RES3DINVx64 ver. 3.13
Basic and Professional versions
with multi-core and 64-bit support

for Windows XP/Vista/7/8/10

Installation and getting
started users guide

July 2017

Rapid 3-D Resistivity & I.P. inversion
using the least-squares method
For 3-D surveys using the pole-pole, pole-dipole,
dipole-dipole, rectangular, Wenner,
Wenner-Schlumberger and non-conventional arrays
On land, aquatic, cross-borehole
and time-lapse surveys

Notice of Copyright

Table of Contents

List of Figures

1   Introduction

This is a very brief guide to help you in installing and getting started with the program. The Res3dinvx64.pdf file has detailed instructions for using the software and should be used as the manual.

RES3DINVx64 is a computer program that will automatically determine a three-dimensional (3-D) resistivity model for the subsurface using the data obtained from a 3-D electrical imaging survey (Li and Oldenburg 1992; Chambers et al. 2006; Loke 2015). On a computer with 8 GB RAM, the RES3DINVx64 Basic program can handle survey grids with about up to about 16000 electrodes. The RES3DINVx64 Professional program can access up to 192GB RAM and support survey grids with up to 50000 electrodes. On a modern multi-core Windows-based microcomputer, the data inversion takes from less than a minute for small surveys with 100 electrodes in a flat area to several hours for extremely large surveys with 6000 electrodes in rugged terrain. A variety of survey configurations are supported, from simple rectangular grids (Figures 1a and 1b), to non-rectangular grids (Figure 1c), to even data sets collated from survey lines in different directions (Figure 1d).

The inversion model used consists of a number of rectangular cells arranged in layers (Figure 2). The program changes the resistivity (and I.P. if available) values of the cells automatically so that the calculated apparent resistivity (and I.P.) values agree as closely as possible with the measured values subject to selected constraints. A finite-difference or finite-element modeling subroutine is used to calculate the apparent resistivity values, and a non-linear smoothness-constrained least-squares optimization technique is used to calculate the resistivity of the model blocks (deGroot-Hedlin and Constable 1990; Loke et al. 2003). If topography is present, the program uses a distorted finite-element grid so that the surface of the grid matches the topography (Loke 2000). If I.P. data is also present, the program will also generate an I.P. model together with the resistivity model.

