EM4Soil
Quick Start

A program for 1-D laterally constrained inversion of EM data

Version-1.01

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February 2012

DISCLAIMER

The programs (software) included in any version of the **EM4Soil** packed are provided "as are" without any express or implicit warranties including their suitability for a particular purpose. The authors will not assume any responsibility for any damage or 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.

1. Introduction

EM4SOIL is a software package that has been developed in order to enable the inversion of electromagnetic (EM) induction data acquired at low induction numbers (LIN). The input data for **EM4SOIL** is the measured apparent soil electrical conductivity (σ_a) as measured by EM instruments. The output data includes but is not limited to estimates of the true electrical conductivity (σ).

The following **Quick Start** guide is intended to provide the first time user with an overview of the basic σ_a data input requirements, σ_a plotting and filtering options, inversion modelling, σ plotting and saving of the inversion output files.

In order to assist the user we have provided a set of DUALEM-421 data (i.e. D421Line0.txt). We use this data to demonstrate σ_a data input, σ_a plotting and filtering, inversion modelling, σ plotting and saving of the inversion output files. We do not go into all the functionalities of EM4soil.

Nevertheless, we have provided the this **Quick Start** guide bearing in mind the simplest instructions that would be required to provide results which could be shown in a written report or in a scientific research manuscript. The first time user should use this **Quick Start** guide as a template of how to achieve these results.

STEP 1. Preparing the σ_a data

All the input files required by **EM4soil** are **ASCII** files. For our Quick Start Guide set of **DUALEM-421** σ_a data the file is set up as follows:

Name of line
N h
X Y Z HCP1m PRP1m HCP2m PRP2m HCP4m PRP4m Lat Lon Time

N is the number of σ_a sites (i.e. 41);
h is the height of the sensor in m (i.e. 0.3);
X, Y and Z are the coordinates in Easting and Northing and elevation (m), respectively;
HCP and PRP are the measured σ_a at site; and,
Lat and Lon are the Latitude and the Longitude in decimal degrees and Time is the time in any format not exceeding 14 characters. I this data does not exist columns still need to be added with 0 values assigned and as indicated.
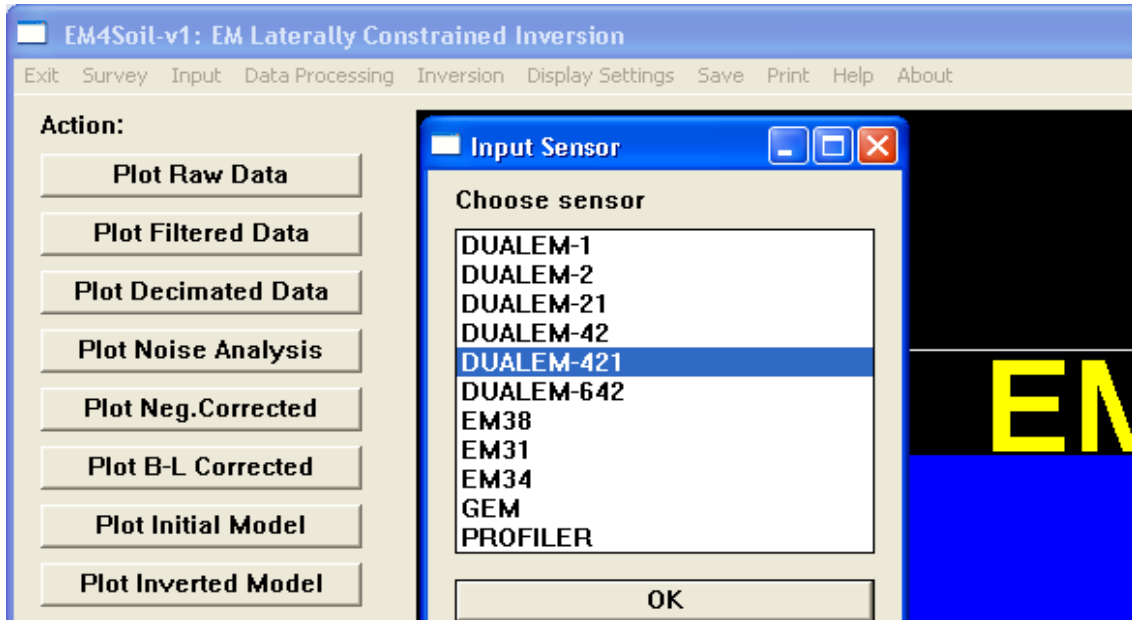
NOTE In our example **DUALEM-421** σ_a data file the data is tab delimited but comma delimited files can also be used.

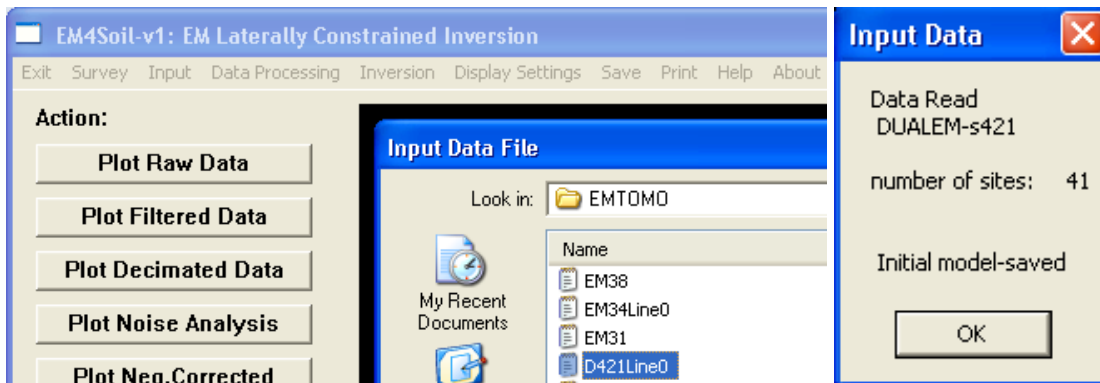**STEP 2. Inputting the σ_a data into EM4soil**

To enter the data into **EM4soil** start the software.

