Setting Moving FDEM systems in EMIGMA

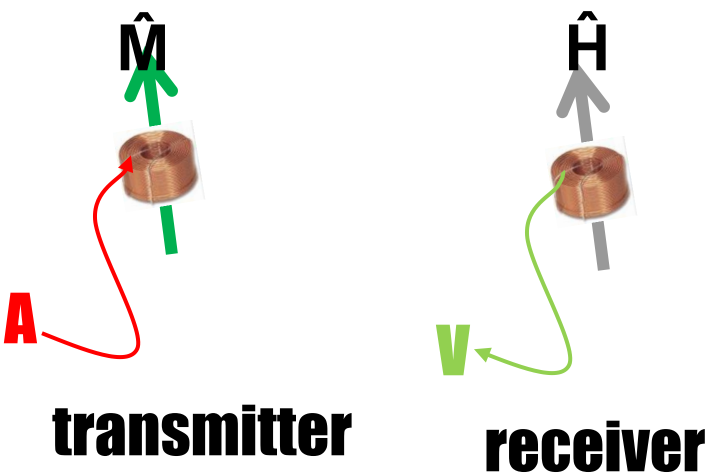
The coordinate system

Normally, the Horizontal coordinate system is used for such systems in EMIGMA.

Horizontal Coordinate System

- *direction of unit vectors change with profile direction*
- *$\hat{X}$ and $\hat{Y}$ are horizontal and $\hat{Z}$ is up.*
- *$\hat{X}$ is directed parallel to the tangent of the profile at each station.*
- *$\hat{Y}$ is perpendicular to the tangent at each station*
- *the station locations are your normal GPS or grid values*

Transmitters and Receivers

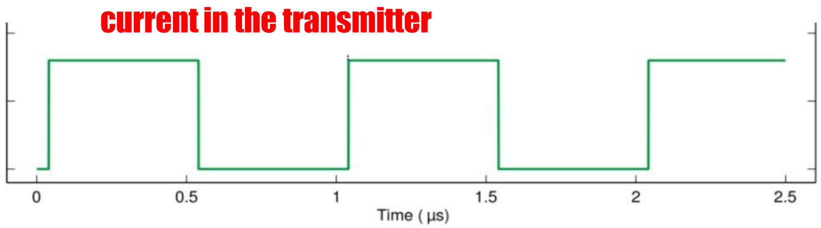


System Components

- *the transmitter and receiver are both wound coils*
- *a current is injected into the transmitter coil and this produces a magnetic moment.*
- *the magnetic field caused by the transmitter and the ground running through the receiver coil produces a voltage which is output*
- *the voltage output can be converted to a value of magnetic field coupling with the coil if desired*
- *the measured magnetic field is aligned with the moment of the receiver coil*
- *mathematically the source and receiver are defined as point electric dipoles – this is satisfactory as the coils are small with respect to the tx-rx separations*

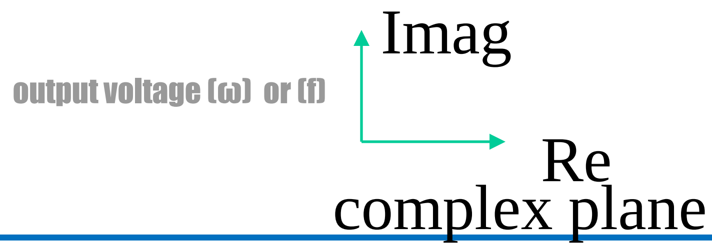
Setting Moving FDEM systems in EMIGMA

Data Processing



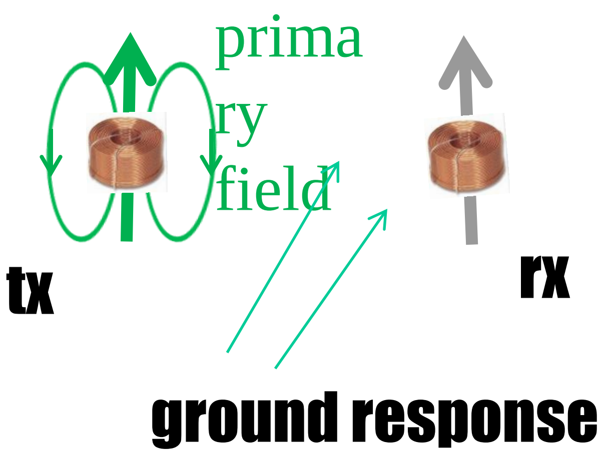
Instrument Aspects

○ *a square wave current of a certain frequency is injected into the transmitter*
○ *the fundamental harmonic of this boxcar is extracted in the receiver which produces a real part and an imaginary part*
○ *the real part is inphase with the current in the transmitter*
○ *the imaginary part is out of phase with the current*



Inphase – a common name for the real part of the output
Quadrature – a common name for the imaginary part of the output

Normalization



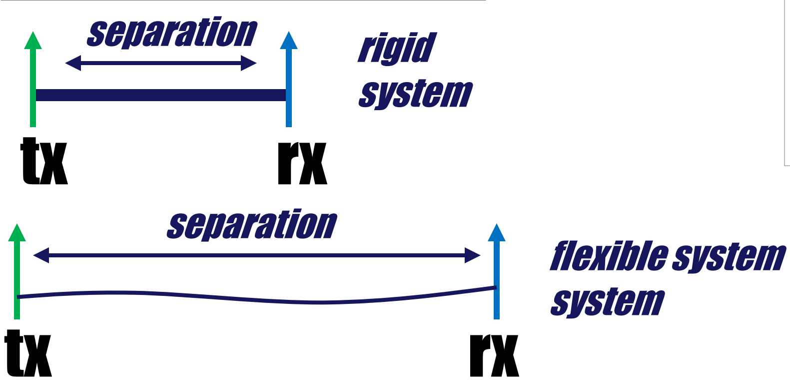
Normalization

○ *the strongest field is that directly from the transmitter which contains no part of the ground response*
○ *this direct (primary) field is inphase and can be computed if the coil strength and the current are known*
○ *this primary field is removed from the output voltage either by computation or by the use of a bucking coil (e.g. airborne systems)*
○ *the remaining voltage is the ground response*
○ *the remaining or secondary voltage is then divided by the primary voltage which was previously subtracted*
○ *the resulting voltage output is then dimensionless*
○ *depending upon the manufacturer the resulting voltage can be adjusted to different units*

Setting Moving FDEM systems in EMIGMA

Data Processing

Normalization 2



Normalization

○ there are two types of systems – rigid and flexible
○ in a rigid system, the tx and rx are housed in a rigid structure so that the separation of tx and rx is fixed – e.g. EM38, EM31, GEM2
○ in a flexible system, the tx and rx are independent and connected via a cable of some sort – e.g. Promis, MaxMin, EM34
○ in a flexible system care must be taken to ensure the cable is at the prescribed length and the coils are coplanar

Additional Comments

○ in an airborne system, the tx and rx and housed in a bird which is flexible during flight and thus normally a bucking coil is used to reduce and normalize to the primary response
○ in the PROMIS system, 3 components of the secondary field are measured simultaneously and so the coil orientation of tx and rx should be made accurately
○ in the older MaxMin system, one can measure Hx as well as Hz but the orientation of the receiver coils in both cases must be made accurately

Setting Moving FDEM systems in EMIGMA

Data Units

Data Units

○ the raw response is always calculated according to the formula below

○ *this ratio, however, can be expressed in various units as below*

$$\text{Response (Re, Im)} = \frac{\{\text{Measured Voltage (Re,Im)} - \text{Primary Field}\}}{\text{Primary Field}}$$

InPhase Units – Percent (%), PPT, PPM

Quadrature Units – Percent (%), PPT, PPM, apparent conductivity

Data Units Apparent Conductivity

○ *it should be noted that the word "apparent" is extremely important for understanding these units*

○ *this does mean actual conductivity, but rather the ratio expressed in terms of an approximate formula which represents an equivalent halfspace for the ground and not the actual ground conductivity*

○ *the formula assumes a halfspace for the ground and then only one (1) term in the accurate representation from physical principles of such a system*

Setting Moving FDEM systems in EMIGMA

Data Units – apparent conductivity

Data Units Apparent Conductivity

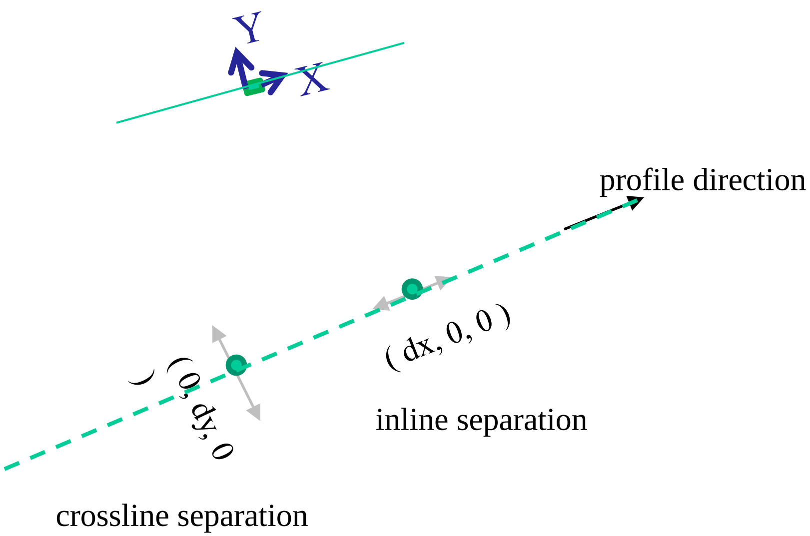
- *it should be noted that the word "apparent" is extremely important for understanding these units*
- *this does mean actual conductivity, but rather the ration expressed in terms of an approximate formula which represents an equivalent halfspace for the ground and not the actual ground conductivity*
- *the formula assumes a halfspace for the ground and then only one (1) term in accurate representation of such a system from physical principles*
- *in the formula below "s" is the distance between transmitter and receiver. This formula assumes no effect from the (1/s) term in the response*
- *if indeed the ground is a halfspace then the expression is most accurate when the induction number,*

$[\ \sigma\ \omega\upsilon_0\, s^2\ ]$ is small

$$\sigma_{app} = \frac{4}{\omega\upsilon_0\, s^2}\ \frac{(H)_{quadrature}}{H_{primary}}$$

Setting Moving FDEM systems in EMIGMA

Tx-Rx separations in EMIGMA



Horizontal Coordinate System

○ direction of unit vectors change with profile direction
○ $\hat{X}$ and $\hat{Y}$ are horizontal and $\hat{Z}$ is up.
○ $\hat{X}$ is directed parallel to the tangent of the profile at each station.
○ $\hat{Y}$ is perpendicular to the tangent at each station
○ the station locations are your normal GPS or grid values
○ these conventions are for the source and receiver dipoles as well as the TX-RX separations
○ separations may be defined as any (dx,dy,dz) with respect to the profile direction

Setting Moving FDEM systems in EMIGMA

Tx-Rx separations in EMIGMA

Some Examples

○ *standard horizontal coplanar inline system configuration (HCP):*

Tx – Mz ; Rx – Hz ; separation (dx, 0, 0)

[EM38 – (1,0,0) , EM31 – (3.66,0,0)

○ *standard horizontal coplanar crossline system configuration (HCP):*

Tx – Mz ; Rx – Hz ; separation (0, dy, 0)

