RES2DMOD ver. 2.2

Rapid 2D resistivity forward modelling using the finite-difference and finite-element methods

Wenner (alpha, beta, gamma), inline & equatorial dipole-dipole, pole-pole, pole-dipole and Wenner-Schlumberger

by

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October 1999

Freeware courtesy of M.H.Loke

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1 Introduction

RES2DMOD is a free 2D forward modelling program which calculates the apparent resistivity pseudosection for a user defined 2D subsurface model. It is largely intended for teaching undergraduates and postgraduate students about the use of the 2D electrical imaging method. The program might also assist the user in choosing the appropriate array for different geological situations or surveys.

The arrays supported by this program are the Wenner (Alpha, Beta and Gamma configurations), pole-pole, inline dipole-dipole, pole-dipole and equatorial dipole-dipole (Edwards 1977). Each type of array has its advantages and disadvantages. This program will hopefully help you in choosing the "best" array for a particular survey area after carefully balancing such factors as the cost, depth of investigation (or equivalent depth), resolution and practicality.

The following figure shows an overhead view of the arrangement of the electrodes for the different arrays.

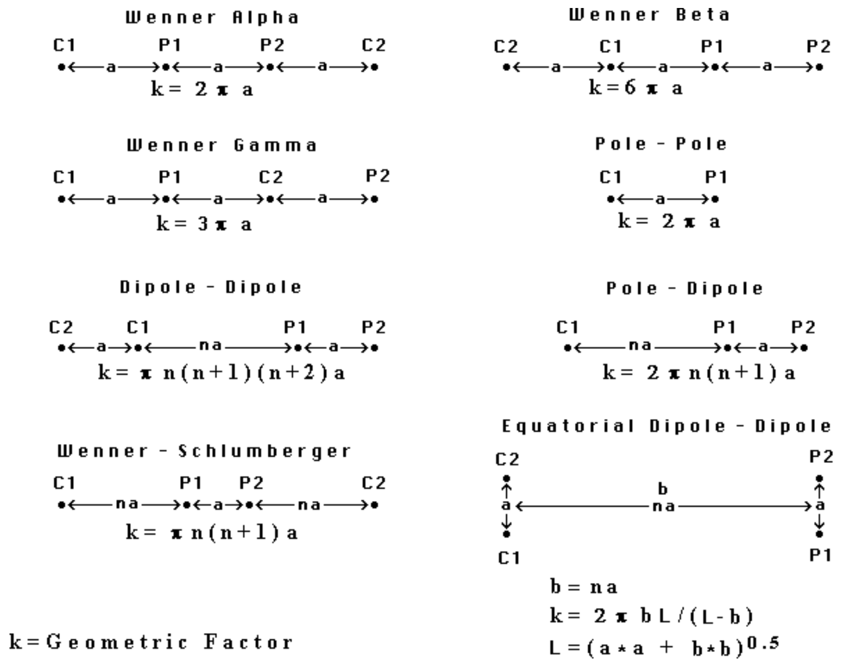

Figure 1 Arrangement of the electrodes for different arrays

You can use a model with a maximum of 101 electrodes (with 2 nodes per unit electrode spacing) or 51 electrodes (with 4 nodes per unit electrode spacing). This limit is set by the resolution of the VGA graphics display. This limits will be removed in the near future in the Windows version of the program.

2 Computer System Requirements

This program is designed to run on IBM PC compatible microcomputers at a reasonable speed. Due to the computational power required for the 2D finite-difference modelling subroutine, it was written for 80386 (or faster) computer systems equipped with a mathematical coprocessor. As such, it will not run on older systems based on the 80286 and 8088 microprocessors. On an 80486DX/33 computer, it will take usually take less than a minute to calculate the apparent resistivity values for a model.

General requirements : Hard disc with at least 2 megabytes free space, and motherboard with at least 8 megabytes RAM. VGA colour graphics system. MS DOS 5 or 6 operating system. 80386/387 or 80486DX or Pentium system.

Before using the RES2DMOD.EXE program, you should first check whether your computer has the resources to run this program. You can do this by using the SYSTEM.COM program provided. To run this program, first make sure you are in the correct drive and subdirectory containing this program and then just type SYSTEM. A brief report on the computer configuration you are using will be displayed. If the computer does not have the mathematical coprocessor or graphics display, a warning will be displayed. Next use the PMINFO.EXE program to check for the amount of extended memory available. If the there is a significant difference (more than 100 kilobytes) between the amount of extended memory physically present and the amount available to DOS/16M programs, this means that some of the extended memory is being used by other programs. If this occurs on systems with less than 8 megabytes of memory, the amount of extended memory available to the RES2DMOD program might not be sufficient for large models. One way to overcome this problem is discussed below.