Go to the **Input** menu option and select the **Input Sensors** option.

The **Input Sensor** pop-up box will appear and the DUALEM-421 sensor is selected by default. Press the **OK** button.

Select the **Input** menu option again and this time select the **Input Data** option.

The **Input Data File** pop-up box will appear. Select the D421Line0 data file. Press the **Open** button. **NOTE:** Ensure that the data file is denoted with a .txt.
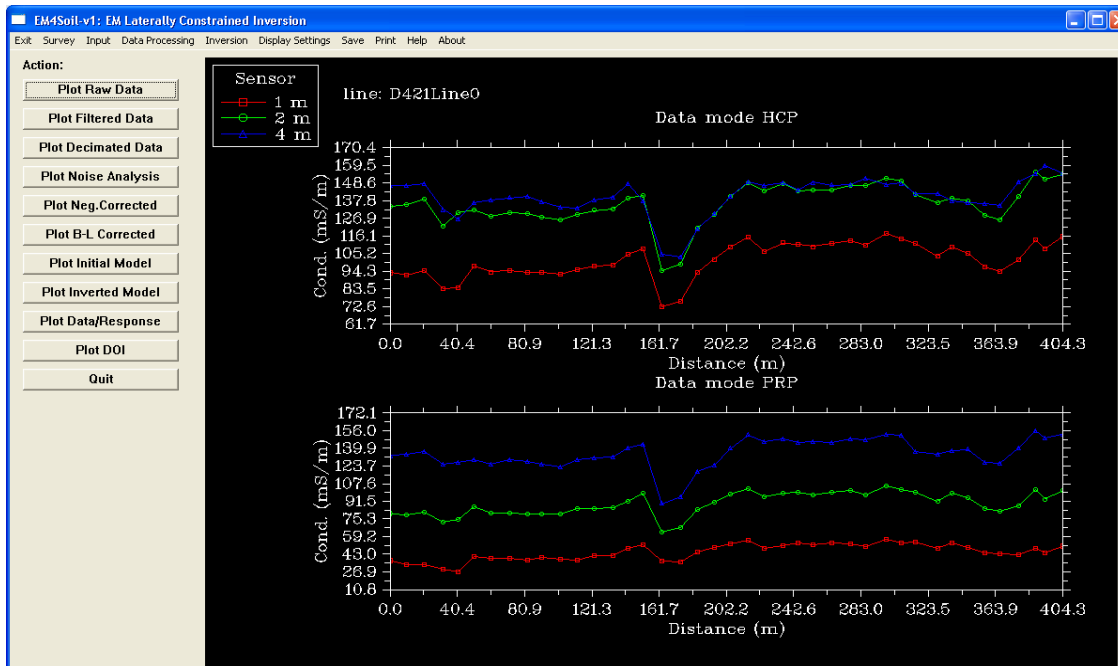
The **Input Data** pop-up box will appear indicating that the DUALEM-421 σ_a data containing 41 σ_a sites has been read successfully.

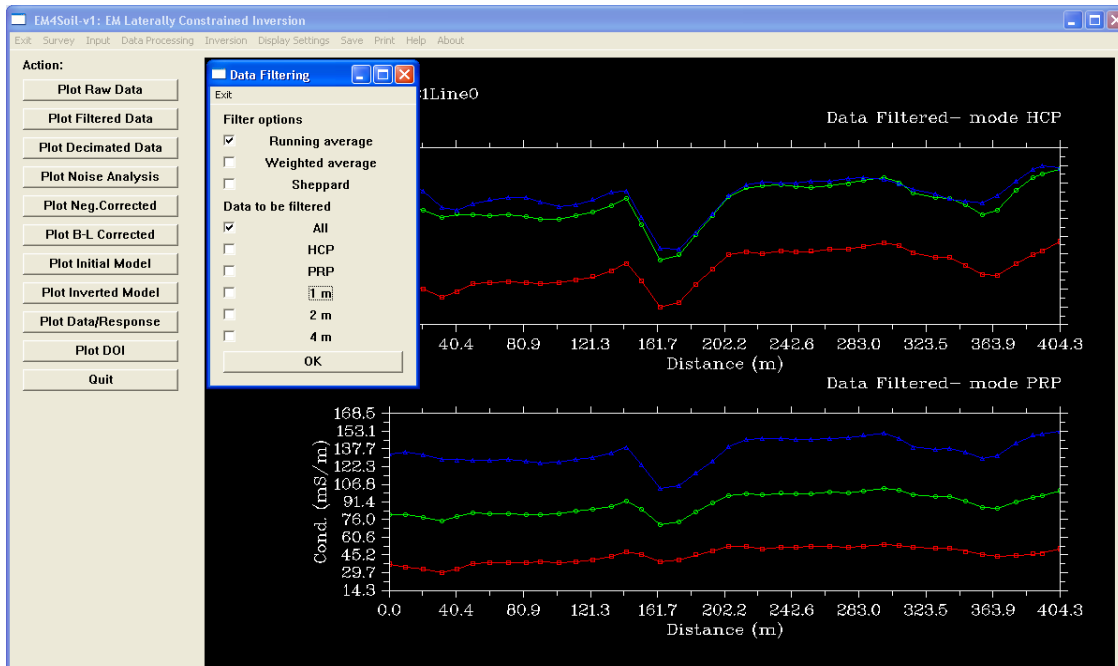An initial model has also been saved automatically. Press **OK**.

STEP 3. Plotting the σ_a data

To plot data in **EM4soil** select the **Plot Raw Data** action button on the left hand side.

STEP 4. Filtering the σ_a data

To filter data in **EM4soil** use the **Data Processing** menu and select the **Data Filtering** option.