○ *standard vertical coplanar in line system configuration (VCP):*

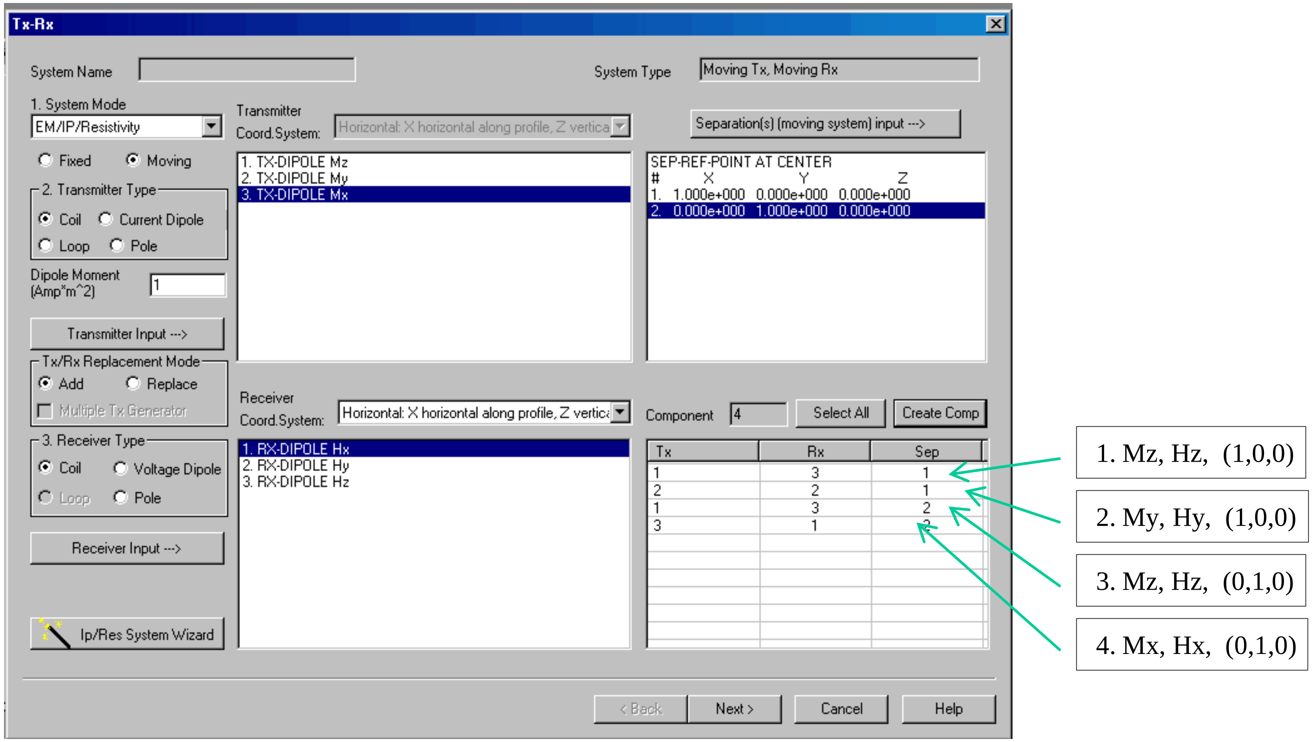
Tx – My ; Rx – Hy ; separation (dx, 0, 0)

○ *standard vertical coplanar crossline system configuration (broadside VCP):*

Tx – Mx ; Rx – Hx ; separation (0, dy, 0)

Setting Moving FDEM systems in EMIGMA

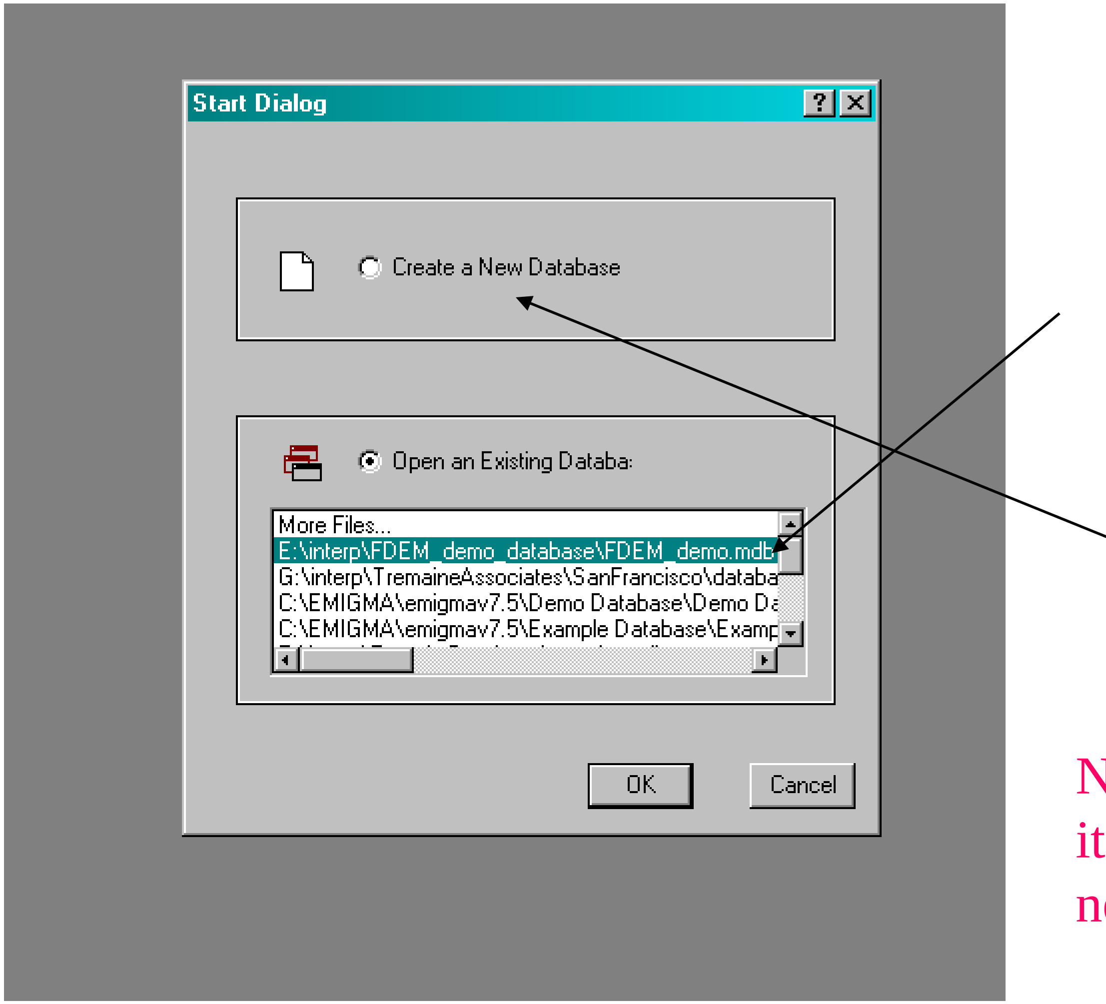
Configuration Page Example in EMIGMA – EM38



<u>System Configurations</u>

- *1: standard HCP*
- *2: standard VCP*
- *3: standard HCP crossline*
- *4: standard VCP crossline, broadside*

