

**AARHUS WORKBENCH - CVES MODULE**

**CONTENTS**

**START-UP (1)**

**IMPORT (2)**

Import - data (2.1)..... 2  
    ASCII file formats for positioning (exy, ewp and ez)  
Import - models (2.2) ..... 4

**PROCESSING (3)**

CVES Explorer (3.1) ..... 5  
    Tab-sheet Profile  
    Tab-sheet Sounding

**INVERSION WITH  
RES2DINV (4)**

Inversion setup (4.1)..... 8  
    Model grid setup  
    Model structure setup  
    Inversion setup  
Running the inversion (4.2) ..... 9  
Viewing inversion results (4.3) ..... 11

This document is concerned with the CVES module for the Aarhus Workbench. General functions, visualization of geophysical models, etc. are described in other documents.

The CVES module has three main parts:

1. Import of data

2. Data processing
3. Inversion using 1D LCI or RES2DINV.

The chapter begins with data import before going on to the tools used in the processing phase and ending with the inversion features.

Additional information is available by accessing the online help (**F1**).

## 1 START-UP

The following steps must be taken before starting the actual import of CVES data:

1. Open a **Workspace** - new or existing.
2. Create a new GERDA database or activate an existing database.

3. Link to a survey info database and enter relevant information about the survey.
4. Make a map and read-in relevant GIS themes (roads, buildings, woods, etc.).

## 2 IMPORT

The CVES importer is accessible via the **File/Import** menu. This opens the **Import CVES** window (see Figure 2.1,

where data can be imported stand-alone or with models. This will be described in the following sections.

### 2.1 IMPORT - DATA

Follow these steps to import CVES raw data:

1. Set CVES Import Mode to **Import data to GERDA**, as seen in Figure 2.1.
2. Point to the file holding the data in the **Processed data file** window. Valid formats are RES2DINV inv-files and dat-files or MEP output databases from the SIP program.
3. Point to the UTM coordinate file. Valid formats are .exy or .ewp (formats described in the next section).
4. Point to the file containing the topography values. Valid file formats are surfer grid files (\*.grd), topography files (\*.eZ - format described in the next section) or RES2DINV inv-files. This step is optional.

5. Press the **Preferences** button to enter a name for the data set, set the uniform data uncertainty and specify other relevant information. The coordinate system for the data is also set here.
6. Press **Import**

The **Plot** buttons, found beside the Browse buttons, displays simple pseudo section plots.

The importer has an option to import both a processed and a raw data set, intended for danish users importing to the national database. Using this option implies that a raw dataset and a processed data set is given in the relevant fields.

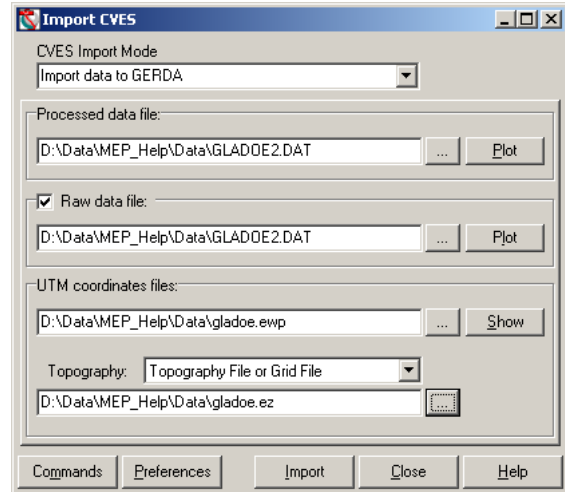


Figure 2.1 The import of CVES data is done using the Import CVES form with CVES import Mode set to Import data to GERDA

**ASCII FILE FORMATS FOR POSITIONING (EXY, EWP AND EZ)**

The formats for the ASCII text files holding information for the positioning of data are as follows:

**UTM XY coordinate file [.eXY]**

A text file holding UTM X and Y coordinates of all electrodes. The format is stated in Figure 2.2:

Elec_no	UTMX	UTMY
1	533490	6148439
2	533337	6148483
.	.	.
.	.	.
56	532875	6148953

Figure 2.2 File format of the eXY-file for positioning of CVES data

**Way Point File [.eWP]:**

A text file holding UTM X and Y coordinate measured at selected electrodes

The format of the file is given in Figure 2.3 :

Elec_No	UTMX	UTMY	STDY	STDY	EDIST	STDE	AngCon
1	574998	6232994	10	10	5	0.05	1
11	575002	6232946	10	10	5	0.05	1
21	574993	6232902	10	10	5	0.05	1
31	575001	6232851	1	1	5	0.05	0
41	575050	6232850	1	1	5	0.05	1
51	575092	6232852	10	10	5	0.05	1

Figure 2.3 File format of the eWP-file for positioning

The file contains UTM positions and standard deviation on each position for STD<sub>X</sub>, STD<sub>Y</sub> (std on the given UTM-coordinates) and STDE (std on the electrode positions). The EDIST column allows specification of different electrode distances between the way points. The values of STD<sub>X</sub>, STD<sub>Y</sub> and STDE are used in an optimization algorithm for positioning the observed way points. In the example above the user has placed a greater confidence in the UTM-positioning of electrode 31 and 41 than the others (+/- 1 m compared to +/- 10 m), making the algorithm look for a solution fitting these points better than the others. The STDE is +/- 0.05 m at all points. The value of AngCon is 0 or 1. This represents a profile angle constraint, setting the profile line at the point either to be a straight line (AngCon=1) or any angle (AngCon=0). The result of the fitting of way points can be plotted on a map while setting up the data import.

**Profile topography file [.eZ]**

The format of this file is the same as the format of the topographical data in a dat-file for RES2DINV as shown in

```

TOPOGRAPHICAL DATA
2
156
100.00 -1.65
200.00 -0.49
300.00 -0.28
.
.
10000.00 4.94
2
    
```

Figure 2.4 File format of the eZ-file for positioning of CVES data

Figure 2.4. First line is a header. Second line is type of x-location where a value of 1 is used if the x-location values are true horizontal distances, while a value of 2 is used if it is the distance along the ground surface. Third line remaining lines contain the X and Z coordinates of the topography points along the profile. Last line: After the last topography data point, the topography data point with the first electrode is written. In the example the first electrode is positioned in horizontal coordinate of 200.

**2.2 IMPORT - MODELS**

Existing inverted CVES models can be imported to already existing datasets by following these steps:

1. Import data as described above.
2. Set **CVES Import Mode** to **Import model to GERDA**, as seen in Figure 2.5.

3. Specify which dataset the models are to be imported to. Existing datasets in the database are found using the **Browse** button.
4. Specify the model type. Valid formats are RES2DINV inv files or SIP databases.
5. Press **Import**.

**3 PROCESSING**

To start the processing a database holding data (see 2.1 "Import - data") and a GIS map is needed.

The processing is accessed via the quick-access tool-bar or by right-clicking on the **Map**-node. Select **Data Processing/CVES Processing**, after which the

**Dataset Selector** window is opened. Specify which dataset to work on and enter a name for the processing. This creates a **CVS** node as a subordinate to the **Map** node. By right-clicking on the **CVS** node and selecting **Process data** the **CVES Explorer** is started.

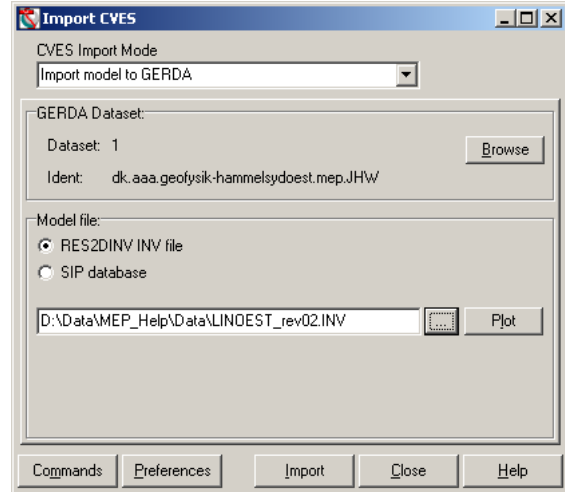


Figure 2.5 The import of CVES models is done using the Import CVES form with CVES Import Mode set to Import Model to GERDA