Version 2 of RES2DMOD is a 32 bit program which runs in protected mode using the Rational Systems DOS/4GW DOS extender. Unlike earlier versions of this software, it can make use of extended memory (i.e. memory above the first megabyte) directly without the need to convert it into expanded memory. In fact, any memory converted into expanded memory using the EMM386.EXE program cannot be used by RES2DMOD ver. 2. So, it is important to delete any line in the CONFIG.SYS file containing the EMM386 filename which might have been set up for earlier versions of this program.

In the MS DOS operating system, the HIMEM.SYS extended memory manager is normally used in the CONFIG.SYS file so that the extended memory can be used by other programs. One common program which makes use of extended memory is the SMARTDRV disk caching program provided with MS DOS. Another common use of extended memory is to load part of the MS DOS operating system into high memory. The CONFIG.SYS or AUTOEXEC.BAT files might contain the following statements.

```
DOS=HIGH
DEVICEHIGH=C:\DOS\SMARTDRV.EXE /X
LH C:\DOS\SMARTDRV.EXE /X
```

If the RES2DMOD program detects other programs that also make use of extended memory, it will reserve the first 4 megabytes of memory for them. This is not a problem for computers with 8 megabytes of memory since 4 megabytes will still be available to RES2DMOD. However, for computers with only 4 megabytes of memory, there might not be much extended memory left for this program. One way to get around this problem is to boot from a floppy disk instead of the hard disc. An example of the CONFIG.SYS and AUTOEXEC.BAT files for the MS DOS operating system (version 5 onwards) that can be used with a boot disc are provided in the program disc. Another solution is to keep two sets of the CONFIG.SYS and AUTOEXEC.BAT files in the hard-disk and use a simple batch file to select which set to use. You can use the REBOOT.COM program provided in the program disks to reboot the computer after changing the CONFIG.SYS and AUTOEXEC.BAT files. If you are using DOS ver. 6 (or higher), you can use the option to have multiple boot sequences.

The RES2DMOD.EXE program makes use of the DOS4GW.EXE extended memory driver. When the RES2DMOD.EXE starts up, it will first execute this extended memory driver. To avoid problems, it is best to copy all the files provided in the RES2DMOD package into the same subdirectory, say C:\RES2DMOD, of the hard-disk and start the program from this subdirectory. Otherwise, you have to ensure that the DOS4GW.EXE program is located in one of the subdirectories on the PATH statement in the AUTOEXEC.BAT file.

This program has been optimised to run under the MS DOS operating system. While it might be possible to run this program from Microsoft Windows 3.1, it will be significantly slower, particularly for large data sets. If you experience problems running this program under Windows 3.1 or Windows 95, quit from the Windows environment and run this program from the DOS operating system.

To use this program, first copy the program and all the other files to a sub-directory on your harddisc. Change to this subdirectory, and then type RES2DMOD.

3 Freeware

This program is released as freeware. However, I am not liable for any problems or possible damages arising from the use of this program. If you find this program useful, please send an email to me at mhloke@pc.jaring.my. I will try to fix bugs, and provide more features in future versions, but that will depend on my free time. A Windows version of the program is currently being developed.

4 Theory

The 2-D model used by the finite-difference or finite-element method divides the subsurface into a number of blocks using a rectangular mesh (Figure 2). Some improvements were made to the Dey and Morrison (1979) finite-difference formulation to improve the accuracy of the calculated apparent resistivity values (Loke 1994). The finite-difference method basically determines the potential at the nodes of the rectangular mesh which consists of L nodes in the horizontal direction and M nodes in the horizontal direction.

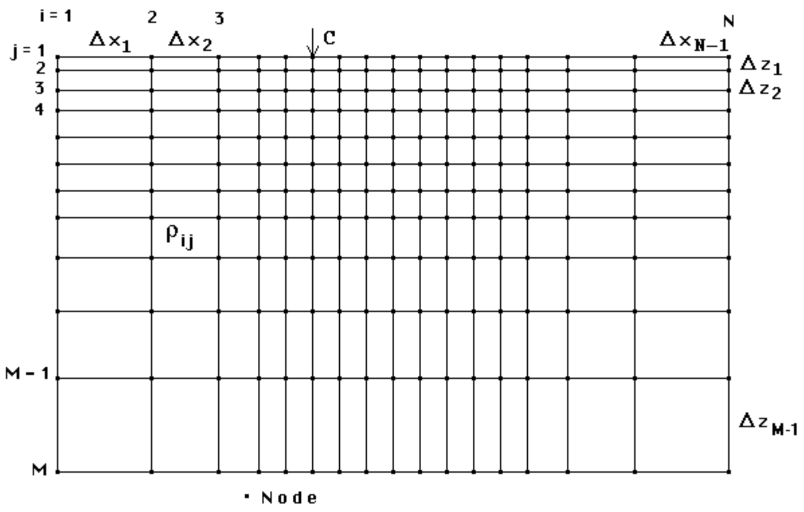

Figure 2 Schematic diagram of the finite-difference or finite-element mesh used by the program.

