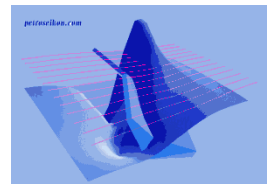


3D RESISTIVITY INVERSION TUTORIAL

Steps:

Page

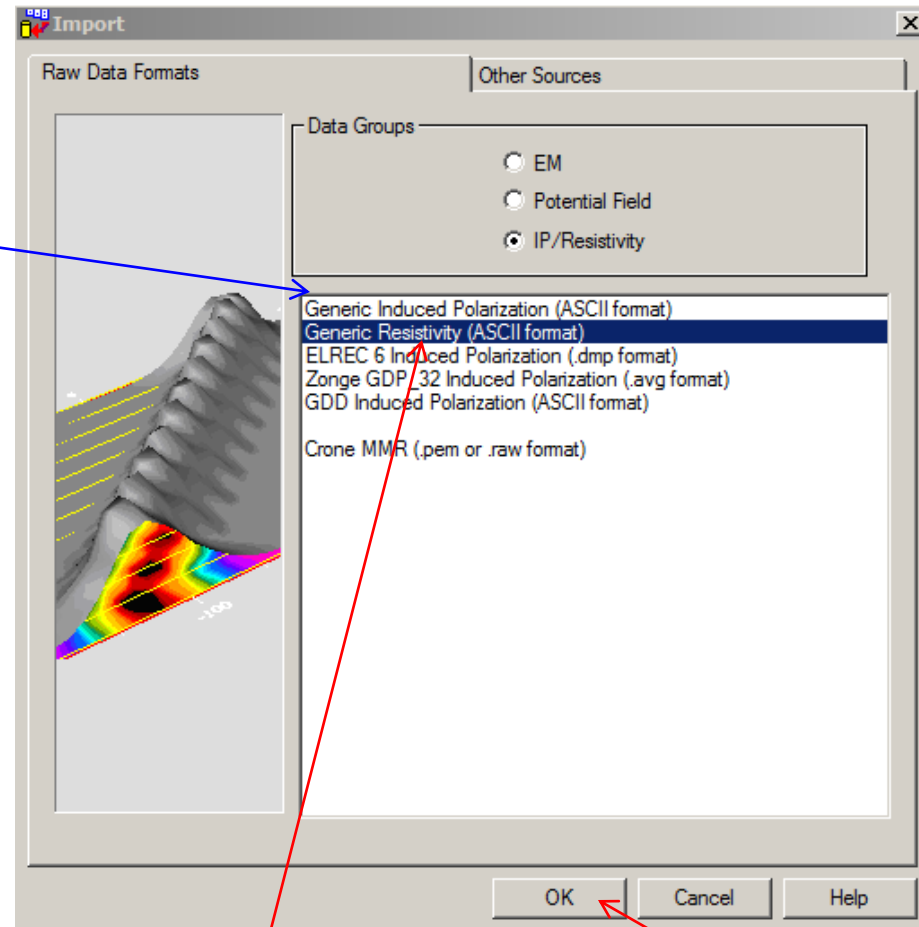
- | | |
|---|----|
| 1. Import data to new or existing database | 2 |
| 2. Examine data | 6 |
| 3. Perform initial forward modeling | 8 |
| 4. Perform 3D resistivity inversions | 9 |
| 5. Check model and create plots | 16 |



1. Import data

2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
5. Check model and create plots

Select “Generic Induced Polarization” if your data is from IP survey



Select “Generic Resistivity” and click “OK” button

1. Import data

2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
5. Check model and create plots

Browse and select data file for import

Select electrode array type and set the distance to infinity pole

Set line direction and select the data column for the line

Set dipole length and reference point position

Inputs: Import Wizard. Setup 1.

File Name: E:\Importdata\Resistivity\Titan\L-69743N_orig_qct_work_east_flip_nodupl.xyz Browse

Select one line as a header line

	C2Y()	P1X()	P1Y()	P2X()	P2Y()
1	79773.00	41200.00	69743.00	41400.00	6974
2	79773.00	41200.00	69743.00	41400.00	6974
3	79773.00	41400.00	69743.00	41600.00	6974
4	79773.00	41200.00	69743.00	41400.00	6974
5	79773.00	41400.00	69743.00	41600.00	6974
6	79773.00	41200.00	69743.00	41400.00	6974
7	79773.00	41200.00	69743.00	41800.00	6974

Reset

☒ Resistivity Only (Static Domain) or Resistivity/Phase (Frequency Domain)

General information from file

Electrode Array Selection

☐ Dipole - Dipole Distance to infinity Pole(m): 10000

☒ Pole - Dipole

☐ Pole - Pole

☐ Gradient

Line Direction

☒ East-West ☒ Line label in selected column

☐ North-South 2 C1Y()

Time base (mSec): 0

Dipole Length: 200

Number of Windows: 1

Reference Point at: Centre point

Output Normalization

☒ Normalize to current (Resistivity)

☐ Normalize to primary voltage (IP)

< Back Next > Cancel Help

Click "Next" button to proceed to next step

1. Import data

2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
5. Check model and create plots

Select vertices for both transmitter and receiver, as well as the units of coordinate

Select the column which contains voltage data and set its units

Data Information. Import Wizard. Step 2.

File View

C1X()	C1Y()	C2X()	C2Y()	P1
41500.00	69743.00	.	79773.00	
41700.00	69743.00	.	79773.00	
41700.00	69743.00	.	79773.00	

Time delay: 0

On-Time window: 0

Window centre(s): 0

Window width: 0

System

Transmitter Vertices:

Electrode 1: 1 C1X()

Electrode 2: 3 C2X()

Receiver Vertices:

Electrode 1: 5 P1X()

Electrode 2: 7 P2X()

Coordinate Units: ☒ meters ☐ feet

Voltage: 10 VP0

Units: ☐ mVolts ☒ Volts ☐ Apparent Resistivity

☐ Current: 1

Units: ☐ mAmp ☒ Amp

☐ Phase

Units

Column #, name	Window width	Column #, name	Window width
☐ Window 1	0	☐ Window 11	0
☐ Window 2	0	☐ Window 12	0
☐ Window 3	0	☐ Window 13	0
☐ Window 4	0	☐ Window 14	0
☐ Window 5	0	☐ Window 15	0
☐ Window 6	0	☐ Window 16	0
☐ Window 7	0	☐ Window 17	0
☐ Window 8	0	☐ Window 18	0
☐ Window 9	0	☐ Window 19	0
☐ Window 10	0	☐ Window 20	0

