

1D MT INVERSION TUTORIAL

Steps:

Page

1. Data organization and import

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2. Examine data through plots and Survey Editor

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3. Perform initial modeling

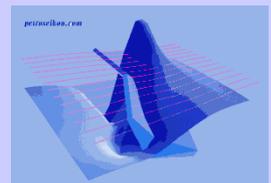
19

4. Perform controlled inversions

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5. Inversion evaluation

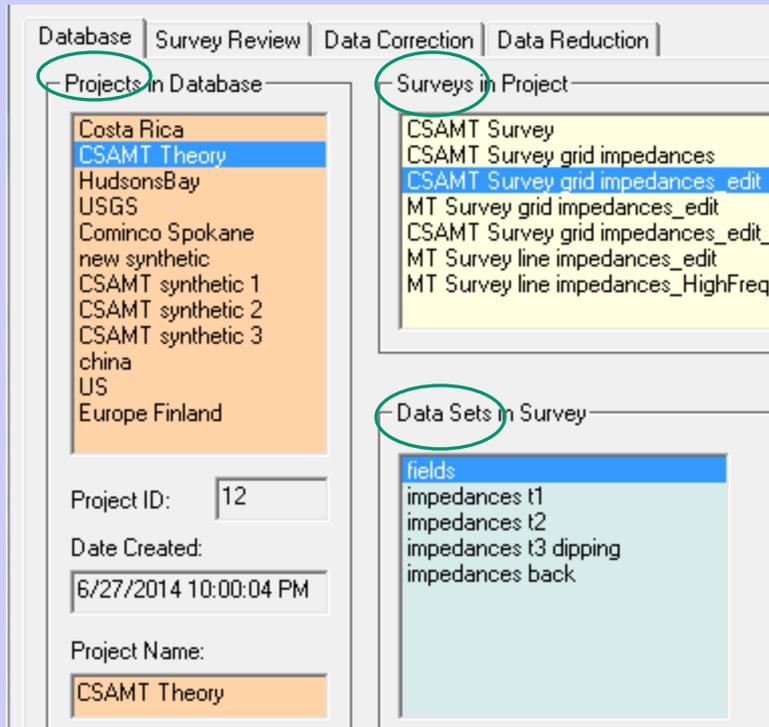
30



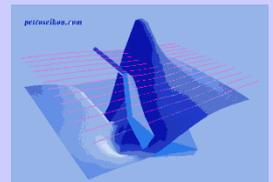
1. Data organization and import

2. Examine data
3. Perform initial modeling
4. Perform controlled inversions
5. Inversion evaluation

The data in EMIGMA is organized into Projects, Surveys and Data Sets.



Across the top, there are four tabs, *Database* (view shown above), *Survey Review*, *Data Correction* and *Data Reduction*, as discussed on the next page.



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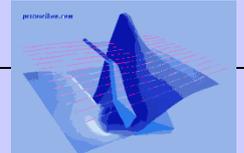
Database – Organizes the data into Projects, Surveys and Data Sets. For each data set, any corresponding models and grids are also shown (if the appropriate ‘model’ or ‘grid’ button is checked)

Survey Review - Allows the user to review the lines and data points. Data sorting, filtering and profile name modification options are available.

Data Correction – Enables the user to delete points and components. The user can also modify values in a number of ways such as applying a shift, multiplication by a factor, inverting the sign, etc.

Data Reduction – Allows the user to reduce entire data sets (measured or simulated) in a single operation

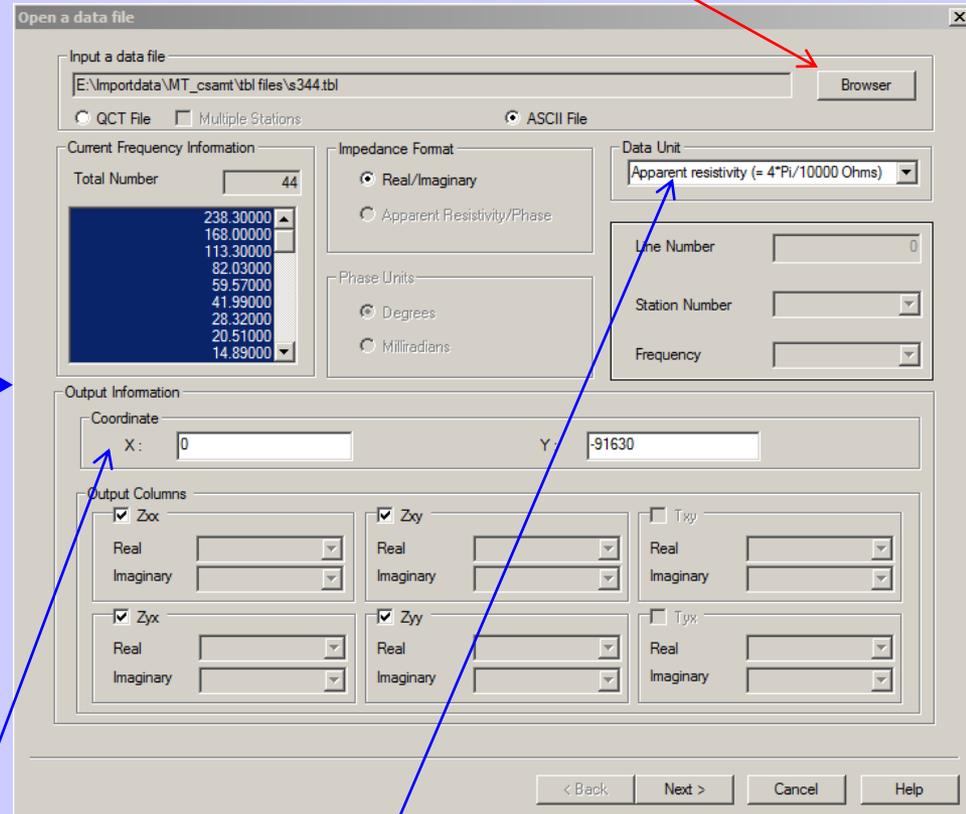
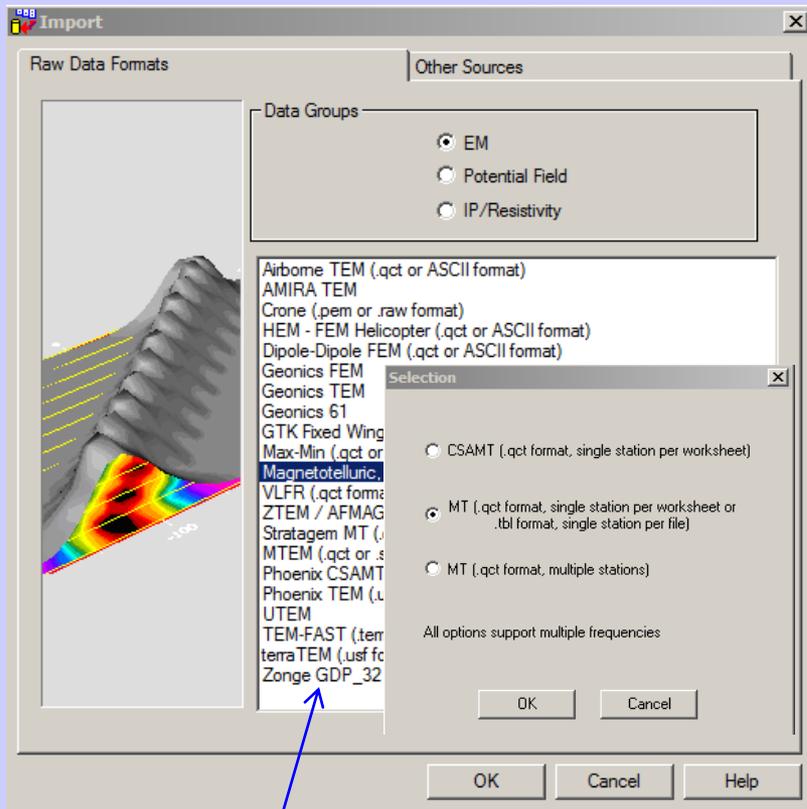
For a detailed description of each feature, please refer to the EMIGMA Manual.



1. Data organization and import

2. Examine data
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Browse and select .qct or .xyz data file for import



You can also import MT data through Zonge import

Set coordinate information and data unit (real/imaginary or apparent resistivity/phase). The data stored in EMIGMA is in real and imaginary. If you select apparent resistivity/phase, they will be converted.

1. Data organization and import
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The screenshot shows the 'Import data to EMIGMA Database' dialog box. The 'Project and Survey information' section contains the following fields:

Field	Value
Project Name :	default
Survey Name :	s344_344
DataSet Name :	Meas MT

The 'System Configuration' dialog box is open, displaying the following settings:

Parameter	Value
Declination of the E polarization (in degrees)	0
Declination of the H polarization (in degrees)	90
Declination of the Receiver X axis (in degrees)	90
Length of the first E field dipoles (in m)	50
Length of the second E field dipoles (in m)	50

The 'Finish' button at the bottom of the main dialog is highlighted with a red arrow.

Click “Import” button and the “System Configuration” dialog will appear. Make configurations according to your system and click “OK” button to start importing.

When running a simulation, the polarization 90 degrees from the one given here is also computed (both are necessary to calculate all four elements of the matrix), but only this one is saved.

After processing is finished, click “Finish” button to complete the import procedure

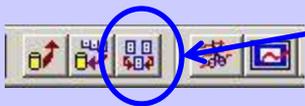
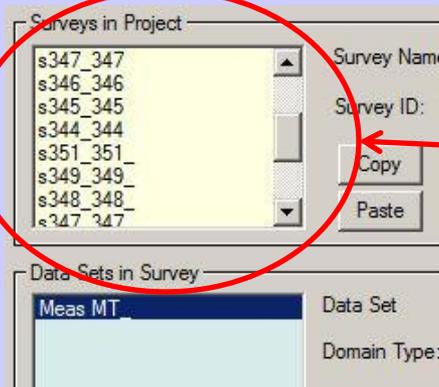
1. Data organization and import

2. Examine data
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Merge data from different datasets

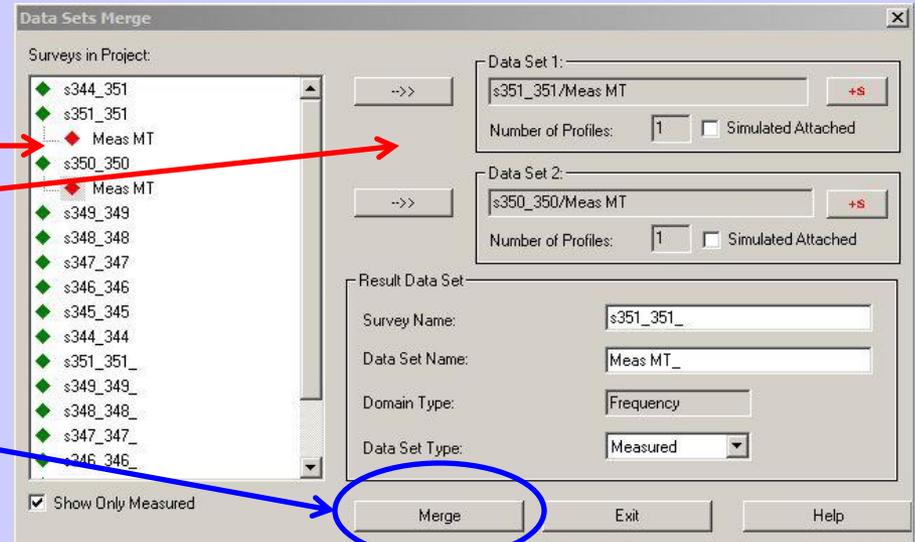
If your import files contain only one location per file as in this case, you have to import them separately as different datasets and merge them into one profile later.

Click “Merge Data Set” button to open the “Data Set Merge” dialog.



Select datasets to be merged from the table respectively, and add them to the right boxes.

Click “Merge” button to generate a new survey (in this case, named “s351_351_”) containing a new dataset (“Meas MT_”).