Opening a database



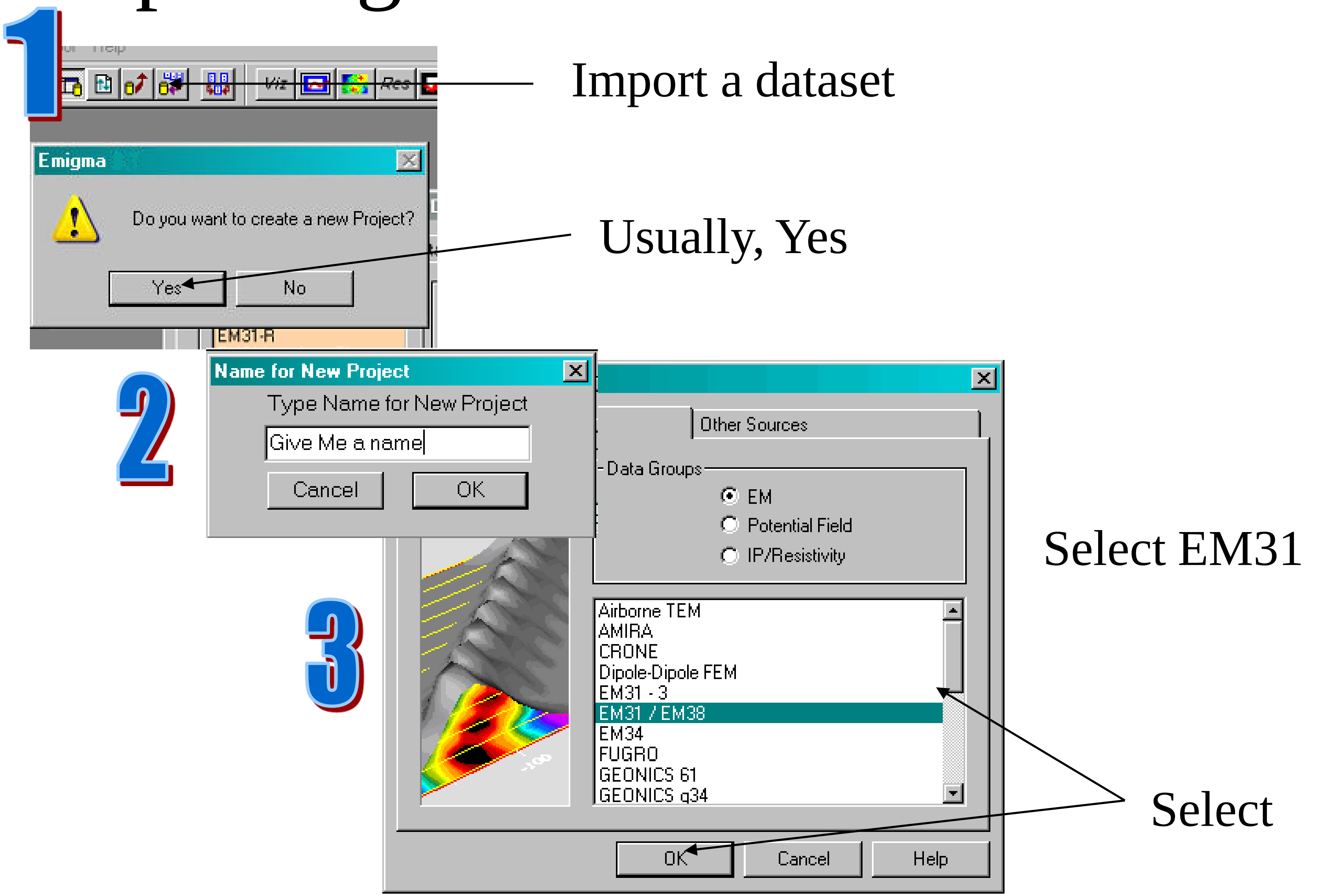
Select a Database

Or

Create a New Database

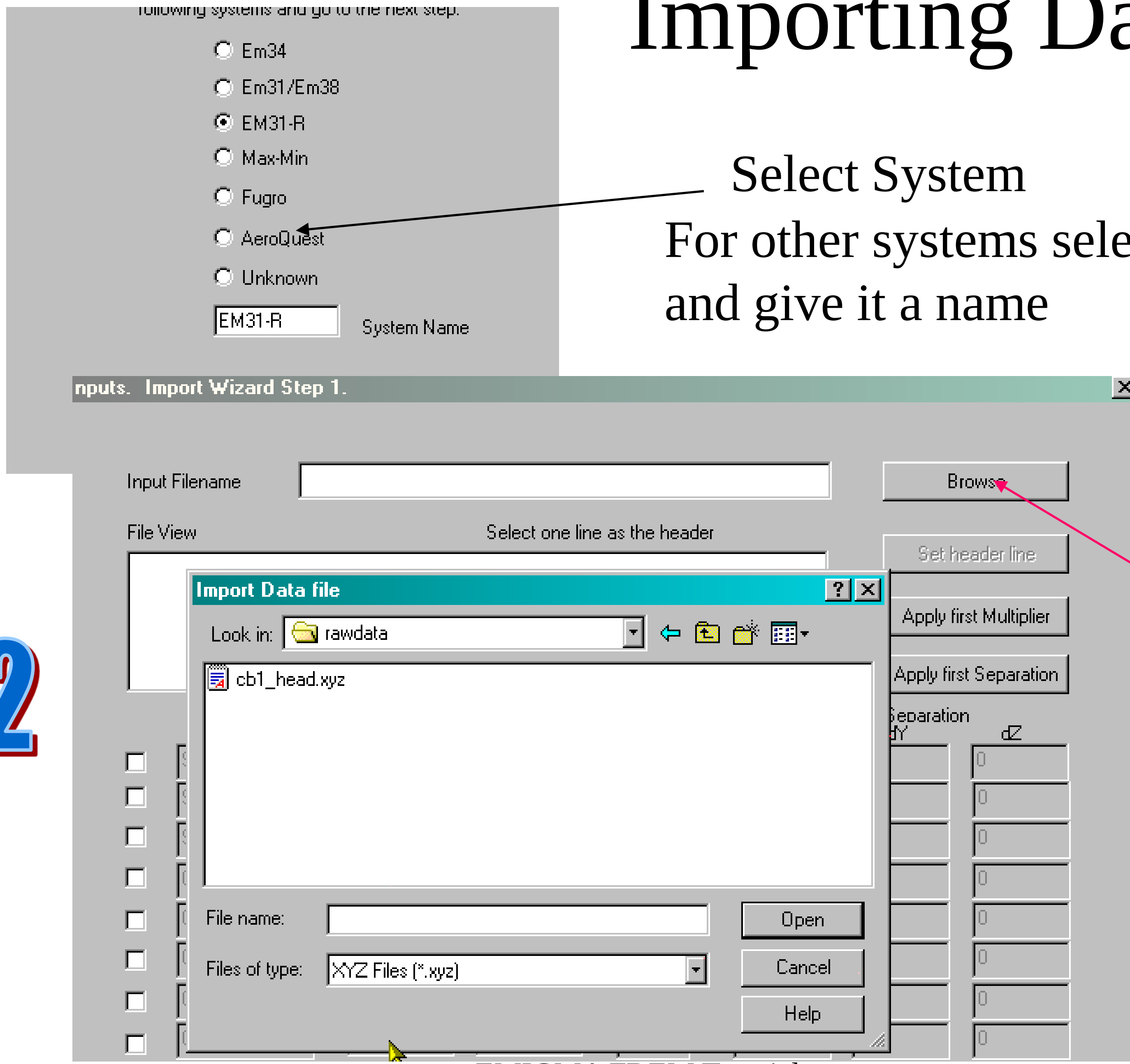
Note: If Creating a new database, it is recommended to put the new database in a new subdirectory

Importing Data - 1



Importing Data - 2

1



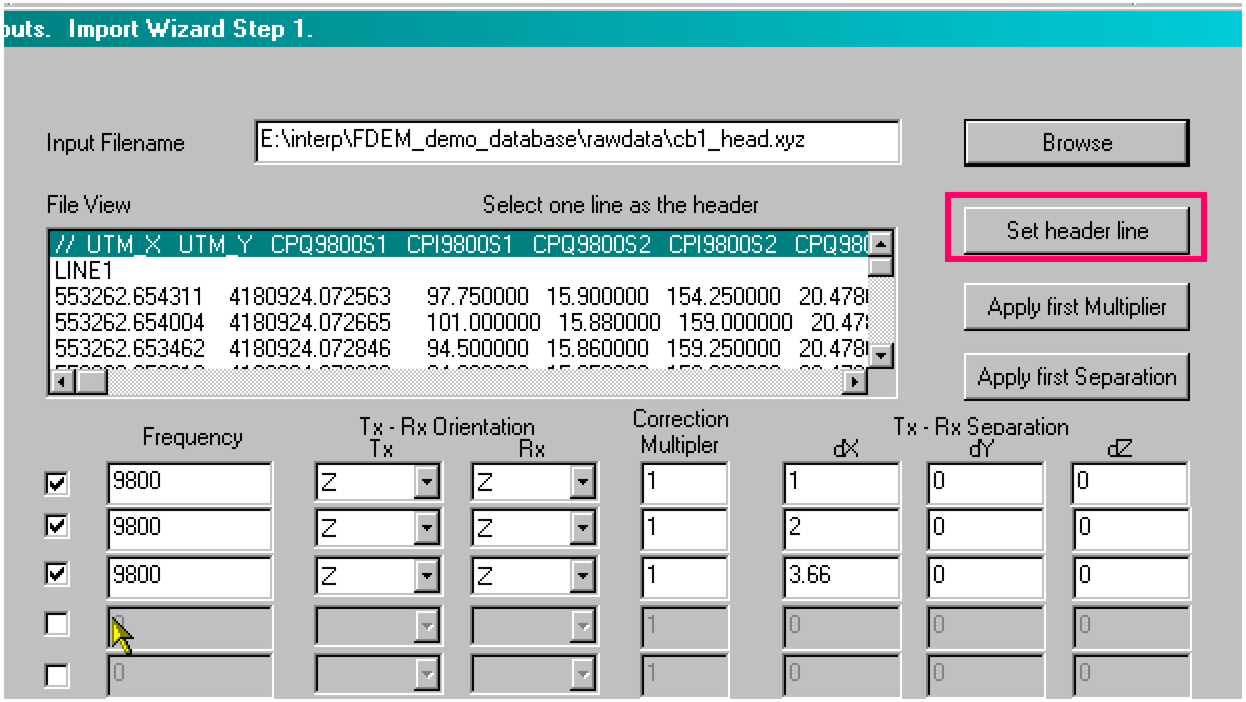
Select System

For other systems select Unknown and give it a name

2

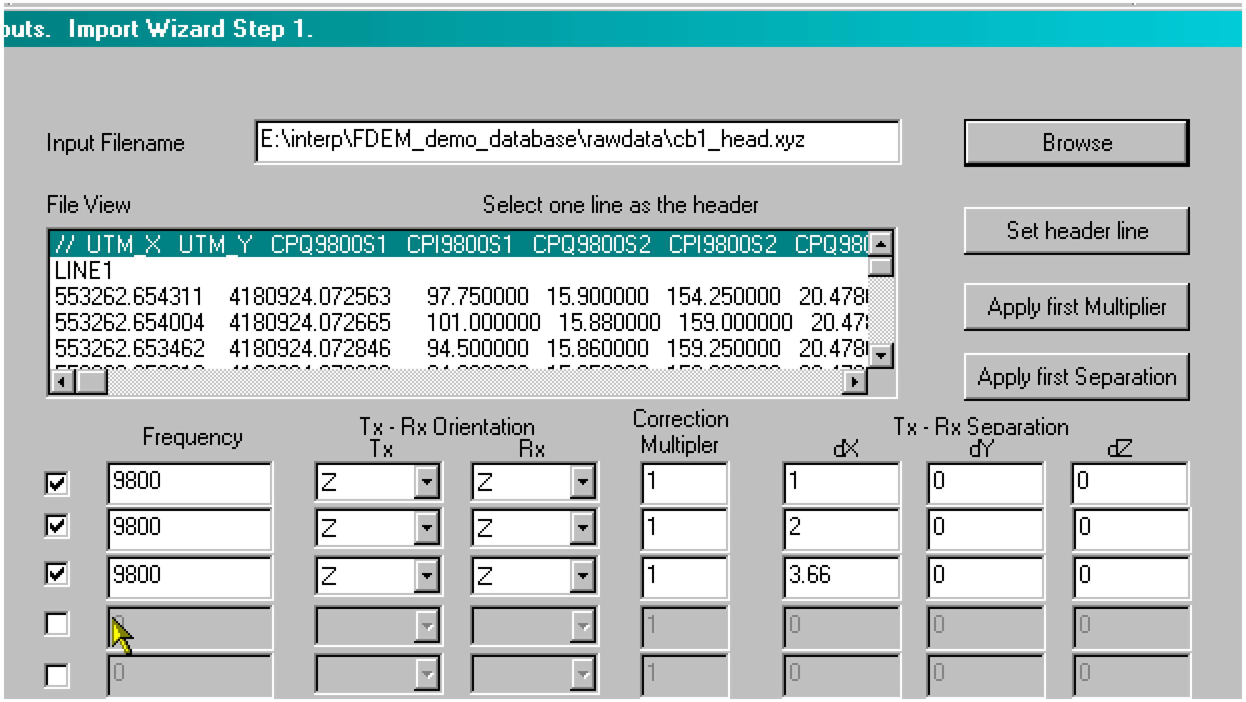
Browse for XYZ columnar datafile

Importing Data - 3



If your file does not contain a Header line with our specific annotation then use ‘Set Header line’ to set the header.
Use the provided example file for assistance.