If you are new to ERT (electrical resistivity tomography) surveys, please refer to the free tutorial notes (Loke 2016) on the 'Downloads' page of the www.geotomosoft.com website. You can also download the latest version of the Res3dinvx64 program from this website.
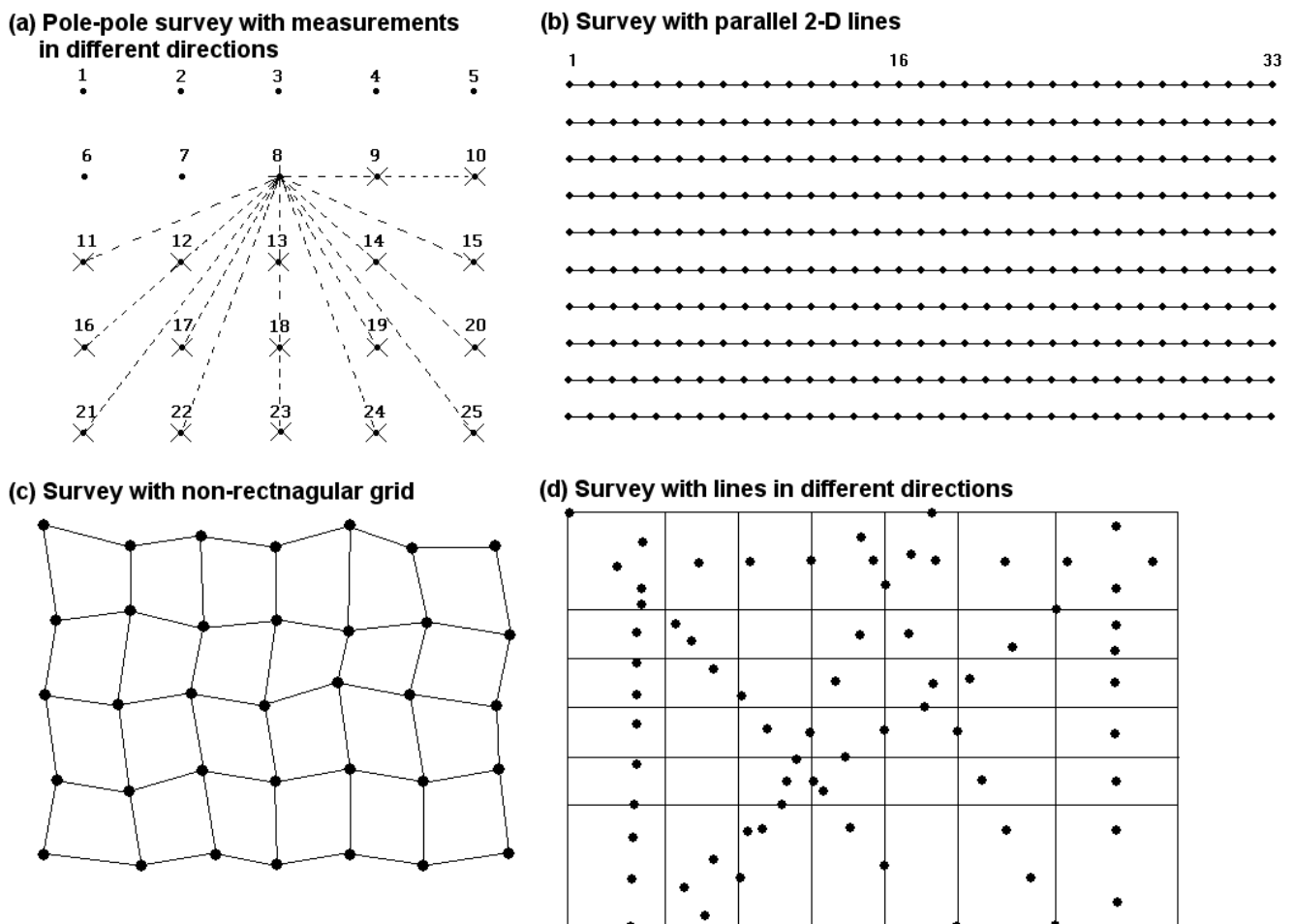

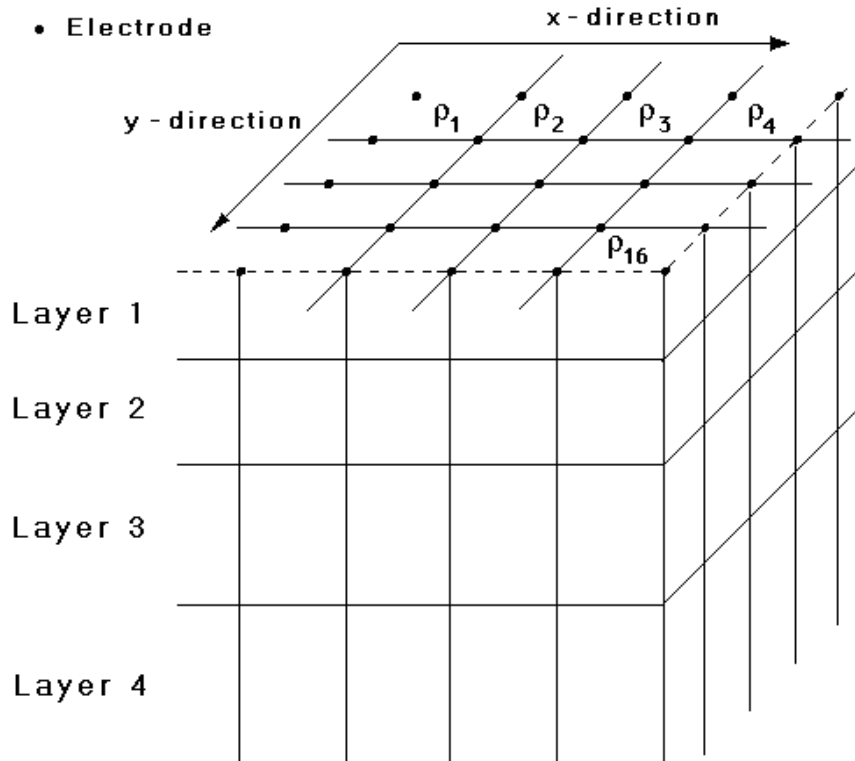Figure 1. Some possible layouts for 3-D surveys.