Note that the grid model has L-1 columns and M-1 rows of rectangular blocks. The blocks can have different resistivity values. By using a sufficiently fine mesh, complex geological structures can be modelled. The program uses a mesh with two or four horizontal nodes per unit electrode spacing for a multi-electrode array (Figure 3).

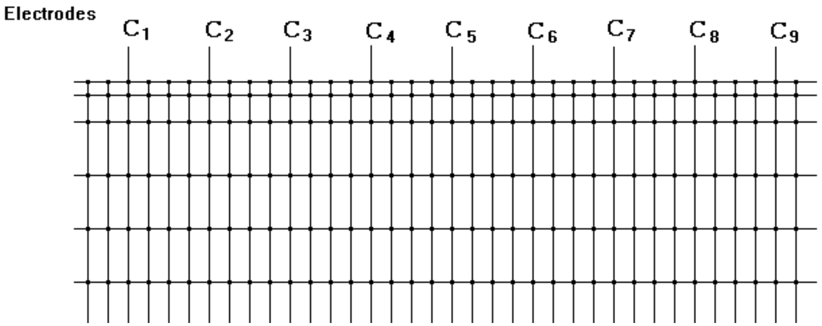

Figure 3 Part of the finite-difference or finite-element mesh showing the location of the electrodes.

The first electrode is placed at the 12th horizontal node from the left edge of the mesh. Similarly there as 12 nodes between the last electrode and the right edge of the mesh. Table 1 shows the vertical depths and horizontal offsets of the mesh lines for an electrode spacing of 1 metre for the default model used by this program. You can also set the depths of the horizontal mesh lines with this program.

The program requires you to supply the resistivity values of the rectangular blocks in between the mesh lines (and other information) using an input data file. The format of the input data file is described in section 5. In general, you should try to use "reasonable" model resistivity values that are not too small or too large.

If you choose to set the depths of the grid lines, use a smaller vertical spacing (*zj in Figure 1) between adjacent horizontal mesh lines near the surface and larger spacings for the deeper mesh lines. The distance between the top two mesh lines should normally not be more than one-quarter of a unit electrode spacing. Near the base of the model, the spacing between the mesh lines are normally progressively increased so that the bottom of the model is sufficiently far away from the surface. However you should not increase the vertical spacing by more than a factor of 2 between adjacent pairs of the mesh lines. The file MODEL41.MOD provides an example of a model with a set of user defined depths for the horizontal mesh lines.

Table 1 : Locations and spacings between the nodes in the 2-D finite-difference grid model. The first electrode on the surface is located at the 12th horizontal node. Subsequent electrodes are placed at 4 horizontal nodes apart. The electrode spacing is 1 metre. The horizontal spacings between the last 11 nodes after the last electrode are the same as that for the first 12 nodes (except in reverse order).

Index	Horizontal Location	Node Spacing	Index	Vertical Depth	Node Spacing
i	x_i	dx_i	j	z_j	dz_j
1	0.00	64.0	1	0.25	0.25
2	64.00	32.0	2	0.50	0.25
3	96.00	16.0	3	0.75	0.25
4	112.00	8.0	4	1.00	0.25
5	120.00	4.0	5	1.55	0.55
6	124.00	2.0	6	2.16	0.61
7	126.00	1.0	7	2.82	0.67
8	127.00	0.50	8	3.55	0.73
9	127.50	0.50	9	4.36	0.81
10	127.75	0.25	10	5.24	0.89
11	128.00	0.25	11	7.02	1.77
12	128.25	0.25	12	10.56	3.54
13	128.50	0.25	13	17.64	7.09
14	128.75	0.25	14	31.82	14.17
15	129.00	0.25	15	60.16	28.35
16	129.25	0.25	16	116.85	56.69
17	129.50	0.25	17	230.23	113.38

You can also choose to use a set of default depths for the mesh rows. The default values are given in the above table for an electrode spacing of 1 metre and 4 nodes per electrode spacing. However, you can also set your own depths for the mesh lines. If you choose to do so, try to use smaller spacings between the top few mesh lines in order to ensure that the results will be sufficiently accurate. In particular, the vertical spacings between the top 3 horizontal mesh lines should not be greater thaan the horizontaal spacings between adjacent verticala mesh lines. The file FAULT.MOD is an example model file with user defined depths for the mesh lines.

