

ResInv - Electrical Survey Inversion Program

Introduction *ResInv* is a computer program for modelling and inversion of resistivity sounding (Vertical Electrical Sounding (VES)) data. This is to say, it computes the theoretical low frequency (pseudostatic) electrical response of a horizontally layered earth model. It also provides means whereby the parameters of the model (the layer thicknesses and resistivities) may be adjusted (manually or automatically) so as to fit a supplied set of observational data. In its usual mode of operation, *ResInv* requires input of an "observation file" that will provide specific observational information from the VES survey that is to be modelled. At minimum, this is a list of the array spacings at which the observations have been made, along with at least a dummy set of resistivity observations.

The "observation file" may be in one of two formats, an "apparent resistivity" format or a "resistance" format. The apparent resistivity format assumes the measurements were made with a Schlumberger electrode array. The resistance format is more general but more complicated. It permits use of any four electrode array (two current and two potential electrodes), but it does not assume any particular survey geometry. Please see the end of this document for the file formats. *ResInv* reads and writes two kinds of file (observation type and model type), both given the file name extension *.dat. The observation type contains apparent resistivities (or resistances) at different array separations (observed and/or modelled) and the model type describes the layer structure of the model (layer thicknesses and resistivities).

When *ResInv* is opened, it asks for names of the observation file and a model data file from which can start. Whenever the user wishes to record modelling that has been completed on the screen, similar files can be output. It is up to the user to supply suitable file names, or to accept defaults, or to 'escape' from the program's requests. All files are in ASCII text format and can be edited with any text editor. Samples are in the \GEOLAB\RESINV directory [respectively OBS.DAT, and MOD.DAT]. You may copy them into \USERS\TEMP and edit them to meet your own needs. (Starting *ResInv* from the icon or start menu will copy them and another "obs" type file called VES.dat to \USERS\TEMP, if the file names are not already present.) An alternative, simple, unsophisticated modelling program called VES creates similar files and can be used to create synthetic Schlumberger observations and a model file. (The only advantageous feature of VES is that it can model Wenner array data.) Your files can be opened and modified with any simple text editor (e.g., *Notepad*, *Wordpad* or *Word*)

Numerical Limitation:

The numerical value of all quantities used by *ResInv* must lie within bounds. The resistivities may vary between .01 and 100,000, and the thicknesses between .01 and 1000. Scale your data (change units) if there is any problem. Note that inversion will work badly if any of the free variables bumps against a bound. So leave a large margin.

Running ResInv:

ResInv is a DOS program that may be started by clicking on its icon on the "desktop", or from the start/ programs/ menu. Most of the controls for the program are found in the program's display window in button boxes located at different places on the screen, indicated by a white

label surrounded by a blue rectangle. These buttons may be activated by clicking the **left** mouse button while the arrow is inside the box.

The screen is divided into three panels. The upper left describes the current model and shows which parameters are fixed or free for the next step of inversion. The upper right displays the apparent resistivity (or potential difference) observations (red points) as a function of array separation and the current modelling of the observations (green points). Note that green plots over red, so it is possible to completely hide the observations if the model data fit very well.

Input of Model and Data:

The buttons at the bottom of the screen are the most important controls. They may be activated using the mouse or the function keys at the top of the keyboard. Begin by entering the name of your observation file (if any) and your model file (if any) using the "F2:Input" button. You will be prompted for file names, as well as being offered a default value. The program sets the current directory to \USERS\TEMP. To enter a file name of your choice, type it in, then hit the "enter" or click on "OK" button (**right** mouse button). To choose the default, just hit "enter" or click on "OK" without typing anything. If you don't want to enter an apparent resistivity or resistance filename, hit the "Esc" key, or click on "Cancel", and the program will continue on. If you only want to calculate a Schlumberger array forward model, just input a model file and *ResInv* will calculate the sounding profile for r at constant logarithmic increments of r from 0.1 to 1000. If you wish to model a different geometry, enter an observation file with array dimensions given but zero potentials. Please note an important peculiarity of *ResInv*. If given an observation file, the displayed graph of apparent resistivity or potential will be plotted against observation sequence number on the x axis, not the more usual log (spacing). It is therefore essential to set up the observation file so that array spacing increments uniformly, preferably in logarithmic steps.

