

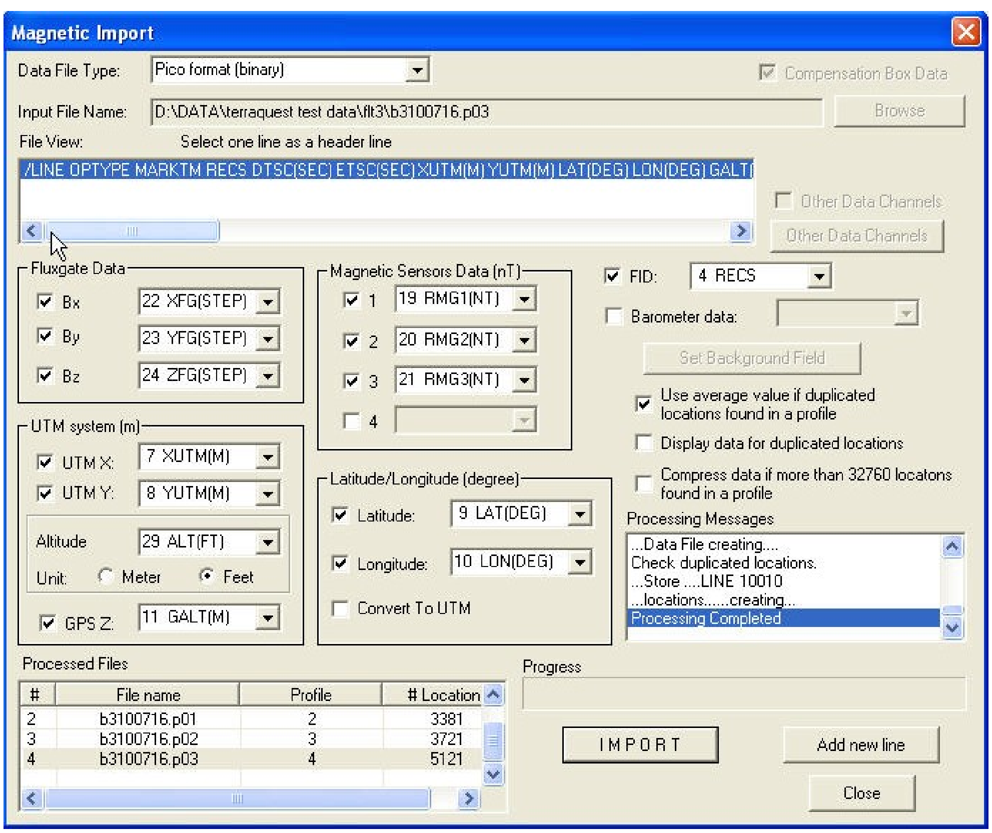


Selecting additional lines to import

Click here to allow selection of additional ..

Click here to import the selected line

Import screen showing the imported lines and the available channels. After all the lines required have been imported click on the close button.



Viewing the Box Data

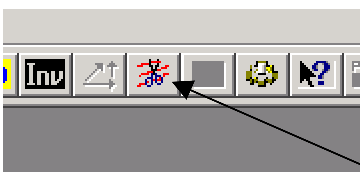
Once the data has been imported into the database it may be viewed in several ways**.** The data can be viewed as analog type graphs or as flight path information. We suggest the data be viewed in both formats to aid in determination of the data's suitability for use in the generation of compensation co-efficients.

From the respect of flight path the user should ensue that the lines for each heading are orthogonal, that the line heading was maintained during each line, and that the headings flown represent the flight line and control line headings for the current survey

The total field magnetic data, fluxgate magnetometer data, as well as barometric altimeter data (if available) should then be displayed in graphical format. This will allow the user to determine the quality of the data. The data may be edited in this mode to remove any unwanted data such as spikes or dropouts, and excess data may be removed. Removing excess data is important. Since the calculation of coefficients is based on the data generated by aircraft maneuvers; the user should take great care to edit the flight data to include only those data sections that represent specific roll, pitch and yaw maneuvers Any extraneous maneuver information such as turns or changes in altitude that are included as part of the compensation calculations will adversely effect the results of the compensation.

VIEWING FLIGHT PATH DATA

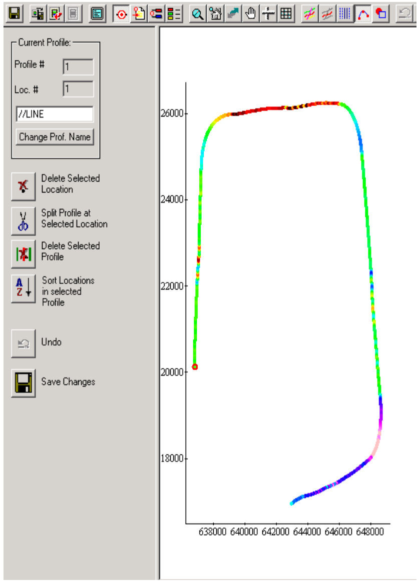
In order to view the flight path data click on the PROFILE MODIFIER icon located on the too bar. (See figure below). This tool can be used to separate headings if the data has been collected in less than 4 files.



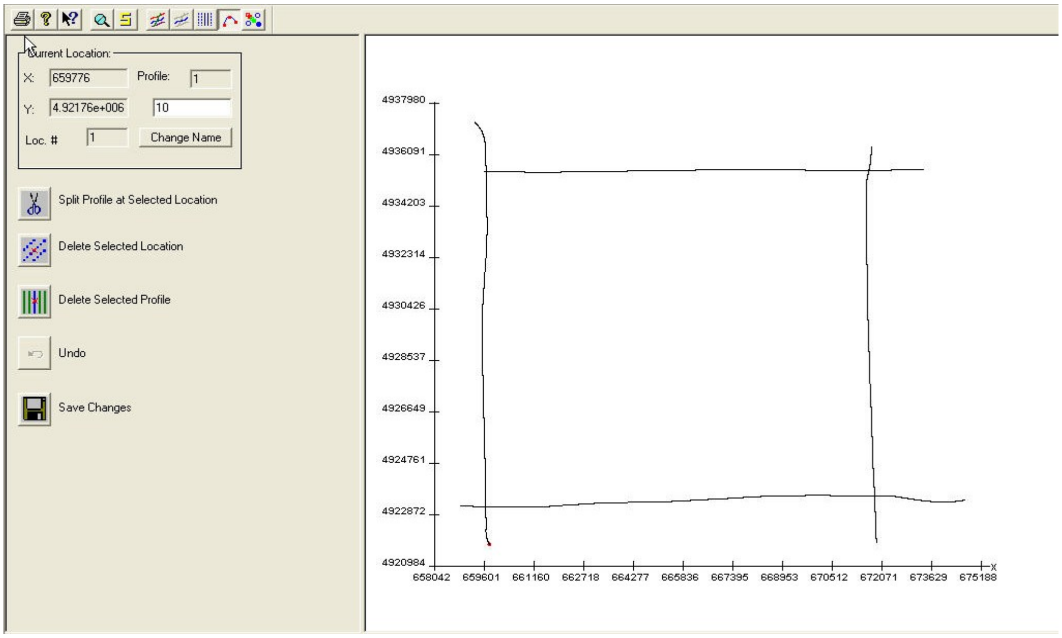
"Survey Editor" (Scissors) may be used to see the flight paths of the box data.

This tool can be used to split the boxlines into separate cardinal directions as well as to clean off superfluous (trim) data positions and portions of the flight such as the flight path into the box.

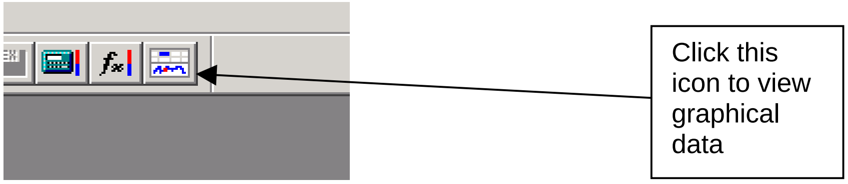
Below are shown two samples of a compensation flight data set. The data shown in the first example would give very poor results in generation of compensation coefficients As can be seen from the displayed flight path the lines flown do not maintain a constant heading throughout their length and are only roughly orthogonal



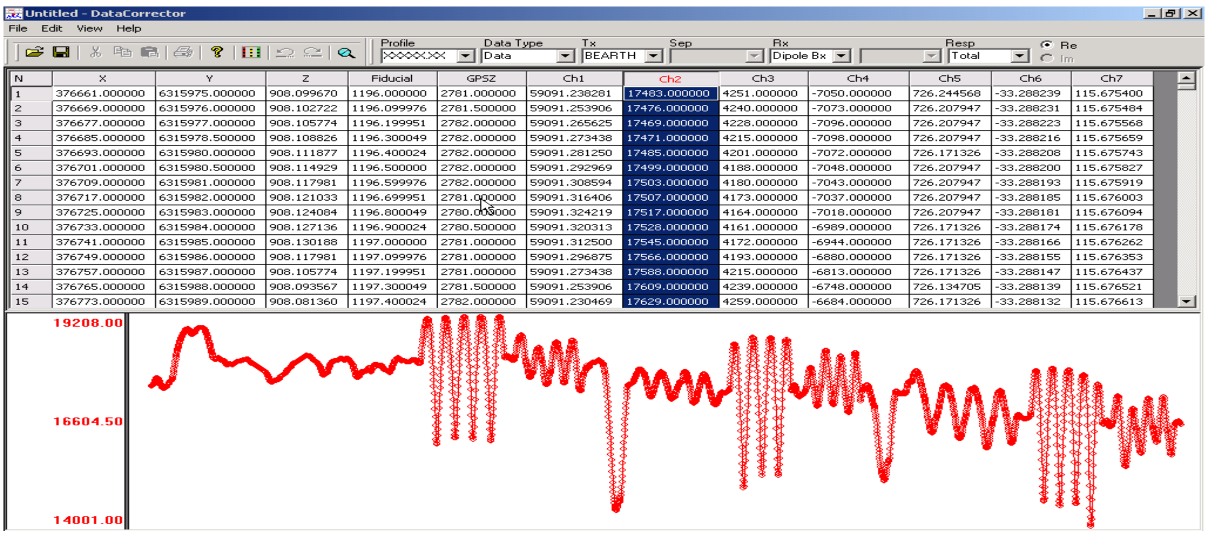
The figure below depicts a much better flight path data set. As can be seen the lines are uniform in direction are very close to orthogonal



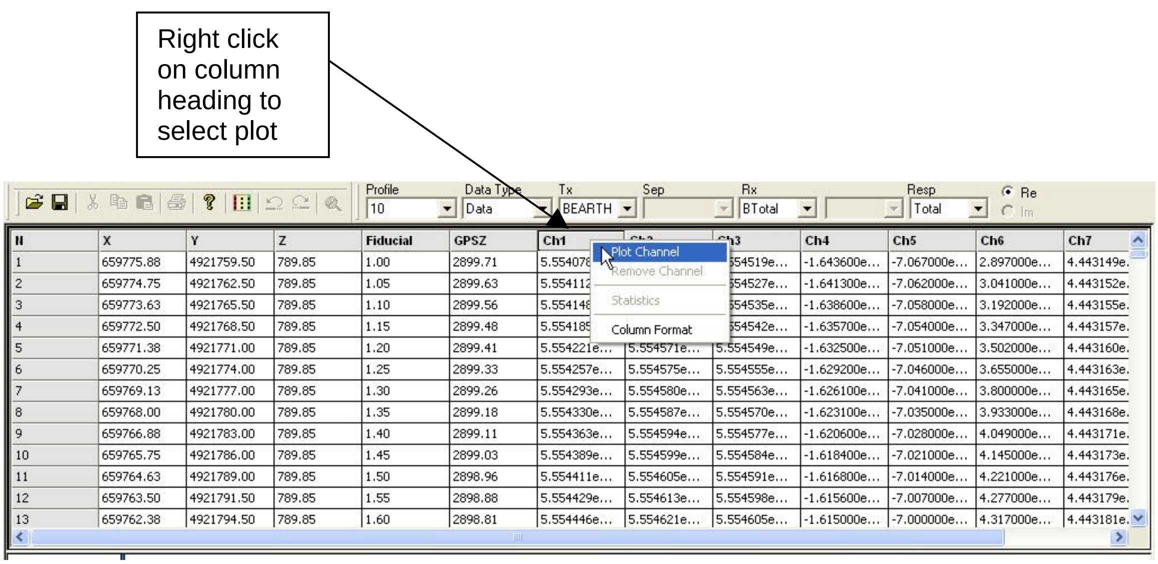
VIEWING GRAPHICAL DATA

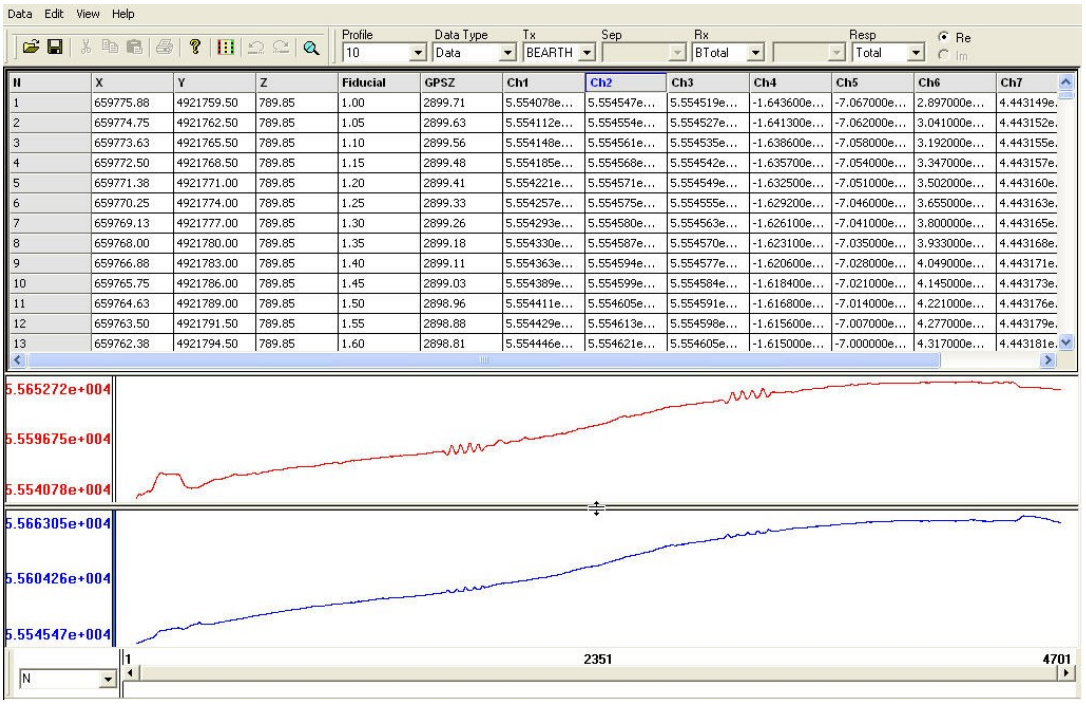


Data Correction" may be used to view the channels of the Box Data including the TMI and the individual fluxgate data as well as the data statistics. Individual or multiple channels may be displayed or edited in single or multiple plot windows.

