HzEMSoft

A program for 2D interpretation of EMFAD data

Version-4.3

This Software is produced by EMTOMO LDA

Email: emtomog@gmail.com

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CONTENTS

DISCLAIMER

The programs (software) included in any version of the **HZEMSOFT** packed are provided “as are” without any express or implicit warranties including their suitability for a particular purpose. The author, EMTOMO LDA and REFLEXOS UNIP will not assume any responsibility for any indirect or consequential damages, or any loss caused by the use of these programs. Efforts will be made to correct any program bug that appears during the usage of the package.

Introduction

EMFAD systems (built by EMFAD-Geophysical Environmental Engineering) are used to locate conductive materials (pipes, barrels, cables etc) or resistive (cavities, graves etc) materials. It can also be used in geological and geophysical studies. **HZEMSOFT** software was developed by **EMTOMO** to help in the interpretation of EMFAD data. The interpretation of data collected over pipes, cables, and cavities, using simple models (SBM) is explained in another manual. The objective of this manual is to explain the use of **HzEMSOFT** to interpret data using 2D modelling and inversion. This approach can be useful in geological and environmental studies.

It is assumed that the user is familiar with the first manual.

How to use HZEMSOFT

When interpreting field data using 2D models, the main steps are:

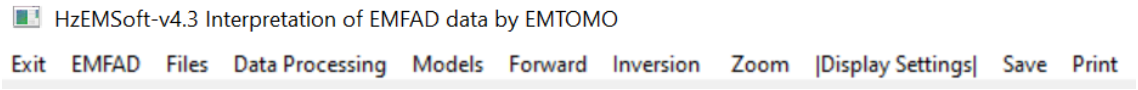
- Choose the EMFAD model you used to collect the data.
- Import the data file (ESD files).
- Select a profile for interpretation.
- Process the data (filter, frequency selection).
- Create an initial model (simple body or 2D) for inversion.
- Define inversion parameters.
- Make the inversion.
- Analyse inversion results.
- Save and print results.
- Save project file.

See the first manual about file input. Interpretation using simple body models (SBM) is made profile by profile. 2D inversion can be made for all profiles after defining the initial model and inversion parameters for the first profile.

Note: The new EMFAD instrument (EMFAD-UG12/XZ) collect Hz and Hx components of the VLF magnetic field, however, only Hz component can be interpreted using 2D models.

Menu operation bar

The main operations (read files, processing data, display, save and print results) are available through the menu bar. Please, see details on the first manual. The buttons on the left of the main windows allows an easier access to some functions (display of results).




Display survey


Display selected profile


Display map (data)


Display filtered profile


Decimated data


Display model (SBM)


Display 2D model


Display data and model response


Zoom In

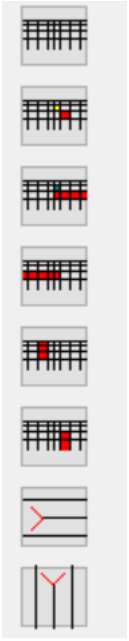

Zoom out

Colour scale


Undo


Update data base


Quit program



Display 2D mesh

Change resistivity of one cell

Change resistivity of right cells

Change resistivity of left cells

Change resistivity of upward cells

Change resistivity of downward cells

Add row to the mesh

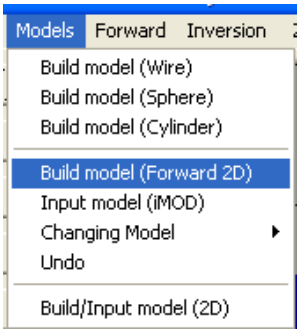
Add column to the mesh

Data Interpretation

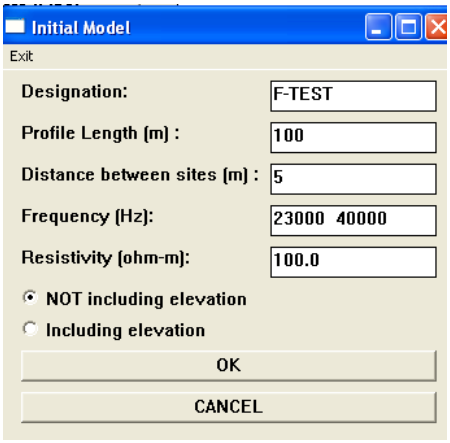
Interpretation of EMFAD data collected over complex geology is very difficult. Data collected over simple targets like wires, pipelines or simple geology like faults is possible. With HZEMSOFT the user can study the answer of complex geology (or simple targets) using the modelling (forward) section based in 2D finite elements approach. 2D inversion is also possible.