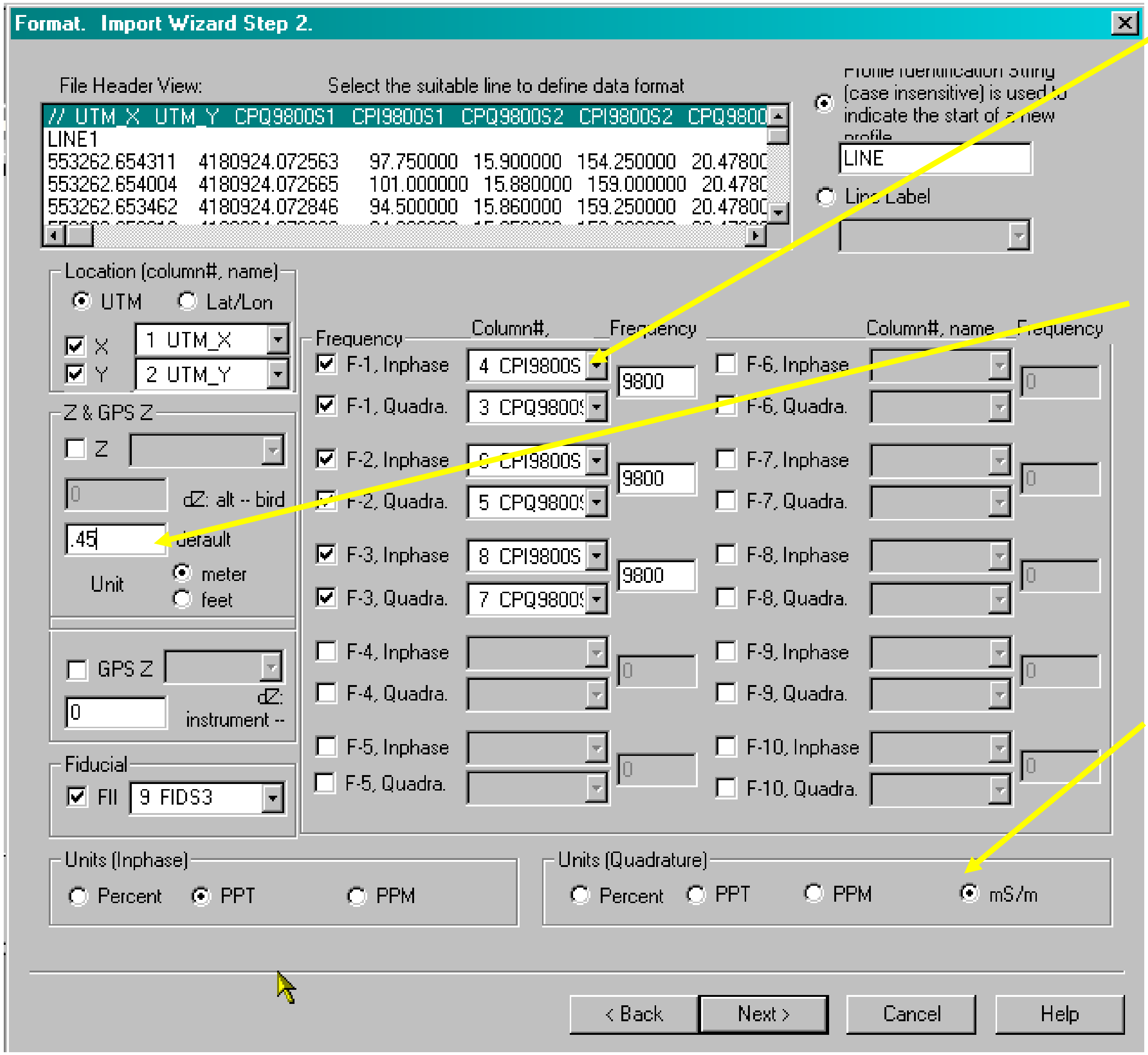
Importing Data - 3b



Note 1: Dipole orientations may be X,Y, or Z. These are in reference to the 'Horizontal" co-ordinate system (Manual). For example, Z-Z is horizontal co-planar and Y-Y or X-X or vertical coplanar. Y is perpendicular to line and X is tangential to the line.

Note 2: Separations may be dX, dY or dZ. dX is along line while dY is across line. For example, a dipole configuration with X-X and a separation of (0,dy,0) is vertical co-planar 'broadside'.

Importing Data - 4



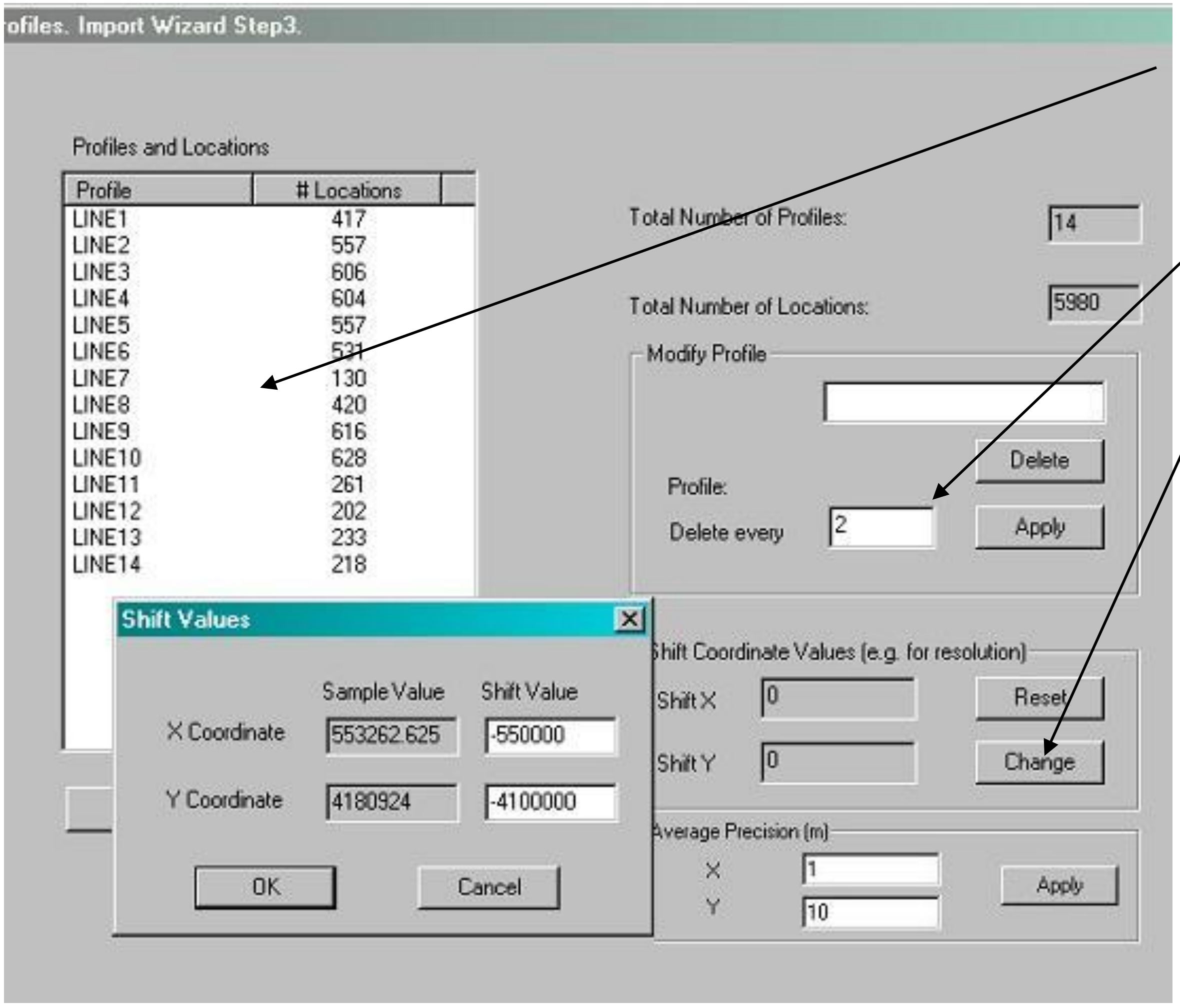
Check that the import has recognized the columns correctly.

Set the height of the instrument.

Check the data units.

Note:
mS/m is not an actual data unit. The data has been converted by the instrument manufacturer through an approximation to this unit. EMIGMA converts it back to the original data units. You may later display in these approximate units.

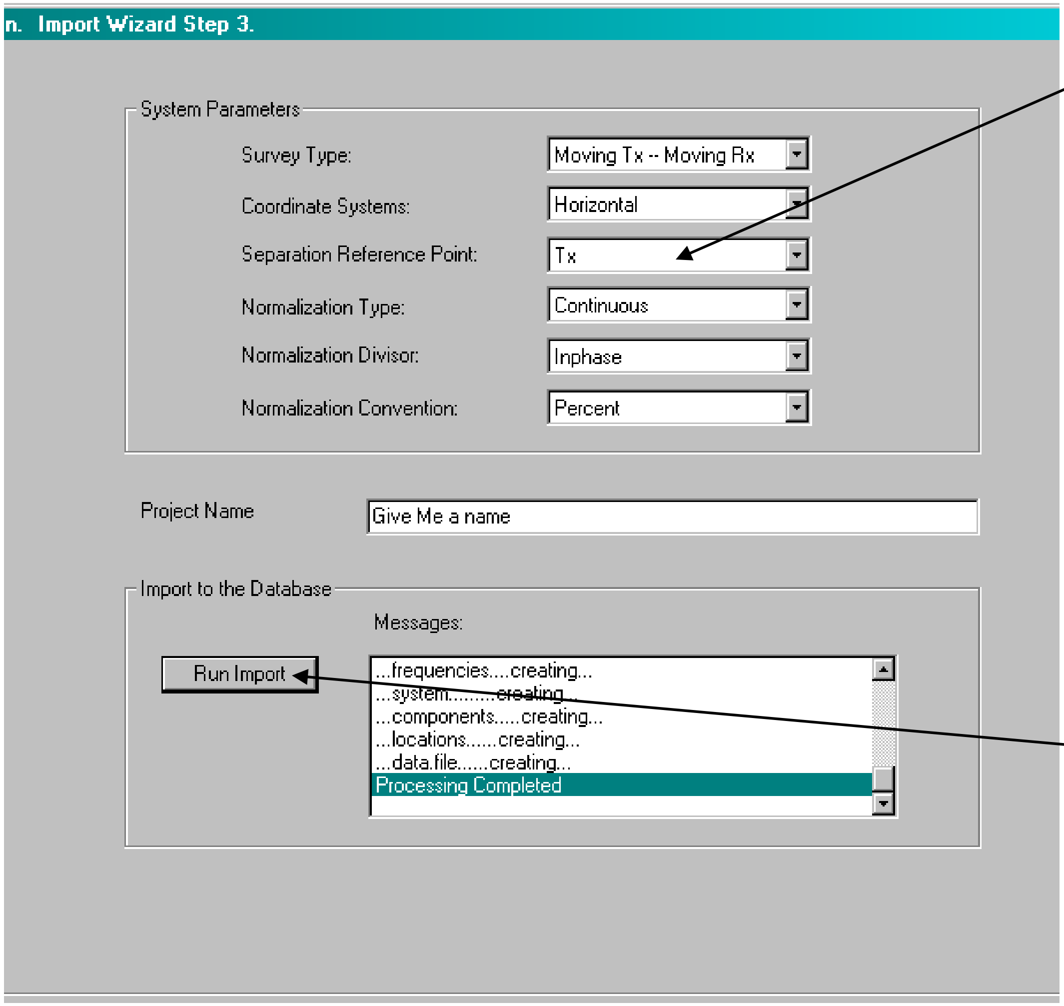
Importing Data - 5



You may choose not to import all profiles or decimate the data.