Figure 2. A simple discretization model used in the inversion program with electrodes at the surface corners of each block in the top layer.

2   Computer system requirements

RES3DINVx64 is a 64-bit program that will run under a 64-bit version of Windows XP/Vista/7/8/10. You will need a microcomputer with a multi-core CPU to run this program. It is recommended that you use a PC with an Intel (rather than an AMD) CPU as the RES3DINVx64 program has options that are optimized for this type of CPU. These options can significantly reduce the calculation time for large data sets.

The RES3DINVx64 program requires at least 4 GB RAM. You will also need at least 32 GB of free hard-disk space that the program can use to store temporary swap files. If you have more than one hard-disk drive, the program will automatically select the drive with the largest amount of free space as the drive to store the swap files. RES3DINVx64 Basic can access up to 8 GB RAM, while the Professional version can use up to 192 GB RAM. The more RAM and free hard-disk space you have, the larger the data set that you can process with this program. For computer systems with more than 12 CPU cores, the remaining bottleneck is probably the speed of the hard-disk which the program uses to store temporary files. The time taken to write and read the temporary files can be significantly reduced by using a Solid Sate Drive (SSD). The amount of free hard-disk space should be at least 8 times the RAM.

There should not be any background programs running (such as word processors, CAD programs, etc.) when executing the RES3DINV program. Please shut down other programs to free the memory for this program. This will reduce memory to hard-disk swapping that slows down the program. In Windows XP/Vista/7/8/10, the active programs are usually listed on the Start bar at the bottom of the screen.

On some versions of Windows it might be necessary to configure the program to run as an Administrator so that it is allowed to create temporary files in the hard-disk. This can be done by right-click the program icon on the Windows desktop and select the 'Run as Administrator' label. This program attempts to make full use of the computer CPU and hard-disk storage when processing a large data set. It is designed for standalone PCs, and it is recommended that it should not be used with a PC in a network (used as a network server) when carrying out the inversion of a very large data set with more than100,000 data points or model cells. We cannot guarantee that it will run smoothly on such network PCs for the inversion of very large data sets and models. Also, it should not with PCs having a dual operating system such as Windows and Linux.

3   Copy protection

The program uses the Aarhus Geosoftware Internet based digital copy protections system for copy protection. Without the digital license, you can use the program to invert data sets with up to 200 electrodes (with a limit of 4 iterations in the inversion routine). With a license that has the RES3DINVx64 software license, the restrictions are removed. When the program is launched for the first time the user is prompted to supply a license

code supplied by the company when you purchased the license. Please refer to the full manual for the Res2dinvx64 program for more details.

4   Software installation

You can download the programs from the www.aarhusgeosoftware.dk website. The RES3DINVx64 package comes in a single compressed installation file SETUP.EXE. It is a Windows-based installation program that will install the program files. The default folder for the program is C:\Program Files (x86)\Geotomo_Software\Res3dinvx64.