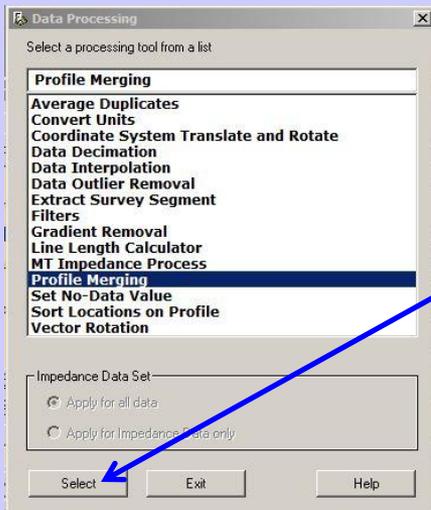
1. Data organization and import

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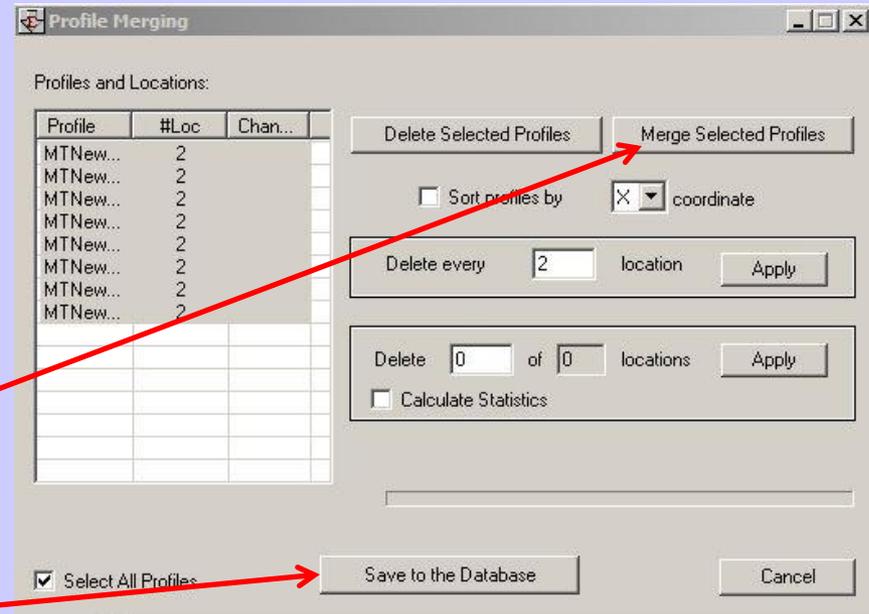
Merge profiles in the same dataset



Click “Data Processing and Filters” button to open the data processing dialog.



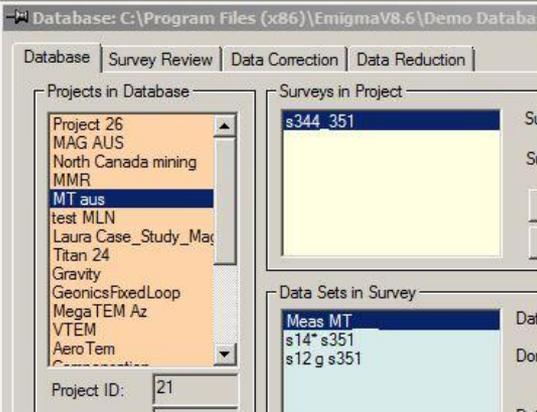
Select “Profile Merging” option and click “Select” button.



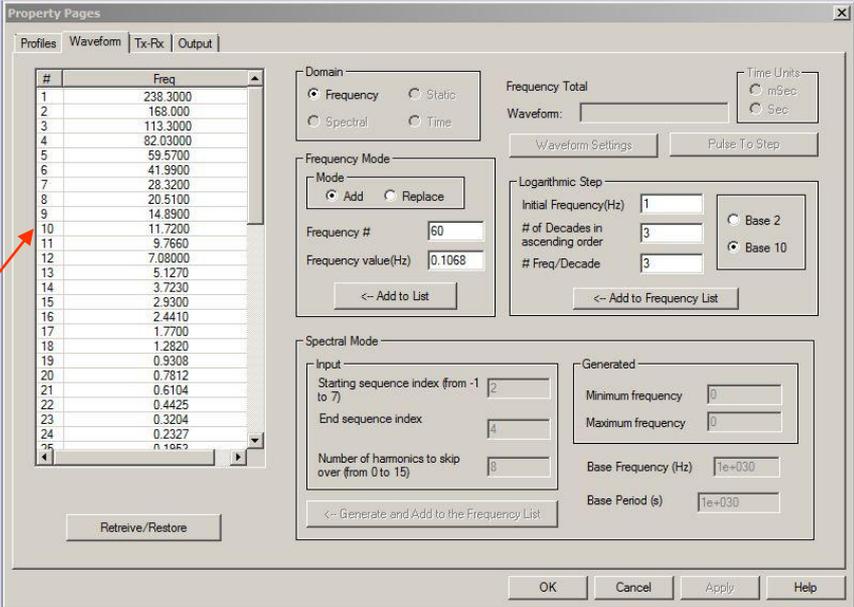
Select profiles to be merged from the dataset, and click “Merge Selected Profiles” button. All profiles will then be merged into one profile and saved into a new dataset by clicking “Save to the Database” button.

- 1. Data organization and import
- 2. **Examine data**
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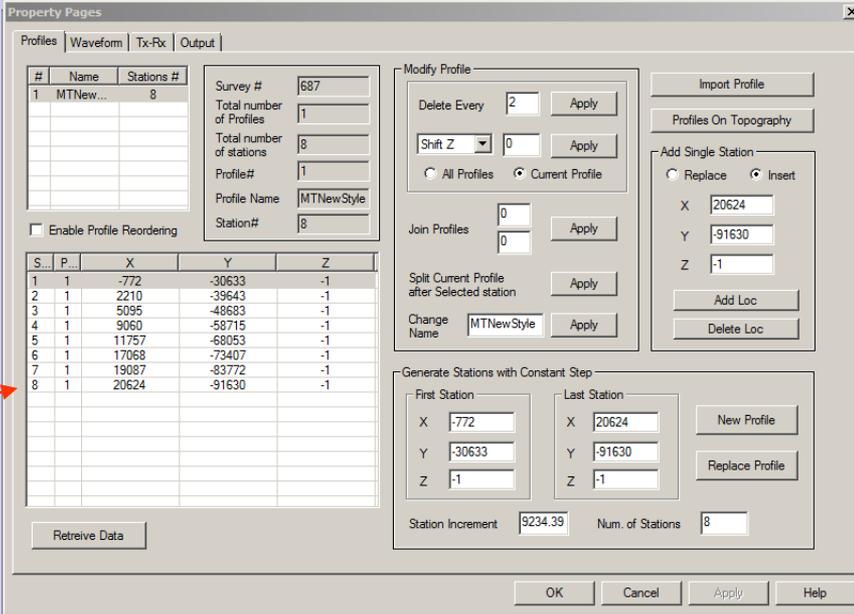
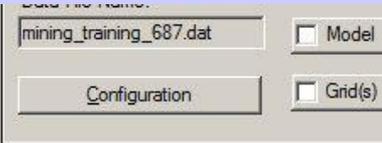
1. Check database for the survey



3. Check frequencies



2. Click configuration



4. Check lines and stations for their correctness

- 1. Data organization and import
- 2. Examine data**
- 3. Perform initial modeling
- 4. Perform controlled inversions
- 5. Inversion evaluation

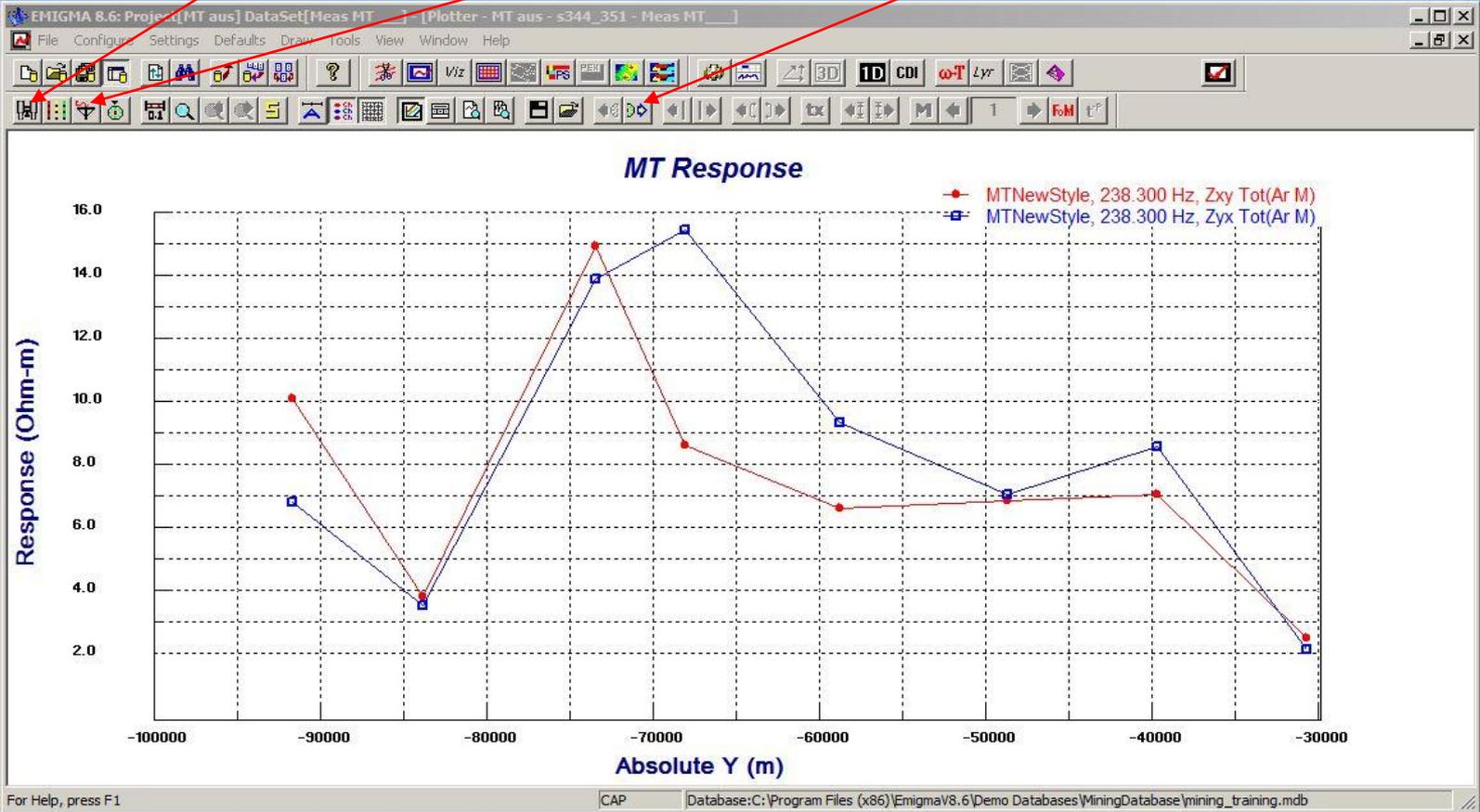


Click "Plotter"...

