

EmaxAIR

Version 5.60g

User Guide

*If you use EmaxAIR with Maxwell
you will need to run **Maxwell version 5.0** or later.
(HeliTEM or other surveys with Rx ahead of Tx should use **Maxwell 6.0** or later)*



November 2021

Contents

1. INTRODUCTION.....	4
1.1 DESCRIPTION	4
1.2 SURVEY GEOMETRY.....	5
1.3 REFERENCES	6
2. INSTALLATION.....	7
2.1 SOFTWARE	7
2.2 OPERATING SYSTEM ENVIRONMENT.....	8
2.3 LICENCE KEY.....	8
3. RUNNING EMAXAIR UNDER MAXWELL	9
3.1 INSTALLATION ISSUES	9
3.2 PROCESSING YOUR DATA	9
3.3 DISPLAYING THE EMAXAIR CONDUCTIVITY DATA	13
3.4 THE CONDUCTIVITY OUTPUT FILES	14
4. RUNNING EMAXAIR IN “STAND-ALONE” MODE	16
4.1 PARAMETERS	16
4.2 DATA UNITS.....	25
4.3 NORMALISATION.....	26
4.4 ARBITRARY WAVEFORM CHECKS	26
4.5 RATE-CONTROLLING FACTORS	26
4.6 MAXIMUM CONDUCTIVITY	26
4.7 THE C-SHARPENING PROCESS (ISHARP=2).....	26
4.8 INPUT DATA FORMAT	27
4.9 NOTE CONCERNING THE VTEM WAVEFORM.....	28
4.10 RUNNING	28
4.11 THE OUTPUT FILES	29
5. SAMPLE DATA.....	32
5.1 SAMPLE DATA – BULL CREEK	32
6. SUPPORT	33
7. APPENDICES	34
7.1 CHOOSING SDMIN0	34
7.2 RECIPROCITY	35
7.3 USING THE CORRECT HEIGHT FOR TEMPEST SURVEYS	36
7.4 THE EFFECT OF “SHARPENING”.....	37
7.5 C-SHARPENING (ISHARP=2) EXAMPLE AND USAGE GUIDELINES	38
7.6 CDI OUTPUT DATA USE IN VPVIEW	40
7.7 SHARPENING COMPARISON: ISHARP = 1 AND ISHARP = 11	43

Licence

EmaxAIR is a licenced software product to be used in accordance with the terms and conditions of your Licence Agreement with Fullagar Geophysics Pty Ltd.

Running EmaxAIR

EmaxAIR runs on IBM compatible machines. Two modes of operation are possible;

The simplest mode is *stand-alone* which runs from a Command Window command line and requires the field data to be in a text file with free-format columns.

The second mode runs EmaxAIR through the *Maxwell™* e/m modelling software interface developed by ElectroMagnetic Imaging Technology (EMIT) in Perth, Western Australia. Maxwell will read a wide variety of data formats, and provides a graphical display of the conductivity-depth output data.

System Requirements

Windows 7 or later.

(Windows 2000, XP, Vista : may run, but are no longer supported)

The program is a 32-bit executable
which will run on either 32-bit or 64-bit machines.

If you use EmaxAIR through Maxwell™ then you will require **Maxwell v5.0** or later.

If you want use Maxwell to process HeliTEM or other surveys with Rx *ahead of* Tx then it is recommended to use **Maxwell v6.0** or later; this will avoid the need to set up the processing using “reciprocity” (i.e. by treating Tx as Rx, and Rx as Tx).

See also the Maxwell system requirements on the EMIT web site.

1. Introduction

1.1 Description

EmaxAIR calculates conductivity versus depth pseudosections from the transient electromagnetic (TEM) data of various airborne EM systems. Conductivity-depth pseudosections are a convenient form of presentation of EM profiles for first-pass interpretation. A number of schemes have been devised for conductivity-depth imaging (CDI) of airborne EM data. EmaxAIR uses an adaptation of a maximum current (Emax) algorithm originally developed for coincident loop and in-loop ground TEM by Fullagar (1989), and later extended to fixed loop and Slingram TEM by Fullagar & Reid (1992) and Reid & Fullagar (1998).

The Emax transformation proceeds in two stages: (1) off-time data are first converted to apparent conductivity, and (2) the depth assigned to each delay time is the depth of the induced current maximum in a half-space with conductivity equal to the apparent conductivity at that time.

In the context of depth conversion methods it is easy to confuse *physical* currents and *image* currents. A physical current (“smoke ring”) is the real flow of charge carriers in the ground; an image current (“current filament”) is a mathematical abstraction which replicates the magnetic field on the surface. The physical current maximum, $|\mathbf{E}|_{\max}$, travels down into a half-space along a straight line path at an angle of approximately 30° , whereas the image current filament travels in a similar manner but more steeply at about 47° . This is so because the “equivalent current filament” which has an infinite current density must always be deeper than the maximum of the actual distributed current system. The consequence of this is that depth conversion methods based on image currents will inherently overestimate penetration depths. The depth conversion method used in EmaxAIR pertains to physical currents.

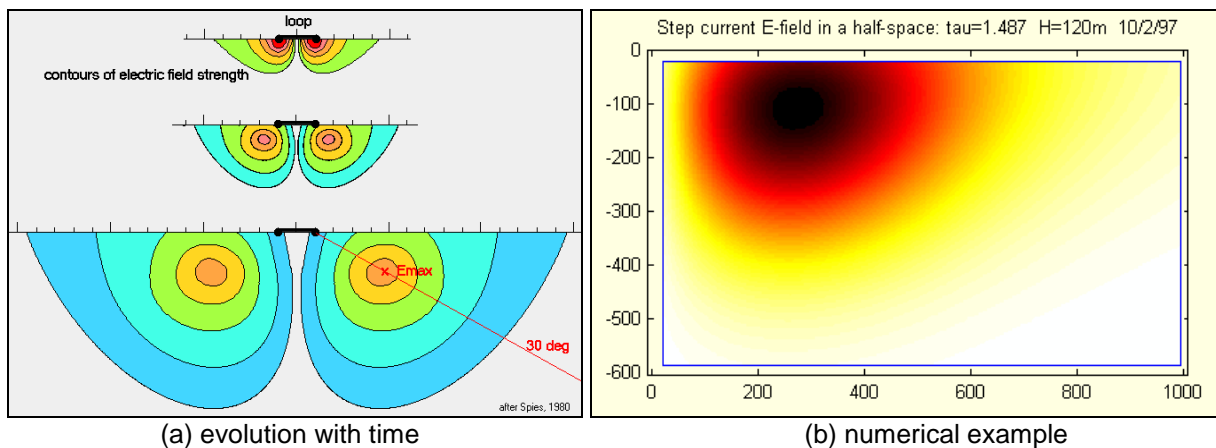


Figure 1 - Secondary physical currents

The advantage of the Emax transformation is that, given its reliance on apparent conductivity, it is readily adaptable to a wide variety of TEM data. The disadvantage is that apparent conductivity is not unique, nor always defined. In practice the non-uniqueness rarely poses difficulties for transformation of airborne EM because the alternative apparent conductivity is usually too extreme to be considered geologically plausible.

The purpose of EmaxAIR’s conductivity-depth processing is to quickly and reliably transform raw data into a useful form for presentation of conductivity at a true depth scale, and to allow for a fast initial interpretation of the data.

1.2 Survey Geometry

EmaxAIR is able to process TEM data from various airborne e/m systems.

	X-comp	Z-comp	B-field	dB/dt
Aerotem	-	yes	-	yes
Geotem	yes	yes	yes	yes
Helitem [*]	yes	yes	yes	yes
Hoistem	-	yes	-	yes
Questem	yes	yes	-	yes
Reptem	-	yes	-	yes
Skytem	yes	yes	-	yes
Spectrem	yes	yes	yes	-
Tempest	yes	yes	yes	-
VTEM	yes	yes	yes	yes
XTEM	-	yes	-	yes

As airborne systems have evolved the number of possible configuration options has increased significantly. The summary above is not a comprehensive list of EmaxAIR's ability to process data from all of the various systems and their variants available today.

[*] HeliTEM is a good example. The original *HeliTEM 30A (2008)* was a half-sine waveform system with the Rx above and ahead of the Tx. The later *HeliTEM 30C* and *HeliTEM 35C (2014)* systems used an Rx at the centre of the Tx and a "MultiPulse" waveform that incorporated both a high moment half-sine pulse and a low moment square pulse. The *HeliTEM² (2018)* system uses an Rx at the centre of the Tx and a square waveform.

When preparing to run EmaxAIR you will need to consider the particular airborne system and configuration, as well as the data type (dB/dt or B-field), when setting up the parameter file for processing a specific survey; not every possible combination of these system parameters may be able to be processed by EmaxAIR at present. For example, there is no single parameter file that will process any and all "HeliTEM" surveys; the parameter file required will depend on the particular HeliTEM configuration and data type used for the survey.

Table 2 and **Table 3** give more detailed information on some of the parameters needed for particular configurations and data types used by different airborne systems.

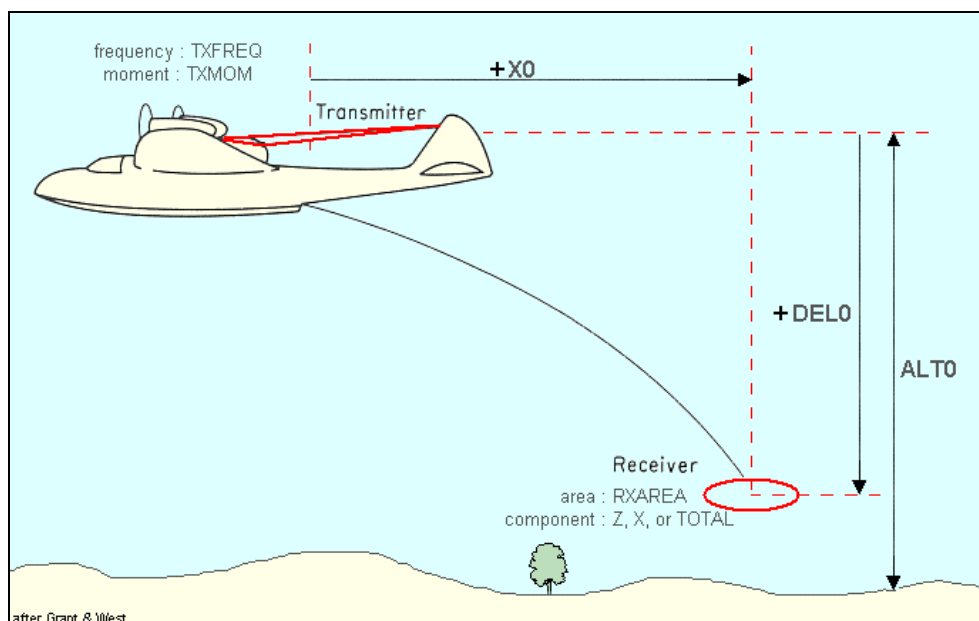


Figure 2 – Generalised survey geometry.