Displaying the initial Model and Data:

After any starting files are read, parameters of the input layered earth model will be displayed in the model window at the upper left. Then the apparent resistivity response calculated from it will be shown in the display window at the upper right (in green). Observation values will also be shown in the display window (red). The graphs are scaled logarithmically. You may choose between displaying apparent resistivity or potential by clicking on the appropriate button in the display window. To determine the value of a particular data point on the graph, click on it, or more the highlighted value using the left and right cursor keys.

Changing the Model:

To alter a particular value of resistivity or thickness in the model, click on it with the **left** mouse button. You will be prompted for a new value. (See "Inversion" about using the **right** mouse button). To "Add" or "Delete" a layer, click on the appropriate button. Clicking on "Undo" will restore the model to whatever it was just before the last time you deleted a layer. You are limited to a maximum of six layers.

Inversion:

The inversion process is begun by typing or clicking the "F3:Invert" key. The inversion will proceed until one or several specified conditions are met (See "Controlling Inversion"). You are

able to select which particular resistivities and thicknesses will be adjusted in the inversion process by "fixing" and "freeing" them. "Free" variables are those whose values in the model window are highlighted in white, while "fixed" variables are gray. You may toggle between the two states by clicking on the values using the **right** mouse button. The inversion process adjusts "free" variables until it finds (hopefully) the best fit of the values calculated for the model to the observed data values. It is a good idea never to have more than four or five free variables at a time, otherwise the inversion process may get bogged down, or even fail completely. Misfit is measured in logarithmic units (i.e., fractional errors are summed, not absolute errors).

Controlling Inversion:

There are a number of specialized inversion parameters whose values may be adjusted using buttons in the "Control" window at the bottom left of the screen. Mostly, these may be safely ignored. The same may be said of most of the inversion information which appears at the bottom right of the screen. However, one important statistic which should be recorded periodically is the overall misfit or "Best RMS" value, which measures the goodness of fit between the observed and modeled data sets. The lower this value, the better the fit. You may wish to compare the current result with others for different models.

Outputting Results and Model Parameters:

By typing or clicking on the "F4: Output" button, you may save the current model and the predicted observations. You will be prompted for file names. The output model file is of the exactly the same type as the input model data. The results "observation" file is in the same format as the input observation file and contains apparent resistivities for both the observations and the fitted model. The data lines are now in the form X,Y1,Y2 instead of X, Y is indicated by changing the 1 in the first active line to a 2. Either kind of file can be plotted by T plot as format 12 or by using Excel. (Excel is more flexible, as you can load several trials into the same workbook). Default file names are mod.dat (the same as the starting model) and resinv.tpl. Be careful not to overwrite what you want to save.

File Formats:

The format of an "obs" file in apparent resistivity form (Schlumberger configuration assumed) is:-

```
{X-axis Title}      )  
{Y-axis Title}      }    the first three lines of text are optional  
{Plot Title}        )  
1  
Ndata  
r(1)  app_res(1)  
r(2)  app_res(2)  
...etc...
```

This is TPLLOT * format 12 (or format 2 if the first three lines of text are not supplied). The line after the Titles must contain 1 to indicate number of data for each r (i). Ndata is the number of r and app_res data points. The r values are one-half the separation of the current electrodes in the Schlumberger array.

A resistance file is constructed in the following format:-

```
Ndata
xC1(1) yC1(1) xC2(1) yC2(1)
xP1(1) yP1(1) xP2(1) yP2(1)
Resistance (1)
xC1(2) yC1(2) xC2(2) yC2(2)
xP1(2) yP1(2) xP2(2) yP2(2)
Resistance (2)
...etc...
```

where Ndata is the number of measurements, the $x_{\text{__}}(i)$ and $y_{\text{__}}(i)$ values are the positions of the current (C1, C2) and potential (P1, P2) electrodes, and Resistance (i) values are the measured voltages per ampere of current ($V_{P1, P2} / I_{C1, C2}$).

The model file has the following format:-

```
Nlayers
resistivity (1)      thickness (1)
resistivity (2)      thickness (2)
...etc...
resistivity (Nlayers)
```

The last layer has infinite thickness, so it has only a resistivity value.

Reference: *ResInv* was written by S. Cheesman and based on the algorithm presented by Scott Holladay in: "Interpretation of EM Sounding Data for a Stratified Earth by Means of Nonlinear Regression", Research in Applied Geophysics No. 16, January 1981, Geophysics Laboratory, Department of Physics, University of Toronto.

* TPLLOT is an obsolete geophysics lab public domain DOS software for quick graph plotting.