The **Data Filtering** pop-up box will appear indicating that the DUALEM-421 σ_a data has been filtered. Press **OK**. To plot filtered data in **EM4soil** select the **Plot Filtered Data** action button on the left hand side.

**STEP 5. Decimating the σ_a data**

To decimate the data in **EM4soil** use the **Data Processing** menu and select the **Data Decimation** option.
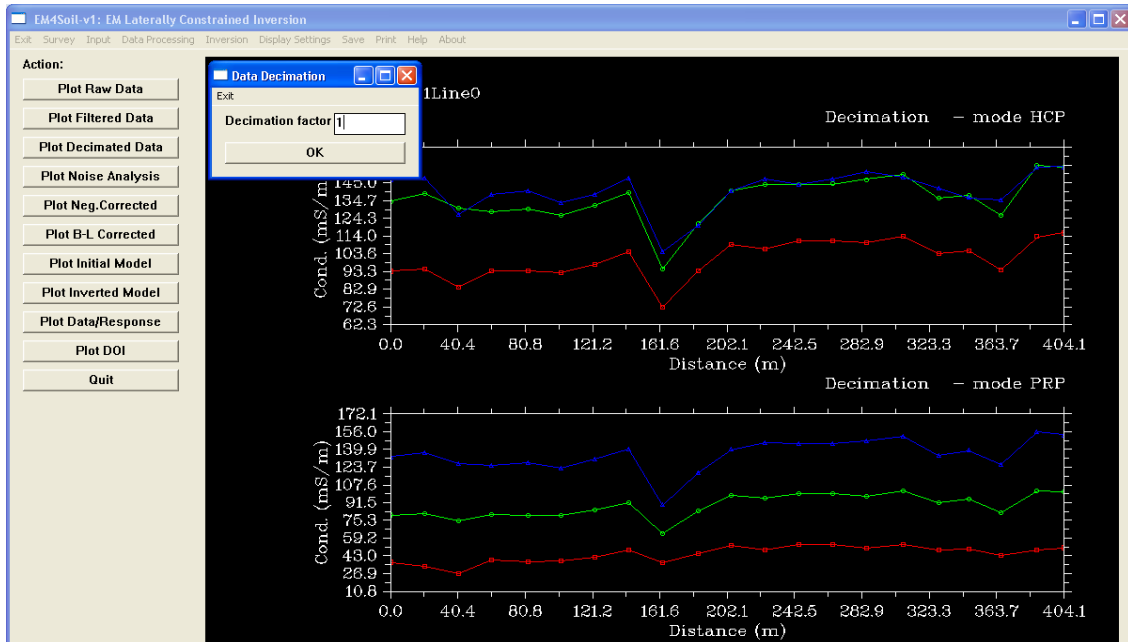
The **Data Decimation** pop-up box will appear. Enter a value of 1 (to halve the raw data), 2, etc. Press **OK**. To plot decimated data in **EM4soil** select the **Plot Decimated Data** action button on the left hand side.

STEP 6. Noise Analysis of the σ_a data

To conduct a noise analysis use the **Data Processing** menu and select **Noise Analysis** option. To plot analysis results select **Plot Noise Analysis** action button on left hand side. This analysis may be used to determine if data requires editing or other correcting.
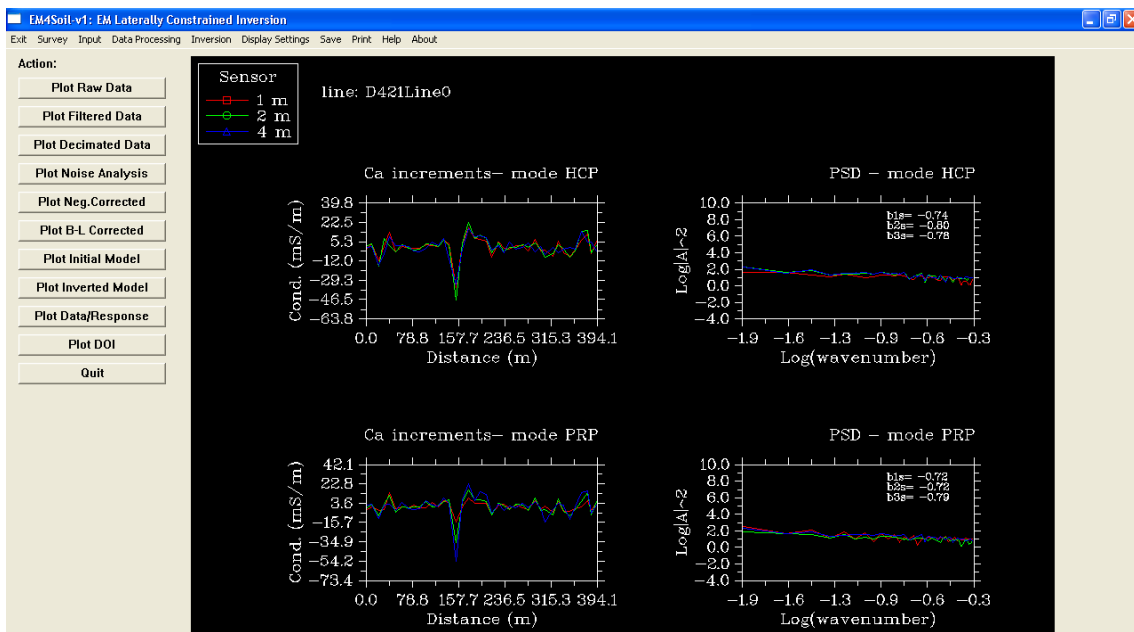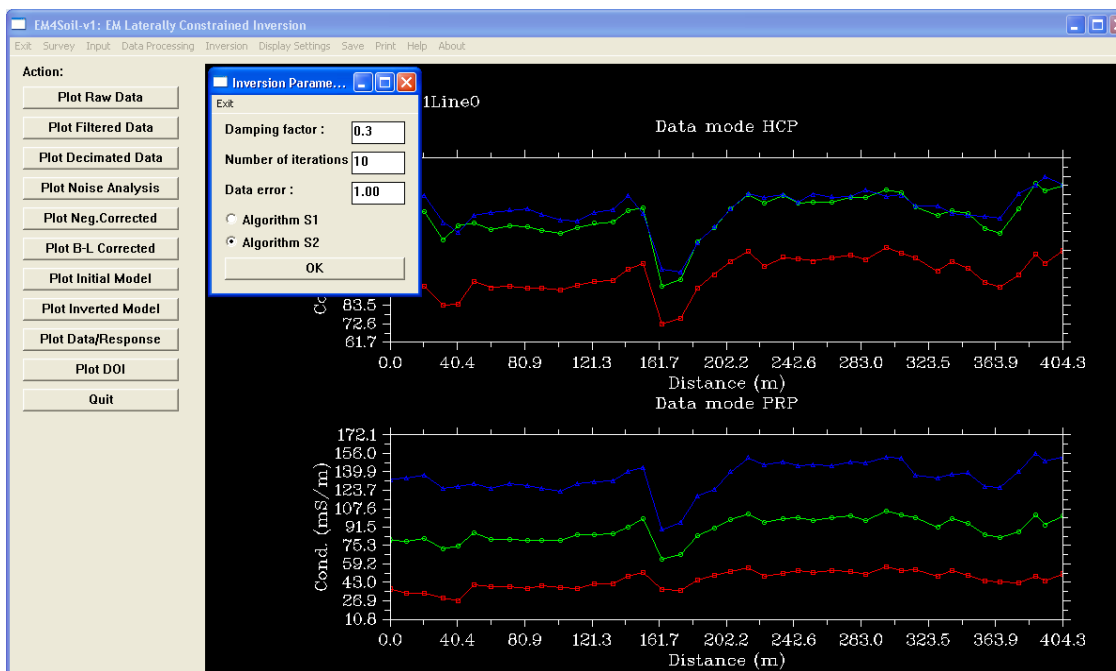
**STEP 7. Inverting the σ_a data**