The highlighted bar shows the current option chosen. You can move the ighlighted bar by using the arrow keys, or by pressing the first letter of the option you wish to select. After the proper option is highlighted, press the Enter key to select it.

If this is the first time you are using the program, try reading in the example model data file TIXALL.MOD provided with the program using the "File" option in the Main Menu. Then select the "Model Computation" option to calculate the apparent resistivity values for this model. After that, use the "Edit/Display" option to take a look at the 2-D model and the apparent resistivity pseudosection. In the following sections, a more detailed description of each item in the above menu is given.

5 File operations

After choosing this option, the following submenu will be displayed.

File input/output

Read data file with forward model
Save results in RES2DMOD format
Use RES2DINV format
Inversion results RES2DINV file
Quit to Main Menu

Press Enter to select choice

Read data file with forward model - In this option, you read in a model data file. When you select this option, the list of files in the current directory (or the last subdirectory from which you read in a model file) which has an extension of .MOD will be displayed. You can use the keyboard cursor arrow keys to move the highlighted bar to select the appropriate file, or to change the subdirectory. You can also type in the name of the file by pressing the F2 key.

The program requires the resistivity model values to be typed in separately in a text file. For an example of the input data format, you should make a printout the MODEL41.MOD data file. The parameters for the finite-difference model are arranged in the following format.

Line 1 - Name of model

Line 2 - Number of electrodes (Maximum of 101)

Line 3 - Number of pseudosection data levels (Absolute maximum of 32 but also depends on the type of array and the number of electrodes).

Line 4 - Flag for underwater survey. Enter 0 for now.

Line 5 - Unit (or smallest) electrode spacing

Line 6 - Flag for type of grid model. Enter 0 or 1 for a grid model with the default depths for the mesh lines. Enter 2 for user defined depths for the mesh lines (see the file MODEL41.MOD). The file MODEL25.MOD gives an example of a model file which uses the default (option 0) depth values given in Table 1. If option 1 is used, the depths are scaled according to the depth of investigation of the array used.

Line 7 - Offset of first block in user-defined model section from the first electrode. Normally enter 0 to avoid problems.

Line 8 - Number of blocks in user-defined model. To avoid problems, use a value of (Number of electrodes - 1) * Number of nodes/unit electrode spacing which will cover all the blocks between the first and last electrode.

Line 9 - Number of resistivity values in the model (maximum of 16)

Line 10 - Number of nodes per unit electrode spacing (2 or 4). You can use a value of 4 for up to a maximum of 51 electrodes.

Line 11 - The model resistivity values.

Line 12 - Number of rows of rectangular blocks in the model (maximum of 29). Note that the number of vertical mesh lines is equals to the number of rows of blocks plus one.

Line 13 - The depth to the horizontal grid mesh line.

Lines 14 to 27 - The resistivity of the model blocks are given row by row. A number "0" means the block has the first resistivity value, "1" for the second resistivity value and so on. For the 11th to the 16th resistivity values, use the letters "A" to "F".

Lines 28 - Type of array. 1 for Wenner, 2 for two-pole, 3 for dipole-dipole, 4 for Wenner Beta, 5 for Wenner Gamma, 6 for inline pole-dipole, 7 for Wenner-

Schlumberger and 8 for equatorial dipole-dipole array. For the equatorial dipole-dipole array, you will also need to enter the separation between the current electrode pair. It is assumed that the potential electrode pair will have the same separation. Please refer to the file MODELEQ.MOD for an example of this array format.

Lines 29 and 30 - Enter 0 for both. These are flags for calculated apparent resistivity and potential values which are used for the output data file produced by this program.

Lines 31, 32 and 33 - Enter 0 for now. They are reserved for possible new features in future versions of this program.

Note that you only have to set the resistivities for a limited section of finite-difference grid model. The program assumes that the resistivity of the blocks to the left side of the first electrode is the same as that of the first model block for which you have set the resistivity value. Similarly the resistivity of the blocks on the right side are set to be the same as that of the last block of the rightmost column in the user-defined model section. Normally it would probably be most convenient to set the resistivities of all the blocks between the first and last electrode of the multi-electrode array. In this case, the offset of the first block in your model from the first electrode is 0 (data for line 7 above). If the total number of electrodes is E and the number of nodes per unit electrode spacing is n, then the number of blocks between the first and last electrode is (E-1)*n. For an example, see the data file MODEL25.MOD.

As an example of model file where the depths to the mesh levels are specified, the upper part of the FAULT.MOD file with comments are given below.