Data Units: ☐ mV/V ☒ V/V ☐ mSec

Time Window Units: ☐ mSec ☐ Sec

Phase Units: ☒ Degree ☐ Rad ☐ mRad

Frequency (Hz): 0

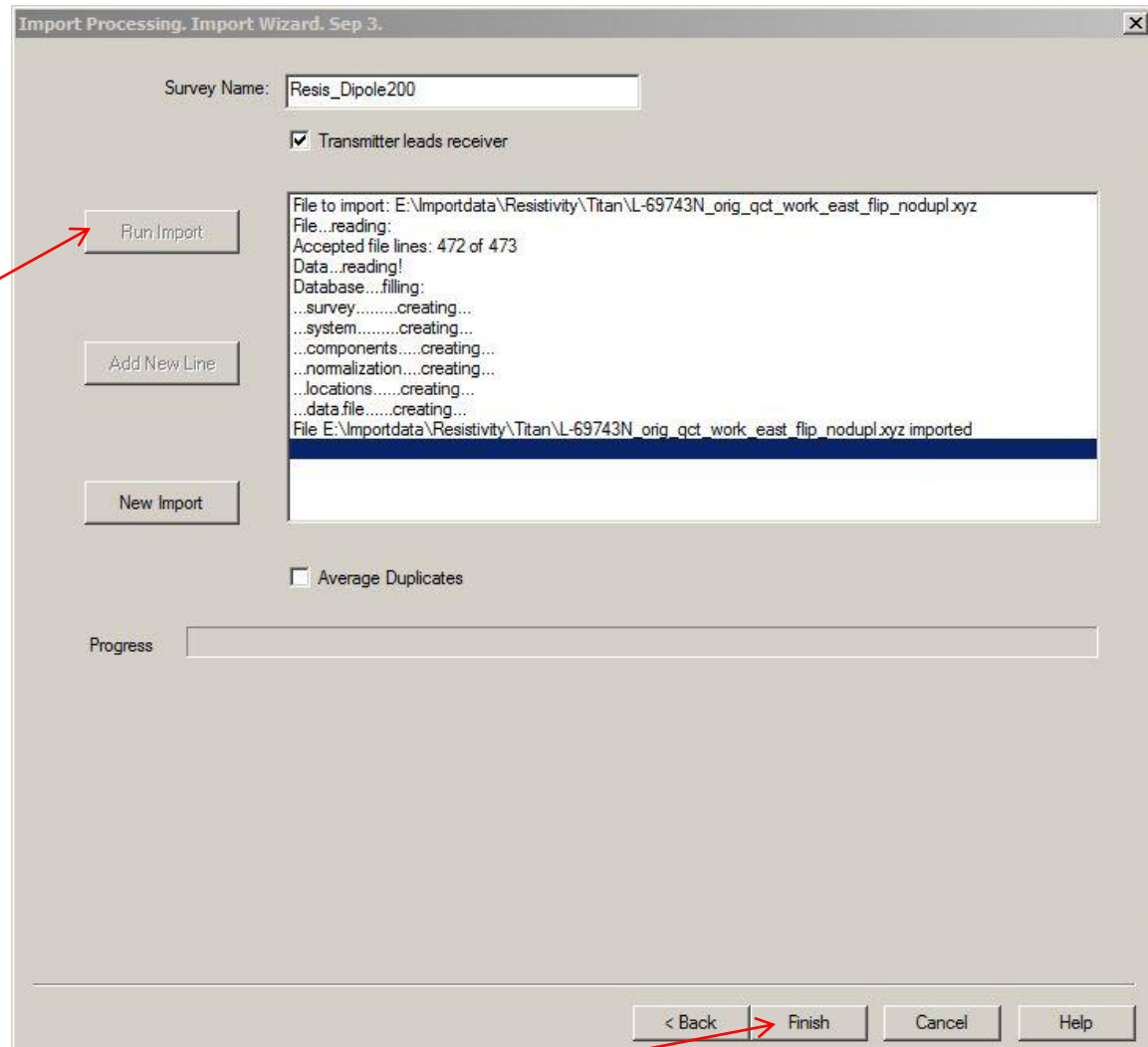
< Back Next > Cancel Help

Click "Next" button to proceed to the next step

1. Import data

2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
5. Check model and create plots

Click “Run Import” button to start importing data into database



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

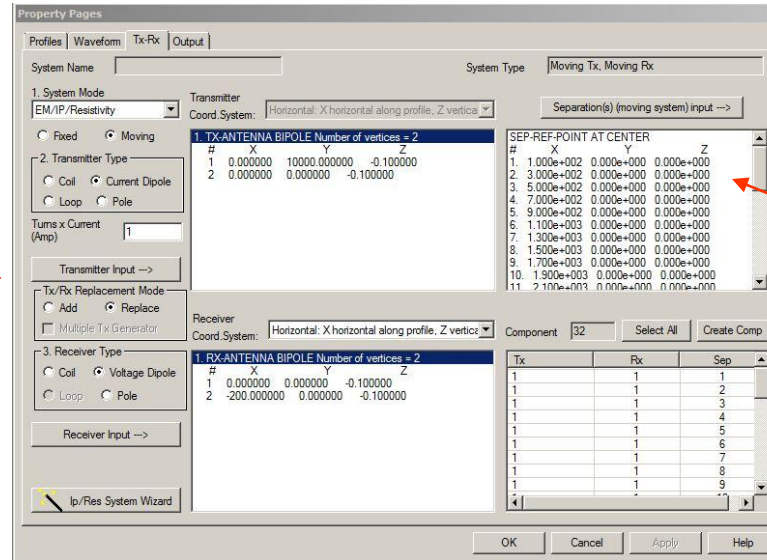
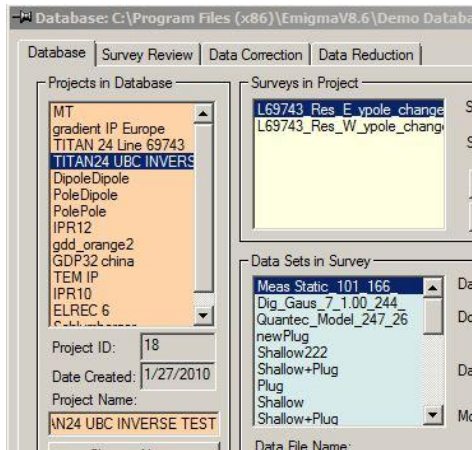
1. Import data
2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
5. Check model and create plots