(note: "X0" is set to the effective loop radius of the Tx coil for central loop systems like Hoistem & VTEM)

1.3 References

- Fullagar, P.K. (1989)
Generation of conductivity-depth pseudo-sections from coincident loop and in-loop TEM data.
Expl. Geophys., 20, 43-45.
- Fullagar, P.K., and Reid, J.E. (1992)
Conductivity-depth transformation of fixed loop TEM data.
Expl. Geophys., 23, 515-519.
- Reid, J.E., and Fullagar, P.K. (1998)
Conductivity-depth transformation of Slingram transient electromagnetic data.
Expl. Geophys., 29, 570-576.
- Fullagar, P.K., and Reid, J.E. (2001)
Emax conductivity-depth transformation of airborne TEM data.
ASEG 15th Geophysical Conference and Exhibition, August 2001, Brisbane.
- Christensen, N.B. (2002)
A generic 1-D imaging method for transient electromagnetic data.
Geophysics 67, 438–447.
- Fullagar, P.K., and Pears, G. (2010)
High Resolution Conductivity Depth Transformation of TEM Data.
ASEG Extended Abstracts, 2010:1, 1-4.
- Fullagar Geophysics Pty Ltd
Emax User Guide

2. Installation

2.1 Software

There are two licence types available.

- A **registry-key** licence. These licences are locked to a single computer and can be issued immediately through an exchange of e-mails. To enable a licence key to be generated you will need to send us your computer's *MAC address* (also known as the *physical address*). This can be found by running the command "ipconfig/all" in a Command Window and noting the physical address of the *Ethernet or WiFi adapter Local Area Connection*. Often multiple physical addresses will be listed; if unsure which one to send, you can download the licence utilities tool "GET_Ethernet_Physical_Address.zip" from www.fullagargeophysics.com and send us the output file it produces.
- A **dongle** licence. We have to ship you the dongle before you can start to use EmaxAIR. These licences are more convenient if you want to install EmaxAIR on more than one computer. You can freely install EmaxAIR on as many computers as you wish, but EmaxAIR will only run on the particular computer which has your dongle attached.

Installation is via a *setup* executable file which can be downloaded from www.fullagargeophysics.com.

You will need to download the setup file that matches your licence type (registry or dongle).

When you run the EmaxAIR software setup file you will need to enter a **setup password**. Please contact us to get the current setup password.

If you are installing the dongle version of EmaxAIR for the first time, before inserting the dongle: download the "run-time setup for dongles – zip" file, unzip and install.

A typical install commences like this;

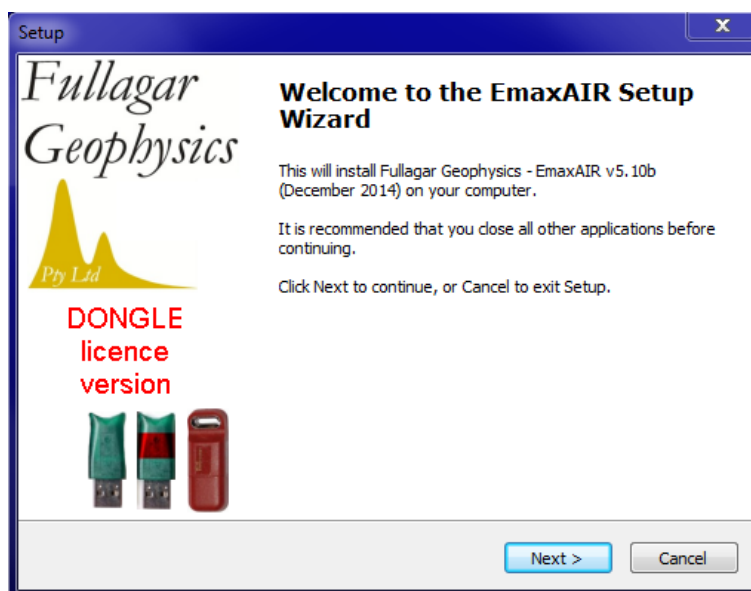


Figure 3 – Installation of EmaxAIR software

Files are installed into the following directory (which is created if necessary);

32-bit operating system C:\Program Files\Fullagar\EmaxAIR

64-bit operating system C:\Program Files (x86)\Fullagar\EmaxAIR

To uninstall, either run the executable (usually named *unins000.exe*) that is stored in the program directory, or use Windows Control Panel (under Programs and Features, or Add/Remove Programs on older systems).

2.2 Operating system environment

For convenient *stand-alone* operation a batch file (EmaxAIR.bat) is included in the program folder

32-bit operating system C:\Program Files\Fullagar\EmaxAIR

64-bit operating system C:\Program Files (x86)\Fullagar\EmaxAIR

and this program folder is automatically added to the operating environment PATH during installation.

To start EmaxAIR in stand-alone mode simply open a Command Window in your working folder and run the command **EmaxAIR** at the prompt. If the operating system environment has been set correctly then EmaxAIR should begin running.

2.3 Licence Key

Your licence is set up separately to the installation of EmaxAIR.

If you installed the version of EmaxAIR that uses a registry licence then we will email you a “.reg” licence file. This attachment will usually arrive with a different filename extension (.txt for example) to prevent internet security software from automatically quarantining the attachment. The attachment should be saved to a temporary folder on disk, unzipped if necessary, renamed to *.reg and double-clicked. This adds the licence information to your computer’s registry; you will be prompted for permission to modify the registry.

You cannot move a registry licence to another computer; the licence remains locked to a specific computer.

If you have installed the version of EmaxAIR that uses a dongle then we will need to ship a dongle to you.

You can install the dongle version of EmaxAIR on multiple computers. The dongle can be moved between computers as required, however EmaxAIR will only run on the computer which has the dongle attached.

3. Running EmaxAIR under Maxwell

3.1 Installation issues

Access to “EMAX_AIR.DLL” is required for Maxwell to process data. Maxwell will normally search for it in the following sequence;

1. In the Maxwell program files folder.
2. In the EmaxAIR program files folder.
3. Somewhere in the PATH.

The first version of the DLL found is the one that Maxwell will use. Be aware that if you have some old versions of this DLL on your computer there is a possibility that Maxwell will find the wrong one first and use it instead of the latest one. To guard against this possibility you should do one of the following;

- (a) Install or re-install EmaxAIR **after** installing Maxwell. The EmaxAIR setup looks for a Maxwell program files folder and, if found, places a copy of the DLL in there.
- (b) Manually copy the latest DLL from the EmaxAIR program files folder into the Maxwell program files folder.

3.2 Processing your data

Load your data into Maxwell as you would normally do.

Display the Line Editor window by doing one of the following (Figure 4);

Either select **Edit and Process Lines** under the **Data/Preferences** pull-down menu, or click the **Line Editing** icon on the toolbar.

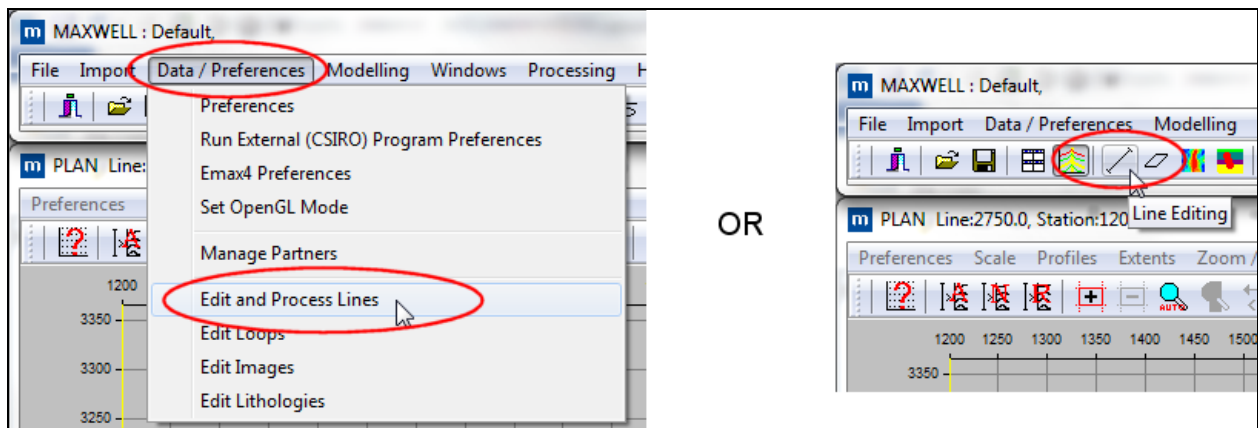


Figure 4 - Starting the Line Editor.

In the Line Editor window (**Figure 5**) select the line or lines you wish to process (yellow highlights).

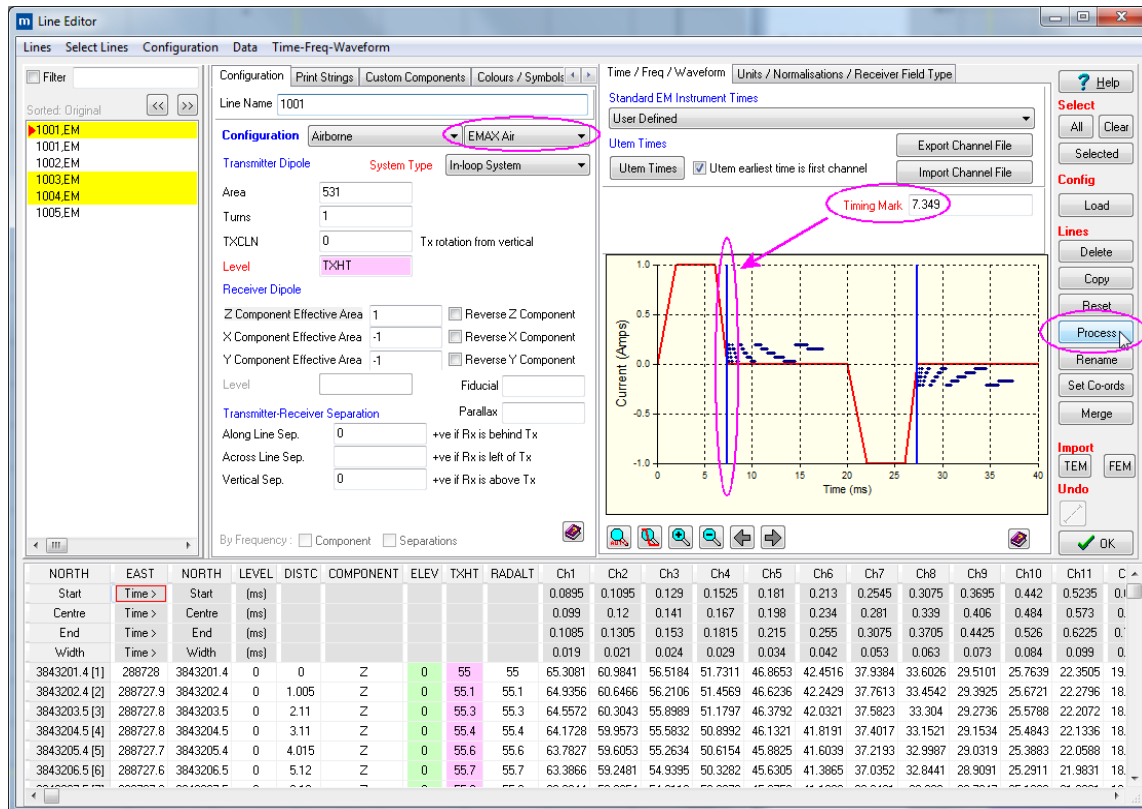


Figure 5 - Line Editor window.