Data in FAULT.MOD file	Comments
Fault and block model	| Title
51	| 51 electrodes in line
15	| 15 data levels
0	| Normal land survey, i.e. not underwater
1.0	| Unit electrode spacing
2	| 2 for user defined mesh lines depths
0	| Offset of first block form first electrode
200	| Total number of blocks in user model
3	| Indicates three model resistivity values
4	| Four nodes between adjacent electrodes
10.0,50.0,100.0	| The model resistivity values
14	| Fourteen rows of model blocks
0.2500,0.5000,0.8125,1.1875,	| The depth to the base of each row straing from the

1.6875,2.3125,3.1875,4.4375,	| top. Note the smaller distance between the top
6.4375,10.4375,18.4375,34.4375,	| two mesh lines, and the large spacings near the
66.4375,130.4375	| bottom
0000000000000000000000000000	| The usual model codes start here
....	| Model codes for other rows
1111111111111111111111111111	| Last row of model codes
1	| 1 indicates Wenner array
0,0,0,0	| Ends with a few zeros

The file LANDFILL.MOD gives an example of an input model file which also contains measured apparent resistivity values from a field survey. The required information is placed in after the value for the type of array. Below is part of this model file with comment about the format of the data (the format is similar to that used by the RES2DINV inversion program).

Data in LANDFILL.MOD	Comments
99999999999999999999999	| Last part of
99999999999999999999999	| model codes.
1	| Wenner array flag
0	| Put 0's in these 2 lines. These are flags used by
0	| RES2DMOD for the output file it produces.
2	| Put 2 here for only measured app. resis. values.
334	| Number of datum points
1	| 0 for location of first electrode, 1 for midpoint
0	| Put zero here, will be used later for I.P. flag
4.50000, 3.00000, 84.90	| The following lines give the field data, arranged
7.50000, 3.00000, 62.80	| as x-location of datum point, electrode spacing,
10.50000, 3.00000, 49.20	| apparent resistivity value. See manual for inversion
13.50000, 3.00000, 41.30	| program for details. At the end of the file, put four 0's.

One common problem encountered in using this program is mistakes in the input data file. If the program stops with an error message it could be due to a mistake in the input data file. First check that the data in the file is arranged according to the format described above.

It is important that you do not edit the output files produced by the program. The program saves the apparent resistivity and potential values calculated in the 'Model Computation' option in its own format.

Save results in RES2DMOD format - In this suboption, you can save the apparent resistivity values into a file with the format used by the RES2DMOD program. Besides the model information, the apparent resistivity and potential values will be saved. By reading this file again, you can display the apparent resistivity values without having to recalculate the potentials.

Use RES2DINV format - This will save the apparent resistivity values into the format used by the RES2DINV inversion program. Note that you cannot read this output file with the RES2DMOD program since it is intended for the RES2DINV program.

Inversion results RES2DINV file - Use this suboption to read in the output file produced by the RES2DINV inversion program. You can convert the inversion results into the format used by RES2DMOD, after which you can modify the model by hand. Another use is to see the pseudosection you would obtain if another array was used for the survey. In the RES2DINV inversion program, the resistivity of a model block can take any value. However, in the RES2DMOD forward modelling program, there is a restriction of 16 different resistivity values. After reading in the inversion output file, you will be asked to select the iteration for which you wish to convert the results. The program will then automatically "digitise" the model resistivity values into 16 different values. When you recalculate the apparent resistivity values using the "Model Computation" option, there might be a small difference in the RMS error since there was a small change in the model resistivity values. The file CAVE.INV is an example inversion results file which you can use to test this option.

6 Edit/Display model

On selecting this option, the following menu will be displayed.

Edit/Display Model

Edit model
Display model
Change Settings
View PCX file
Quit to Main Menu

Press Enter to select choice

Edit model - Under this option, you can change the resistivity of the blocks in the model interactively using the mouse or keyboard. The individual rectangular blocks and the finite-difference grid together with the apparent resistivity pseudosection are displayed.

To change the resistivity of a single block, move the "+" shaped cursor with the mouse or keyboard arrow keys to the centre of the block. Then click the left mouse

button. The colour of the block should change to black. After that move the cursor to one of the rectangular blocks in the legend just above the top left of model grid section. Press "C" (or a mouse button) and the colour of the small rectangular block within the model should change to the colour you have chosen. You can change the resistivity of several blocks to the same resistivity value by first clicking them with the left mouse button, and then use the "C" key with the cursor at the appropriate block on the legend.

The following keys are also used :-

Right mouse button or "4" key - Change the resistivity of 4 blocks to the right of the cursor.

"D" key - Change the resistivity of a whole column of blocks downwards to the bottom edge of model.

"]" key - Change the resistivity of a whole row of blocks rightwards to the right edge of model.

"[" key - Change the resistivity of a whole row of blocks leftwards to the left edge of model.

"}" key - Change the resistivity of all the blocks to the right and below the cursor.