To prepare the data for inversion use the **Inversion** menu and first select the **Inversion Parameters** option.

The **Inversion Parameters** pop-up box will appear. Enter a value of 0.3 to 30. The number of iterations is set to 10 by default but this along with the choice of algorithm and damping factor should be determined empirically. Press **OK**.

The **Inversion Parameters** pop-up box will appear. Enter a value of 0.3 to 30. The number of iterations is set to 10 by default but this along with the choice of algorithm and damping factor should be determined empirically. Press **OK**.

To actually invert the data re-use the **Inversion** menu and now select the **Inversion Q2D** option. There are two options. **Inversion Calculation (CF)** uses a linear algorithm and is suitable for σ_a data that is generally below 100 mS/m. **Inversion Calculation (FS)** uses the so-called full-solution algorithm and is suitable for σ_a data that is over more conductive terrain and can exceed 100 mS/m.
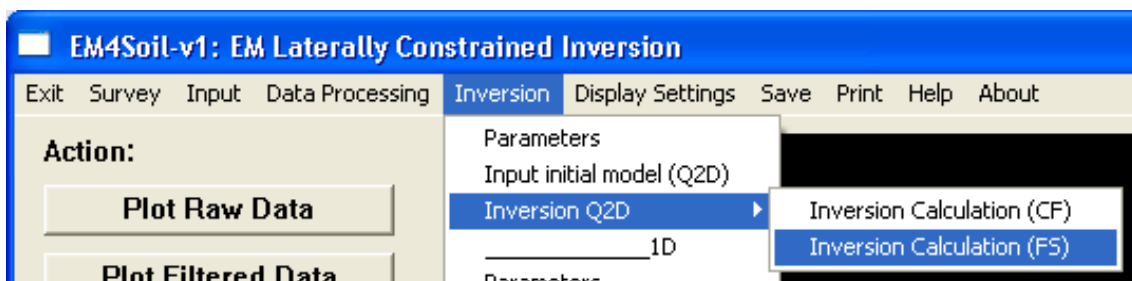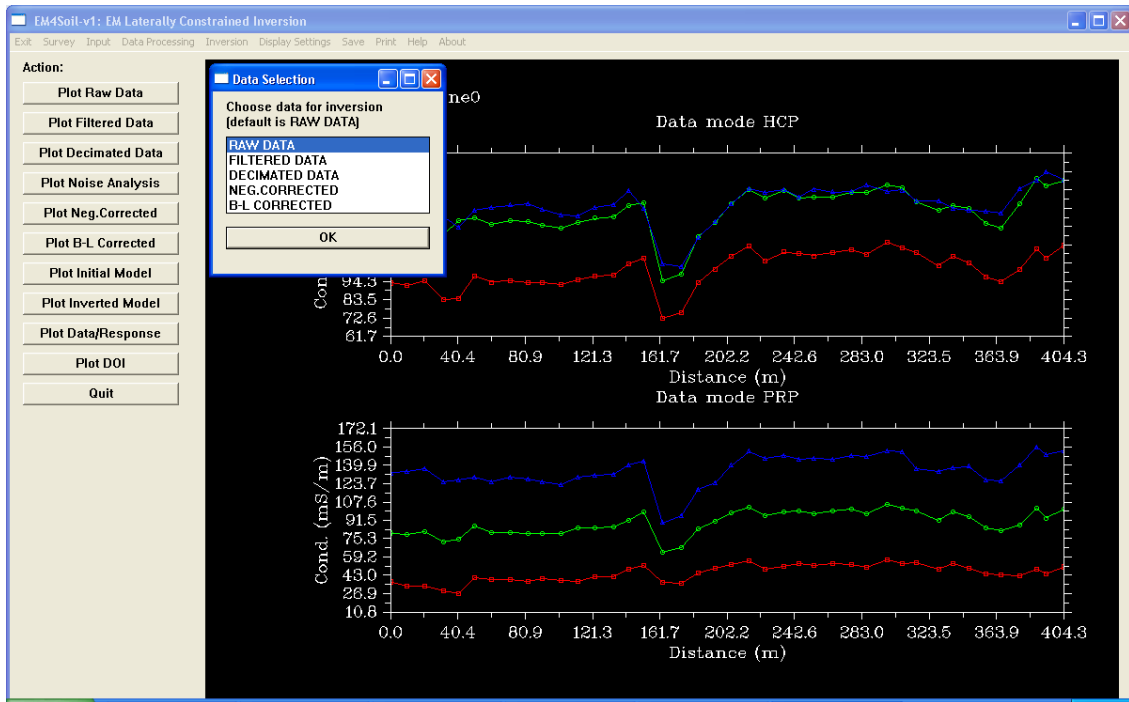