Set the configuration to the correct survey type, and select “EmaxAIR”.

Set values for the parameters: those with **red** titles are mandatory, while **orange** are optional and **black** are not relevant. Note too that certain parameter keywords settings, eg. Units, will also affect the relevance (colour) of other parameter keywords.

Transmitter Dipole Level cell: For EmaxAIR these cell values should be ground clearance values, i.e. metres above the ground surface (ELEV/DTM column/value), rather than absolute heights.

Waveform, timing and window channels: EmaxAIR processes off-time data only, i.e. after the cessation of Tx current flow, except for 100% duty cycle systems (see section 4.1 parameter file, record 14 description). EM channels are positioned using the waveform, timing mark and window times. Adjust either of these (see Maxwell Help) or remove (delete) on-time channels prior to processing.

If required you can set an arbitrary waveform in Maxwell if you are processing data from certain systems. **Figure 6** below shows the waveform graph with the arbitrary pasted waveform in grey on top of the standard waveform plotted in red that it replaces. The pasted waveform takes precedence. To not use it, delete it from the graphic using right mouse button option. Click HELP button below the graphic in Maxwell for additional information on pasted waveforms.

You should also check the parameters under the “Units / Normalisations / Receiver Field Type” tab.

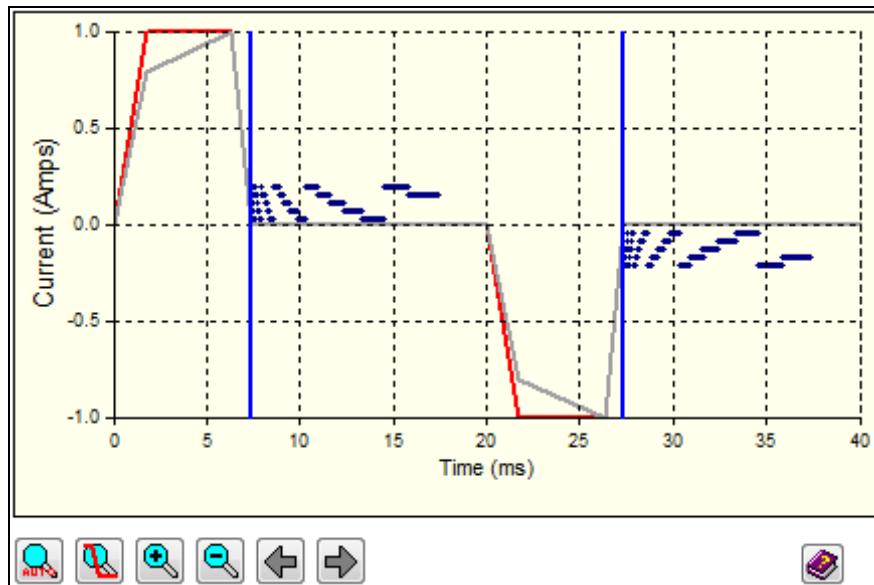


Figure 6 – The grey line shows an arbitrary waveform.

Once you have finished setting parameters in the Line Editor window, click **Process** (see [Figure 5](#)).

A Line Processing window should now appear. In the left panel, open the Electromagnetics branch of the navigation tree structure and click on the **EmaxAIR** option ([Figure 7](#)).

To output EmaxAIR conductivity data to file, tick the **Save To File** checkbox. The default filename for each line has the line {LINE} embedded in it. *If you are processing multiple lines but remove {LINE} from the filename then all lines will be given the same filename so each successive line processed will overwrite the data from the previously processed line. There are other “Character Conversion Strings” apart from {LINE} which can also be used. Click the Help button on the EmaxAIR parameter area for more information.*

Choose the preferred **Output Units** for conductivity.

If the **Create Grid** checkbox is ticked then a grid file will be created *internally* within Maxwell for each selected line. These grids can subsequently be displayed as images in Maxwell's Section Panels of the Profile Window. The default grid name is specified in the same manner as the filename mentioned in the previous paragraph.

If the **Sharpen** checkbox is ticked then the calculated apparent conductivity curve for each station is internally reprocessed to enhance features prior to output. While sharpening will better define good quality anomalies, for poor or noisy data the sharpening process may accentuate unwanted features. So that users are familiar with the effect of sharpening on their data, some trials with and without sharpening are advised before embarking on routine processing of data using this option.

Choose the data **Component** you want to process from the component(s) you have in your data.

Set **Contract Survey Altitude** to the nominal survey Tx loop altitude specified in the flying contract.

Set **Starting Conductivity** to an estimate of the average ground conductivity (S/m) for the area.

Select the **Waveform Type**. Maxwell will attempt to select the best option automatically based on the existing waveform parameters, but it cannot automatically distinguish between all of the asymmetric bipolar options.

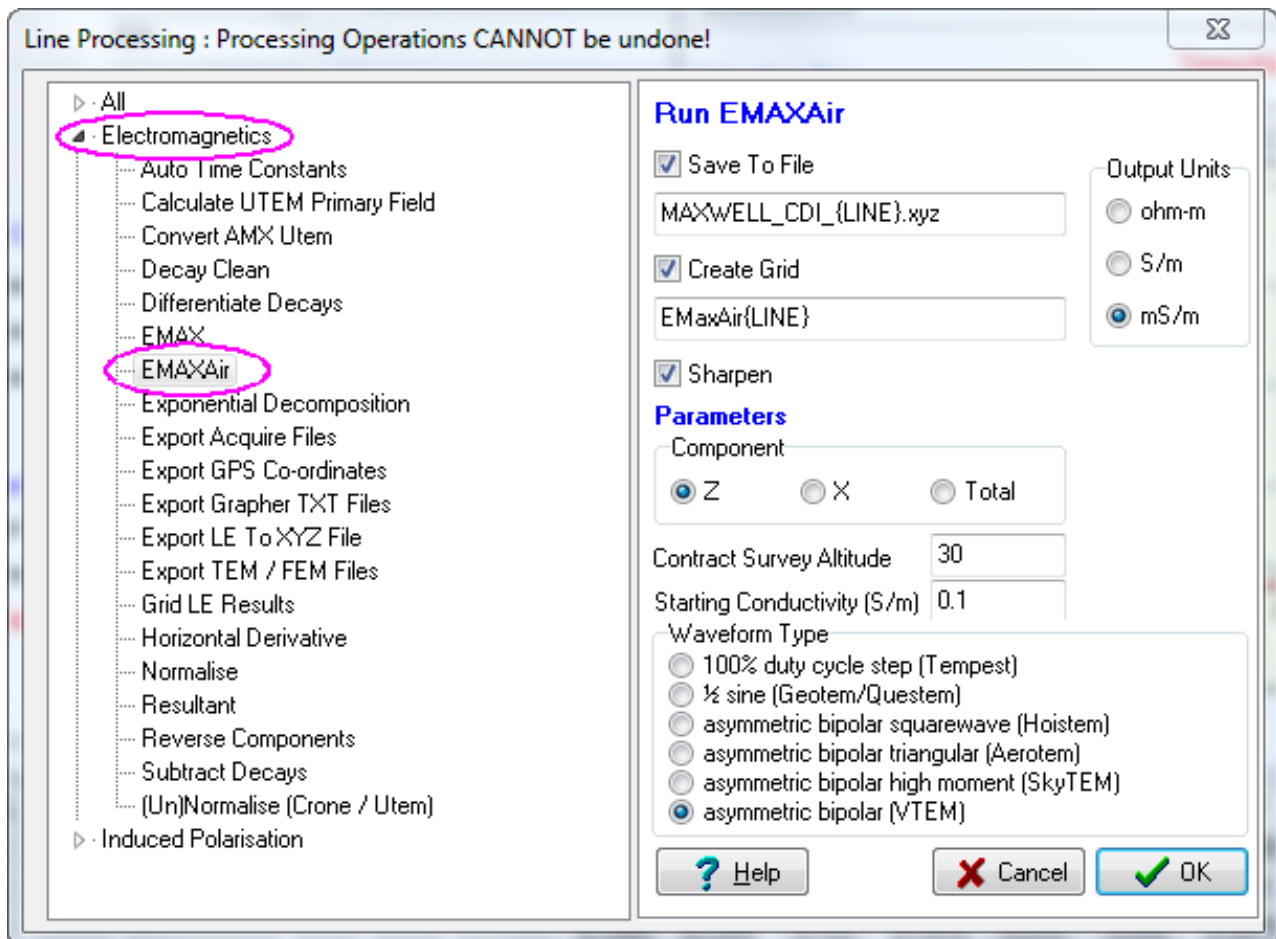


Figure 7 – Selecting the processing options for EmaxAIR.

Click the **OK** button to begin processing the data.

The program may remain unresponsive for some time while processing is in progress.

If you ticked the Create Grid checkbox then once processing is complete, a Grid Setup window (**Figure 8**) is displayed. Unless you need to change parameters, simply click the **OK** button.