### 3.1 CVES EXPLORER

The **CVES Explorer** is the gathering point of the CVES processing. The window itself is a list-box consisting of two tab-sheets, as seen in Figure 3.1.

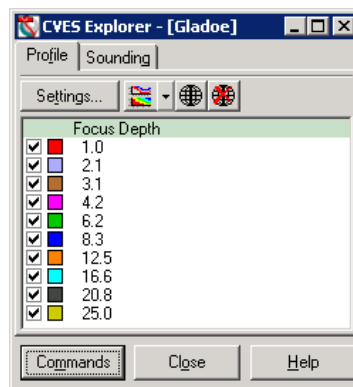


Figure 3.1 The CVES explorer which is the centre of the CVES processing. Here tab sheet Profile is shown.

Tab-sheet **Profile** is intended for profile views of the data with the configurations separated based on their focus depth. The tab-sheet **Sounding** gives access to the data separated into

soundings along the profile. The two tab-sheets are described in larger detail in the next sections.

Click the **Commands/Statistics** button to see a statistical table of the data set as in Figure 3.2. Clicking **Commands/Map Symbols** gives access to alter symbols used on the map.

Field	Value
First Electrode [m]	0.0
Last Electrode [m]	320.0
Min Lat. Focus Distance [m]	12.0
Max Lat. Focus Distance [m]	308.0
Min Vert. Focus Depth [m]	1.0
Max Vert. Focus Depth [m]	25.0
Min Rhoa [ohmm]	14.5
Max Rhoa [ohmm]	3930.8
Average Rhoa [ohmm]	85.4
Array Type	WennerA
No. Data	536
No. Electrodes	161

Figure 3.2 The Statistics table.

**TAB-SHEET PROFILE**

The tab-sheet **Profile** (Figure 3.1) displays various views along the profile. The configurations are separated based on their focus depth (50% cumulated sensitivity). Each configuration or focus depth is identified by a color in the list. If identical, but mirrored configurations are in the data set (e.g. gradient array) the mirror-pairs are identified by a "left" and "right" extension in the list.

The **Settings** button gives the possibility of defining when two focus depths are treated as the same and to separate left and right configurations focus depths (only applicable for data with non-symmetric configurations, e.g. gradient array type data).

Three different profile plots are opened by clicking the profile button to the right of the **Settings** button. They show electrode positions, data profile as apparent resistivity data curves and the pseudo section. They are all seen in Figure 3.3.

The plots are cross-linked, i.e. if a number of electrodes are selected on the electrode positions plot data points measured with the use of any of the selected electrodes are selected as well, on both the pseudo-section and on the profile plot. Selected electrodes are automatically highlighted on the **GIS Map**. The automatic highlight can be disabled by un-checking the **Auto Update Map** under the **Commands** button. If disabled the map is updated by pressing the **Update Map Positions** button on the **CVES Explorer**.

The profile plots have two common buttons - **Zoom Lock** and **Align**. The **Zoom Lock**-button locks the zoom-level, so that all plots share the same x-axis zoom-level. **Align** aligns all three plots with respect to the one on which the **Align**-button was clicked.

The **Electrode Positions** plot shows the electrode positions along the profile with topography (if topography data is present).

The **Data Profile** plot shows data curves of individual configurations separated based on their focus depths. Only configurations selected on the **CVES Explorer** are shown. Each data point is plotted with an error-bar showing one standard deviation as indicated when importing the data. The **Curve shift factor** allows the user to shift curves visually, thereby separating otherwise overlapping curves. Setting the **Curve shift factor** to 1 enables view of actual data values.