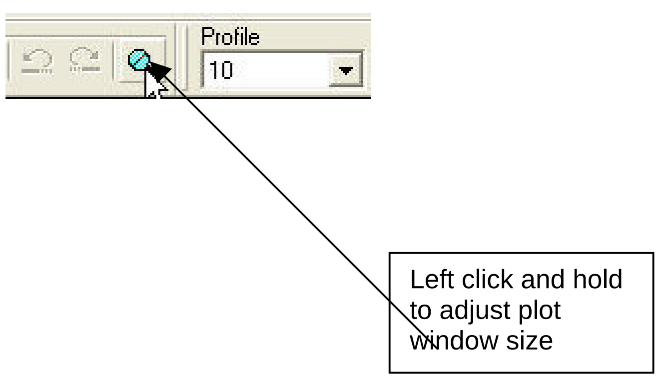


This window allows the user to display single or multiple graphs of the data. The user may delete extraneous data, delete spikes or dropouts and visually confirm data integrity.

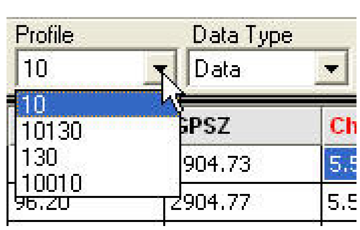




Data can be viewed in more detail by clicking on the zoom icon (shown at left) and selecting the region of interest



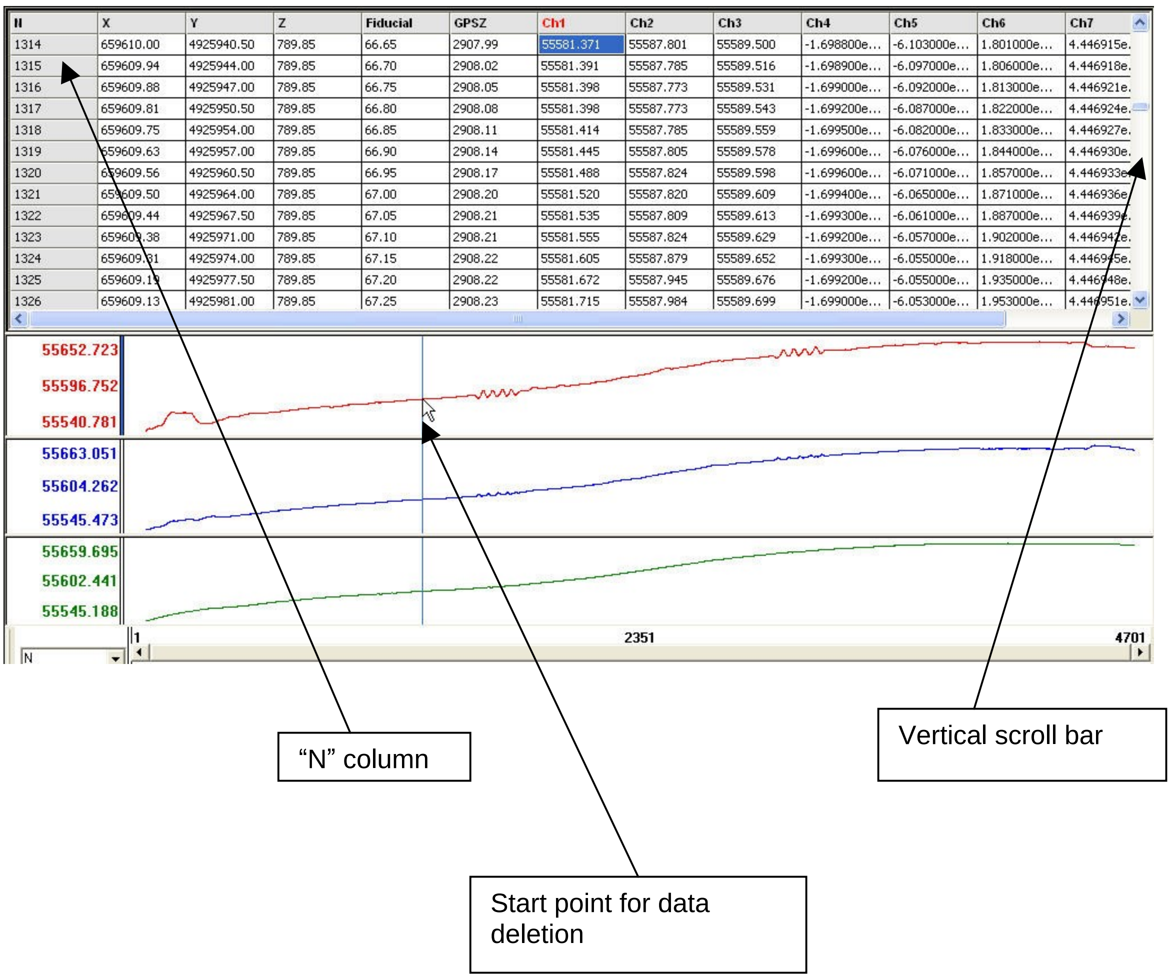
The user may view different lines by clicking on the profile selection box. A drop down window appears displaying the lines currently loaded into the data base. Click on the desired line to display that data set.



EDITING BOX DATA

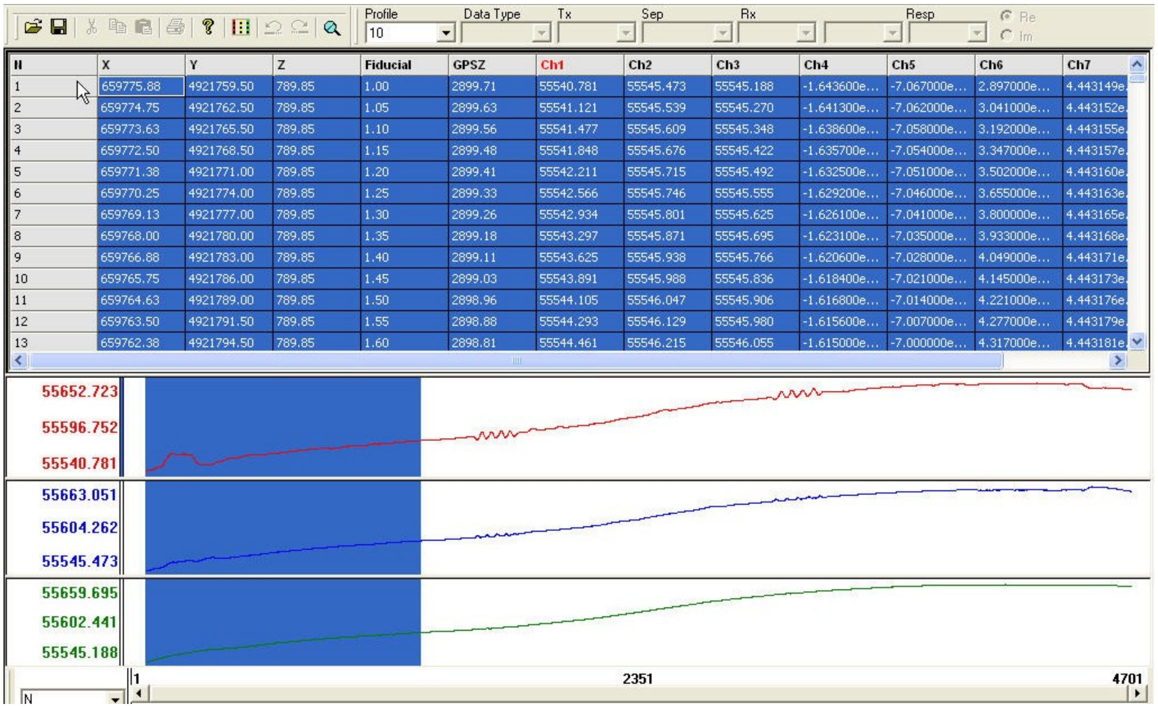
Removing unwanted or superfluous data is a simple procedure involving several steps:

1> Pick a point on the graph where you wish data editing to begin. Click on the profile at this point. A cursor line appears and the corresponding point in the database is highlighted (see figure below)

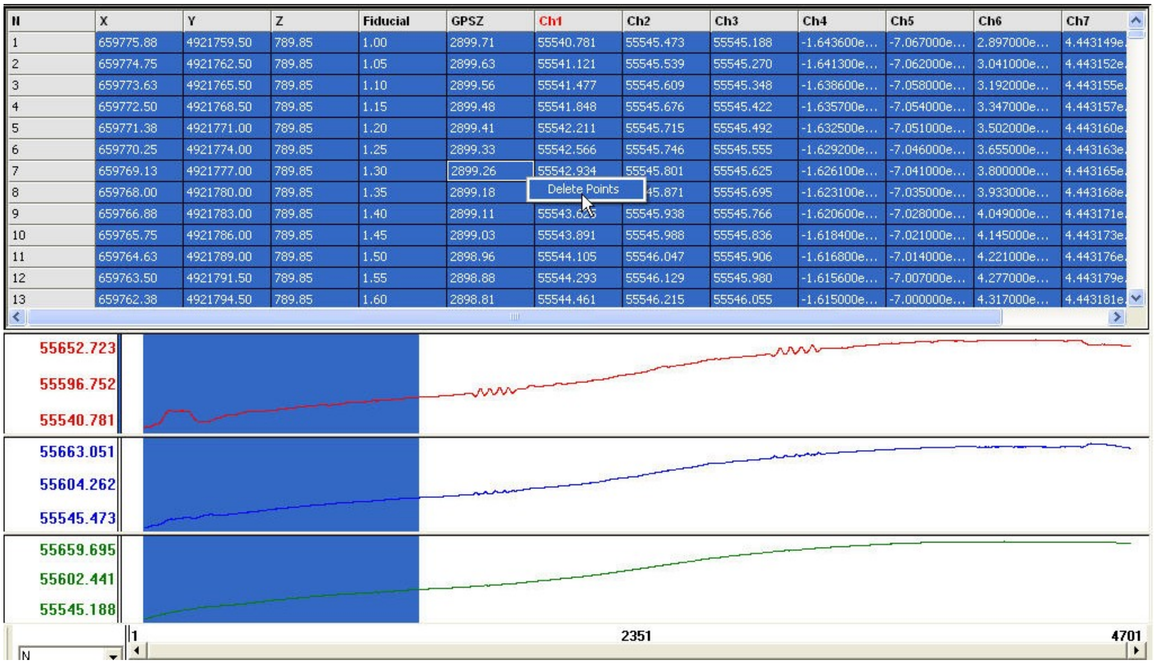


2>Click on the corresponding “N” cell (blue column on the left side of the data base. This defines the start point for the data to be edited / removed. In the example above we wish to remove all the data to the left of our reference point. Using the mouse and the vertical scroll bar on the right of the data base display scroll upwards to the beginning of the data set.

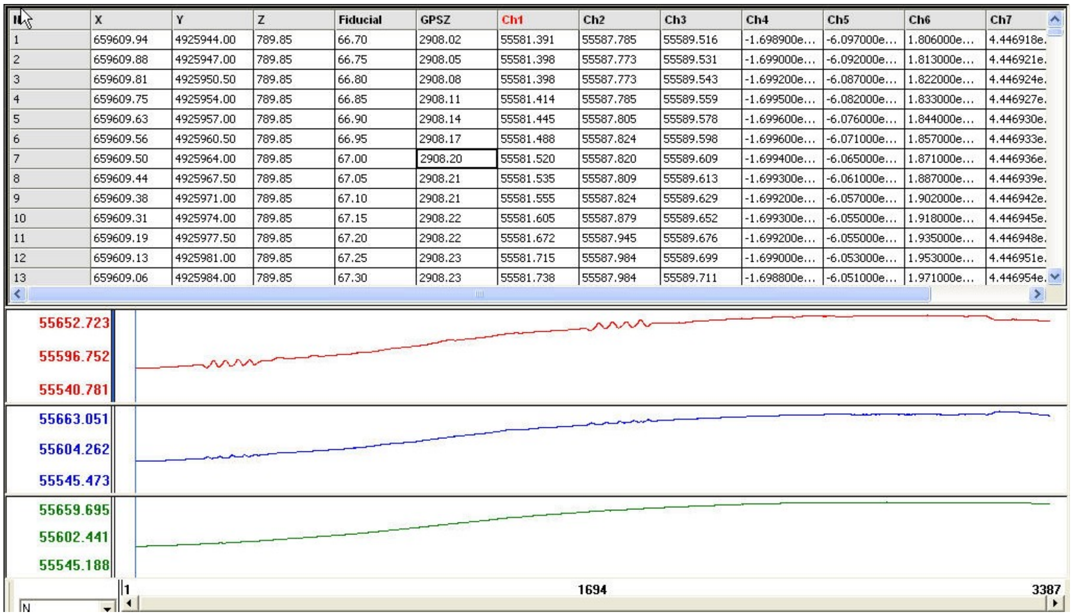
Press and hold the SHIFT key on the keyboard and click on the top “N” cell in the database. The selected range of cells will become highlighted as shown in the next figure. Depending on the size of the region selected for deletion and the speed of the computer used this may take several seconds to accomplish.