Resistivity Inverse

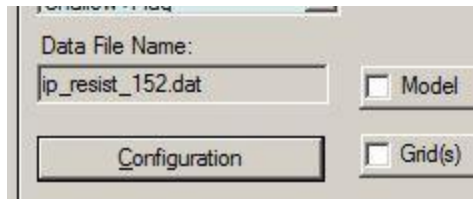
6

3. Check separations

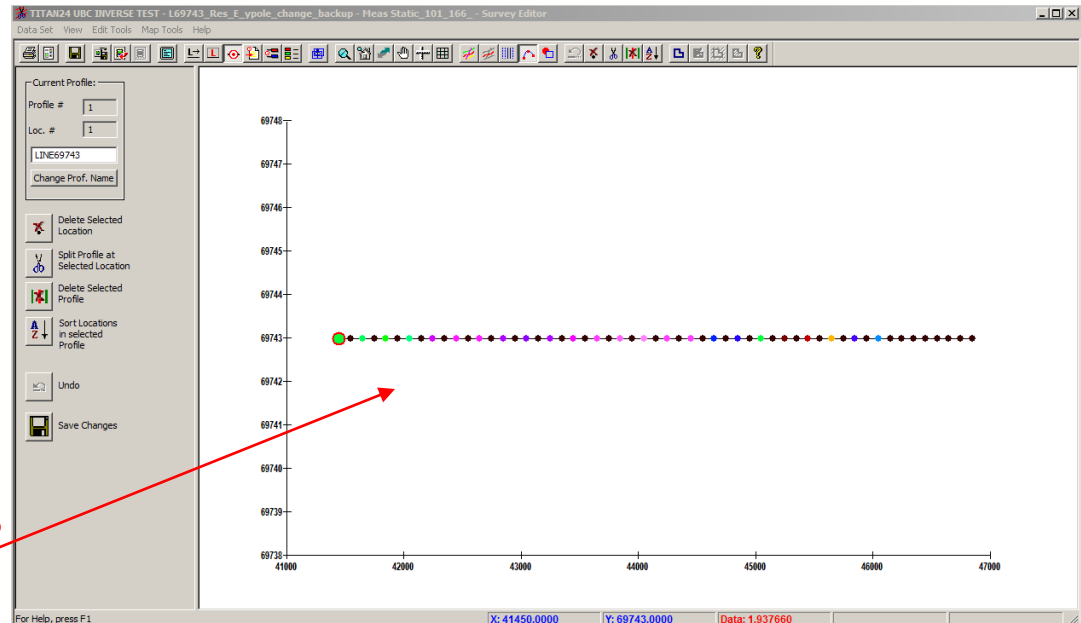
1. Check database for the survey



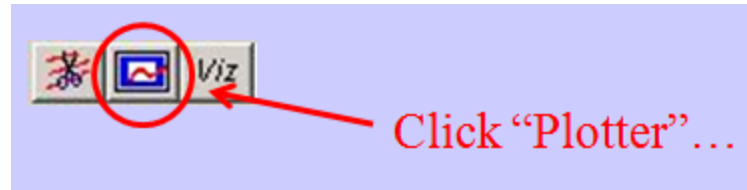
2. Click configuration



4. Check lines and stations by clicking
“Survey Editor” button

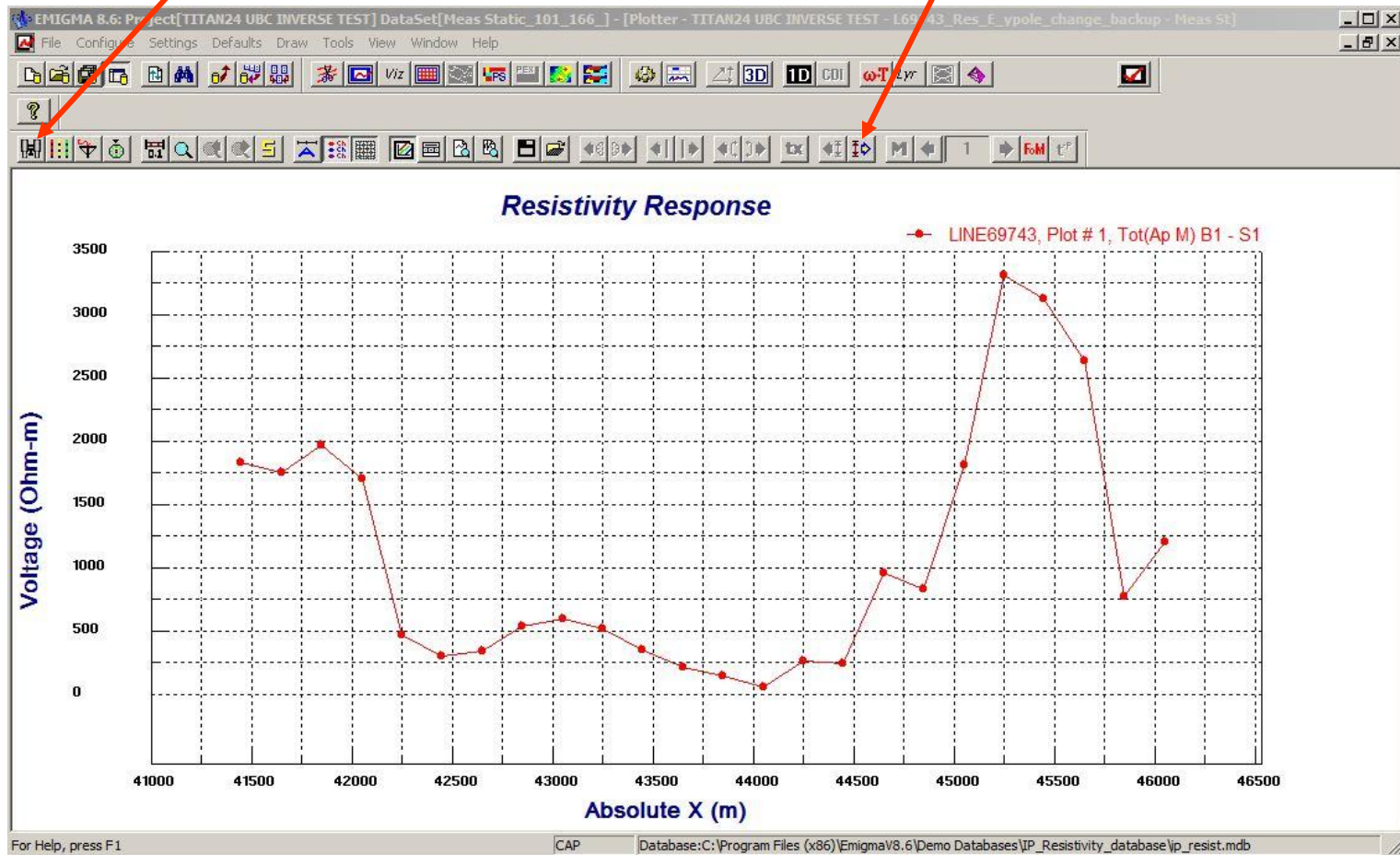


1. Import data
- 2. Examine data**
3. Perform initial modeling
4. Perform 3D resistivity inversions
5. Check model and create plots



Load data set in plotter

Toggle between separations

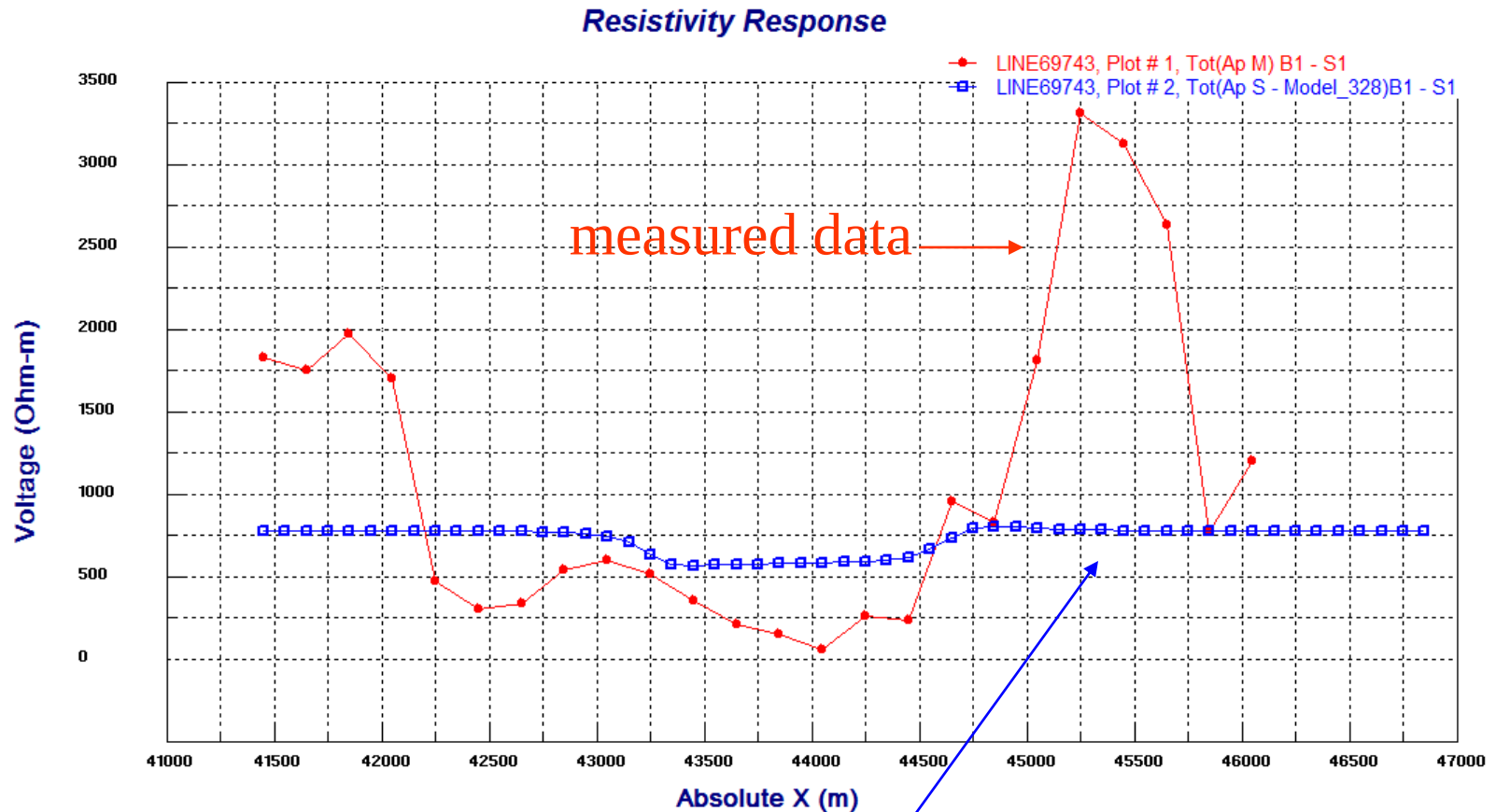


1. Import data
2. Examine data
- 3. Perform initial modeling**
4. Perform 3D resistivity inversions
5. Check model and create plots

Resistivity Inverse

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



1. Import data
2. Examine data
3. Perform initial modeling
- 4. Perform 3D resistivity inversions**
5. Check model and create plots

Resistivity Inverse

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The image shows a workflow for performing 3D resistivity inversions. On the left, a 'Data Sets in Survey' window lists several data sets. A red arrow points from the 'Meas Static 101 166' entry to the '3D' button in a toolbar. The '3D' button is circled in red. An arrow points from the '3D' button to the main 'Resistivity 3D Inversion' window. The main window contains various settings for the inversion process.

