Res2DInv and Res3DInv

- Theory and demonstration

Knud Valdemar T. Lassen

Aarhus GeoSoftware

Program

- Theory
  - Introduction to DC and IP theory
  - Introduction to inversion theory
- Res2DInv and Res3DInv
    - Distribution and installation of software
  - 2D inversion and hands om exercises
    - Processing, inversion and troubleshooting
    - Presentation and visualization
  - 3D inversion and hands om exercises
    - Same procedure
  - Questions etc.

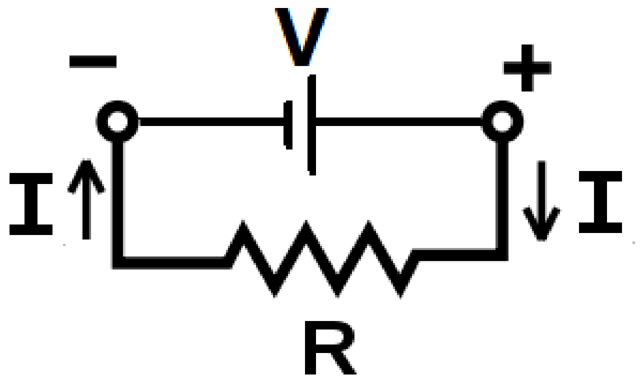
Terminology

- DC = Direct current method = ERT = Electrical Resistivity Tomography = ERI = Electrical resistivity Imaging etc.
- IP = induced polarization
- Processing = preparation of data before inversion
- Inversion = computation of geophysical model (resistivity and chargeability distribution) from measured data

Theory – Ohm's law

General formulation:

$$R = {}^{V}/_{I}$$

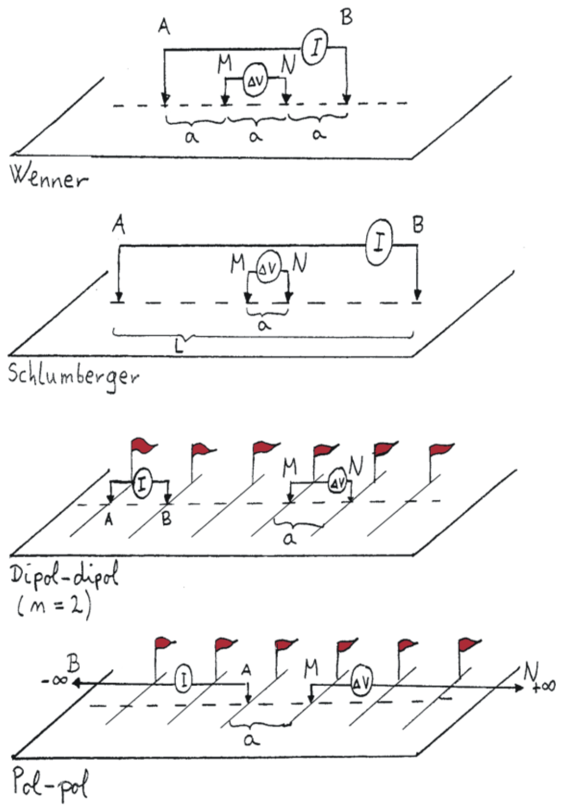


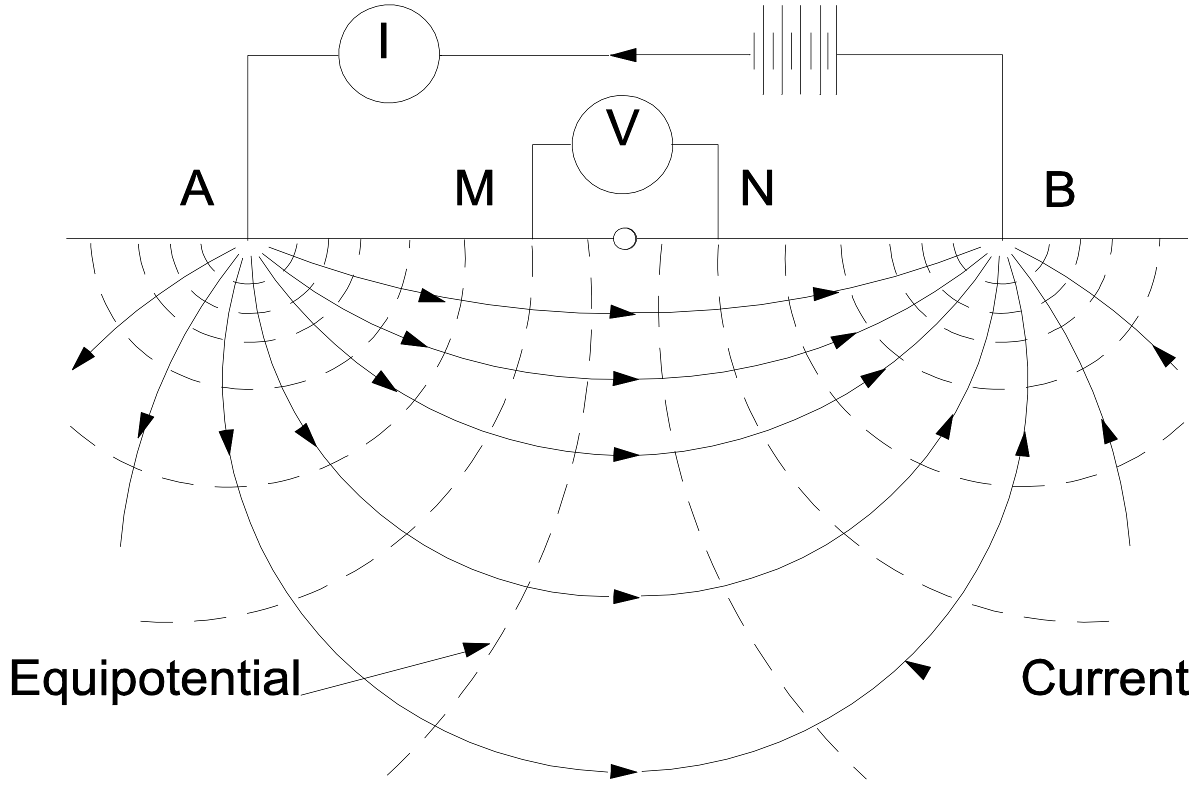
Geophysicists formulat

$$\rho_a = k\frac{\Delta V_{MN}}{I_{AB}}, \qquad \mathbf{k} = \frac{2\pi}{\left(\frac{1}{AM} - \frac{1}{BM}\right) - \left(\frac{1}{AN} - \frac{1}{BN}\right)}$$

Theory – Ohm's law

$$\rho_a = k\frac{\Delta V_{MN}}{I_{AB}}, \qquad k = \frac{2\pi}{\left(\frac{1}{AM}-\frac{1}{BM}\right)-\left(\frac{1}{AN}-\frac{1}{BN}\right)}$$





How does current flow in the ground?

There are 3 main modes of current conduction in the subsurface, these are described by Archie's law:

- Bulk water
- Surface conduction
- Surface polarization

AGS Aarhus GeoSoftware

Archie’s law: 3 current paths

bulk water

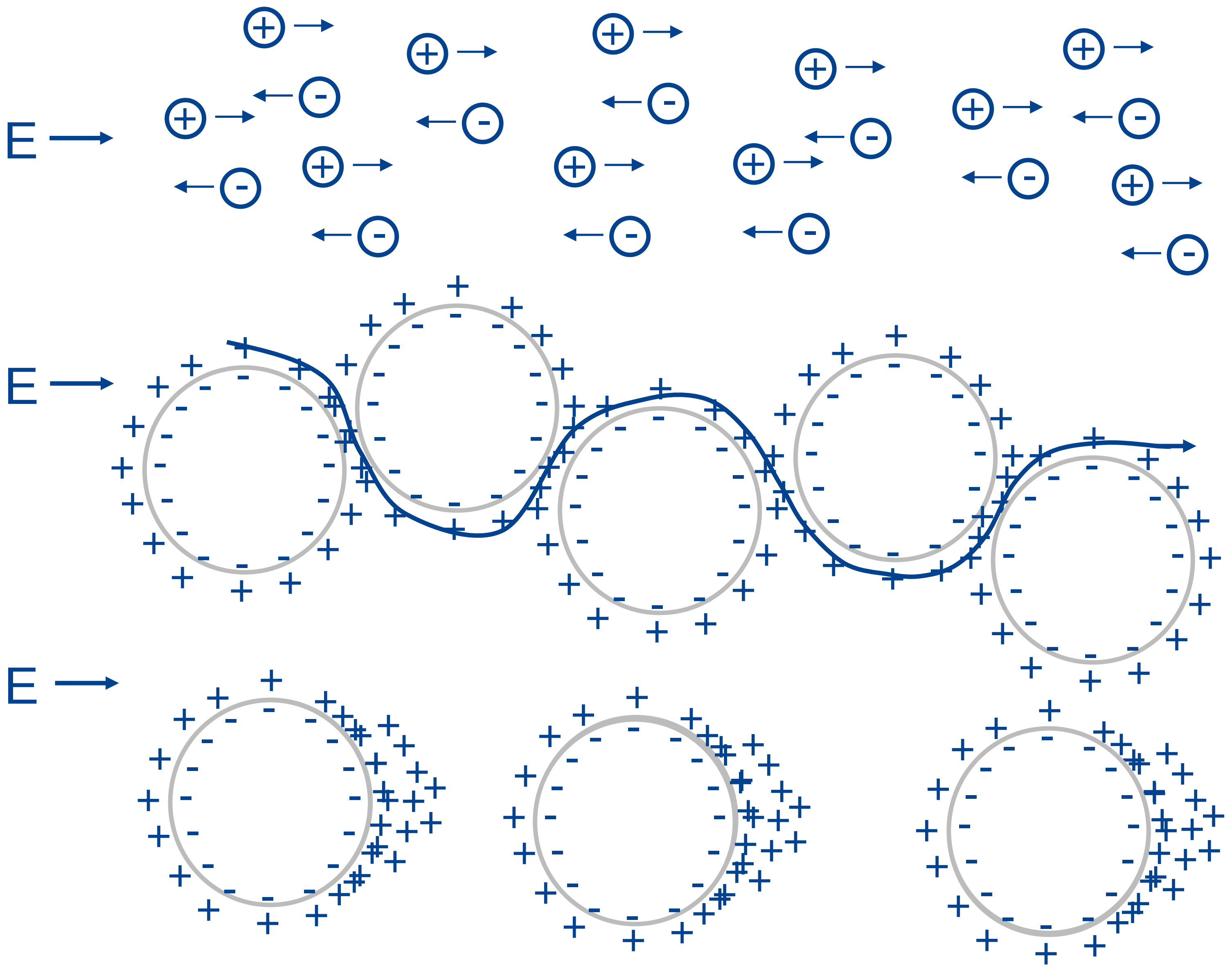
$$\sigma = \frac{1}{F}\sigma_W$$

surface conduction

$$\sigma = \sigma'_{surf}$$

surface (grain) polarization

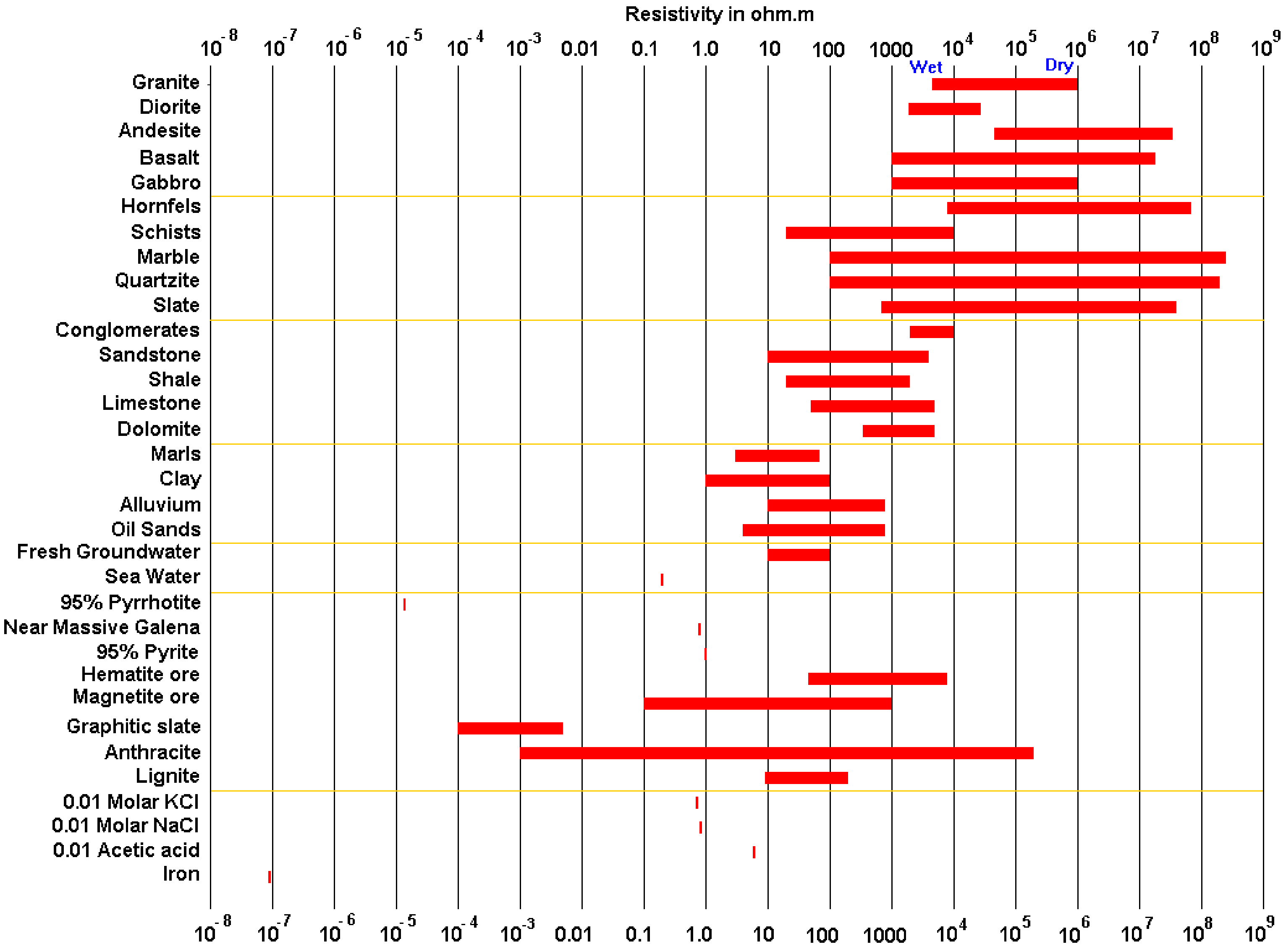
$$\sigma = i\sigma''_{surf}$$



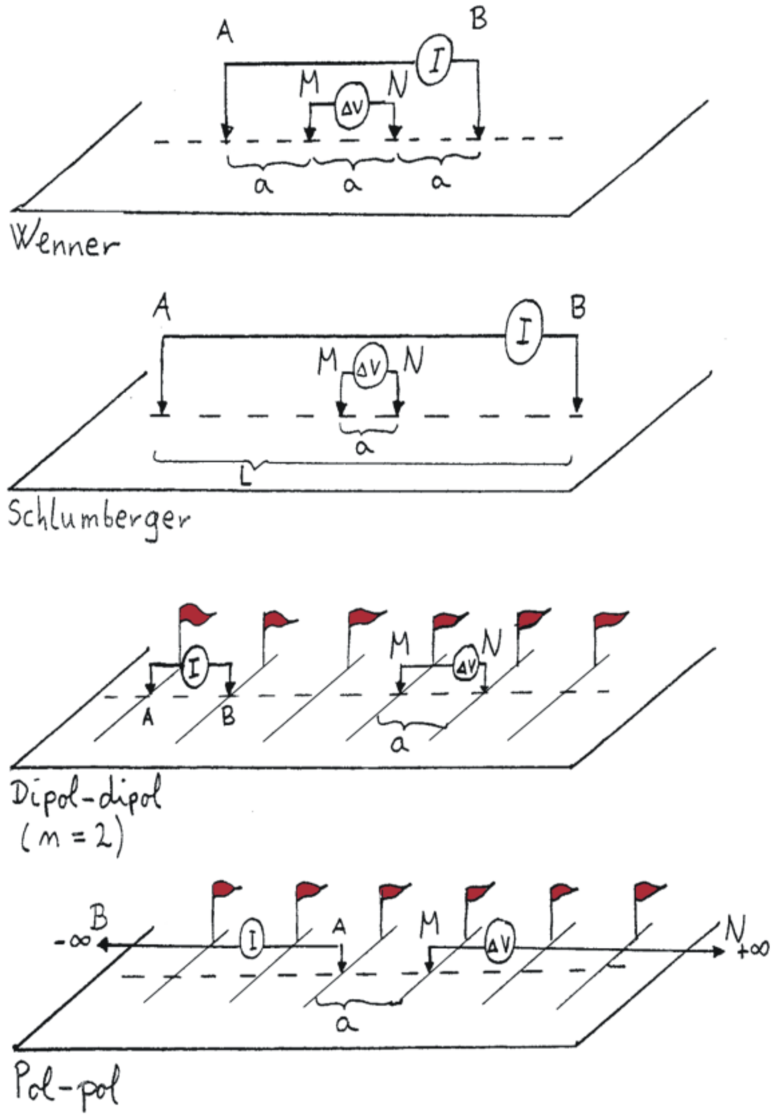
Archie's Law

	bulk water		surface conduction		surface polarization
$\sigma =$	$\frac{1}{F}\sigma_W$	+	σ'_{surf}	+	$i\sigma''_{surf}$

Examples of resistivities

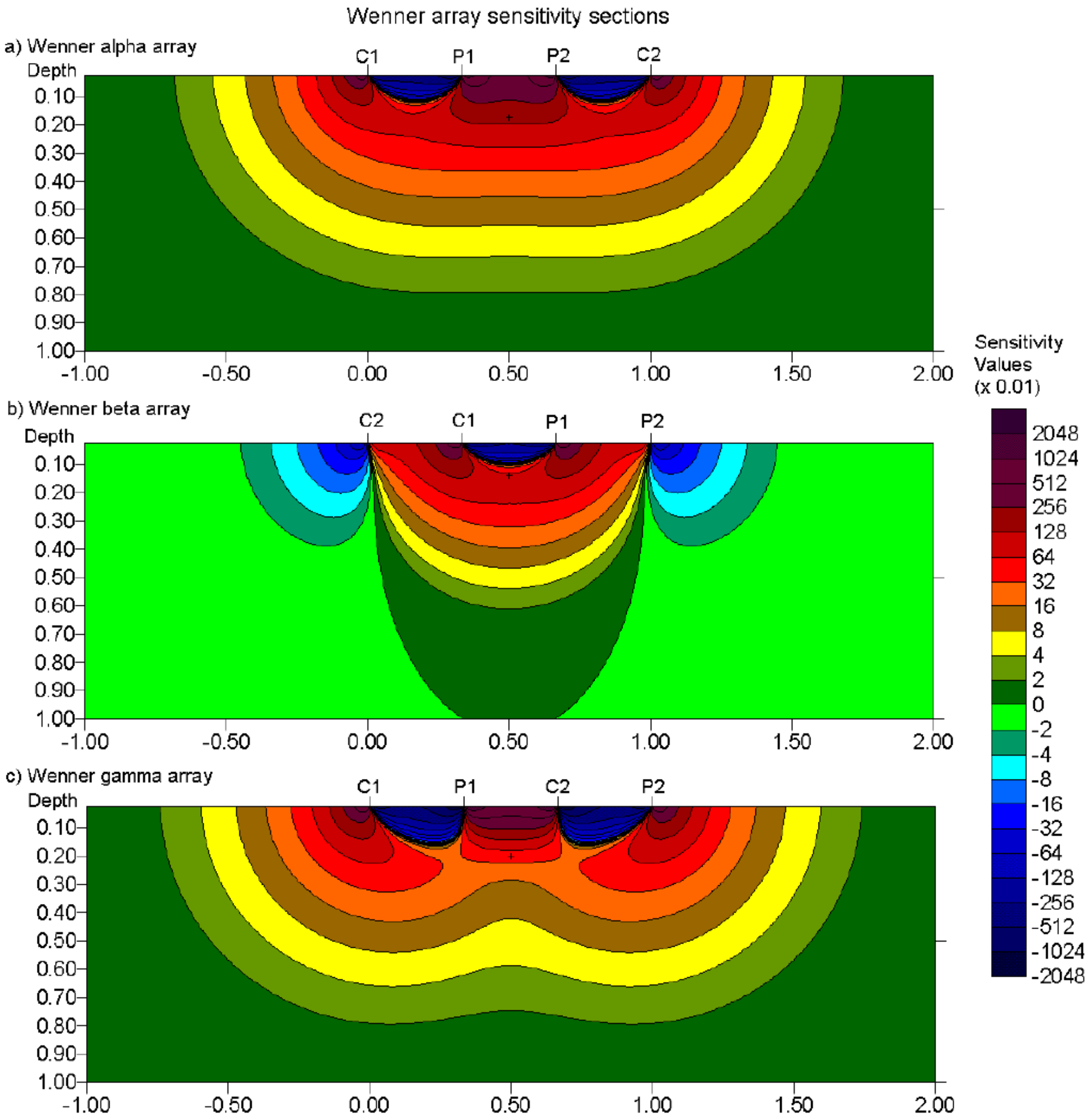


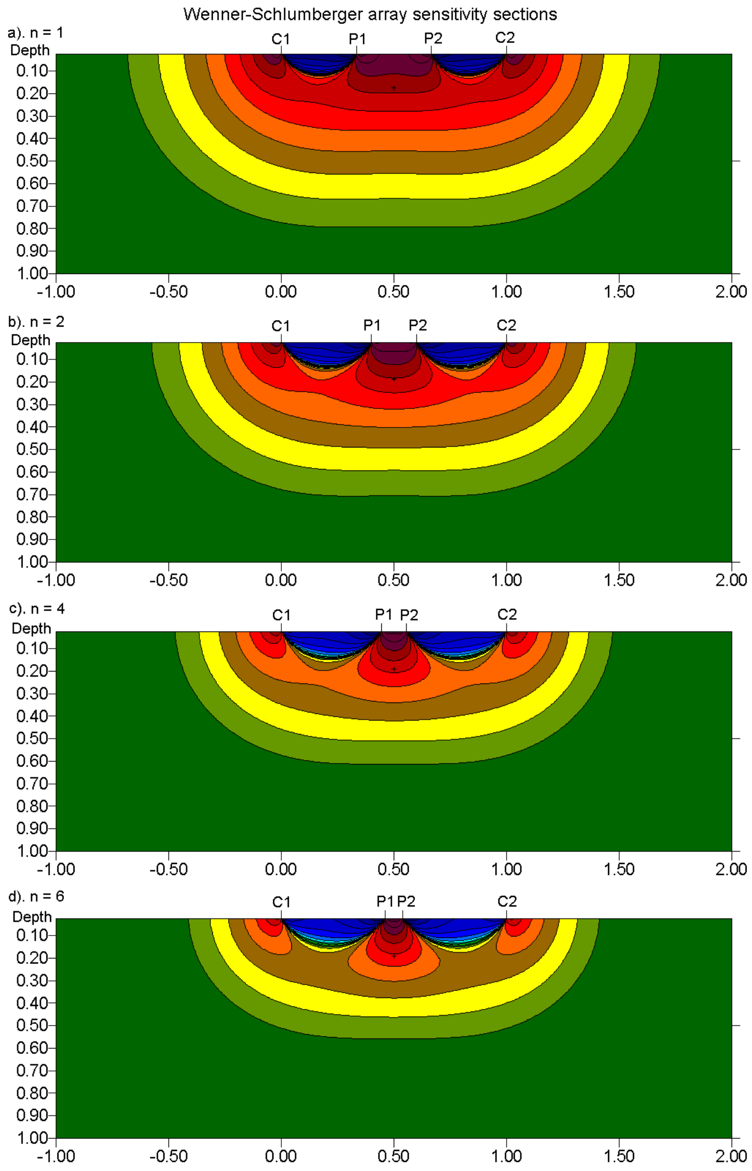
Sensitivity distribution of different configurations



AGS Aarhus GeoSoftware

Sensitivity distribution of different configurations

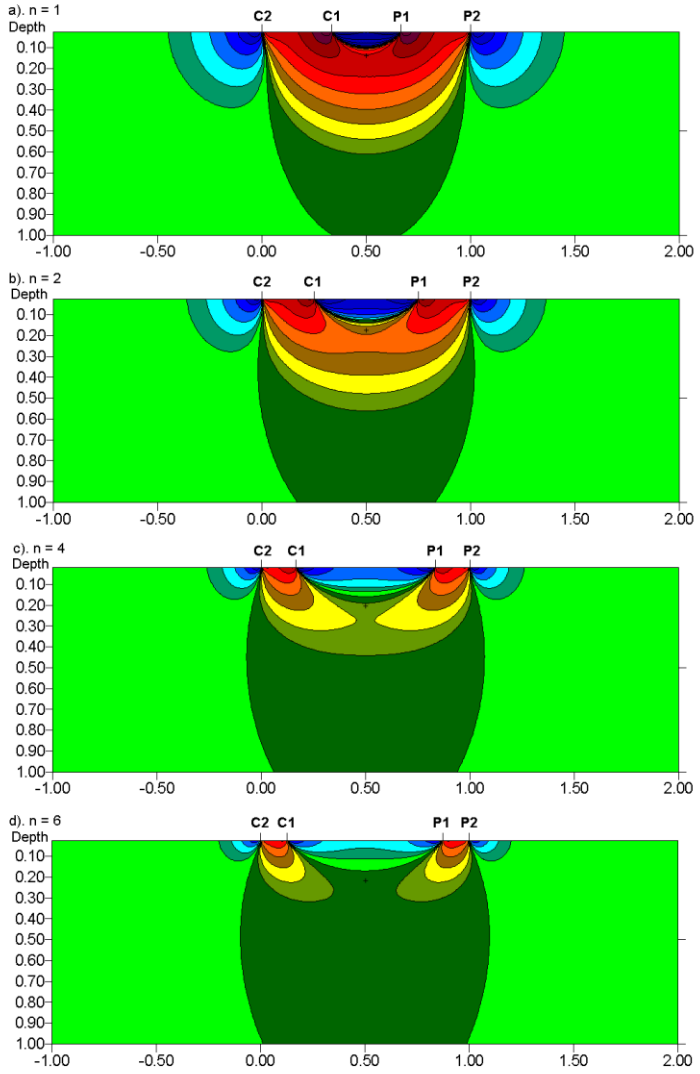




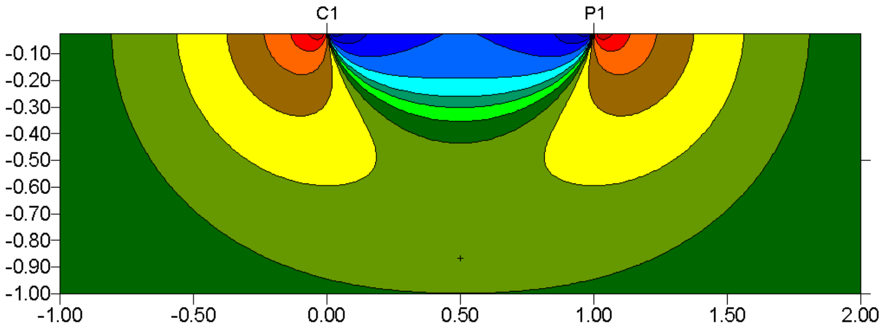
AGS Aarhus GeoSoftware

Sensitivity distribution of different configurations

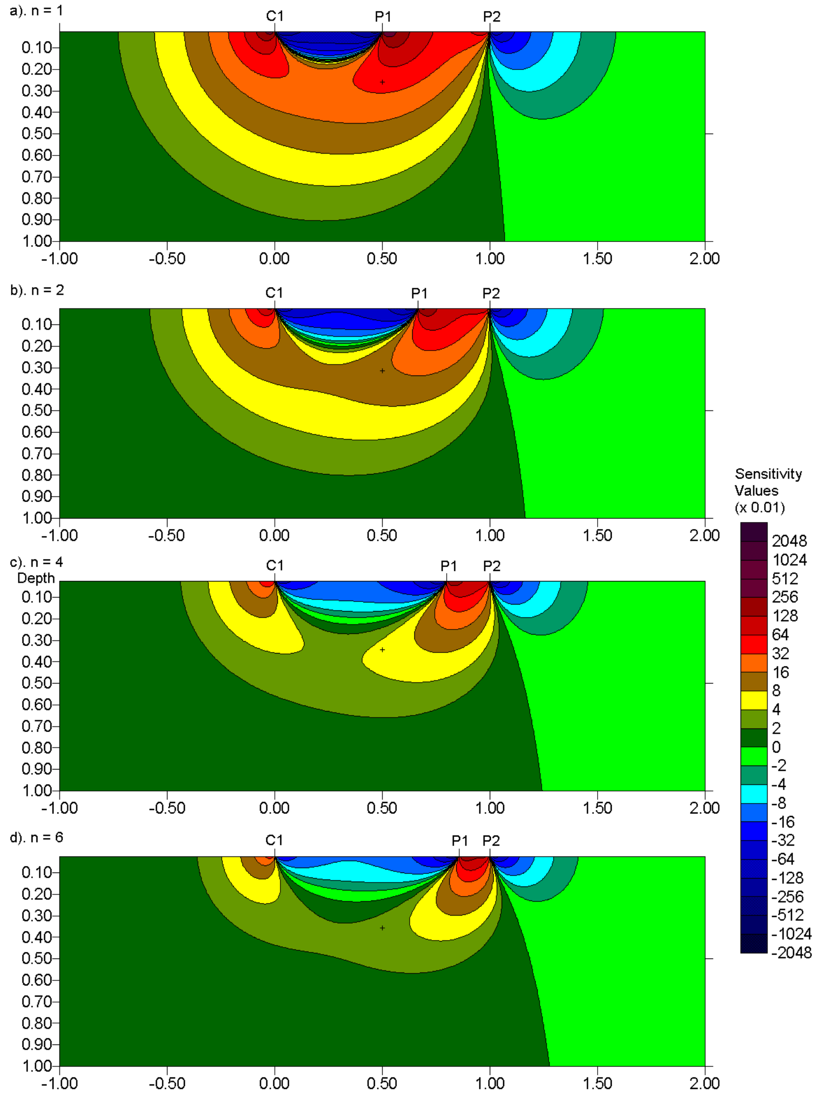
Dipole-dipole array sensitivity sections