In addition, if you require sub-metre accuracy in your data positioning you may wish to strip off the leading numbers of the UTM positions

Importing Data - 6



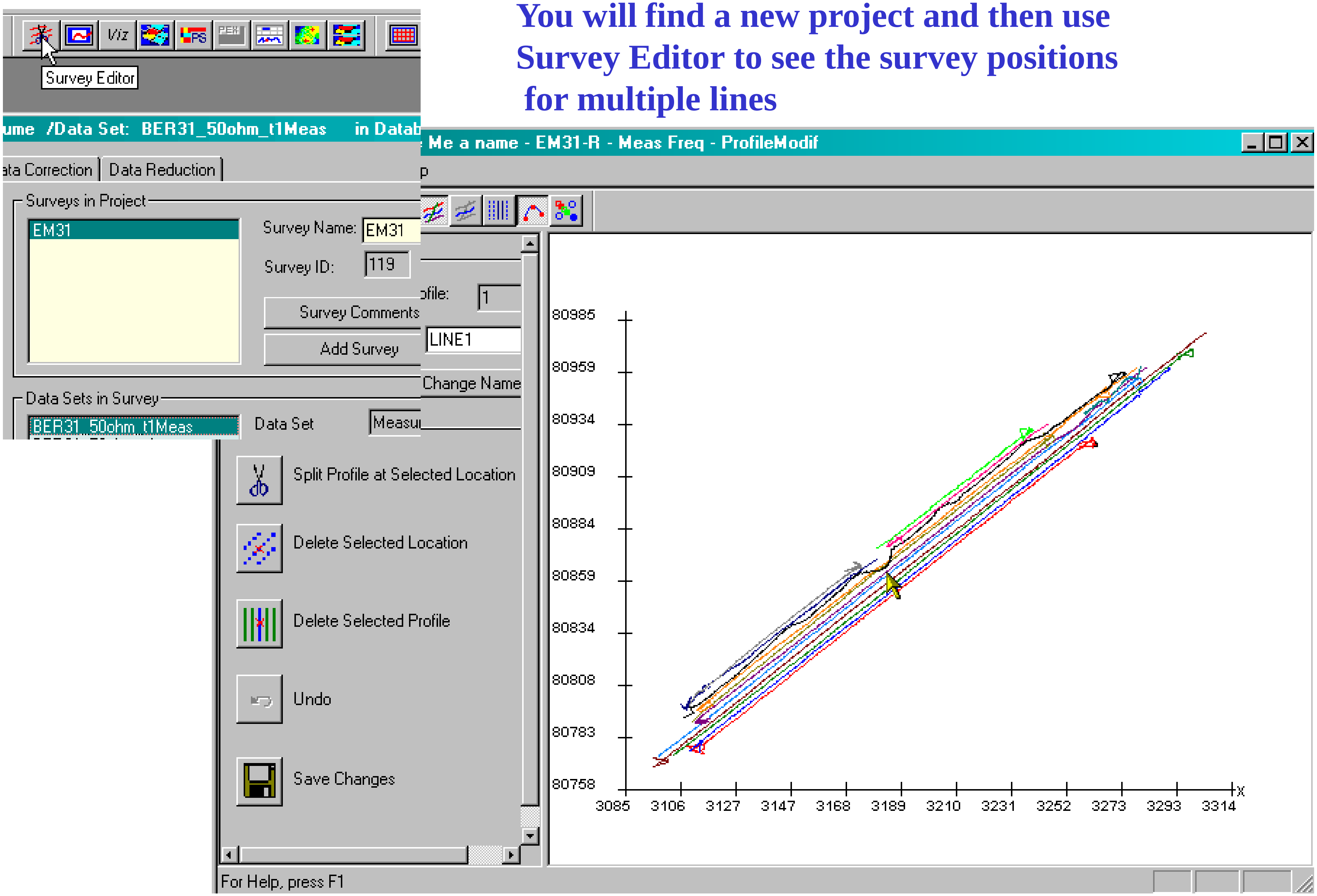
If using an EM31-R, then your data is probably positioned at a common Tx reference point. This is because the data is collected from a common Tx antennae

Note: The centre point of the 3 Rx-Tx data are not the same.

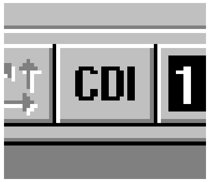
Run Import:

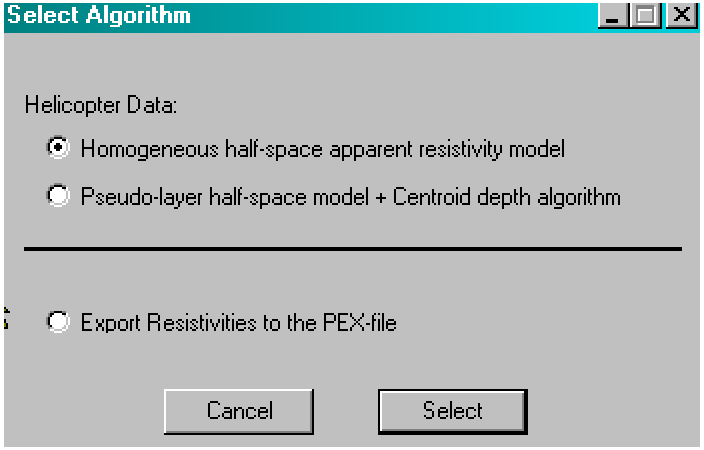
Importing Data - Final

You will find a new project and then use Survey Editor to see the survey positions for multiple lines

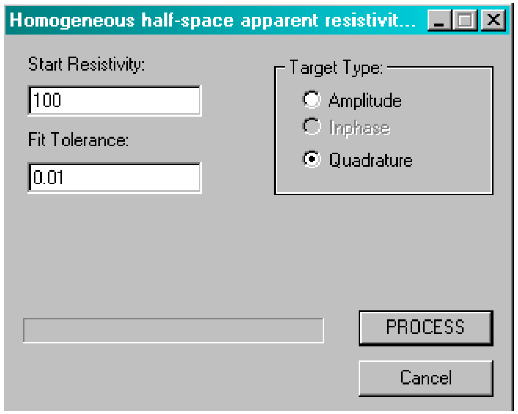


Calculating Apparent Resistivity





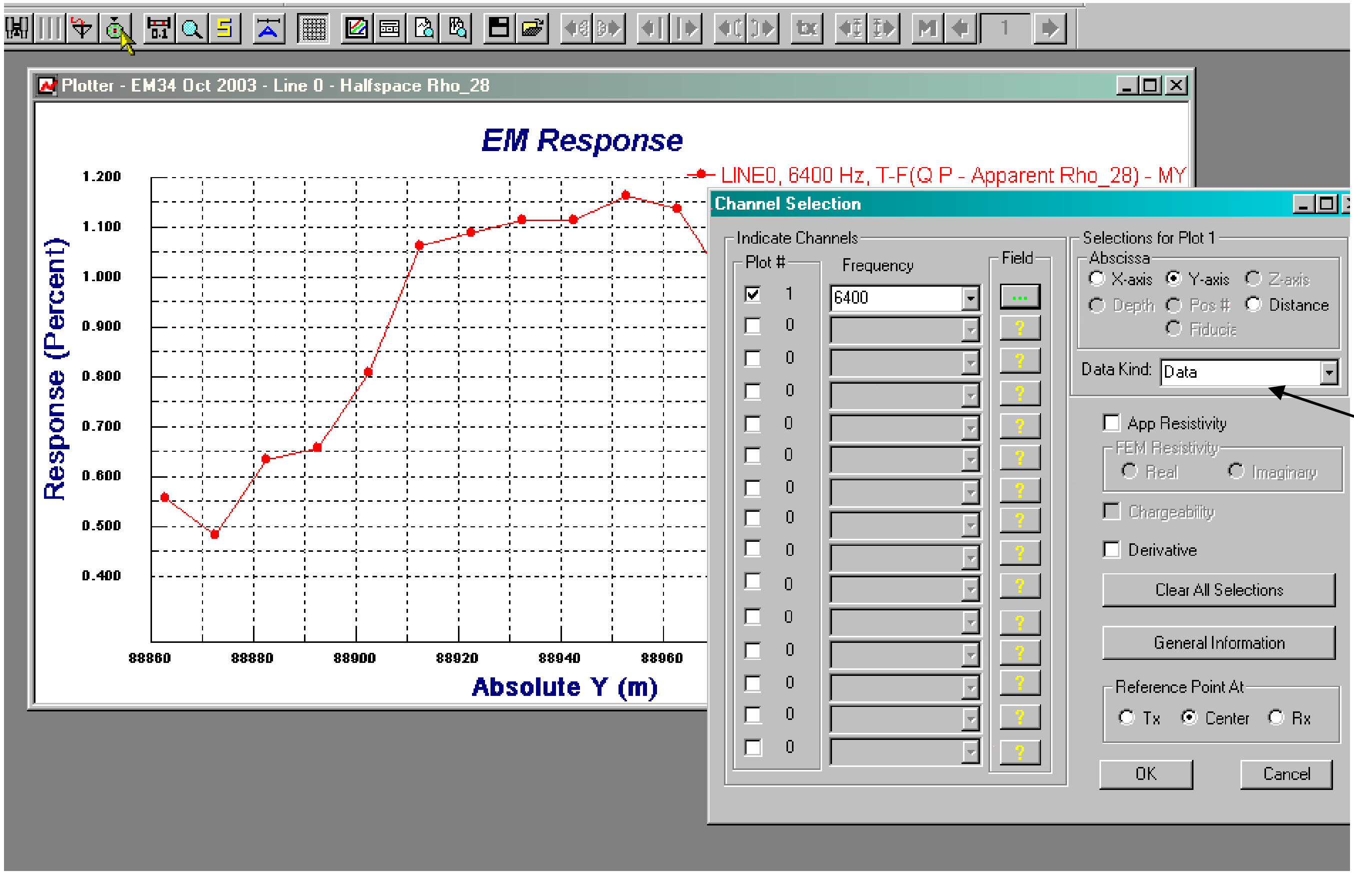
Calculate the best fitting half-space app rho for any dipole-dipole frequency EM data airborne or ground



Calculate the best fitting half-space app rho choose which data elements to use e.g. for EM34 then Quadrature is default

Store to new dataset or attach to original data

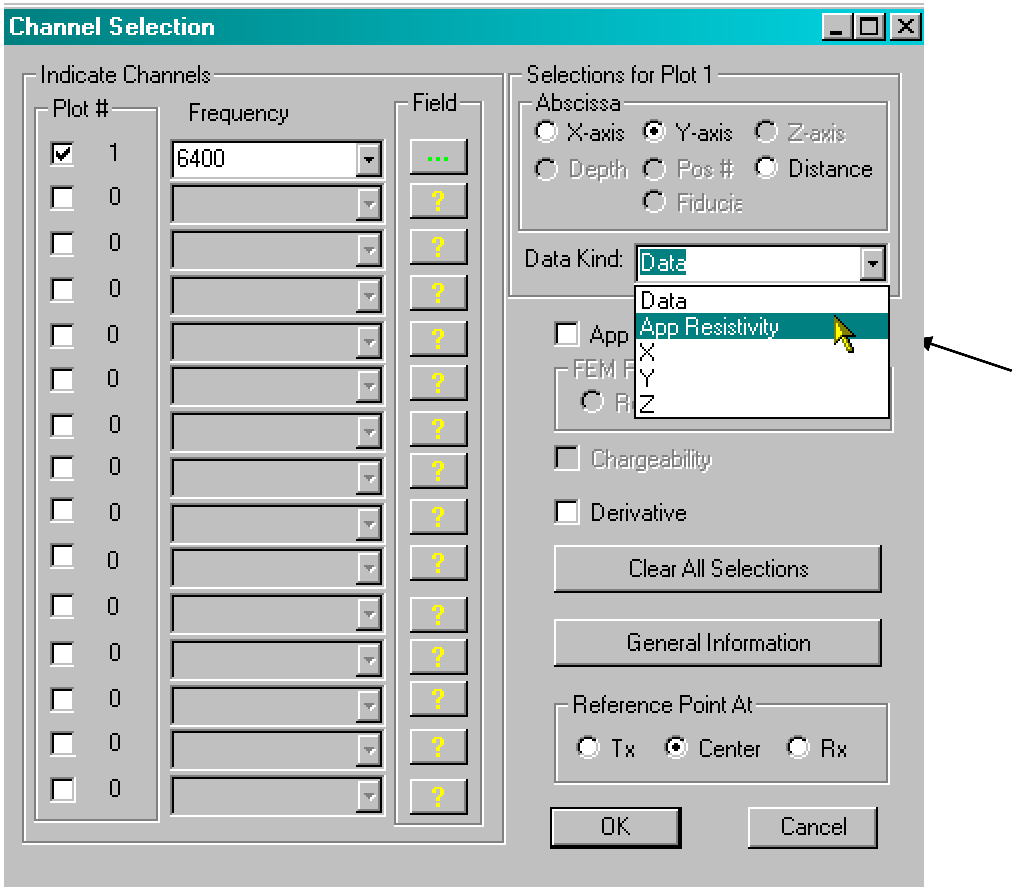
Plotting Data - 1 (V90_tutorial .pdf for more details)



app rho display
converts normalized data to app rho through short separation algebraic formula