Select measured data

Resistivity 3D Inversion

☐ Flip data sign

Forward Method

☒ Born ☐ Superposition LN

Component and Weight

Select

No. of Selected Component: 32

Background Layers

☒ Set Layer Model Set Layers

No. of Layers: 1

☐ Use Initial Model

Set Initial Model

Inversion Parameters

Target Misfit: 5

Max iterations: 20

Smoothness: 0.5

Get Settings From a Log File

Search Volume

Center X	Center Y	Top Z	Horizontal Angle (degree)
44150	69743	-1	0

Size X: 5300 Size Y: 2650 Thickness: 9450

Select search area

Select survey area

Grid Settings

Cells in X	Cells in Y	Cells in Z	Total	Cell size X	Cell size Y	Top cell thickness
106	1	378	40068	50	2650	25

Spacing Z direction: ☒ Evenly ☐ Exponentially (based on Z)

Cell Sampling: X: 1 Y: 1 Z: 1

Output Model Resistivity Constraint (Ohm*m)

Sensitivity	Min	Max
1e-006	54	5485

☐ Remove cells between

Min	Max	Output cells
1328.4	1623.6	40068

Inversion Message

Progress: _____

☐ Close application when inversion completes

Run Close Help

1. Import data
2. Examine data
3. Perform initial modeling
- 4. Perform 3D resistivity inversions**
5. Check model and create plots

Set search volume and grid:

User can input the search volume's center position (X, Y), top Z position and horizontal angle with the coordinate, also the volume's regime on X and Y axis as well as its thickness. User can also manually select the search area on the graphic tool by clicking the "Select search area" button

User can set grid by input cell size on X, Y and Z axis as well as number of cells in Z (can be evenly or exponentially spaced). The sampling rate of cells for all axes can be set in "Cell Sampling" area

Choose "Flip data sign" option if it is not in accordance with system

Select forward simulation method: Born approximation or Superposition LN

Select components for inversion and assign weights on them

Set background layers parameters (resistivity and thickness) within which the model situated

Create or import initial model for inversion in the pop-up dialog

Set constraint for output model's resistivity to exclude inverted models with unwanted resistivity values

User can also remove model cells whose resistivity values are within a certain range to accelerate processing

Set inversion parameters: tolerant data error (Target Misfit), maximum number of iterations (Max iterations) and Smoothness of the model

The screenshot shows the 'Resistivity 3D Inversion' software window. Annotations with arrows point to various settings:

- Flip data sign:** A checkbox at the top left.
- Forward Method:** Radio buttons for 'Born' (selected) and 'Superposition LN'.
- Component and Weight:** A 'Select' button.
- No. of Selected Component:** A text box containing '32'.
- Background Layers:** A checked 'Set Layer Model' checkbox and a 'Set Layers' button.
- No. of Layers:** A text box containing '1'.
- Use Initial Model:** A checkbox.
- Set Initial Model:** A button.
- Inversion Parameters:**
 - Target Misfit: 5
 - Max iterations: 20
 - Smoothness: 0.5
- Get Settings From a Log File:** A button.
- Search Volume:**
 - Center X: 44150, Center Y: 69743, Top Z: -1, Horizontal Angle (degree): 0
 - Size X: 5300, Size Y: 2650, Thickness: 9450
 - Buttons: 'Select search area' and 'Select survey area'.
- Grid Settings:**
 - Cells in X: 106, Cells in Y: 1, Cells in Z: 378, Total: 40068
 - Cell size X: 50, Cell size Y: 2650, Top cell thickness: 25
 - Spacing Z direction: 'Evenly' (selected) and 'Exponentially (based on 2)'.
- Cell Sampling:**
 - X: 1, Y: 1, Z: 1
- Output Model Resistivity Constraint (Ohm*m):**
 - Sensitivity: 1e-006, Min: 54, Max: 5485
 - Remove cells between: 'Min: 1328.4, Max: 1623.6' (checkbox is unchecked)
 - Output cells: 40068
- Inversion Message:** A large empty text area.
- Progress:** A progress bar.
- Close application when inversion completes:** An unchecked checkbox.
- Buttons:** 'Run', 'Close', and 'Help'.

1. Import data
2. Examine data
3. Perform initial modeling
- 4. Perform 3D resistivity inversions**
5. Check model and create plots

Selection of components

Click “Select” button

Select Components

Components

N	Tx	Rx	Separation (x, y, z)	Weight
☒ 1	Bipole 1	Bipole 1	100.000000, 0.000000, 0.000000	1.000000
☒ 2	Bipole 1	Bipole 1	300.000000, 0.000000, 0.000000	2.236128
☒ 3	Bipole 1	Bipole 1	500.000000, 0.000000, 0.000000	3.415997
☒ 4	Bipole 1	Bipole 1	700.000000, 0.000000, 0.000000	4.583706
☒ 5	Bipole 1	Bipole 1	900.000000, 0.000000, 0.000000	5.747348
☒ 6	Bipole 1	Bipole 1	1100.000000, 0.000000, 0.000000	6.909889
☒ 7	Bipole 1	Bipole 1	1300.000000, 0.000000, 0.000000	8.072943
☒ 8	Bipole 1	Bipole 1	1500.000000, 0.000000, 0.000000	9.237676

Default Weights

☐ Uniform weights
 ☐ Geometric weights
 ☒ Square root geometric weights

Sum of Weights: 633.86

Tx/Rx information

Tx/Rx	N	X	Y	Z
Tx	1	0.000000	10000.000000	-0.100000
Tx	2	0.000000	0.000000	-0.100000
Rx	1	0.000000	0.000000	-0.100000
Rx	2	-200.000000	0.000000	-0.100000

OK Cancel Help

Component and Weight

No. of Selected Component: 32

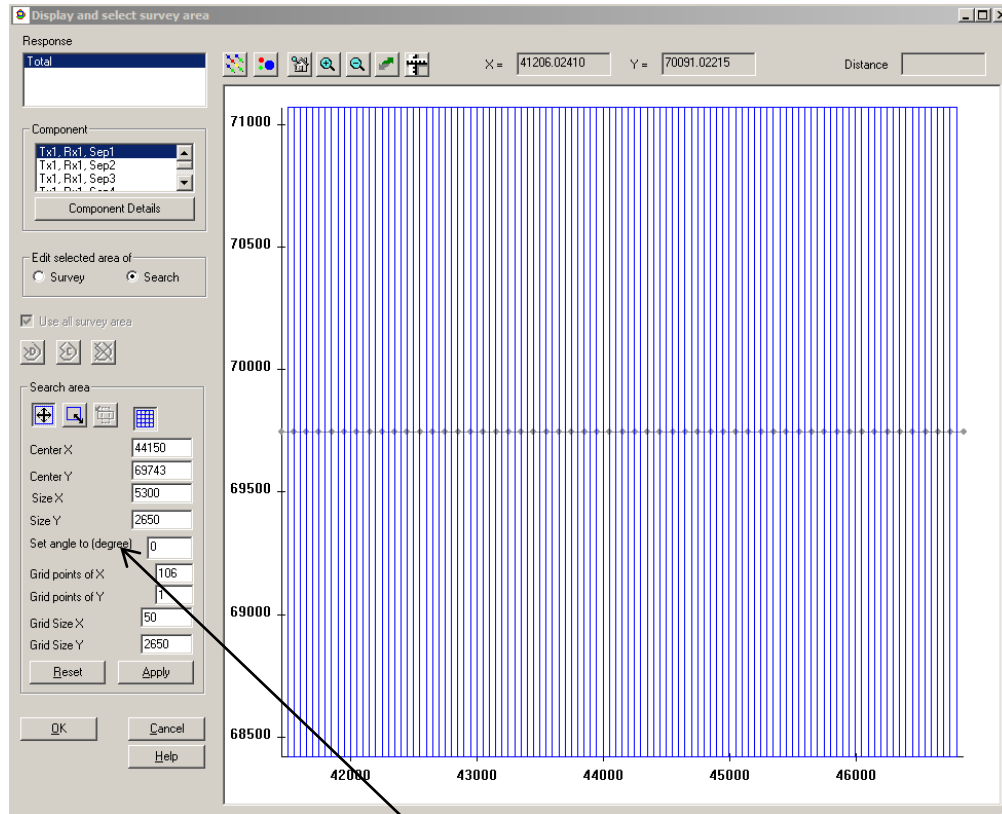
Click “OK” button after it is done

Users can select components involved with inversion. For the case of 3D resistivity inversion, different components are actually different separations. Users can also give weightings to different components. Use more components in inversion will make the inverted model more accurate

1. Import data
2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
5. Check model and create plots

Resistivity Inverse 12

Clicking either the **Select Search Area** or **Select Survey Area** buttons launches the same window. But search area means the area of data which the inversion algorithm works on, while survey area is the whole part of the imported data.



Survey Area

Click the Select survey area button to launch the graphical tool which enables you to specify the data points that will be used in the inversion calculations.

Search Volume

The default parameters in the **Search Volume** section will create a grid that covers the entire survey. You can modify the search area parameters by entering new values or by using the graphical tool

If change the value in “Set angle to (degree)” box,
the angle between search area and survey area will
be changed accordingly

1. Import data
2. Examine data
3. Perform initial modeling
- 4. Perform 3D resistivity inversions**
5. Check model and create plots

The 'Grid Settings' dialog box contains the following fields and options:

- Cells in X:** 106
- Cells in Y:** 1
- Cells in Z:** 17
- Total:** 40068
- Cell size X:** 50
- Cell size Y:** 2650
- Top cell thickness:** 555.882
- Spacing Z direction:** ☒ Evenly, ☐ Exponentially (based on 2)
- Cell Sampling sub-dialog:**
 - X:** 1
 - Y:** 1
 - Z:** 1

Grid Settings

Confirm the number and layout of grid points to be used in the inversion in the **Grid Settings** area. The points will be evenly spaced in the x and y directions. Choose **Evenly** for evenly spaced points in the z direction or **Exponentially (based on 2)** for exponentially spaced points.