5   Using the program – a quick start

After installing the program, just click the RES3DINVx64 icon to start the program. The program will first check the computer system to ensure that it has the necessary resources that is required. It will check for the available memory and hard-disk space. If the program displays a warning, you should quit from the program and make the necessary changes. As an example, below is a typical initial information box displayed by the RES3DINVx64 program.
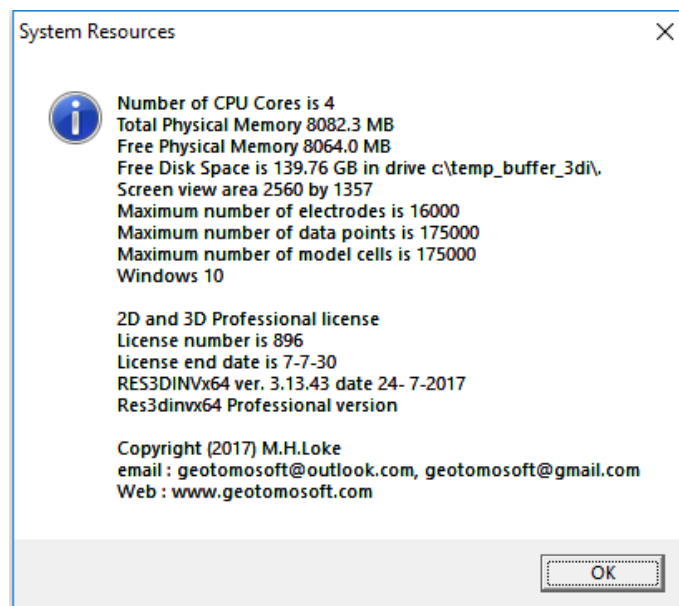

After checking the computer configuration, the program will then display the following Main Menu bar near the top of the screen.
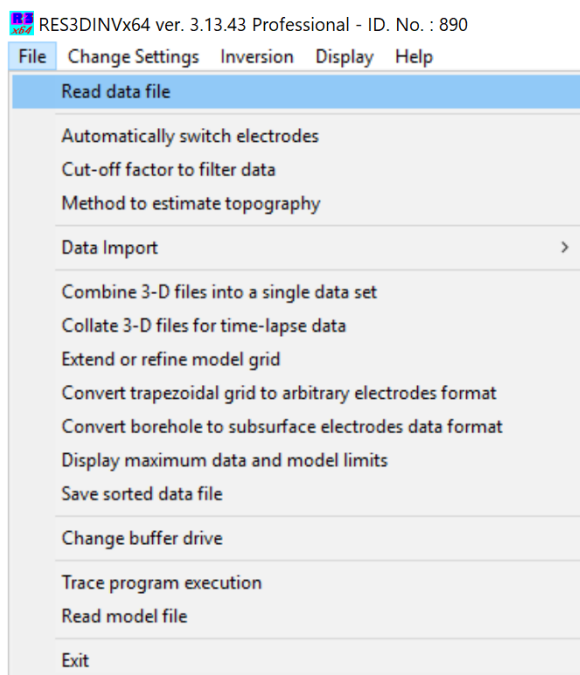
You can select an option by clicking it with the mouse cursor. If this is the first time you are using the program, try reading in one of the smaller files such as ROOTS7.DAT provided with the program. Click the File choice, followed by the "Read data file" menu choice. After that, if necessary, navigate to the folder where the RES3DINV program is installed. After reading in the file, go to the "Inversion" option, and then choose the "Carry out inversion" option. The inversion subroutine will start. Wait for about a minute for the data to be inverted. If you need to stop the inversion routine at any time, just click the 'Next' sub-window at the bottom-right of the screen, and wait for a short while. By default, the program will carry out 6 iterations that can be increased if necessary.

It is assumed that the input data is in the format used by this program. A detailed description of the data format is given in the Res3dinvx64.pdf file. Most multi-electrode resistivity equipment manufacturers supply a program to convert data from the native format used by the equipment to the format used by Res3dinv. The Res2dinvx64 program also has a utility to combine data from different 2-D survey lines into a single 3-D data file.