Given the latter is the case for the σ_a data contained within the D421Line0 file choose **Inversion Calculation (FS)**.
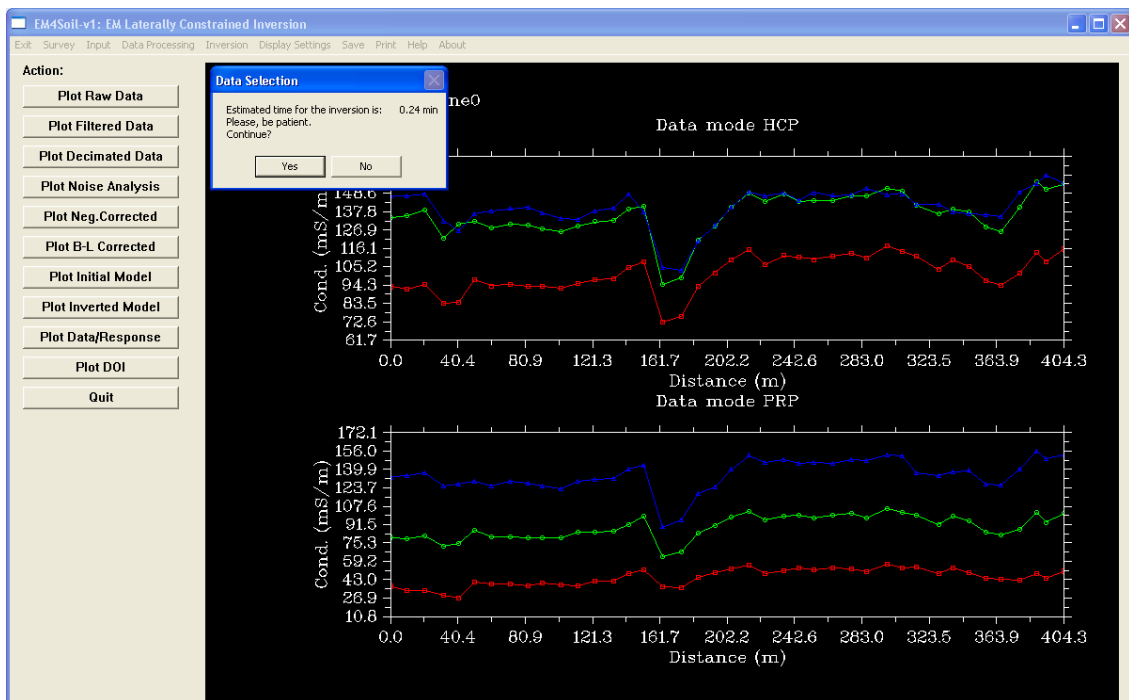
The **Data Selection** pop-up box will appear. Choose either the RAW DATA. Press **OK**.


The **Data Selection** pop-up box will appear. Choose either the RAW DATA. Press **OK**.

Another **Data Selection** pop-up box will appear. It indicates an approximate time for the completion of the inversion process. Press **Yes**.


At this point the screen may go blank. However, EM4soil is in operation. Evidence for progress of the inversion iterations can be seen by clicking on the software, which is running in the menu bar.
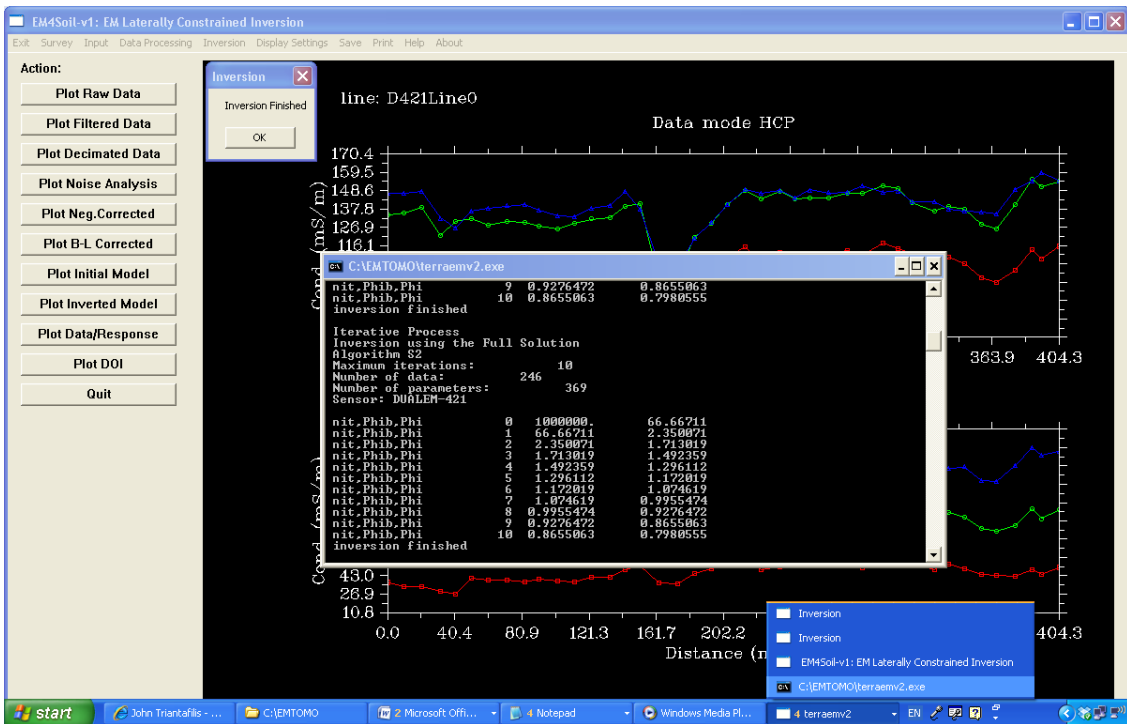
When the number of iterations designated have been completed, the **Inversion** pop-up box appears. Press **OK**.