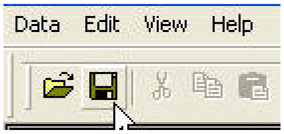
Place the mouse cursor anywhere on the highlighted region and right click the mouse
A delete points button will appear. Place the mouse pointer on the DELETE POINTS button and left click the mouse or press the enter key on the keyboard Refer to the figure below



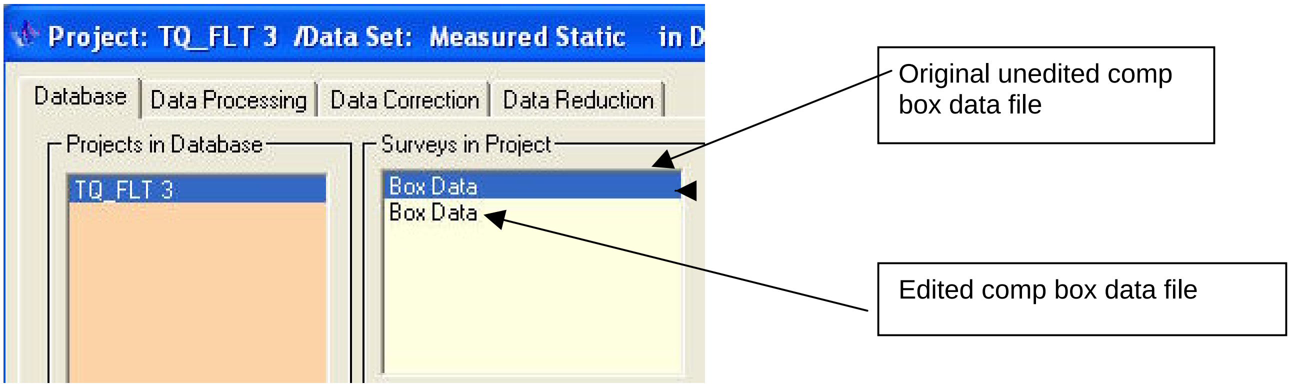
Once the unwanted cells have been deleted the data graphs will be redrawn to show the remaining data as shown below:



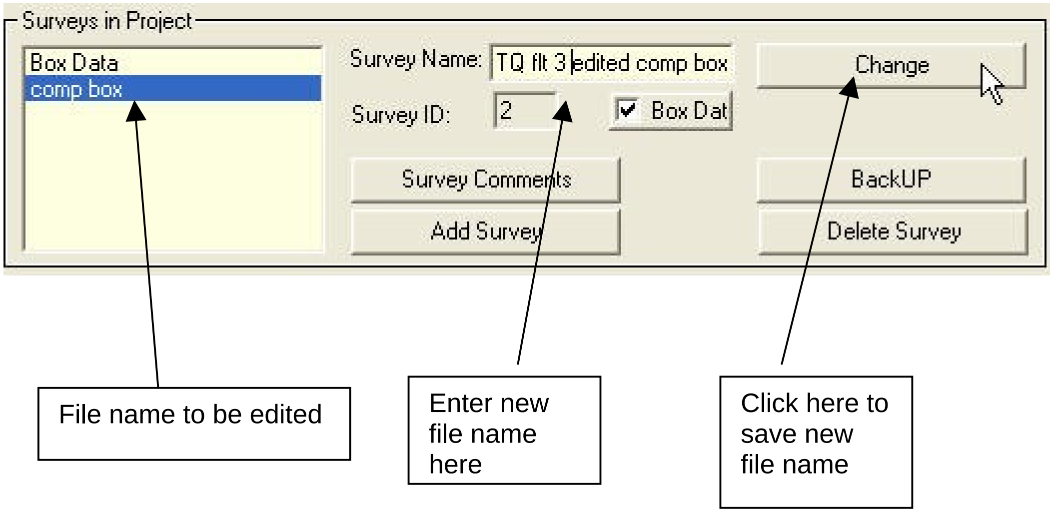
Repeat the process as required for all the lines in the comp box. After the editing process has been completed remember to save the edited data file with a unique file name . This is done by clicking on the save data icon shown below. This will save the edited data and return the user to the main database screen.



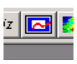
The user will see that there are now two database files with the same name The edited database will be the bottommost file.

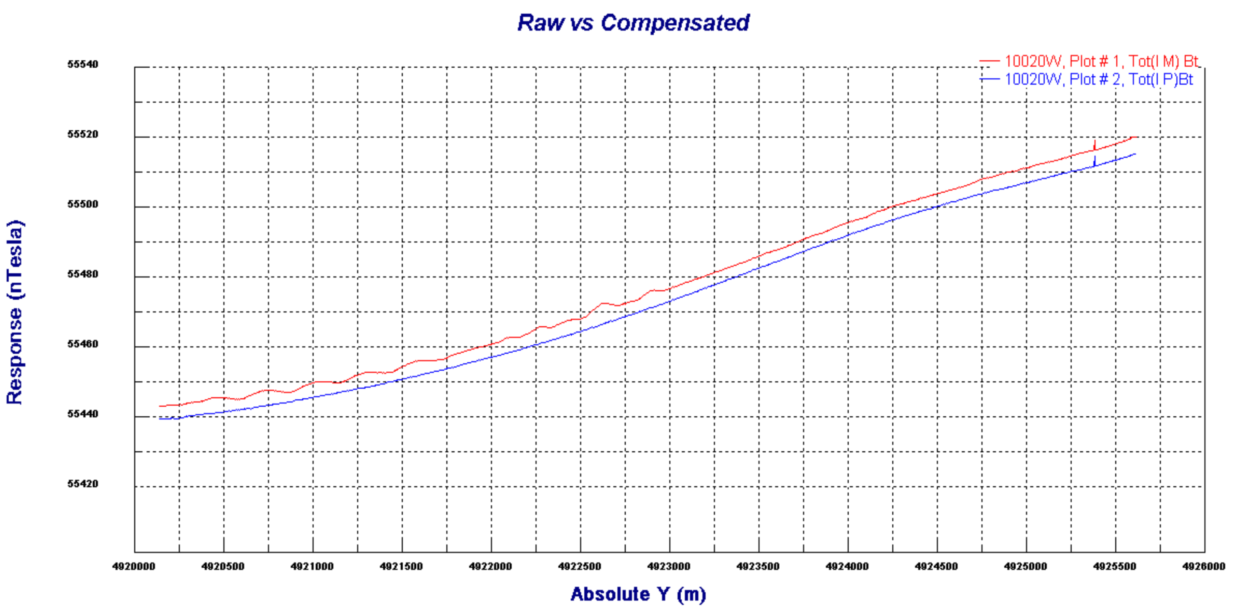


IN order to change the edited comp box file name highlight the file name by placing the mouse cursor over the file name and left click. The current file name will appear in the SURVEY NAME window box. Place the curser in the Survey Name window and left click. Edit the name as required and then left click on the change button. The new name will replace the original.



In addition to the Data Correction tool, there is a useful plotter provided.

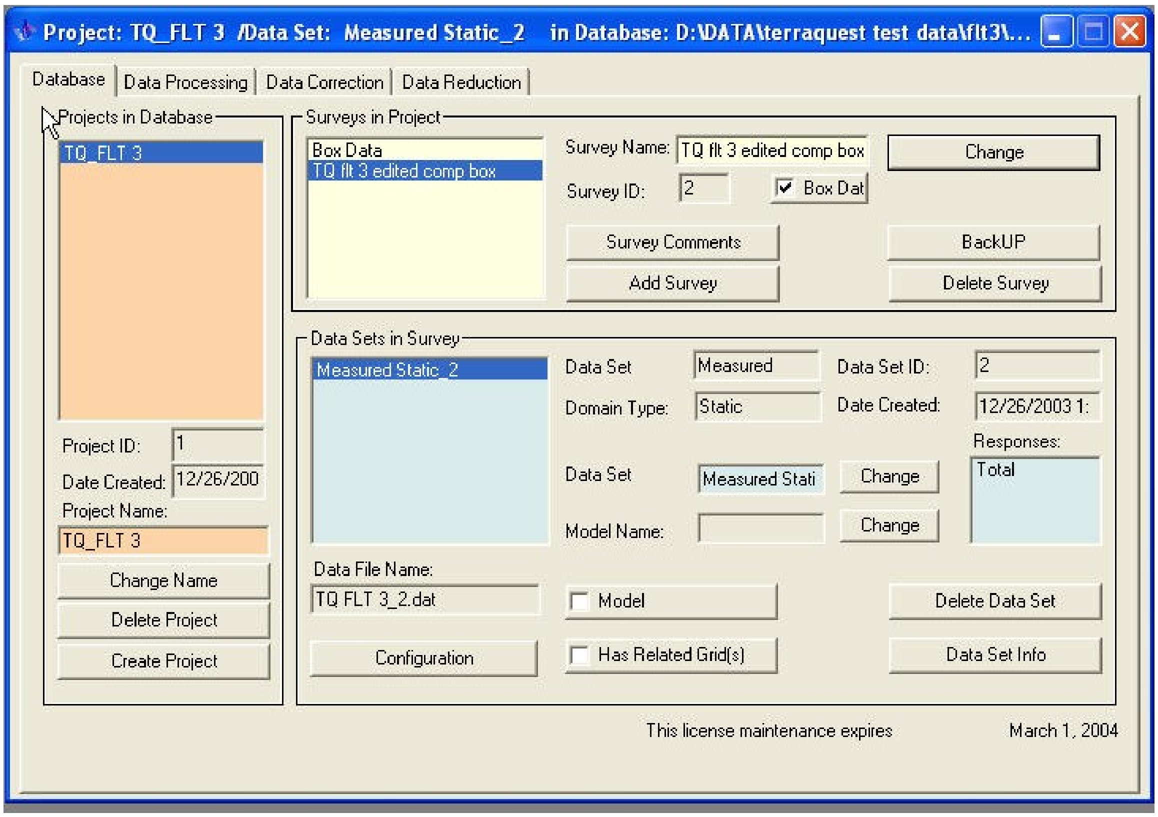


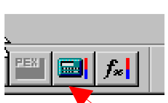


Coefficient Calculation

When your comp box data has been entered into the database and suitably edited; you can launch the coefficient calculation application

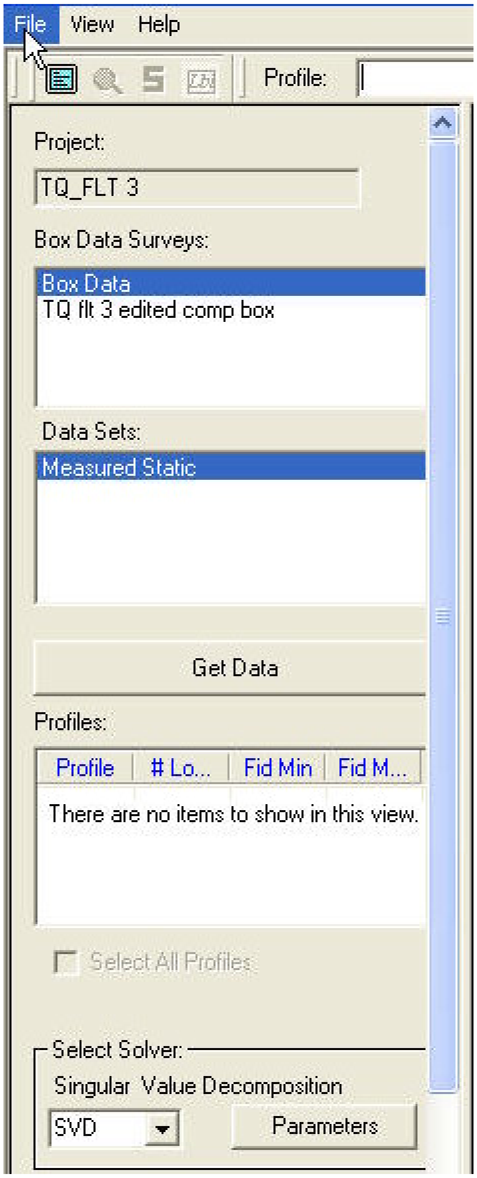
From the main project screen select the PROJECT with edited Comp Box Survey Data; click the button "Compensation Coefficient Calculation" from the toolbar (button with calculator image).





Coefficient Calculation

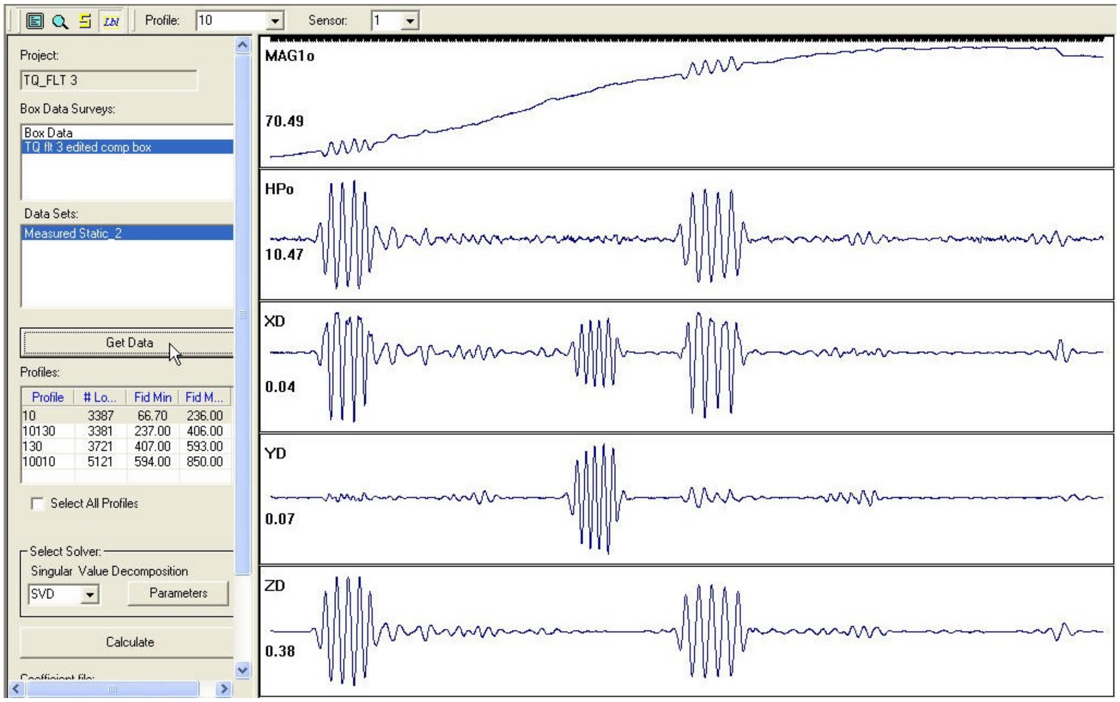
The following screen will appear.