Load data set in Plotter

Put into Spectrum mode

Toggle between frequencies

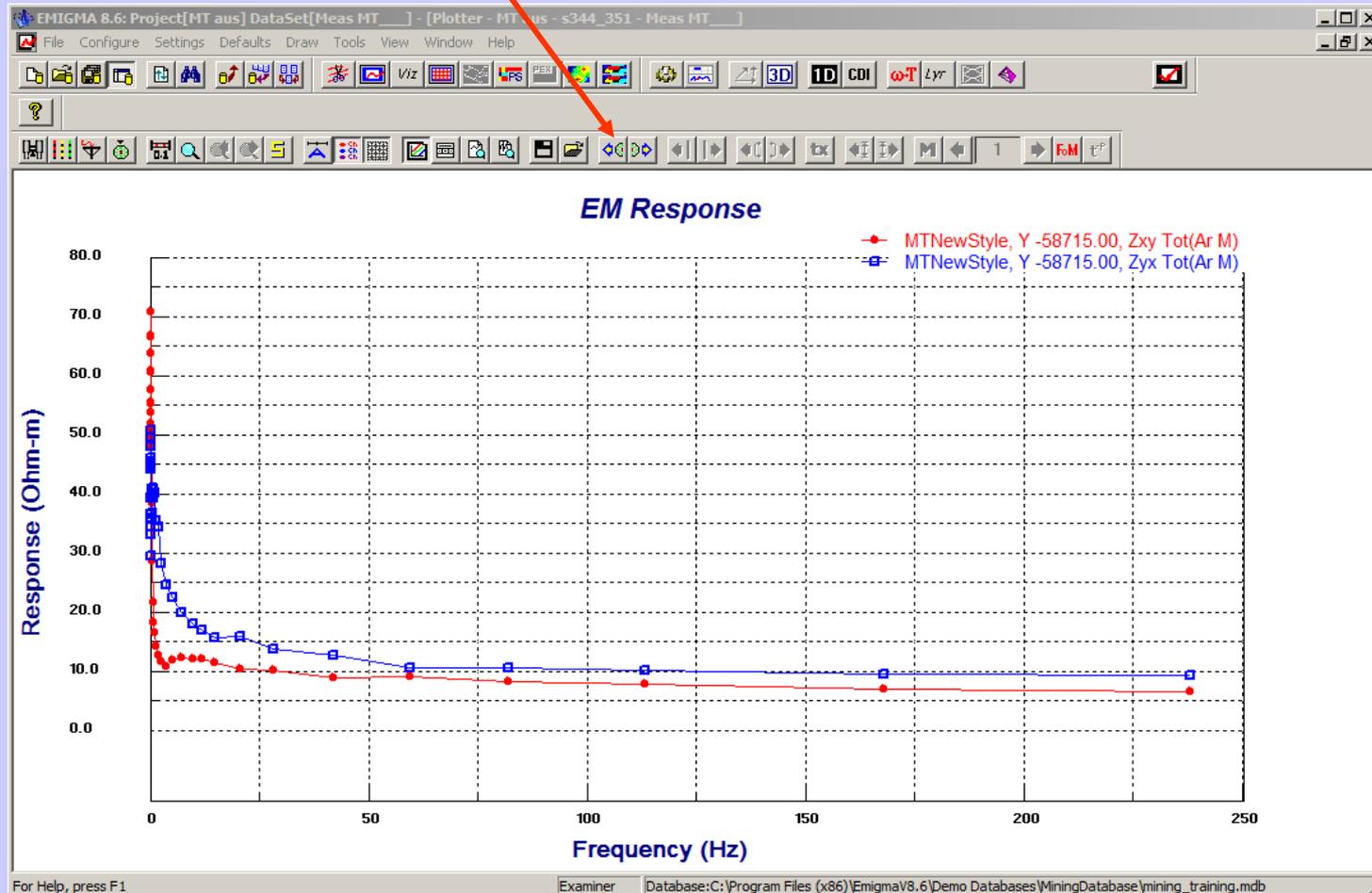


1. Data organization and import
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Click "Plotter"...

Toggle between stations



Spectrum

- 1. Data organization and import
- 2. **Examine data**
- 3. Perform initial modeling
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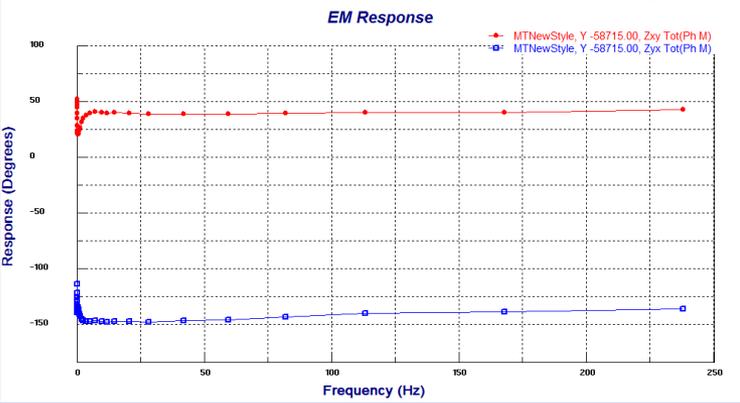


Click "Plotter"...

Click "Channels" button, and select "Field" in popup dialog

Check "Phase" option, and click "OK" to bring up the plot of phase

Phase



1. Data organization and import
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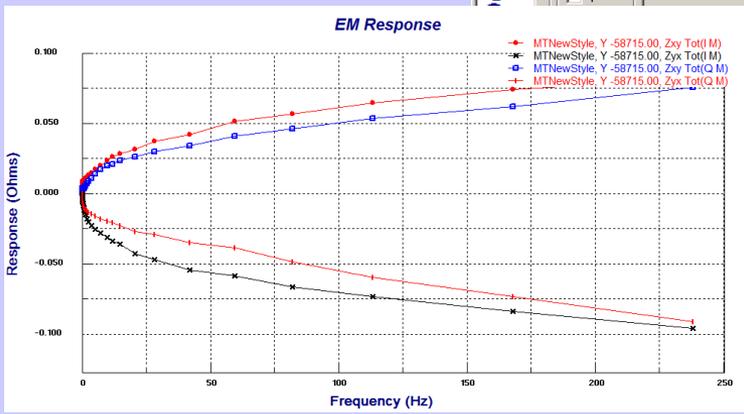
Click "Plotter"...

Click "Channels" button, and select "Field" in popup dialog

Check "Real" and "Imaginary" option, and click "OK" to bring up real/imaginary data plot

The screenshot shows the EMIGMA 8.6 software interface. The 'Channel Selection' dialog is open, showing a list of channels with 'Field' selected. The 'FM Response' dialog is also open, with 'Real' and 'Imaginary' options checked. The 'MT/CSAMT Tensor Selection' dialog is visible in the background, showing 'Meas MT' as the selected data set. The 'Response' section of the 'FM Response' dialog has 'Total' checked. The 'Phase Unit' is set to 'Degree'. The 'Z Rotation' is set to 0 degrees. The '2D Decomposition Features' section has 'Rotational Angle' and 'Skew Angle' unchecked. The 'Principal Impedances' section has 'Zxy' and 'Zyx' unchecked.

Real/Imaginary data



- 1. Data organization and import
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Click "Plotter"...

If you want to observe one tensor element instead of two, check only the one you want in Impedance Tensor section and click "OK" button. You can also select more elements here.

Channel Selection

Plot #	Profile Position	Field
<input checked="" type="checkbox"/> 1	-48683.00	
<input type="checkbox"/> 2		
<input type="checkbox"/> 3		
<input type="checkbox"/> 4		
<input type="checkbox"/> 5		
<input type="checkbox"/> 6		
<input type="checkbox"/> 7		
<input type="checkbox"/> 8		

Position Display

X-Coor Y-Coor Z-Coor

Depth Pos # Profile dist

Fiducial Keep Settings

Data Kind: Data

Phasor

Real Imaginary

Element

Impedance Tensor

Zxx Zxy Z ave

Zyx Zyy Z det

Z Rotation (in degrees): 0

Response

Total Incident

Profile(s) Available: 1

2D Decomposition Features

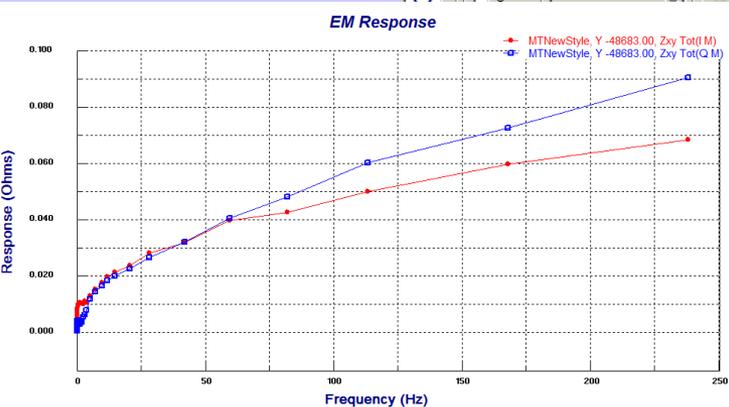
Rotational Angle Skew Angle

Principal Impedances

Zxy Zyx

OK Cancel Help

Real/Imaginary data



1. Data organization and import
2. **Examine data**
3. Perform initial modeling
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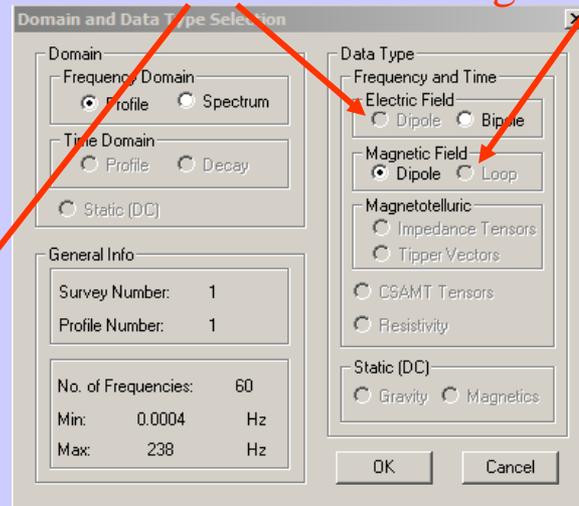
Click "Plotter"...

Select whether you want to view electric field or magnetic field

From here, we use the example of simulated dataset (s14*s352) in the same survey

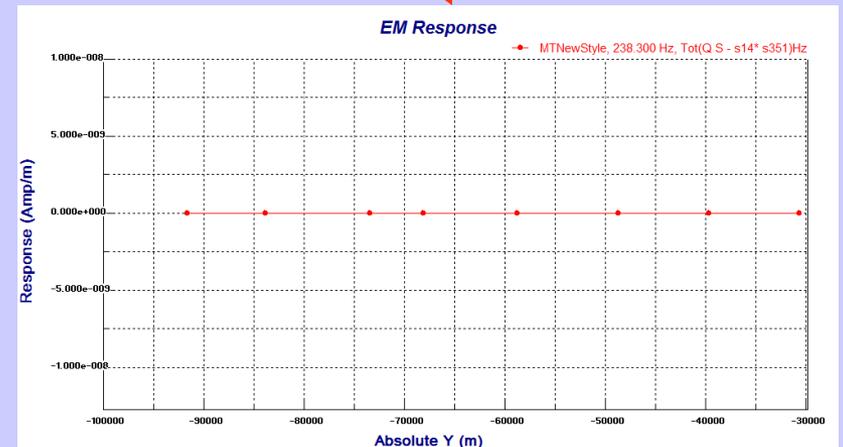
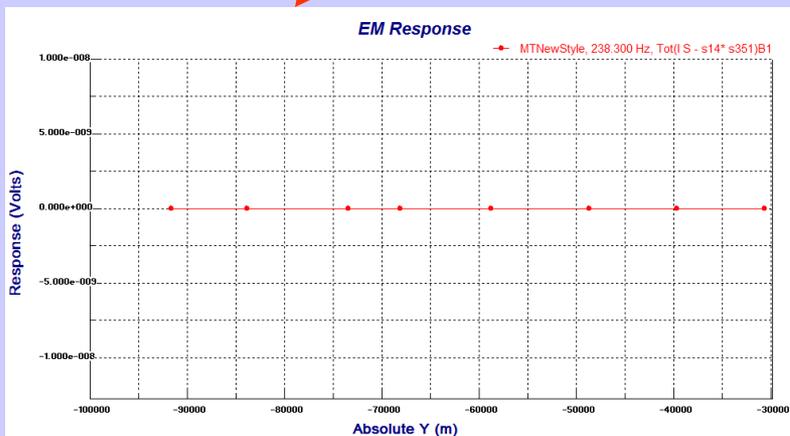
Show IMPEDANCE Data Sets in Survey

Uncheck this option to show field data, please note field data can only be shown for simulated dataset



E field

H field

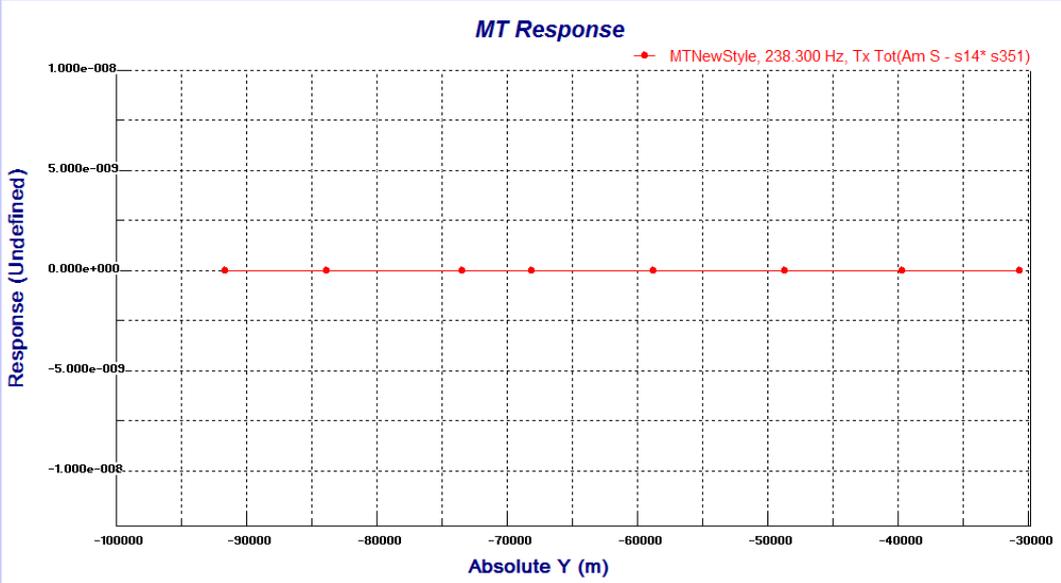
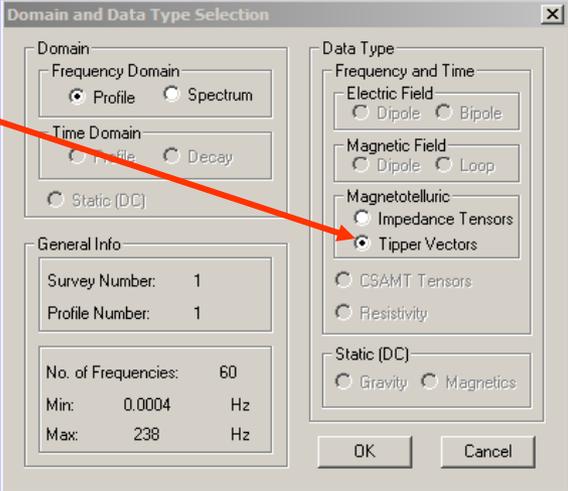


- 1. Data organization and import
- 2. Examine data**
- 3. Perform initial modeling
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- 5. Inversion evaluation



Click "Plotter"...