1- Modelling by 2D forward calculations

HZEMSOFT allows the calculation of EMFAD response of simple or more complex structures that can be designed in a regular mesh. This tool can be used for different objectives: i) design of a survey, ii) understand the response of EMFAD at specific bodies or geology, iii) perform sensitivity tests or, iv) rough interpretation of experimental data by trial-and-error.
In any case the first step in this process is the definition of the mesh to build a model.



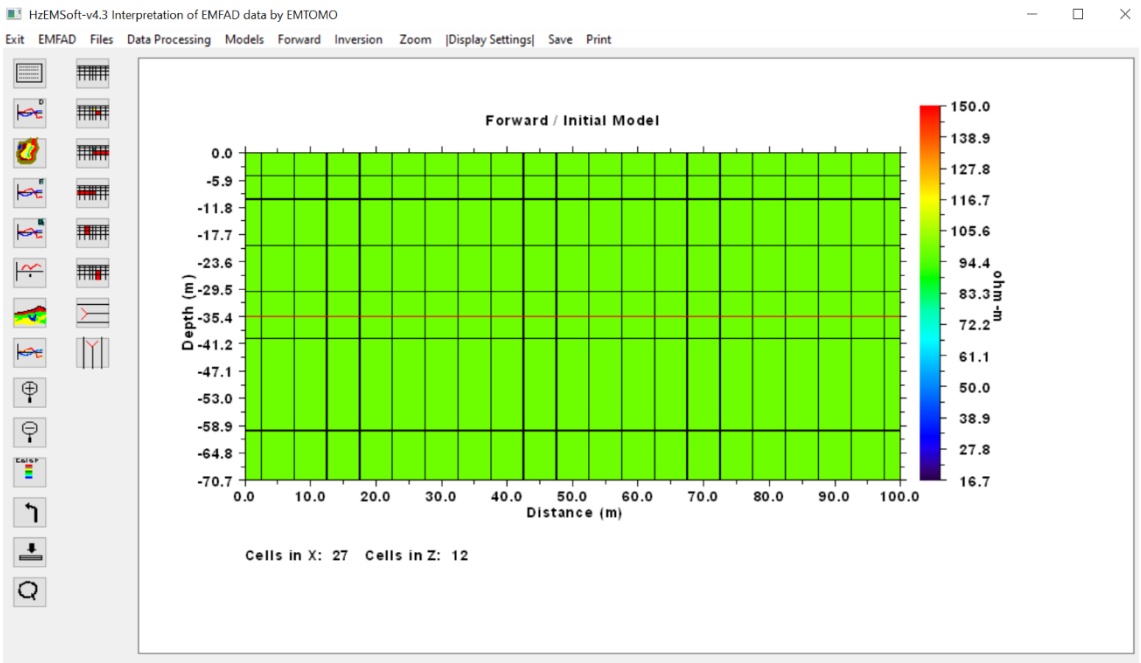
Clicking in this option, the menu that allows the setup of the model will open:



Setup of a model for forward calculations.

The frequencies are separated by space. By default, the topography (elevation) is not included in the model. However, it can be considered, importing a file with the appropriated values (see Format section).

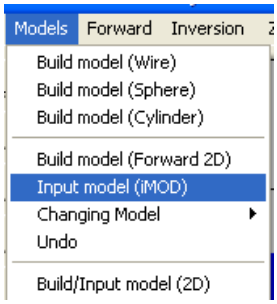
The model can be viewed by clicking in the "Plot Init/Forw.Model(2D)" action button. The red and magenta lines represent the skin depth considering the highest and lowest frequencies and the environmental resistivity. The vertical and horizontal lines make a mesh of rectangular blocks (cells) that can be used to build bodies of different resistivity, simulating geological structures. The user can then calculate the response of such "conceptual" earth.



Displaying the initial model.

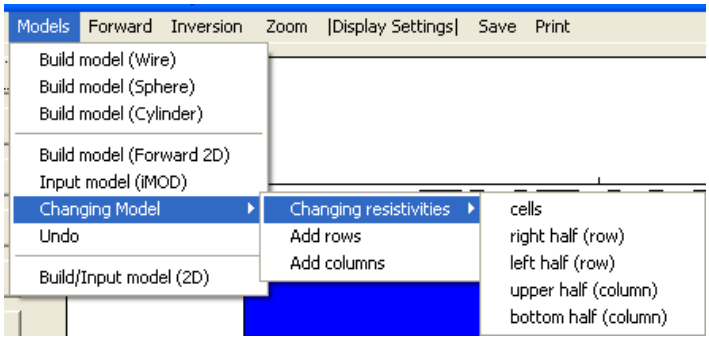
NOTE: In the models (inversion or forward), the elevation is always referred to its minimum value. However, the correct elevation (altitude) will be displayed in the figures of the final model.