"{" key - Change the resistivity of all the blocks to the left and below the cursor.

"R" key - Change colour of background from black to white. Sometimes it is easier to see changes in the colour of the blocks with a white background. This is also used before making a screen capture so that the image has a white background.

"S" key - The screen image will be saved into a bit-mapped graphics PCX file. By using the Windows Paintbrush or DOS Neopaint program, you make a printout of the screen image using a colour inkjet printer.

After editing the model, quit from this option using the "Q" key. Then use the "Model Computation" option in the Main Menu to calculate the apparent resistivity pseudosection. After the calculations are completed, you can use the "Edit/Display" option again to take a look at the apparent resistivity pseudosection as well as the model section. Figure 4 shows an example of a model with its apparent resistivity pseudosection.

Display model - Under this option, the model without the grid lines and the apparent resistivity pseudosection will be displayed. You can also save the screen image into a PCX file by pressing the "S" key.

View PCX file - This option allows you to view the PCX graphics file that you had created in the above options.

Change Settings - The following submenu will be displayed on selecting this option. The current setting is displayed next to each item in this submenu.

Change Settings

Array type	Wenner Alpha
Current number of levels	6
Number of model resistivities	6
Display apparent resistivity	Yes
Sort model resistivity values	Not Sorted
Reverse colour scheme	No
Use scaling for model display	Yes
Quit to Main Menu	

Press Enter to select choice

Array type - This option enables you to change the type of array. This is useful to investigate the effect of the type of array used on the shape of the anomalies in the apparent resistivity pseudosection. This will hopefully assist you in selecting the "best" array for a particular problem.

Current number of levels - You can change the number of datum levels up to a maximum of 24. If you use less than 72 electrodes, the maximum number of datum levels might be less than 24 for some arrays.

Number of model resistivities - This allows you to add a new model resistivity value that can be assigned to any of the blocks in the model. The maximum number of model resistivity values is 16.

Display apparent resistivity - If the apparent resistivity values had been computed, the pseudosection will normally be displayed together with the model section. However, you can use this option to avoid displaying the apparent resistivity pseudosection so that you can display a larger section of the model.

Sort model resistivity values - You can use this option to sort the model resistivity values in ascending order so that the colour scheme for the model section will approximately follow that of the apparent resistivity pseudosection.

Reverse colour scheme - This enables you to reverse the colour scheme so that blue will be used for the higher resistivity values rather than for the smaller resistivity values.

Use scaling for model display - The model section displayed will normally be scaled vertically according to the depth of investigation of the array used. You can turn off this feature so that the model section display has a uniform vertical scale.

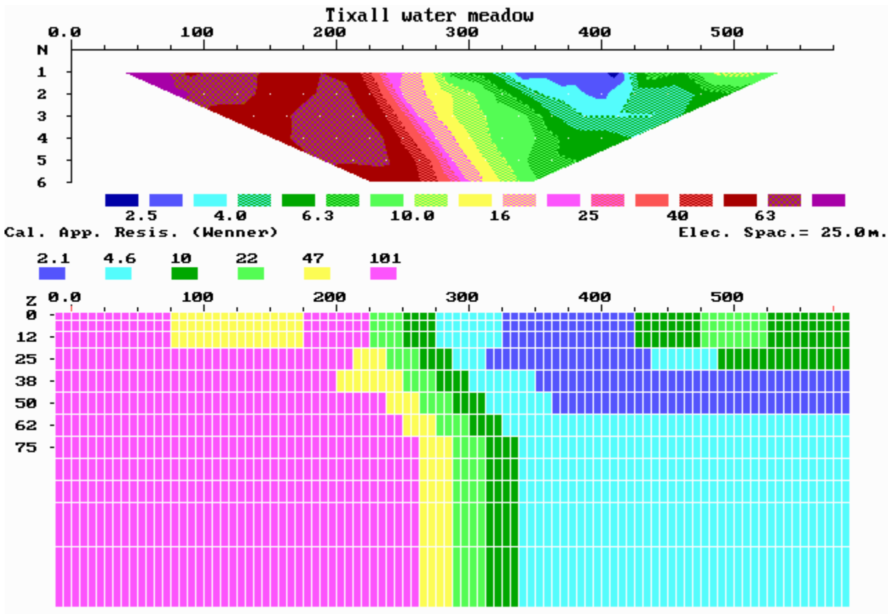

Figure 3 An example of a 2-D model with the calculated apparent resistivity pseudosection.

Figure 4. Model with apparent resistivity pseudosection.

7 Change Parameters

In this option, you can change certain parameters which affects the calculation of the apparent resistivity values.