To observe tipper data, select "Tipper Vectors" option and click "OK"



Tipper data

1. Data organization and import
2. **Examine data**
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5. Inversion evaluation



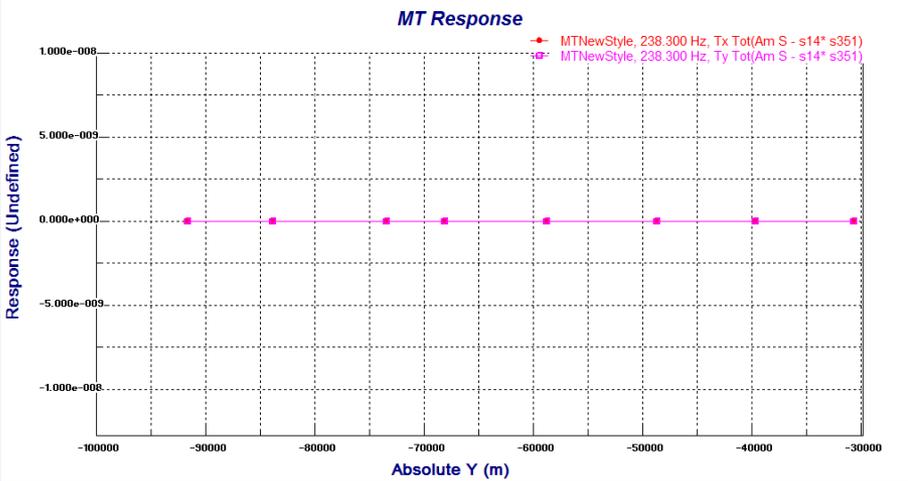
Click "Plotter"...

To observe both Tx and Ty tipper data:

The screenshot shows the 'MT/CSAMT Tensor Selection' dialog box with the following settings:

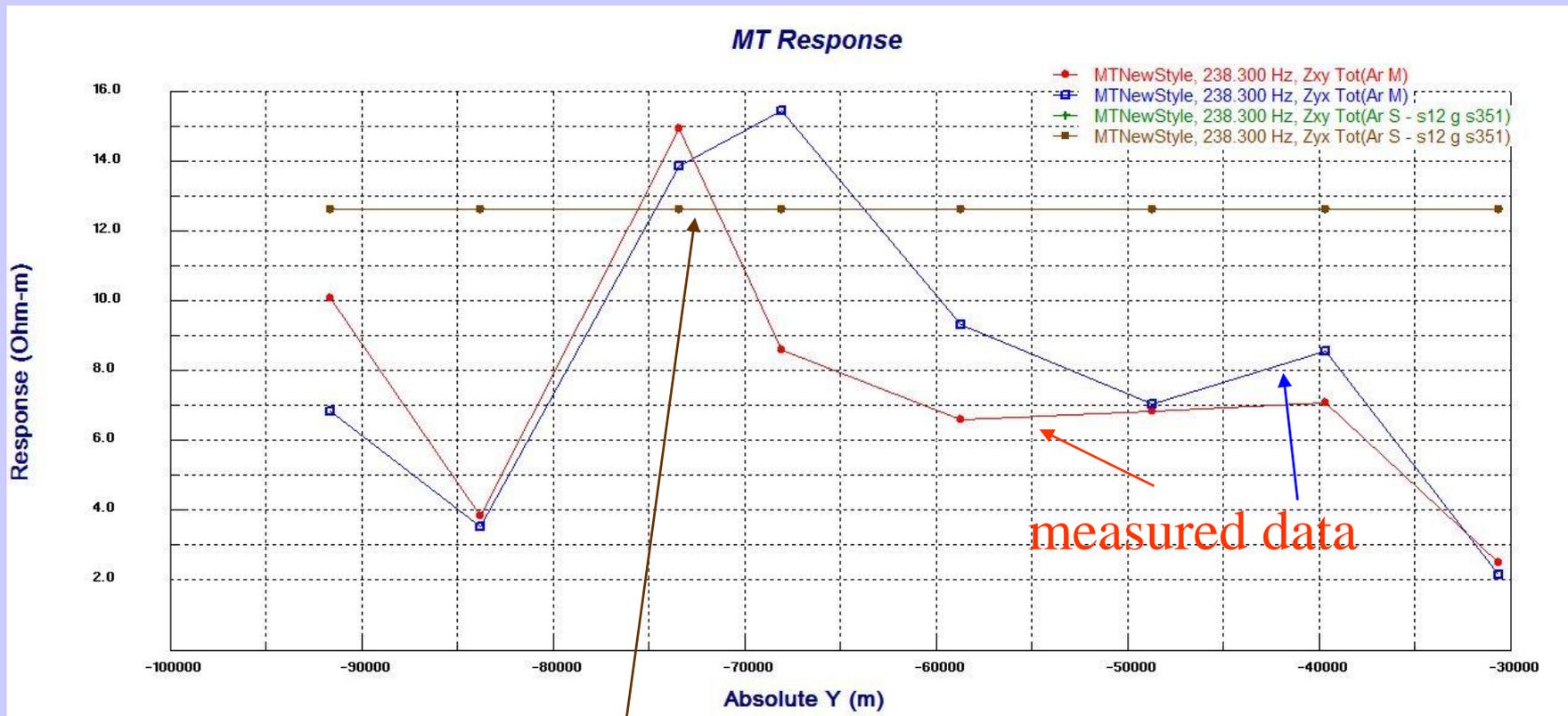
- Available Data Sets in Survey: s14* s351 Imped
- Phasor: Amplitude
- Element: Tipper (with Tx and Ty selected)
- Response: Total
- Phase Unit: Degree

Tipper data



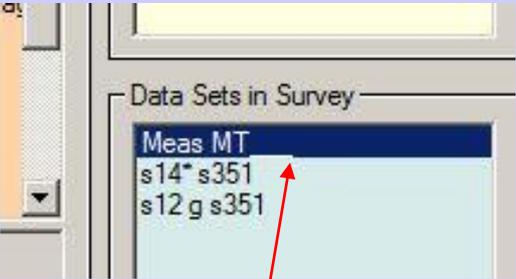
1. Data organization and import
2. Examine data
3. **Perform initial modeling**
4. Perform controlled inversions
5. Inversion evaluation

Note: Performed some initial modeling to get a “feel” of the background resistivity and estimate parameters of initial model for inversion.

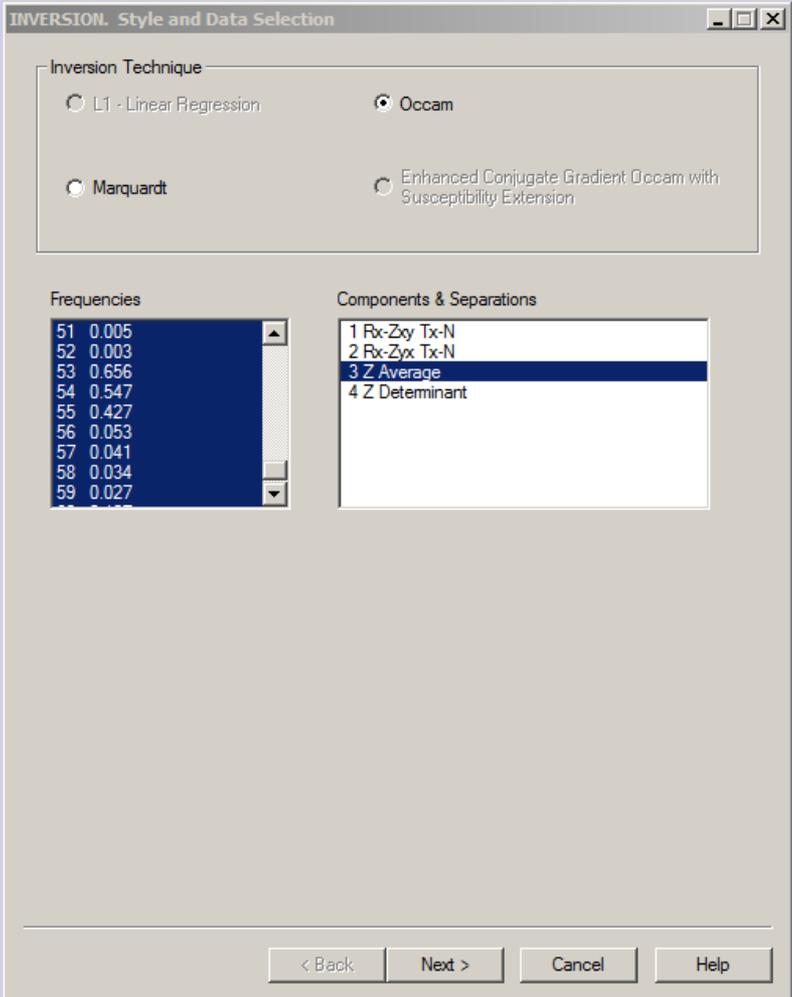


simulated data with a forward model

- 1. Data organization and import
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform controlled inversions**
- 5. Inversion evaluation



Select survey data



1. Data organization and import
2. Examine data
3. Perform initial modeling
- 4. Perform controlled inversions**
5. Inversion evaluation

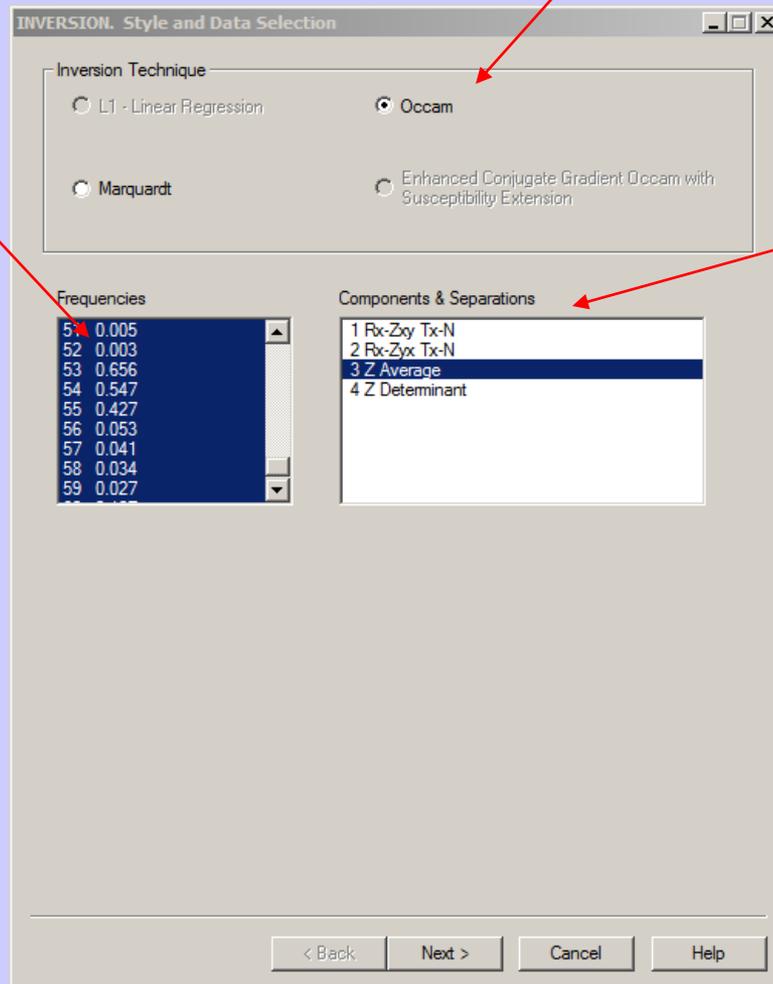
Inversion style

Occam: keep the layer thickness fixed and only inverse for resistivity

Marquardt: inverse for both layer thickness and resistivity

Select frequencies to be inverted.
 Note: the maximum number of frequencies for an inversion is 50.