For apparent conductivity:
Settings -> Custom -> App Cond

Plotting Data - 2



app rho display

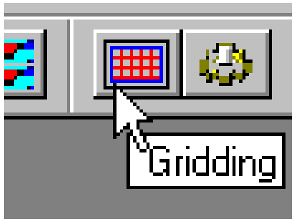
use calculated best fit apparent resistivity

for apparent conductivity
Settings -> Custom -> App Cond

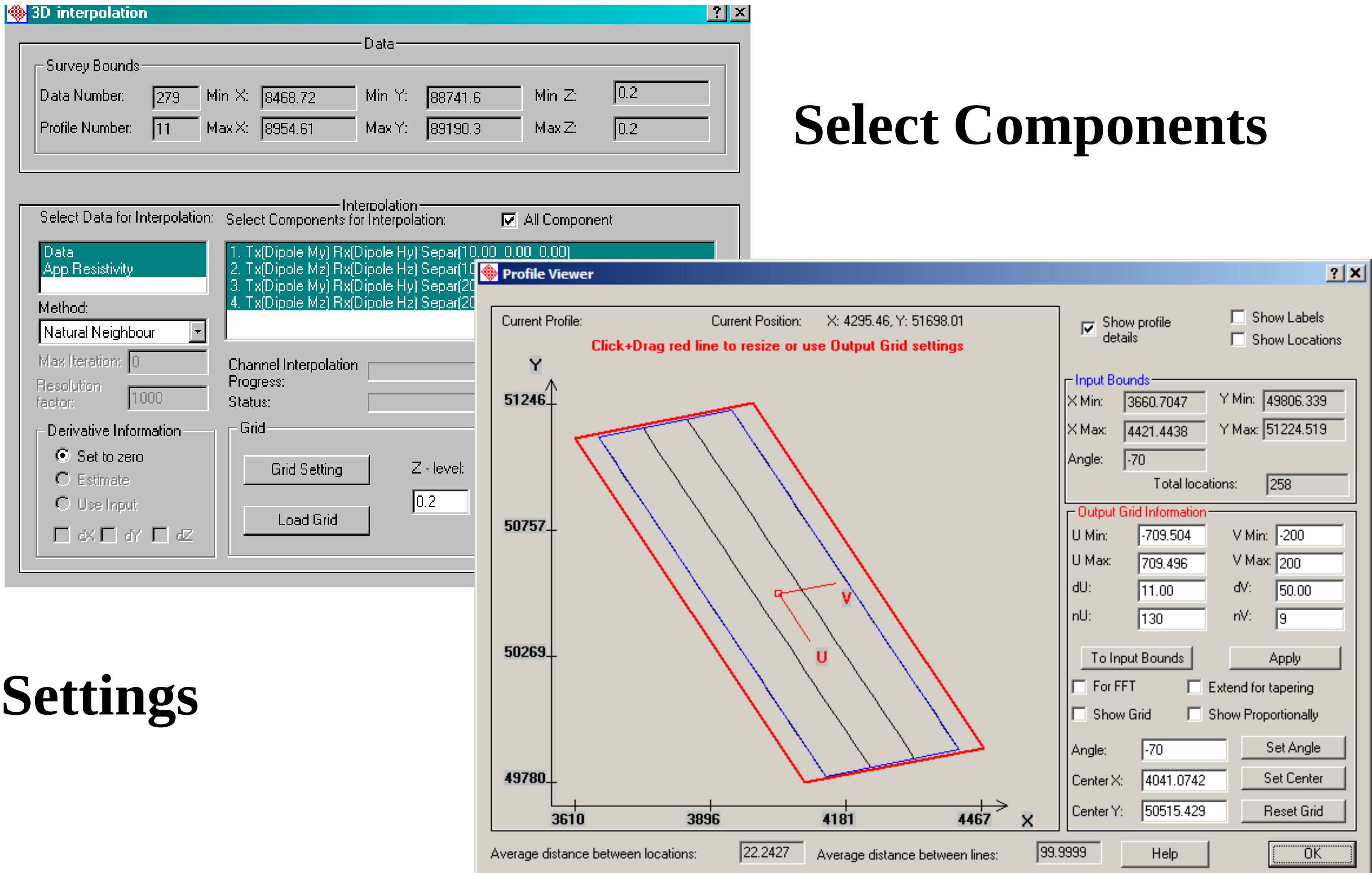
Gridding data - 1

Interpolate to Grid

interpolate to regular grid

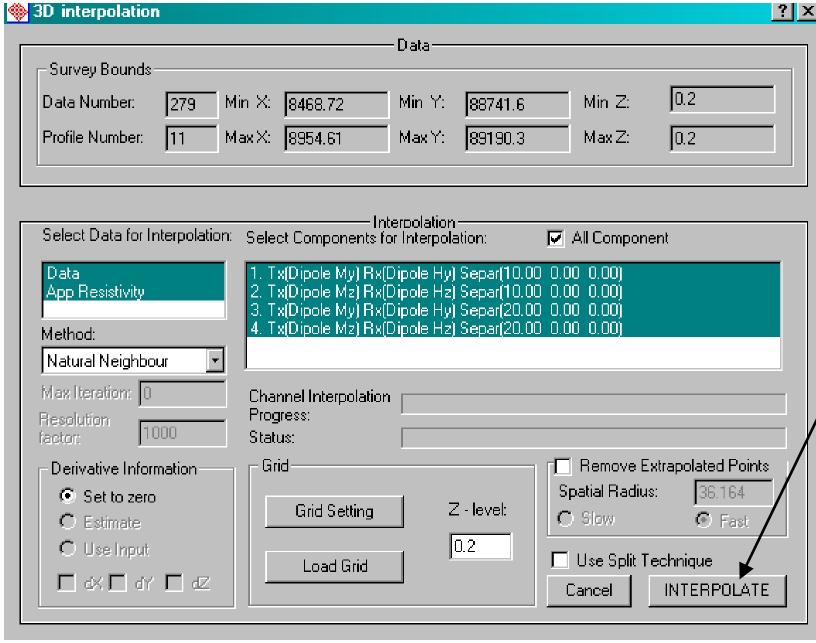


Select Components

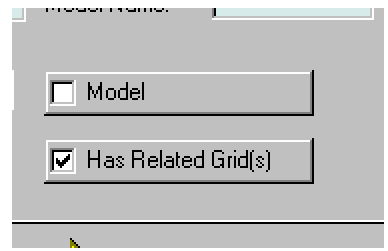


Set Grid Settings

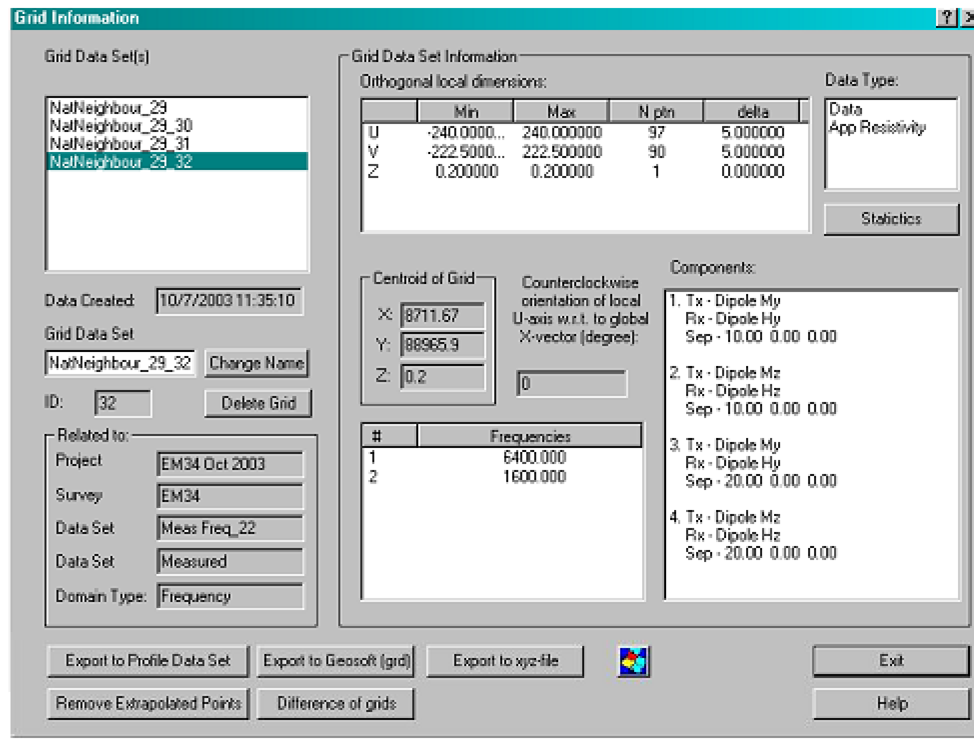
Gridding data - 2



Interpolate to Grid

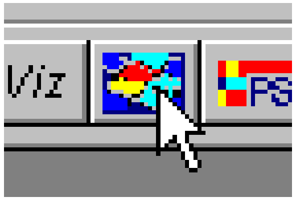


View Grids

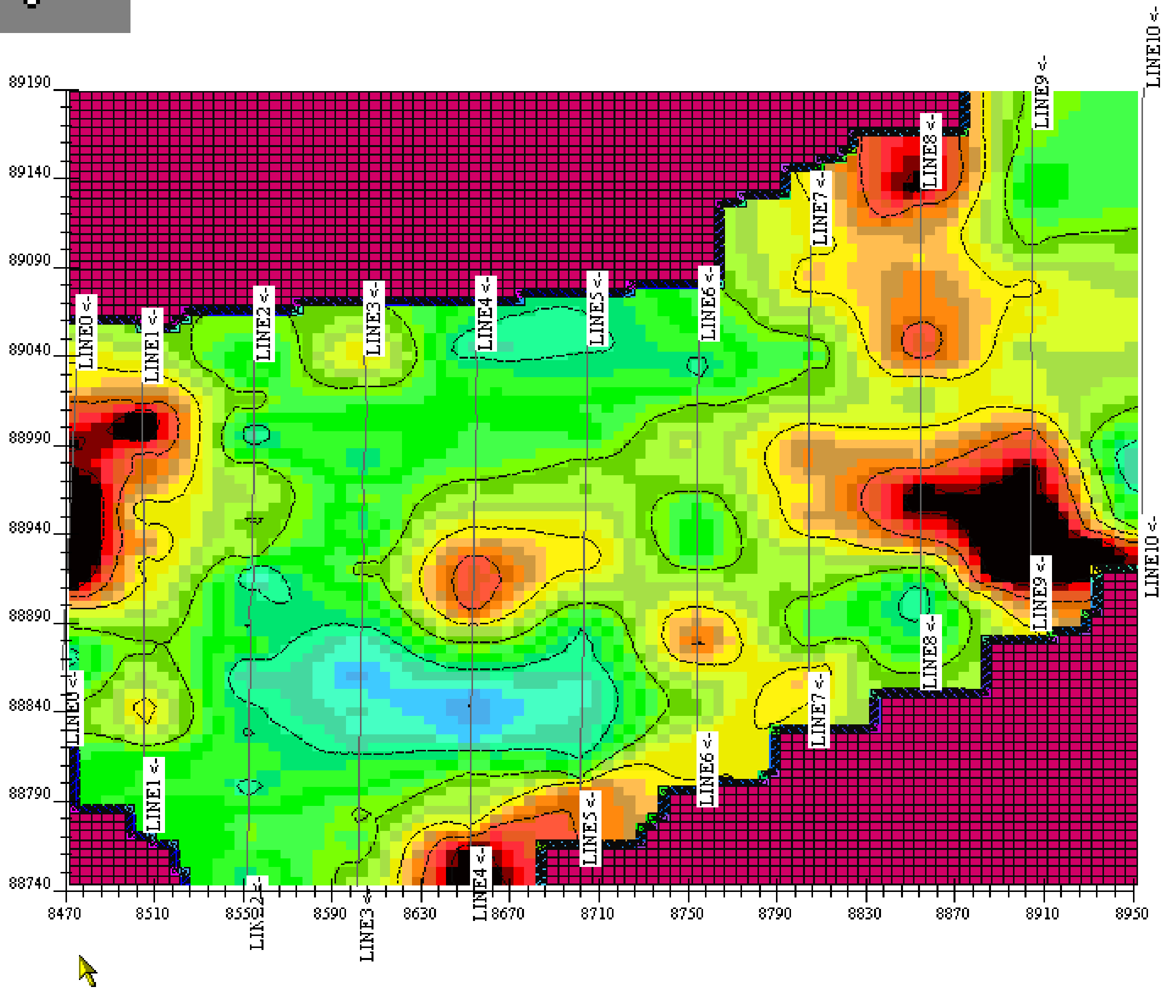


View Grid Characteristics