Box Data surveys will appear in the corresponding control list. One project could have several surveys with box data. Select the desired data set (in this example we wish to use the edited comp box data. The mouse cursor would be placed on the desired data set and left clicked.

Once the desired data set has been highlighted, click on "Get Data" button.

The selected data set will be loaded and a series of graphs will be displayed.



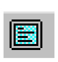
The displayed data includes the following:
1. 5 plots with magnetic data and hi-passed magnetic and flux gate normalized data.
2. List of profiles with range of fiducials.
3. Combo boxed with list of profiles and sensors in the toolbar to choose desired selection for plots.

If the user wishes to change the range of data participated in the coefficients calculation just click on the cell with the fiducial minimum or maximum number. The user will then be allowed to enter a new value. The program will then read in the required data over the newly defined fiducial range

Use buttons:

 To zoom the data area on any plot. Minimum and maximum of fiducial will be changed automatically regarding to selection.

 To view data in initial fiducial range.

 To view plots in full screen mode.

In figure above, the top trace, MAG1o, is the original MAG, auto scaled to show the dynamic range over the selected range of fiducials. Effectively the background level has been removed.

The second trace, HPo, is the high passed version on MAGo. This is used to remove the effect of long wavelength geological and diurnal anomalies on the data. If barometric correction has been selected this will also be corrected for the selected vertical magnetic gradient.

The third, fourth and fifth traces contain the auto scaled X, Y and Z direction cosines with the background removed. The direction cosines are the coupling between the fluxgate axis and the magnetic field vector. Different responses can be seen for the different axes for the pitch, roll and yaw motions. These also vary with heading.

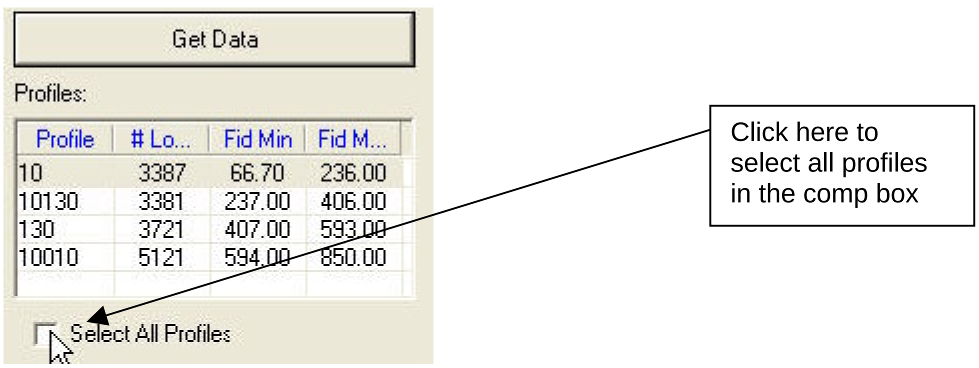
The interference effects on the mag and fluxgate traces are the summation of the uni-polar and bipolar responses, in and out of phase with the motion. They are dependent on a heading, through the coupling with the magnetic field, the type of motion and the individual magnitudes of the interference components.

The user should use these traces to ensure that the data set is valid. Any spikes should removed if present. A reasonably constant heading from the fluxgate should be seen. There should be no obvious ground interference. There should be no areas where the magnetometer sensor data appears to have dropped out or the motion appears too extreme.

Ideally the data should have been gathered around 8000 feet above ground away from ground effect and in an area of long wavelength magnetic change. The ability to accomplish this will depend on the type of aircraft used and the ground elevation above sea level in the survey area. If a non-turbo charged piston engine powered aircraft is used and the ground elevation is already more than six or seven thousand feet above sea level it may not be possible to achieve the desired height above ground. In such case the maximum achievable altitude should be used and effort should be expended to locate an area where the magnetic gradient is minimal and magnetic objects on the ground are minimal.

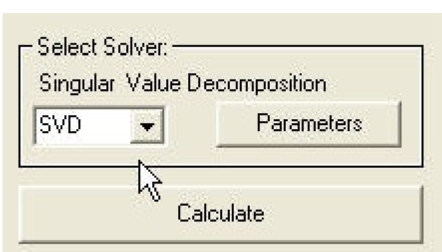
The residual magnetic data should contain only frequencies associated with the motion. If any other longer wavelength anomalies or ringing at the ends of the trace are visible in the high passed mag, HPo then a different fiducial selection should be tried to see if it disappears. This may be necessary if the geological effects were strong or the data set too long or too short.

Before you click on "Calculate" button make sure you have selected profiles you wish to calculate coefficients for.



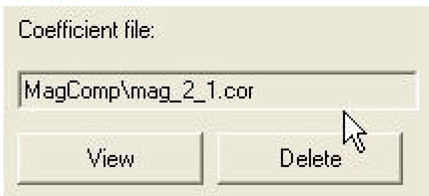
The user may calculate coefficients for each individual line or he can select all profiles. This will generate a coefficient set that is valid for all directions in the survey

SELECT SOLVER



The software provides several methodologies for calculating the co-efficients. Because there are many combinations of variables and conditions under which data may be collected a single solver may not always produce the best results. The default solver (SVD) usually gives the best results in most conditions. In the event that the desired level of compensation is not achieved the user may elect to recalculate the compensation coefficients using one of the other provided solvers. After selecting the desired solver click on the calculation button. The user should experiment with the number of terms (through "Parameters") to find the best results. By testing the compensation with box data, this allows for the best results when correcting the actual survey data.

The length of time required to calculate the coefficients will vary depending on the solver selected, the length of the lines in the compensation data file and the speed of your computer. When calculations are complete the following window will appear. Click on OK



When calculation of the coefficients is finished you can see the coefficient file name in the special control. You can view this file by clicking on button "View" or delete it by "Delete" button if you do not like the results.

The software will create a subdirectory called MAGCOMP (if it doesn't already exist) in the directory used to process the data. It will be given a unique file name. This allows different sets of parameters to be used and tried without overwriting previous results.

THE USER SHOULD KEEP CAREFUL NOTES AS TO THE FILE NAMES GIVEN TO DIFFERENT SETS OF COEFFICIENTS

.

EXAMPLE OF TYPICAL SET OF COEFFICIENTS FOR NORTH HEADING

_7020.0N 0 Sensors 2 Ang 359
30

50167.310011249967000	50180.191013749980000	M_AV	1
0.901068421430980	0.901068421430980	X_AV	2
-0.401071537591340	-0.401071537591340	Y_AV	3
0.146134477313536	0.146134477313536	Z_AV	4
0.000000000000000	0.000000000000000	CONO	5
-6.210427040762355	-8.386201421230732	XS	6
-2.659618427906260	-4.713554467773923	YS	7
-14.554975284857377	-6.116321934625224	ZS	8
0.000000000000000	0.000000000000000	X2	9
0.000107032104440	0.000074005136053	XY	10
0.000096677474941	0.000058658344039	XZ	11
-0.000075504881691	0.000060281667377	YZ	12
0.000110040961133	0.000029927459216	Z2	13
0.000202047555711	0.000293907080544	Y2	14
0.000000000000000	0.000000000000000	DXX	15
0.000245336329606	0.000014017613258	DXY	16
-0.000170890976665	-0.000019691175589	DXZ	17
0.000216231672625	0.000244881930981	DYX	21
-0.000086717760520	-0.000100416026859	DYY	19
0.000027911376371	0.000035755524798	DYZ	20

-0.000152631848576	-0.000099043569107	DZX	21
0.000057307901985	0.000042494894827	DZY	22
0.000624456693965	0.000121012690309	DZZ	23
0.000000000000000	0.000000000000000	BARO	24
7540.337552083333300	7540.337552083333300	A4_AV	25
0.000000000000000	0.000000000000000	OFFSET	26
3044.377387115921900	3044.377387115921900	TOT_AV	27
0.000000000000000	0.000000000000000	X_DIF	28
0.000000000000000	0.000000000000000	Y_DIF	29
0.000000000000000	0.000000000000000	Z_DIF	30

Coefficients for all sensors and all selected profiles are stored in one file.
These coefficients can now be used by the real-time data acquisition program and any desired post-processing. Real-time compensation can be carried out on total field at 10 Hz sampling, with the recording of all raw and corrected data. Post-processing compensation runs much faster than real-time data collection.

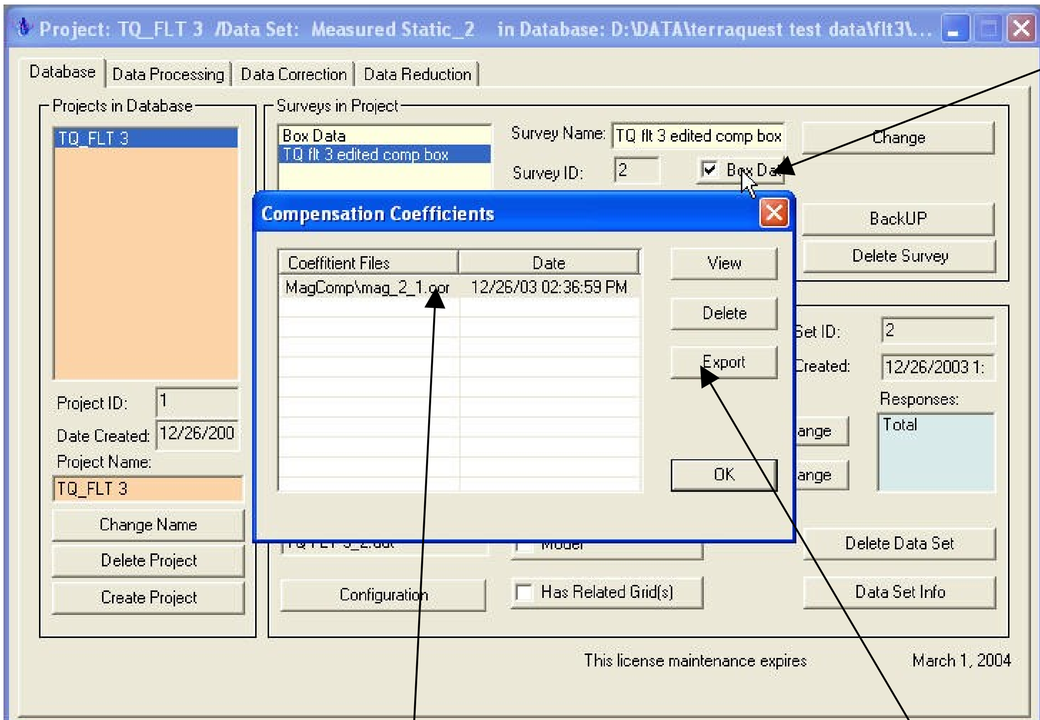
Note 1: For users wishing real-time corrections during data acquisition, please contact PetrosEikon.

Note 2: The correction of the flight data may now be done in either EMIGMA or QCTool. We suggest QCTool as QCTool is more versatile for merging, filtering, removing outliers, etc. Both QCTool and EMIGMA will request the user to select the coefficient file for correction of the actual survey data.

EXPORTING COEFFICIENT FILES FOR USE IN AGIS REAL TIME COMPENSATION

In order to be used in the AGIS real time compensation software the coefficient file must be exported from EMIGMA. The process for this is as follows:

From the main screen as shown below , double click on the compbox button



Double click on box data button to open list of coefficient files

Highlight desired coefficient file for export

Click here to export file to desired directory

A window opens up displaying the existing coefficient files that have been created using this data set. Select the desired file by highlighting it and click on the export button. A directory window opens to allow the file to be exported to the directory of choice.

EXPORTING COEFFICIENT FILES FOR USE IN QCTool COMPENSATION

The coefficient file may then simply be copied to the required computer where the QCTool compensation will be carried out. For example, the coefficient calculation may be carried out with someone experienced at head office and sent to the field for correction by a field technician in Qctool.

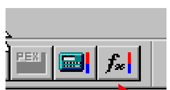
For compensation in Qctool skip to Page 45.