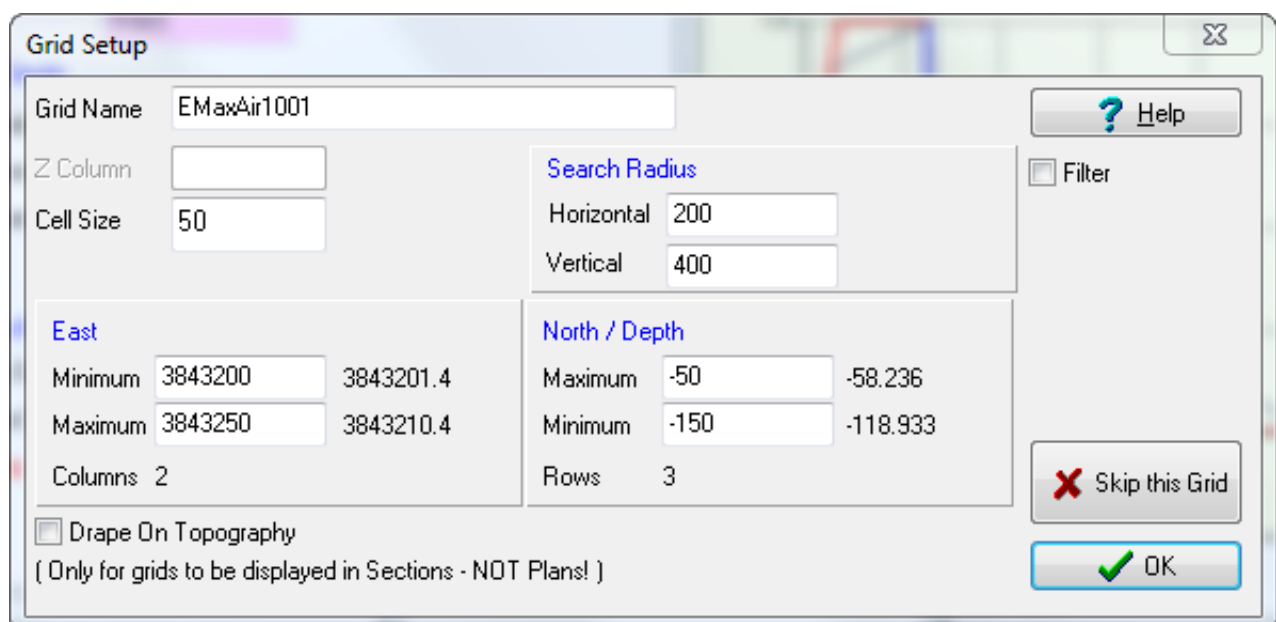


Figure 8 – Grid Setup window.

Once processing is completed the Line Editor window (Figure 5) is once again active. This window can now be closed and the grid(s) displayed in Maxwell's Section Panels.

3.3 Displaying the EmaxAIR conductivity data

Near the top of the **Profile Window's** scrollable Preferences area select **Section Panels** and tick the **Display This Panel** checkbox (Figure 9).

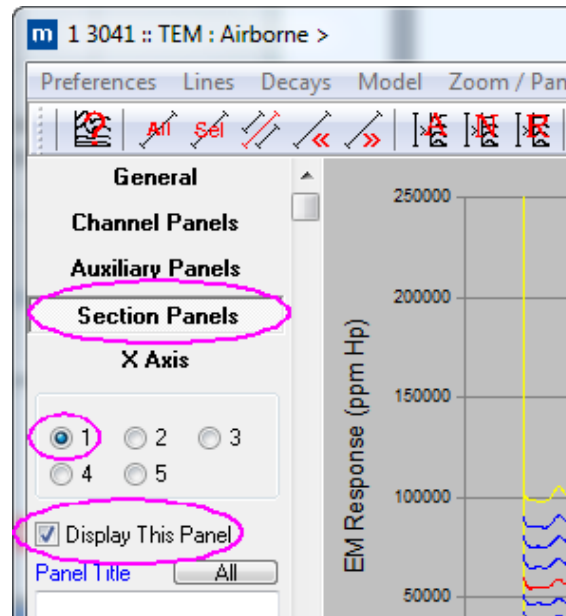


Figure 9 - Profile Window's Preferences area (top part).

Then scroll to the bottom of the Preferences area (Figure 10) and click on the **Image** button. A new Profile Image Select window pops up. Select the image to display. Click **OK**.

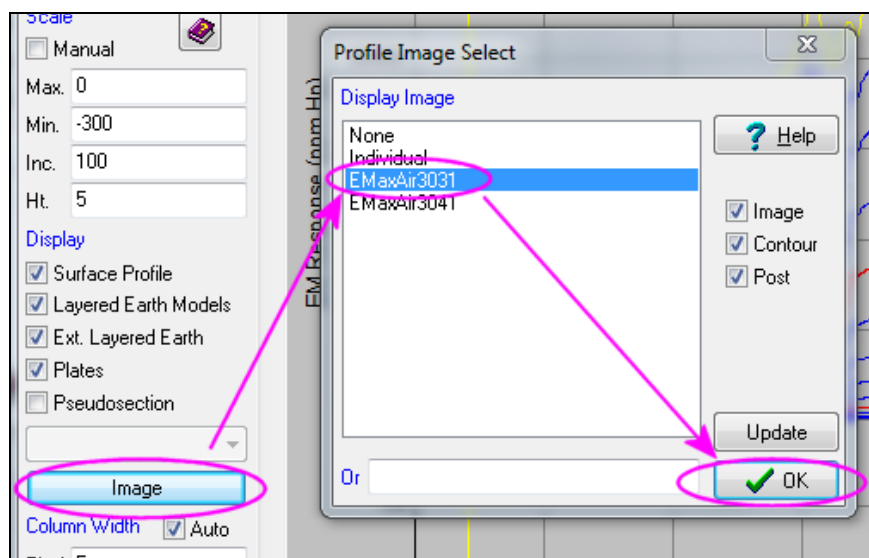


Figure 10 - Profile Window's Preferences area (bottom part), overlain by image selection window.

The displayed image ([Figure 11](#)) is *not necessarily* for the same line of data as the displayed profiles. You should check that the image which you selected for display corresponds to the line for which the profiles are displayed.

To automatically insert the correct grid for multiple line plotting select **Individual** from the list (see [Figure 10](#)) and type the grid name in the **Or** edit box using the {LINE} keyword. (In [Figure 10](#) for example, the images have an “EmaxAIR” prefix before the line name so if you want these individual images to automatically display with their correct profiles as you scroll through different lines, insert *EmaxAIR{LINE}* in the **Or** edit box).

The flight line is shown at the top-left corner of the Profile Window. To change the flight line displayed use either the << or >> button at the top of the window to go to previous or next flight line. Moving the mouse cursor over the image will display position, depth, and conductivity values in the bottom left corner of the Profile Window.

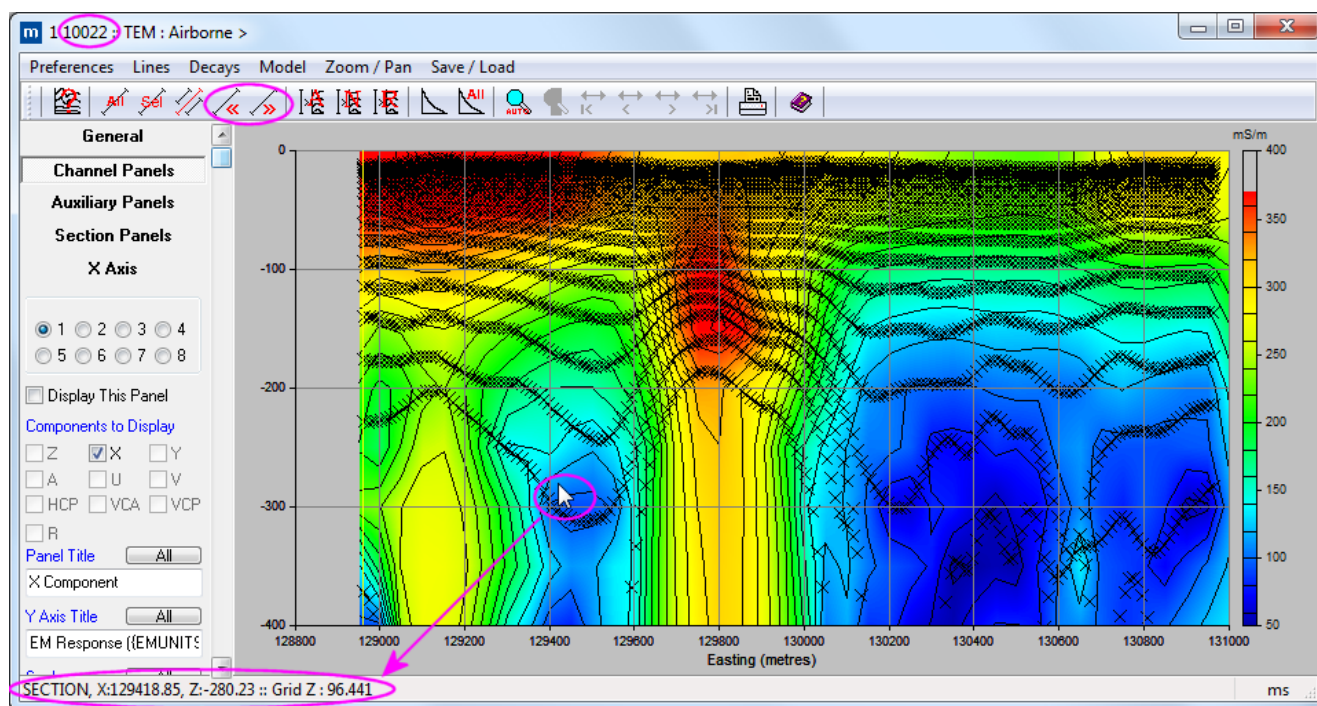


Figure 11 - Profile Window display of EmaxAIR conductivity data.

3.4 The conductivity output files

If the **Save To File** checkbox was ticked ([Figure 7](#)) then for each line selected for processing ([Figure 5](#)) there will be a separate “XYZ” output file written. An example of this **Maxwell output format** is shown in [Figure 12](#).

If for some reason EmaxAIR does not compute a valid apparent conductivity then the values output (running through *Maxwell*) are; depth = -999.25 and conductivity = 999.25. Output data with this depth should be treated as dummies.

East	North	Active Coordinate	Conductivity or Resistivity	Depth (m)	Time (ms)
288728.0000	3843201.4000	3843201.4000	2010.8581	14.3613	0.4840
288728.0000	3843201.4000	3843201.4000	1439.7868	17.5786	0.5730
288728.0000	3843201.4000	3843201.4000	1096.8949	19.3604	0.6820
288728.0000	3843201.4000	3843201.4000	985.9469	21.5305	0.8180
288728.0000	3843201.4000	3843201.4000	815.8330	24.0441	0.9740
288728.0000	3843201.4000	3843201.4000	668.2950	26.7827	1.1510
288728.0000	3843201.4000	3843201.4000	575.5466	30.3988	1.3700
288728.0000	3843201.4000	3843201.4000	498.0216	33.8729	1.6410
288728.0000	3843201.4000	3843201.4000	431.8060	37.8227	1.9530
288728.0000	3843201.4000	3843201.4000	351.0272	42.3085	2.3070
288728.0000	3843201.4000	3843201.4000	297.7294	47.8903	2.7450
288728.0000	3843201.4000	3843201.4000	249.4239	53.7980	3.2860
288728.0000	3843201.4000	3843201.4000	208.6454	60.4436	3.9110
288728.0000	3843201.4000	3843201.4000	176.6968	68.6139	4.6200
288728.0000	3843201.4000	3843201.4000	149.3304	76.6569	5.4950
288728.0000	3843201.4000	3843201.4000	123.4135	87.1920	6.5780
288728.0000	3843201.4000	3843201.4000	76.9088	99.5617	7.8280
288728.0000	3843201.4000	3843201.4000	32.3917	112.9936	9.2450
288727.9000	3843202.4000	3843202.4000	2044.0520	14.2442	0.4840
288727.9000	3843202.4000	3843202.4000	1449.2339	17.5273	0.5730
288727.9000	3843202.4000	3843202.4000	1097.2513	19.2987	0.6820
288727.9000	3843202.4000	3843202.4000	991.2512	21.4533	0.8180
288727.9000	3843202.4000	3843202.4000	819.3457	23.9492	0.9740

Figure 12 – Maxwell's conductivity output file (*column headers have been manually added for clarity*).