NOTE: models from 2D modelling and saved in the format iMOD can be read and modified to perform forward calculation.



Changing model

This entrance allows to build/change the initial model. It is possible to change the resistivity of blocks and the number of blocks adding new rows and columns to the model.



Menu for changing the model.

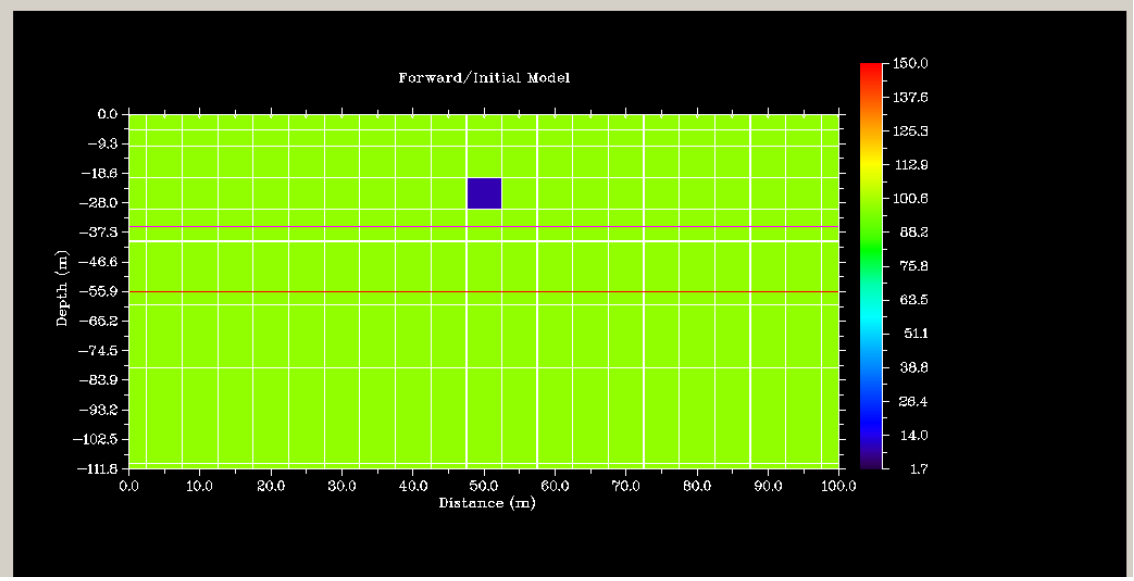
Clicking in “Changing resistivities” a new menu open with several options that allows you to change the resistivity value of individual cells; to change the resistivity of a group of cells in the same row and localized on right or left of a selected cell or the resistivity of the cells localized in a column upper or down of a selected sell. Selecting one option will open a menu and answering yes, the mouse cursor will change to a cross (+). Select the cells you want to have the same resistivity, clicking with the left mouse button. Stop the selection by clicking with the right button. Type the wanted resistivity. The process can continue or not. Use the action button (plot initial model) to see the new model. A similar procedure is used to add row or columns to the model.

NOTE: When adding columns or rows do not cut a block (cell) more than once. If you want to have a fine mesh, repeat the procedure for every cell you want to divide.

NOTE: Accuracy of the calculations depends on the mesh. However, computational effort greatly depends on the number of cells, too. Therefore, do not increase the number of cells unnecessarily. A good balance between accuracy and computational time should be the target.