Cell Sampling

Grid cells can be divided into smaller units when calculate the simulated data. Type your values in the **X**, **Y** and **Z** boxes to specify the number of samples in the X, Y and Z directions

1. Import data
2. Examine data
3. Perform initial modeling
- 4. Perform 3D resistivity inversions**
5. Check model and create plots

Resistivity Inverse

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Initial Model

Click the checkbox labeled **Use Initial Model** to specify an initial model. Return to the initial model window by clicking the **Set Initial Model** button.

The starting model is described by a list of prisms with various properties in the box labeled **Initial Model**.

add a prism to the model list

Specify the conductivity, size, position and orientation of the new prism in the **Build a model** section.

Click the **Add a prism** button.

modify an existing prism in the model list

Select the number of the prism to be modified in the anomaly list, and double-click the parameters to make modification directly.

apply the same values for a group of selected prisms

Click the **Set conductivity to all selected prisms** button to modify the conductivity.
Click the **Set angles to all selected prisms** button to modify the angles.
Click the **Set size to all selected prisms** button to modify the size.

delete prisms from the model list

Select the prisms to be deleted in the anomaly list.
Click **Delete all selected prisms**

import a model from another data set in the current database

Click **Import a model**.
Select the project, survey, and data set with the desired model
Click **OK** and the model will appear in the **Initial Model**.

1. Import data
2. Examine data
3. Perform initial modeling
- 4. Perform 3D resistivity inversions**
5. Check model and create plots

Resistivity Inverse
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Executing the Inversion

Resistivity 3D Inversion

Component and Weight

Select

No. of Selected Component: 32

Background Layers

☒ Set Layer Model

Set Layers

No. of Layers: 1

☐ Use Initial Model

Set Initial Model

Select survey area

Search Volume

Center X: 44150, Center Y: 69743, Top Z: -1, Horizontal Angle (degree): 0

Size X: 5300, Size Y: 2650, Thickness: 9450

Select search area

Grid Settings

Cells in X: 106, Cell size X: 50, Spacing Z direction: Evenly

Cells in Y: 1, Cell size Y: 2650, Exponentially (based on 2)

Cells in Z: 378, Top cell thickness: 25

Total: 40068

Cell Sampling: X: 1, Y: 1, Z: 1

Output Model Resistivity Constraint (Ohm*m)

Sensitivity: 1e-006, Min: 54, Max: 5485

☐ Remove cells between

Min: 1328.4, Max: 1623.6, Output cells: 40068

Inversion Parameters

Target Misfit: 5, Max iterations: 20, Smoothness: 0.001

Get Settings From a Log File

Inversion Message

Prepare data ...

Start inversion.

Initializing Optimization...

Setting up equation system...

Progress

☐ Close application when inversion completes

Run, Close, Help

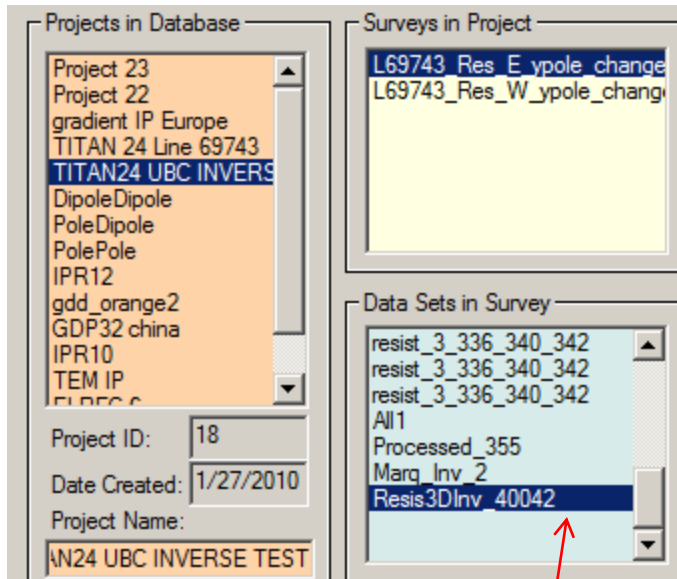
The right window (in white) shows each data point's progress.

The "Progress" bar shows the total progress of this inversion.

Click "Run" button to start inversion

1. Import data
2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
- 5. Check model and create plots**

Inversion Evaluation

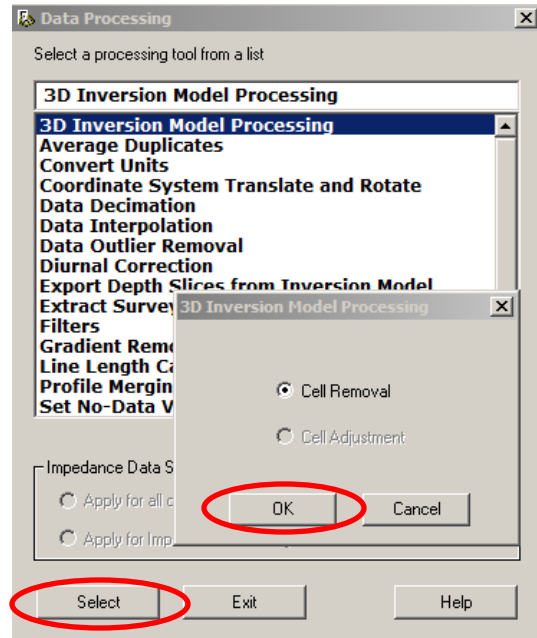


Our 3D inversion model dataset

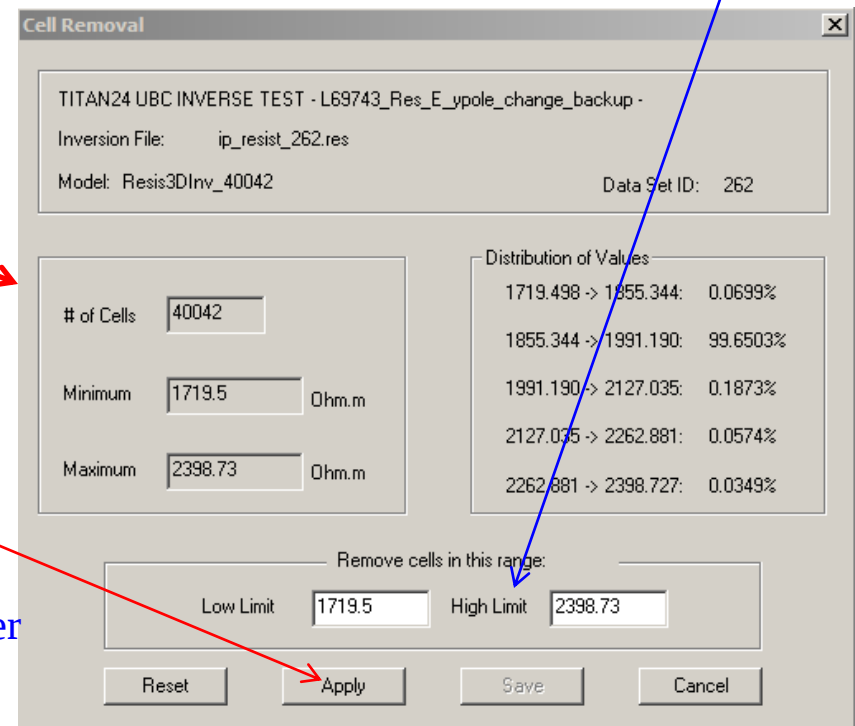
In each survey, there will be several data sets after modeling, inversion and processing. In this case, we have several forward models, one 1D inversion model (Mar_Inv_2, achieved from 1D inversion) and one 3D inversion model (Resis3DInv_40042, as highlighted). Each forward model has a new data set containing 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. Import data
2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
5. **Check model and create plots**

Inversion Evaluation



Users can use “3D Inversion Model Processing” tool to remove cells in inverted model. Follow the routine shown in this page and arrive “Cell Removal” dialog. Choose the removal range of cells: “Low Limit” and “High Limit” (any cell within this range will be removed)



Click “Apply” button when it is done

Therefore, users can reduce the range of model either before inversion (by Select Search Area) or after inversion (by Cell Removal)