The **Pseudo Section** plot displays data values plotted with respect to their lateral and vertical focus point. Each data point is then colored with respect to the measured apparent resistivity value. No gridding is involved in plotting the pseudo section, which enables direct identification of bad data points. With the **Settings** button on the **Pseudo Section** you can change the plot setup such as color scale.

Data points can be toggled on and off on the **Data Profile** and **Pseudo Section** plots using the standard selector tools, which are available via the **Chart Tools** bar or the right click menu on the plot windows. It is also possible to add extra noise to specific data points.

**TAB-SHEET SOUNDING**

Tab-sheet **Sounding** (Figure 3.4) shows a list of the data as soundings. The data are divided into soundings based on the position of the lateral focus point for each configuration. The width of the sounding intervals is adjusted by clicking the **Settings** button.

Clicking **Sounding Plot** opens up a sounding curve plot showing the data and the data error as an errorbar indicating one standard deviation. The same information is available in a tabular form by clicking **Data Table**.

Sounding positions are automatically updated on the map.

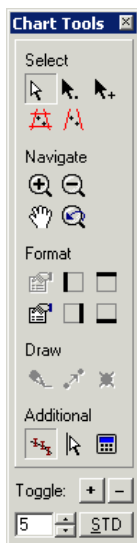


Chart tools menu-bar

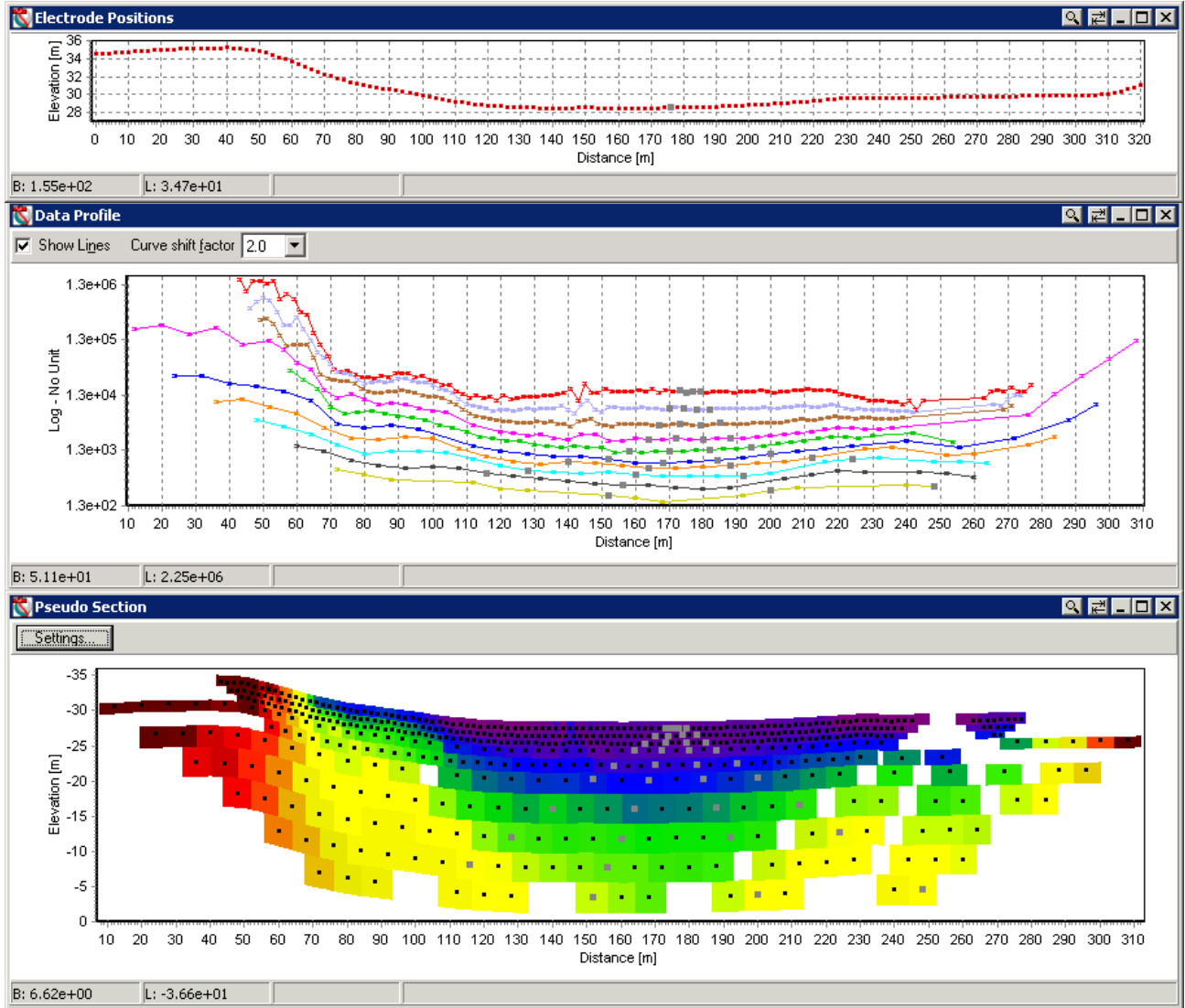


Figure 3.3 The three profile plots used in the processing of CVES data. On top the Electrode Positions, in the middle Data Profile and in the bottom the Pseudo Section. Notice how one selected electrode migrates to a suite of selected data points measured using that electrode.

The **Sounding** plot form is cross-linked to the profile plot forms so that data points selected on the **Sounding** plot are mapped to selections on the **Electrode Positions** plot, the **Data Profile** plot and the **Pseudo Section** plot and vice versa. Likewise, data can be toggled on and off and the data error can be adjusted on the Sounding plot.

On the **Settings** menu, the sounding distance is given, as well as an option