Note that these Maxwell output files write DEPTH as POSITIVE DOWN.

4. Running EmaxAIR in “stand-alone” mode

EmaxAIR can be run as a stand-alone application from the command line. The only limitation is that the input data must be available in a free-format type file as described below in [Section 4.8](#).

4.1 Parameters

Parameters are read, record by record, from the parameter file in free format as described in [Table 1](#) below. The user is prompted to enter the *parameter* file name when the program executes. *The actual input data file name is read from the parameter file.*

For convenience a parameter file may contain comments appended to the ends of records containing numeric input parameters; i.e. all records except the first three. The only requirement is that a comment is separated from the last numeric parameter by at least one space. The convention used in example files is to begin comments with an exclamation mark (refer to the supplied sample files).

The parameter file format changed slightly with EmaxAIR v3 and the updated format is detailed in [Table 1](#). The main change was the ability to optionally read the transmitter waveform from an ASCII file which can be specified at the end of the parameter file. The channel time zero-reference point was also changed for most waveform types. To enable backward compatibility with older v2 format parameter files, the v3 parameter files have the special identifier `#v3#` on the first record.

PAR file record	Parameters and Description
	Parameters new in EmaxAIR version 5.60 are highlighted in green
1	#v3# The first record contains just the four characters as shown above. This is an identifier to indicate that the PAR file is in version 3 format. If this record is absent then EmaxAIR treats the PAR file as an older version 2 format which allows for backward compatibility with previous versions of EmaxAIR.
2	TITLE Text to describe the data being processed.
3	DATA FILENAME An ASCII column or GEOSOF “Line header” XYZ format is assumed (see Section 4.8). An arbitrary number of header or comment records are allowed, but only at the beginning of the file. These records are identified by a slash (/) in the first column.
4	NVAR Total number of data columns in the data file. A negative value indicates input data will be read from a Hoistern binary BDB file.
5	iLINE, iX, iY, iTxALT, iDATi, iDATf, iDTXRL, iOFFX, iOFFZ, iTxCrnt, iDEM, iRALT, iDATi2, iDATf2, iDATi3, iDATf3 <i>Note that the parameters shown above should appear on one record in the PAR file, not separated onto three records – they are only shown separated here for illustration purposes while reading the following comments;</i> Parameters 1-6 are mandatory

	<p> iLINE column number containing flightline number. iX column number containing eastings. iY column number containing northings. iTxALT column number containing transmitter altitude (metres above ground surface). iDATi column number of <i>first</i> TEM data window to be processed. iDATf column number of <i>last</i> TEM data window to be processed. (data is either X or Z component, depending on the value of MODE). </p> <p>Parameters 7-16 are optional. They are described in three groups below. If any parameter in a group is defined then all parameters in that same group, plus parameters in all preceding groups, must also be defined. While not mandatory, for clarity it is recommended to enter values for all 16 parameters. Use a dummy value of 0 (zero) for a parameter that is not relevant or not used.</p> <p>Parameters 7-10;</p> <p> iTXRL column number containing RL of the transmitter (m ASL)*. iOFFX column number containing horizontal Tx-Rx offset (m). iOFFZ column number containing vertical Tx-Rx offset (m). iTxCrnt column number containing Tx current (amps). </p> <p>Parameters 11-12;</p> <p> iDEM not used; enter 0. iRALT not used; enter 0. </p> <p>Parameters 13-16;</p> <p>These parameters define the component data columns when Total Field values are to be calculated by EmaxAIR using either $\sqrt{x^2 + z^2}$ or $\sqrt{x^2 + y^2 + z^2}$. In this case the columns for one of the components are defined by parameters iDATi and iDATf (see parameters 5 and 6 above), and the remaining one or two components by the following four parameters. All components defined should each have the same number of data columns.</p> <p> iDATi2 Only required for MODE=0; otherwise leave iDATi2 blank or set to 0. If processing total field computed from the X & Z components, iDATi2 is the column number containing the <u>first TEM window</u> for the vertical (Z) component. If processing total field computed from the X, Y, & Z components, iDATi2 is the column number containing the <u>first TEM window</u> for the transverse (Y) component. </p> <p> iDATf2 Same as iDATi2, but specify the column for the <u>last TEM window</u>. </p> <p> iDATi3 Only required for MODE=0; otherwise leave iDATi3 blank or set to 0. If processing total field computed from the X, Y, & Z components, iDATi3 is column number containing the <u>first TEM window</u> for the vertical (Z) component. </p> <p> iDATf3 Same as iDATi3, but specify the column for the <u>last TEM window</u>. </p> <p><i>The TEM data columns are assumed to be sorted in order of increasing delay time, and the columns for any single component must be in contiguous columns. Data files with up to 200 columns can be read.</i></p> <p><i>*For Hoistem data, TXRL must be calculated prior to running EmaxAIR: $TXRL = GPS_Z - (radaralt / 3.281) + laseralt \text{ (with radaralt in feet)}$</i></p> <p><i>Some systems include on-time channel data (eg. MegaTEM, Aerotem). These channels should <u>not</u> be included when defining the channels for processing.</i></p>
6	<p>LMIN, LMAX</p> <p> LMIN = the <i>minimum</i> survey line number to be processed. LMAX = the <i>maximum</i> survey line number to be processed. </p> <p>The data is assumed to be sorted in order of increasing survey line number. The program terminates as soon as a line number greater than LMAX is encountered.</p>

7	<p>XMIN, XMAX, YMIN, YMAX</p> <p>XMIN, XMAX are the min, max <i>eastings</i> of the area to be processed. YMIN, YMAX are the min, max <i>northings</i> of the area to be processed.</p>
8	<p>IDAT, ConversionFactor</p> <p>IDAT = 1 for normalised dB/dt data IDAT = -1 for dimensional dB/dt IDAT = 2 for normalised B data IDAT = -2 for dimensional B data (refer to Table 2 or Table 3 for data units)</p> <p>ConversionFactor is used to convert the input data into the units required by EmaxAIR. Channel data are multiplied by <i>ConversionFactor</i> prior to processing. If the data units in the input file are not as defined in Table 2 or Table 3 then <i>ConversionFactor</i> should be set to the appropriate factor necessary to achieve this. <i>For example, if for some reason SkyTEM is supplied as nV, then ConversionFactor should be set to 0.001 so that after conversion the unit is μV.</i></p> <p>Default value is 1.</p> <p><i>For some systems both IDAT and an appropriate non-default value of ConversionFactor must be specified. You will also need to account for any normalisations like Tx area and Rx area that may have been applied to the data by setting appropriate values for TXMOM and RXAREA.</i></p> <p>A <u>VTEM</u> example;</p> <p><i>VTEM dB/dt is usually supplied in units of $pV/(A \cdot m^4)$, in which case a ConversionFactor of 10^{-6} is required. VTEM B-field is usually supplied in units of $(pV \cdot ms)/(A \cdot m^4)$, in which case a ConversionFactor of 0.001 is required. Since VTEM data are already normalised with respect to transmitter moment and receiver area, set TXMOM = 1 and RXAREA = 1 in both cases.</i></p> <p>An <u>AeroTEM</u> example with nT/s units;</p> <p><i>AeroTEM dB/dt is usually supplied in units of nT/s, in which case a ConversionFactor of 0.001 is required. Since units of nT/s x 0.001 are equivalent to μV <u>normalised by RxArea</u>, set RXAREA = 1 but keep TXMOM = actual Tx moment.</i></p> <p>Other systems with nT/s units;</p> <p><i>Unlike AeroTEM (ISTEP=-3), other dB/dt systems with data supplied in units of nT/s (ISTEP=0 in Table 2) only require a ConversionFactor of 1. The settings RXAREA = 1 and TXMOM = actual are also used here too.</i></p>
9	<p>NSKIP, POSLAG</p> <p>NSKIP stations skipped between each station processed. Set NSKIP = 0 to process decays at all stations.</p> <p>POSLAG controls the positional lag adjustment. POSLAG = 0 if data coordinates refer to Tx-Rx midpoint. POSLAG = 1 if data coordinates refer to Tx. POSLAG = -1 if data coordinates refer to Rx.</p> <p><i>If POSLAG = 1 or -1, coords. <u>are</u> altered to Tx-Rx midpoint by EmaxAIR. If POSLAG = 0, coords. are <u>not</u> altered (assumed to refer to Tx-Rx midpoint in the data file).</i></p>
10	<p>TXFREQ, TXMOM, RXAREA</p> <p>TXFREQ is the transmitter "fundamental" operating frequency (Hz).</p>

	<p>TXMOM is the transmitter moment (amp.turn.m²). True moment is required when data is dimensional (ie. when IDAT < 0), and the value specified here should take into account any normalisations in the data. Otherwise TXMOM is a dummy parameter (ie. when IDAT > 0).</p> <p>RXAREA is the effective area of the receiver (turn.m²); does not affect results, only the computed value of the primary voltage. The value specified here should take into account any normalisations in the data.</p>
11	<p>PULSE, ISTEP</p> <p>PULSE is the duration of the source pulse, in microseconds. For Helitem / Geotem a perfect half-sine pulse is assumed. For bipolar square wave PULSE is the on-time duration (excluding RON and ROFF). For 100% duty cycle step-current waveform PULSE is a dummy value (e.g. SPECTREM). For other waveforms, PULSE is zero.</p> <p>ISTEP = 1 for 100% duty cycle step-current Slingram (SPECTREM, TEMPEST*). ISTEP = 0 for half-sine Tx waveform Slingram (HELITEM, GEOTEM, MEGATEM). ISTEP = -1 for bipolar square wave central loop (HOISTEM, or similar systems without a specific ISTEP). ISTEP = -3 for triangular waveform central loop (AEROTEM). ISTEP = -4 for bipolar square wave central loop (SKYTEM High or Low Moment) ** ISTEP = -5 for bipolar square wave central loop (VTEM) ** ISTEP = -6 for arbitrary waveform Slingram (dB/dt data only)</p> <p><i>* Be careful when setting up TEMPEST parameters. Data are typically supplied by the contractor as "raw" and "final" varieties. You would normally use the final data for processing. This final data has usually been normalised to 100% duty cycle and 1m² Tx area. Check your survey specifications!</i></p> <p><i>** An arbitrary waveform may also be used.</i></p>
12	<p>MODE</p> <p>MODE = 0 for total field data inversion. (see the six "iDAT" parameters defined on record 5 above).</p> <p>MODE = 1 for horizontal-axis receiver. (normalised w.r.t. primary horizontal component if data is in ppm, ie. DAT>0)</p> <p>MODE = -1 for horizontal-axis receiver. (normalised w.r.t. total primary field if data is in ppm, ie. IDAT>0)</p> <p>MODE = 2 for vertical-axis receiver. (normalised w.r.t. primary horizontal component if data is in ppm, ie. DAT>0)</p> <p>MODE = -2 for vertical-axis receiver. (normalised w.r.t. total primary field if data is in ppm, ie. IDAT>0)</p> <p>MODE = 22 for vertical-axis receiver. (normalised w.r.t. primary vertical component if IDAT>0)</p> <p><i>MODE and -MODE are equivalent if data are dimensional, ie. if IDAT < 0.</i></p>