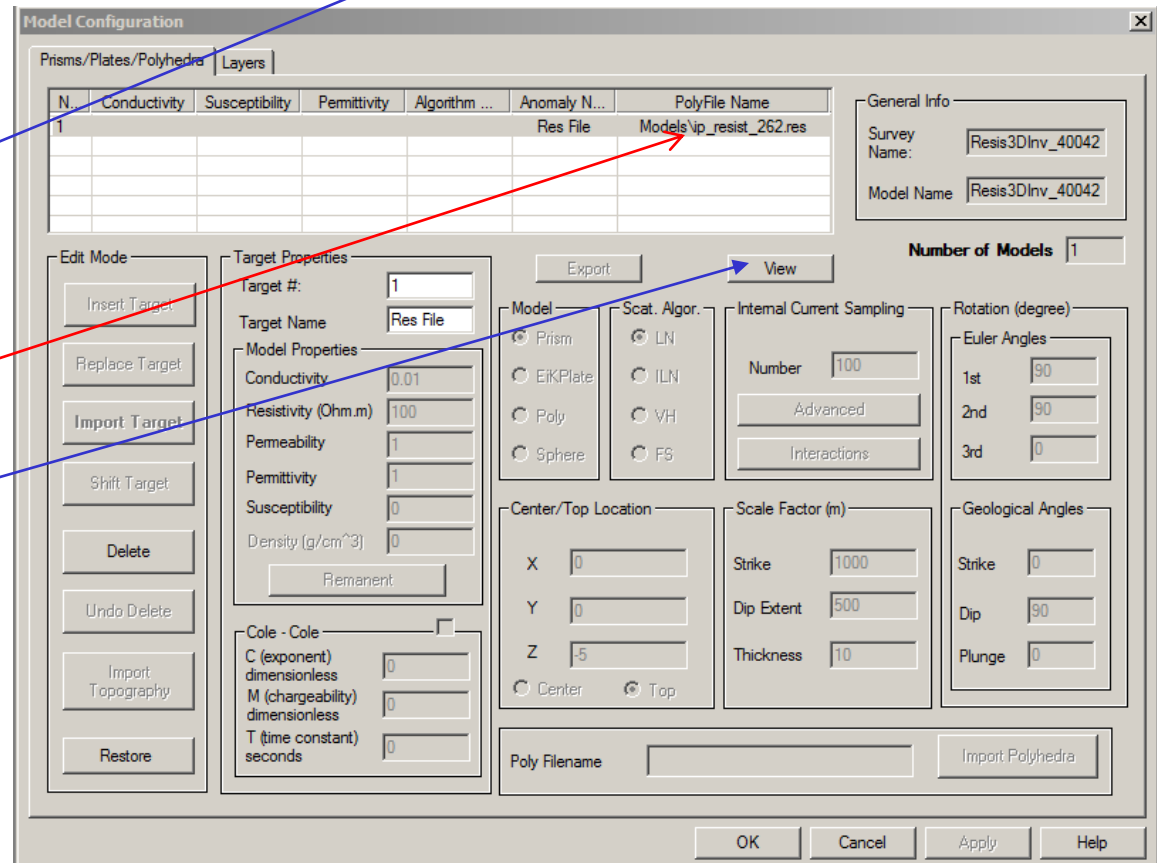
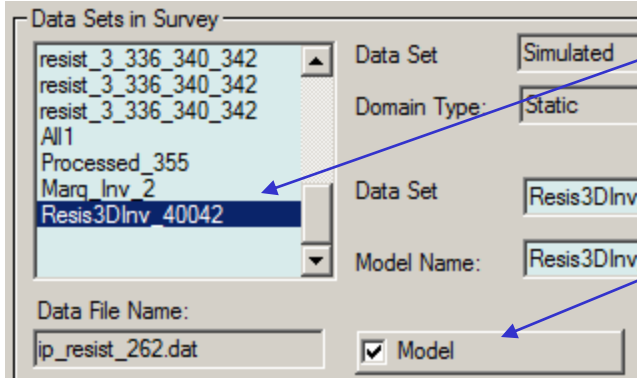
1. Import data
2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
5. Check model and create plots

Resistivity Inverse

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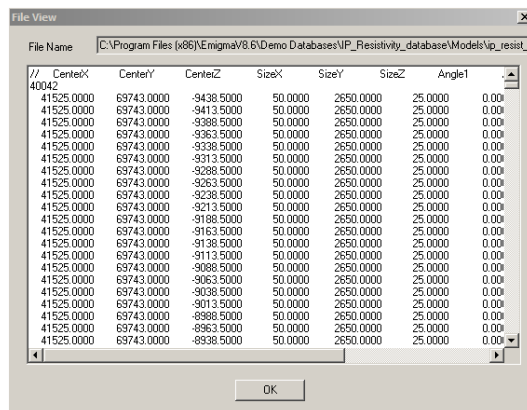
Inversion Evaluation

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



The model will be saved as a “Res File” with its name and folder shown in the “PolyFile Name” column of the table

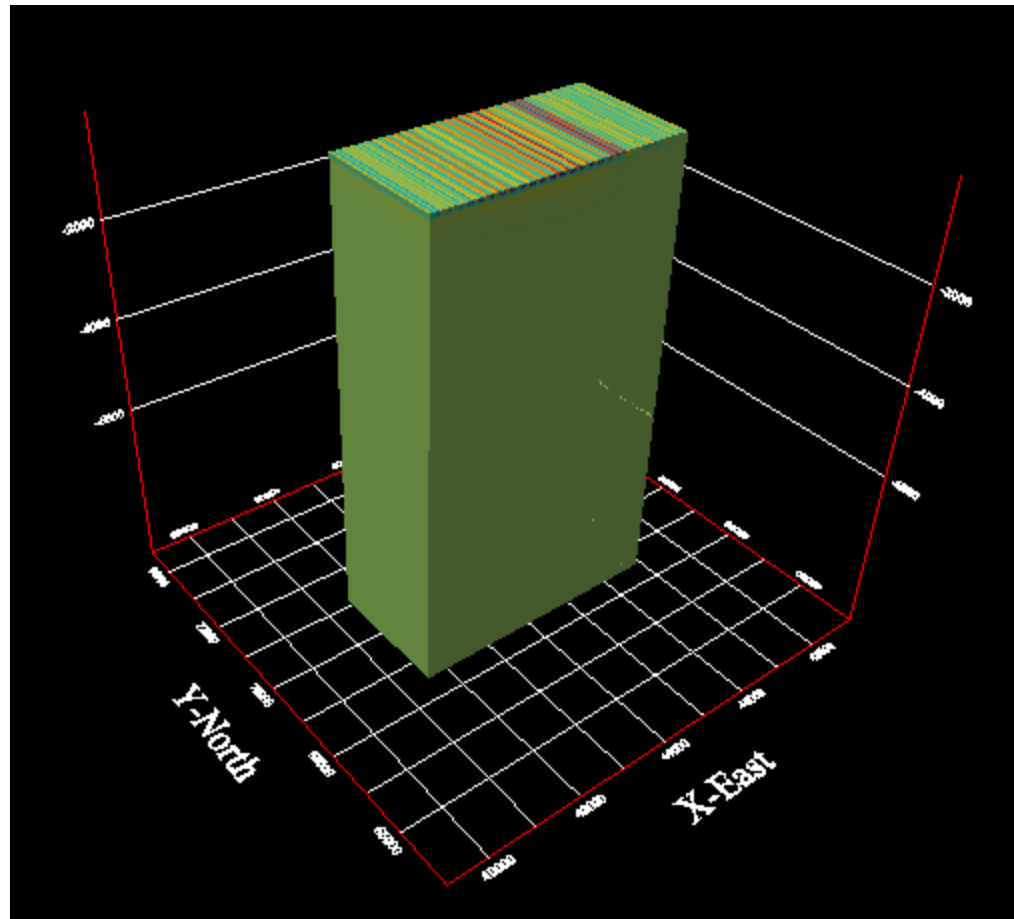
Click “View” button to open this file...



1. Import data
2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
- 5. Check model and create plots**

Inversion Evaluation

Click  button to open Visualizer tool to view the inverted 3D model...