Select components used for inversion



1. Data organization and import
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Create a Starting Model

Generate a Starting model:

Select how many layers in total that you would like in the model, set the initial resistivity and thickness. Then click “Apply” button.

Insert a layer:

Set resistivity and thickness of the layer and check “Insert” radio. Select one layer from the table and click “Add to List” button. The new layer will be added below the selected one.

Editing Starting model:

After making a starting model (whether by importing or generating), the user may edit either the resistivity or the thickness of the layer. Simply click on the parameter and make change at “Resistivity” and “Thickness” boxes above the table. Select “Replace” option and click “Add to List” button. The user may also join two adjacent layers by selecting one layer and clicking “Join Layers” button to merge this one with the layer below.

Import Layers:

If you already have a forward model that you like to use, you may import it as the starting model by clicking “Import” button and select from appeared dialog.

INVERSION. Starting Model

Set a layered starting model for inversion. The model consists of several layers over a half space with resistivity and thickness defined for each of them.

Note: the model does not include the upper half space (i.e. the air).

Generate uniform layering

Total layers above half space (maximum 50 layers) Resistivity

Total thickness above half space Susceptibility

Inversion Parameters

Resistivity Susceptibility Joint

Insert Replace

Layer #	Resistivity	Susceptibility	Thickness
16	100	0	1e+008
1	1.000e+002	0.000e+000	3.333e+002
2	1.000e+002	0.000e+000	3.333e+002
3	1.000e+002	0.000e+000	3.333e+002
4	1.000e+002	0.000e+000	3.333e+002
5	1.000e+002	0.000e+000	3.333e+002
6	1.000e+002	0.000e+000	3.333e+002
7	1.000e+002	0.000e+000	3.333e+002
8	1.000e+002	0.000e+000	3.333e+002
9	1.000e+002	0.000e+000	3.333e+002
10	1.000e+002	0.000e+000	3.333e+002
11	1.000e+002	0.000e+000	3.333e+002

Join the selected layer with the following one.

Import a layer model

From previous inversion result From a dataset

Parameters to Invert

Allowed number

Selected number

< Back Next > Cancel Help

1. Data organization and import
2. Examine data
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5. Inversion evaluation

Model and Simulation Parameters Settings

INVERSION. Parameters Settings

Data Type

Apparent Resistivity and Phase

Apparent Resistivity Only

Inversion Parameters

Max Iterations: 40

Target Misfit: 1e-005

Reset Default

< Back Next > Cancel Help

Data type:

Select type of data to inverted: Apparent Resistivity and Phase, or Apparent Resistivity Only.

Max. Iterations:

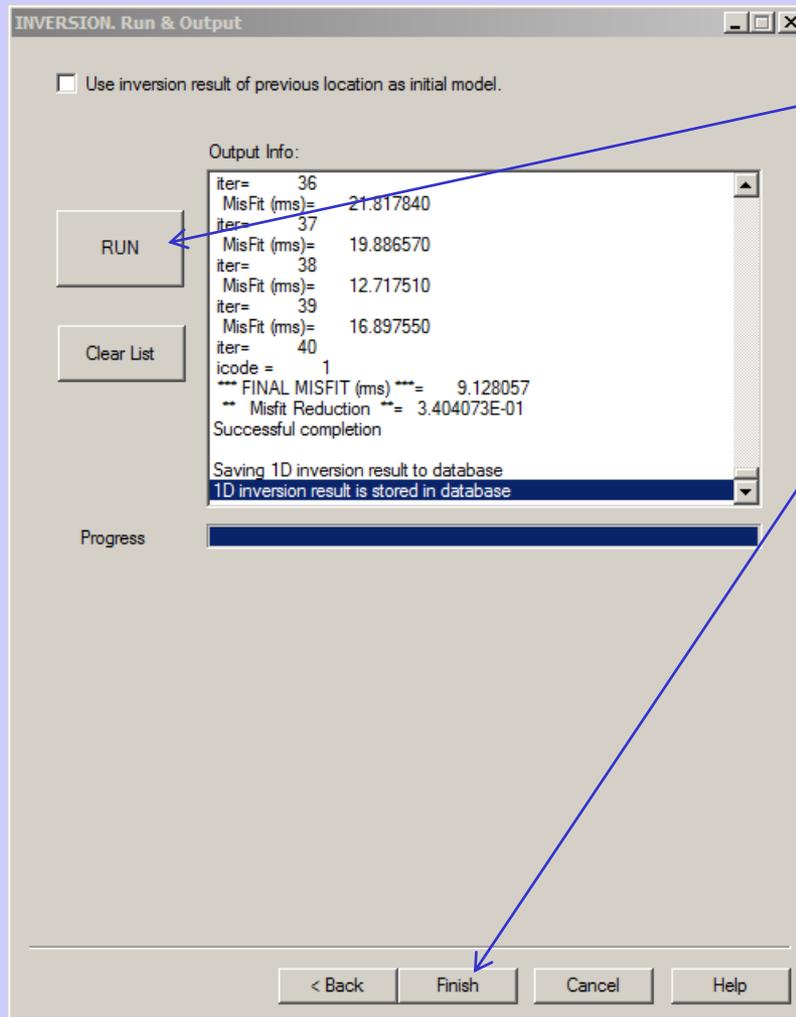
A higher value will help ensure accuracy but execution time will increase

Target Fit:

The residual between the simulated data under the best model and the measured data.

1. Data organization and import
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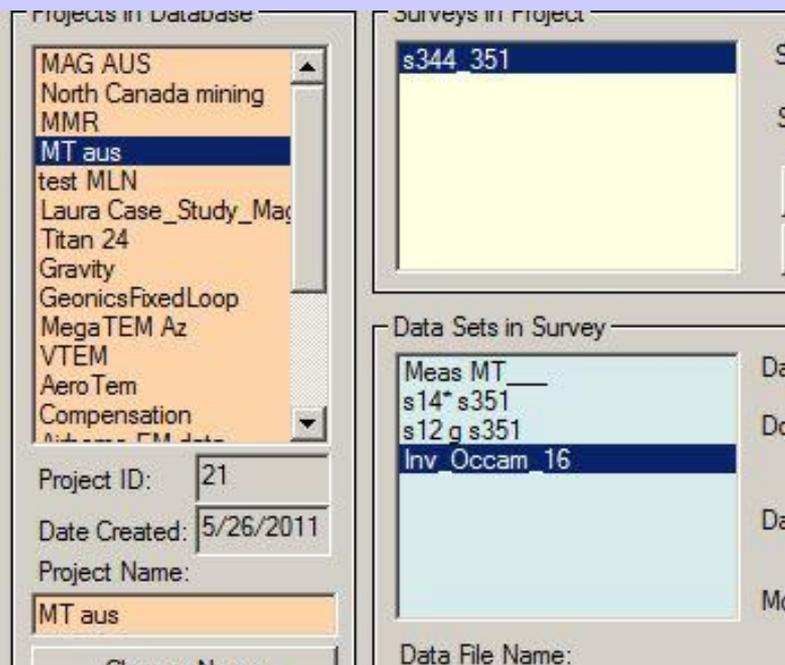
Executing the Inversion



Finally, click the “Run” button. The right window (in white) shows each data point’s progress. Click “Finish” button to complete inversion procedure.

1. Data organization and import
2. Examine data
3. Perform initial modeling
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- 5. Inversion evaluation**

Inversion Evaluation



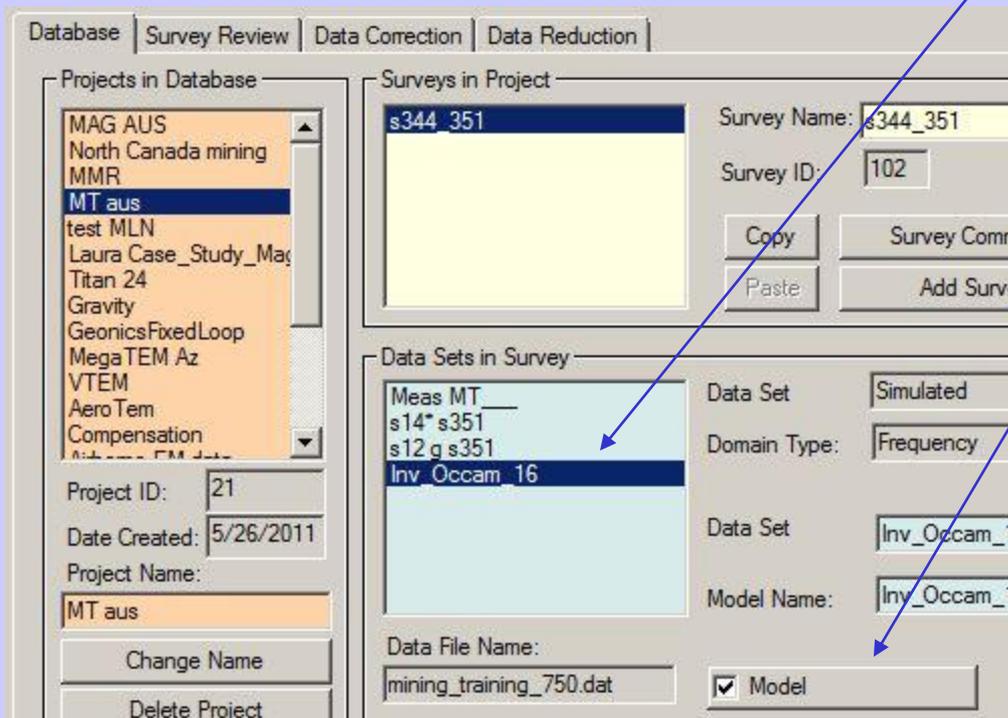
In each survey, there will be several data sets after modeling, inversion and processing. In this case, we have 2 half space models and 1 inversion. The forward model has a new data set containing the simulated data under the model. Similarly, each inversion contains a new dataset containing the simulated data set under the inversion model (for each point) and attached to that data set is the inversion model.

1. Data organization and import
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- 5. Inversion evaluation**

Inversion Evaluation

An inversion is selected. You will note the “Model” button is checked.

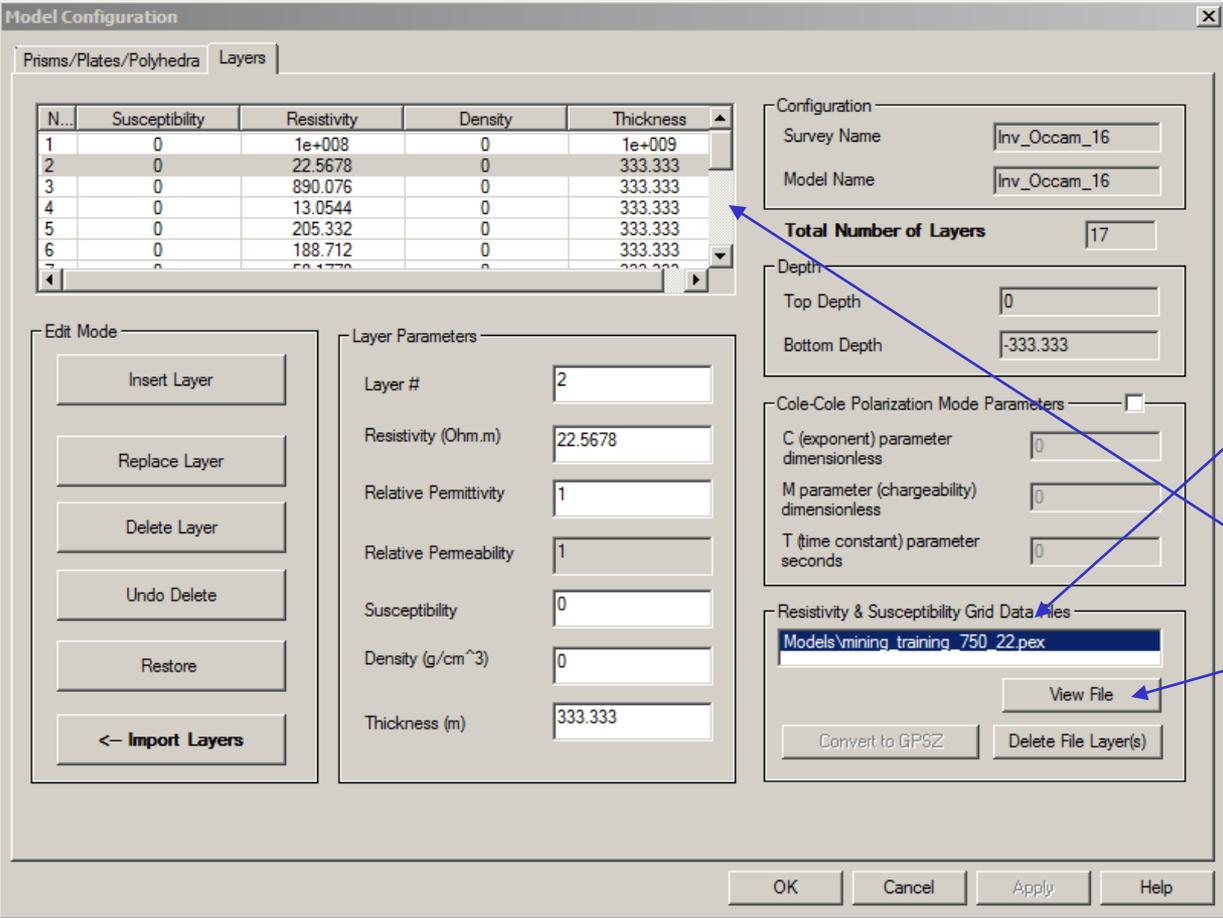
If the model button is clicked...