to **Average Coincident Configurations**. Coincident configurations might be data of the same configuration falling in the same interval, or mirror-pairs from asymmetrical configurations (e.g. gradient array). If average is chosen a new standard deviation is estimated based on the stack of the averaged data.

Press the **Close** button on the **CVES Explorer** when the processing is

finished. If changes have been made to data the option to save these is given. After this the Workbench inversion module can be used. Data can be inverted using 1D-LCI, 2D-LCI and Res2dinv. The 1D-LCI module is a general module and described separately in "Aarhus Workbench - 1D-LCI inversion". The module for RES2DINV inversion is described in the next section.

Distance	No. Data Raw	No. Data Ave
15	2	1
25	2	2
35	4	3
45	12	7
55	22	8
65	25	9
75	27	10
85	27	10
95	25	9
105	23	8
115	25	10
125	27	10
135	24	9
145	26	9
155	27	10
165	25	10
175	26	9
185	25	9
195	23	9
205	27	10
215	26	9
225	24	9
235	21	8
245	8	6
255	7	5
265	9	4
275	10	6
285	3	3
295	2	2
305	2	1

Figure 3.4 The Sounding tab of the CVES explorer

## 4 INVERSION WITH RES2DINV

The CVES module has a build-in interface for RES2DINV. The execution is based on the batch mode option in RES2DINV, which reads in an ivp-file holding the inversion settings and then executes the program in hidden mode.

Use the quick-access tool-bar or right-click on the **CVS**-node and select **Invert Data** and then **RES2DINV**. State a unique name for the RES2DINV inversion, which will also be the name of the **CVS** inversion node.

### 4.1 INVERSION SETUP

This brings up the **RES2DINV settings** window. The window has three tab-sheets to setup RES2DINV. They hold a selection of the most commonly used settings for RES2DINV. If you find settings that is not accessible from the tab-sheets you can use the

**Load** option and use your own ivp-file with preferred settings. Furthermore you can save the current setup to an ivp-file using the **Save** option.

Click **Help** to bring up RES2DINV-help on the different settings.