POST FLIGHT PROCESSING USE OF COEFFICIENTS in EMIGMA

It is most often desirable to test the coefficients on the data prior to commencing survey data acquisition, or to post process already acquired data in the event some problems are observed with the real time compensation**.**

This can be accomplished within the EMIGMA software package. It is important to remember that EMIGMA treats compensation data and flight data as two separate entities. If the user desires to test the calculated compensation coefficients on the data set used to create the coefficients that data must be imported into the data base twice once as “box data” and once again as “flight data”

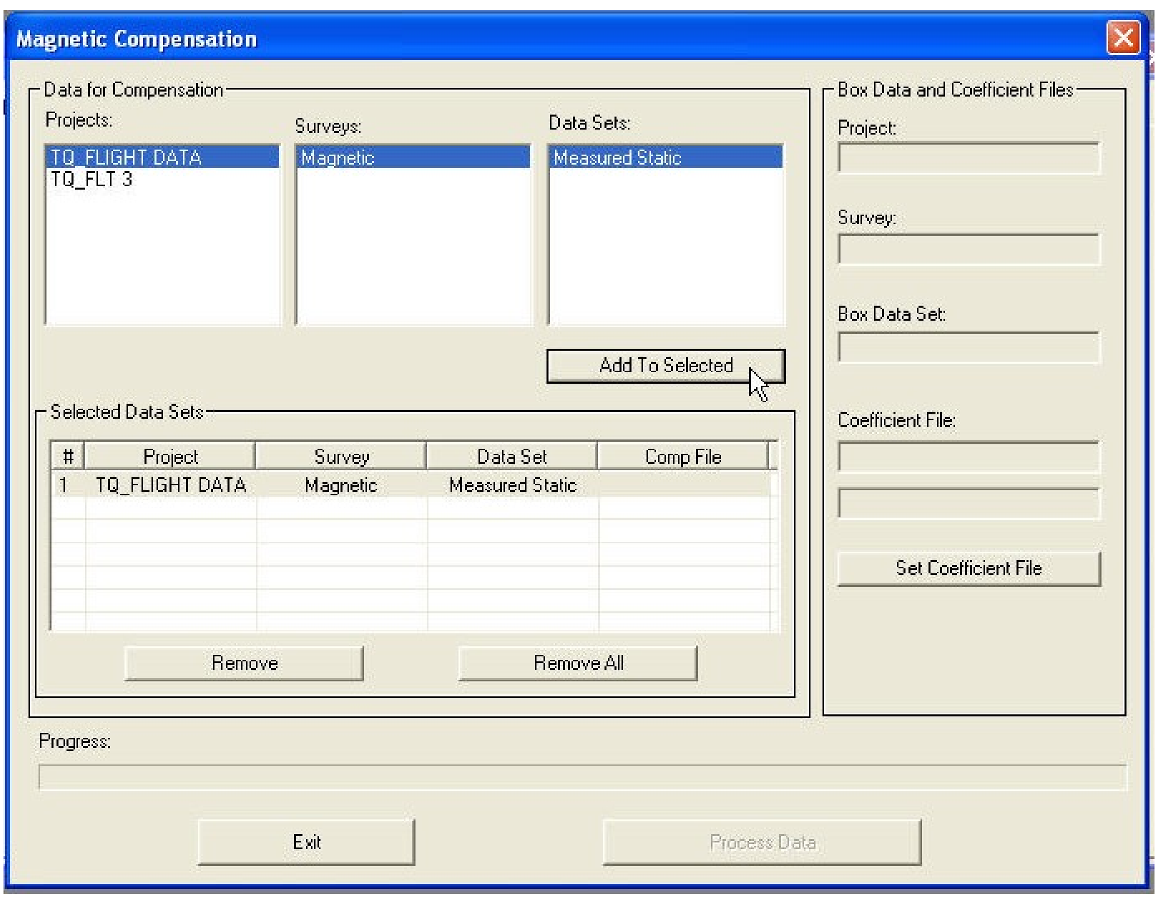
Once the data has been imported as flight data, and coefficients have been calculated the user can commence processing the flight data using the compensation coefficients.



Magnetic
Compensation

From the main screen select the desired project and click on "Magnetic Compensation" button with *fx* image on it.

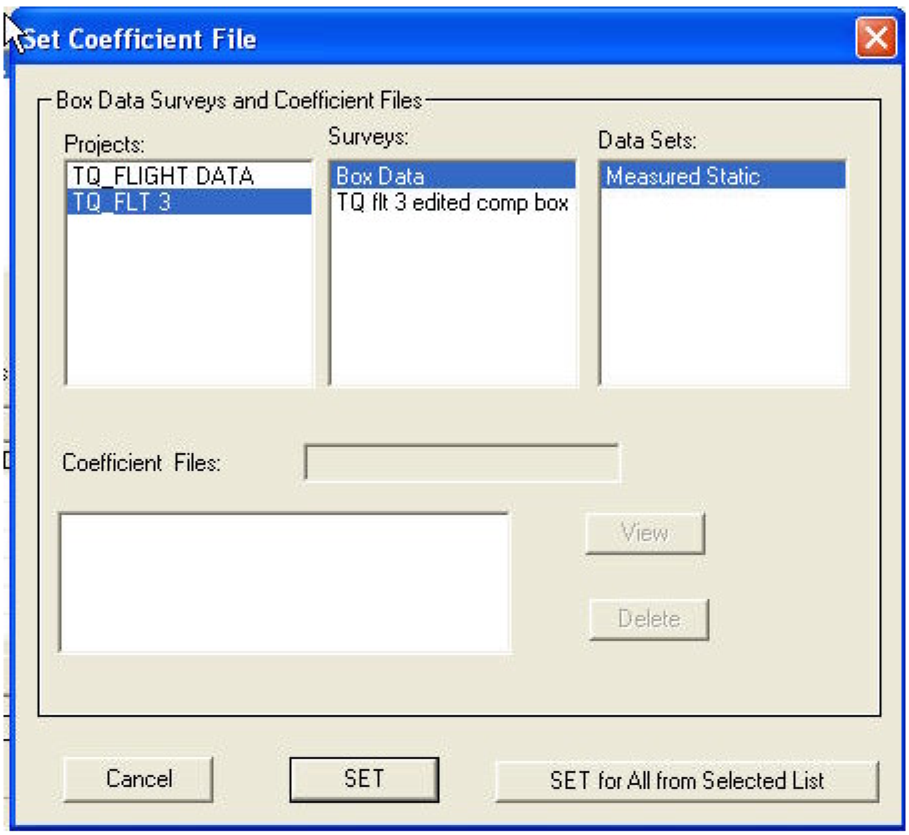
The window shown below will open. Highlight the appropriate data file to be compensated and click on the ADD TO SELECTED button. The data file will be loaded into the selected data sets window. If there is more than one file to be processed repeat the highlight and ADD functions until all desired files are loaded.



All surveys with box data have a special parameter in the database that allows distinguishing them from surveys with real data and filling all survey lists in the window automatically. If your current project has the Box Data Set with the attached calculated coefficient file, this file will appear in the “Box Data and Coefficient Files” pane. Current version of application allows compensating several data sets in one time. You can navigate through the Projects, Surveys and Data Sets lists. Click on the desired data set and press the “Add To Selected” button. The selected data set will be copied to the “Selected Data Sets” pane, coefficient file form the “Box Data and Coefficient Files” pane will be applied to chosen magnetic data.

You can remove some or all data sets from the “Selected Data Sets” list by highlighting the desired data set and clicking on the REMOVE button

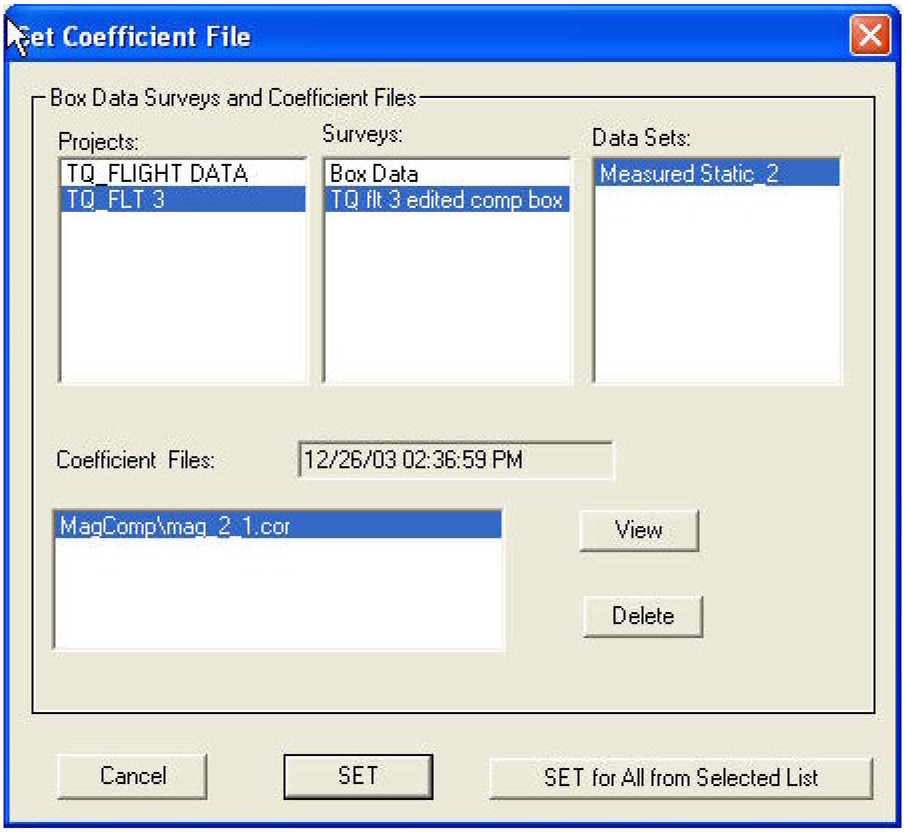
To select the coefficient file to be used in the compensation process click on the “Set Coefficient File” button. The dialog “Set Coefficient File” will appear.



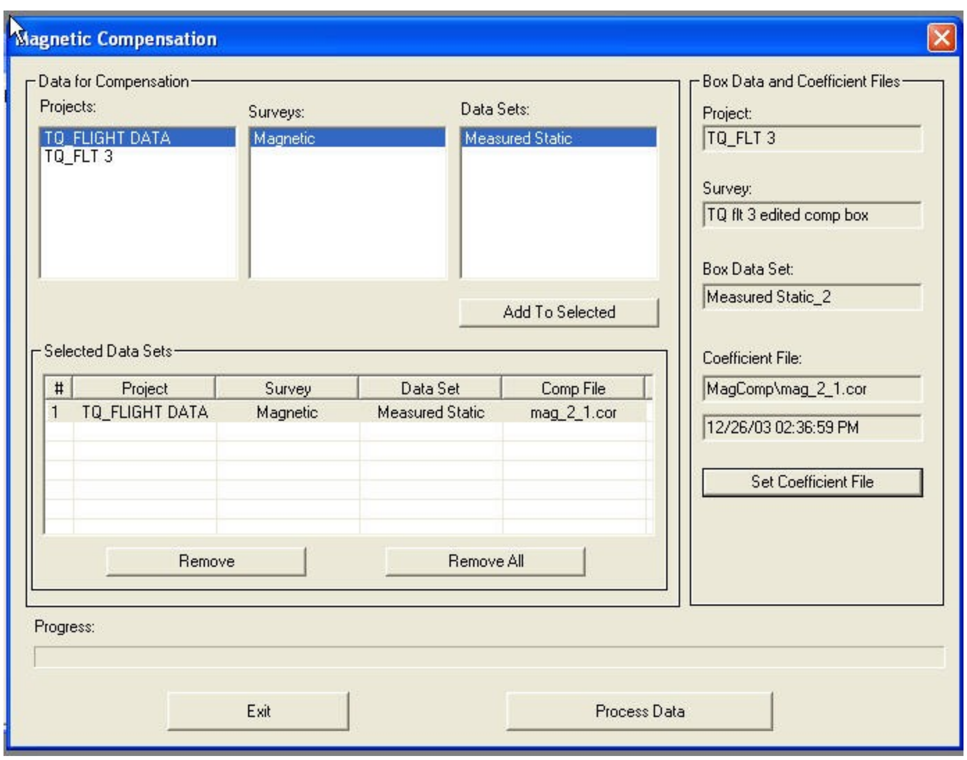
Highlight the and left click the appropriate project that contains the compensation coefficient data. The related data bases information for the highlighted project will appear in the Surveys window.

Click on the desired survey data set (in our example this would be:

TQ flt 3 edited comp box
AS seen below this will locate and display the available compensation coefficient files from this data set. If there is more than one coefficient file available, highlight the file to be used and click the set button



After clicking on the SET button the compensation window returns . It now shows all the information required to process the data set. To start the data compensation click on the PROCESS DATA button.



AS soon as the data processing sequence has been completed the

Information box will appear. Click on the OK button and EXIT button. This returns the user to the main screen. Processed data set(s) will be stored in the same Survey where you choose the data set(s) for magnetic compensation.

Now that the data set has been compensated it is possible to display both the compensated and uncompensated data together as graphical data for comparison in the DBPlotter application.

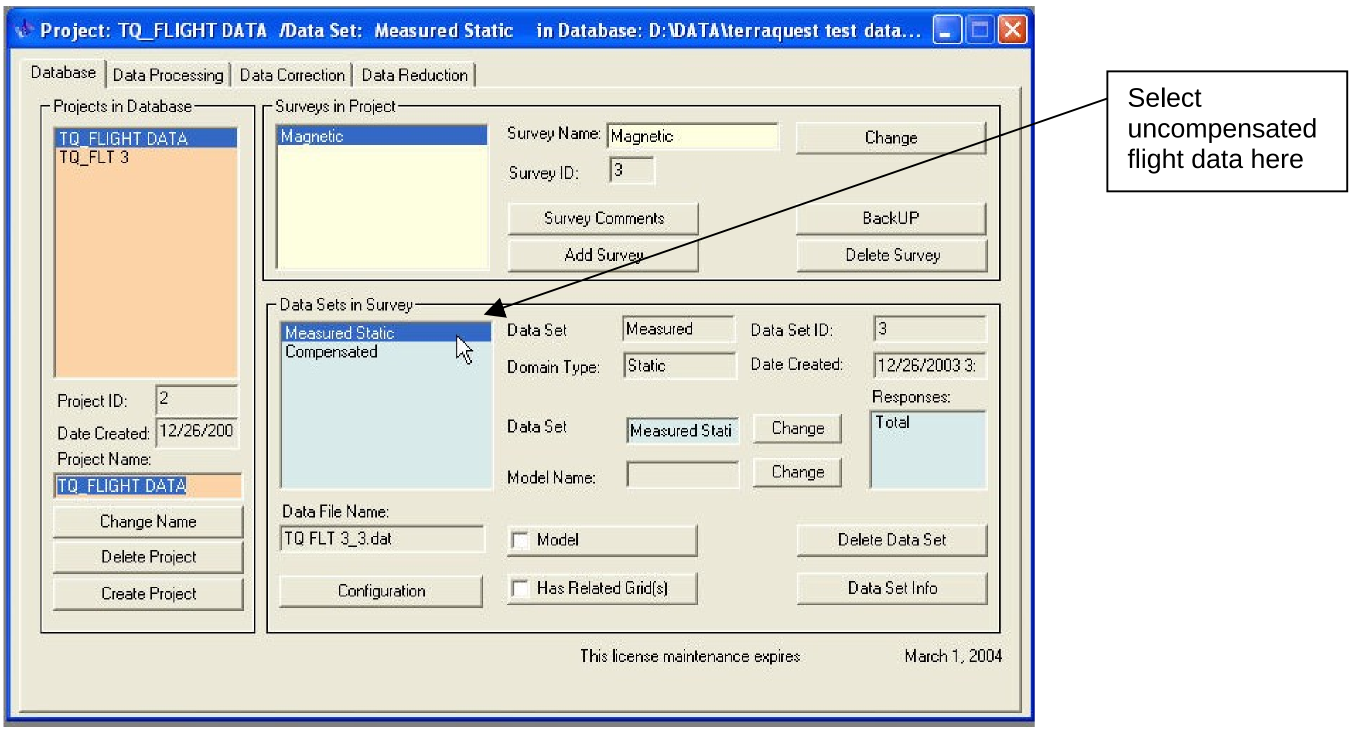
DBPlotter Application

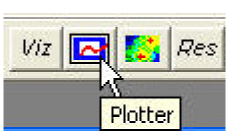
After the data has been compensated it is often desirable to plot the data as analog type graphs. This allows the user to compare the effectiveness of the compensation coefficients on the data set with the original unprocessed data.