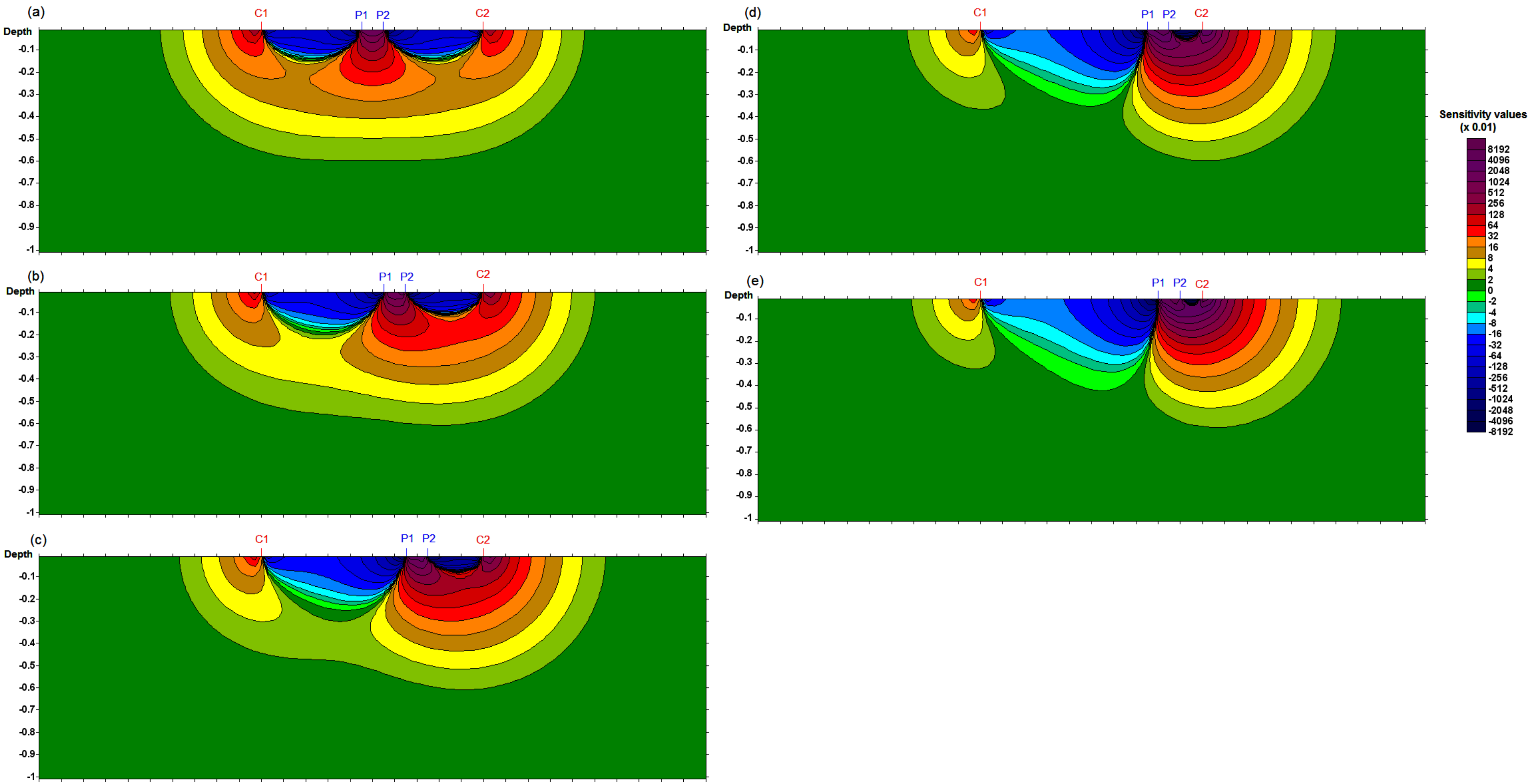
Pole-pole array sensitivity section



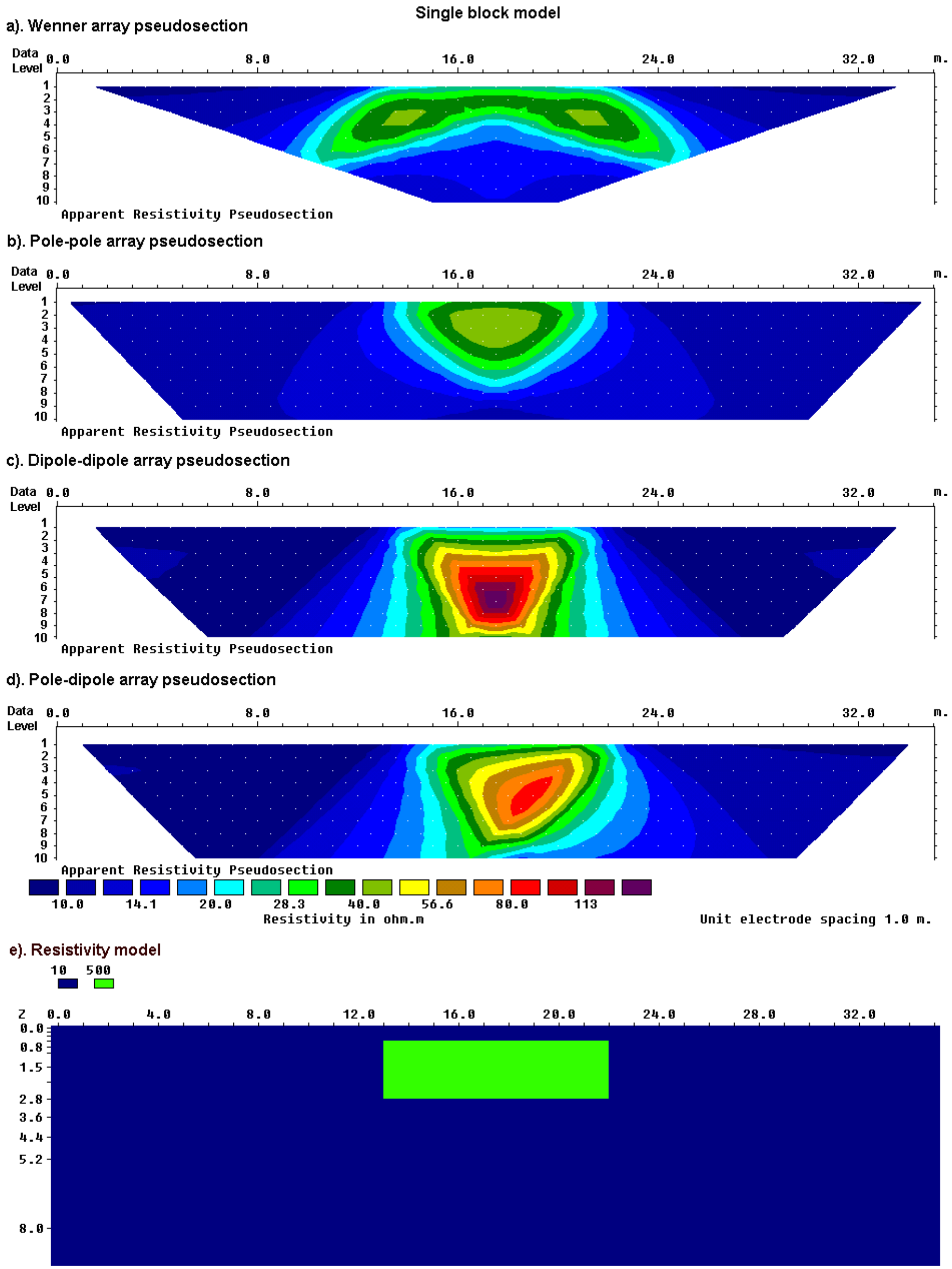
Pole-dipole array sensitivity sections



Gradient Array



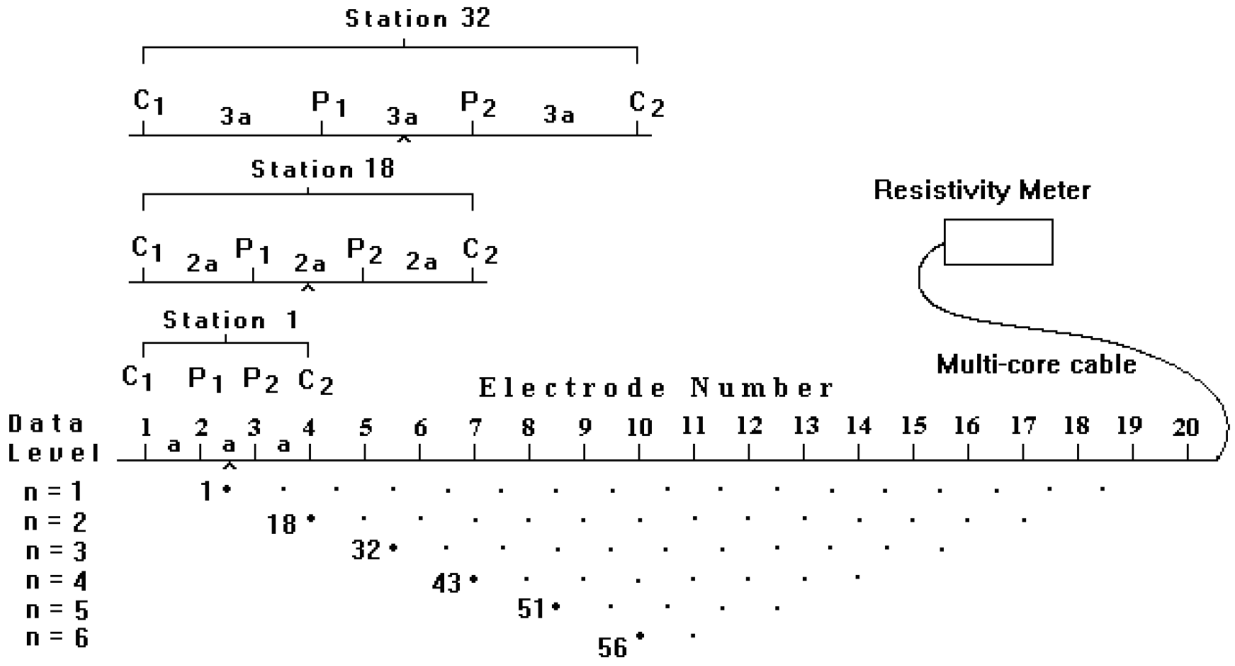
Pseudosection



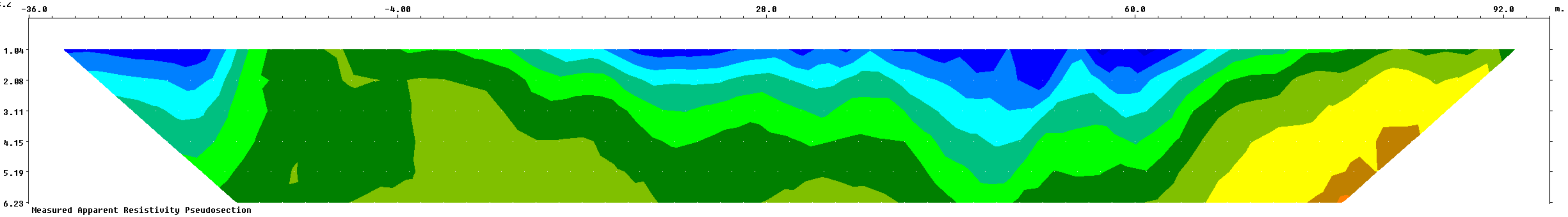
Inversion theory

What do we have?

A series of measurements of resistivity.



Sequence of measurements to build up a pseudosection

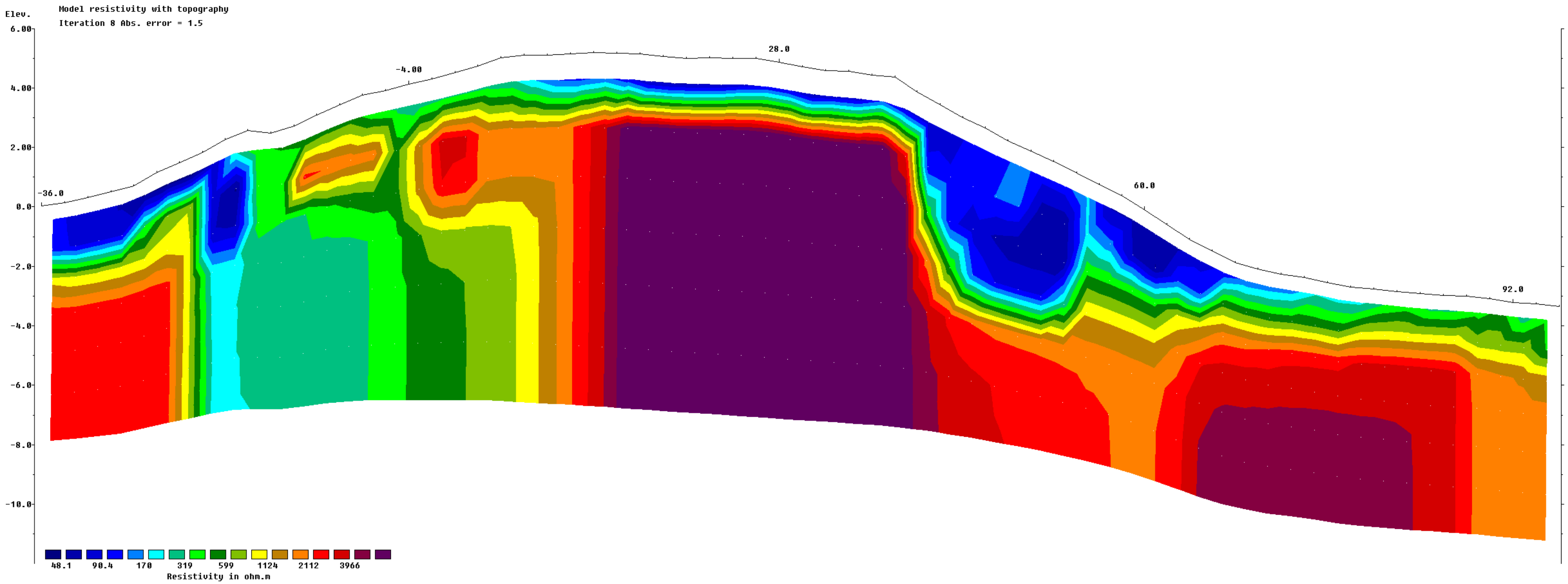


Measured Apparent Resistivity Pseudosection

Inversion theory

What do we want?

A model of the resistivity distribution of the subsurface:

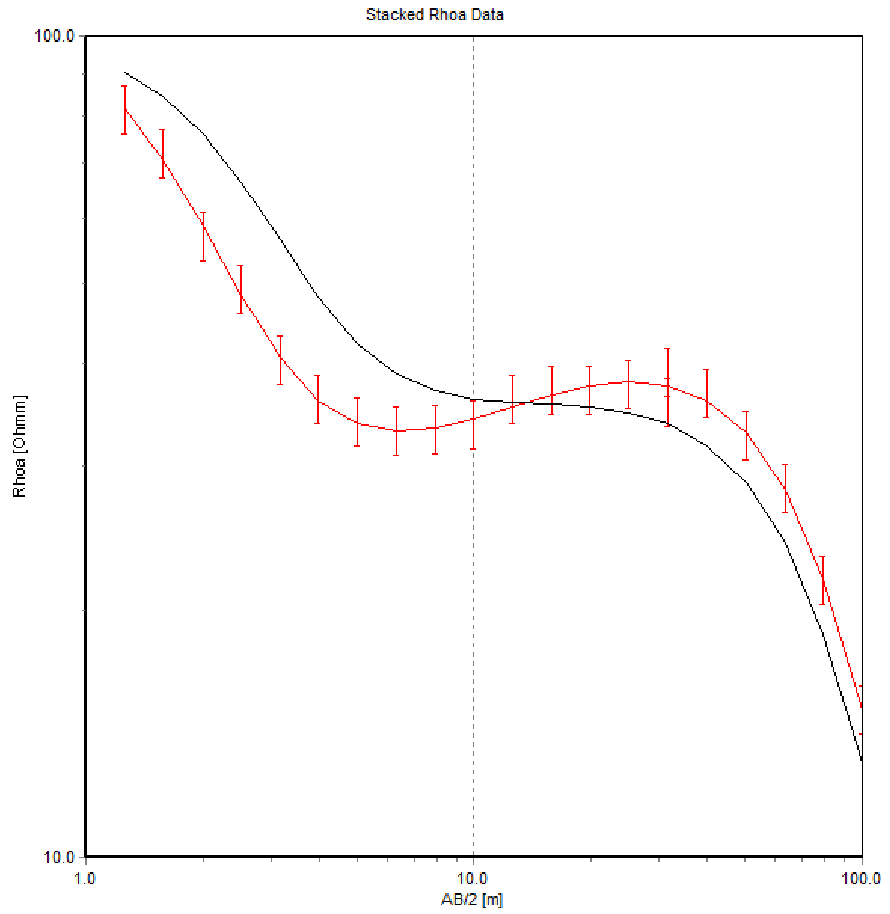


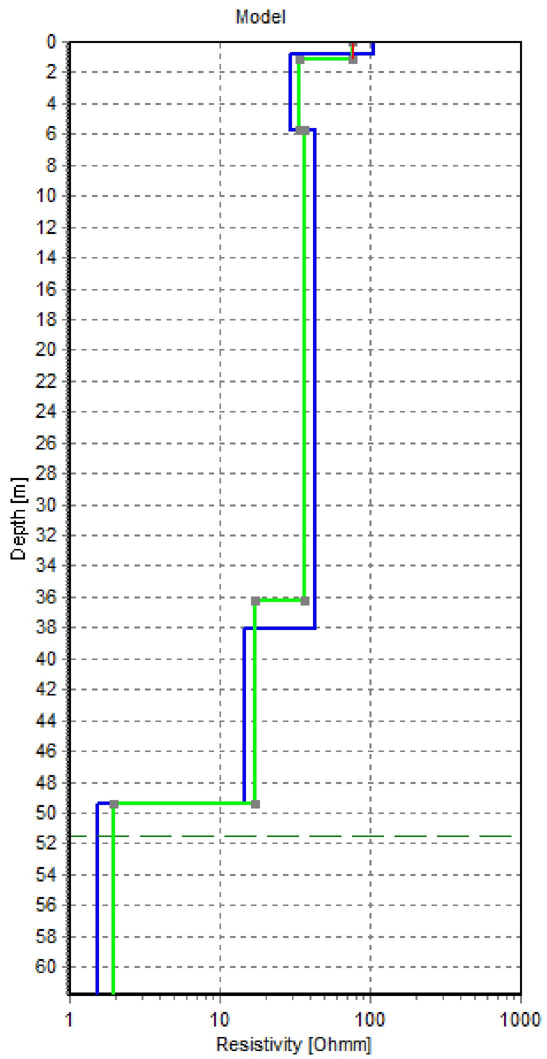
Inversion theory – how do we get there

Starting model → **Forward calculation** → **Comparison of forward calculation and measured data, is stopping criterion reached?** → Yes → **Done!**

No ↓

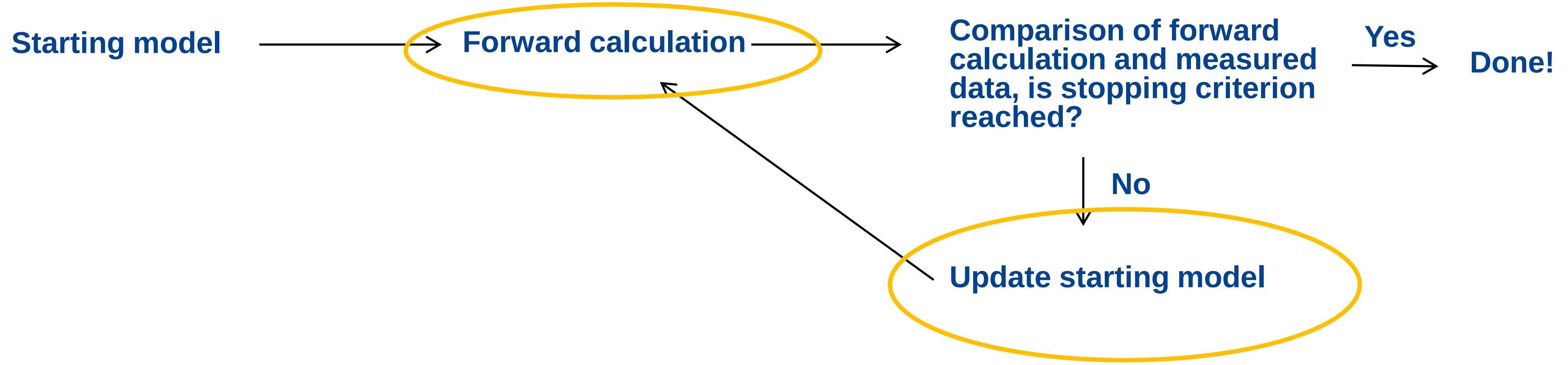
Update starting model → **Forward calculation**





AGS Aarhus GeoSoftware

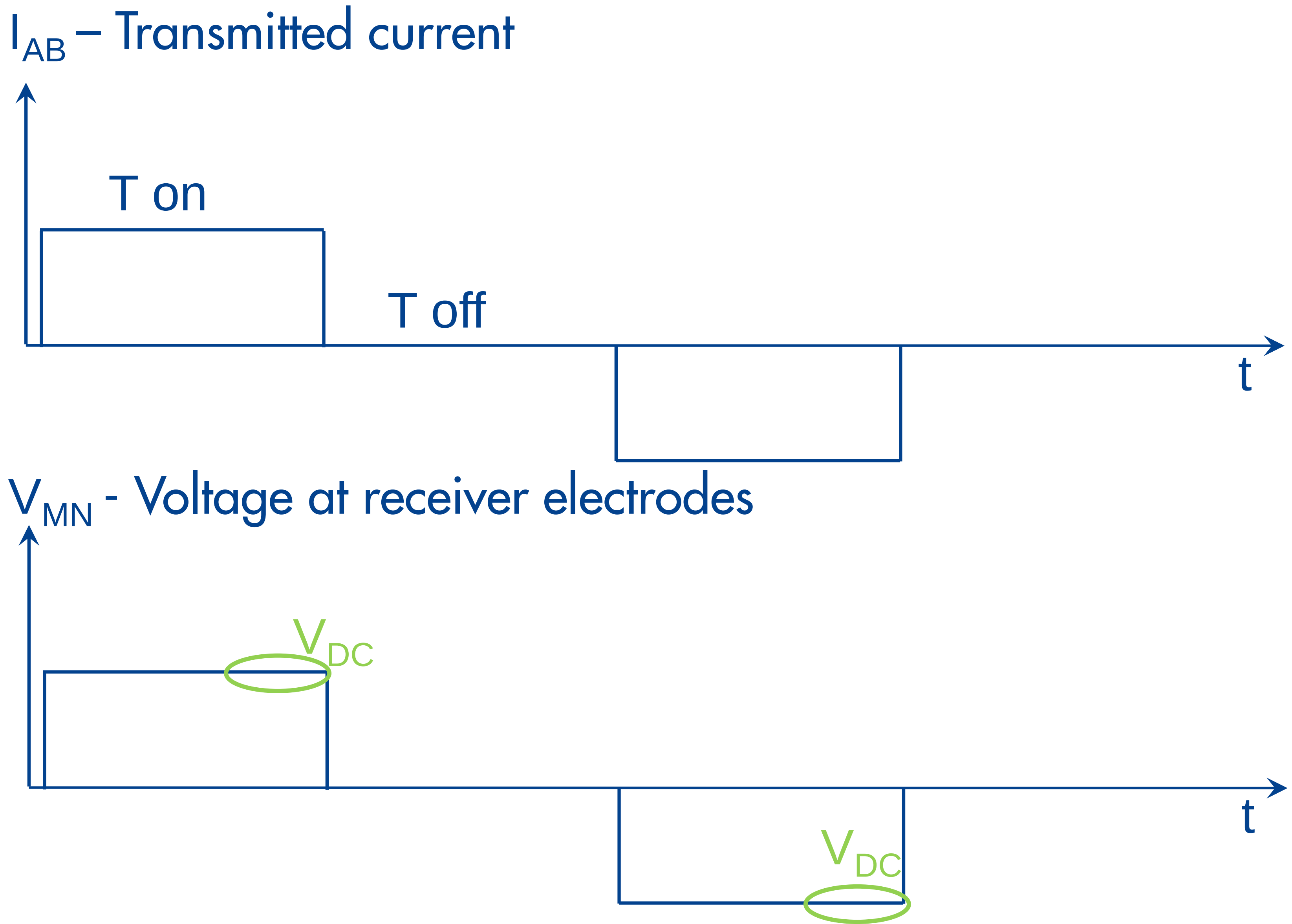
Inversion theory – looks easy… why is it so hard?