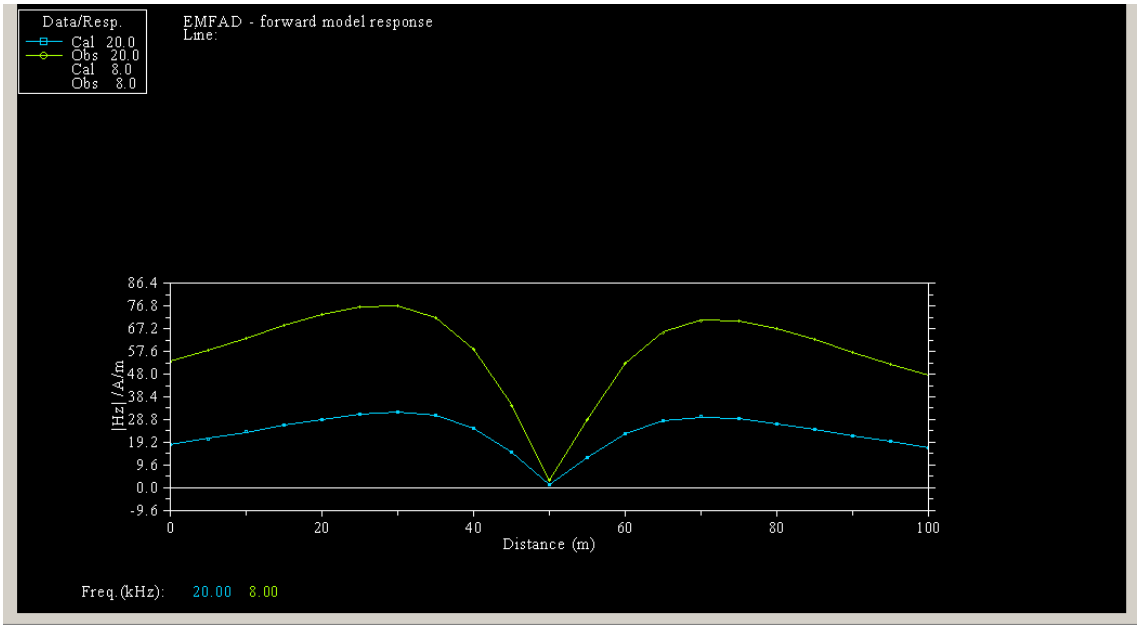
NOTE: The undo option allows you to reverse the last modification.

The figure below shows a modified initial model prepared for forward calculations.



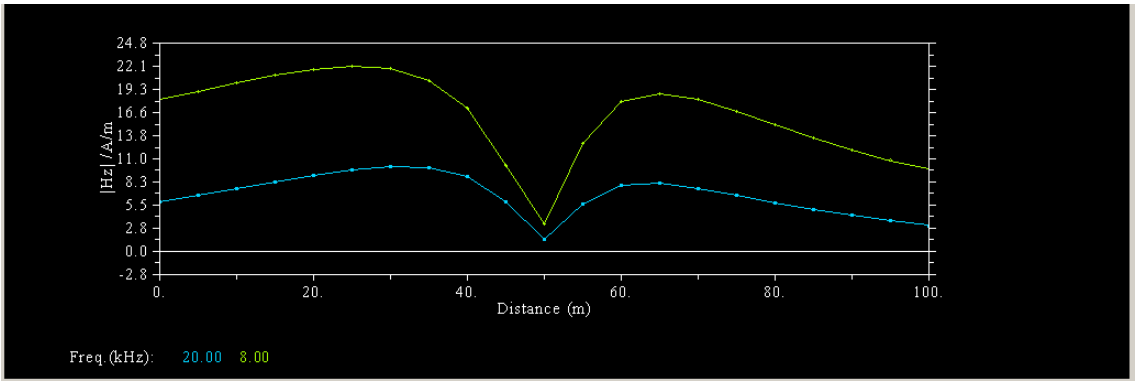
Example of a model with one anomalous body of 10 ohm-m in a 100 ohm-m environment.

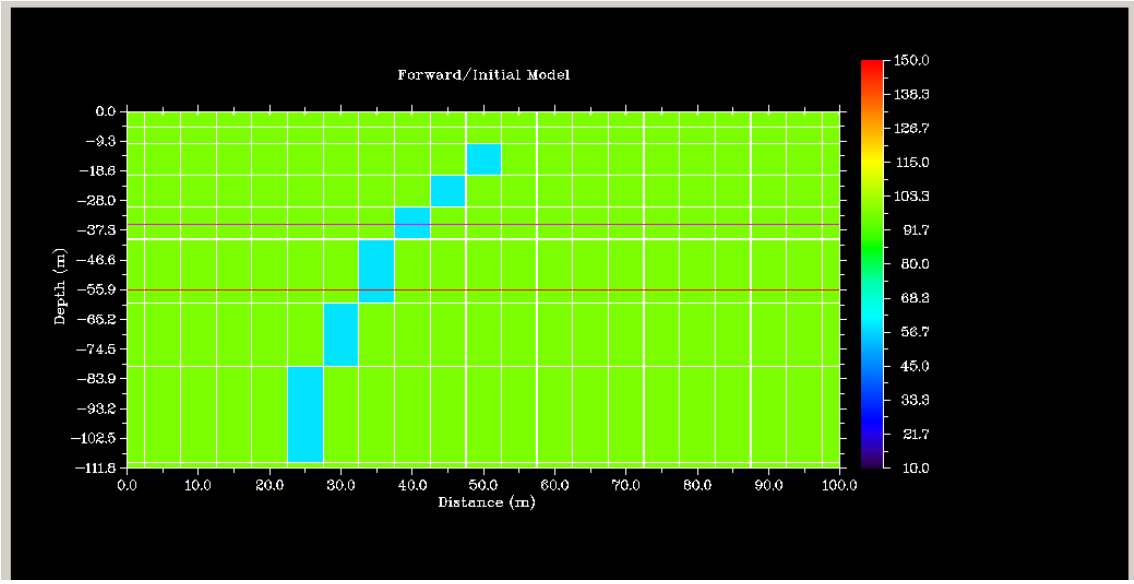
To calculate the response of the model goes to Forward in the menu bar.