- 1. Data organization and import
- 2. Examine data
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- 5. Inversion evaluation**

Inversion Evaluation

a window will open



Attached to the database in a subdirectory called "Models" is the inversion results in a simple ASCII XYZ file (*.pex) which may be viewed here. This file may easily be imported to another application although graphical viewing tools are provided within EMIGMA.

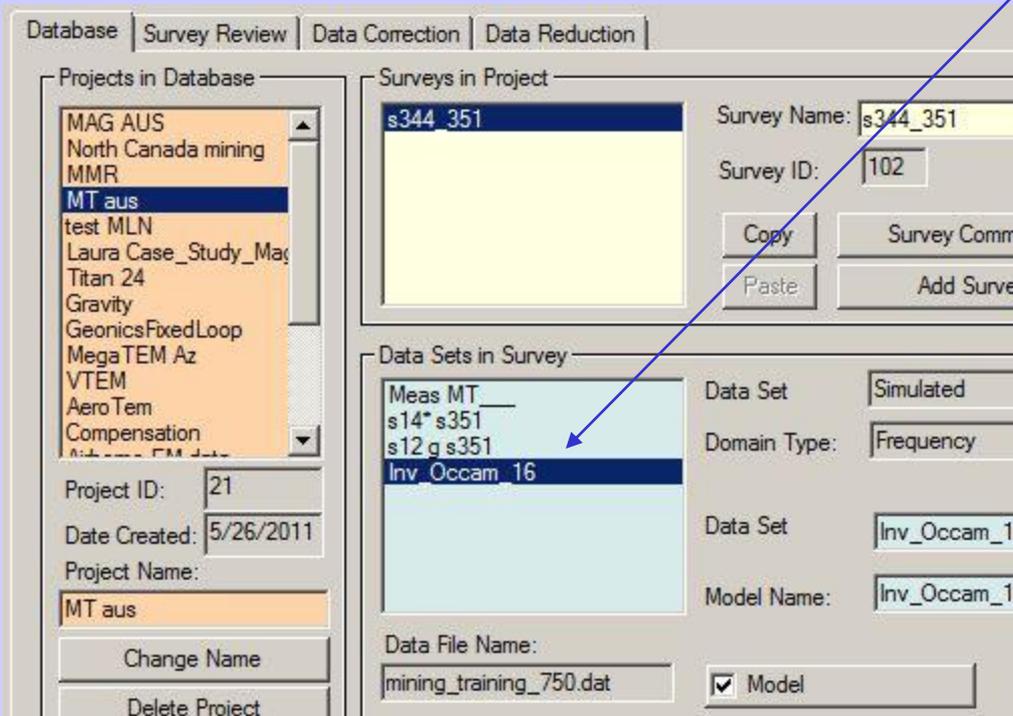
The 1D model for the final data point is also included.

Click "View File" button to view the data file of the saved 1D layered model.

1. Data organization and import
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Inversion Evaluation

Select the inversion.



Choose CDI Viewer to view a stacked section of the results

1. Data organization and import
2. Examine data
3. Perform initial modeling
4. Perform controlled inversions
5. **Inversion evaluation**

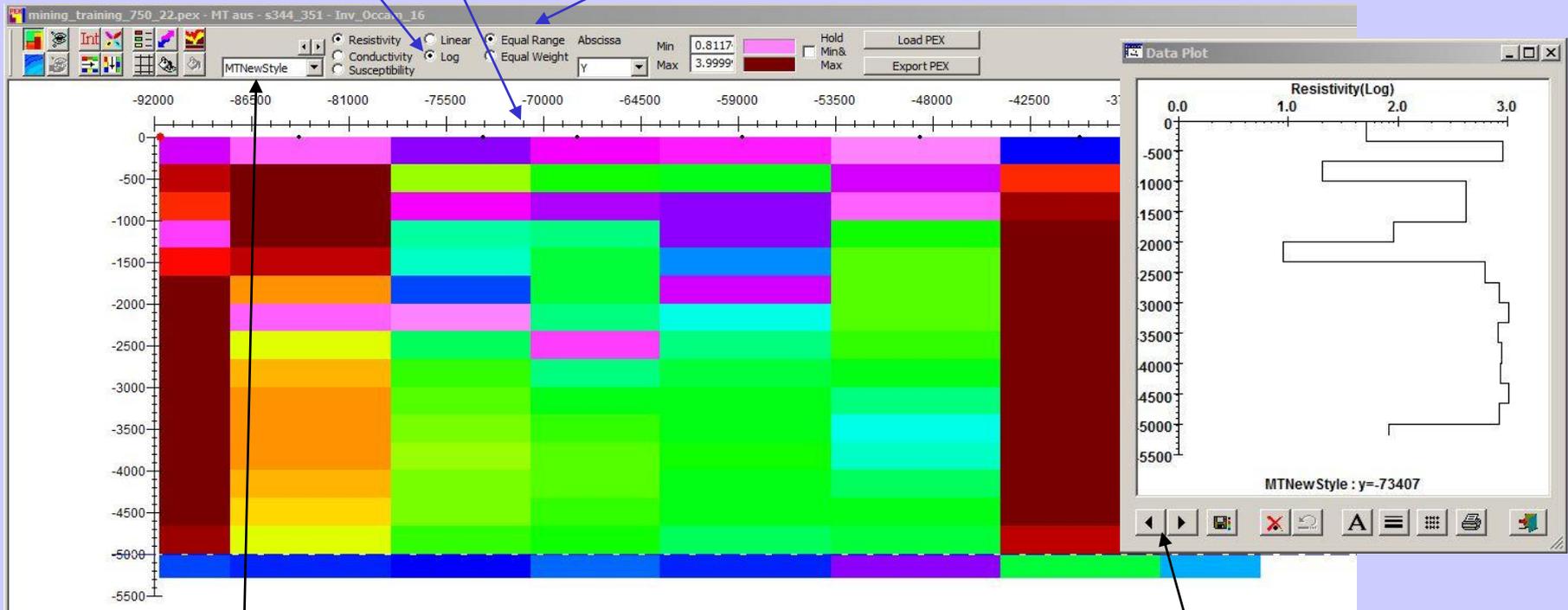
Inversion Displays

MT Inverse
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Choose CDI viewer to graphically view the results

The results for each **data point** are shown (without interpolation) initially in **log(Resistivity)** with **Equal Range** display.



If there is more than one line then **other lines** may be selected.

A plot of resistivity vs. depth for a single station is also provided and you may **step** along the profile. You may also save the layered model of the current point by clicking 

1. Data organization and import
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5. **Inversion evaluation**

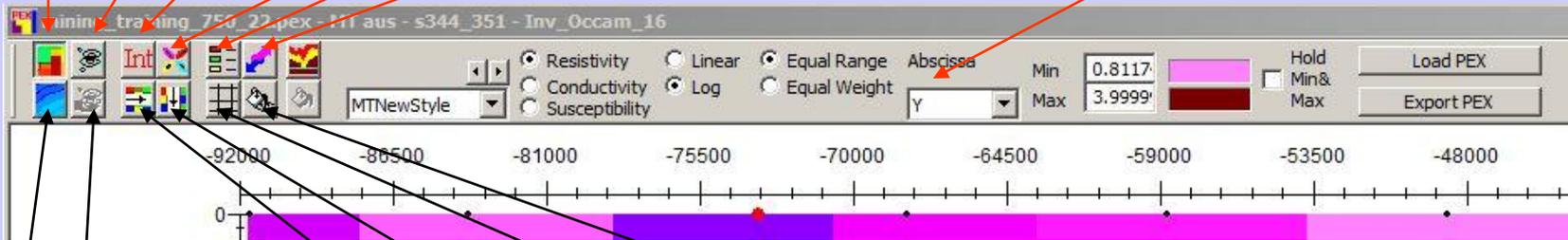
Inversion Displays

MT Inverse
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Choose CDI viewer to graphically view the results

Show Contour Lines Reset Show Legend
 Show Grid Interpolate Proportional View Use X or Y coordinate



Filled Contour Depth Interpolation Show Grid Lines
 Contour Attributes Location Interpolation Refresh View

Equal Range: assign different colors to different ranges which are equal independently of the number of data falling within these ranges

Equal Weight: assign colors to different ranges which are unequal but covering the same number of data

Min: Any data values below Min will be displayed as the color to the right of the edit field

Max: Any data values above Max will be displayed as the color to the right of the edit field

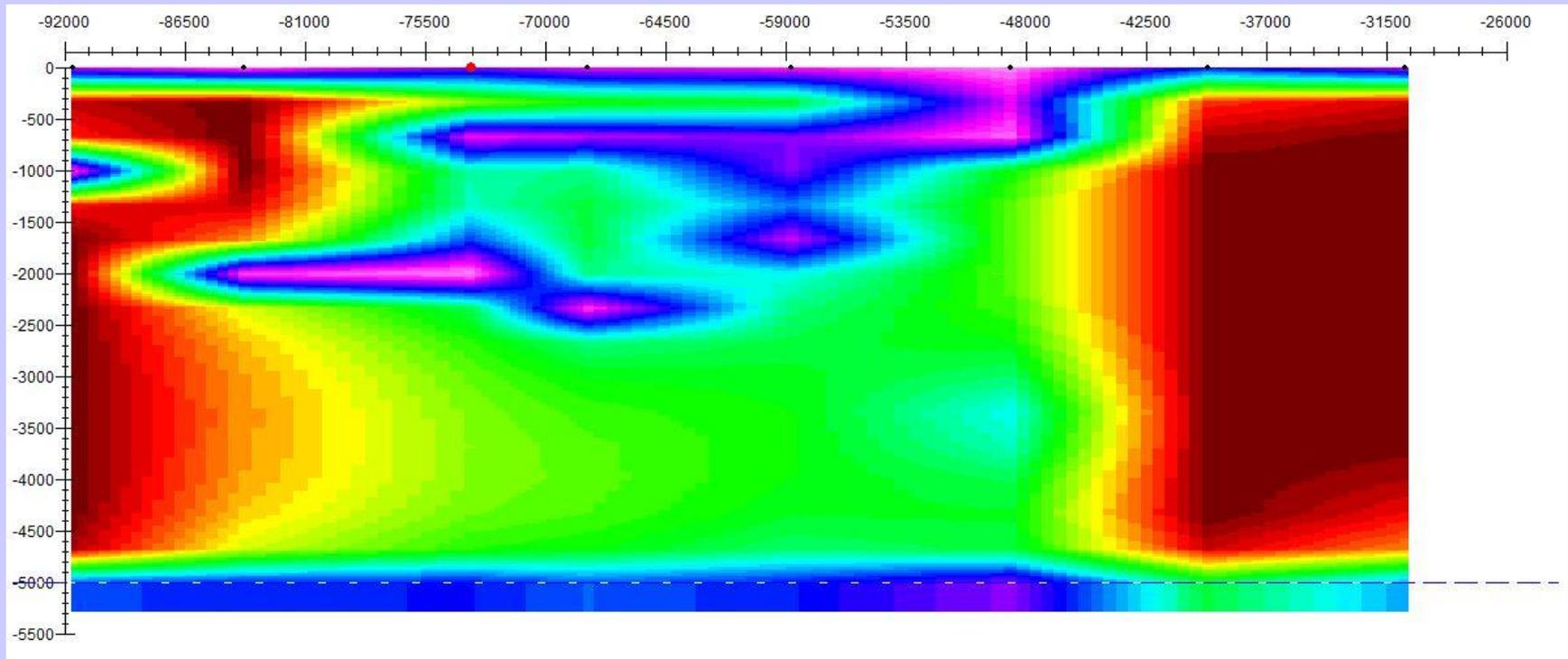
1. Data organization and import
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Inversion Displays

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Choose CDI viewer to graphically view the results