	<p>For IDAT>0, the following table summarises the MODE values when data is normalized ppm. For IDAT<0, MODE values 1, -1 are functionally equivalent, and MODE values 2, -2, 22 are functionally equivalent</p> <p>MODE values when data is provided as normalized ppm (IDAT>0) {for example, in some Spectrem surveys}.</p> <table><tr><td>normalising PRIMARY field --></td><td>total</td><td>horizontal along-line</td><td>vertical</td></tr><tr><td>total field data</td><td>0</td><td></td><td></td></tr><tr><td>horizontal along-line component data</td><td>-1</td><td>1</td><td></td></tr><tr><td>vertical component data</td><td>-2</td><td>2</td><td>22</td></tr></table>	normalising PRIMARY field -->	total	horizontal along-line	vertical	total field data	0			horizontal along-line component data	-1	1		vertical component data	-2	2	22
normalising PRIMARY field -->	total	horizontal along-line	vertical														
total field data	0																
horizontal along-line component data	-1	1															
vertical component data	-2	2	22														
13	<p>X0, DEL0, ALT0, ALT0_flag</p> <p>X0 : depends on the type of system flown; - For Slingram type systems it is the notional (survey specification) Tx-Rx horizontal separation (metres), and relative to the flying direction it is; +ve if Tx is ahead of Rx, or -ve if Tx is behind of Rx.</p> <p>- For central loop systems (eg. VTEM, SkyTEM, Hoistem*, and similar) it is the radius of the Tx loop. (May be referred to as alternative name "R0").</p> <p>DEL0** : the notional (survey specification) Tx-Rx vertical separation (metres), and is; +ve if Rx is below the Tx, or -ve if Rx is above the Tx.</p> <p>ALT0*** : the notional (survey specification) Tx altitude (metres height above ground).</p> <p>ALT0_flag : a flag to force processing using ALT0 as a constant Tx altitude, instead of using the variable altitude data contained in data column iTxALT (see record 5 above in this table). This parameter was added in v5.39 to make processing of TEMPEST data easier (see Appendix 7.3).</p> <p>ALT0_flag = 0 (default) uses actual altitude recorded in data column iTxALT. ALT0_flag = 1 processes data with constant Tx altitude ALT0 instead of using the actual altitude recorded in data column iTxALT. RLs are then corrected for output by subtracting the difference {ALT - ALT0}.</p> <p>X0 and DEL0 govern the magnitude of the normalisation voltage, for calculation of ppm values. The actual horizontal Tx-Rx separation for the recorded data is assumed to be X0, unless IOFFX is non-zero (see record 5 above). Likewise, the actual vertical Tx-Rx separation is assumed to be DEL0 unless IOFFZ is non-zero (see record 5 above).</p> <p>*For Hoistem data recorded before early 2002, X0 = 9.79m = effective radius of 301m² Tx coil; for Hoistem data recorded after early 2002, X0 = 10.93m = effective radius of 375m² Tx coil.</p> <p>**Normally for central loop systems such as VTEM and Hoistem DEL0 = 0. However DEL0 <> 0 is still permitted has an Rx that is at a different height to the Tx.</p> <p>*** The "actual" Tx altitude (from radar altimeter) at each station is read from the TEM data file.</p>																
14	<p>T, CHW, PCERR, SDMIN</p> <p>T is the midpoint* time (microseconds) for the TEM window. CHW is the window width (microseconds). PCERR is percent error (%) for the TEM channel (use -1 if not defined). SDMIN is minimum allowable standard deviation (TEM data units) (use -1 if not defined).</p> <p>The program will expect NCHAN = IDATF – IDATI + 1 successive records in the parameter file here (refer to record 5 above), each with a window midpoint time and width.</p>																

	<p><i>* From EmaxAIR v3 the zero-time reference point for window times in the EmaxAIR PAR file is the “cessation of current”, the point on the waveform after the main Tx pulse where the current has fallen to zero. <u>The only exception is for a 100% duty cycle waveform.</u></i></p> <p><i>Depending on the waveform the description varies slightly; for half-sine: the end of the half-sine pulse. for bipolar square: the end of the Tx off-ramp. for triangular: the end of the Tx off-ramp (ie. waveform regarded as just an on- and off-ramp). for an arbitrary waveform : the point where current first returns to zero after the waveform start. for 100% duty cycle step-current : the start of the step.</i></p> <p><i>PCERR and SDMIN values for individual channels defined here take precedence. Where an individual channel’s error parameters are not defined (PCERR = -1), the default values are used, viz. PCERR0 and SDMIN0 defined on record 16+ NCHAN.(see below)</i></p> <p><i>A channel width of 0 (meaning instantaneous recorded voltage) is not valid in this version.</i></p> <p><i>Times may need to have PULSE subtracted from them if the contractor measures times from the start of the pulse (eg. GeoTEM, MegaTEM).</i></p> <p><i>Some systems include on-time channel data (eg. MegaTEM). These channels should <u>not</u> be included when defining the channels for processing.</i></p>
14+ NCHAN	<p>ITMAX, PERT, TOL, IPRINT</p> <p>ITMAX is the maximum number of iterations allowed for determination of apparent conductivity for one time window. <i>Usually 10.</i></p> <p>PERT is the maximum fractional change in the conductivity at each iteration. <i>Usually 0.5.</i></p> <p>TOL controls the convergence condition for cases when the data are not consistent with a homogeneous half-space response; iterations cease if the ratio of perturbation to current conductivity value is less than TOL. <i>Usually 0.01.</i></p> <p>IPRINT controls the written output. If IPRINT = 0, the written output is minimal. <i>Recommended setting is 0.</i> If IPRINT = 1, voluminous details of the run are written to “*.OUT” file.</p>
15+ NCHAN	<p>IINT</p> <p>IINT governs the time sampling interval, DELTA, used for convolution in the half-sine waveform cases (ISTEP=0). DELTA is defined as PULSE/IINT, in microseconds. DELTA need not correspond to the acquisition time sampling interval. A typical value for IINT is 30.</p> <p>IINT is a dummy parameter for step-current systems (ISTEP = 1, -1).</p>
16+ NCHAN	<p>SIG1, SIG1MAX</p> <p>SIG1 is the initial conductivity estimate (S/m) for the <i>first channel</i> at the <i>first station</i>. For other stations, the starting conductivity for the first channel at a station = the apparent conductivity solution for the first channel at the previous station. The starting conductivity for the second and successive channels = the apparent conductivity solution for the previous channel. However, the starting value at a new station is not allowed to exceed SIG1MAX. If ISHARP = 2, SIG1 is the surface conductivity (see record 17+ below).</p> <p>SIG1MAX (S/m) is the maximum permitted starting conductivity at any station. This provides a degree of immunity against non-uniqueness: low signals can be due to extremely high conductivity as well as to low conductivity. If all apparent conductivities appear to be unrealistically high then try a re-run with a</p>

	<p>much smaller SIG1MAX. Conversely, if all apparent conductivities appear to be too low, re-run with a much larger SIG1MAX.</p> <p>Normally set SIG1MAX = SIG1.</p>
17+ NCHAN	<p>PCERR0, SDMIN0, IEDIT</p> <p>PCERR0 is the percentage error assumed for each recorded decay value. The error is regarded as the standard deviation of a Normal random variable. Convergence is presumed when the normalised squared misfit between the calculated and observed data value for a delay window is less than or equal to unity, this being the expected value for the corresponding chi-squared random variable.</p> <p>SDMIN0 is the minimum allowable standard deviation (TEM data units). <i>Express as ppm or dimensional units according to the value of IDAT.</i> Percentage error can become unreasonably small at late times, as the signals decay. SDMIN is an absolute error, which can be regarded as the noise floor. Also see Section 7.1 for more comments.</p> <p>IEDIT controls editing of depth reversals in the output data. If the Rx decay signal is not monotonically decreasing with time then it will cause depths to reverse and get shallower, instead of deeper, with later delay times. Typically these reversals occur at late times when noise becomes significant, so the default is to reject remaining data in the decay once a reversal is detected. However there can occasionally be a reversal at very early times resulting in most or all of the decay being rejected. The cause of such an early time reversal may be a dubious instrumentation signal, or it may be due to an otherwise unknown cause. In this situation you will likely want to disable the depth reversal editing in order to prevent the removal of the intermediate and later channels' data.</p> <p>IEDIT = 0 do not remove depth reversals. IEDIT = 1 remove depth reversals (default)</p> <p><i>PCERR0 and SDMIN0 are used as default values when individual channel PCERR and SDMIN are not defined at record 14 above.</i></p>
18+ NCHAN	<p>ISHARP, ITSHEET, OutputFmt, NUM_SPLIT</p> <p>ISHARP = 0 : no "sharpening" is applied.</p> <p>ISHARP = 1 : original apparent conductivities are treated like conductances, and are differentiated to produce a final "sharpened" apparent conductivity section.</p> <p>ISHARP = 11 : a modified version of ISHARP = 1. This option is often better at handling some of the data peculiarities that can generate artefacts in the CDI data; for example, it is less prone to vertical conductivity offsets when the first acceptable channel in the CDI is earlier or later than at adjacent stations. Solutions for ISHARP = 11 tend to be slightly "tighter" and shallower than for ISHARP = 1.</p> <p>ISHARP = 2 : original apparent conductivities are treated like inner products of the true conductivity with the linear sensitivity functions of Christensen (2002). A simple inversion yields a "C-sharpened" estimate of true conductivity vs. depth. This is a more aggressive sharpening option than either ISHARP=1 or 11. (requires NUM_SPLIT; see below).</p> <p>ITSHEET = 0 : homogeneous halfspace model for conductivity calculation (value of 0 is for normal usage).</p> <p>ITSHEET = 1 : thin sheet model for conductivity calculation (use this value <i>only for Hoistern</i>, if desired).</p>