STEP 8. Plotting the inverted σ_a data (i.e. true electrical conductivity σ)

To plot the inverted data use the **Plot Inverted Model** from the action menu on the left hand side.
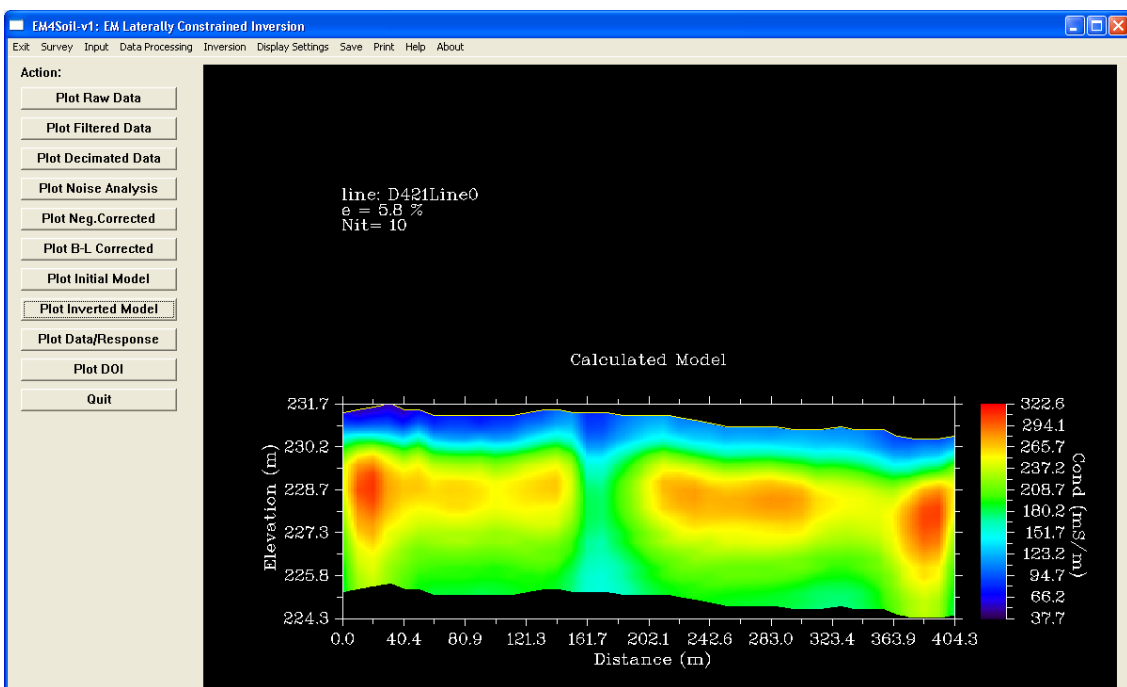
STEP 9. Plotting σ_a against the modelled σ_a data response

To plot the observed σ_a data against the modelled σ_a use the **Plot Data/Response** from the action menu on the left hand side.
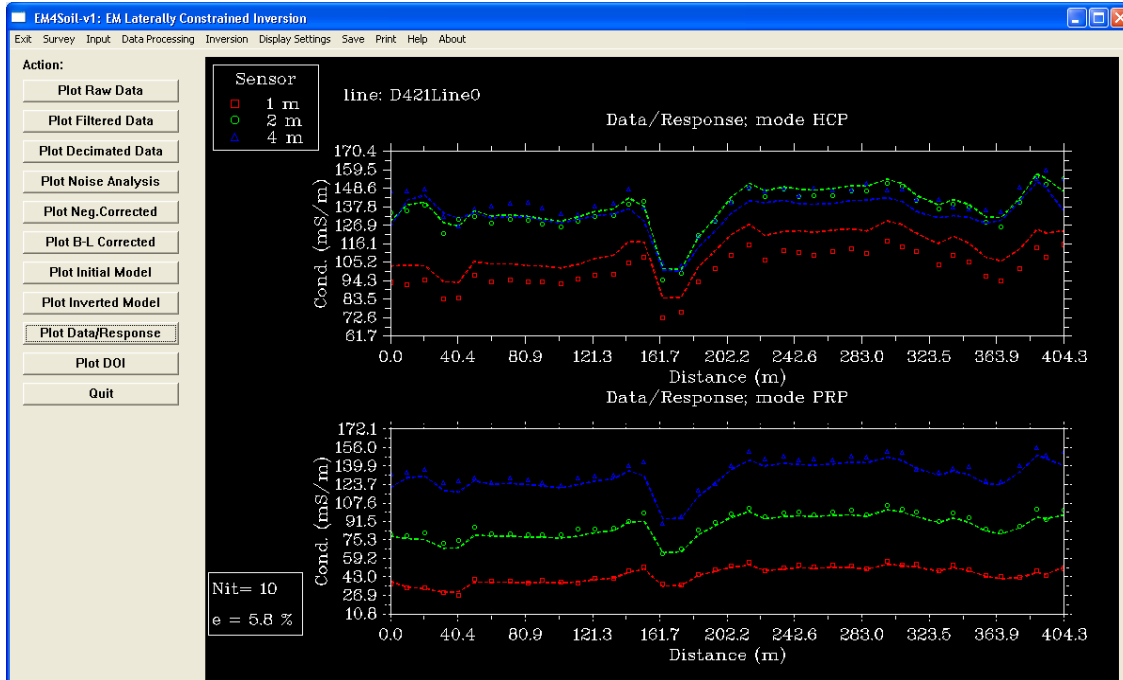
STEP 10. Saving inversion modelled data