Change Parameters

Apparent Resistivity Normalisation No
Number of Fourier Transform Values 10
Finite-Element Method No
Quit to Main Menu

Press Enter to select choice

Apparent Resistivity Normalisation - If this option is enabled, the program will first calculate the potentials for a homogeneous earth model. These values will then be used as correction factors for the potentials calculated for the input model. In most cases, there will be a slight increase in the accuracy of the calculated apparent resistivity
values.

Number of Fourier Transform Values - Normally, 10 Fourier transform wave-number values are used in calculating the potentials. For most situations, this will give reasonably accurate results. For the equatorial dipole-dipole array, if the spacing between the current electrodes pair is significantly smaller than the unit spacing between the current and potential electrodes pairs, you might need to use a larger number of the Fourier transform values to get more accurate results. You can use up to 20 values.

Finite-Element Method - In this suboption, you can select the finite-element (Silvester and Ferrari, 1990) or finite-difference method which will be used to calculate the apparent resistivity values. The file MODEL2.MOD contains a comparison of the results obtained with the finite-difference and finite-element methods for a two-layer model. For most models, there is not much difference in the apparent resistivity values calculated by the two methods. However, some of the older finite-element implementations contain an interesting error whose effect shows up more prominently for certain arrays (see the lower section of the MODEL2.MOD file).

8 Model Computation

After making the necessary changes to your model, select this option to calculate the apparent resistivity values. The model section will be displayed when the calculations are being carried out. After calculating the apparent resistivity values, you can save the results in a disk file in a format that can be read by this program. If you read this file at a later time, it will not be necessary to recalculate the apparent resistivity values. With present day Pentium class and faster computers, the calculations probably takes less than a minute for most models.

9 Options

In this section, you can choose several miscellaneous functions. On selecting this menu item, the following submenu will be displayed.

Miscellaneous Functions

Text Editor
Shell to DOS
Information
Quit to Main Menu

Press Enter to select choice

Text Editor - This option enables you to start up a text editor to make changes to your data files. The name and path location of text editor in your computer harddisc must be given in the first line of the RES2DINV.CFG configuration file. By default, the program assumes that the text editor is available at

C:\DOS\EDIT.COM

which is the text editor that comes free with MS DOS 5 and 6. If you prefer to use another text editor, just change the first line in the RES2DINV.CFG file.

Shell to DOS - In some circumstances you might want to make some changes to the apparent resistivity data file or other operations that cannot be carried out from within the RES2DINV.EXE program. By selecting this option you can quit temporarily from the program, make the changes you want, and then return back to the program by typing "EXIT" on the DOS command line. The DOS COMMAND.COM program is normally located in the root directory of the C: hard-disk drive, i.e. at C:\COMMAND.COM. If it is located at a different place, you need to modify the second line in the RES2DINV.CFG file.

Information - This option will display some information about the program.

10 Help

Selecting this option will load the electronic manual MAN2DMOD.EXE. This file must be in the same subdirectory as the RES2DMOD.EXE program.

11 Printing the pseudosections

Besides displaying the pseudosections on the screen, you might make a printout of the model sections. There are two methods of making a printout.

The simplest method is to use the RES2DMOD.EXE to display the pseudosection and model sections which you want to print by using the 'Edit/Display model' option in the Main Menu. After the program has completed drawing the pseudosection, just press the 'S' key and the screen image will be saved into a PCX graphics file. PCX is a standard graphics format. You can read, edit and print out the images in the PCX files using most standard bit-mapped graphics packages. Two such programs that you can use are the NEOPAINT shareware program, or the PAINTBRUSH program which is in the Accessories group within Microsoft Windows 3.1.

To use the PAINTBRUSH program, start up Microsoft Windows and then select the PAINTBRUSH icon in the Accesssories group. You can read the PCX file with this program. After reading the PCX file, you can edit the file before making a printout. Then select the Print option to make the printout. Note that you must first install the driver for your printer.

12 Pitfalls

While this program will show you the apparent resistivity pseudosection for a given model and array, there are many other factors that should be considered before selecting an array for actual field measurements. One important factor is the potential that will be measured by the potential electrodes. All field instruments have a finite accuracy in measuring the potential caused by the input current used. This is further degraded by the presence of random noise. This is particulary an important factor for the inline dipole-dipole, equatorial dipole-dipole, pole-dipole and Schlumberger arrays. You can determine the potential by dividing the apparent resistivity value by the geometric factor (see Figure 1) for the array and multiply this by the current used. An interesting and common mistake, particularly in North America, is the use of the inline dipole-dipole array in many situation where it is not suitable (especially with "n" values exceeding 6, please refer to Appendix A in the RES2DINV manual or the free lecture notes "Electrical imaging surveys for environmental and engineering surveys").

References

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Edwards, L.S., 1977, A modified pseudosection for resistivity and induced-polarization. Geophysics, 42, 1020-1036.