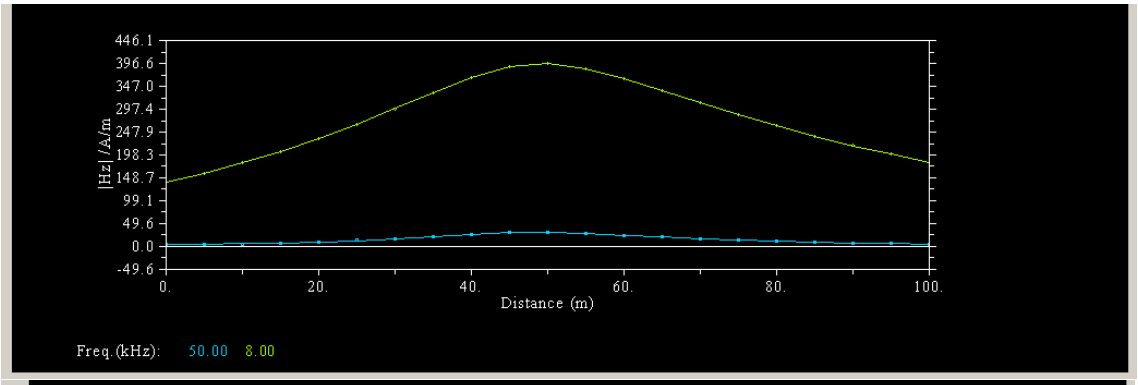
Response of the model shown in the previous figure for frequencies of 20 and 8 kHz. Note the symmetry of the response.

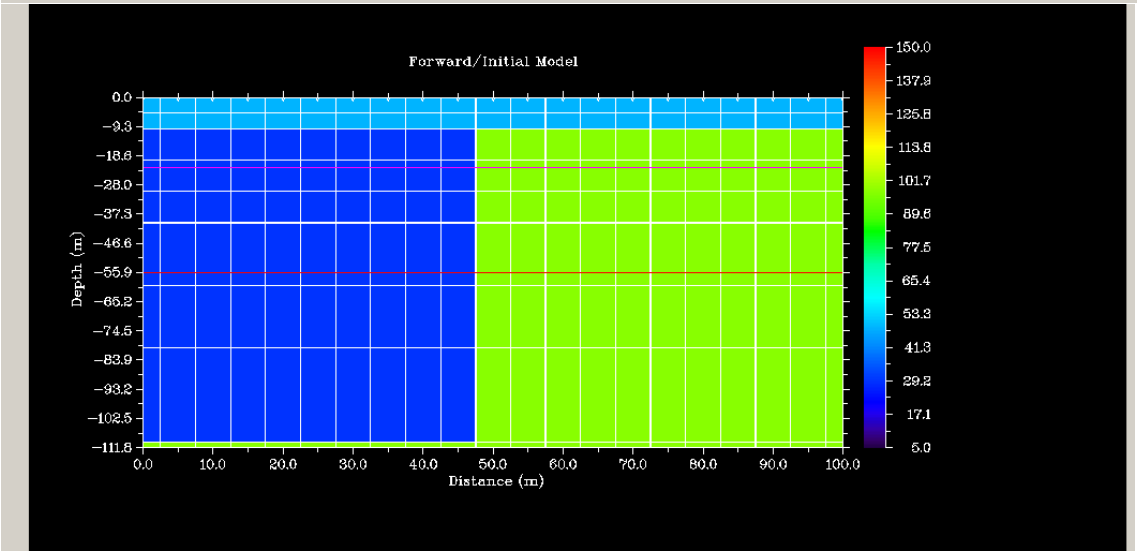
Figures below show the response and the respective model that can be representative of a dipping sheet. Note the asymmetry on the response for the lowest frequency.