Induced polarization

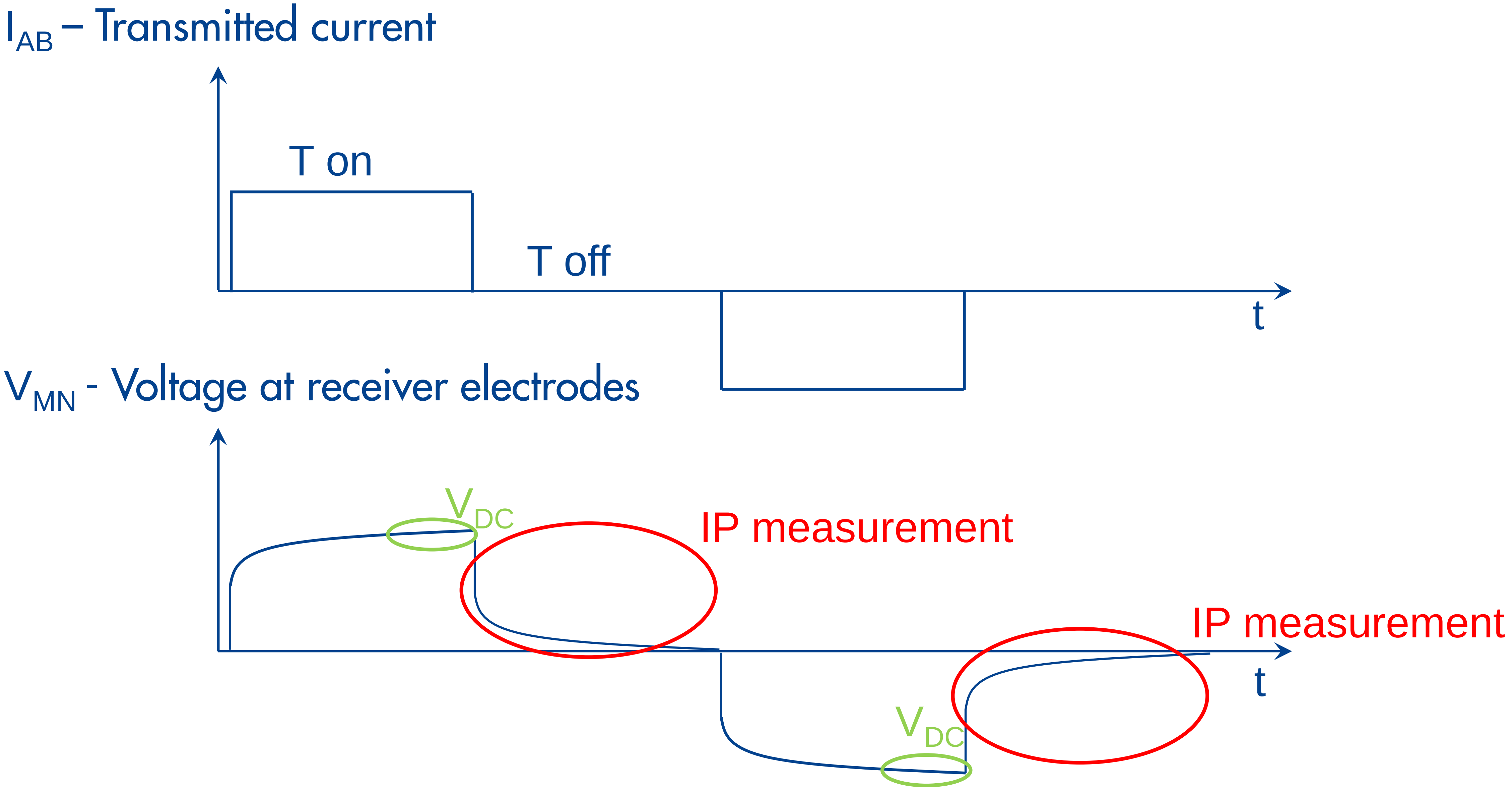
- Induced polarization is the polarization of the subsurface as a result of the transmitted current
- The measurement and inversion principles for induced polarization are very similar to those of direct current methods, but the measured parameter is different
- Induced polarization can be uesful in detecting minerals, and in distinguishing clay from other sediments with comparable resistivities

Induced polarization – No IP effect example



AGS Aarhus GeoSoftware

Induced polarization – Example with IP effcts



AGS Aarhus GeoSoftware

What causes the induced polarization effect?

bulk water

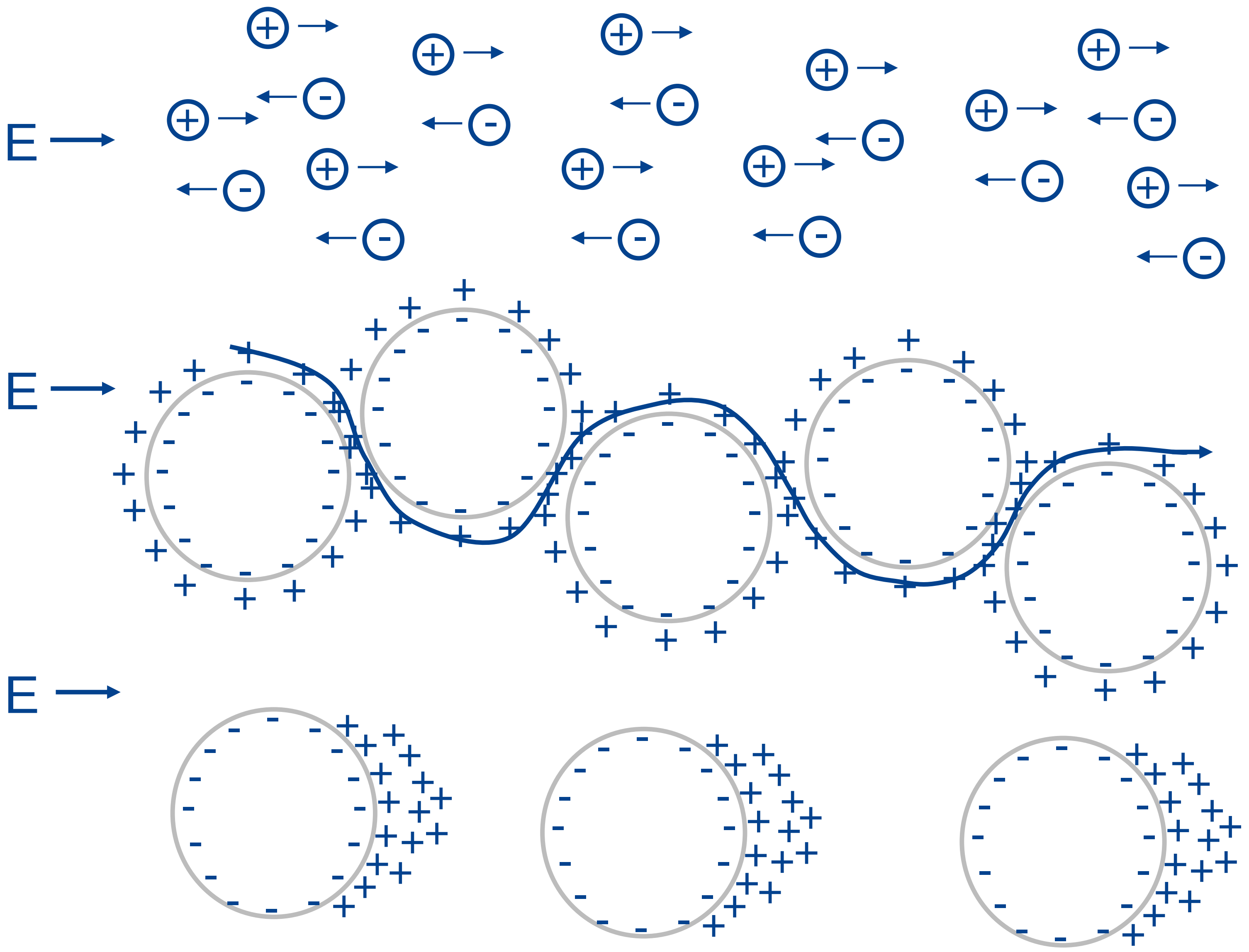
$$\sigma = \frac{1}{F}\sigma_W$$

surface conduction

$$\sigma = \sigma'_{surf}$$

surface (grain) polarization

$$\sigma = i\sigma''_{surf}$$



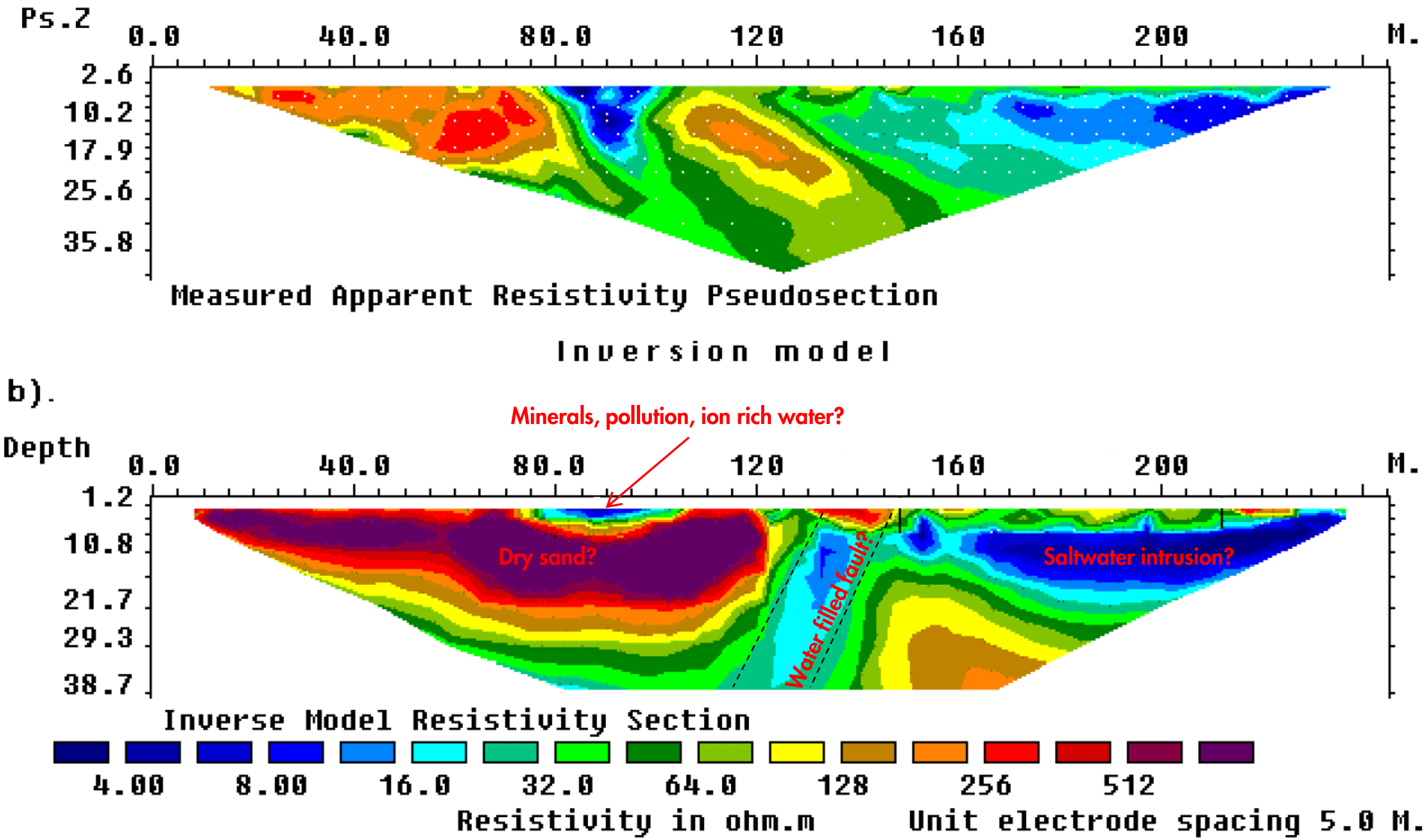
Interpretation

Key requirements for a successful interpretation of geophysical results:

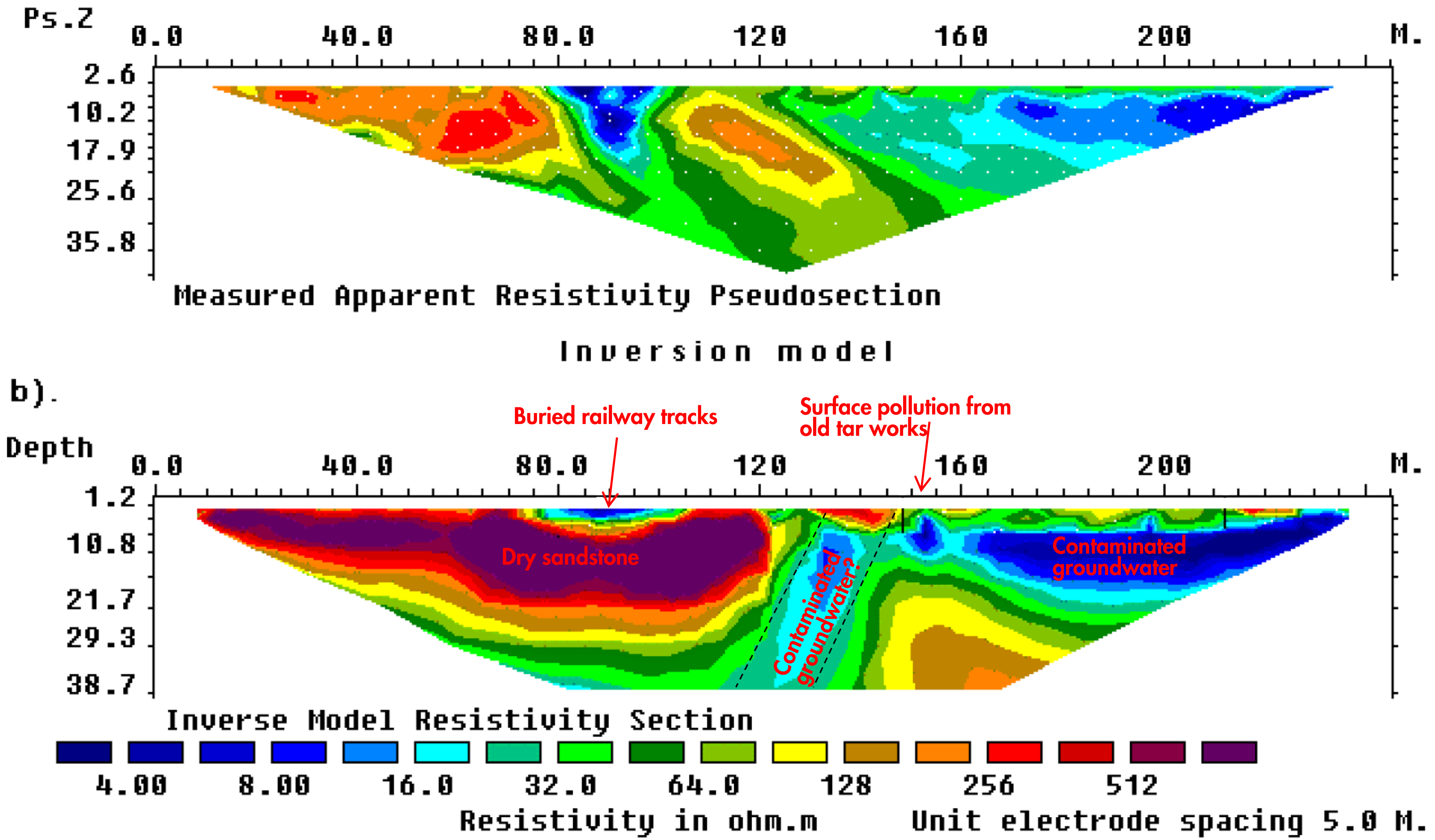
- Good inversion result (low data misfit and correct inversion settings, we will get back to that)
- Good visualization of inversion results (correct axis and color scales, we will also get back to that)
- Prior general knowledge of the geology in the area
- Knowledge about expected resistivity ranges for geological bodies found in the area
- Any additional information if accessible (borehole logs and reports, other geophysical surveys)

AGS Aarhus GeoSoftware

Interpretation – example



Interpretation – example



After the break – Res2DInv

Res2DInv

Input: .dat file

- measured data

- a priori information

- coordinates, topography

.ivp file

- Inversion settings

Output: .inv file

- Models and forward calculations from all iterations
- Inversion settings
- Data

Hands on #1 – running a standard inversion

1. **Install Res2DInv**
2. **Register the license**
3. **Load general_array_simple.dat file by pressing “File -> Read data file” and selecting the file**
4. **Run a simple inversion by pressing “Inversion -> carry out inversion” and select where to save the inversion result**

AGS Aarhus GeoSoftware

The .dat file – simple example

Header lines

Data lines

`General array format example`	Comment/title line
`1.0`	Unit electrode distance
`11`	Array type (General array)
`0`	Array sub-type (unspecified)
`Type of measurement (0=app. resistivity,1=resistance)`	Header
`0`	Measurement type indication
`407`	Number of data points
`1`	Format of x-coordiantes (0 or 1 for true horizontal distances)
`0`	Flag for IP data
`4 0.00 0.00 3.00 0.00 1.00 0.00 2.00 0.00 10.158`	Number of electrodes, x and z coordinates of C_1, C_2, P_1 and P_2 electrodes, apparent resistivity or resistance
`4 1.00 0.00 4.00 0.00 2.00 0.00 3.00 0.00 10.168`	
`4 2.00 0.00 5.00 0.00 3.00 0.00 4.00 0.00 10.184`	
`4 3.00 0.00 6.00 0.00 4.00 0.00 5.00 0.00 10.225`	
`4 4.00 0.00 7.00 0.00 5.00 0.00 6.00 0.00 10.337`	
`4 5.00 0.00 8.00 0.00 6.00 0.00 7.00 0.00 10.708`	
`4 6.00 0.00 9.00 0.00 7.00 0.00 8.00 0.00 11.668`	
`4 7.00 0.00 10.00 0.00 8.00 0.00 9.00 0.00 12.542`	
`4 8.00 0.00 11.00 0.00 9.00 0.00 10.00 0.00 12.871`	
`4 9.00 0.00 12.00 0.00 10.00 0.00 11.00 0.00 13.238`	
`4 10.00 0.00 13.00 0.00 11.00 0.00 12.00 0.00 13.342`	
`4 21.00 0.00 20.00 0.00 27.00 0.00 28.00 0.00 3.422`	
`4 22.00 0.00 21.00 0.00 28.00 0.00 29.00 0.00 7.834`	
`4 23.00 0.00 22.00 0.00 29.00 0.00 30.00 0.00 7.977`	
`4 24.00 0.00 23.00 0.00 30.00 0.00 31.00 0.00 7.343`	
`4 25.00 0.00 24.00 0.00 31.00 0.00 32.00 0.00 5.907`	
`4 26.00 0.00 25.00 0.00 32.00 0.00 33.00 0.00 3.974`	
`4 27.00 0.00 26.00 0.00 33.00 0.00 34.00 0.00 6.765`	
`0`	End all files wit a zero

AGS Aarhus GeoSoftware

The .dat file – special formats

1. **Induced polarization**
2. **Pole-pole and pole-dipole arrays**
3. **Topography**
4. **Global coordinates**
5. **Surveys in water**
6. **Cross borehole data and buried electrodes**
7. **Known boundaries and fixed regions**

The .dat file – IP data

`General array with IP`	Comment/title line
`1.0`	Unit electrode distance
`11`	Array type
`0`	Array sub-type
`Type of measurement (0=app. resistivity,1=resistance)`	Header
`0`	Measurement type indication
`228`	Number of data points
`1`	Format of x-coordiantes (0 or 1 for true horizontal distances)
`1`	Flag for IP data
`Chargeability`	Type of IP data
`mV/V`	IP data unit
`0.0,1.0`	Delay, Integration time

IP data (last column)

```
4      1.00 0.00     0.00 0.00     2.00 0.00     3.00 0.00    13.301    12.5858
4      2.00 0.00     1.00 0.00     3.00 0.00     4.00 0.00    13.298    12.5886
4      3.00 0.00     2.00 0.00     4.00 0.00     5.00 0.00    13.297    12.5867
4      4.00 0.00     3.00 0.00     5.00 0.00     6.00 0.00    13.297    12.5917
4      5.00 0.00     4.00 0.00     6.00 0.00     7.00 0.00    13.297    12.5953
4      6.00 0.00     5.00 0.00     7.00 0.00     8.00 0.00    13.297    12.6043
4      7.00 0.00     6.00 0.00     8.00 0.00     9.00 0.00    13.299    12.6218
4      8.00 0.00     7.00 0.00     9.00 0.00    10.00 0.00    13.302    12.6501
4      9.00 0.00     8.00 0.00    10.00 0.00    11.00 0.00    13.307    12.6990
4     10.00 0.00     9.00 0.00    11.00 0.00    12.00 0.00    13.317    12.7835
4     11.00 0.00    10.00 0.00    12.00 0.00    13.00 0.00    13.336    12.9266
4     12.00 0.00    11.00 0.00    13.00 0.00    14.00 0.00    13.375    13.1871
4     13.00 0.00    12.00 0.00    14.00 0.00    15.00 0.00    13.458    13.7017
4     14.00 0.00    13.00 0.00    15.00 0.00    16.00 0.00    13.665    14.8151
4     15.00 0.00    14.00 0.00    16.00 0.00    17.00 0.00    14.107    16.9138
4     16.00 0.00    15.00 0.00    17.00 0.00    18.00 0.00    12.544     9.5202
4     17.00 0.00    16.00 0.00    18.00 0.00    19.00 0.00    10.183    -1.7850
4     18.00 0.00    17.00 0.00    19.00 0.00    20.00 0.00     9.640    -2.2646
4     19.00 0.00    18.00 0.00    20.00 0.00    21.00 0.00     9.881    -1.0075
4     20.00 0.00    19.00 0.00    21.00 0.00    22.00 0.00    10.011    -0.8956
4     21.00 0.00    20.00 0.00    22.00 0.00    23.00 0.00    10.181    -1.8721
4     22.00 0.00    21.00 0.00    23.00 0.00    24.00 0.00    10.565    -4.4820
4     23.00 0.00    22.00 0.00    24.00 0.00    25.00 0.00     8.331    15.1685
```

The .dat file – Pole-pole and pole-dipole arrays

If the location of the remote electrode(s) for pole-pole and pole-dipole configurations aren't specified the program assumes the conditions for an ideal pole-pole or pole-dipole array is met.

```
Pole-pole survey with remote electrodes not specified
1.00000
11
2
Type of measurement (0=app. resistivity,1=resistance)
0
295
2
0
2      0.00000     0.00000     1.00000     0.00000     9.71588
2      1.00000     0.00000     2.00000     0.00000     9.77284
2      2.00000     0.00000     3.00000     0.00000     9.82908
2      3.00000     0.00000     4.00000     0.00000     9.91349
2      4.00000     0.00000     5.00000     0.00000    10.04541
2      5.00000     0.00000     6.00000     0.00000    10.27310
2      6.00000     0.00000     7.00000     0.00000    10.72195
2      7.00000     0.00000     8.00000     0.00000    11.68144
2      8.00000     0.00000     9.00000     0.00000    13.53788
2      9.00000     0.00000    10.00000     0.00000    15.54942
2     10.00000     0.00000    11.00000     0.00000    16.61592
2     11.00000     0.00000    12.00000     0.00000    16.94865
2     12.00000     0.00000    13.00000     0.00000    16.68214
2     13.00000     0.00000    14.00000     0.00000    15.68086
2     14.00000     0.00000    15.00000     0.00000    13.75145
2     15.00000     0.00000    16.00000     0.00000    12.01413
2     16.00000     0.00000    17.00000     0.00000    11.24185
2     17.00000     0.00000    18.00000     0.00000    11.21267
2     18.00000     0.00000    19.00000     0.00000    12.14866
```

```
Pole-pole survey with remote electrodes specified
1.00000
11
2
Type of measurement (0=app. resistivity,1=resistance)
0
Remote electrodes specified
C2 far electrode X and Y location
-25.000,10.000,0.000
P2 far electrode X and Y location
60.000,0.000,0.000
Exact geometric factor used
295
2
0
2      0.00000     0.00000     1.00000     0.00000     9.71588
2      1.00000     0.00000     2.00000     0.00000     9.77284
2      2.00000     0.00000     3.00000     0.00000     9.82908
2      3.00000     0.00000     4.00000     0.00000     9.91349
2      4.00000     0.00000     5.00000     0.00000    10.04541
2      5.00000     0.00000     6.00000     0.00000    10.27310
2      6.00000     0.00000     7.00000     0.00000    10.72195
2      7.00000     0.00000     8.00000     0.00000    11.68144
2      8.00000     0.00000     9.00000     0.00000    13.53788
2      9.00000     0.00000    10.00000     0.00000    15.54942
2     10.00000     0.00000    11.00000     0.00000    16.61592
2     11.00000     0.00000    12.00000     0.00000    16.94865
```

Header for remote electrode specification

Indication of geometric factor used

The .dat file – topography – 2 options

In separate list:

```
4   56.00000  0   92.00000  0   68.00000  0   80.00000  0 1091.00000
4   58.00000  0   94.00000  0   70.00000  0   82.00000  0 1160.00000
4   60.00000  0   96.00000  0   72.00000  0   84.00000  0 1680.00000
Topography in separate list
2
24
-36,0.044
-34,0.134
-32,0.311
-30,0.503
-28,0.712
-26,1.161
-24,1.492
-22,1.833
-20,2.269
-18,2.578
-16,2.483
-14,2.714
-12,3.088
-10,3.443
-8,3.758
-6,3.924
-4,4.122
-2,4.306
0,4.526
2,4.747
4,5.028
6,5.104
8,5.111
10,5.138
 1
0
```

Last 3 data lines

Header for topography

1 for true horizontal, 2 for surface distances

Number of topography points

Topography data: x-coordinates, elevation

Topography data point coinciding with first electrode

End of file

In data lines, as z coordinates:

```
General array format with topography example
1.0
11
0
Type of measurement (0=app. resistivity,1=resistance)
 0
407
1
0
4        0.00 1.78      3.00 1.68      1.00 1.93      2.00 1.89     10.158
4        1.00 1.93      4.00 1.32      2.00 1.89      3.00 1.68     10.168
4        2.00 1.89      5.00 1.32      3.00 1.68      4.00 1.32     10.184
4        3.00 1.68      6.00 0.31      4.00 1.32      5.00 1.32     10.225
4        4.00 1.32      7.00 0.48      5.00 1.32      6.00 0.31     10.337
4        5.00 1.32      8.00 0.83      6.00 0.31      7.00 0.48     10.708
4        6.00 0.31      9.00 1.31      7.00 0.48      8.00 0.83     11.668
4        7.00 0.48     10.00 1.78      8.00 0.83      9.00 1.31     12.542
4        8.00 0.83     11.00 1.93      9.00 1.31     10.00 1.78     12.871
4        9.00 1.31     12.00 1.89     10.00 1.78     11.00 1.93     13.238
4       10.00 1.78     13.00 1.68     11.00 1.93     12.00 1.89     13.342
4       11.00 1.93     14.00 1.32     12.00 1.89     13.00 1.68     13.231
4       12.00 1.89     15.00 1.32     13.00 1.68     14.00 1.32     12.855
4       13.00 1.68     16.00 0.31     14.00 1.32     15.00 1.32     12.511
4       14.00 1.32     17.00 0.48     15.00 1.32     16.00 0.31     11.598
4       15.00 1.32     18.00 0.83     16.00 0.31     17.00 0.48     10.471
4       16.00 0.31     19.00 1.31     17.00 0.48     18.00 0.83      9.203
```

The .dat file – global coordinates

```
4        235.00        4.82     355.00        7.41     305.00        8.33     315.00        8.44     138.0700
4        235.00        4.82     355.00        7.41     315.00        8.44     325.00        8.28     134.3600
4        235.00        4.82     355.00        7.41     325.00        8.28     335.00        8.00     138.9900
4        235.00        4.82     355.00        7.41     335.00        8.00     345.00        7.72     138.6200
0
Global Coordinates present
Number of coordinate points
17
Local Longitude Latitude
   85.00     572088.12    6222426.57
   90.00     572088.28    6222421.58
  110.00     572088.91    6222401.60
  115.00     572089.07    6222396.61
  120.00     572089.23    6222391.62
  125.00     572089.39    6222386.66
  160.00     572090.50    6222351.66
  165.00     572090.66    6222346.67
  170.00     572090.82    6222341.68
  175.00     572090.98    6222336.68
  200.00     572091.77    6222311.72
  205.00     572091.93    6222306.74
  250.00     572093.36    6222261.85
  255.00     572093.52    6222256.88
  260.00     572093.67    6222251.91
  325.00     572098.11    6222187.28
  355.00     572100.26    6222157.44
0
```

Last 4 data lines, or topography section

Header lines

Number of corrdinate points

Header line

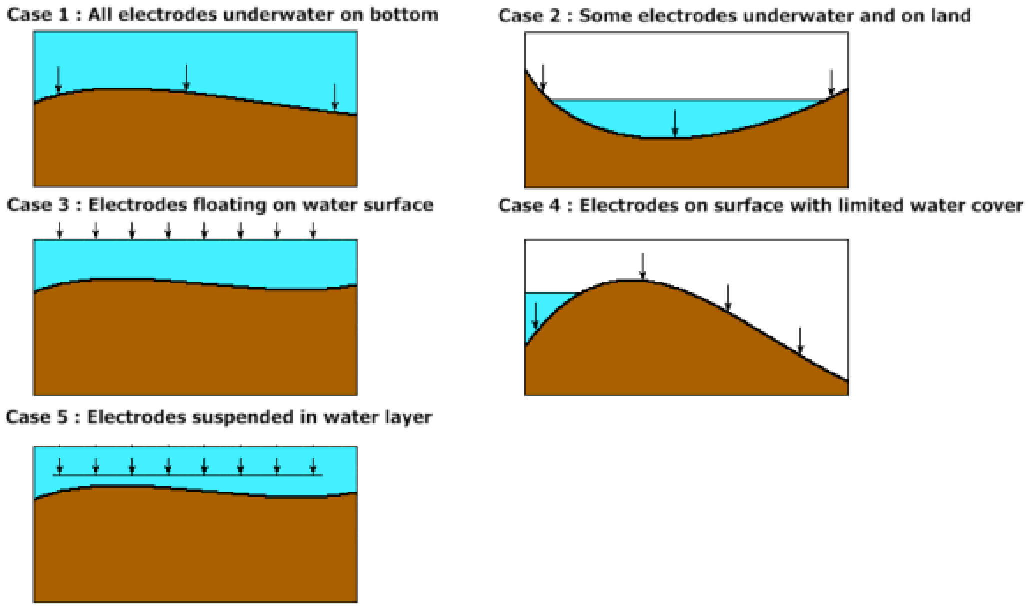
X-coordinate along profile, Longitude/UTMX, Latitude/UTMY

End of file

Note: topography information must always come before global coordinates, coordinates must be in meters!