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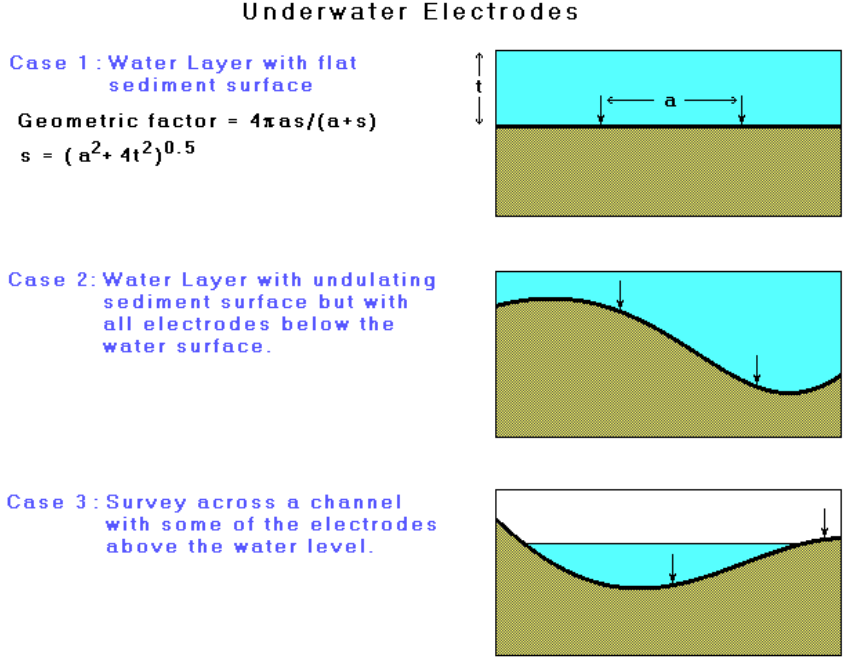
Appendix A : Underwater surveys

The following diagram shows the various possible situations for underwater resistivity surveys.



The present program supports the situation shown in Case 1 with a water layer of constant thickness over a flat sediment surface. The file WATER.MOD is an example model data file with a water layer. The initial part of the file with format used is as follows :-

WATER.MOD file	Comments
Model with water layer	Title
51,16	51 electrodes, 16 datum levels
1	1 to indicate water layer, normally 0
50.00,-100.00,200.00,-4.0	Water resistivity, left limit of water layer, right limit, water thickness
1.00	Unit electrode spacing
2	Number of model resistivity values
	The rest of the file follows the standard format

The left and right horizontal limits of the water layer is not used by the present version of the program which only supports Case 1 in Figure 5. It is included for

future use with Case 3 where the water layer has a finite horizontal extent. Note that the water layer thickness is given as a negative value. The depth of the electrodes are set at 0 m., i.e. the depth datum level, and the depth values are positive downwards. Since the top of the water layer is above the 0 datum level, following this convention, the water thickness has a negative value.

Appendix B : I.P. models

The file MODELIP.MOD gives an example of a model file where the I.P. values (note in terms of chargeability with units of V/V which is 1000 times smaller than the more usual unit of mV/V). Essentially an extra section is included following the section with the model resistivity values. The lower part of the MODELIP.MOD file is hown below with comments.

WATER.MOD file	Comments
1111111111111111111111	| Last line of model resistivity codes
IP present	| keyword 'IP present' to indicate IP model
3	| Three model IP vaalues
0.00,0.10,0.20	| The chargeability values
0000000000000000000000	| The IP codes

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 distributor will assume responsibility for any damage or loss caused by the use of this program.

Since this is a free program, no warranties are given. I will be grateful for bug reports and every effort will be made to correct the bugs. If you wish to contact me, please press contact me by email aat mhloke@pc.jaring.my or drmhloke@hotmail.com.

What's New

Version 1.x - Old version using expanded memory.

Version 2.0 - New version using a DOS extender and more friendly user interface. The rectangular (equatorial dipole-dipole) array has been added.

Version 2.10 - An option to read the inversion results files produced by the RES2DINV.EXE program was added to the RES2DMOD program. An option to use the Finite-Element method (with first order triangular elements) was aslo included.

Version 2.20 - Support for underwater surveys with a water layer of constant thickness was added.

Version 3.x - Windows version scheduled for year 2000.

What's Next

The present DOS version which started about 8 years ago is probably nearing the end of it's useful life. With Windows 2000, which like Windows NT will probably have serious incompatibilities with DOS programs, it will be obsolete. The Windows version of RES2DMOD is currently being developed, and hopefully by year 2000 it will join RES2DINV, RES3DMOD and RES3DINV in the Windows universe.