To save the inverted σ_a data (i.e. modelled true electrical conductivity σ) select the Save menu and select the **Save Inverse Model** option.
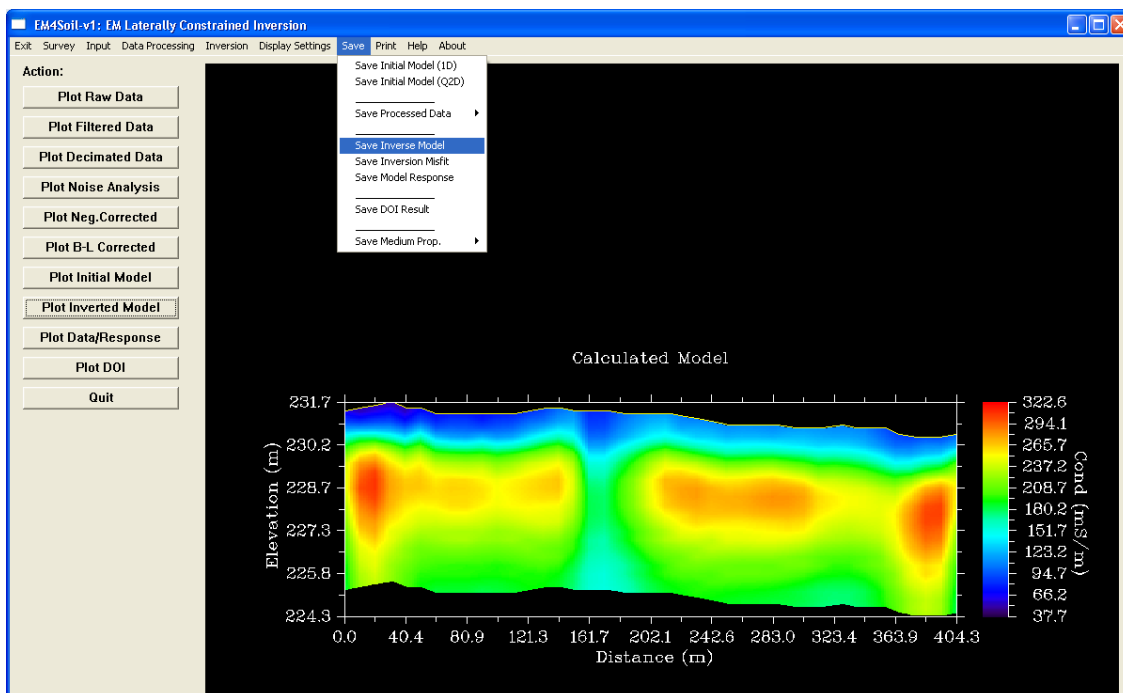
The **Save Model File** pop-up box appears. Save the file using an appropriate file name. The authors to denote the inversion model commonly use notation as follows:
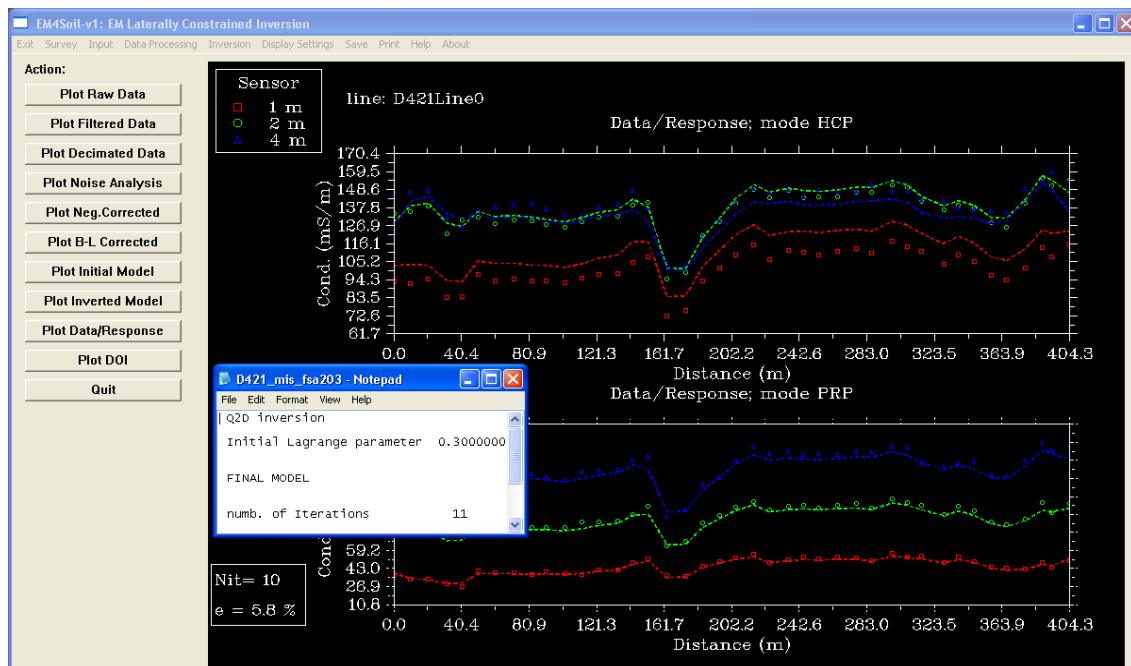
> D421_mod_fsa203.txt
>> which denotes;
>>> D421 - original sensor data,
>>> mod - modelled results
>>> fs - achieved using the full solution,
>>> a2 - implementing algorithm 2 and
>>> 03 - considering 0.3 as the damping factor.