To display the inversion model, completed, click the "Display" menu option that will bring up the following window.
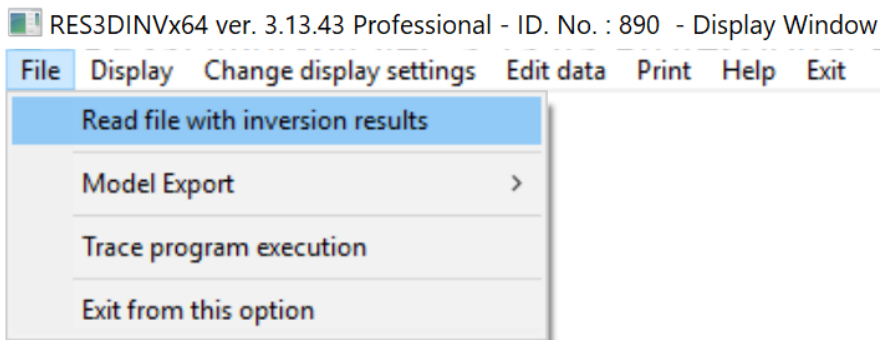
Select the 'Read file with inversion results' to read in the file with an inv extension (such as ROOTS7.inv) that contains the inversion results. Then select the "Display - Display inversion model" sub-option. You will then be asked to select the iteration number, type of model slice (horizontal or vertical) and type of contour intervals. After you have made the appropriate choices, the program will then display the model slices. Figure 3 shows an example of a model displayed in the form of horizontal slices from a landfill survey at Ekeboda, Sweden (Loke and Dahlin 2010).

The program can also export the inversion model values into the formats used by a number of 3-D graphics programs, such as Paraview and Voxler. Figure 4 shows an example of the landfill model displayed by Voxler with topography included.
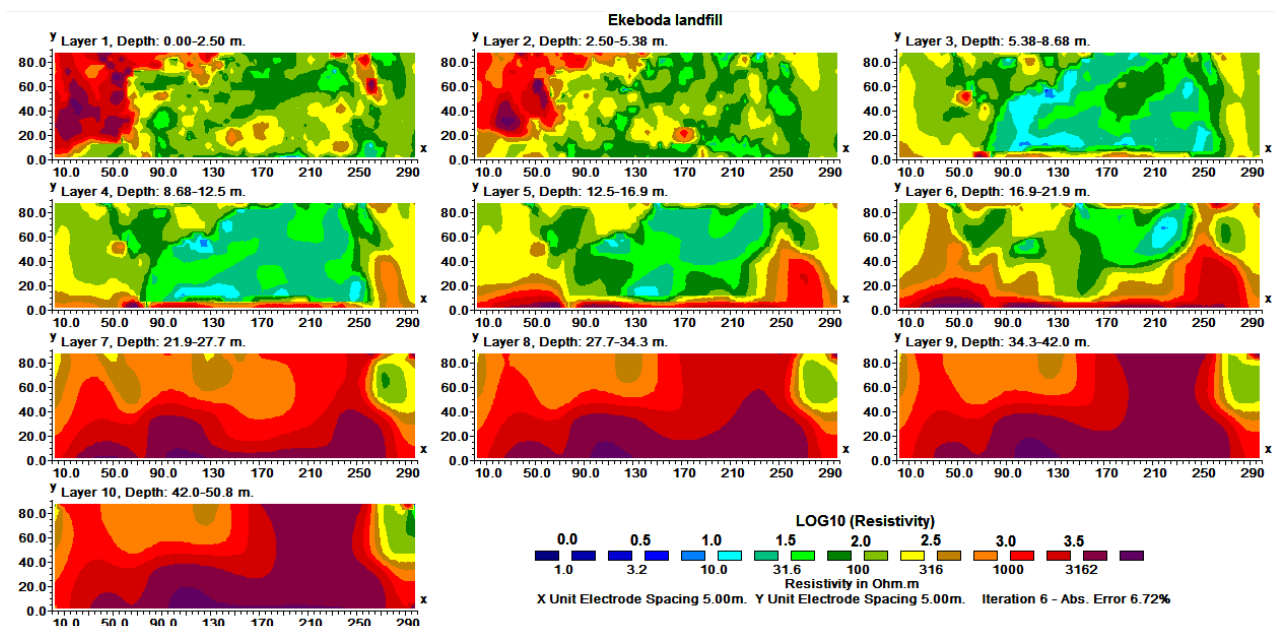