EMIGMA 7.7 provides a comprehensive suite of software for viewing, plotting , and gridding the data. This section provides a very basic set of instructions for viewing the data sets. For a complete description of the facilities provided in EMIGMA please refer to the EMIGMA users manual

VIEWING DATA

From the main screen (as shown below) select “measured static” data from the “Data Sets in Survey window.

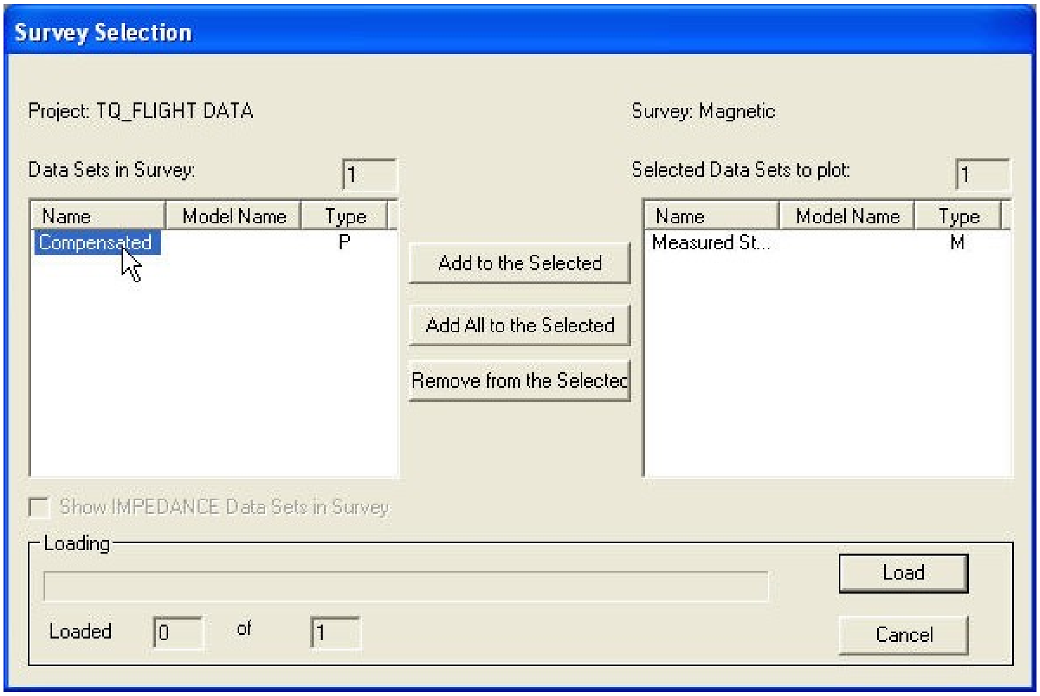




After Select ion of the original data set from the project, click on the Plotter button to compare original and compensated data. A window will open asking if the user wishes to compare other data sets

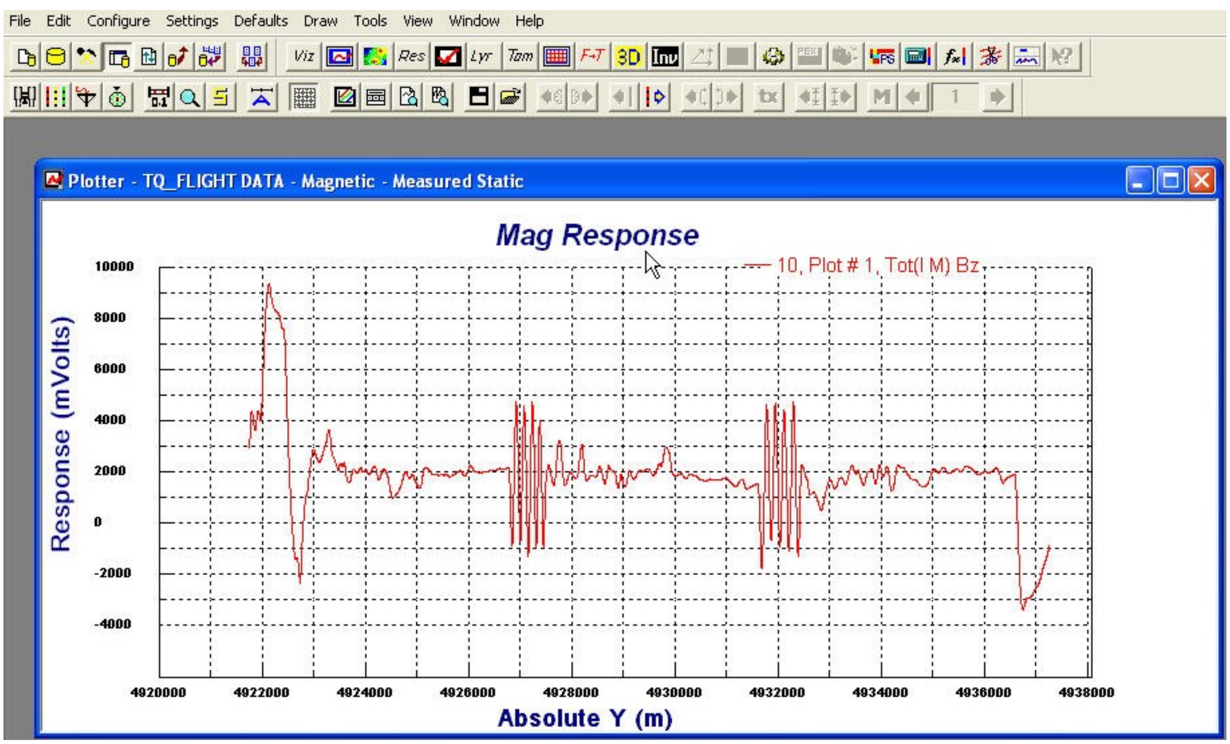
Answer "Yes" to "Do you want to compare with other Data Sets?" question.

From the survey selection window that opens highlight the COMPENSATED data set

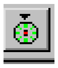


Click on "Add All to the Selected" and "Load" buttons to load original and compensated data. The selected data sets will be loaded and a new window will open displaying a plot of the original magnetic data of the first available sensor in nTesla

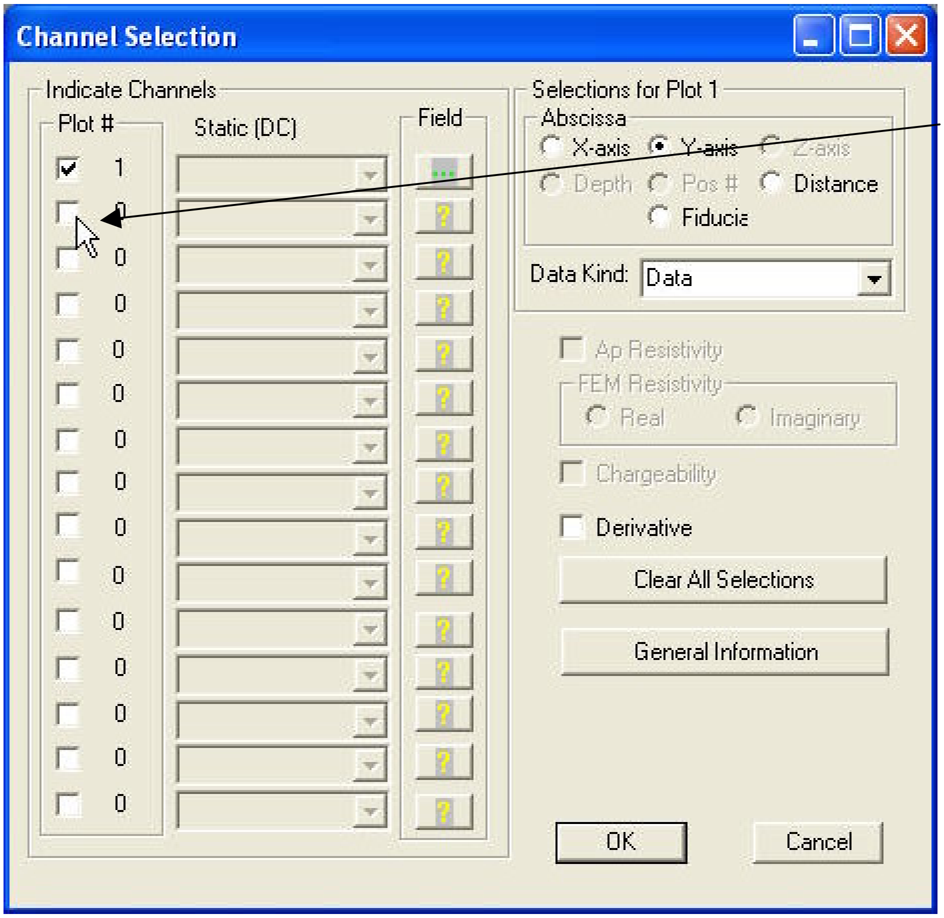
An additional toolbar will also be added to the top of the screen this allows the user to zoom, scale, add and remove channels etc. For complete details on all the functions provided please refer to the EMIGMA users manual



ADDING / CHANGING VIEWED CHANNELS



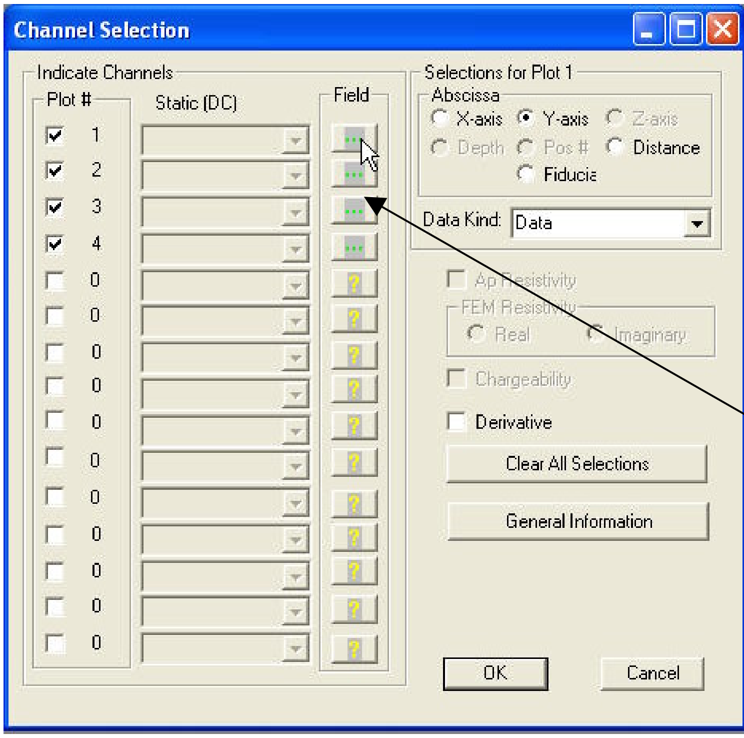
Click on "Channels" button in the toolbar. The dialog "Channel Selection" will appear` as shown below:



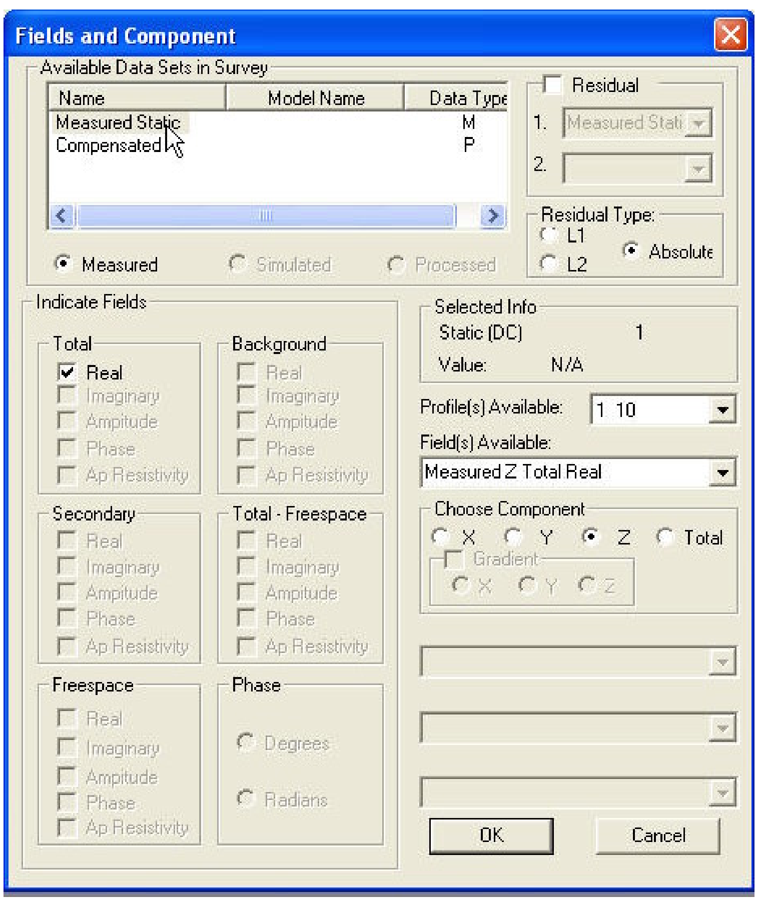
Place a checkmark in the first available Plot # by positioning cursor over the check box and left click the mouse

As many as 15 channels may be displayed simultaneously Enable as many channels as required for viewing by clicking on the plot number boxes. Bear in mind the more data that is displayed at one time the more difficult it will be to asses the data.