The .dat file – surveys in water – several options

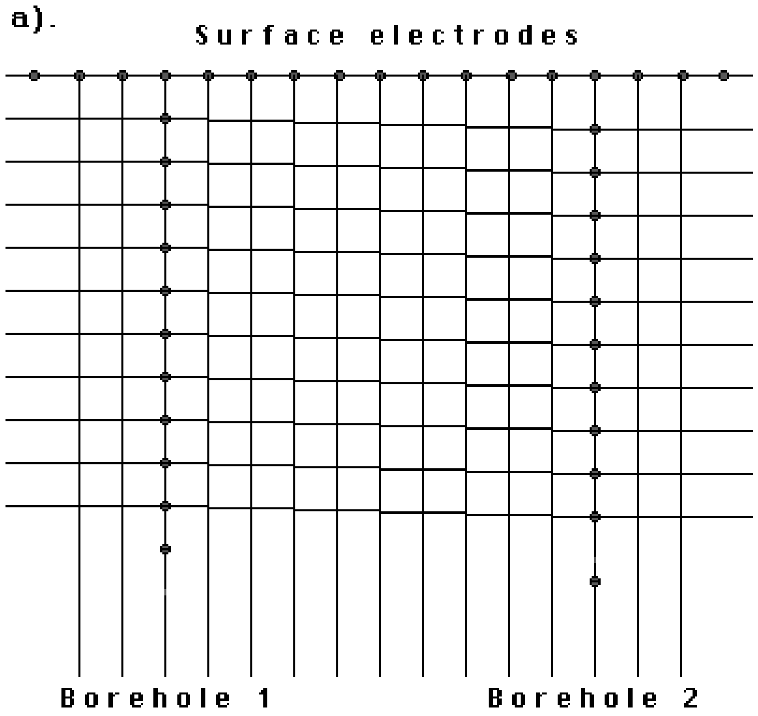
Several options:



- **The water layer can be modelled**
- **Resistivity must be known**
- **Big impact on inversion result, especially for saline water**

See manual and file examples for specific formats, or ask.

The .dat file – cross borehole and buried electrodes

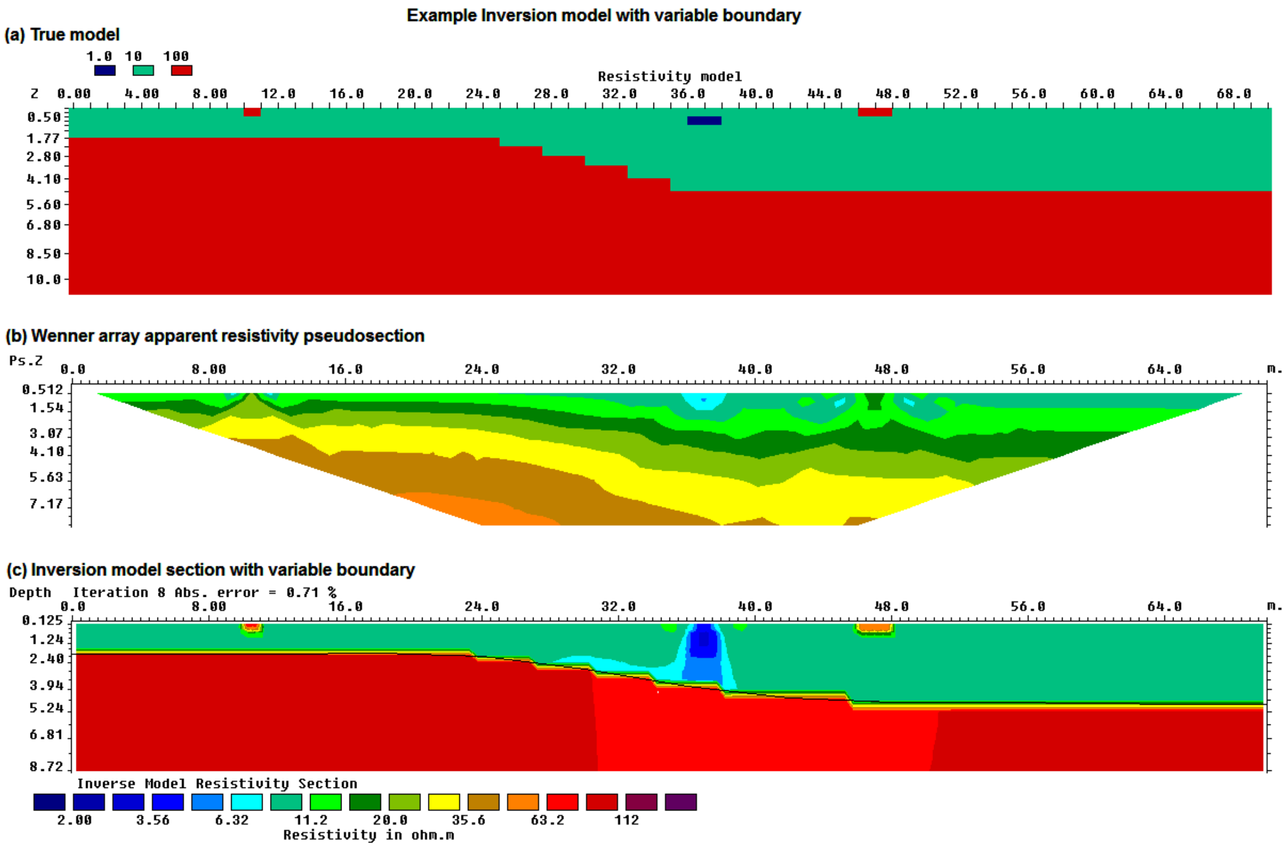


Data format specified in section 7.4 of the manual, please note:

- **All electrodes must be specified in beginning of file**
- **Consider using resistance values as apparent resistivitiy calculations are not universally agreed on**
- **Define dummy electrodes to fulfill format requirements**
- **Note that topography must be provided as the elevation of the surface electrodes**
- **Format of data lines is as usual, but electrode positions must be consistent**

BOREDIFF.DAT file	*Comments*
Borehole electrodes at different depths	*Name of survey line*
1.0	*Unit electrode spacing*
12	*Array number 12 for cross-borehole survey*
840	*Number of data points*
2	*2 to indicate XZ location format is used*
0	*0 for no I.P.*
Surface Electrodes	*Header for surface electrodes*
16	*Number of surface electrodes*
0.0, 0.0	*x- and z-location of first surface electrode*
1.0, 0.0	*Location of second surface electrode*
..	*Note 0.0 z value for surface electrode*
..	*Similar format for other surface electrodes*
..	
15.0, 0.0	*Last surface electrode*
Number of boreholes	*Header*
2	*Two boreholes in this data set*
Borehole 1 Electrodes	*Header for first borehole*
10	*Number of electrodes in first borehole*
4.0, 1.0	*x- and z-location of first electrode*
4.0, 2.0	*x- and z-location of second electrode*
4.0, 3.0	*Note electrodes are listed from the topmost*
..	*below the surface downwards*
..	*Similar format for other borehole electrodes*
..	
4.0, 10.0	*Last electrode in first borehole*
Borehole 2 Electrodes	*Header for second borehole*
10	*Number of electrodes in second borehole*
11.0, 1.5	*x- and z-location of first electrode*
11.0 2.5	*x- and z-location of second electrode*
..	
..	*Similar format for other borehole electrodes*
11.0, 10.5	*Last electrode in second borehole*
Measured data	*Header for section with the measurements*
3 0.0 0.0 1.0 0.0 2.0 0.0 101.5718	*The format for each data point is :-*
3 0.0 0.0 2.0 0.0 3.0 0.0 99.5150	*Number of electrodes used in measurement,*
3 0.0 0.0 3.0 0.0 4.0 0.0 99.2303	*x- and z-location of C1, C2, P1, P2*
3 0.0 0.0 4.0 0.0 5.0 0.0 99.1325	*electrodes, apparent resistivity value.*
..	
..	*Same format for other data points*
...	
3 11.0 11.0 11.0 3.5 11.0 2.50 120.8297	*Last data point*
0,0,0,0	*End with a few zeros.*

The .dat file – known boundaries and fixed regions

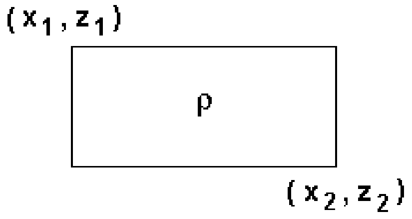


Fixing model resistivities

Data format

R
x_1, z_1
x_2, z_2
ρ
2.0

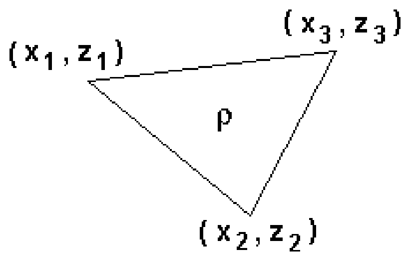
Rectangular regions



Data format

T
x_1, z_1
x_2, z_2
x_3, z_3
ρ
2.0

Triangular regions



AGS Aarhus GeoSoftware

The .dat file – known boundaries and fixed regions

It is possible to specify the resistivity of known regions of the subsurface:

```
4      5.00000     0.00000    35.00000     0.00000    15.00000     0.00000    25.00000
4      6.00000     0.00000    36.00000     0.00000    16.00000     0.00000    26.00000
4      7.00000     0.00000    37.00000     0.00000    17.00000     0.00000    27.00000
4      8.00000     0.00000    38.00000     0.00000    18.00000     0.00000    28.00000
4      9.00000     0.00000    39.00000     0.00000    19.00000     0.00000    29.00000
4     10.00000     0.00000    40.00000     0.00000    20.00000     0.00000    30.00000
0
2
R
    24.00000,    0.70000,    28.00000,    0.70000,    2.00000,    2.00000
T
    30.00000,    0.00000,    30.00000,    3.00000,    45.00000,    3.00000,    10.00000,
0
```

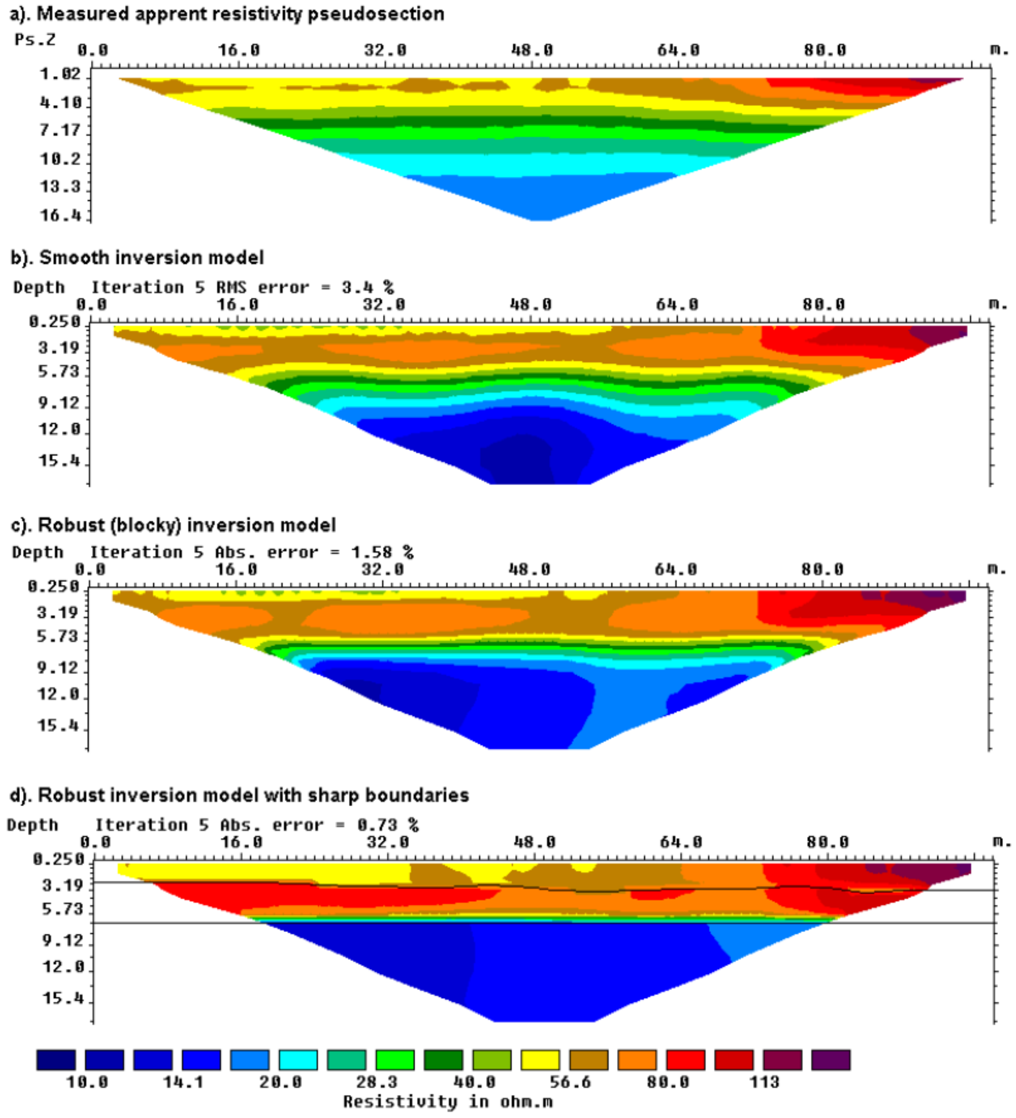
- Last 3 data lines
- 0 – Topography information (none in this case)
- 2 – Number of fixed regions
- R – Shape of fixed region (R=rectangular, T=triangular)
- X and Z coordinates of upper left and lower right corner of rectangle, resistivity value, damping factor
- T – Shape of fixed region (R=rectangular, T=triangular)
- X and Z coordinates of all 3 corners of triangle, resistivity value, damping factor
- 0 – End all files wit a zero

The damping factor controls how much the resistivity can vary during the inversion, 1.0 means that the resistivity can vary normally during the inversion, typical values range between 1.5 and 2.5, a high value e.g. 100 means that the resistivity of the region is completely fixed during inversion

The .dat file – known boundaries and fixed regions

It is possible to specify the depth to a known layer boundary e.g. from a seismic survey, even though the resistivities of the layers are unknown.

The format is very similar to the topography format, see section 7.10 of the manual



Hands on #2 – running an unsatisfactory inversion

1. **Open Res2DInv**
2. **Load “GRUNDF1.dat” select “OK” in all popups and run inversion with standard settings**

Troubleshooting an unsatisfactory inversion

1. **Removal of bad data points**
2. **Inversion method**
3. **Model discretization**
4. **Damping/smoothing settings**

Processing / removal of outliers – pre inversion

1. **Load a data file**
2. **Select ‘Edit->Exterminate bad data points’**
3. **Click the datapoints to remove**
4. **Exit, save modified data, reload**

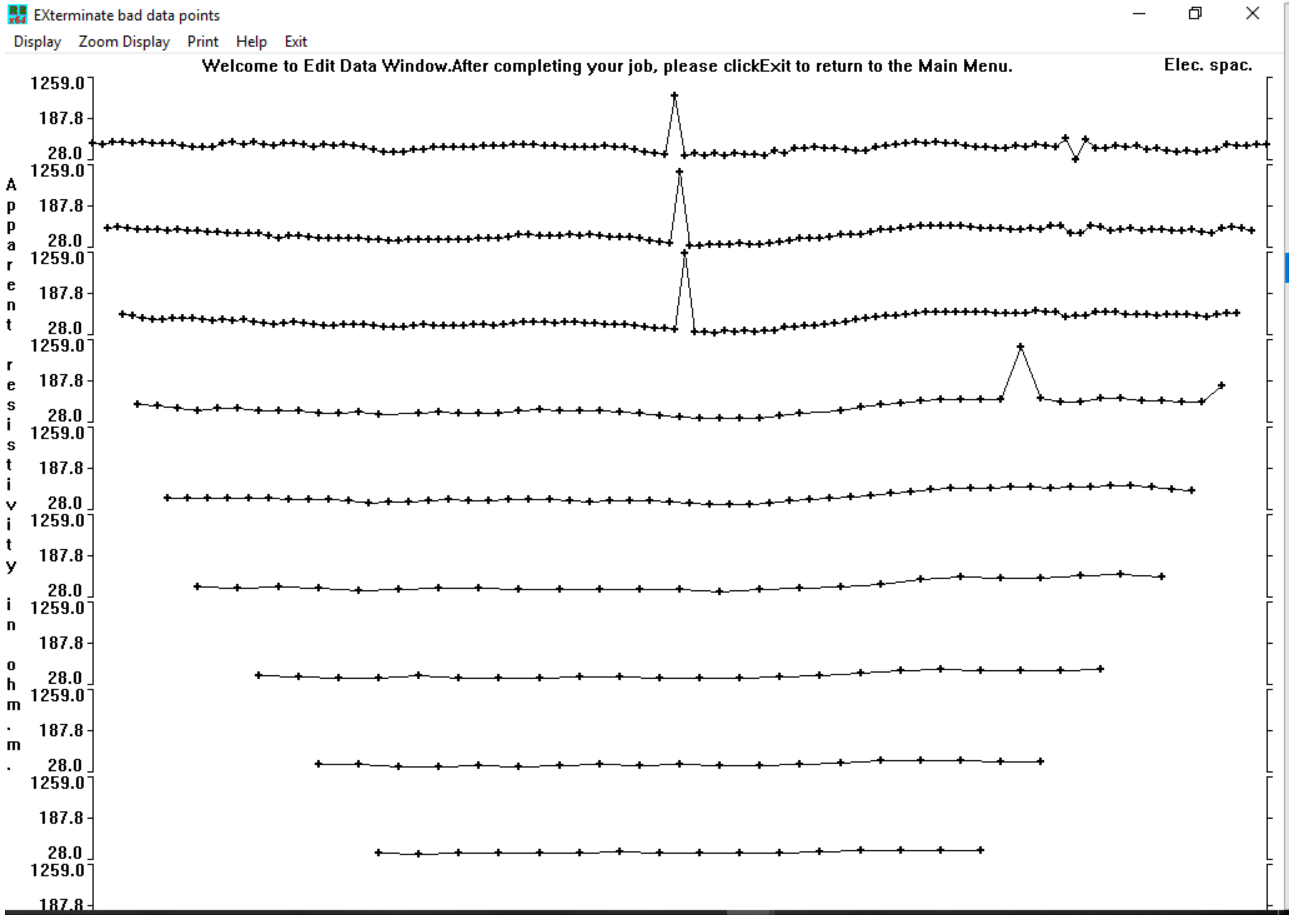
Function of keys to remove data points

To remove a data point, move the cursor to the point and click the left mouse button. To restore a point, click it again. The keys below will remove different sets of data points sharing a common electrode with the selected data point.

A : Points using the present C1 electrode
B : Points using the present C2 electrode
C : Points using the present C1 or C2 electrode
M : Points using the present P1 electrode
N : Points using the present P2 electrode
P : Points using the present P1 or P2 electrode
L : All points in the data level is removed
R : Restore all points in the data level

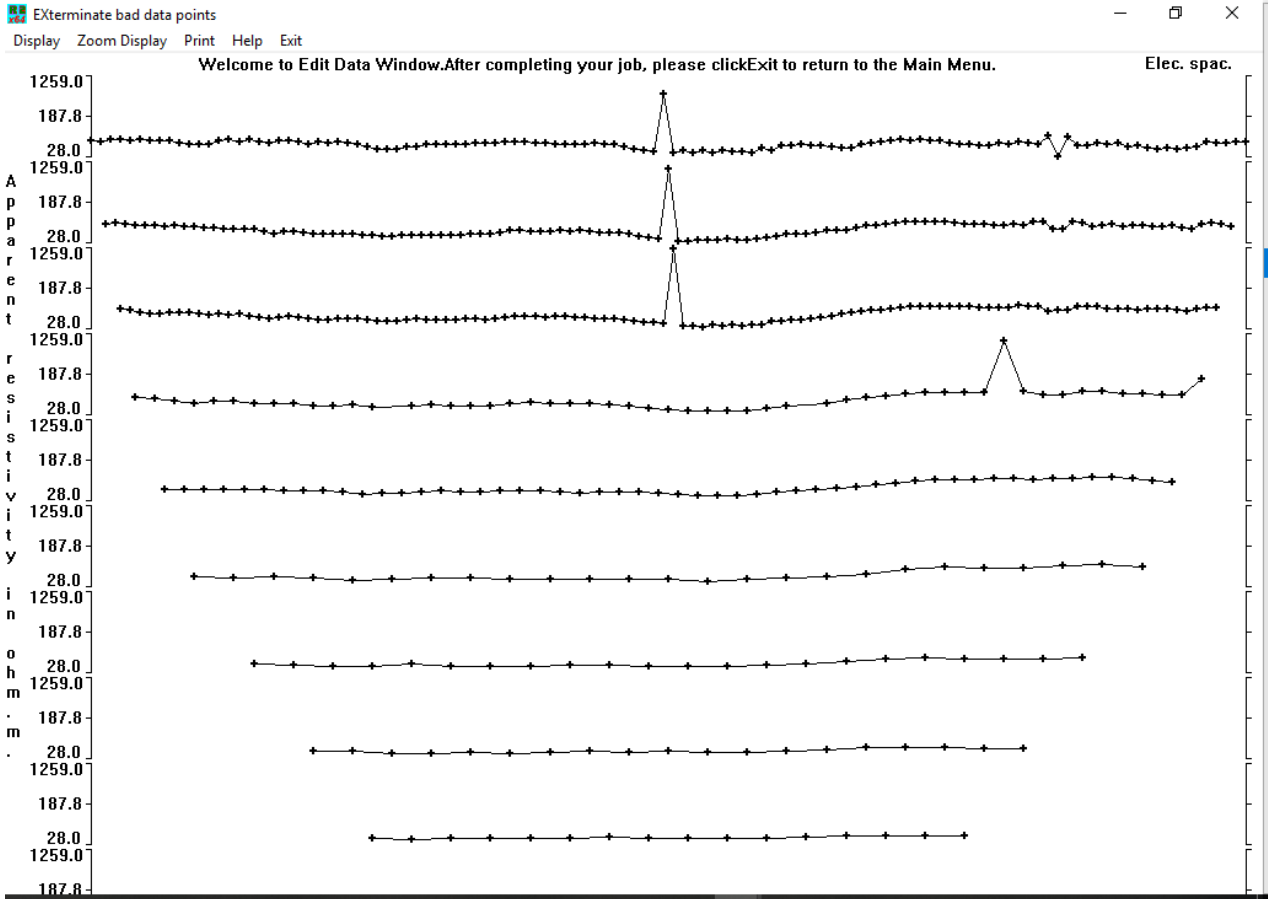
To remove a series of data points on the same profile, move the cursor to the left point and click the right mouse button. Next move the cursor to the right point and click the right mouse button.

OK

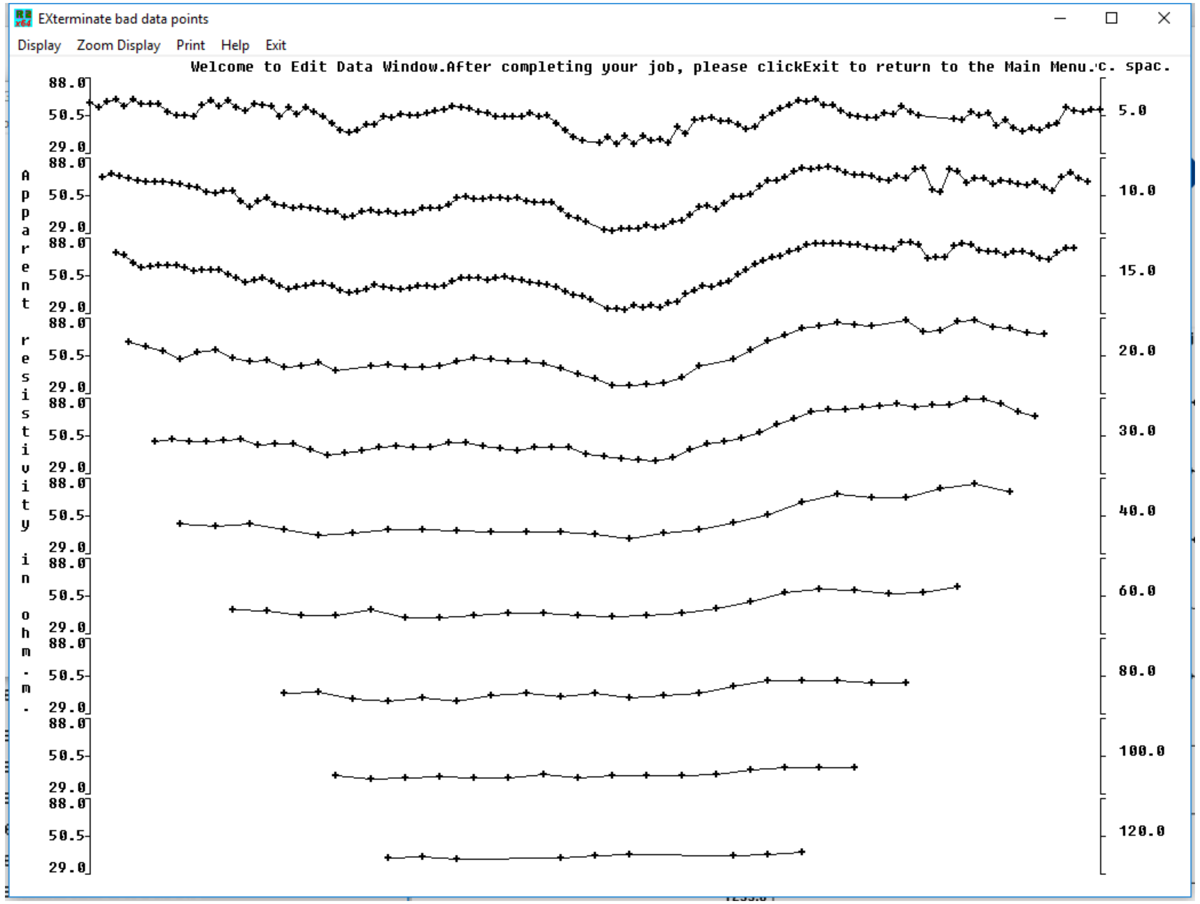


Processing / removal of outliers – simple example

Before:

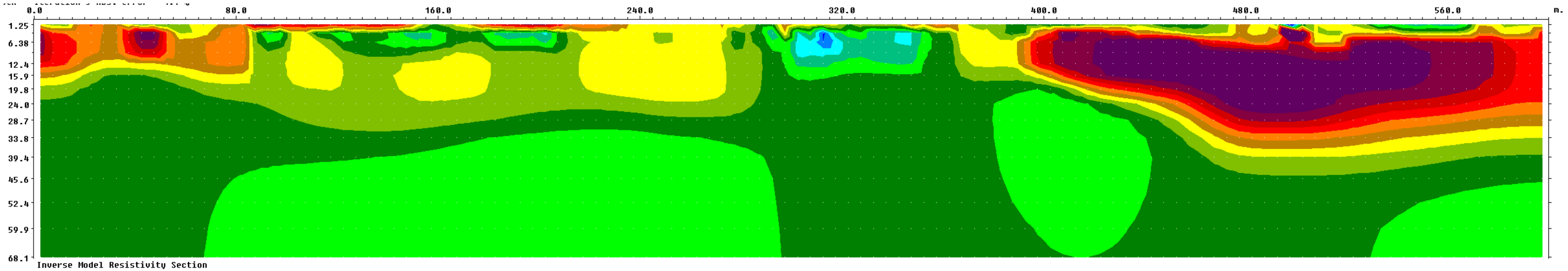


After:

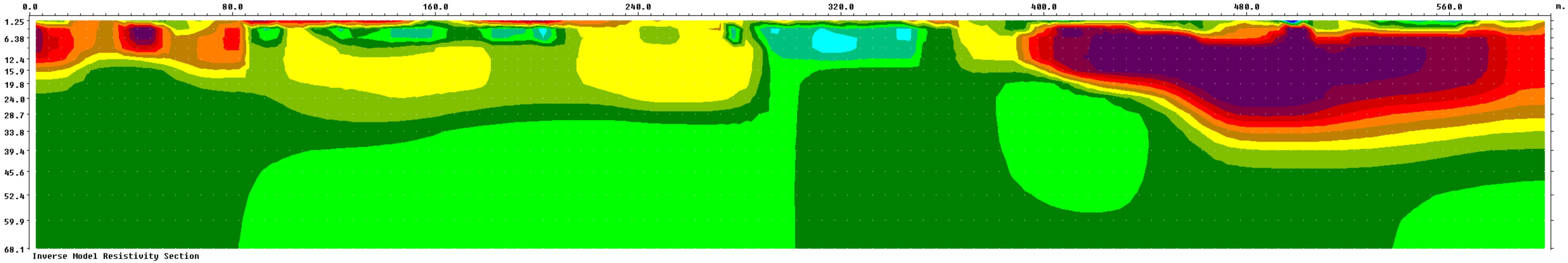


Processing / removal of outliers – simple example

Before:

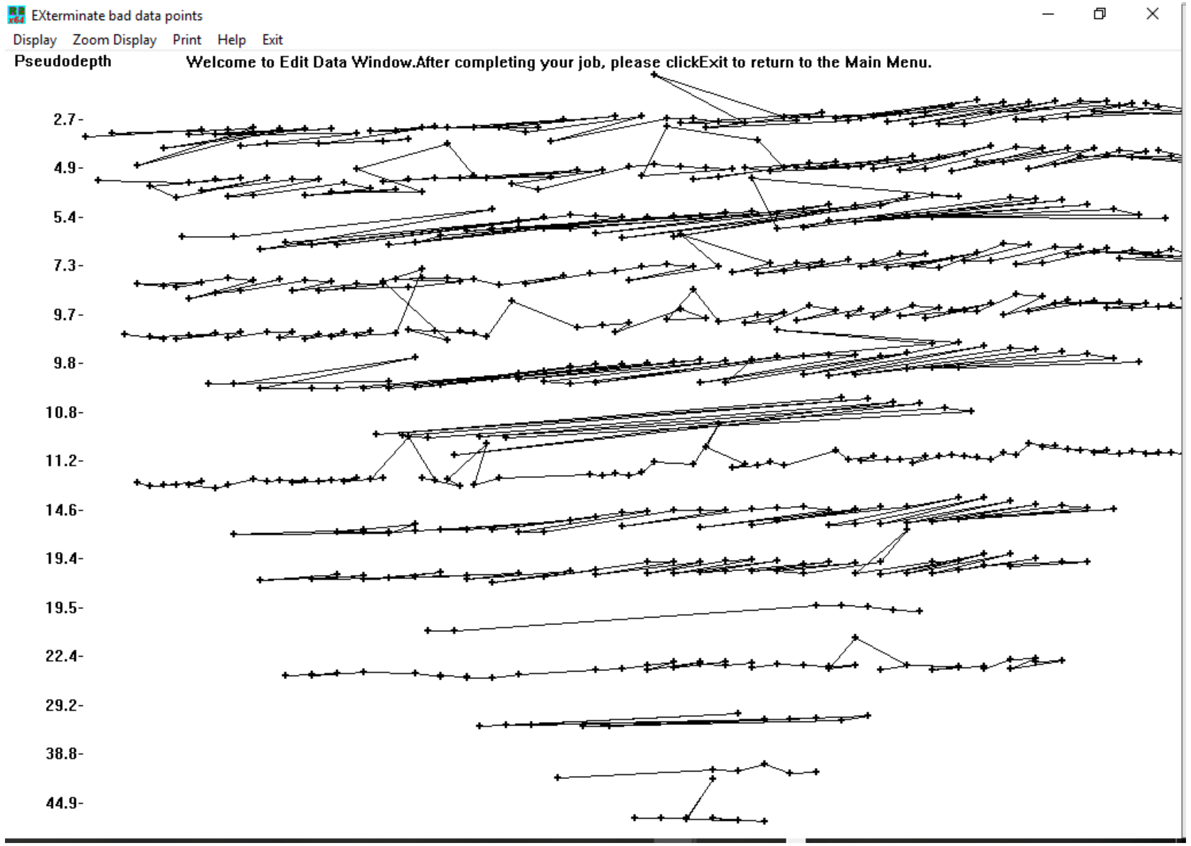


After:

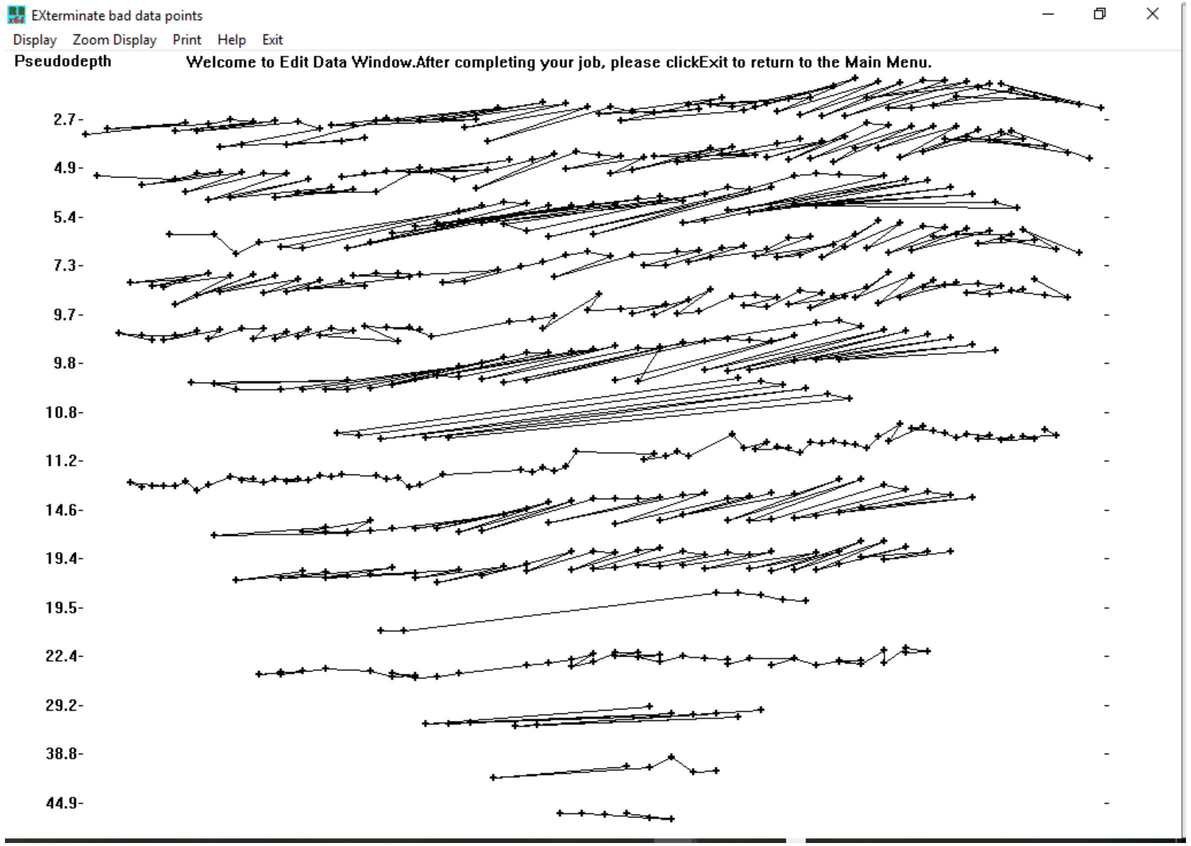


Processing / removal of outliers – Advanced example

Before:

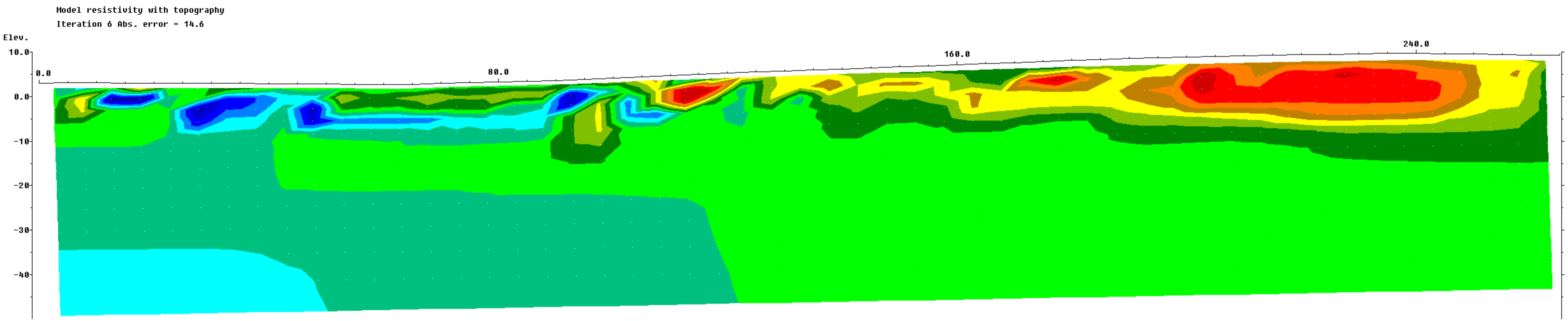


After:

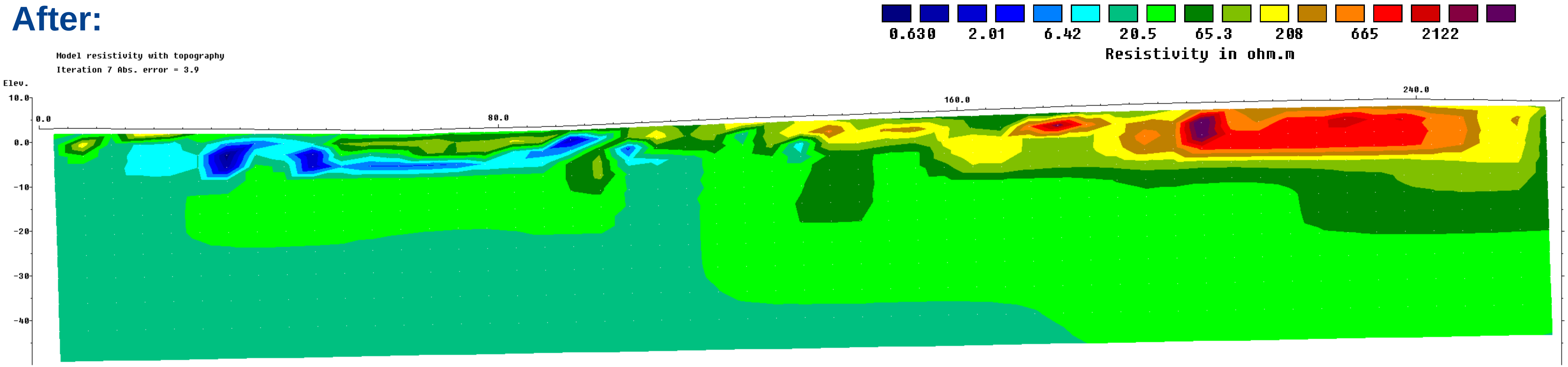


Processing / removal of outliers – Advanced example

Before:

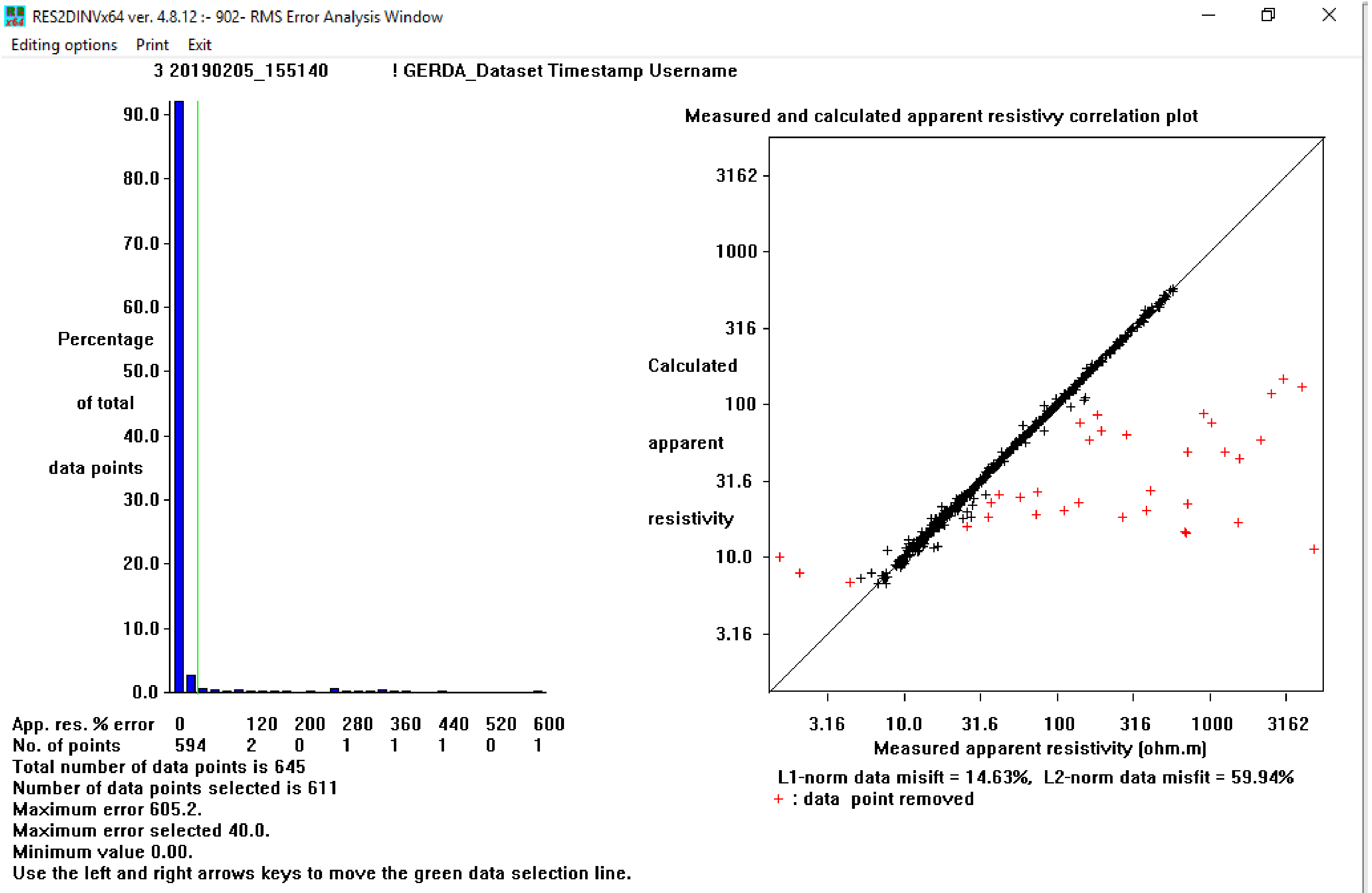


After:



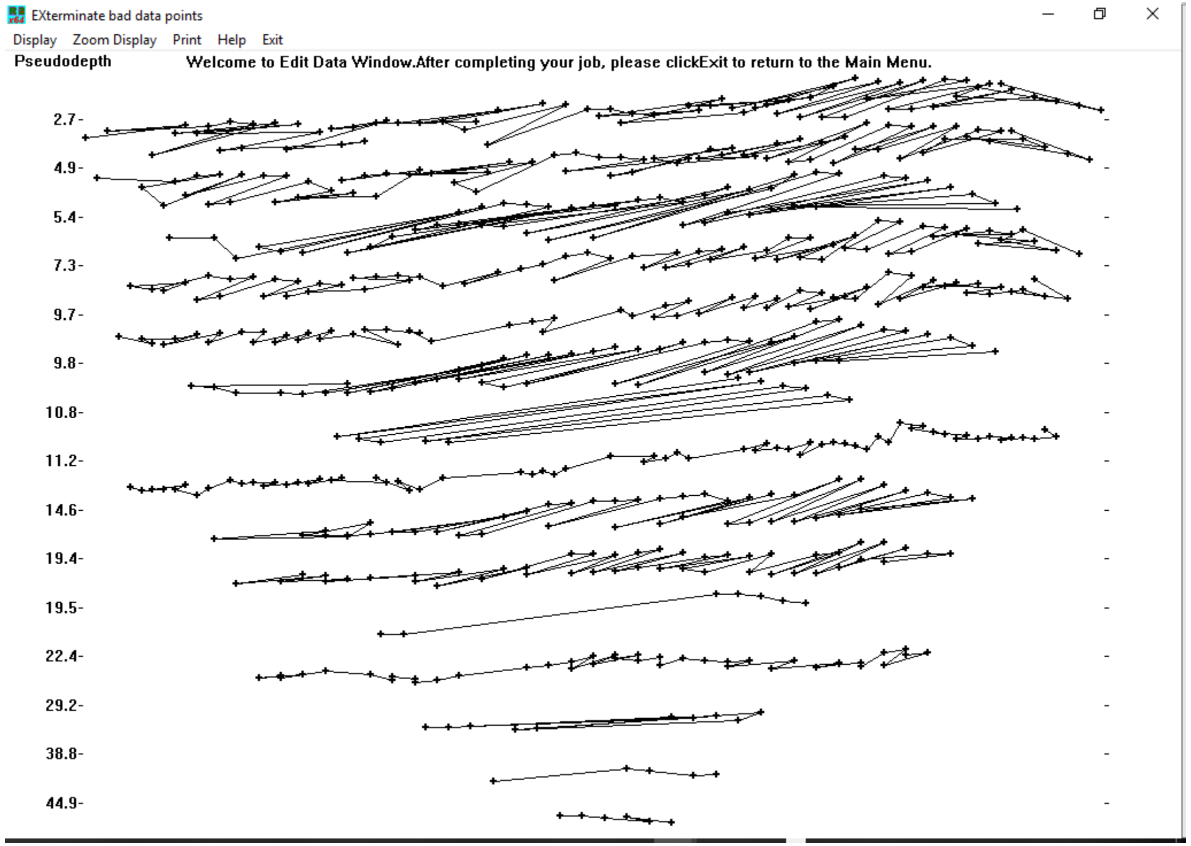
Processing / removal of outliers – statistical

1. **Go to display mode and load .inv file after inversion**
2. **Select 'Edit data->RMS error statistics'**
3. **Select the datapoints to remove using arrow keys**
4. **Exit, save modified data, reload**

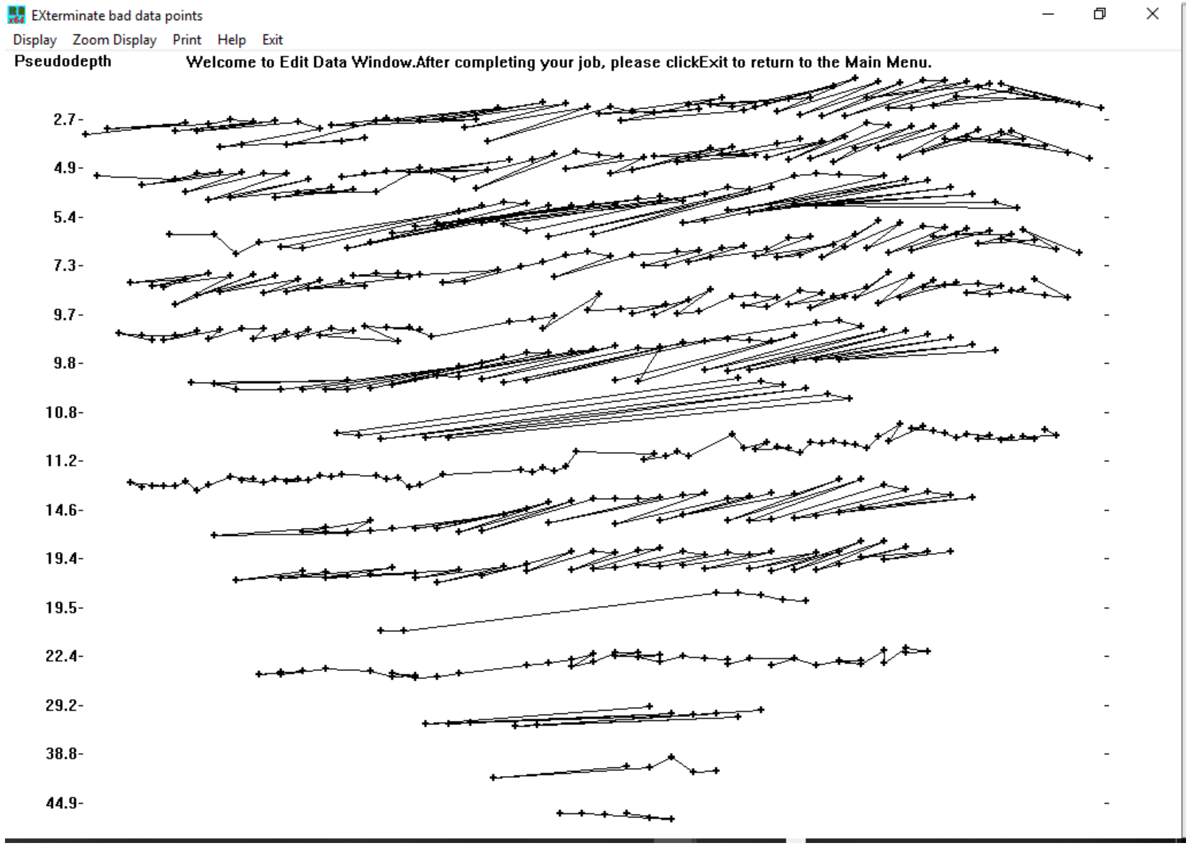


Processing / removal of outliers – statistical

Statistical:



Manual:



Processing / removal of outliers – statistical

Pitfalls of statistical processing:

- **The removal of data points is solely based on how well they are fitted by the inversion**
- **By removing data points with a high misfit we are feeding the inversion “what it wants” and can create artificially god data fits**
- **That a datapoint isn’t fitting doesn’t necessarily mean that it is wrong, it can also be due to:**

1. **The geology is too complicated to be described with the used inversion settings, or at all**
2. **The dataset is so noisy that it is affecting the inversion**

- **In the worst case we are fitting the noise and throwing away good datapoints**

Processing / removal of outliers – hands on

1. Load the datafile GRUNDF1.dat. Go to the ‘Display’ window, and then the ‘Display data and model sections’ option. The bad data points should be quite obvious.
2. leave the ‘Display’ window, choose ‘Edit data’ on the top menu bar followed by the ‘Exterminate bad data points’ option. Pick out the bad data points. After that save the edited data in a file. Read in this edited data file, and then go back to the ‘Display’ window and check the pseudosection again.
3. Leave the ‘Display’ window, and then run an inversion of the data set using the ‘Inversion’ and then the ‘Least-squares inversion’ menu options.
4. After the inversion has finished, go the ‘Display’ window to take a look at the model. After that choose the ‘Edit data’ and then the ‘RMS error statistics’ options. Take a look at the bar chart. Is it possible to remove more bad data points?
5. Try running an inversion of the data set without first manually removing the bad data points. Then use the ‘RMS error statistics’ option to remove them. Does this get rid of the bad data points also?
6. Compare the inversion results before and after removing the bad data points.

Inversion settings – introduction

As mentioned earlier: The inversion result in ununique

- **The result is shaped by the inversion setup**
- **The inversion setup should reflect prior knowledge and assumptions about the geology**

  - Inversion method
  - Damping parameters
  - Model discretization
  - Forward modelling methods
  - Stopping criteria

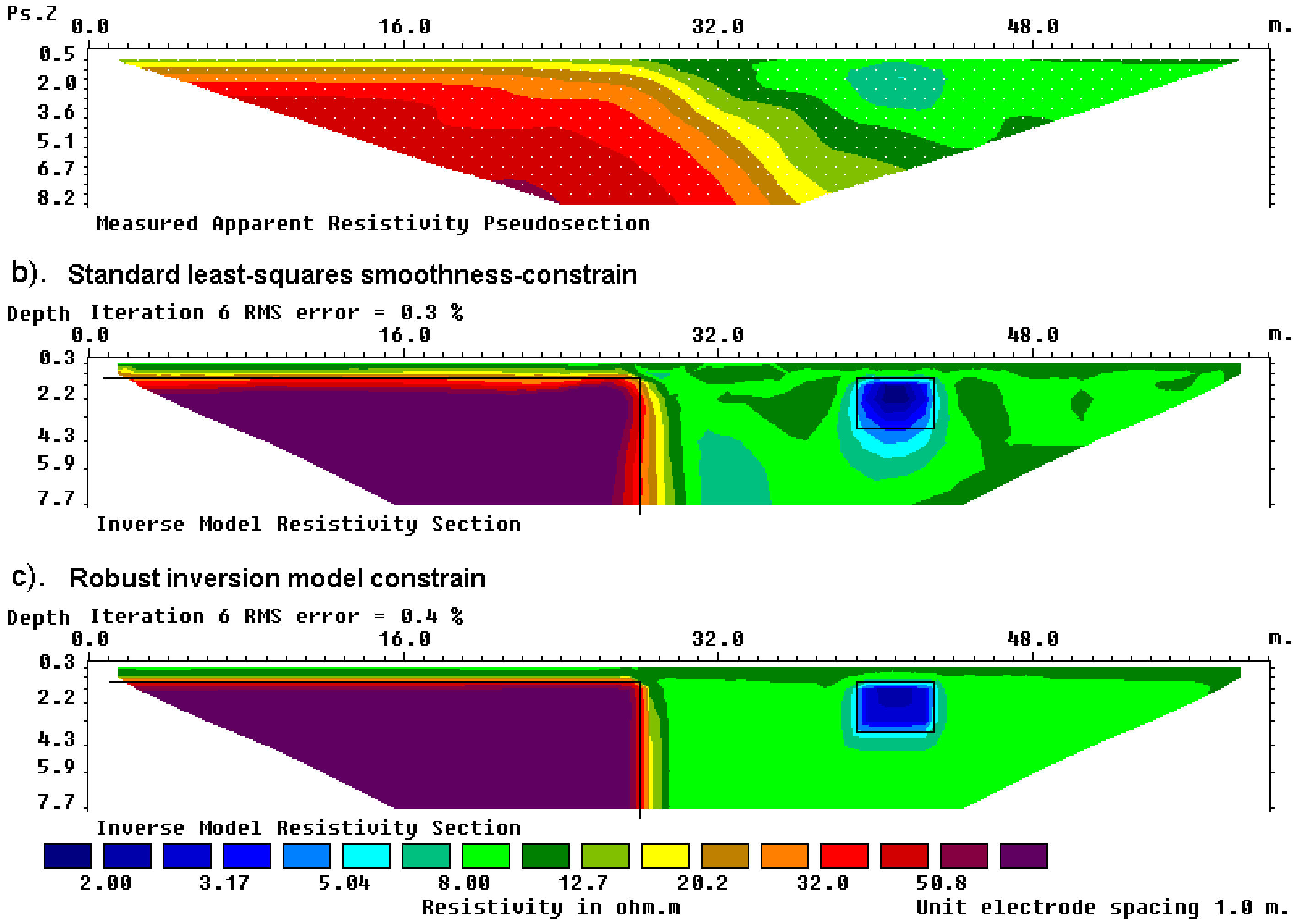
Inversion settings – Inversion method

Smoothness constrained least square inversion

This formulation constrains the *change* in the model resistivity values, to be smooth but does not guarantee that the resistivity values change in a smooth manner.

Additional Option – Direct smoothing of the model resistivities as well, resulting in a smooth model.

This is the standard inversion method used by Res2DInv!