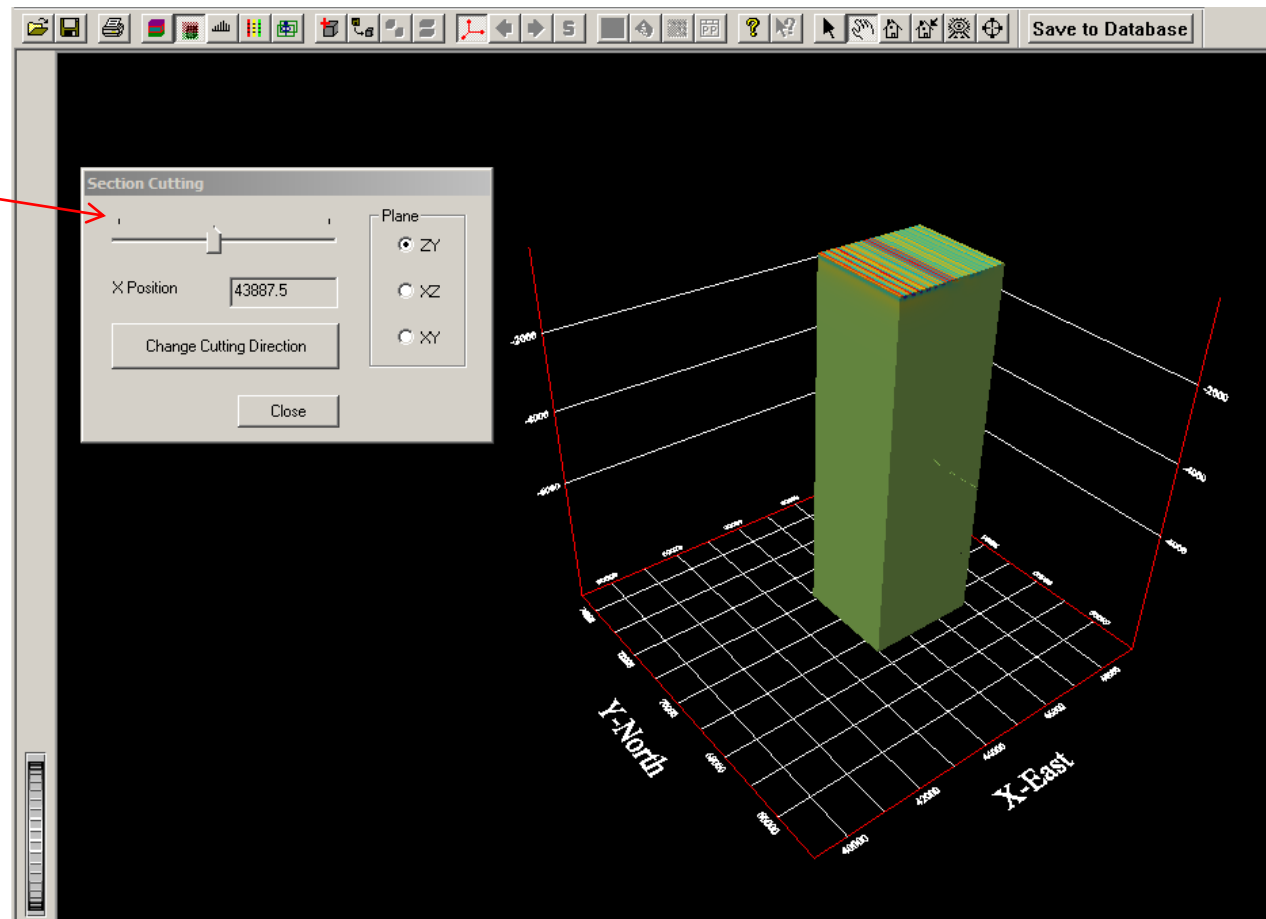
1. Import data
2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
- 5. Check model and create plots**

Inversion Evaluation

Select from menu “Model -> Mag/Grv/Res File -> mag/grv/res Cutting” to open the Section Cutting tool.

By adjusting the bar...

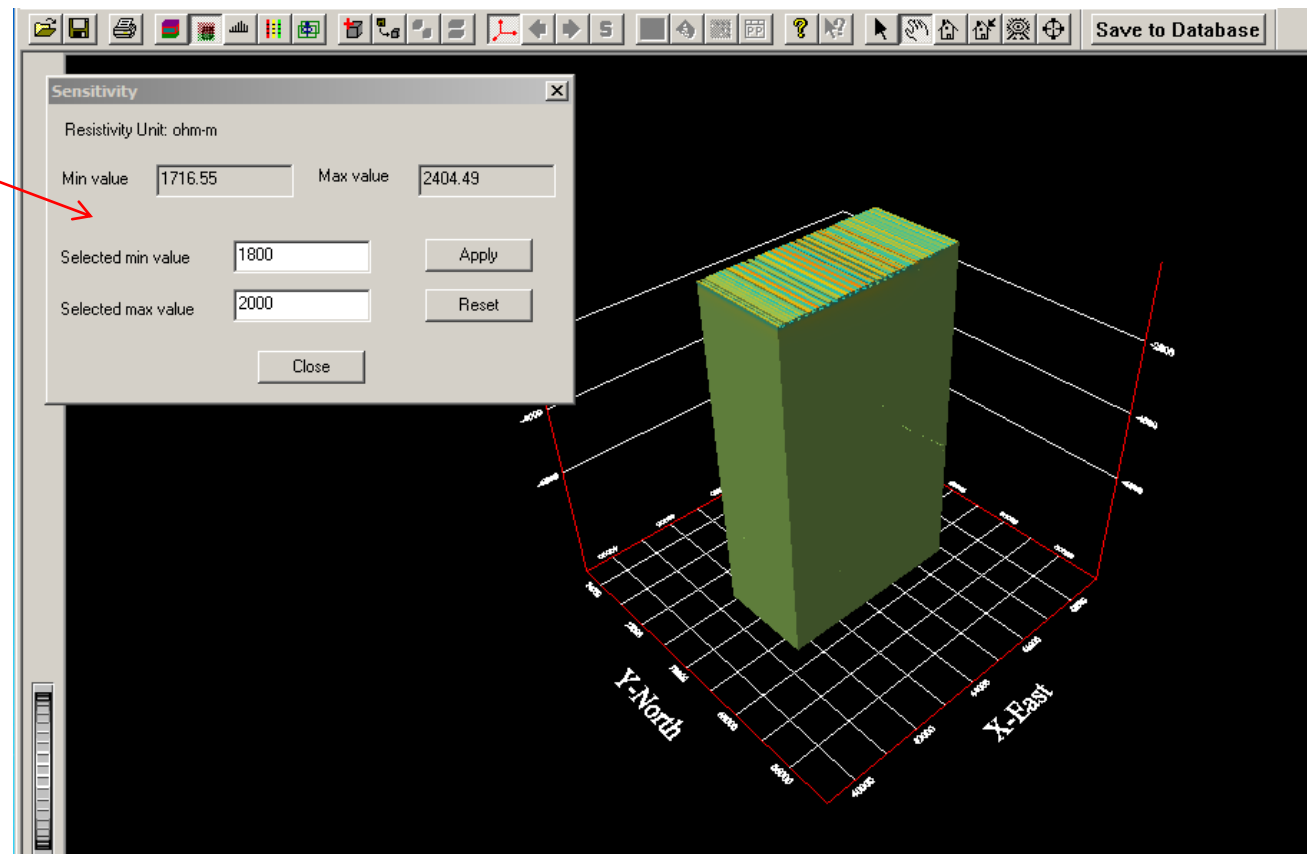
User can view sections of the 3D model from XY, XZ and ZY planes with any penetration depth



1. Import data
2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
- 5. Check model and create plots**

Inversion Evaluation

Select from menu “Model -> Mag/Grv/Res File -> Sensitivity” to open the Section Cutting tool.



By adjusting minimum value and maximum value shown in the figure...

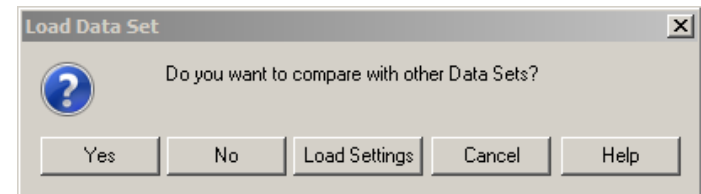
The model in this figure will only exhibit cells with values specified in this range