**MODEL GRID SETUP**

The first tab-sheet (Figure 4.1) relates to the model-grid setup for RES2DINV:

- The thickness of the model blocks is determined in the first two fields

by a fraction of the unit electrode spacing and a thickness increase factor with depth.

- Settings relating to the width of the model blocks are set in the bottom half of the tab-sheet.

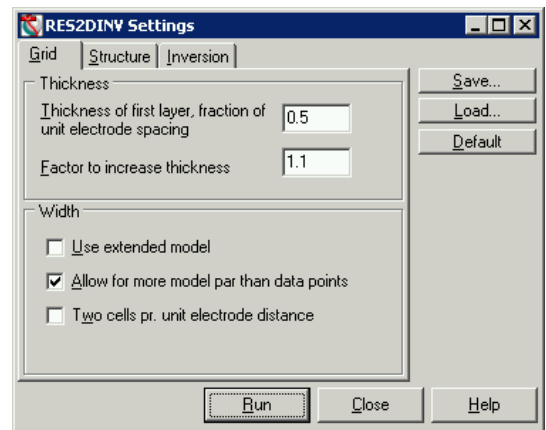


Figure 4.1 RES2DINV settings - tab-sheet grid.

**MODEL STRUCTURE SETUP**

The tab-sheet **Structure** (Figure 4.2) holds settings controlling the preferred structure of the 2D-model. The settings are grouped in two:

- **Model Smoothness** controls the vertical to horizontal smoothness ratio as well as the option to use an L1-norm inversion (also called robust inversion). A **Vertical/Horizontal** smoothness ratio larger than 1 enhances vertical structures whereas a value smaller than 1 enhances horizontal structures. Use **L1-norm inversion** for a blocky model result.
- **Resistivity Limits** can be used to force the result to be within a given resistivity range.

**INVERSION SETUP**

The last tab-sheet (Figure 4.3) controls the inversion progress parameters:

- The **Relative RMS Change** determines when the inversion stops in terms of the relative change in the RMS-error.
- The **Absolute RMS Limit** sets the absolute termination of the inversion job in terms of RMS-value.
- **Number of iterations** is the maximum number of iterations made.
- The **Advanced** button controls settings related to Quasi-Newton calculations and optimizations using Incomplete Gauss-Newton (Figure 4.4).

**4.2 RUNNING THE INVERSION**

Click the **Run**-button to execute RES2DINV with the current settings. This brings up the **RES2DINV viewer**

(Figure 4.5) which controls the execution of the program and visualization of the results.

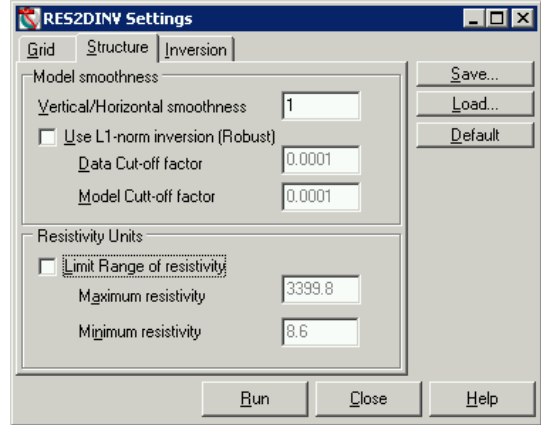


Figure 4.2 RES2DINV settings - tab-sheet structure.

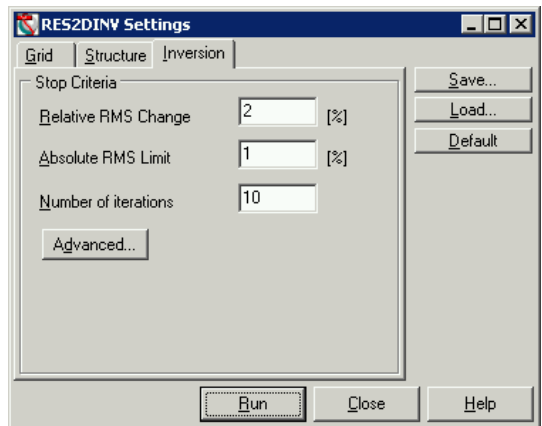


Figure 4.3 RES2DINV settings - tab-sheet inversion.