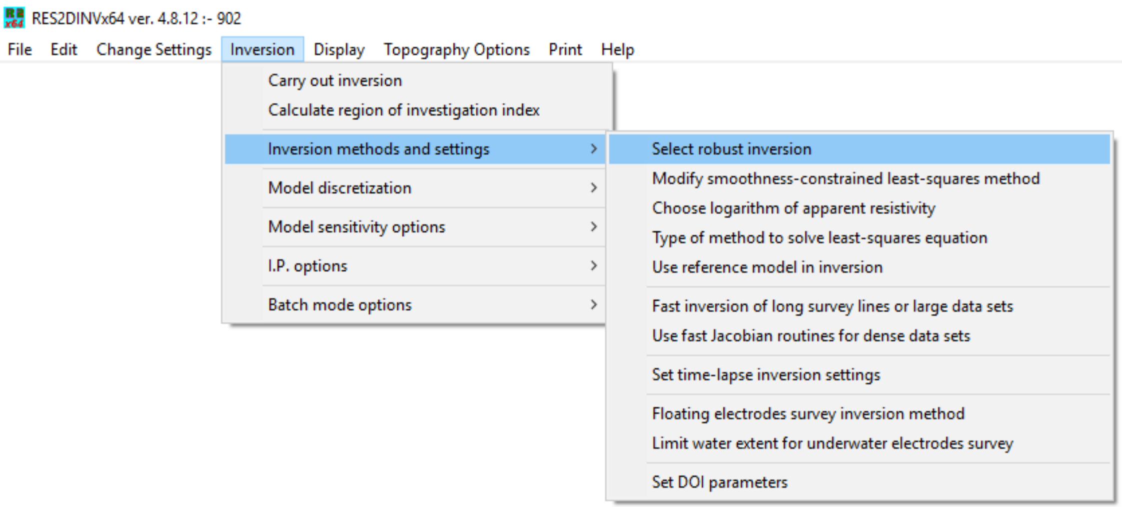


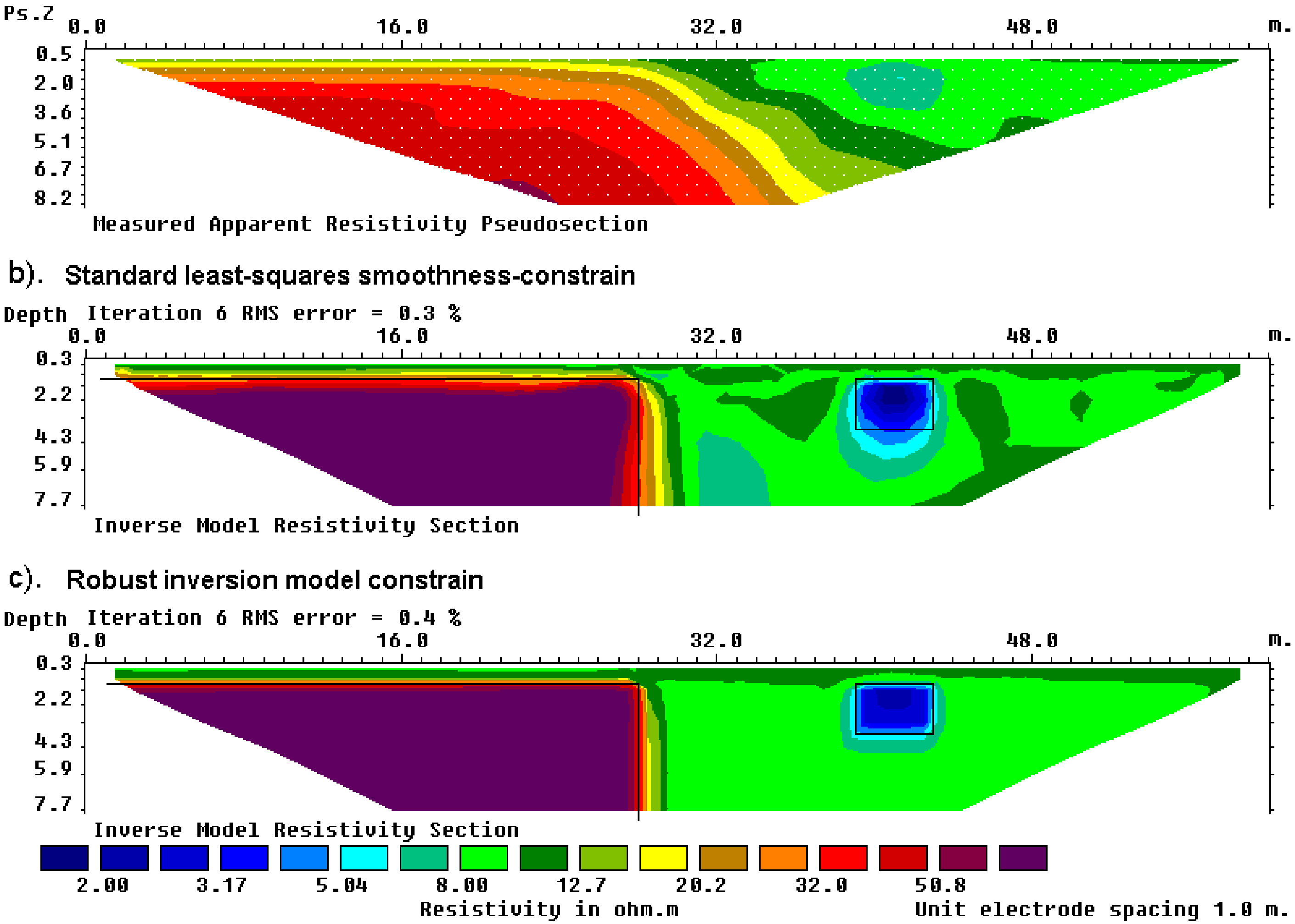
AGS Aarhus GeoSoftware

Inversion settings – Inversion method

Blocky (L1-norm) inversion

Favor models that are piecewise constant which is well suited for discrete geological variations





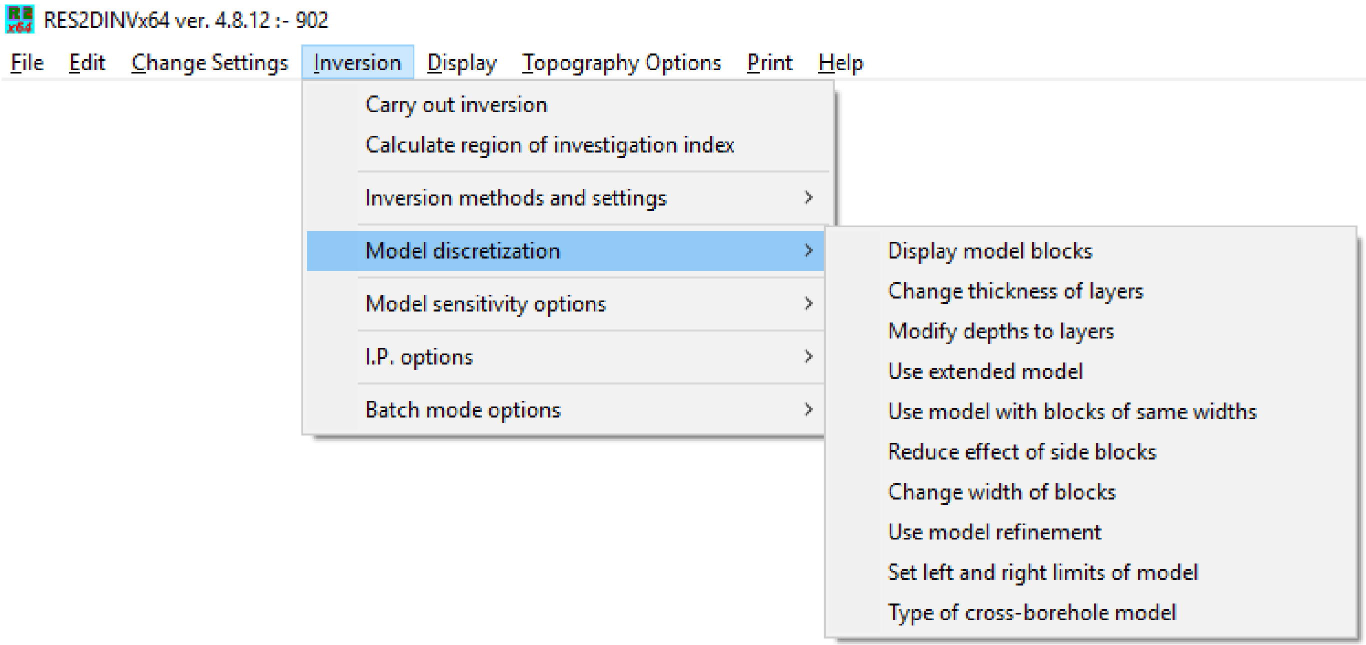
AGS Aarhus GeoSoftware

Vertical and horizontal model discretization

The standard discretization is fine in most cases

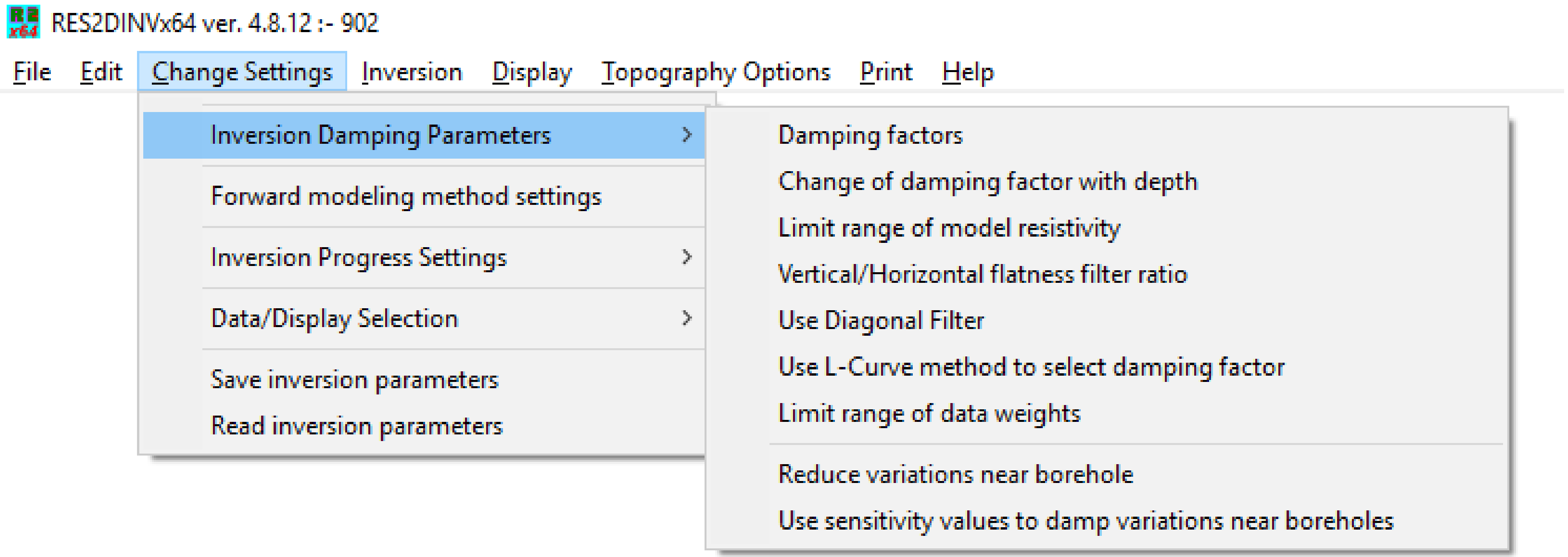
Reasons to change the discretization:

- **Slow inversion of large datasets**
- **Unsatisfactory data fit**
- **Artefacts in inversion results**
- **Special conditions or interests**



AGS Aarhus GeoSoftware

Inversion settings Filters / smoothing



Assessing the quality of an inversion

- **Depth of investigation (DOI)**
- **Model uncertainty**

AGS Aarhus GeoSoftware

Assessing the quality of an inversion – DOI

Is a measure of to which degree the inversion result is constrained by the measured data as opposed to the starting model.

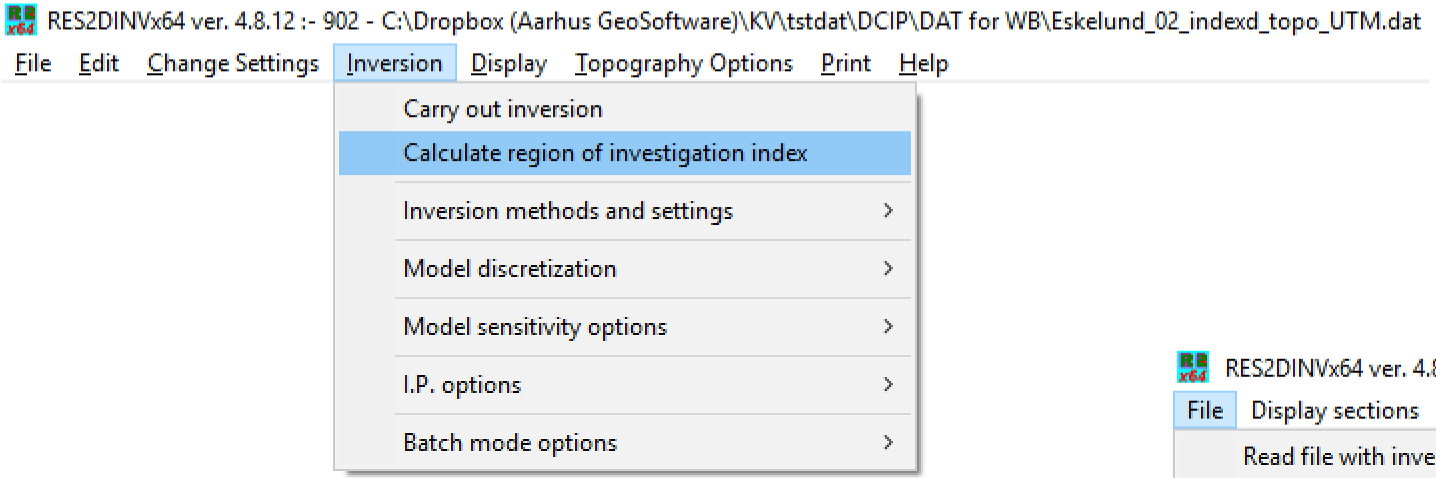
$$R(x,z) = \frac{q_1(x,z) - q_2(x,z)}{q_{m1} - q_{m2}}$$

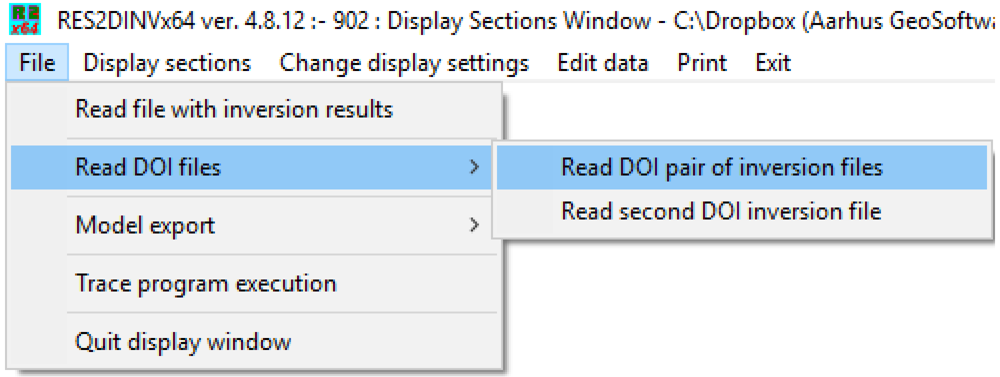
Where q_{m1} and q_{m2} are the starting model resistivities, and $q_1(x,z)$ and $q_1(x,z)$ are the inversion results. Low value = data driven result, high value = constrain driven result.

AGS Aarhus GeoSoftware

Assessing the quality of an inversion – DOI

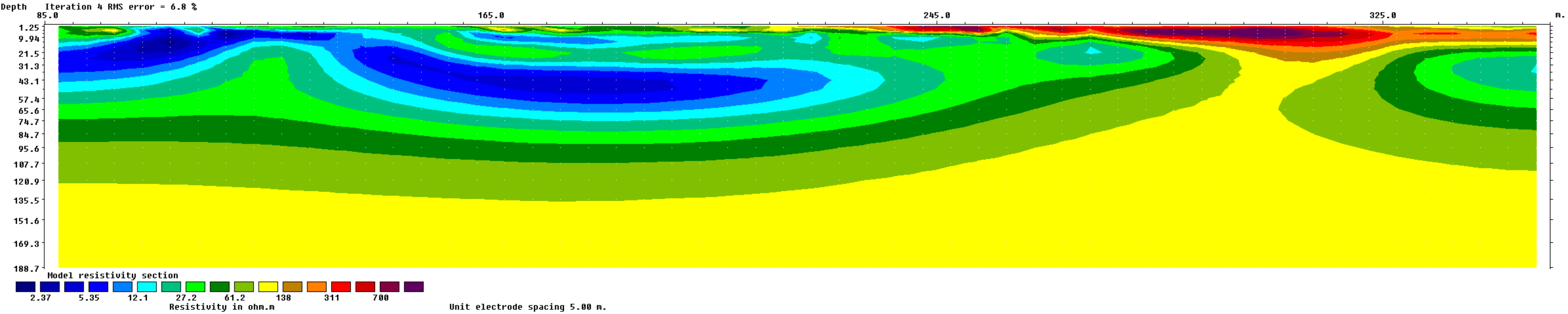
Must be run and loaded as a separate inversion:

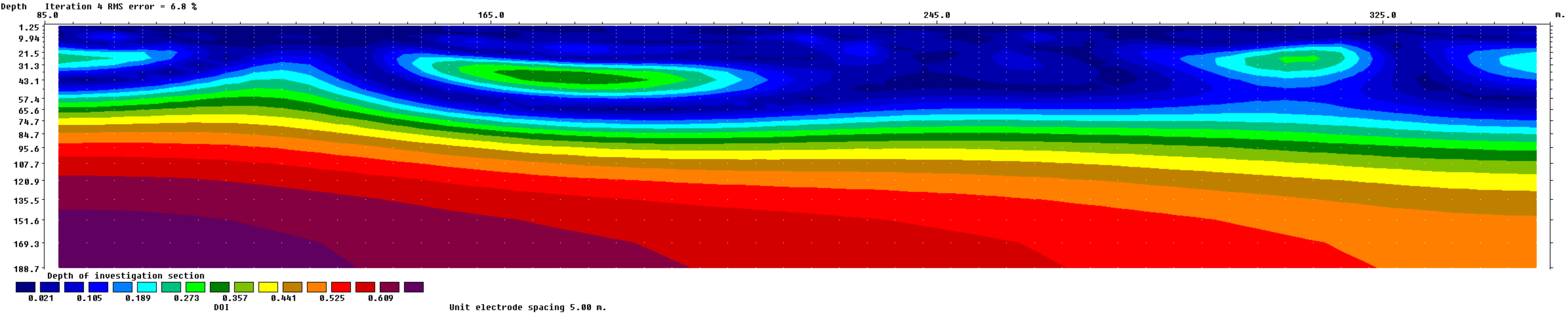




AGS Aarhus GeoSoftware

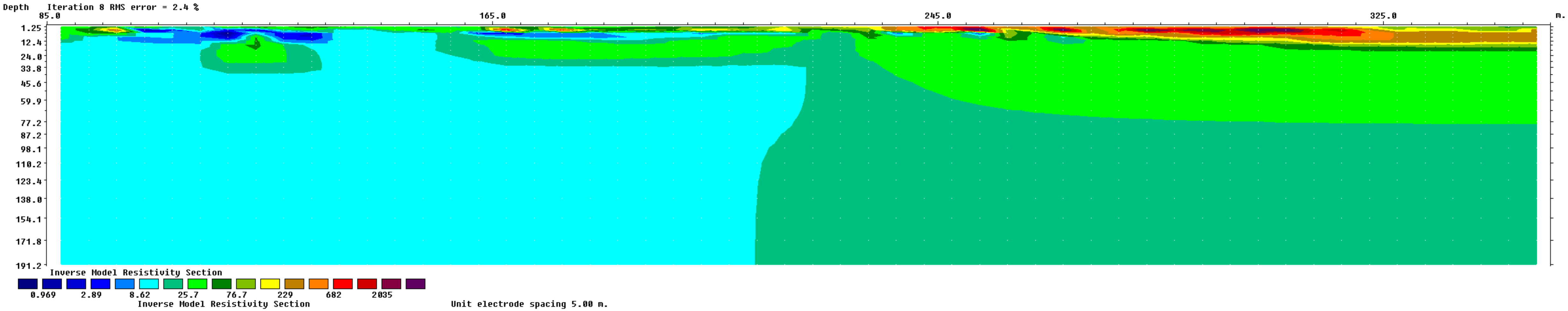
Assessing the quality of an inversion – DOI

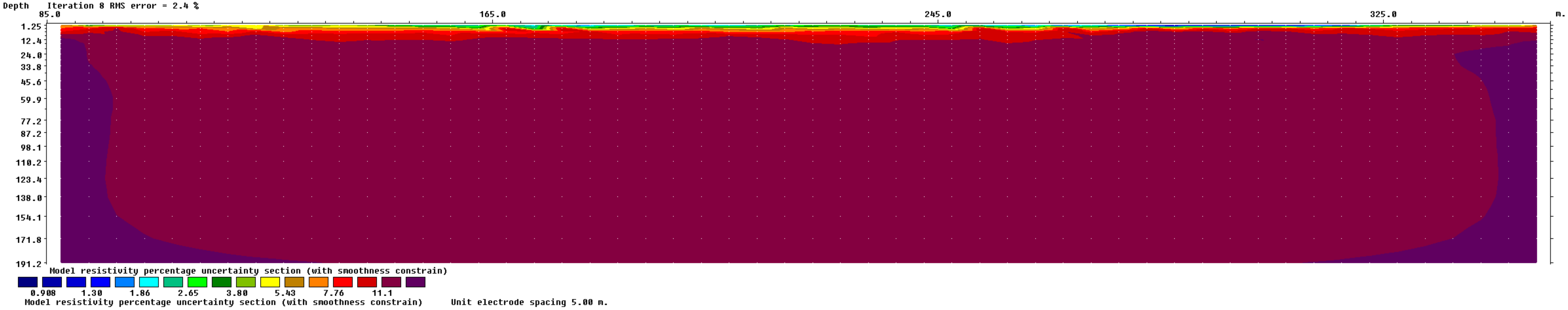




Assessing the quality of an inversion – uncertainty

Not as precise as DOI, but doesn't require extra calculations





AGS Aarhus GeoSoftware

Inversion settings – hands on

1. Read in the data set GRUNDFOR.DAT andcarry out the inversion with the default model discretization. You can take a look at the model discretization by selecting the 'Display model blocks' option.
2. choose the option to 'Allow number of model blocks to exceed data points', and run the inversion again. Make sure to use a different name for the inversion results file, for example GRUNFOR2.INV. Check out the arrangement of the cells again using the 'Display model blocks' option.
3. Now reduce the width of the side cells as well. Select the 'Make sure model blocks have same widths' option, and check out the arrangement of the cells. Next run the inversion again.

Compare the different inversions to see the effect of the model discretization on the inversion result.

Inversion settings – hands on

1. Read in the data set BLOCK_ONE.DAT and carry out the inversion with the default settings.
2. Next select the ‘Select robust inversion’ option, and enable both the robust model and data constrains. Run the inversion again, remember to use another name for the .inv file.

Compare the different inversions to see the effect of the inversion settings on the inversion result.

Try the option to display the inversion result as model blocks instead of contours to see the direct infect on the final model.

Inversion settings – hands on

1. Read in the data set ODARSLOV.DAT and carry out the inversion with the default settings.
2. Next change the inversion settings to robust inversion. Run the inversion again, remember to use another name for the .inv file.
3. Note the extreme resistivity values at the bottom-left and bottom-right corners can take. To reduce this effect, select the ‘Reduce effect of side blocks’ option, and then run the inversion again.

Compare the different inversions to see the effect of the different inversion settings on the inversion result.

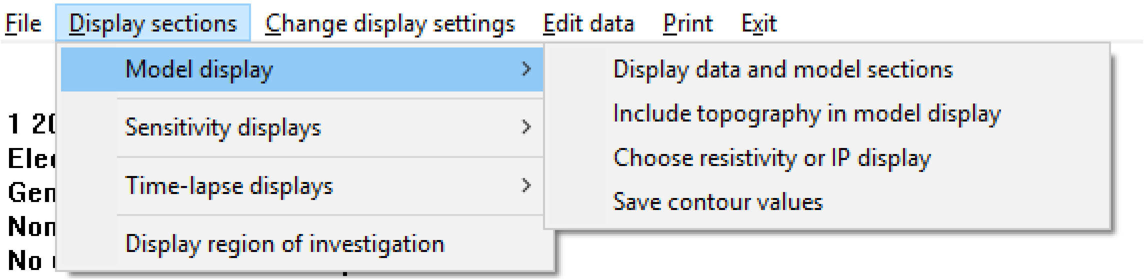
Again, try the option to display the inversion result as model blocks instead of contours to see the direct infect on the final model.

Visualization options

- **Build in visualization**
- **Exports for visualization in other software**

Visualization options – build in visualization – hands on

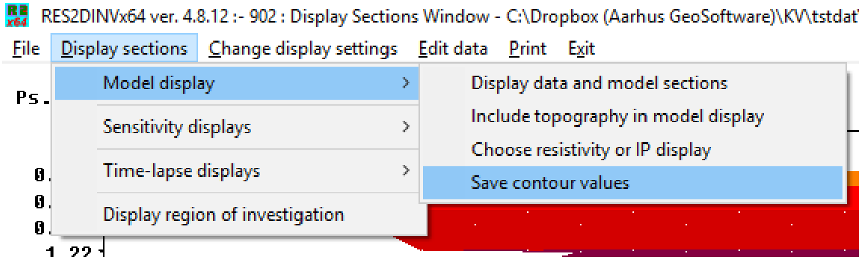
1. **Enter display mode by selecting ‘Display-> Show inversion results’**
2. **If you have just run and inversion the result is automatically loaded, otherwise load it in using the file menu**
3. **Load rathcro.inv (use ipmodel.inv to test IP displays)**
4. **Test the different options in:**



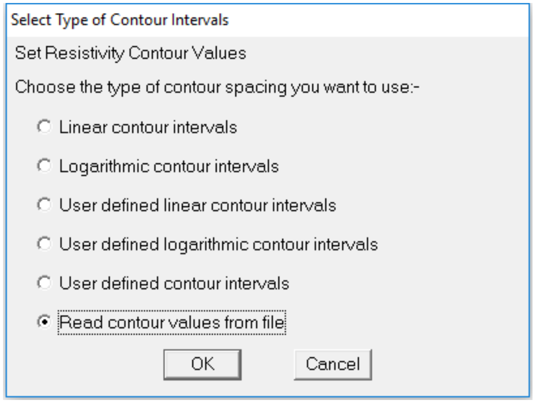
Visualization options – build in visualization – hands on

It is often useful to reuse the same color scale to compare results across profiles or inversions:

6. Saving a colorscale:

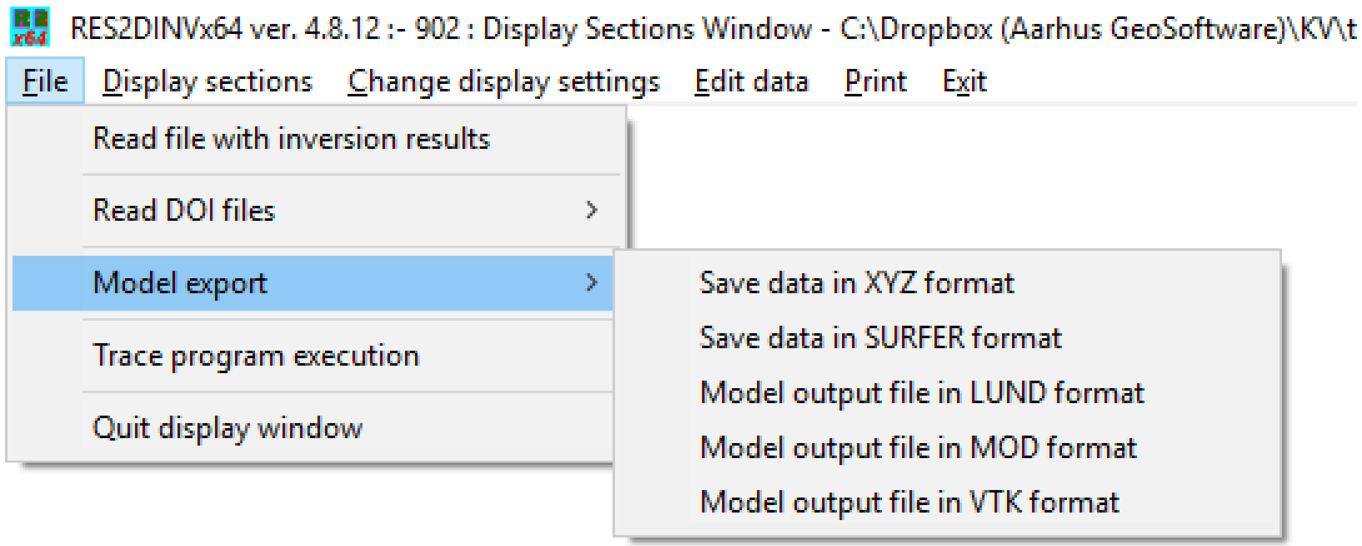


7. Loading a colorscale:



Visualization options - Exports

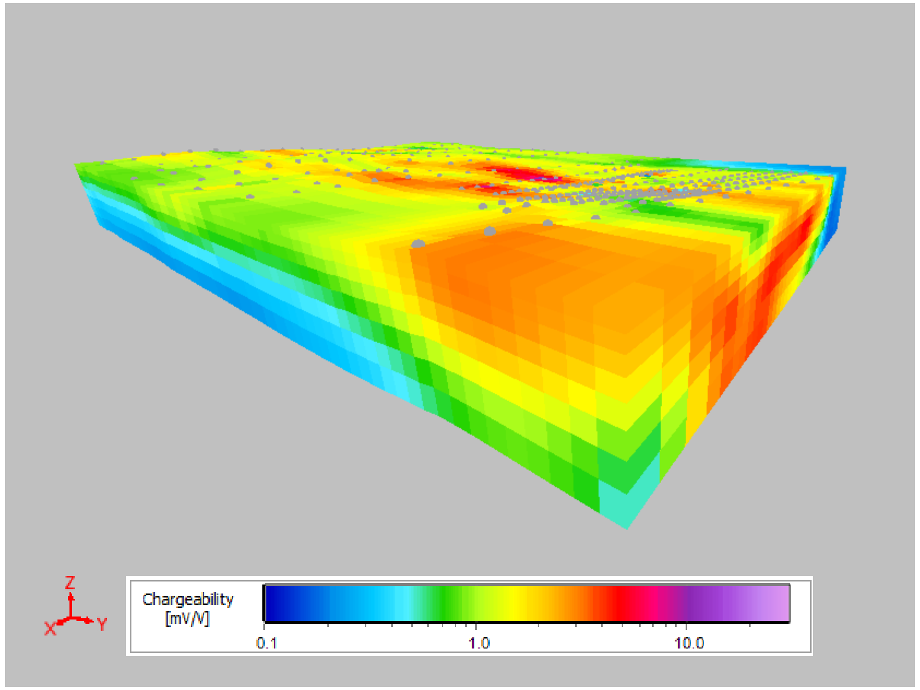
Res2DInv can export visualization results in a range of formats for use in visualization and modelling software:



After the break - Res3DInv

Res3DInv vs Res2DInv

- **More complex than Res2DInv because everything is 3D**
- **Inversion settings and running inversions very similar**
- **Much more computationally demanding**
- **Data format is simpler in some ways and more complex in others**



Model discretization

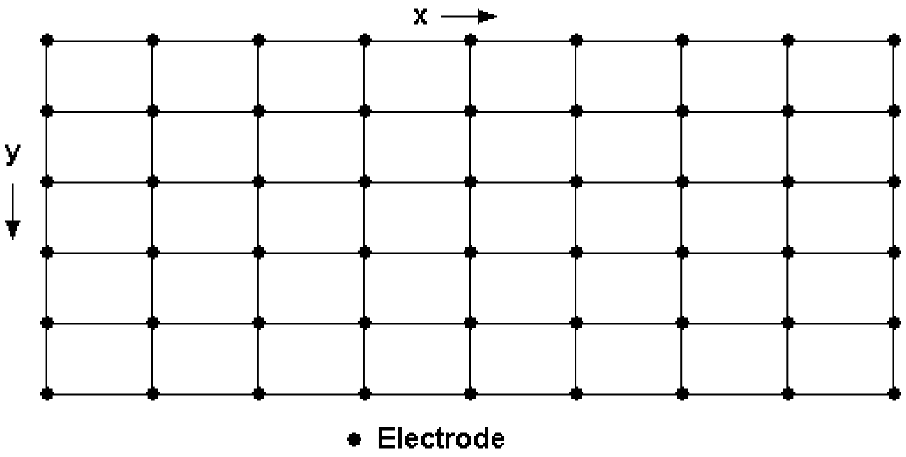
Because of the increased computational load of 3D inversion and the increased degrees of freedom much more care must be taken when defining the model discretization

- **For structured grids the x-y discretization is defined in the header**
- **For the arbitrary electrode locations format the x-y discretization is also defined in the header, but can also be edited from within the program**
- **Also remember to consider the number of layers and the thickness of those**
- **Rotating the grid can also decrease the size**

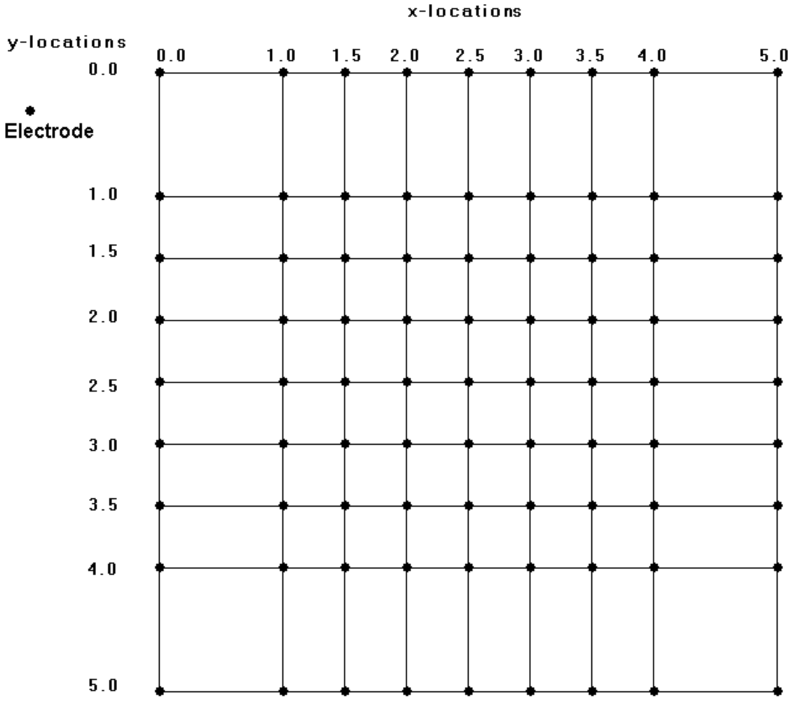
Res3DInv data format – survey grid and electrode locations

All the computational grid and electrode positions are specified at the beginning of the file, there are several options:

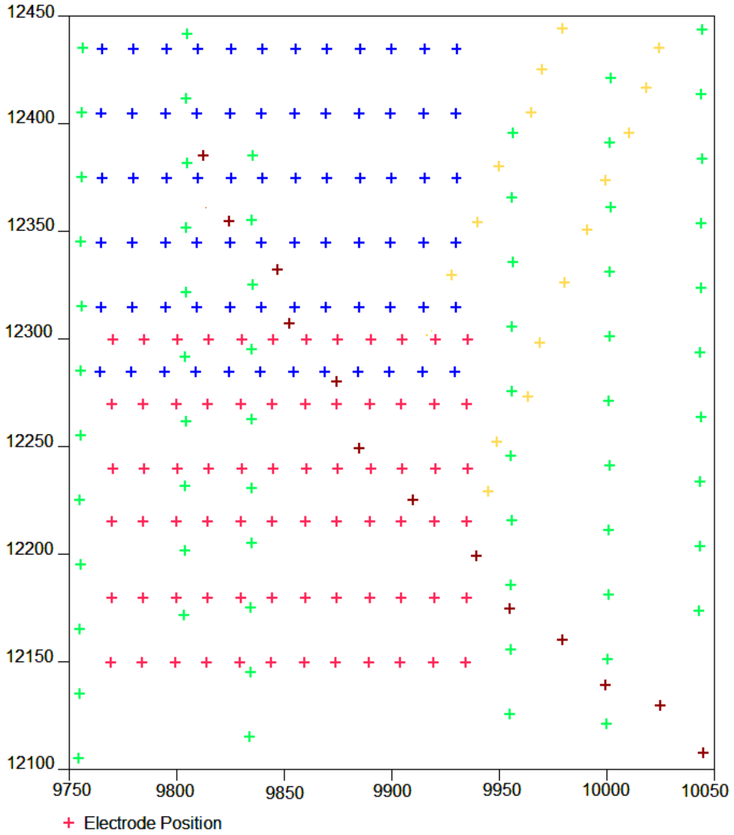
Uniform rectangular survey grid



Nonuniform rectangular survey grid



Arbitrary survey grid



AGS Aarhus GeoSoftware

Res3DInv data format – Uniform and nonuniform rectangular grid - header lines

All the computational grid and electrode positions are specified at the beginning of the file, there are several options:

Uniform rectangular survey grid

```
Uniform rectangular survey grid example
7       Number of electrodes in x-direction
7       Number of electrodes in y-direction
0.5     Unit electrode spacing in x-direction
0.5     Unit electrode spacing in y-direction
2       Array type (2 for pole-pole)
468     Number of data points
0.00      0.00      1.00 0.00    398.05
0.00      0.00      1.50 0.00    424.08
0.00      0.00      2.00 0.00    413.83
0.00      0.00      2.50 0.00    373.76
0.00      0.00      3.00 0.00    320.77
0.00      0.00      0.00 0.50    465.25
0.00      0.00      0.00 1.00    454.78
0.00      0.00      0.00 1.50    460.16
```

Nonuniform rectangular survey grid

```
Nonuniform rectangular survey grid example
9       Number of electrodes in x-direction
9       Number of electrodes in y-direction
Nonuniform grid    Header indicating nonuniform grid
x-location of grid-lines
0.0 1.0 1.5 2.0 2.5 3.0 3.5 4.0 5.0
y-location of grid-lines
0.0 1.0 1.5 2.0 2.5 3.0 3.5 4.0 5.0
2       Array type (2 for pole-pole)
992     Number of data points
0.000    0.000    1.000    0.000    29.934
0.000    0.000    1.500    0.000    29.918
0.000    0.000    2.000    0.000    29.927
0.000    0.000    2.500    0.000    29.932
0.000    0.000    3.000    0.000    29.923
```

In these grids electrodes can only be located on the grid nodes

Res3DInv data format – arbitrary electrode position - header lines

AGS Aarhus GeoSoftware

```
3-D arbitrary electrodes data format
68,80 X and Y surface grid size
Nonuniform grid Header for non-uniform rectangular grid
x-location of grid-lines
  571880.000   571885.000   571890.000   571895.000   571900.000   571905.000   571910.000   571915.000   571920.000   571925.000 X-location of all grid lines
  571930.000   571935.000   571940.000   571945.000   571950.000   571955.000   571960.000   571965.000   571970.000   571975.000 (global coordinates)
  571980.000   571985.000   571990.000   571995.000   572000.000   572005.000   572010.000   572015.000   572020.000   572025.000
  572030.000   572035.000   572040.000   572045.000   572050.000   572055.000   572060.000   572065.000   572070.000   572075.000
  572080.000   572085.000   572090.000   572095.000   572100.000   572105.000   572110.000   572115.000   572120.000   572125.000
  572130.000   572135.000   572140.000   572145.000   572150.000   572155.000   572160.000   572165.000   572170.000   572175.000
  572180.000   572185.000   572190.000   572195.000   572200.000   572205.000   572210.000   572215.000
y-location of grid-lines
 6222155.000  6222160.000  6222165.000  6222170.000  6222175.000  6222180.000  6222185.000  6222190.000  6222195.000  6222200.000 Y-location of all grid lines
 6222205.000  6222210.000  6222215.000  6222220.000  6222225.000  6222230.000  6222235.000  6222240.000  6222245.000  6222250.000 (global coordinates)
 6222255.000  6222260.000  6222265.000  6222270.000  6222275.000  6222280.000  6222285.000  6222290.000  6222295.000  6222300.000
 6222305.000  6222310.000  6222315.000  6222320.000  6222325.000  6222330.000  6222335.000  6222340.000  6222345.000  6222350.000
 6222355.000  6222360.000  6222365.000  6222370.000  6222375.000  6222380.000  6222385.000  6222390.000  6222395.000  6222400.000
 6222405.000  6222410.000  6222415.000  6222420.000  6222425.000  6222430.000  6222435.000  6222440.000  6222445.000  6222450.000
 6222455.000  6222460.000  6222465.000  6222470.000  6222475.000  6222480.000  6222485.000  6222490.000  6222495.000  6222500.000
 6222505.000  6222510.000  6222515.000  6222520.000  6222525.000  6222530.000  6222535.000  6222540.000  6222545.000  6222550.000
11 General array data format
0  No sub array type
Type of data (0=apparent resistivity,1=resistance)  Data unit header
0  Apparent resistivity data
Point Electrodes outside grid present Header for arbitrary electrode positions
Number of point electrodes Header for number of arbitrary electrodes
334 Number of arbitrary electrodes
Compressed format used for point electrodes coordinates  Header for “compressed format” this is usually used
   1,  571884.9200, 6222499.4000,       1.6300             Electrode number, X-location, Y-location, Elevation (only electrodes not located on
   2,  571889.8900, 6222498.9800,       1.6500             grid nodes need to be listed here.)
   3,  571894.8700, 6222498.5600,       1.6700
   4,  571899.8400, 6222498.1400,       1.6900
   5,  571904.8200, 6222497.7300,       1.7000
   6,  571905.4100, 6222545.3600,       1.6300
   7,  571909.7900, 6222497.3100,       1.7200
   8,  571909.8200, 6222543.0100,       1.6400
   9,  571914.2300, 6222540.6600,       1.6600
```

Res3DInv data format – data lines

The data line format is the same for all grid types:

Pole-pole example with IP:

	C1-X	C1-Y	P1-X	P1-Y	A.Res.	I.P.
298	1.000	2.000	6.000	2.000	9.8064	-0.7452
299	1.000	2.000	7.000	2.000	9.7419	-1.4738
300	1.000	2.000	0.000	3.000	10.3088	2.1841
301	1.000	2.000	1.000	3.000	10.3778	2.6690
302	1.000	2.000	2.000	3.000	10.9918	6.7572
303	1.000	2.000	1.000	4.000	10.5644	4.1239
304	1.000	2.000	3.000	4.000	11.0035	9.2132
305	1.000	2.000	1.000	5.000	10.4259	3.3120
306	1.000	2.000	4.000	5.000	9.9305	1.7297
307	1.000	2.000	1.000	6.000	10.2240	1.8794
308	1.000	2.000	5.000	6.000	9.5697	-2.2696
309	1.000	2.000	1.000	7.000	10.0957	0.9139
310	1.000	2.000	6.000	7.000	9.6073	-2.4194
311	2.000	2.000	3.000	2.000	11.1181	7.9622
312	2.000	2.000	4.000	2.000	11.2147	9.7495
313	2.000	2.000	5.000	2.000	10.5308	5.5019
314	2.000	2.000	6.000	2.000	10.0787	1.7192
315	2.000	2.000	7.000	2.000	9.9123	0.1283
316	2.000	2.000	1.000	3.000	10.8094	5.5007
317	2.000	2.000	2.000	3.000	11.1181	7.9619
318	2.000	2.000	3.000	3.000	11.8588	14.6974

General/mixed array example, resistivity only:

	N.elec.	C1-X	C1-Y	C2-X	C2-Y	P1-X	P1-Y	P2-X	P2-Y	App.Res.
30	4	4.000	0.000	3.000	0.000	6.000	0.000	7.000	0.000	30.316
31	4	4.000	0.000	3.000	0.000	7.000	0.000	8.000	0.000	30.694
32	4	4.000	0.000	3.000	0.000	8.000	0.000	9.000	0.000	30.810
33	4	5.000	0.000	4.000	0.000	6.000	0.000	7.000	0.000	29.997
34	4	5.000	0.000	4.000	0.000	7.000	0.000	8.000	0.000	30.236
35	4	5.000	0.000	4.000	0.000	8.000	0.000	9.000	0.000	30.438
36	4	6.000	0.000	5.000	0.000	7.000	0.000	8.000	0.000	29.986
37	4	6.000	0.000	5.000	0.000	8.000	0.000	9.000	0.000	30.096
38	4	7.000	0.000	6.000	0.000	8.000	0.000	9.000	0.000	29.968
39	4	1.000	1.000	0.000	1.000	2.000	1.000	3.000	1.000	30.051
40	4	1.000	1.000	0.000	1.000	3.000	1.000	4.000	1.000	31.123
41	4	1.000	1.000	0.000	1.000	4.000	1.000	5.000	1.000	31.877
42	4	1.000	1.000	0.000	1.000	5.000	1.000	6.000	1.000	31.993
43	4	1.000	1.000	0.000	1.000	6.000	1.000	7.000	1.000	31.854
44	4	1.000	1.000	0.000	1.000	7.000	1.000	8.000	1.000	30.523
45	4	1.000	1.000	0.000	1.000	8.000	1.000	9.000	1.000	29.504
46	4	2.000	1.000	1.000	1.000	3.000	1.000	4.000	1.000	30.581
47	4	2.000	1.000	1.000	1.000	4.000	1.000	5.000	1.000	32.157
48	4	2.000	1.000	1.000	1.000	5.000	1.000	6.000	1.000	32.987
49	4	2.000	1.000	1.000	1.000	6.000	1.000	7.000	1.000	33.142
50	4	2.000	1.000	1.000	1.000	7.000	1.000	8.000	1.000	31.788

Res3DInv data format – extra header for IP

When IP data is present a few extra header lines are added, these are added after the “number of data points” line:

```
2              End of grid definition
712            Number of data points
IP present            IP header
Chargeability         Type of IP data
mV/V                  Unit for IP data
0.1,1.0               Delay and integration time for IP data
   0.000     0.000     1.000     0.000  10.0544    0.3702 Data lines
   0.000     0.000     2.000     0.000  10.1311    0.8952
   0.000     0.000     3.000     0.000  10.1860    1.3004
   0.000     0.000     4.000     0.000  10.1808    1.3179
   0.000     0.000     5.000     0.000  10.1235    0.9504
   0.000     0.000     6.000     0.000  10.0573    0.4828
   0.000     0.000     7.000     0.000  10.0095    0.1319
   0.000     0.000     0.000     1.000  10.0544    0.3700
   0.000     0.000     1.000     1.000  10.1214    0.8158
   0.000     0.000     0.000     2.000  10.1312    0.8948
   0.000     0.000     2.000     2.000  10.4994    3.1920
   0.000     0.000     0.000     3.000  10.1860    1.2999
   0.000     0.000     3.000     3.000  10.5749    4.4965
   0.000     0.000     0.000     4.000  10.1808    1.3179
   0.000     0.000     4.000     4.000  10.0542    1.8797
   0.000     0.000     0.000     5.000  10.1235    0.9505
   0.000     0.000     5.000     5.000   9.5838   -2.3194
   0.000     0.000     0.000     6.000  10.0572    0.4825
   0.000     0.000     6.000     6.000   9.6499   -2.2744
```

AGS Aarhus GeoSoftware

Topography options

Several options:

Z-coordinates on point/arbitrary electrodes (XXX slides back)

Topography in a structured list

```
   7.000   10.000    9.000   10.000 124.2985
   7.000   10.000   10.000   10.000 120.3522
   8.000   10.000    9.000   10.000 115.0855
   8.000   10.000   10.000   10.000 113.3131   Last data lines
   9.000   10.000   10.000   10.000 102.7262
Topography          Topography header
2                   Surface distances used, 1 for true horizontal/global distances
0.00 0.00 0.00 -0.50 -1.00 -1.50 -1.00 -0.50 0.00 0.00 0.00 Elevation of all grid
0.00 0.00 0.00 -0.50 -1.00 -1.50 -1.00 -0.50 0.00 0.00 0.00 nodes, in x→ and y↓
0.00 0.00 0.00 -0.50 -1.00 -1.50 -1.00 -0.50 0.00 0.00 0.00 directions
0.00 0.00 0.00 -0.50 -1.00 -1.50 -1.00 -0. 50 0.00 0.00 0.00
0.00 0.00 0.00 -0.50 -1.00 -1.50 -1.00 -0.50 0.00 0.00 0.00
0.00 0.00 0.00 -0.50 -1.00 -1.50 -1.00 -0.50 0.00 0.00 0.00
0.00 0.00 0.00 -0.50 -1.00 -1.50 -1.00 -0.50 0.00 0.00 0.00
0.00 0.00 0.00 -0.50 -1.00 -1.50 -1.00 -0.50 0.00 0.00 0.00
0.00 0.00 0.00 -0.50 -1.00 -1.50 -1.00 -0.50 0.00 0.00 0.00
0.00 0.00 0.00 -0.50 -1.00 -1.50 -1.00 -0.50 0.00 0.00 0.00
0.00 0.00 0.00 -0.50 -1.00 -1.50 -1.00 -0.50 0.00 0.00 0.00
0 End of file
0
0
0
```

Topography at specified points

```
   7.000   10.000   10.000   10.000 120.3522
   8.000   10.000    9.000   10.000 115.0855
   8.000   10.000   10.000   10.000 113.3131
   9.000   10.000   10.000   10.000 102.7262  Last data lines
Topography        Topography header
2                 Surface distances used, 1 for true horizontal/global distances
Topography in unstructured list   Header for topography at specified points
Number of topography data points  Header for number of topography points
121 Number of topography points
Topography data points (index,x,y,z) Header
1     0.0   0.0 0.00   Point number, x, y and z coordinate
2     1.0   0.0  0.00
3     2.0   0.0  0.00
4     3.0   0.0 -0.50
5     4.0   0.0 -1.00
6     5.0   0.0 -1.50
7     6.0   0.0 -1.00
8     7.0   0.0 -0.50
9     8.0   0.0  0.00
10    9.0   0.0  0.00
```

AGS Aarhus GeoSoftware

Inversion settings & other options

The inversion and settings and other options are very similar to Res2DInv

- **Smoothness constrained (L2) and and robust/blocky (L1 norm) inversion methods**
- **Limit on model resistivities, vertical and horizontal flatness filters etc.**
- **Underwater surveys and buried electrodes**
- **Fixed regions and known boundaries**

Special options in Res3DInv

- **Combination of Res2DInv data files into Res3DInv data files**
- **Time lapse inversion for tracking the changes in datasets and models between measurements**
- **Used for monitoring lands slides, injections, migration of tracers/pollutions and remediation**

AGS Aarhus GeoSoftware

Combine Res2DInv data files into Res3DInv data files

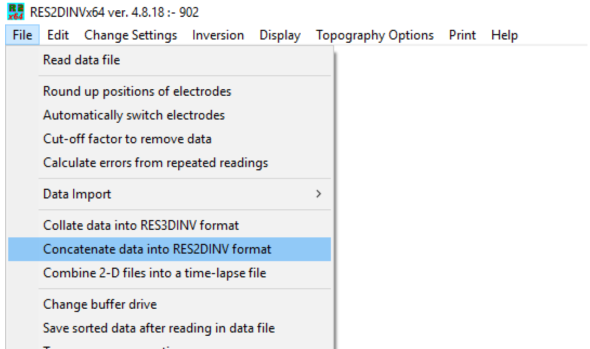
Lines in an orthogonal grid

```
Collate 3 Lines Title line
Number of files to collate Header for number of files to combine
3  Number of files to combine
File 1 parameters Header for file 1
Name of data file in RES2DINV format Header for file name
d:\test\FILE2D_1.DAT Full file path and file name for file 1
X and Y location of first electrode along this line Header for line location
0.0,0.0  X and Y location of first electrode in line
Line direction (0=X,1=Y) Header for line direction
0  Line is in X direction (1 for Y direction)
Line sign (0=positive,1=negative) Header for line sign
0 Electrode numbers increase in positive direction in 3D grid
File 2 parameters Same information for file 2
Name of data file in RES2DINV format
d:\test\FILE2D_2.DAT
X and Y location of first electrode along this line
0.0,-0.5
Line direction (0=X,1=Y)
0
Line sign (0=positive,1=negative)
0
File 3 parameters
Name of data file in RES2DINV format
d:\test\FILE2D_3.DAT
X and Y location of first electrode along this line
0.0,-1.0
Line direction (0=X,1=Y)
0
Line sign (0=positive,1=negative)
0
Name of Output file in RES3DINV format Header for output file name
d:\test\FILE_3D.dat Full file path and file name for output file
End of file
```

Lines in arbitrary directions

```
3-D arbitrary electrodes data format Title line
Number of files to collate Header for number of files to combine
3 Number of files to combine
Arbitrary point electrodes format Header for arbitrary electrode locations
X model grid spacing Header for model X discretization
1.0    Model discretization in X-direction
Y model grid spacing Header for model Y discretization
1.0    Model discretization in Y-direction
File 1 parameters  Header for file 1
Name of data file in RES2DINV format Header for file name
c:\Test\block32x19b-x-00.DAT Full file path and file name for file 1
File 2 parameters Same information for file 2
Name of data file in RES2DINV format
c:\Test\block32x19b-x-02.DAT
File 3 parameters
Name of data file in RES2DINV format
c:\Test\block32x19b-x-04.DAT
Name of Output file in RES3DINV format Header for output file name
c:\Test\block32x19b-3D.dat Full file path and file name for output file
End of file
```

Files are combined using Res2DInv:



Data processing/removal of bad data points in Res3DInv

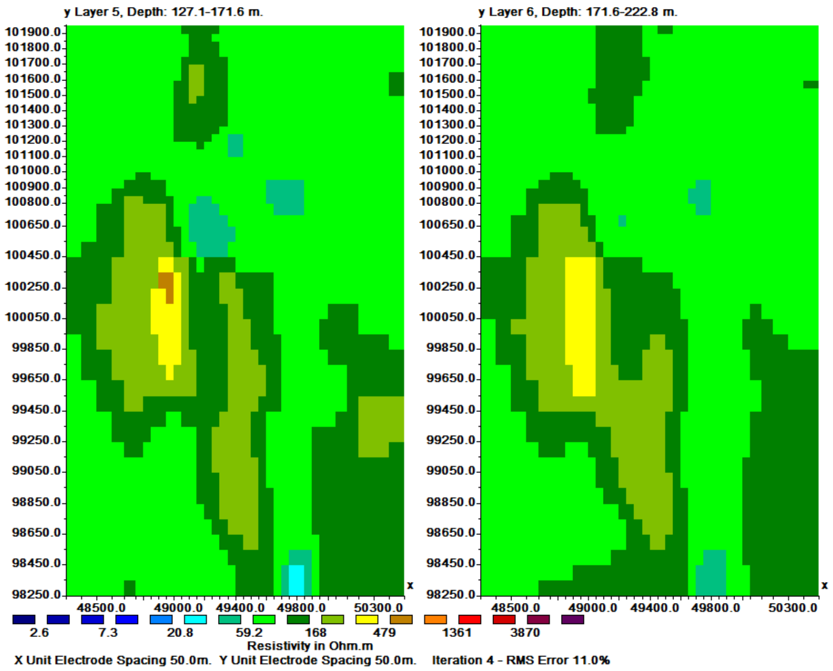
Due to the huge amount of data points and 3D complexity of 3D ERT data it is hard to do visual/manual processing of the data to improve inversion results, there are 2 options:

- **The statistical approach based on an initial inversion as demonstrated in Res2DInc**
- **For datasets joind of serveral 2D lines the manual processing can be done to the 2D lines using Res2DInv prior to combining the lines into a 3D data file**

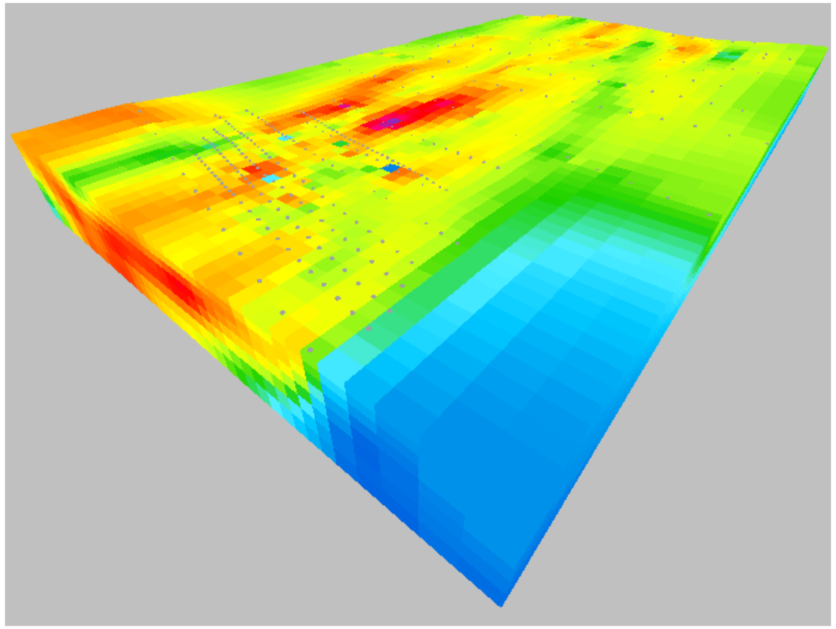
Visualization

Res3DInv has several visualization options, to enter “display mode” select ‘Display->display results’

Classic build in visualization:



3D Viewer:

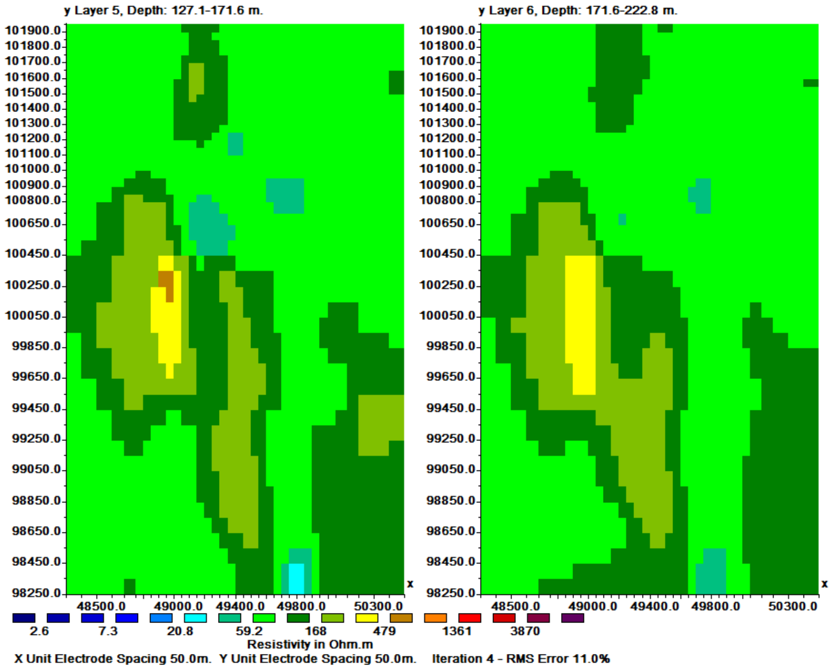


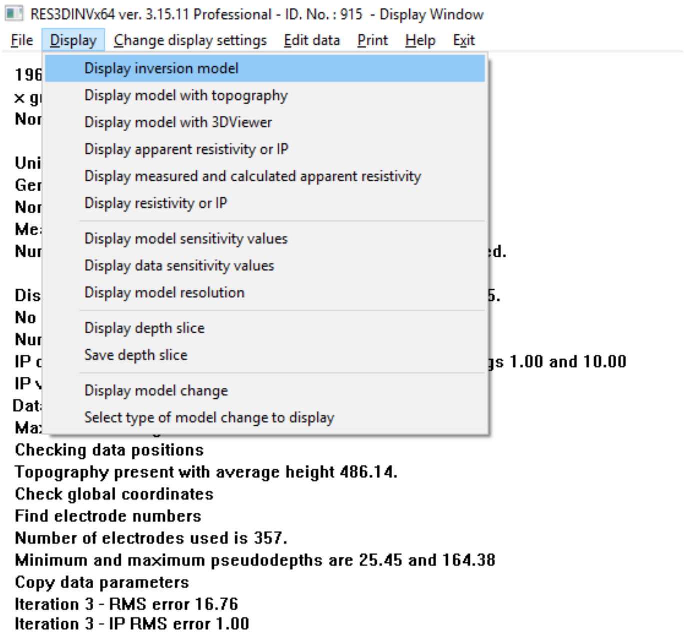
Exports:

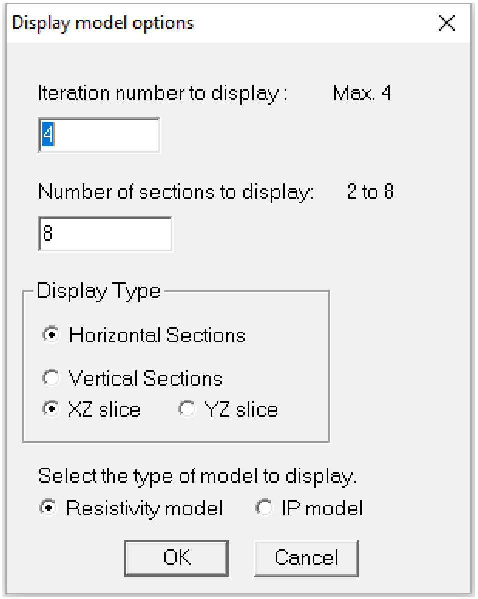
```
/Name of survey line is 1966_IP_data_all_final_nodtm.BDB
/Number of blocks is 14112
/Results for iteration 4
/The x, y and z coordinates the centres of the model blocks, and
/the resistivity, conductivity and IP value of each block is given below.
/The I.P. is given in terms of Percent Frequency Effect with units in %
/        X           Y          Elevation    Resistivity      Conductivity
  48350.0000   98300.0000     498.0921        78.0237          0.012817
  48450.0000   98300.0000     496.2501        77.4654          0.012909
  48550.0000   98300.0000     490.6038        78.3246          0.012767
  48637.5000   98300.0000     482.8150        90.6875          0.011027
  48712.5000   98300.0000     478.1996        71.4942          0.013987
  48775.0000   98300.0000     474.8938        69.6839          0.014351
  48825.0000   98300.0000     471.4896        54.0520          0.018501
  48875.0000   98300.0000     469.1854        46.1332          0.021676
  48925.0000   98300.0000     466.9939        36.8043          0.027171
  48975.0000   98300.0000     465.3968        26.2511          0.038094
  49025.0000   98300.0000     465.9678        22.3539          0.044735
  49075.0000   98300.0000     466.1528        18.2205          0.054883
  49125.0000   98300.0000     466.2152        16.1321          0.061988
  49175.0000   98300.0000     469.6369        19.2623          0.051915
  49225.0000   98300.0000     472.0463        49.2114          0.020320
  49275.0000   98300.0000     476.6610        64.9709          0.015392
  49325.0000   98300.0000     480.9317       212.7277          0.0047008
  49375.0000   98300.0000     482.7738       413.8167          0.0024165
  49425.0000   98300.0000     487.3830        84.9816          0.011767
  49475.0000   98300.0000     490.0945        17.5093          0.057113
  49525.0000   98300.0000     493.1746        22.2833          0.044877
  49575.0000   98300.0000     494.3861        62.1920          0.016079
  49625.0000   98300.0000     492.8252       122.4661          0.0081655
  49675.0000   98300.0000     492.9211       173.3137          0.0057699
  49725.0000   98300.0000     493.2687       160.3539          0.0062362
  49775.0000   98300.0000     495.1201       136.4403          0.0073292
  49825.0000   98300.0000     497.4661       237.3000          0.0042141
  49875.0000   98300.0000     501.5447       313.0403          0.0031945
```

Classic build-in visualization

In this mode it is possible to show vertical and horizontal slices of the inverted model on a color scale, the settings and options are very similar to those of Res2DInv.

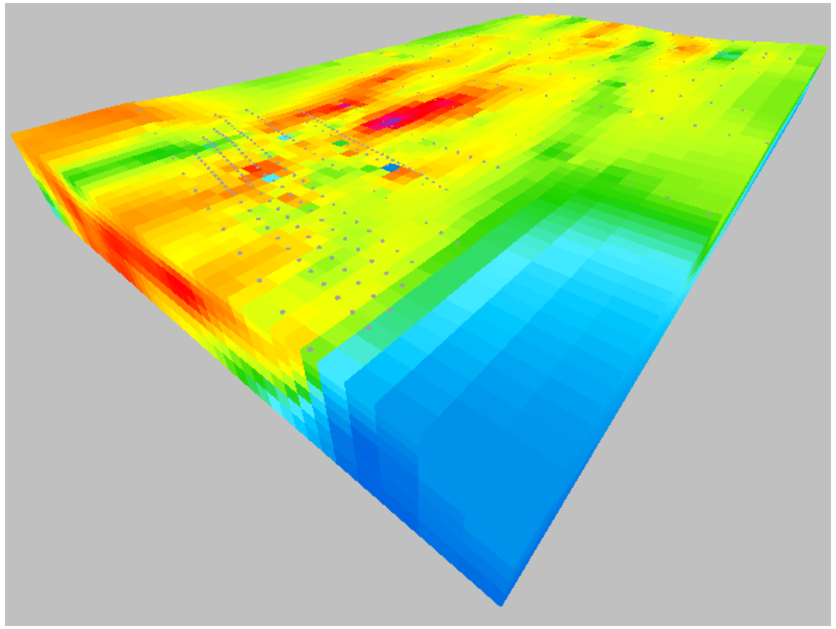






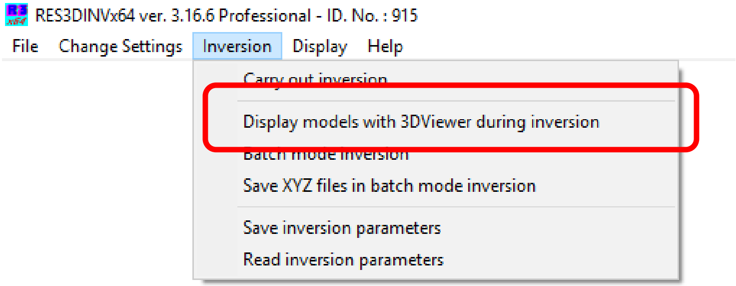
AGS Aarhus GeoSoftware

3D Viewer

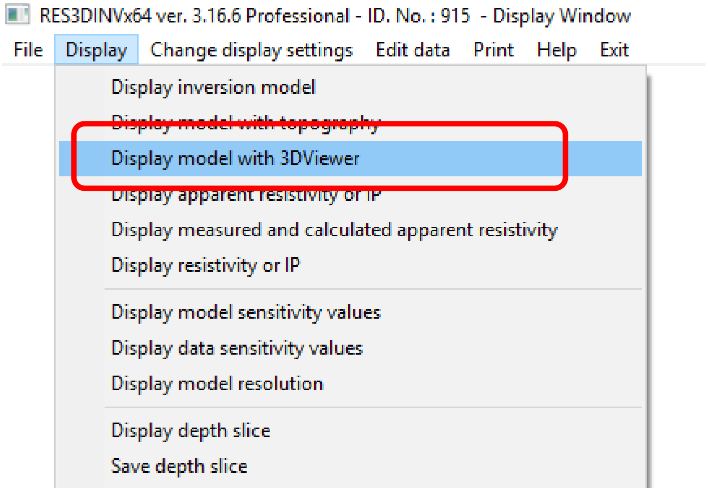


Can be used to view results in 3D both during and after inversion.

To display results during inversion:



To display results after inversion in display mode:



3D Viewer – Live demo

- **Display models during inversion**

Display mode:

- **Rotation, zoom and move center**
- **Axes and center**
- **Layer selection**
- **Color scale**
- **Wire frame**
- **Cut planes and subnodes**

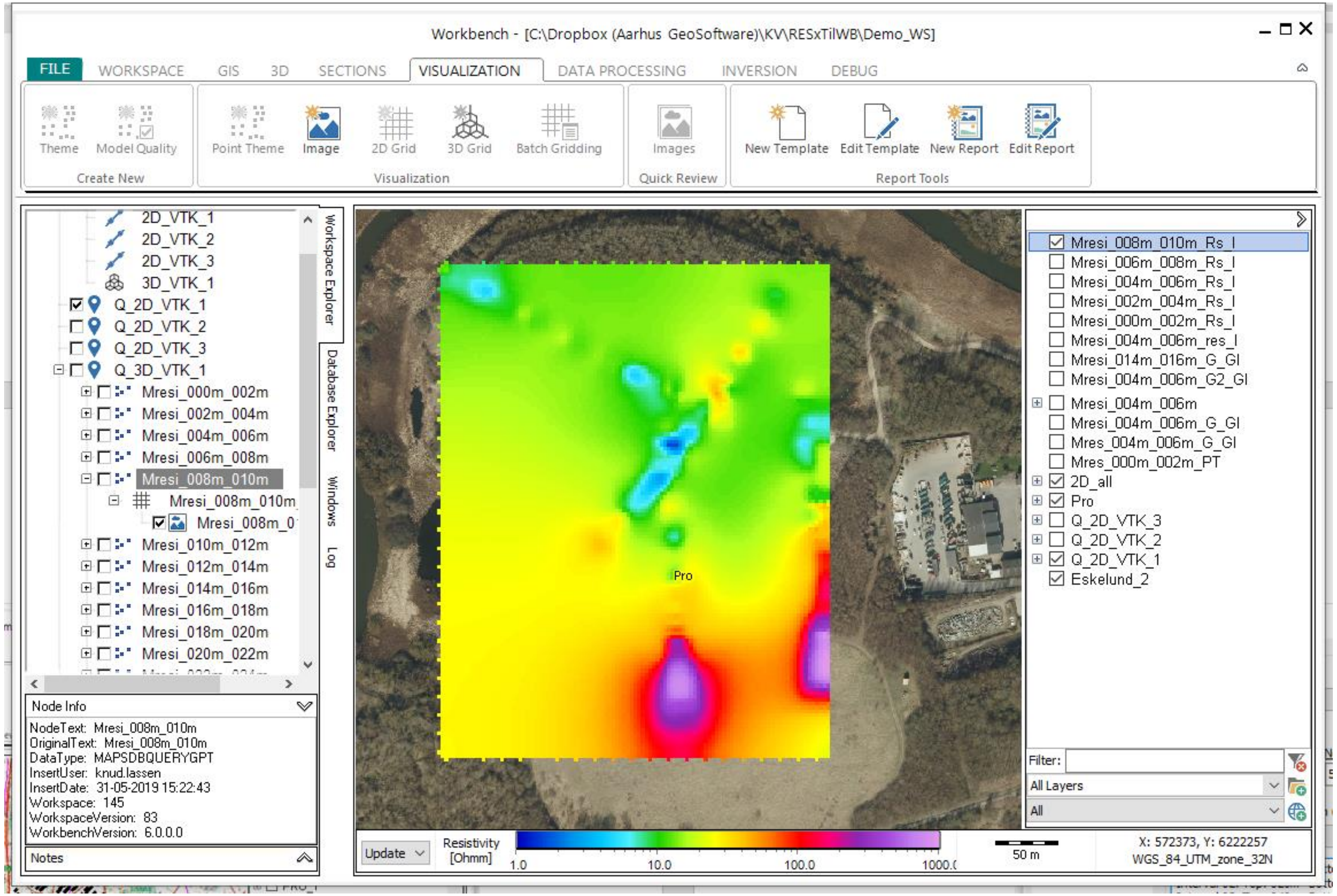
Bonus – Res2DInv and Res3DInv results in Aarhus Workbench

It is possible to load inversion results from Res2DInv and Res3DInv into Aarhus workbench for improved visualization and interpretation options, in the following a few examples are shown. For instruction on how to use these options please refer to the manual for using Res2DInv inversion results in Aarhus Workbench, which can be downloaded here: XXXXXXXX

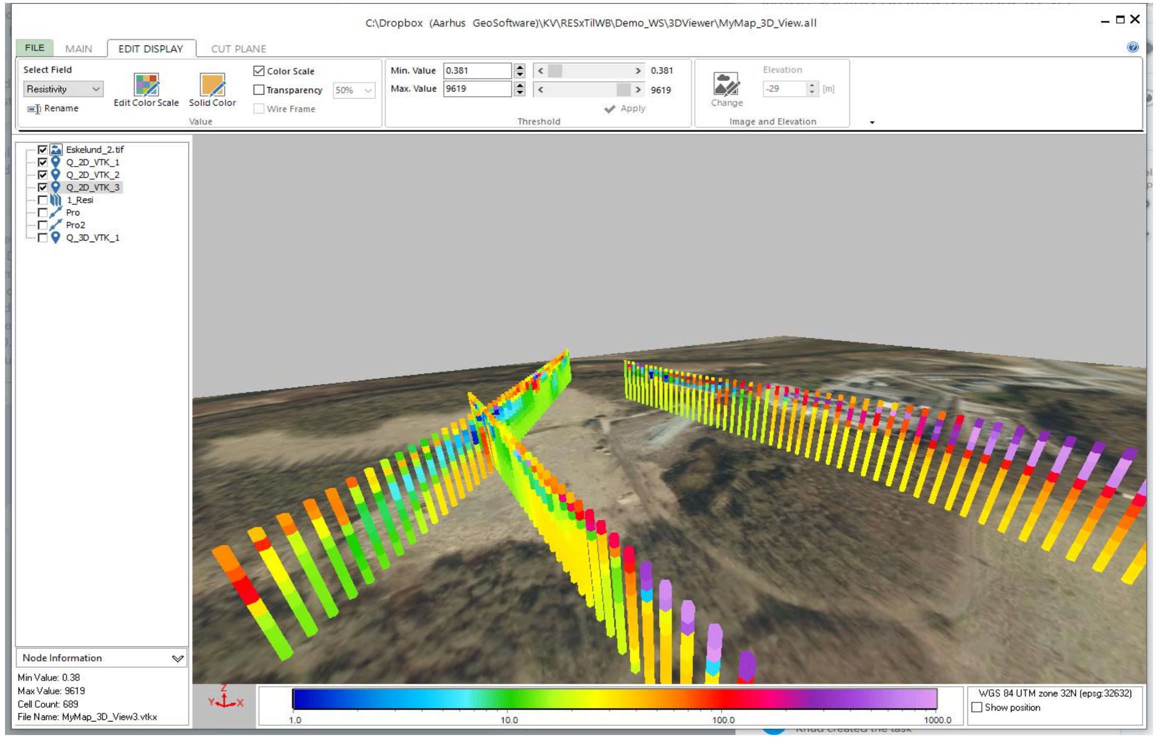
Note that these options require a Aarhus Workbench Essential License.

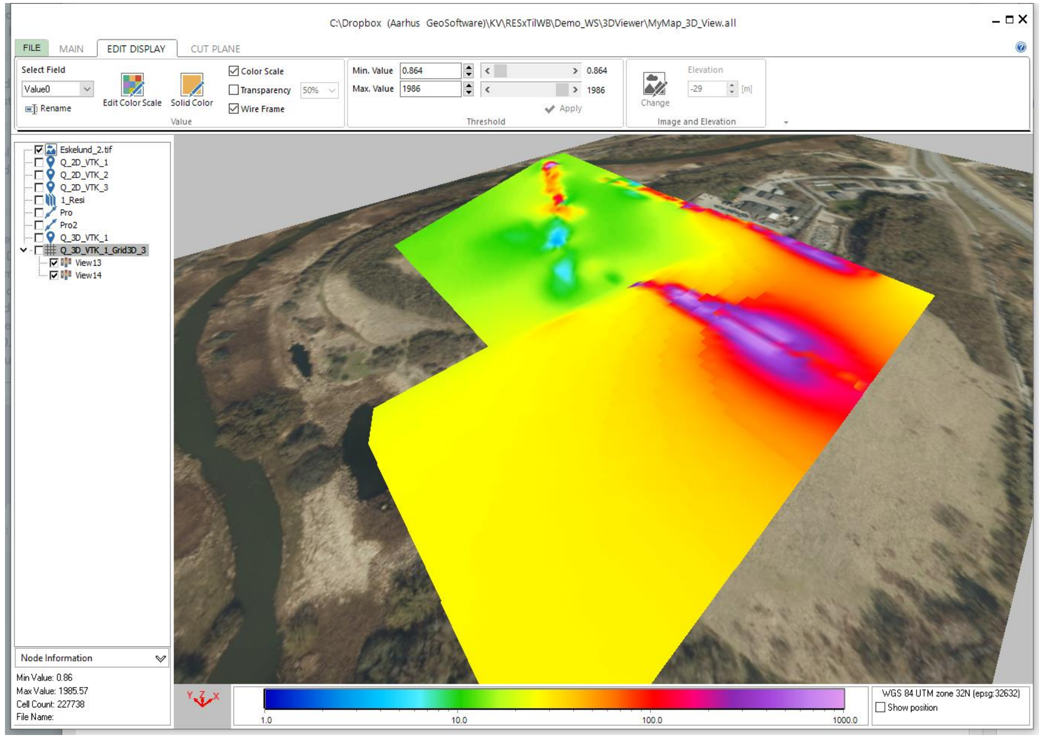
Show location of data, inversions, boreholes etc. on a GIS map

Create horizontal maps, showing e.g. mean resistivity

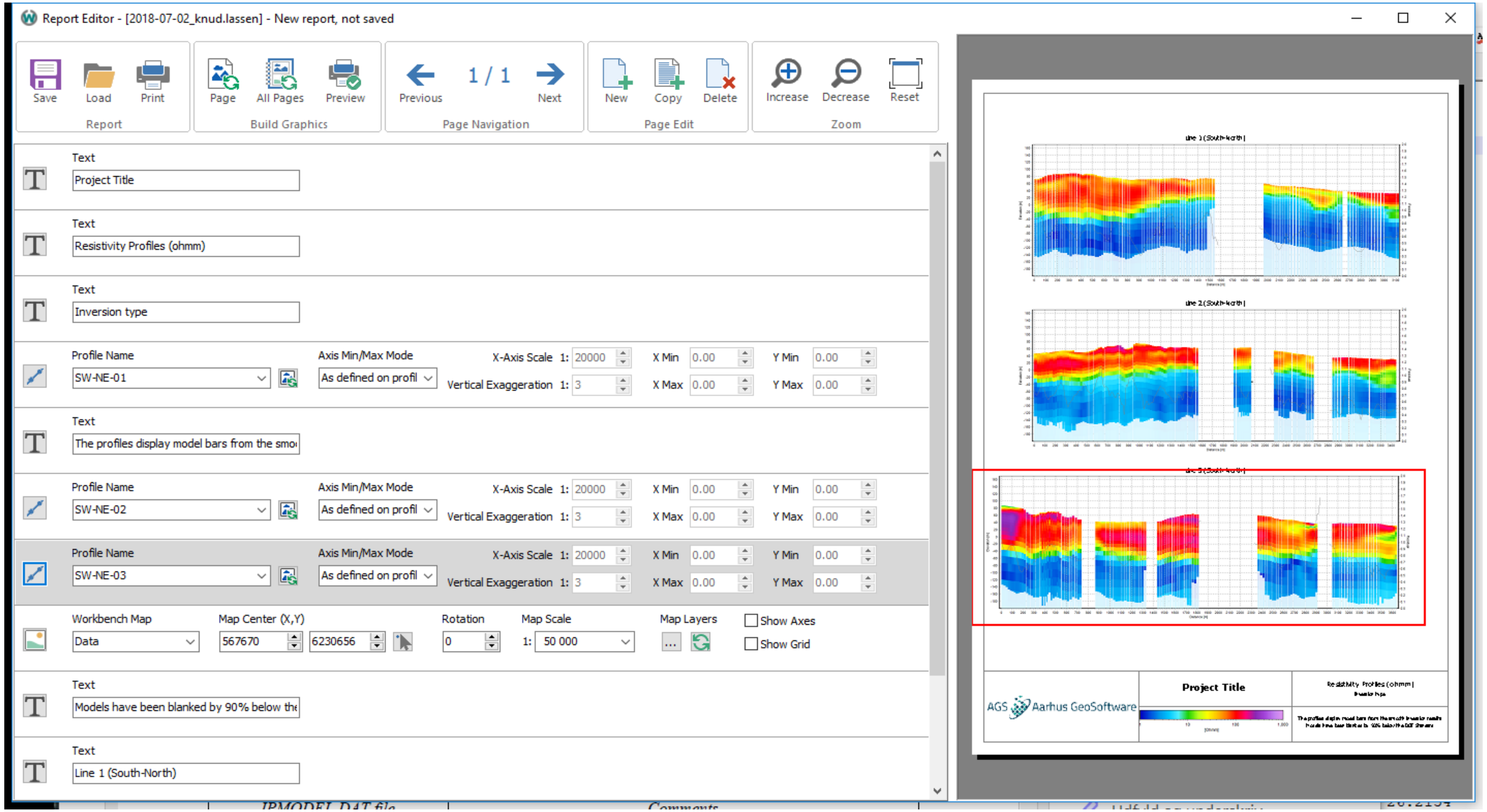


Display 2D and 3D inversion results in the 3D viewer



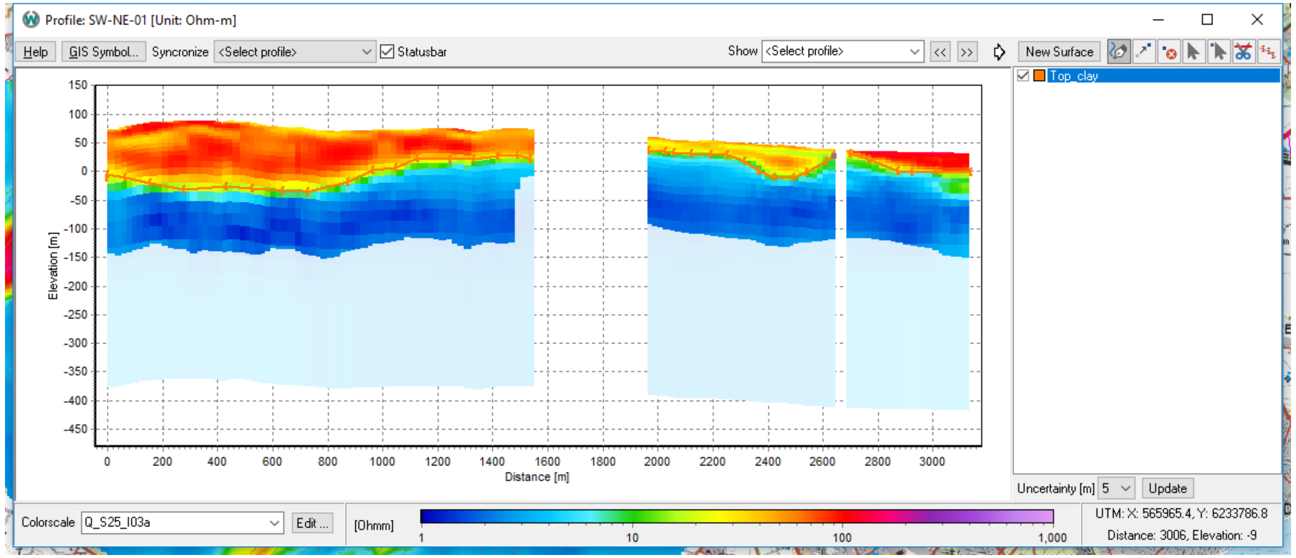


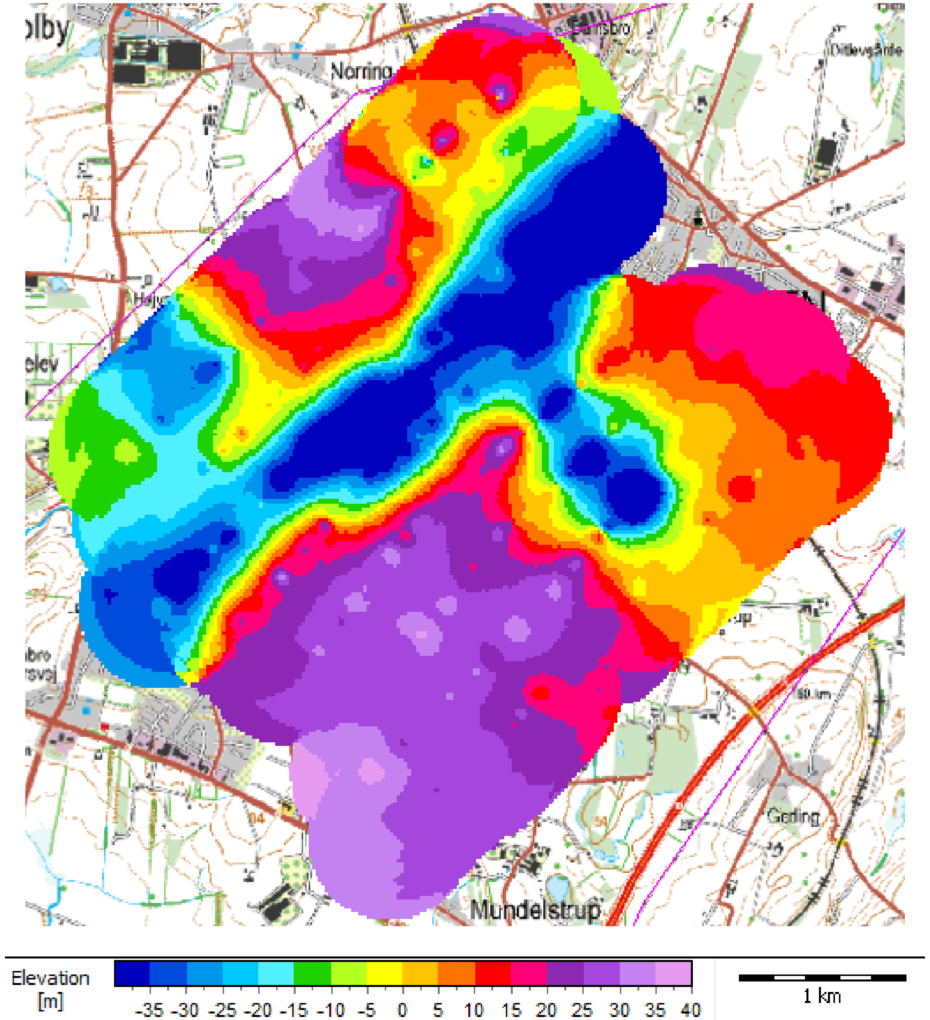
Create automatized PDF reports for fast reporting on fieldwork



AGS Aarhus GeoSoftware

Perform geological interpretation using geological surfaces





AGS Aarhus GeoSoftware

Thank you – questions?