1. Import data
2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
- 5. Check model and create plots**

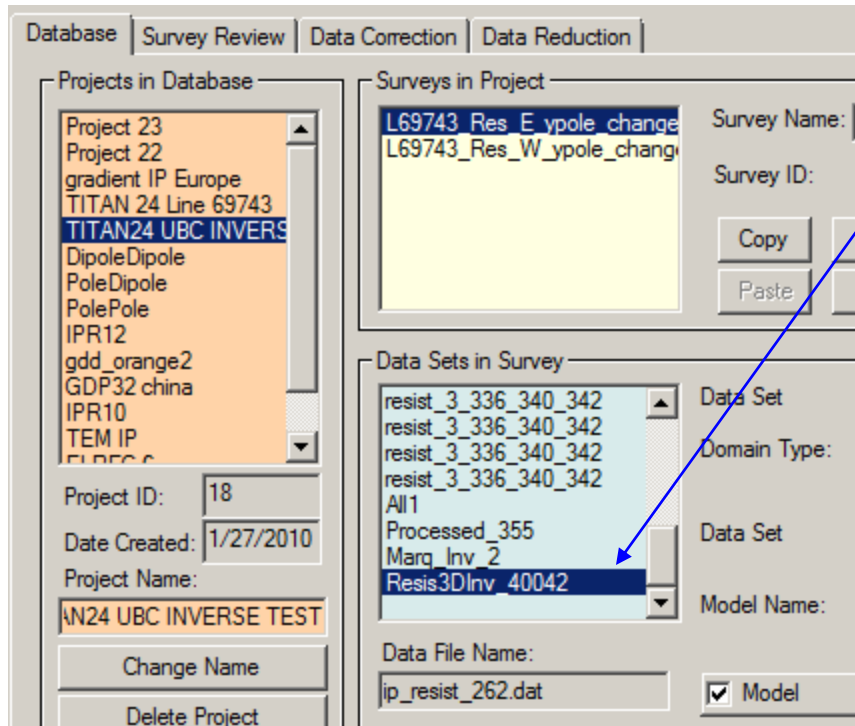
Resistivity Inverse
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Inversion Evaluation

To assess how well the inversion model fits the data at each station, select the inversion data set and then select the plotter.



Select “Yes”, if this dialog is appeared



1. Import data
2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
5. **Check model and create plots**

Inversion Evaluation

Resistivity Inverse

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

Survey Selection

Project: TITAN24 UBC INVERSE TEST Survey: L69743_Res_E_vpole_change_backup

Data Sets in Survey: 20 Selected Data Sets to plot: 2

Name	Model Name	Type
Dig_Gaus_7_1_00...		P
Quantec_Model_2...	Model_201	S
newPlug	Plug	S
Shallow222	shallow222	S
Shallow+Plug	Shallow+plug	S
Plug	Plug	P
Shallow	shallow222	P
Shallow+Plug	Shallow+plug	P
Shallow_328	Model_328	S
Shallow_2	Shallow_2	S
Shallow_2	Shallow_2	S

Data Units: Volts

Add to --> Add All to --> <-- Remove from

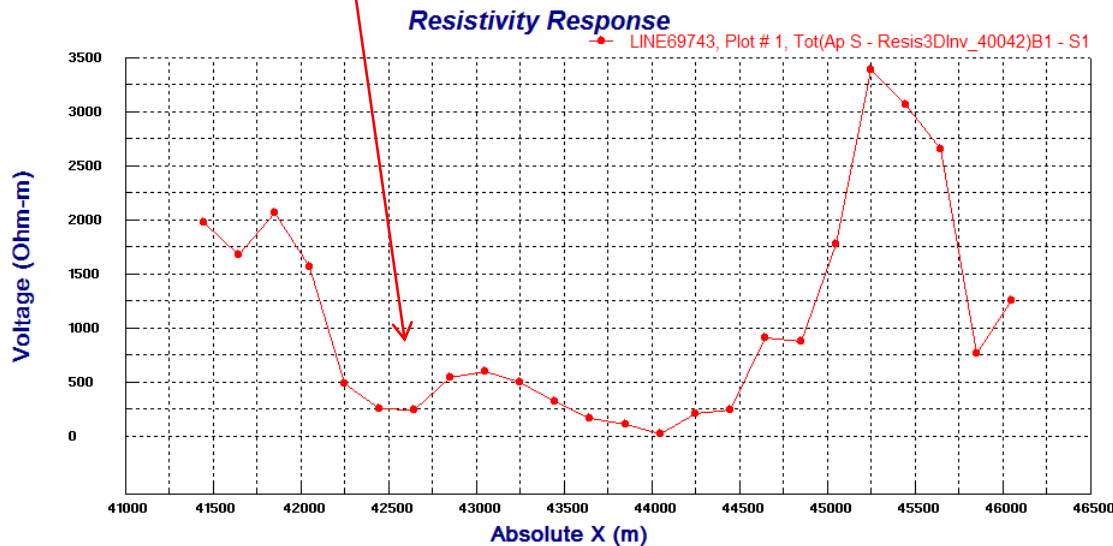
Name	Model Name	Type
Resis3DInv_40042	Resis3DInv_40042	S
Meas Static_101_...		M

☐ Show IMPEDANCE Data Sets in Survey

Loading: Loaded 0 of 2

Load Cancel

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



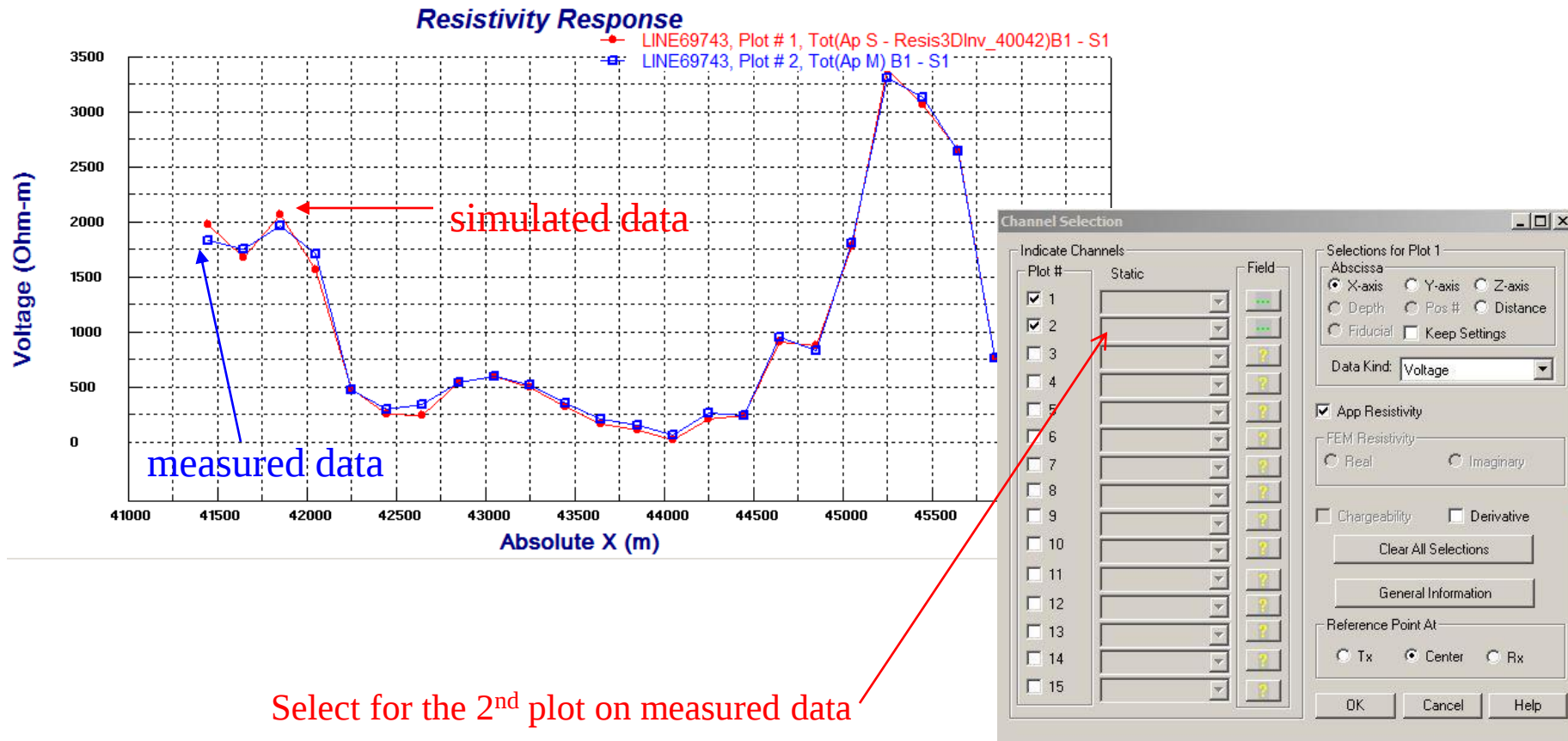
1. Import data
2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
5. **Check model and create plots**

Inversion Evaluation

Resistivity Inverse

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



1. Import data
2. Examine data
3. Perform initial modeling
4. Perform 3D resistivity inversions
5. **Check model and create plots**

Inversion Evaluation

Resistivity Inverse
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Multiple plots can be shown for various inversions and models in “Static” mode. The user may step through different separations by simply clicking the arrow.