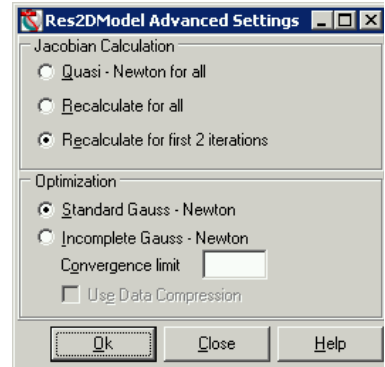


Figure 4.4 RES2DINV settings - advanced inversion settings.

The bottom part of the window is a log of actions stating the time and the action. In the main frame you can follow the iteration count and the RMS residual for each iteration. When the first iteration has ended four windows will automatically open (Figure 4.6):

1. Pseudo section of observed data
2. Pseudo Section of forward data

3. Difference section as percentage error of forward section relative to pseudo section
4. Model section

These four windows will automatically update for each new iteration finished.

The **Commands** button gives access to colorbars and other settings controlling the visual appearance of the four sections.

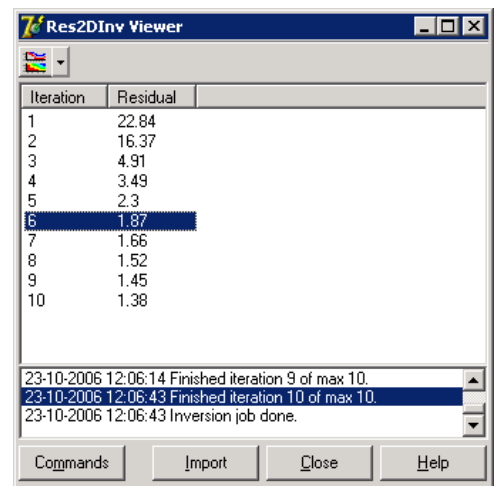


Figure 4.5 RES2DINV viewer.

To select the iteration that should be kept, set the selection to that iteration and click **Import**. This will pass that iter-

ation back to the Workbench where it will be saved in the database.

### 4.3 VIEWING INVERSION RESULTS

After import a 2D inversion-node appears in the **Workspace Manager**. Right-click on the node to access the inversion result. This brings up the window seen in Figure 4.7.

the plots are linked to position all electrodes on the map. The plots are also cross-linked so that data points selected on one plot selects the same data points on the other plots.

Clicking the icon-button in the top-left corner brings up the four displays as described above only in this view

Data points can be disabled either manually or automatically for resubmission of the inversion job:

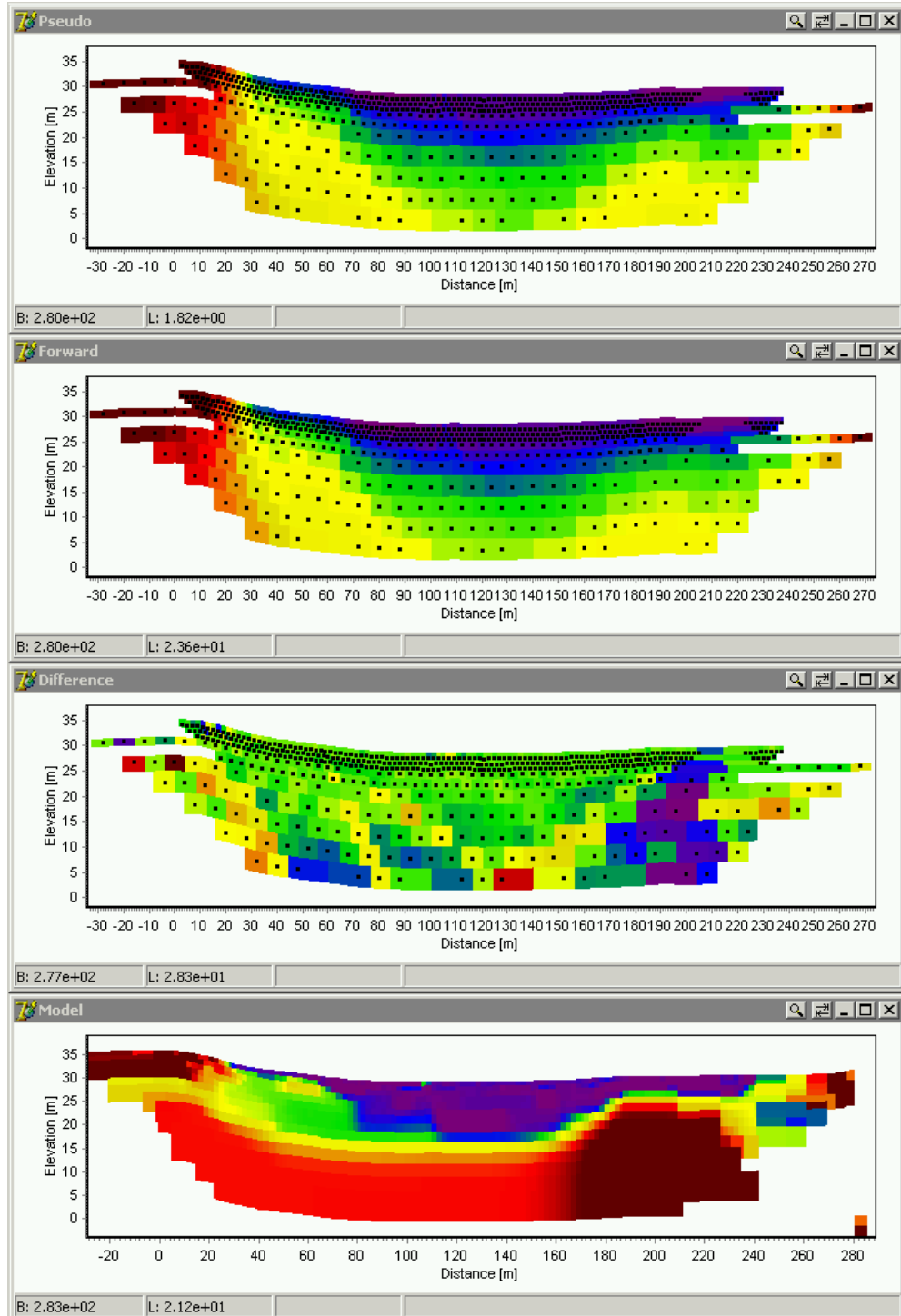


Figure 4.6 RES2DINV inversion results.

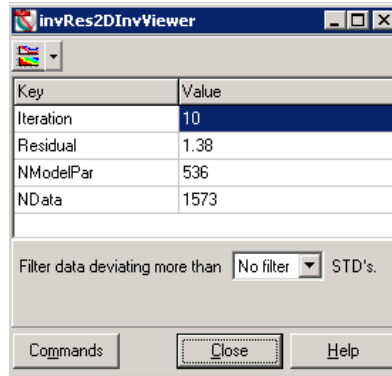


Figure 4.7 RES2DINV - Show inversion result.

- Select data points manually using the **Chart Tools** and click the **Toggle-minus** button to remove the data points (they can be added again by clicking **Toggle-plus**).
- Select data points automatically using the filter-dialog on the main form (Figure 4.7). The selection is based on the standard deviation assigned to the data points. Thus, with a 5 % STD (1.05) assigned to the data points all data points deviating more than 5% from the observed data will be filtered setting the **Filter data deviating more than...** to 1.

The re-processed data set can be resubmitted for inversion clicking **Resubmit Data for Inversion** in the **Commands** menu.