	<p>OutputFmt is used to control which of multiple possible output formats are created.</p> <p>There are four options, and each option has a numeric flag associated with it;</p> <p>option A, flag = 1 : standard “CDI” format.</p> <p>option B, flag = 2 : Geosoft XYZ format – with Line headers; one output file per flightline.</p> <p>option C, flag = 4 : Geosoft XYZ format – with flightline column but <i>no</i> Line headers.</p> <p>option D, flag = 8 : Geosoft XYZ format – suitable for array channel import to Oasis Montaj.</p> <p>Set OutputFmt equal to the <u>sum of the flags</u> that correspond to the output formats you require. For example to output three files in formats A,C,D set OutputFmt to a value of 1 + 4 + 8 = 13. To output all formats set OutputFmt to 15.</p> <p>NUM_SPLIT is required when ISHARP = 2.</p> <p>This is the number of extra layers to be inserted between the ground surface and the depth assigned to the earliest processed channel.</p> <p>Normally a maximum value of 10 is allowed. Although not recommended, this limit can be overridden in special circumstances by specifying a negative value for NUM_SPLIT; for example specifying -15 will be processed as +15.</p> <p>If not defined in the PAR file it will default to 0.</p> <p>See section 7.5 C-sharpening (ISHARP=2) example and usage guidelines for a fuller description of NUM_SPLIT usage.</p> <p><i>A maximum conductivity value of 10 S/m is enforced if sharpening is used, i.e. ISHARP = 1 or 2.</i></p>
19+ NCHAN	<p>IHC</p> <p>IHC is a switch for height-corrected output data. Adjusted data values are computed at a uniform ground clearance, with the Tx at the notional survey altitude, ALT0.</p> <p>Height-corrected data are written to a separate output file.</p> <p>IHC = 0 : no height-corrected data output.</p> <p>IHC = 1 : yes, height-corrected data output.</p> <p>IHC = -1 : yes, height-corrected data output : written in Hoistern binary BDB format.</p> <p><i>Output data units are always those defined by IDAT.</i></p> <p><i>Where a value of ConversionFactor (see parameter record 8) was used to convert the units during data import, the original input data units will be different to the output data units.</i></p> <p>The height correction is intended to suppress the effect of altitude variation as a preparatory step for generation of "time channel maps", i.e. it is purely intended to improve the interpretability of "raw" data display. <i>EmaxAIR accounts for the survey height variation explicitly when computing the apparent conductivity, whether or not the height-correction option is turned on.</i></p>
20+ NCHAN	<p>RON, ROFF</p> <p>RON = turn-on ramp time (microseconds).</p> <p>ROFF = turn-off ramp time (microseconds).</p> <p>These parameters are only relevant for systems using a bipolar square or a triangular waveform; they are treated as dummy parameters for other systems.</p> <p>For Aerotem, RON = ROFF is half the duration of the triangular pulse.</p>
anywhere after the “RON ROFF” record	<p>#WAVEFORM# <filename></p> <p><filename> is the name of a file containing the points on an arbitrarily defined waveform.</p> <p><i>THIS RECORD IS OPTIONAL.</i></p> <p><i>If it is present then the standard waveform defined above by ISTEP, RON, ROFF will be</i></p>

	<p><i>ignored and the arbitrary waveform used instead.</i></p> <p>The file should contain two columns separated by spaces or a comma; Time (seconds) and Current (normalised to a maximum value of 1). For example</p> <pre> 0.000000 0 0.000500 0.4 0.000900 0.38 0.001350 0.69 0.001700 0.66 0.002150 0.83 0.002550 0.80 0.003000 0.88 0.003350 0.85 0.003850 0.92 0.004200 0.89 0.004700 0.96 0.005000 0.93 0.005500 1.00 0.005900 0.96 0.006050 0.99 0.007349 0 </pre> <p>A Maxwell “.mcg” configuration file can also be specified (<i>although EMIT discourage this as they do not guarantee that the .mcg file format will remain unchanged</i>). If specified then EmaxAIR will attempt to extract an arbitrary waveform from the data in the .mcg file.</p> <p>To avoid unnecessary computations due to excessive waveform sample points, two automatic checks are performed when an arbitrary waveform is used. These checks are described in section 4.4 below.</p>
anywhere after the “RON ROFF” record	<p>#ROTATE# DEC, XREF, YREF, IADD_LOC</p> <p>Rotate input coordinates from survey grid to local grid prior to processing and output.</p> <p><i>THIS RECORD IS OPTIONAL.</i></p> <p>DEC = flight line bearing (declination) clockwise from survey grid north. XREF = survey grid reference point Easting about which to rotate. YREF = survey grid reference point Northing about which to rotate. IADD_LOC = add XREF,YREF back onto local coordinates after rotation. 0 = no, 1 = yes</p>

Table 1 – Parameters used in .PAR file for stand-alone processing.

4.2 Data Units

EmaxAIR expects sensor data to be supplied in specific data units. These are generally the data units native to the airborne system used. In most cases the required ConversionFactor is 1, however in some situations the ConversionFactor is *not* 1 for native data units as shown in the table below.

If your data units are not as shown in the table below then you should vary the ConversionFactor accordingly. (refer to record 8 in table in [Section 4.1](#) for explanation of ConversionFactor).

The [Table 2](#) and [Table 3](#) show expected data units for dB/dt and B-field systems respectively, as well as the parameter settings that are generally needed.

dB/dt system	supplied data units	IDAT	ConversionFactor	ISTEP	Tx Moment (Am ²)	RxArea (m ²)
Aerotem	nT/s	-1	0.001	-3	actual	1
Geotem	nT/s	-1	1	0	actual	1
Geotem	pV/m ²	-1	0.001	0	actual	1
Geotem	ppm	+1	1	0	1	1
Helitem *	nT/s	-1	1	0	actual	1
Helitem *	nT/s	-1	0.001	-1	actual	1
Hoistem	μV	-1	1	-1	actual	actual
Questem	nT/s	-1	1	0	actual	1
Questem	ppm	+1	1	0	1	1
Reptem	μV	-1	1	-1	actual	actual
SkyTEM Lo Mom	μV	-1	1	-4	actual	actual
SkyTEM Hi mom	μV	-1	1	-4	actual	actual
SkyTEM Lo Mom	pV/(A.m ⁴)	-1	0.000 001	-4	1	1
SkyTEM Hi mom	pV/(A.m ⁴)	-1	0.000 001	-4	1	1
VTEM	pV/(A.m ⁴)	-1	0.000 001	-5	1	1
XTEM	μV	-1	1	-1	actual	actual
Slingram systems	μV	-1	1	-6	actual	actual

Table 2 – Data units for dB/dt systems.

B-field system	supplied data units	IDAT	ConversionFactor	ISTEP	Tx Moment (Am ²)	RxArea (m ²)
Geotem	pT	-2	1	0	actual	1
Helitem *	pT	-2	1	0	actual	1
Spectrem	ppm	+2	1	1	1	1
Tempest	fT/(A.m ²)	-2	0.001	1	1	1
VTEM	pV.ms/(A.m ⁴)	-2	0.001	-5	1	1

Table 3 - Data units for B-field systems.

* Beware! “*HeliTEM*” has had various configurations since its inception. You need to use the correct set of EmaxAIR parameters for the particular configuration; Rx ahead or central? Halfsine or square pulse? “Multipulse” (high moment halfsine plus later low moment square pulse)? Wrong EmaxAIR settings will likely produce no output.

4.3 Normalisation

Knowing the normalisation convention used is critical when transforming ppm data;

- Is the "primary" used for normalisation of the B-field or dB/dt?
- Is the primary field amplitude proportional to maximum Tx current or to current range [max-min]?
- Are the data normalised by total field or by one of the components?
- If by a component, which one?

Unfortunately, a plain English definition of the normalisation convention is not usually included in the header file. EmaxAIR will often invert quite happily, even if the assumed normalisation does not tally with actuality.

4.4 Arbitrary Waveform checks

To avoid unnecessary computations due to excessive waveform sample points, two automatic checks are performed when an arbitrary waveform is used;

- (a) At the beginning or end of the waveform, any sample points which have normalised amplitudes less than 0.01 are eliminated.
- (b) If two adjacent sample points anywhere in the waveform are separated by less than 1 microsecond then the sample point with the lowest normalised amplitude is eliminated. If the separation involves the very first or the very last sample point in the waveform then that sample is always retained (even if it's amplitude is lower) and the second or second-last point [respectively] is eliminated instead.

4.5 Rate-controlling factors

Speed can be increased in the following ways:

- Set the expected error, controlled by PCERR and SDMIN, high; the acceptable data fit will be relaxed accordingly.
- Increase NSKIP, to skip over more stations.
- Invert the x- or z-component, not total field.
- Reduce ITMAX, the maximum number of iterations. This may mean a more sparsely populated CDI section (i.e. fewer apparent conductivities).
- Set IPRINT to zero, to suppress non-essential output.
- For Geotem, MegaTEM, and Questem, increase the time sampling interval by reducing IINT, the number of time intervals spanning the transmitter pulse.
- Increase TOL.

4.6 Maximum conductivity

A maximum value of 10 S/m is imposed if sharpening is applied, i.e. if ISHARP = 1.

4.7 The C-sharpening process (ISHARP=2)

See Fullagar & Pears (2010) for a detailed description of the C-sharpening process. The conclusions from that paper follow here;

An existing CDI algorithm, based on apparent conductivity, has been modified to provide higher resolution conductivity depth sections. The apparent conductivity versus depth curve can be regarded as a smoothed version of the true conductivity. Mathematically, the smoothing can be represented as depth integrals of the true conductivity weighted by Frechet kernels. The Frechet kernel at each time can be approximated as a linear function, decreasing from a maximum value at the surface to zero at the depth of penetration. For a layered model, the integral for each delay time reduces to a weighted summation of the true conductivities. Therefore, given apparent conductivities from the original CDI algorithm, the true conductivities can be

estimated via solution of a system of linear equations. The conductivity with minimum structure is sought, subject to an acceptable fit to the apparent conductivities.

The C-sharpened CDI is generated very quickly, and can be regarded as an approximate 1D inversion section. Although originally derived in the context of central loop B-field TEM, the methodology has been applied successfully to dB/dt data and to slingram systems. This has been illustrated via synthetic and field data examples. C-sharpening of synthetic data yielded a model bearing a close resemblance to the true conductivity. C-sharpening of TEMPEST and VTEM data provided an enhancement of detail in the CDI section.

4.8 Input data format

The input data file needs to be in free-format. This means that each column of data must be separated from the next column of data either by at least one blank space, or by a comma. There must be the same number of values on every data record; asterisks are used to indicate missing or dummy channel data values.

Geosoft XYZ format files with embedded "Line" headers are allowed. If a data *column* containing the flight line number is also present then specify that column number using the parameter **iLINE** (see record 5 in table in [Section 4.1](#)), but if a flight line data *column* does not exist set **iLINE** to 1. Note that if the file contains both Line headers and a flight line data column, the Line headers take precedence.

Header records are permitted at the start of the data file (before any data records). The *first* character on a header record must be a forward (/) or back (\) slash.

Data is assumed to be in order of increasing flightline number.

Two examples of input data files are shown in [Figure 13](#) and [Figure 14](#).