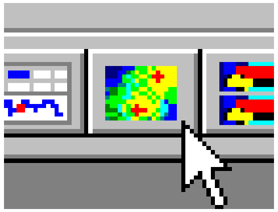
Viewing Gridded Data - 1



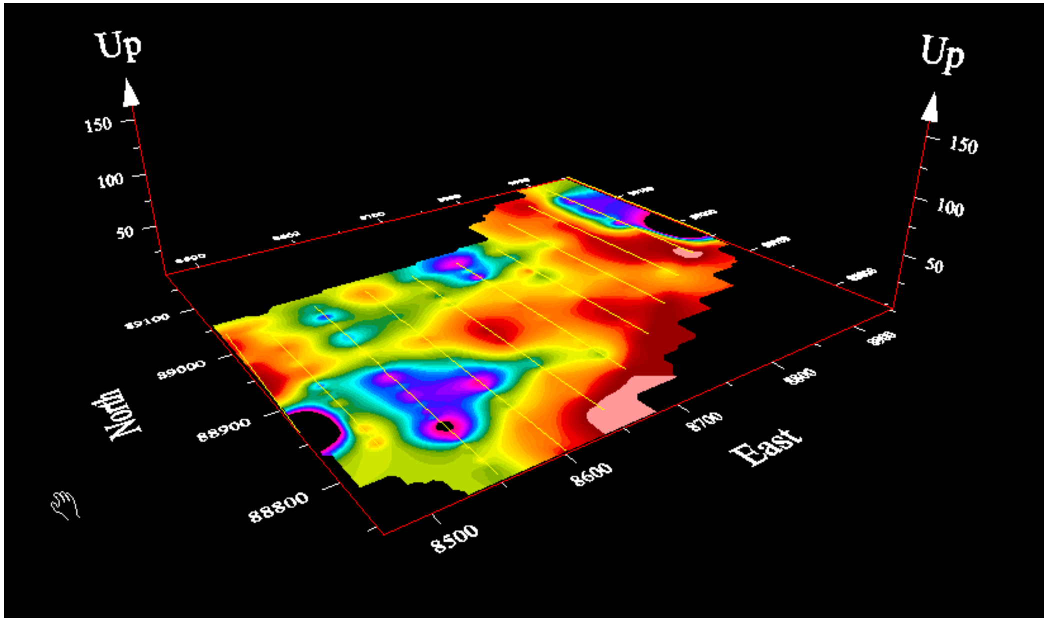
Grid Presentation



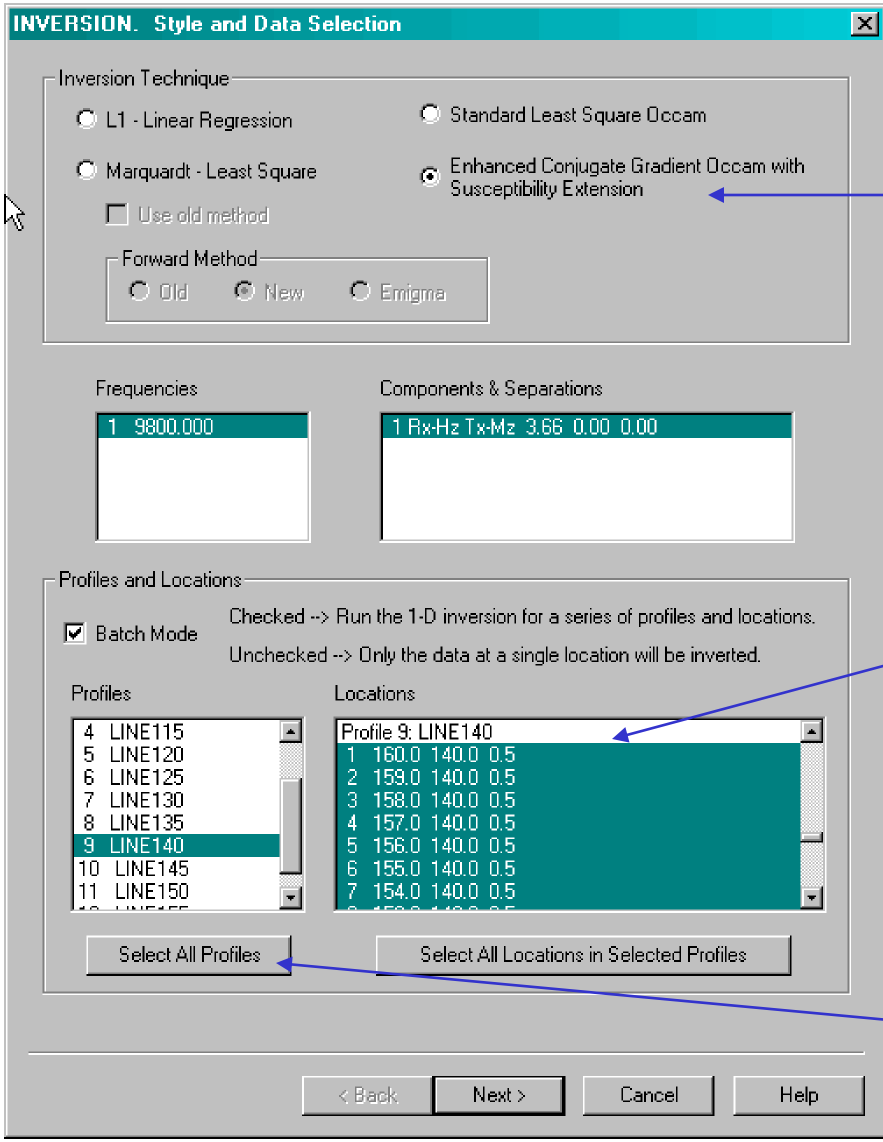
Viewing Gridded Data - 2



Contour



1D FEM Inversion - 1

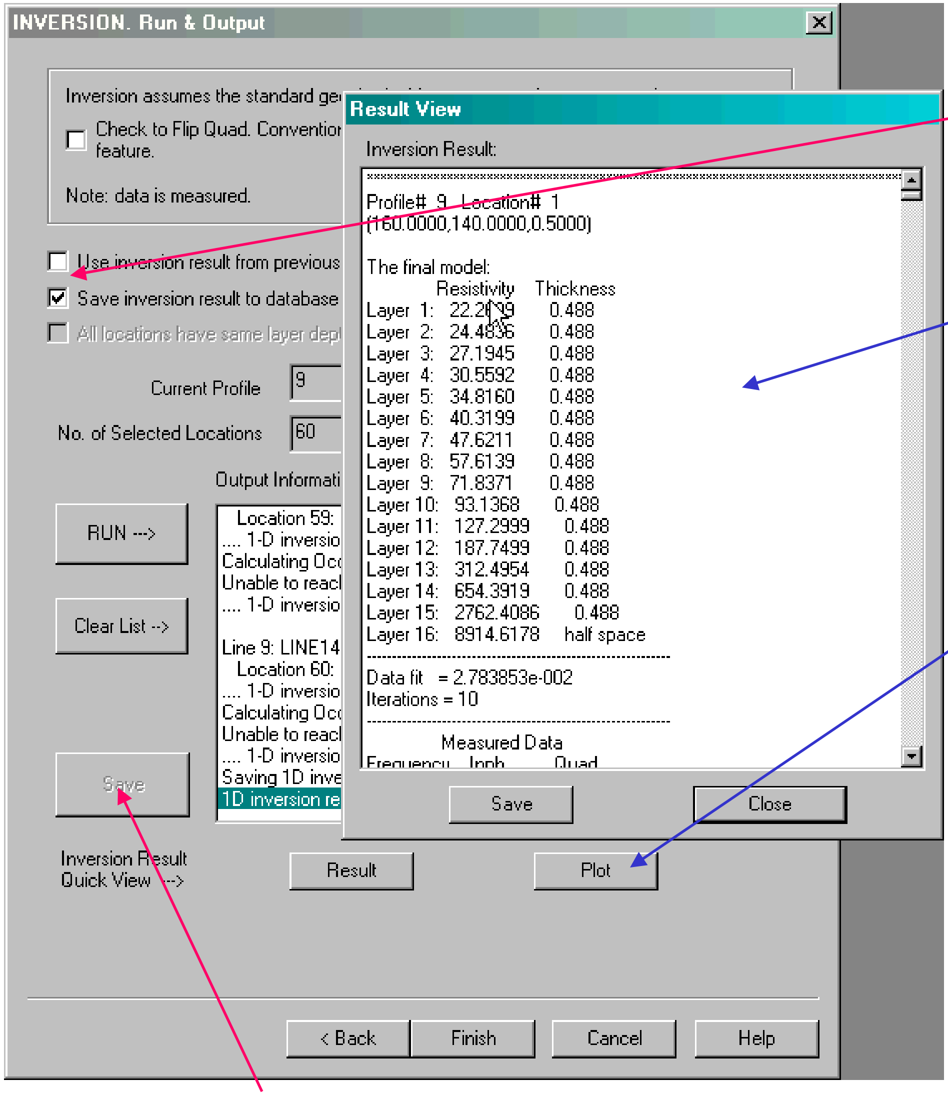


Optimized conjugate-gradient or Occam, Linear Regression and Marquardt

data points for selected profile

Invert single profile or All profiles

1D FEM Inversion - 2



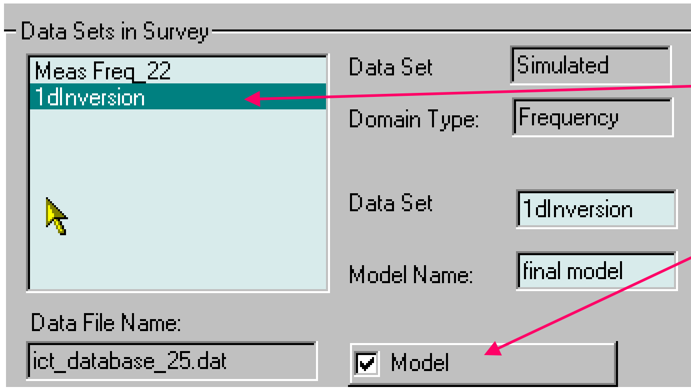
automatic save to database

contents of *.mod file point by point information

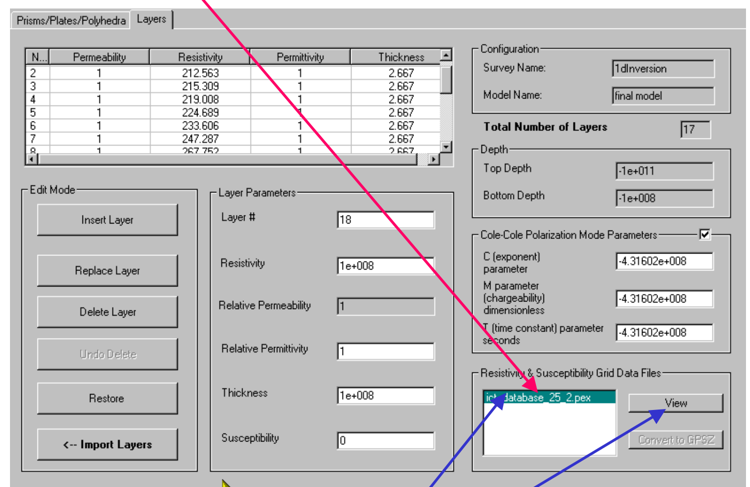
Single line depth contour available only for single line inversions