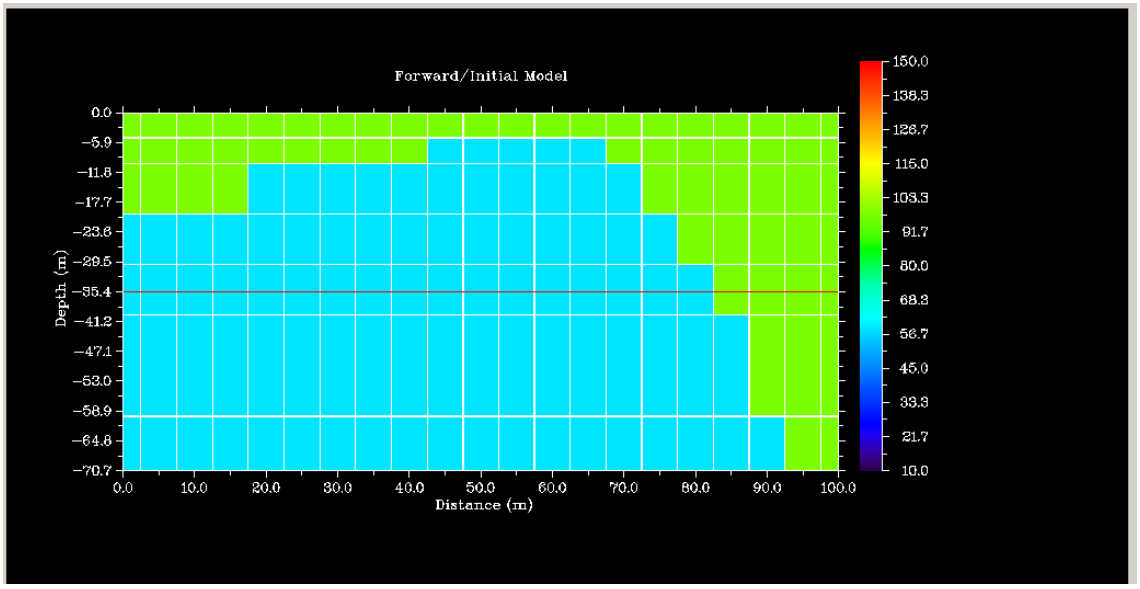


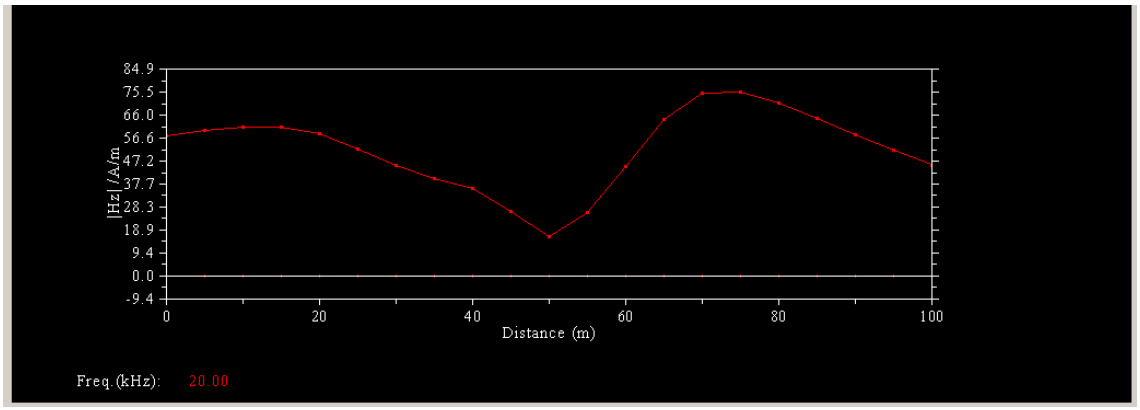
The following figures are the response and model of a contact between two media with different resistivity covered by an overburden.





The model shown in the next figure is different from the previous one mainly because the limits of the conductive body are not "smooth". The response of the model shows the "consequence" of such features.