Figure 3. Example inversion model displayed in the form of horizontal slices from the Ekeboda landfill survey.
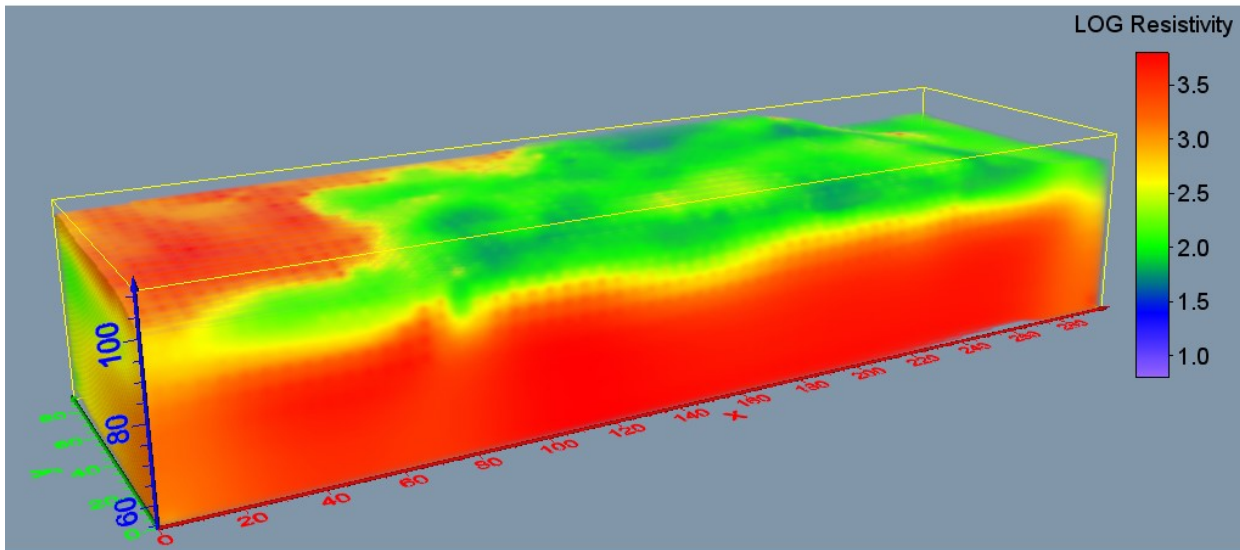
Figure 4. Volume rendered plot for the Ekeboda landfill model with topography included.

6   Differences between RES3DINVx64 Basic and Professional

The version of RES3DINVx64 that the can be used depends on the license that was puchased. The main differences between the two versions are as follows.

1).   Res3dinvx64 Basic is limited to 8 GB RAM memory space while Res3dinvx64 Professional can access up to 192GB RAM.

2).   Only Res3dinvx64 Professional supports 3-D time-lapse inversion. The Basic version does not support this type of data.

3).   Res3dinvx64 Basic is limited to a finite-difference/element mesh model with a maximum of 1.4 million nodes. In Res3dinvx64 the maximum mesh size depends on the computer RAM. With 128GB, it supports up to about 10 million nodes.

RES3DINVx64 Basic is probably sufficient for medium size surveys with up to about a thousand electrode positions. RES3DINVx64 Professional is recommended for more complex survey arrangements (particularly for mineral exploration) with very large surveys grids with several thousand electrode positions and tens of thousands of data points and model cells, or for time-lapse surveys (Loke et al. 2014).