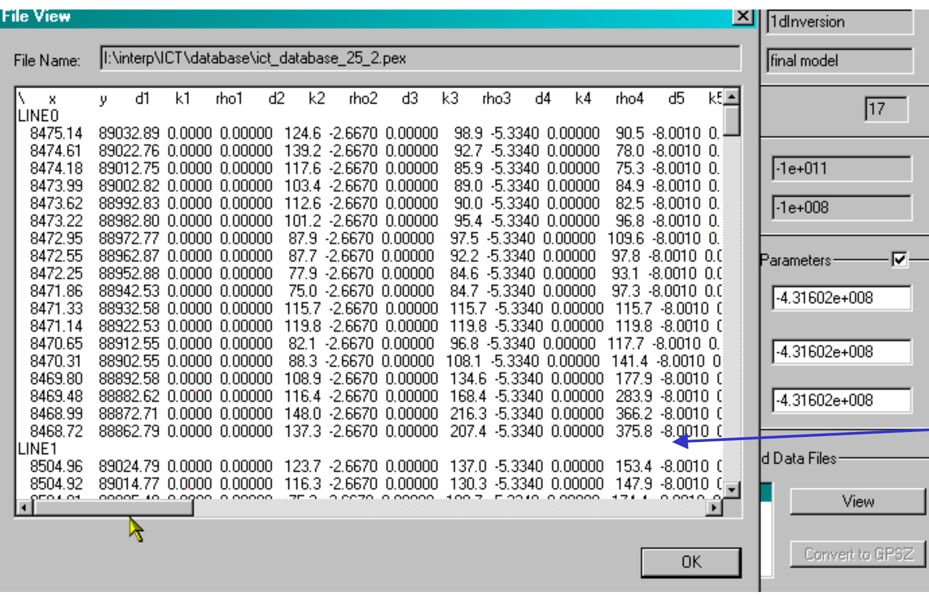
Save to database after completion

1D FEM Inversion - 3



inversion results saved to database contains synthetic data under the model with the model attached – (*.pex)



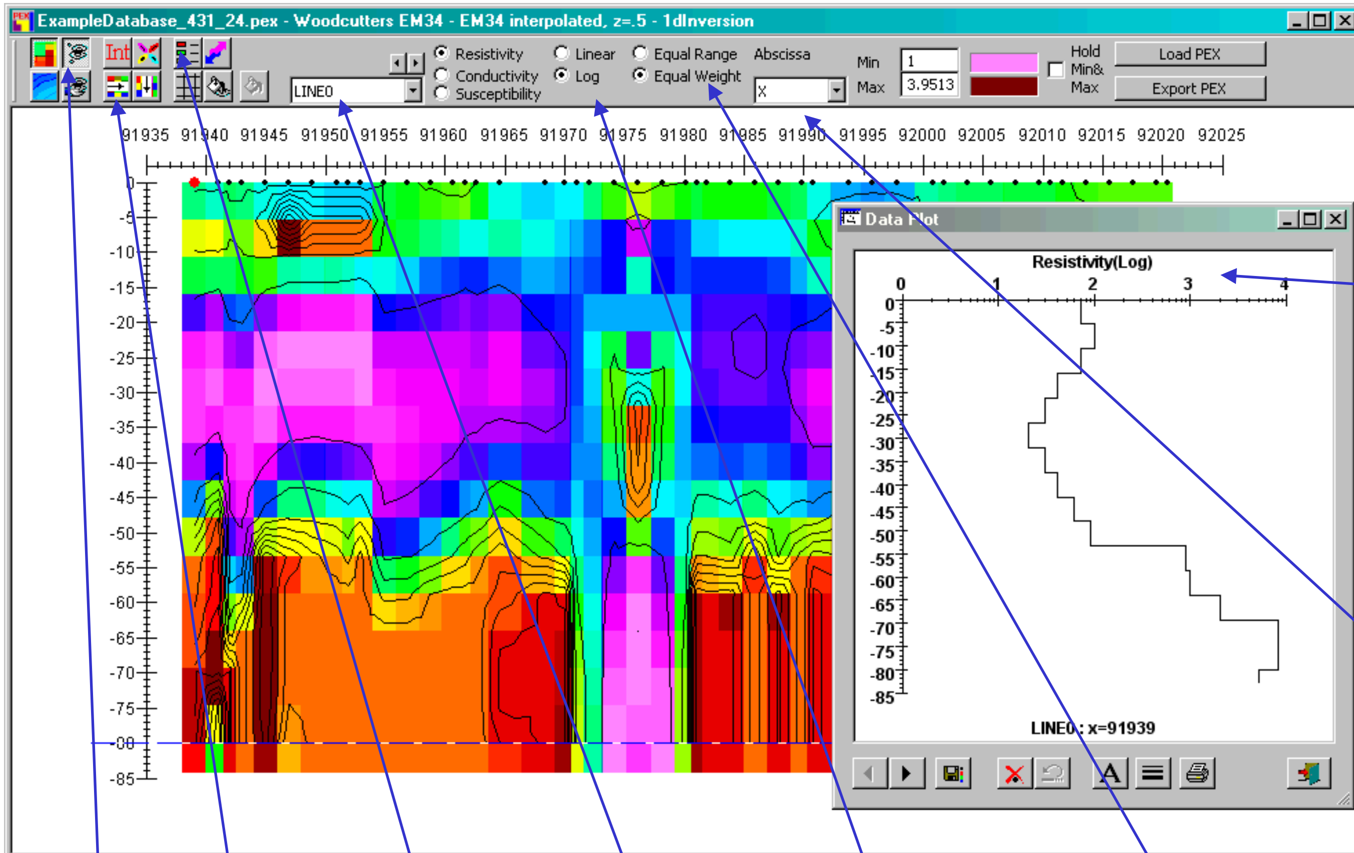


The *.pex file is a columnar ASCII file inside your database directory

Use CDI Viewer for viewing models

1D FEM Inversion - 4

CDI Viewer



Plot of Resistivity vs. Depth for single point

Horizontal Axis selection

Apply Contour

Legend

Model Units

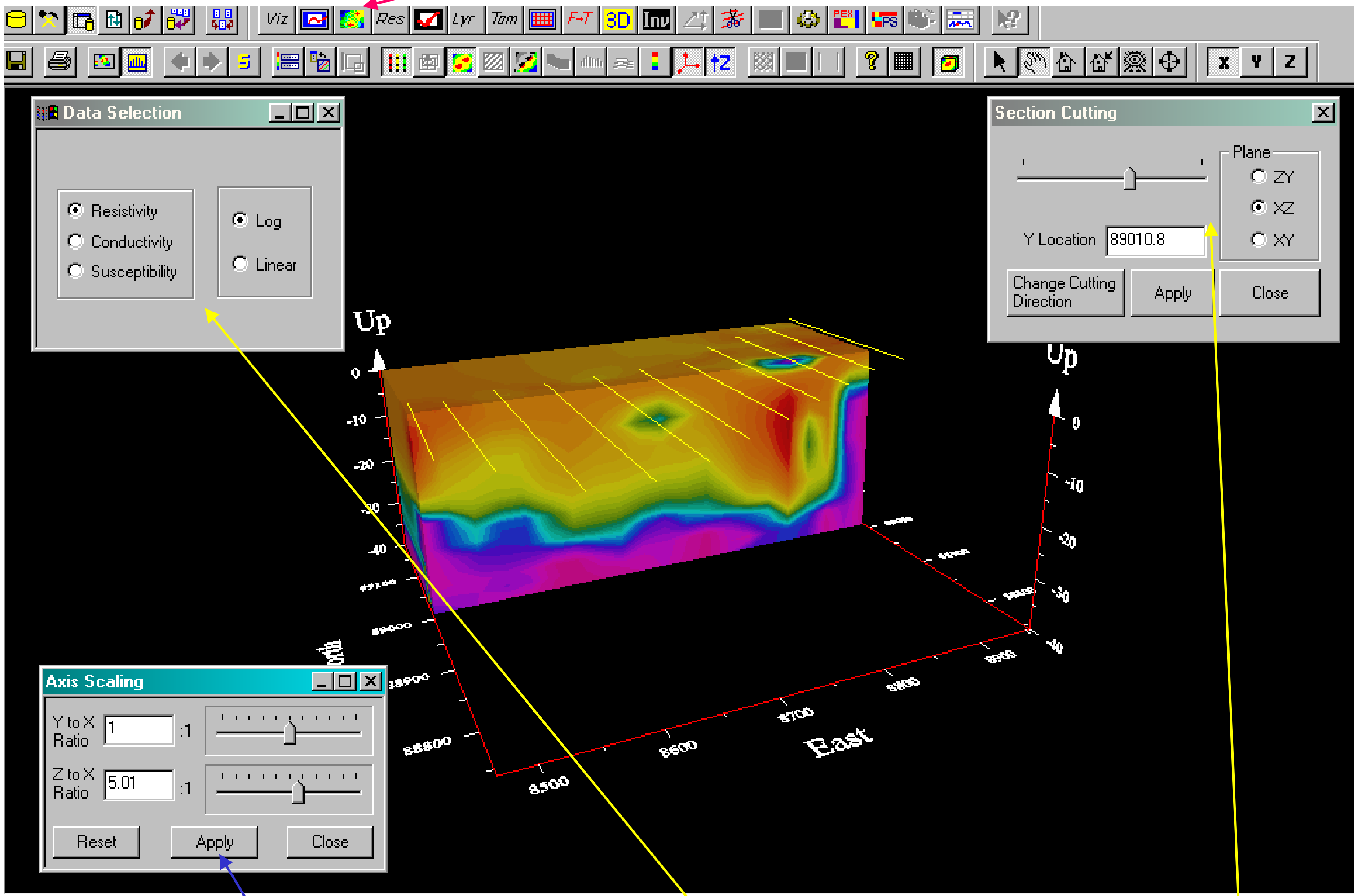
Colour Distribution
Equal Range – intervals equal
Equal Weight – distribution equal

Select Line

2D Interpolation

1D FEM Inversion - 5

3D Volume Contour (with Inversion model dataset selected)



Axis Scaling **Model Units** **Section Cutting**