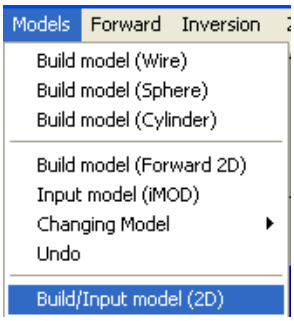


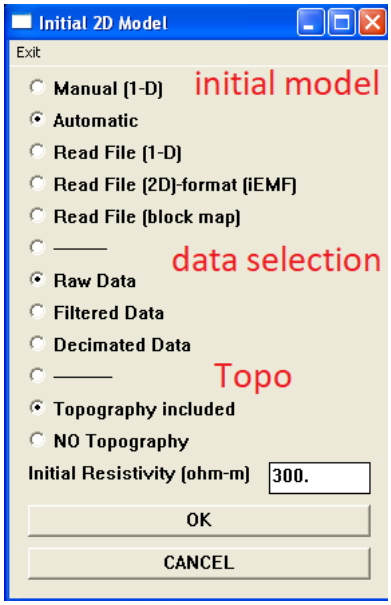
2- 2D Inversion

HZEMSOFT performs 2D inversion over the converted amplitude of the vertical magnetic component (in microA/m) data. The fundamentals of 2D inversion can be found in Sasaki (1989, 1994) for example.

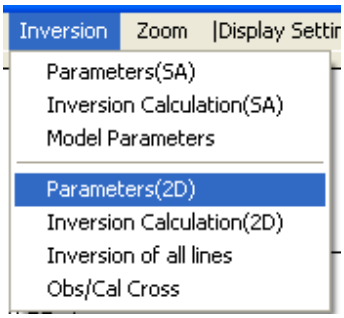
HZEMSOFT has two different algorithms for 2D inversion based on the Occam method. To perform a 2D inversion do as follows:

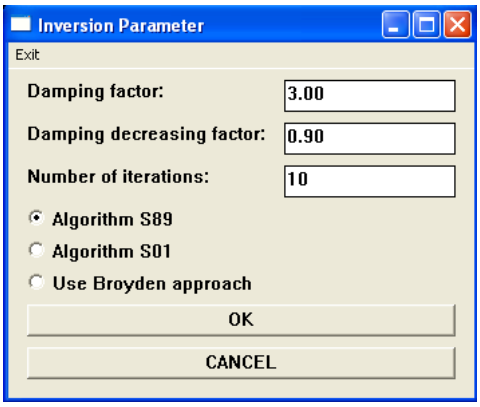
i) select the frequencies to be inverted (usually 2 or 3),
ii) define a reasonable resistivity value for initial model,



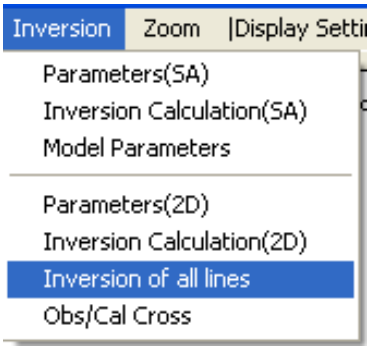


iii) perform the inversion after defining the number of iterations and the damping factor (Inversion parameters). By default, the program uses full derivatives calculations. To speed the calculations Broyden approach can be select. The precision is inferior, and a grater of iteration must be used (between 20-30).





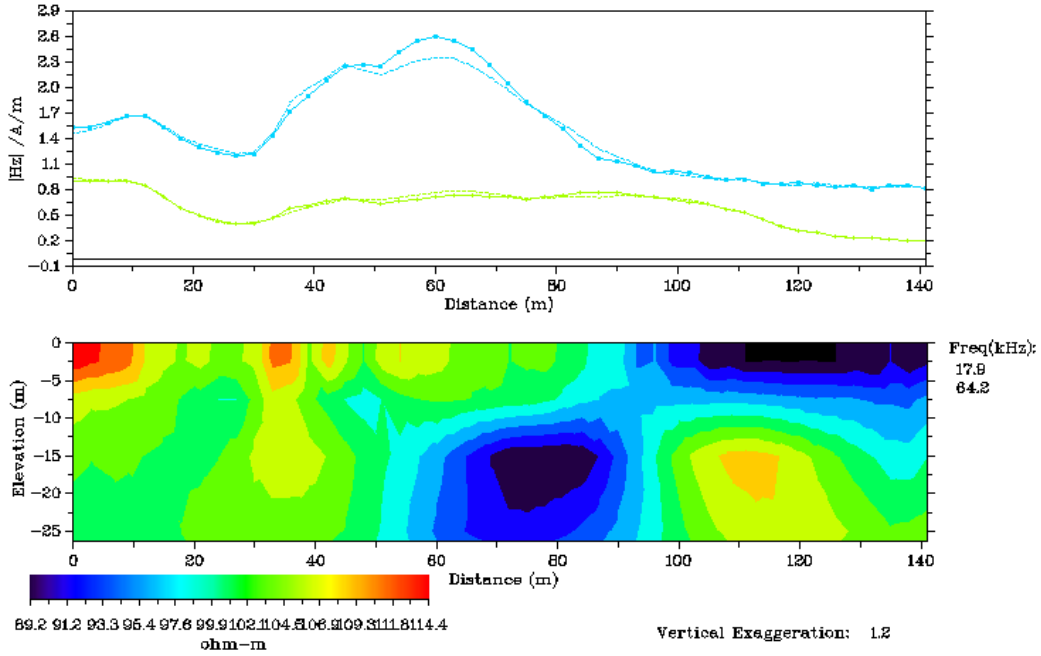
iv) the inversion of all lines in the survey is possible (using the same inversion parameters). The results can be recovered reading the respective INV files, which were saved in the folder /inverse.