The data can be opened in **Notepad** or any other software package.
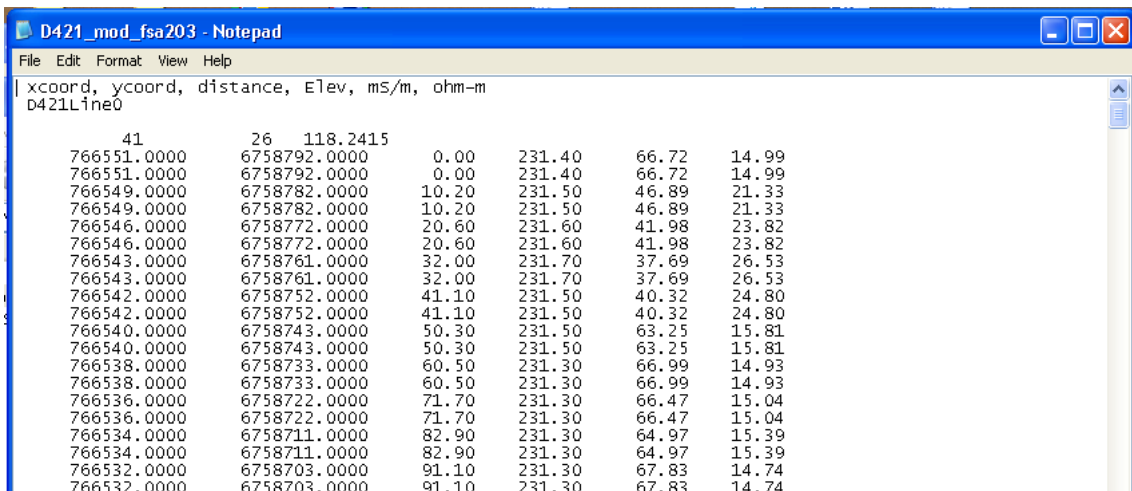
STEP 11. Saving response data

To save the σ_a response data (i.e. observed σ_a and modelled σ_a) select the Save menu and select the **Save Model Response** option.
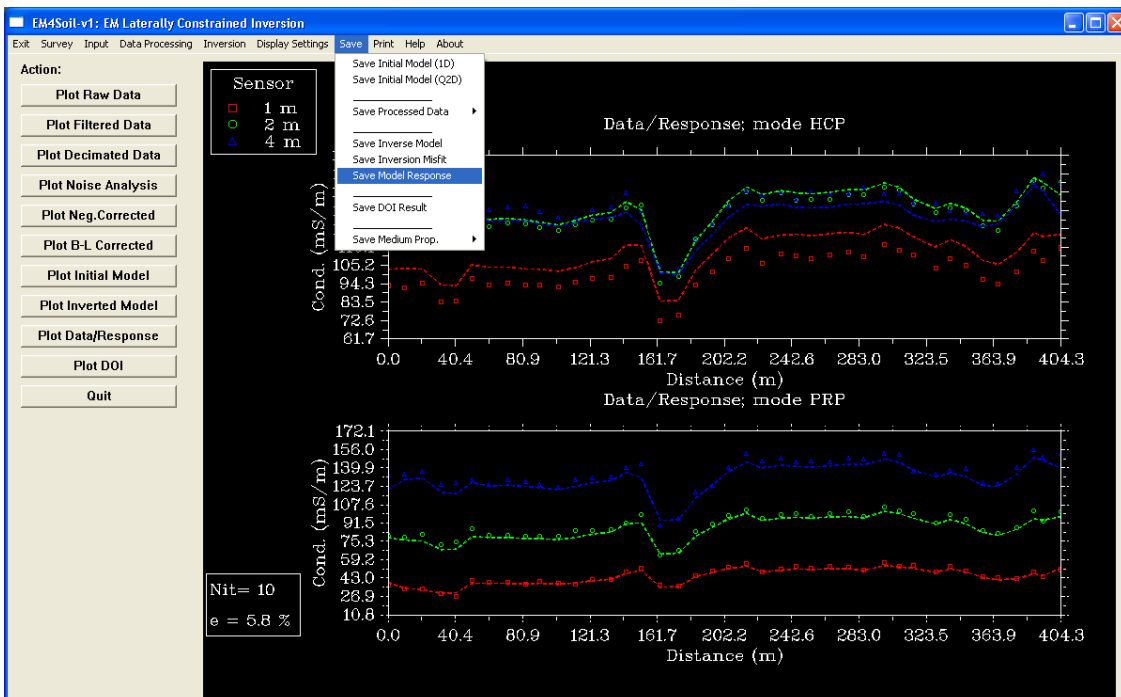
The **Save Model Response File** pop-up box appears. Save the file using an appropriate file name. Again the above notation can be followed with a slight modification to distinguish it from above as follows:

> D421_res_fsa203.txt
>> which denotes;
>>> D421 - original sensor data,
>>> res – response modelled results
>>> fs - achieved using the full solution,
>>> a2 - implementing algorithm 2 and
>>> 03 - considering 0.3 as the damping factor.

STEP 12. Saving response data misfit value

To save the σ_a response data misfit select the Save menu and select the **Save Inversion Misfit** option.

The **Save Misfit** pop-up box appears. Save the file using an appropriate file name. Again the above notation can be followed with a slight modification to distinguish it as follows: D421_miss_fsa203.txt