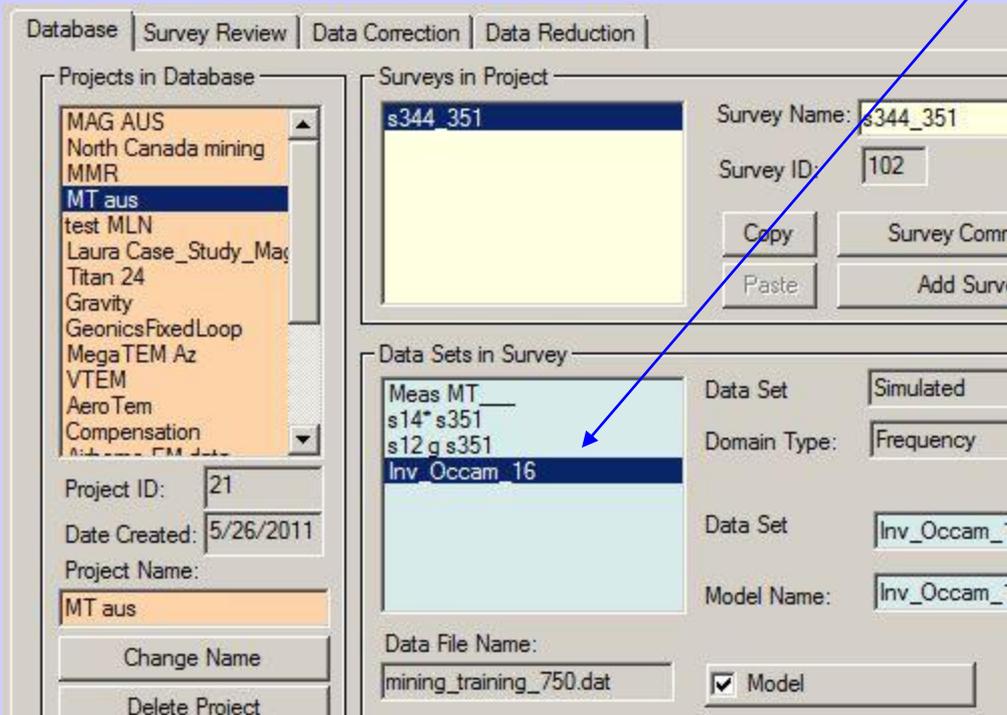
Axes may be edited by double-clicking on it, and you can change Max, Min, Labels and Titles etc. on the popup dialog

Depth and location interpolated may be repeated (note: the results of previous interpolations are used in the next interpolation so use with care)

1. Data organization and import
2. Examine data
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- 5. Inversion evaluation**

Inversion Evaluation

To assess the success of the inversion, select the measured data and then select the plotter.



Select "Yes", if this dialog is appeared

1. Data organization and import
2. Examine data
3. Perform initial modeling
4. Perform controlled inversions
5. **Inversion evaluation**

Inversion Evaluation

Select the data sets required for comparison and then “Load”

Survey Selection

Project: MT aus Survey: s344_351

Data Sets in Survey: Selected Data Sets to plot:

Name	Model Name	Type
s14° s351 Imped	s14° s351	S
s12 g s351 Imped	s12 g s351	S

Data Units: Ohms

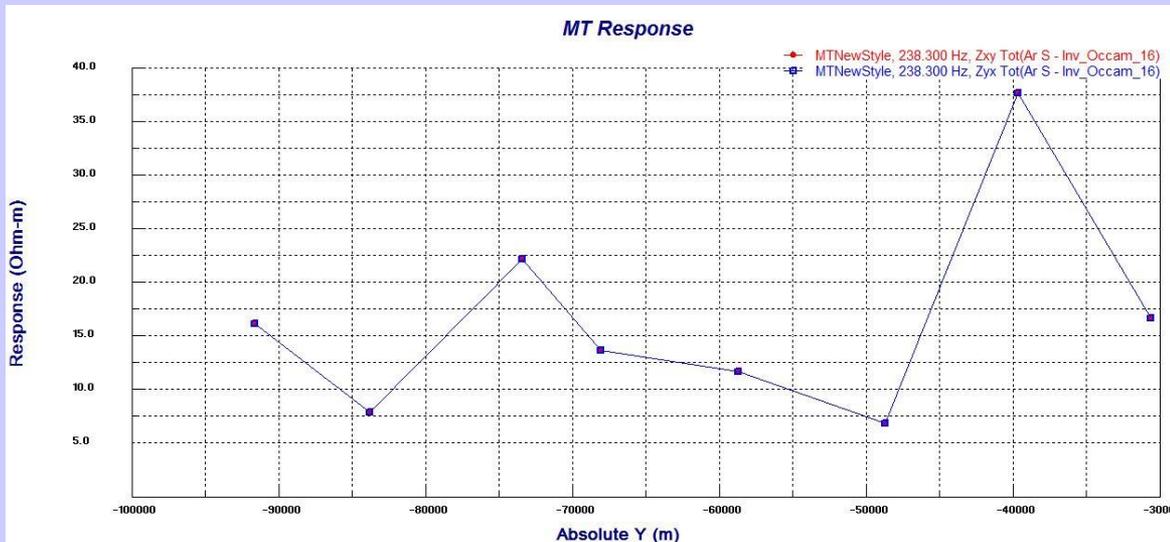
Name	Model Name	Type
Inv_Occam_16	Inv_Occam_16	S
Meas MT ____		M

Show IMPEDANCE Data Sets in Survey

Loading: _____

Loaded: of

All selected data sets are then loaded to the Plotter application and the plot appears showing the first channel of the simulated data.



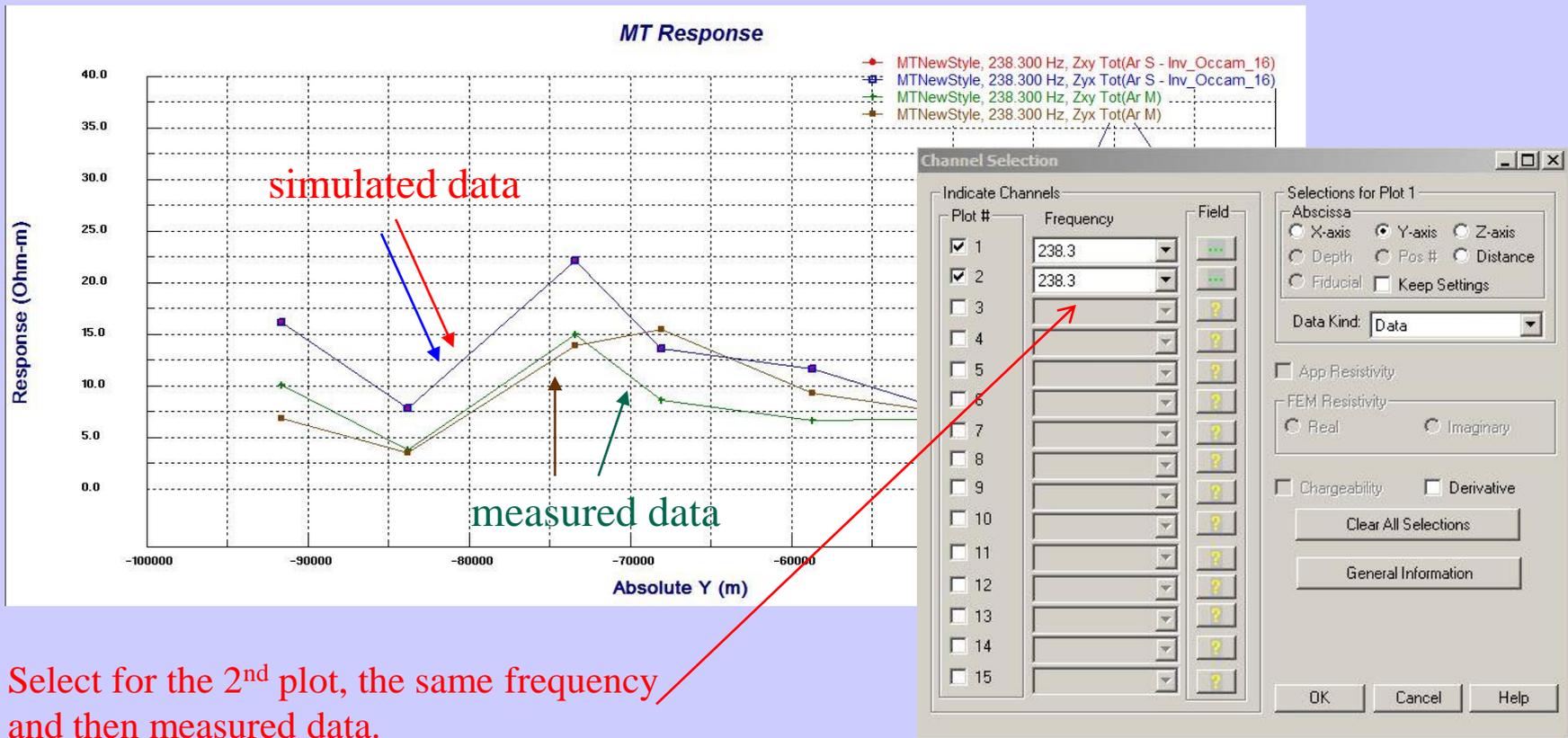
Note: The amplitude of Zxy and Zyx will always be the same for 1D model.

1. Data organization and import
2. Examine data
3. Perform initial modeling
4. Perform controlled inversions
5. **Inversion evaluation**

Inversion Evaluation

MT Inverse
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The user may select other data sets to plot by simply double clicking on the plot

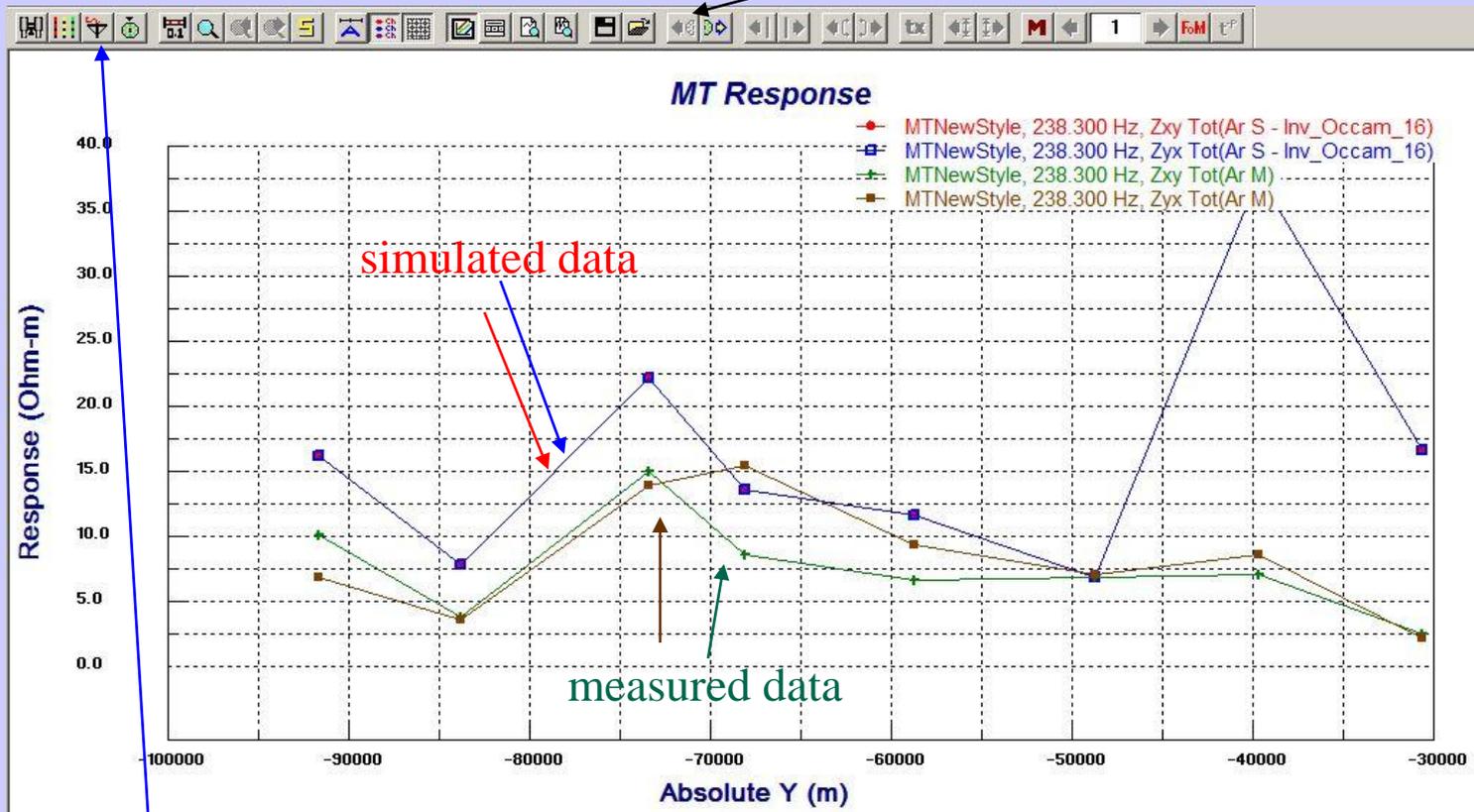


1. Data organization and import
2. Examine data
3. Perform initial modeling
4. Perform controlled inversions
5. **Inversion evaluation**

Inversion Evaluation

MT Inverse
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Multiple plots can be shown for various inversions and models in “Profile” mode. The user may step through time windows by simply clicking the arrow.