Once the desired number of channels to be displayed has been determined and selected, the user can now define the content of each displayed channel.



As can be seen from the figure on the right, 4 channels have been chosen for display. To determine the data displayed for each of the channels, click on the appropriate button in the "Field column.



Clicking on the field button for each channel opens the window shown to the left. The user can choose any channel of information from either the processed or unprocessed database.

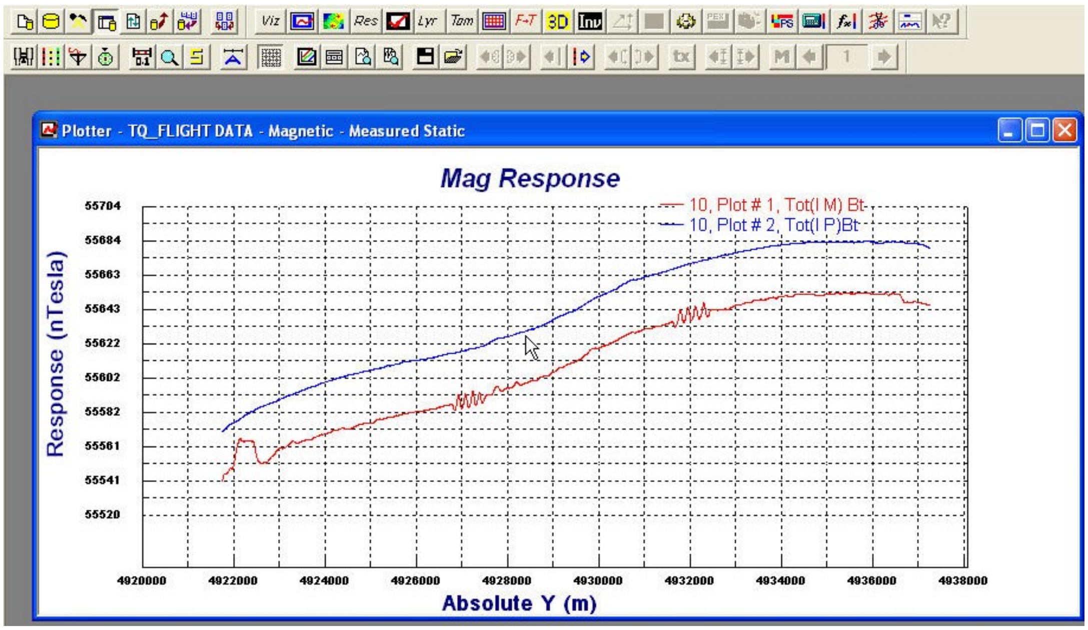
For Example: in order to display the total field magnetometer data both compensated and uncompensated for our sample data set the user would select the following:

1. Highlight and click on "measured Static from the Available data sets
2. From the "Fields Available" pull down window select "Measured T Total Real" If there are more than one total field sensor (as in a gradiometer installation) select the desired sensor (1, 2, or 3) from the "Choose Component section.
3. Click on the OK button

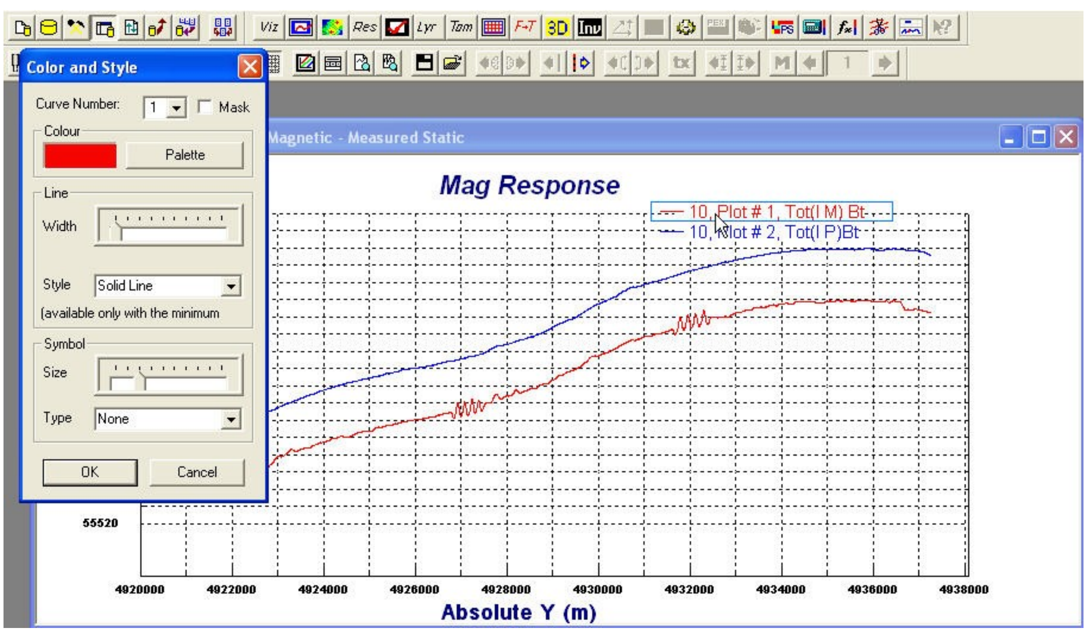
4. Repeat steps 1, 2, and 3 for the remaining channels, selecting data from either the compensated or uncompensated dataset

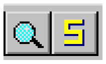
Once all the desired channels have been selected and configured, exit from the Fields and components window and the Channel Selection window by clicking on the OK buttons at the bottom of each window.

The user will then be presented with a graphical display of the selected channels as seen below



To change curve thickness and style double click on its legend. The following window will open



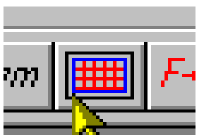


Use buttons "Zoom", "Zoom Home" to zoom specific area to see the details.

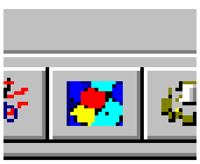
You may easily step between profiles using the arrows at the top of the plotting application. Additional sets of coefficients may be calculated and the data reprocessed. It is easy in the DBPlotter application to not only compare your original data with “compensated data” but to compare different compensations using different portions of the box data.

Gridding Your Data:

You may now create grids of both your original data and your compensated data. EMIGMA approaches the “gridding” of data in a somewhat different manner than other software. The user is given more control over the gridding process. This is accomplished by first separating the process of defining a set of points (i.e. the grid) that the user wants to interpolate the profile data onto from the interpolation process by which the original or “compensated” data is interpolated onto the defined. There are many other features to EMIGMA’s gridding process including the ability to use non-square grid cells allowing the user to maintain in-line data variations without over interpolating between lines. Both the measured and the compensated data may be included in the same “grid” to allow easy comparison and many other features.

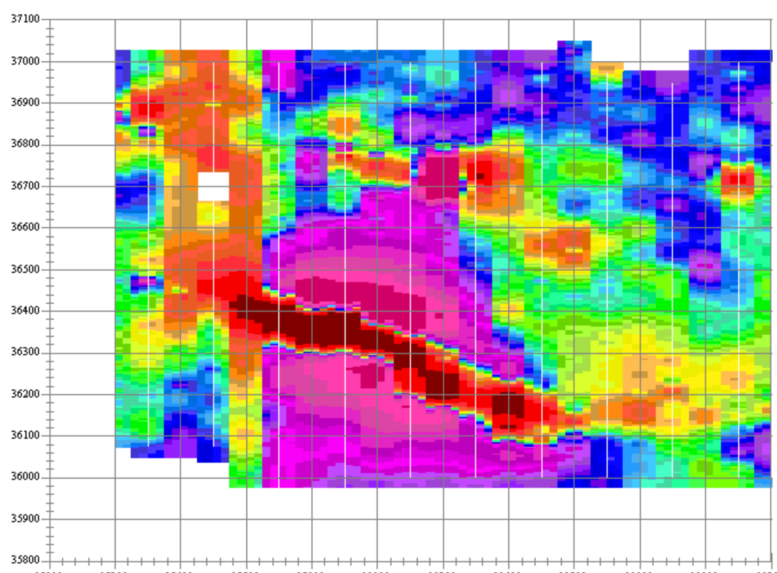


Allows the generation and interpolation of the data. Note, the NN (Natural Neighbour) technique is recommended for aeromagnetic data. The minimum curvature technique is also available but is not recommended for this type of data due to its global (whole survey) dependent requirement which can tend to destroy or add artefacts for local anomalies.

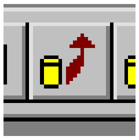


Allows viewing of the interpolated “grid” as well as profile data.

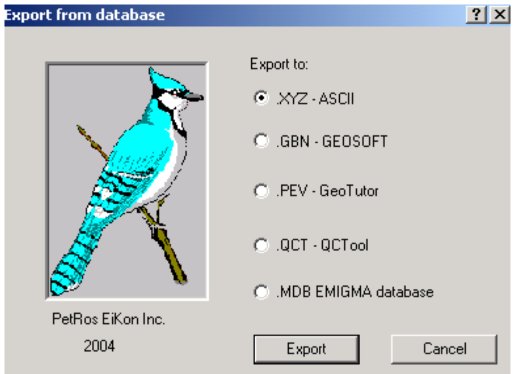
Allows examination of all associated grids, naming grids, examining statistics of grid,



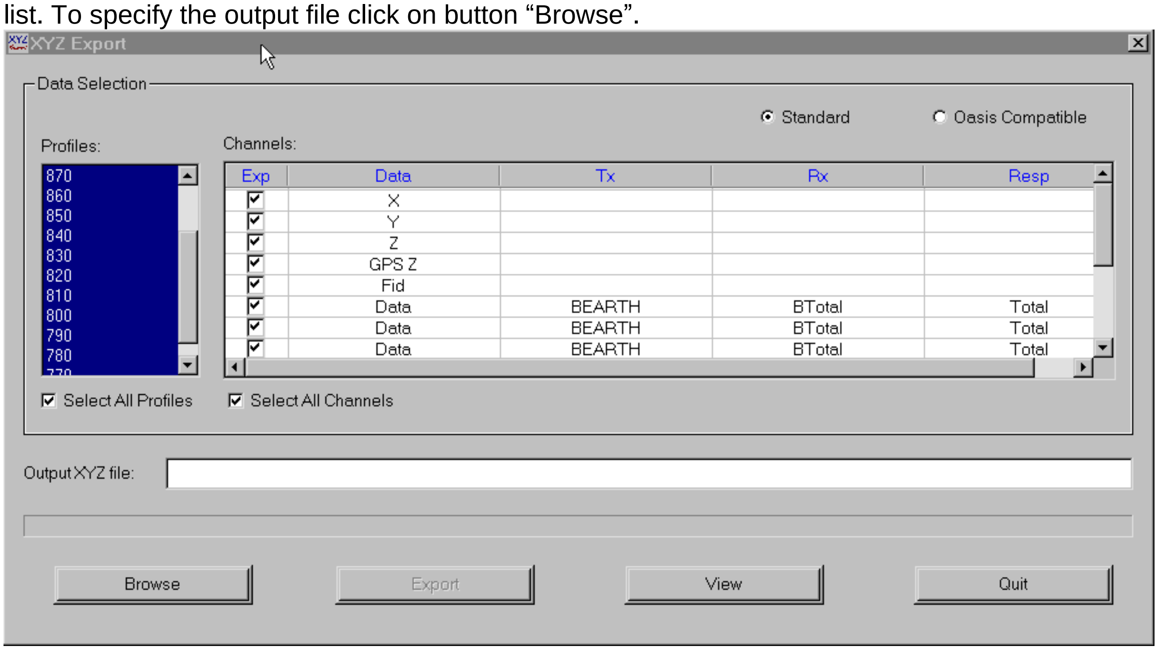
Export to the XYZ-file:



To export data click on button “Export” of the toolbar and then select the format required press the “Export” button:



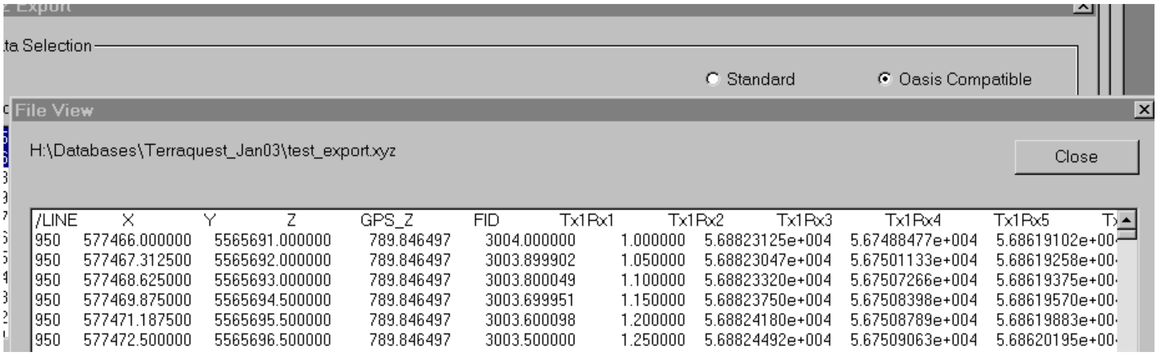
Select lines from “Profile” list you would like to export and all desired channels from “Channels” list. To specify the output file click on button “Browse”.



You may specify the format of output file.