7   Detailed instruction manual

This manual is a very brief guide to help you in installing, and getting started in using the Res3dinv program. The detailed instructions for using the programs are given in electronic form as the Res3dinvx64.pdf file that is copied to the same folder where the program was installed. This manual has detailed instructions on the input data format and on using the different options in the software. When you install the program, a copy of this PDF file will also be copied into the program folder. Online help files are also installed with the program. The latest version of the program, as well as the manual, can be downloaded from the www.geotomosoft.com website.

Disclaimer

This software is provided "as is" without any express or implied warranties including its suitability for a particular purpose. Neither the author nor the subagent will assume responsibility for any damage or loss caused by the use of this program. In the event of program bugs, every effort will be made to correct the bugs and an update program will be provided over the Internet. Registered users are entitled to free software updates and support for the first year. After the first year, there is an annual fee for software updates and technical support. However, the original software version provided and downloaded updates released up to one year after the software purchase can still be used indefinitely if the user chooses not to upgrade. Please refer to the 'Ordering & Enquires' page of the www.geotomosoft.com website (or send an email to geotomo.aus@gmail.com with your license ID number) for the annual fee that is applicable to your software license.

Support

Please contact your distributor if you have any questions concerning this program. A frequent source of queries is when the results obtained are not what you expect, or the program refuses to accept your data file. In such a case, support will only be provided if a copy of the data file is sent together as an attachment with your email, preferably compressed into a ZIP file. The most common causes of problems are (a) the data in the DAT file is not given in the correct RES3DINV format, (b) excessive noise in the data set (particularly for dipole-dipole surveys and/or I.P. data sets), and (c) instrument malfunction or field survey errors. It is only possible to trace the source of the problem if a copy of the data file is provided. Please note that support is only available for registered users of the full version of the program. Technical support is not provided for users of the demo version of this software. For technical support, you can contact the software provider at the following email addresses.

geotomosoft@gmail.com, support@geotomosoft.com, geotomosoft@outlook.com

The following information will be required for technical support.

1. Your license ID number. This ID number is displayed near the middle of the initial information box when the RES3DINVx64 program starts up if a license was purchased and installed on the computer.

2. The name of your company or institution.

3. Approximate date (month/year) your company or institution purchased the software.

If you purchased the software more than one year ago, please refer to the 'Ordering & Enquires' page of the www.geotomosoft.com website on renewing the support.

References

Chambers , J.E., Kuras, O., Meldrum, P.I., Ogilvy, R.O. and Hollands, J., 2006. Electrical resistivity tomography applied to geologic, hydrogeologic, and engineering investigations at a former waste-disposal site. Geophysics, **71**, B231-B239.

deGroot-Hedlin C. and Constable S.C. 1990. Occam's inversion to generate smooth, two-dimensional models from magnetotelluric data. Geophysics, **55**, 1613-1624.

Kenma, A., Binley, A., Ramirez, A. and Daily, W., 2000. Complex resistivity tomography for environmental applications. Chemical Engineering Journal, 77, 11-18.

Li, Y. and Oldenburg D.W., 1992. Approximate inverse mappings in DC resistivity problems. Geophysical Journal International, **109**, 343-362.

Loke, M.H., 2000. Topographic modelling in resistivity imaging inversion. 62nd EAGE Conference & Technical Exhibition Extended Abstracts, D-2.

Loke, M.H., Dahlin, T., Rucker, D.F., 2014. Smoothness-constrained time-lapse inversion of data from 3-D resistivity surveys. Near Surface Geophysics, **12**, 5-24.

Loke, M.H., 2016. Tutorial : 2-D and 3-D electrical imaging surveys. (available for download from www.geotomosoft.com).

Loke, M.H., Acworth, I. and Dahlin, T., 2003. A comparison of smooth and blocky inversion methods in 2D electrical imaging surveys. Exploration Geophysics, **34**, 182-187.

Loke, M.H. and Dahlin, T., 2010. Methods to Reduce Banding Effects in 3-D Resistivity Inversion. Near Surface 2010 – 16th European Meeting of Environmental and Engineering Geophysics 6 - 8 September 2010, Zurich, Switzerland, A16.