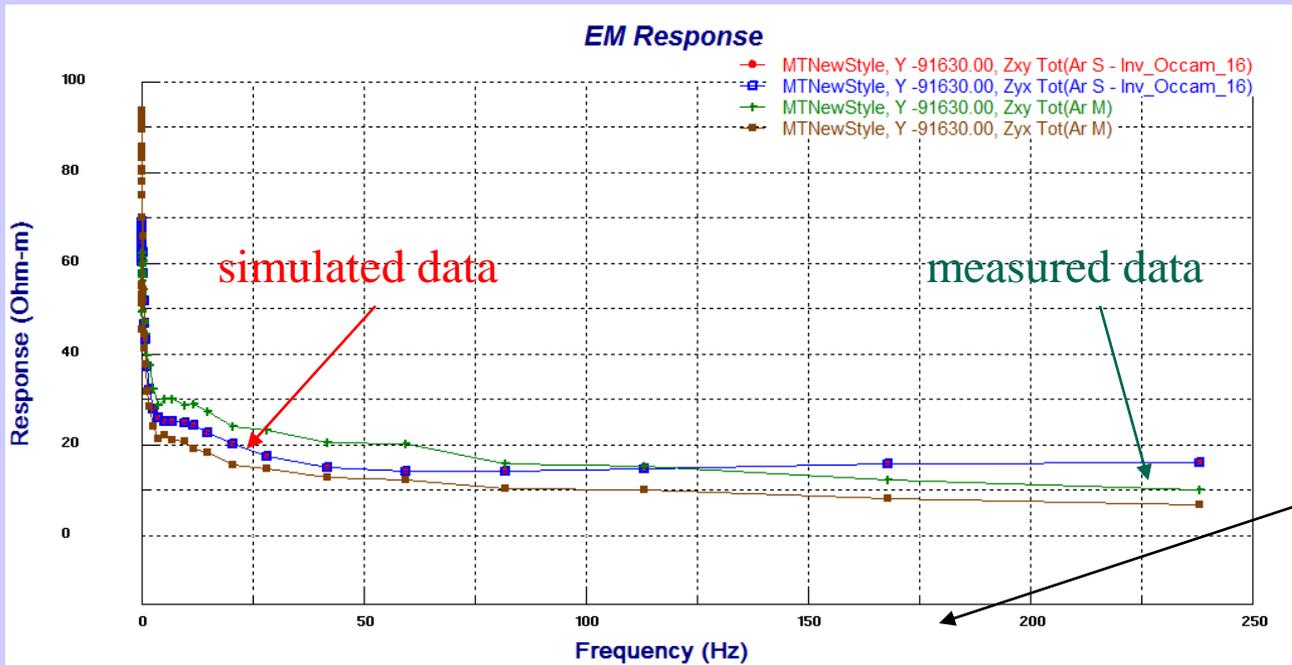
To show in “Spectrum” mode use the “Domain” button.

1. Data organization and import
2. Examine data
3. Perform initial modeling
4. Perform controlled inversions
5. **Inversion evaluation**

Inversion Evaluation

MT Inverse
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Here, spectrums are compared for a single data point in linear-linear mode. The user may move to other data points by simply clicking the arrows.



The step-frequency function of the arrows is now converted to step position.

It is useful to compare in log mode. This functionality is accessed by double-clicking either axis.

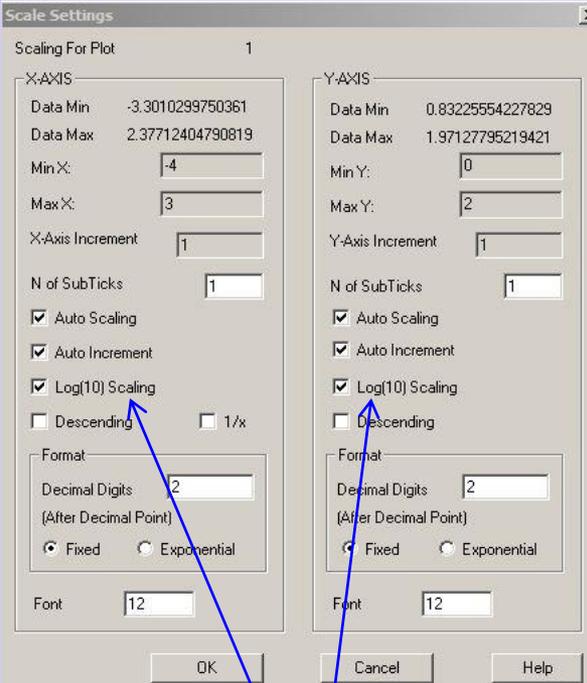
1. Data organization and import
2. Examine data
3. Perform initial modeling
4. Perform controlled inversions
5. **Inversion evaluation**

Inversion Evaluation

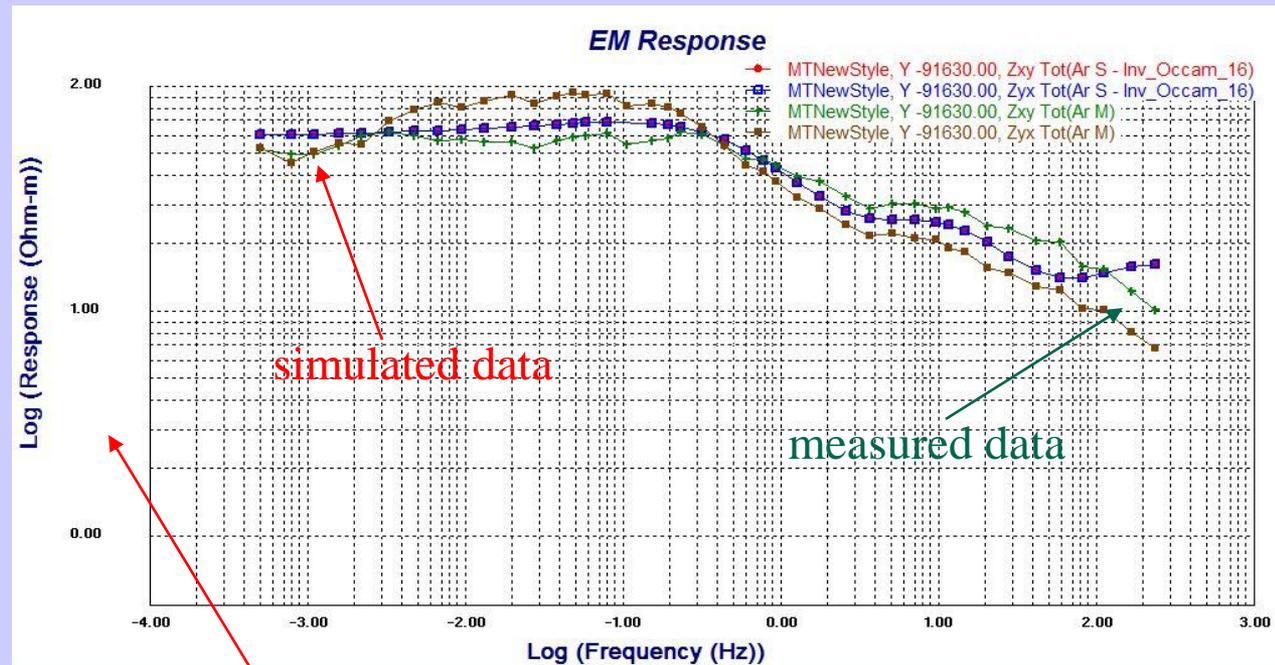
MT Inverse

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Here, we select **log(frequency) vs. log(amplitude)**



Select "Log(10) Scaling" option

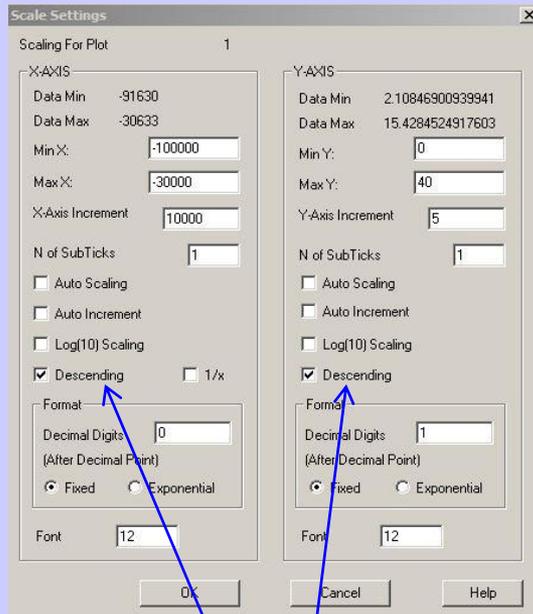


Double click axis to popup the "Scale Setting" dialog

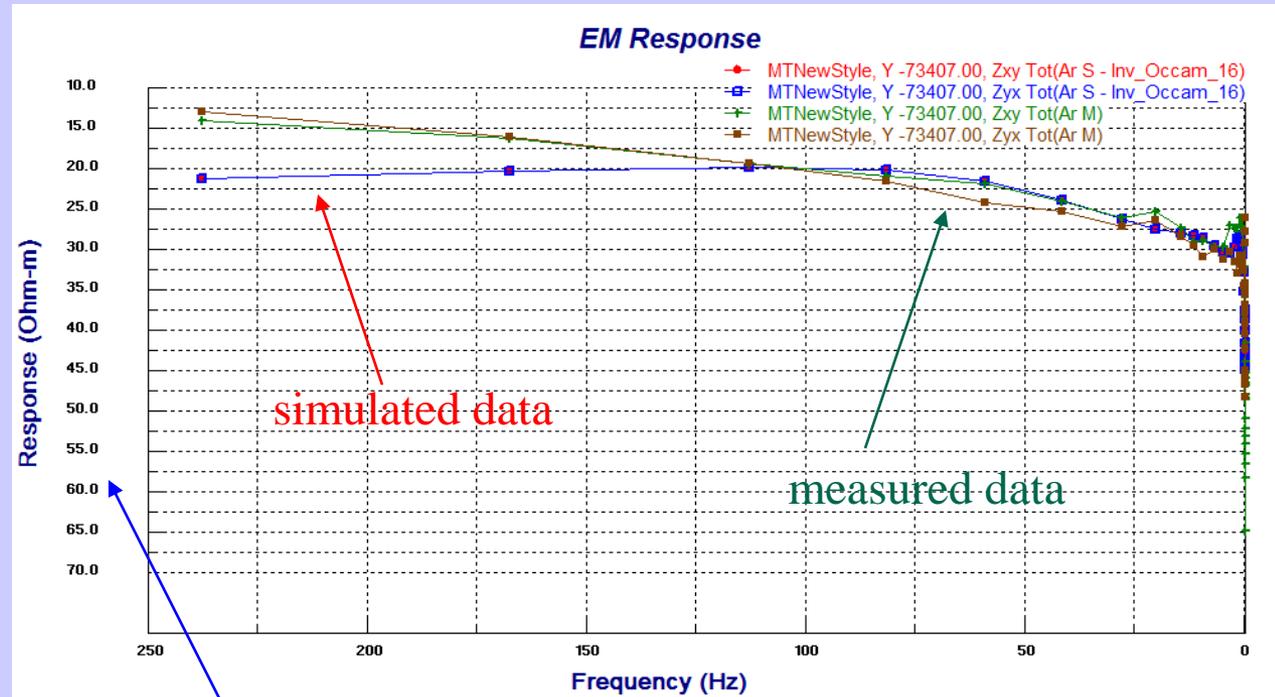
1. Data organization and import
2. Examine data
3. Perform initial modeling
4. Perform controlled inversions
5. **Inversion evaluation**

Inversion Evaluation

Here, we select **frequency vs. amplitude**



In CSAMT/MT, it is common to observe data in **Descending** order of frequencies (from high to low)



Double click axis to popup the “Scale Setting” dialog

Note: based on results of inversion, you may run additional inversions with different settings, and compare the resulting sections in the CDI viewer and the fit in the plotter.