Click on “Export” button to perform the operation.

Use the “View” button to have a look on output file (not recommended for big files).

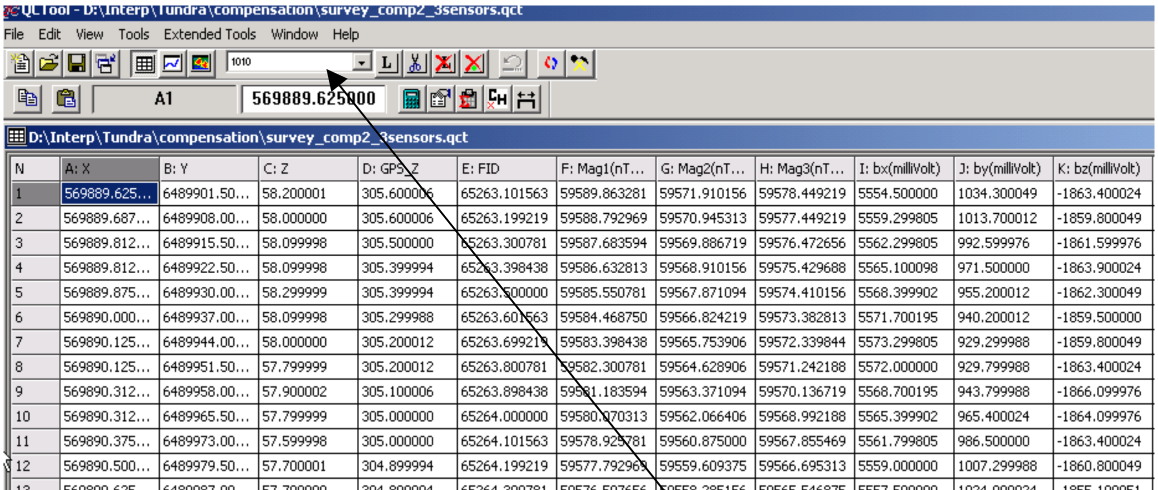

ta Selection
Standard
Oasis Compatible
File View
H:\Databases\Terraquest_Jan03\test_export.xyz
Close
/LINE X Y Z GPS_Z FID Tx1Rx1 Tx1Rx2 Tx1Rx3 Tx1Rx4 Tx1Rx5
950 577466.000000 5565691.000000 789.846497 3004.000000 1.000000 5.68823125e+004 5.67488477e+004 5.68619102e+00
950 577467.312500 5565692.000000 789.846497 3003.899902 1.050000 5.68823047e+004 5.67501133e+004 5.68619258e+00
950 577468.625000 5565693.000000 789.846497 3003.800049 1.100000 5.68823320e+004 5.67507266e+004 5.68619375e+00
950 577469.875000 5565694.500000 789.846497 3003.699951 1.150000 5.68823750e+004 5.67508398e+004 5.68619570e+00
950 577471.187500 5565695.500000 789.846497 3003.600098 1.200000 5.68824180e+004 5.67508789e+004 5.68619883e+00
950 577472.500000 5565696.500000 789.846497 3003.500000 1.250000 5.68824492e+004 5.67509063e+004 5.68620195e+00

POST FLIGHT PROCESSING USE OF COEFFICIENTS in QCTool

Your survey data may be in a number of formats, ASCII XYZ , binary XYZ, PicoBinary or Picodas Binary or Geosoft .gbn. If the data is in an Oasis database, we suggest exporting as .gbn has the files are more compact and faster to read. The files may contain either a single flight, single survey line or an entire survey.

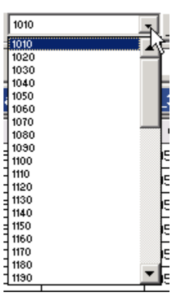
Be sure that the data to be imported contains the UTM x and y channels, the FID channel, elevation channels, all Mag channels and the 3 fluxgate channels. It may contain all data channels if desired. Qctool offers excellent tools for merging separate flights, separate surveys, or separate lines.

Qctool has its own manual in .pdf format in the installation directory as well as Help inside the application.



N	A: X	B: Y	C: Z	D: GPS_Z	E: FID	F: Mag1(nT…	G: Mag2(nT…	H: Mag3(nT…	I: bx(milliVolt)	J: by(milliVolt)	K: bz(milliVolt)
1	569889.625…	6489901.50…	58.200001	305.600006	65263.101563	59589.863281	59571.910156	59578.449219	5554.500000	1034.300049	-1863.400024
2	569889.687…	6489908.00…	58.000000	305.600006	65263.199219	59588.792969	59570.945313	59577.449219	5559.299805	1013.700012	-1859.800049
3	569889.812…	6489915.50…	58.099998	305.500000	65263.300781	59587.683594	59569.886719	59576.472656	5562.299805	992.599976	-1861.599976
4	569889.812…	6489922.50…	58.099998	305.399994	65263.398438	59586.632813	59568.910156	59575.429688	5565.100098	971.500000	-1863.900024
5	569889.875…	6489930.00…	58.299999	305.399994	65263.500000	59585.550781	59567.871094	59574.410156	5568.399902	955.200012	-1862.300049
6	569890.000…	6489937.00…	58.099998	305.299988	65263.601563	59584.468750	59566.824219	59573.382813	5571.700195	940.200012	-1859.500000
7	569890.125…	6489944.00…	58.000000	305.200012	65263.699219	59583.398438	59565.753906	59572.339844	5573.299805	929.299988	-1859.800049
8	569890.125…	6489951.50…	57.799999	305.200012	65263.800781	59582.300781	59564.628906	59571.242188	5572.000000	929.799988	-1863.400024
9	569890.312…	6489958.00…	57.900002	305.100006	65263.898438	59581.183594	59563.371094	59570.136719	5568.700195	943.799988	-1866.099976
10	569890.312…	6489965.50…	57.799999	305.000000	65264.000000	59580.070313	59562.066406	59568.992188	5565.399902	965.400024	-1864.099976
11	569890.375…	6489973.00…	57.599998	305.000000	65264.101563	59578.925781	59560.875000	59567.855469	5561.799805	986.500000	-1863.400024
12	569890.500…	6489979.50…	57.700001	304.899994	65264.199219	59577.792969	59559.609375	59566.695313	5559.000000	1007.299988	-1860.800049
13	569890.625…	6489987.00…	57.799999	304.899994	65264.300781	59576.597656	59558.285156	59565.546875	5557.500000	1024.900024	-1855.199951

In this case, X,Y channels , radar (Z), GPS_Z, 3 Mag channels and 3 fluxgate channels have been imported.

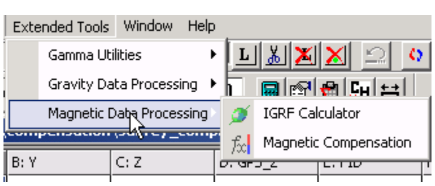


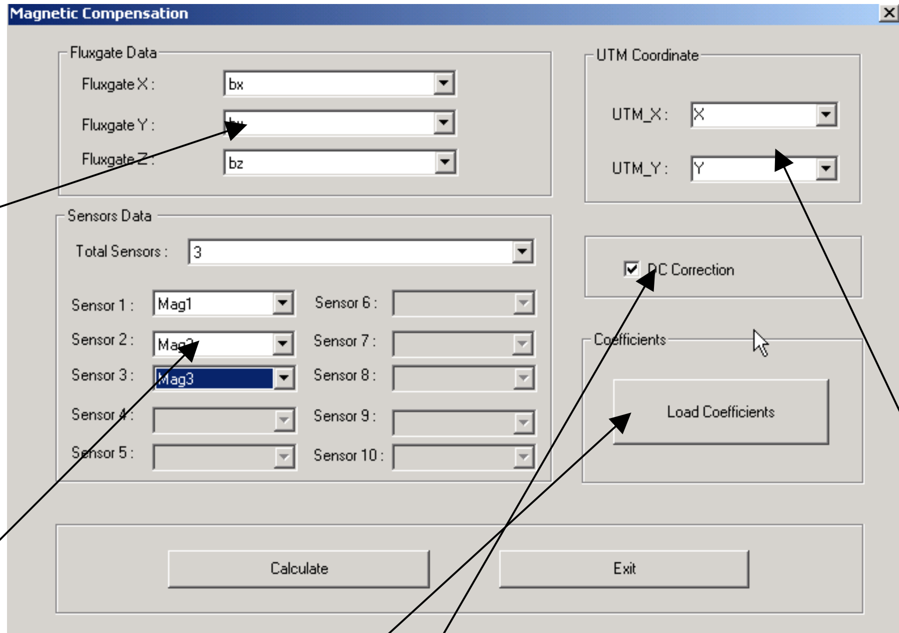
In this case, numerous lines have been imported.

Channel labels may be either imported from the data header or reset inside QCTool

The user may now filter, remove spikes, do diurnal corrections and IGRF corrections if desired prior to compensation.

Compensation: The compensation function is found in the Extended Tools menu





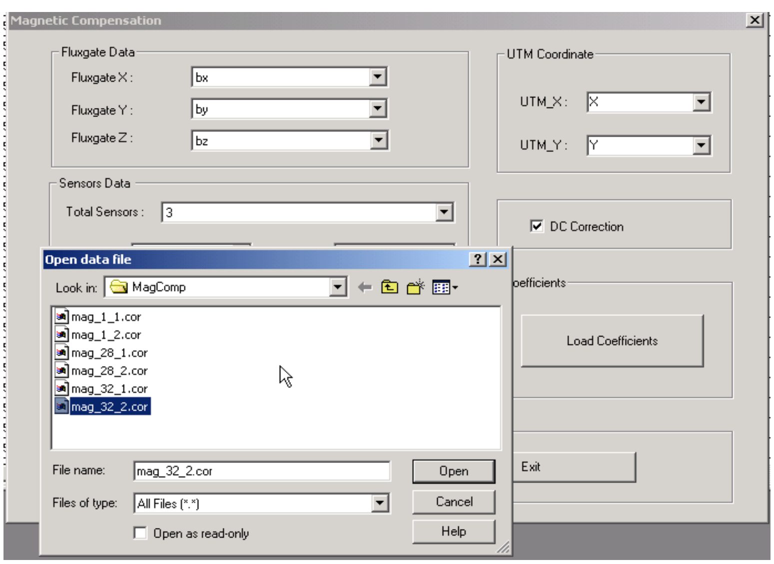
The fluxgate channels

The user selects the number of mag sensors and the channels according to their labels

Default is to correct the DC level to that of the original data line

User selected Easting and Northing channels

Load Coefficients:



Upon selecting Load Coefficients, the user then browses to find the correct coefficient file and determined in EMIGMA and copied to their computer.

<u>Calculate</u> is then clicked and the compensation is then done on all sensors and all lines and the output is made to new channels – 1 channel for each sensor.

N	A: X	B: Y	C: Z	D: GPS_Z	E: FID	F: Mag1(nT...	G: Mag2(nT...	H: Mag3(nT...	I: bx(milliVolt)	J: by(milliVolt)	K: bz(milliVolt)	L: QC_COMP1	M: QC_COMP2	N: QC_COMP3
1	569889.625...	6489901.50...	58.200001	305.600006	65263.101563	59589.863281	59571.910156	59578.449219	5554.500000	1034.300049	-1863.400024	59589.88270[illegible]	59571.539965	59578.452184
2	569889.687...	6489908.00...	58.000000	305.600006	65263.199219	59588.792969	59570.945313	59577.449219	5559.299805	1013.700012	-1859.800049	59588.887909	59570.496279	59577.394603
3	569889.812...	6489915.50...	58.099998	305.500000	65263.300781	59587.683594	59569.886719	59576.472656	5562.299805	992.599976	-1861.599976	59587.706871	59569.338903	59576.391573
4	569889.812...	6489922.50...	58.099998	305.399994	65263.398438	59586.632813	59568.910156	59575.429688	5565.100098	971.500000	-1863.900024	59586.655275	59568.248057	59575.318109
5	569889.875...	6489930.00...	58.299999	305.399994	65263.500000	59585.550781	59567.871094	59574.410156	5568.399902	955.200012	-1862.300049	59585.566098	59567.090568	59574.282271
6	569890.000...	6489937.00...	58.099998	305.299988	65263.601563	59584.468750	59566.824219	59573.382813	5571.700195	940.200012	-1859.500000	59584.482754	59565.948239	59573.238675
7	569890.125...	6489944.00...	58.000000	305.200012	65263.699219	59583.398438	59565.753906	59572.339844	5573.299805	929.299988	-1859.800049	59583.417544	59564.812741	59572.187117
8	569890.125...	6489951.50...	57.799999	305.200012	65263.800781	59582.300781	59564.628906	59571.242188	5572.000000	929.799988	-1863.400024	59582.323781	59563.671370	59571.101891
9	569890.312...	6489958.00...	57.900002	305.100006	65263.898438	59581.183594	59563.371094	59570.136719	5568.700195	943.799988	-1866.099976	59581.203397	59562.457885	59570.030648
10	569890.312...	6489965.50...	57.799999	305.000000	65264.000000	59580.070313	59562.066406	59568.992188	5565.399902	965.400024	-1864.099976	59580.082833	59561.243566	59568.929261
11	569890.375...	6489973.00...	57.599998	305.000000	65264.101563	59578.925781	59560.875000	59567.855469	5561.799805	986.500000	-1863.400024	59578.941698	59560.178716	59567.825514

In this case, 3 new channels are created which are the compensated data for each of the 3 sensors.

Plotting: The user may then plot each or all channels. (ref. QCTool manual)
Gridding: The user may grid the resulting data (ref. QCTool manual)
Spike Removal: The user many remove data spikes.

In addition, the data may be merged with a time fiducial with base station data for diurnal correction. IGRF corrections may be made as well. Filtering is also available.

Merging in QCTool

Merging of separate flights is done by first importing and compensating each flight, saving the resulting .qct file and then merging the .qct files into a new file. Data may first be merged and compensated together by first importing each flight, saving and merging .qct files and then compensating the in the merged file.

Exporting in QCTool

Once all processing is completed the user may export to ASCII XYZ format, by selecting ***Save As***