The most important inversion parameter is the damping factor. Its value depends on several factors, namely, data quality and frequencies. In general, a value around 3.0 is adequate. However, the user must try different values in the range of 0.07 to 10.0 to choose the best model. As a rule, the damping factor should increase if a previous value does not reach convergence. Normally, for higher values of damping factor a higher number of iterations should be used (20 – 30).

NOTE: Although data from antennas A and B are read in ESD file, only data from antenna A will be inverted.

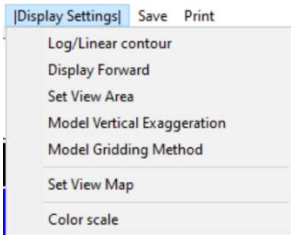
NOTE: There is a limit on number of data that can be inverted: it is about 400 values for all frequencies that will be inverted. If the number of data is larger than that value considers: i) to decimate the data, ii) use less frequencies or iii) split the line into two or more sections.



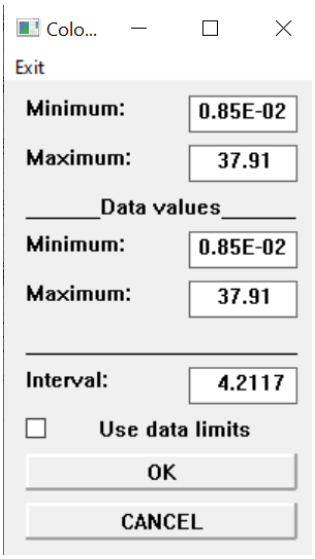
Example of a 2D inversion of data for 2 frequencies (17.9 and 64.2 kHz).

Display Settings

Display Settings in the menu bar allows the user to modify some aspects of the displays.



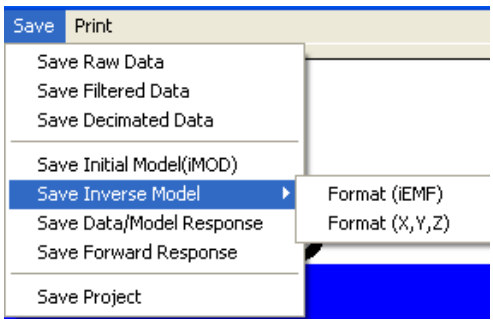
Available options to display data.



Options for colour scale.

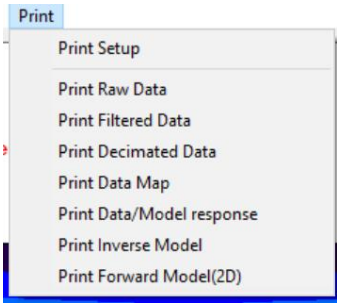
Save and Print

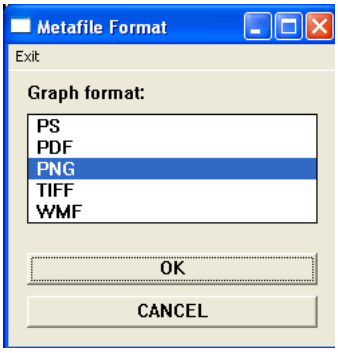
Results can be saved in ASCII files for records or to be used in other programs.



With Save Project all data and the last processing and results will be saved in a PRJ file. This file can be open using the appropriated option in the menu Files.

Results can also be “print” in figures using different formats.





Choosing the type of file for print.

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