/ column 1	2	3	4	5	28	29
/ line	NOTUSED	east	north		ch19	ch20
0.1002100E+05	0.6602000E+03	0.1265549E+06	0.1326312E+06	0.1022281E-03	0.3998170E-04	
0.1002100E+05	0.6604000E+03	0.1265654E+06	0.1326382E+06	0.9798150E-04	0.3946690E-04	
0.1002100E+05	0.6606000E+03	0.1265759E+06	0.1326452E+06	0.9396660E-04	0.3883410E-04	
0.1002100E+05	0.6608000E+03	0.1265864E+06	0.1326527E+06	0.9030080E-04	0.3809010E-04	
0.1002100E+05	0.6610000E+03	0.1265969E+06	0.1326597E+06	0.8749130E-04	0.3773190E-04	
0.1002100E+05	0.6612000E+03	0.1266074E+06	0.1326667E+06	0.8564570E-04	0.3780120E-04	
0.1002100E+05	0.6614000E+03	0.1266179E+06	0.1326737E+06	0.8404640E-04	0.3757290E-04	
0.1002100E+05	0.6616000E+03	0.1266283E+06	0.1326807E+06	0.8264540E-04	0.3721840E-04	
0.1002100E+05	0.6618000E+03	0.1266388E+06	0.1326877E+06	0.8147810E-04	0.3676810E-04	
0.1002100E+05	0.6620000E+03	0.1266493E+06	0.1326947E+06	0.8052660E-04	0.3630220E-04	
0.1002100E+05	0.6622000E+03	0.1266597E+06	0.1327017E+06	0.7976590E-04	0.3590450E-04	
0.1002100E+05	0.6624000E+03	0.1266701E+06	0.1327087E+06	0.7913320E-04	0.3561930E-04	
0.1002100E+05	0.6626000E+03	0.1266806E+06	0.1327157E+06	0.7856480E-04	0.3552540E-04	
0.1002100E+05	0.6628000E+03	0.1266910E+06	0.1327227E+06	0.7794170E-04	0.3565320E-04	
0.1002100E+05	0.6630000E+03	0.1267015E+06	0.1327297E+06	0.7718920E-04	0.3601480E-04	
0.1002100E+05	0.6632000E+03	0.1267119E+06	0.1327367E+06	0.7633670E-04	0.3664400E-04	

Figure 13 – First example of an EmaxAIR stand-alone input data file.

/ 1	2	3	4	5	6	7	8	9	10	11	12	13	14
/line	east	north	alt	ch1	ch2	ch3	ch4	ch5	ch6	ch7	ch8	ch9	ch10
10021,126554,132631,120,0.009906,0.009024,0.008403,0.007936,0.007424,0.006767,0.006091,0.005386,0.004658,0.003													
10021,126565,132638,120,0.009824,0.008946,0.008337,0.007872,0.007365,0.006712,0.006041,0.005341,0.004620,0.003													
10021,126575,132645,120,0.009748,0.008875,0.008279,0.007814,0.007313,0.006662,0.005996,0.005301,0.004586,0.003													
10021,126586,132652,120,0.009680,0.008814,0.008231,0.007763,0.007268,0.006620,0.005958,0.005267,0.004556,0.003													
10021,126596,132659,120,0.009617,0.008762,0.008192,0.007719,0.007231,0.006584,0.005925,0.005238,0.004531,0.003													
10021,126607,132666,120,0.009564,0.008723,0.008163,0.007684,0.007202,0.006555,0.005899,0.005215,0.004510,0.003													
10021,126617,132674,120,0.009515,0.008690,0.008136,0.007652,0.007175,0.006528,0.005875,0.005192,0.004488,0.003													
10021,126628,132681,120,0.009475,0.008667,0.008113,0.007625,0.007152,0.006504,0.005853,0.005171,0.004468,0.003													
10021,126638,132688,120,0.009440,0.008647,0.008087,0.007600,0.007127,0.006479,0.005830,0.005148,0.004446,0.003													
10021,126649,132695,120,0.009418,0.008632,0.008064,0.007579,0.007106,0.006457,0.005809,0.005127,0.004425,0.003													
10021,126659,132703,120,0.009399,0.008616,0.008043,0.007560,0.007084,0.006436,0.005788,0.005106,0.004404,0.003													
10021,126670,132710,120,0.009383,0.008599,0.008023,0.007543,0.007062,0.006415,0.005768,0.005086,0.004384,0.003													
10021,126680,132717,120,0.009371,0.008585,0.008008,0.007529,0.007044,0.006398,0.005750,0.005069,0.004368,0.003													
10021,126691,132725,120,0.009360,0.008573,0.007996,0.007519,0.007030,0.006384,0.005736,0.005055,0.004356,0.003													
10021,126701,132732,120,0.009347,0.008561,0.007984,0.007508,0.007016,0.006372,0.005723,0.005043,0.004346,0.003													
10021,126711,132739,120,0.009339,0.008555,0.007978,0.007503,0.007009,0.006364,0.005714,0.005036,0.004339,0.003													

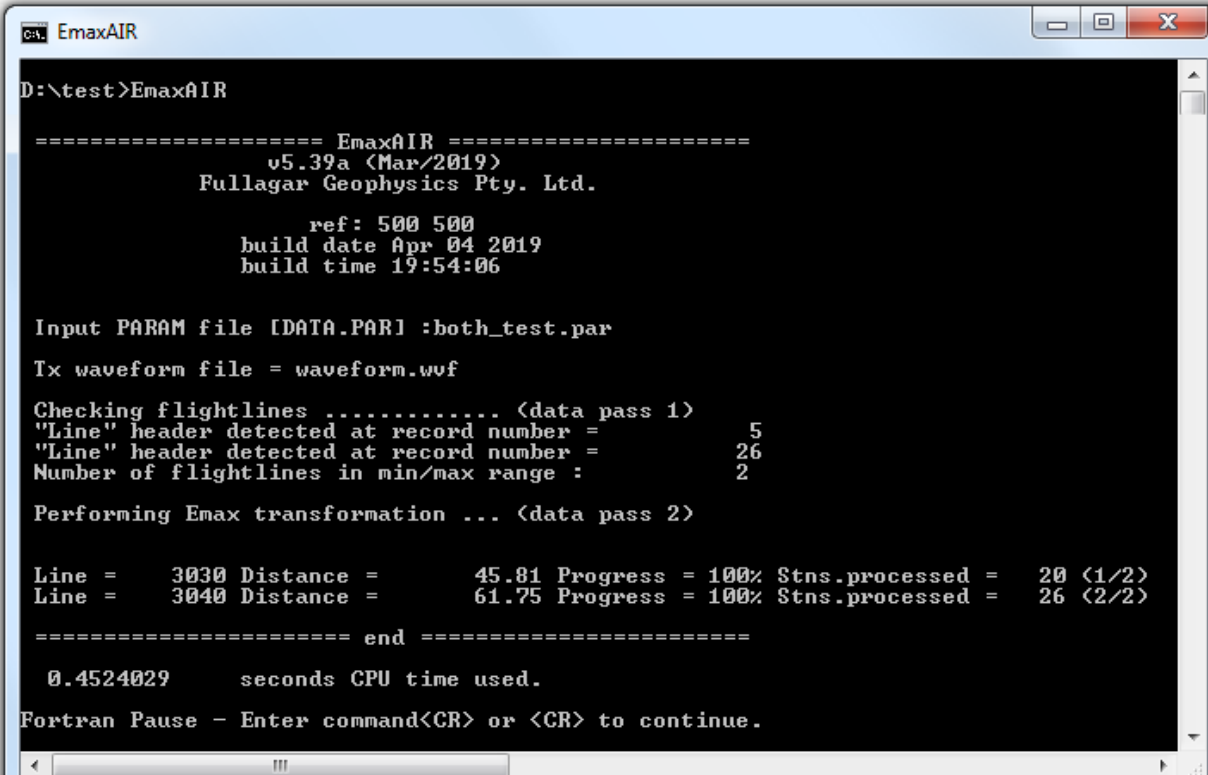
Figure 14 – Second example of an EmaxAIR stand-alone input data file.

4.9 Note concerning the VTEM waveform

Since about 2013 Geotech have been deconvolving their VTEM data. This means that the effective waveform is some "ideal" construct, not the real waveform actually transmitted. The delay times are also different to what they had been previously. The effective waveform and times should all be documented in the relevant survey report. Take care that you use the correct waveform for the data being processed.

4.10 Running

From a Command Window run the **EmaxAIR** executable ([Figure 15](#)).



```

D:\test>EmaxAIR

===== EmaxAIR =====
      v5.39a (Mar/2019)
    Fullagar Geophysics Pty. Ltd.

      ref: 500 500
    build date Apr 04 2019
    build time 19:54:06

Input PARAM file [DATA.PAR] :both_test.par
Tx waveform file = waveform.wvf

Checking flightlines ..... <data pass 1>
"Line" header detected at record number =          5
"Line" header detected at record number =          26
Number of flightlines in min/max range :           2

Performing Emax transformation ... <data pass 2>

Line =   3030 Distance =      45.81 Progress = 100% Stns.processed =   20 <1/2>
Line =   3040 Distance =      61.75 Progress = 100% Stns.processed =   26 <2/2>

===== end =====

  0.4524029      seconds CPU time used.
Fortran Pause - Enter command<CR> or <CR> to continue.
```

Figure 15 – EmaxAIR run as stand-alone.

Give the name of your *parameter* file. A default name is shown in square brackets and can be accepted by just hitting the enter key. Alternatively you can enter the parameter filename on the command line, eg;

```
D:\data> EmaxAIR example.par
```

The program begins without further user input: the name of the *data* file is read from the parameter file, and this name is used to automatically generate the output filenames.

4.11 The output files

The output from EmaxAIR stand-alone is in multiple formats, and is selectable by the user.

If for some reason EmaxAIR does not compute a valid apparent conductivity then the values output (running *stand-alone*) are; depth = 999.25 and conductivity = 999.25. Output data with this depth should be treated as dummies.

Note that these stand-alone output files write DEPTH as NEGATIVE DOWN.

Option A

The “CDI” output file contains all conductivity-depth results written to a single file in the same manner as earlier versions of EmaxAIR. An example is shown in [Figure 16](#).

LINE : is the flightline number

X : is the easting.

Y : is the northing.

DIST : is the distance from the start of the flightline.

DEPTH : is the depth below surface, -ve down.

CONDUCT : is the conductivity in mS/m.

RL : is the depth relative to the RL datum (eg. sea level), -ve down.

TIME : is the channel delay time in microseconds of the processed point.

ALT : is the Tx altitude above the ground surface.

TXRL : is the Tx height relative to the RL datum (eg. sea level), -ve down.

/	LINE	X	Y	DIST	DEPTH	CONDUCT	RL	TIME	ALT	TXRL
	1001	288728.00	3843201.40	0.00	-16.04	2374.30	-6.10	818.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-20.23	1486.08	-10.29	974.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-23.57	949.30	-13.63	1151.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-26.85	748.56	-16.91	1370.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-30.92	600.49	-20.98	1641.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-35.20	479.60	-25.26	1953.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-39.84	405.83	-29.90	2307.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-44.89	336.89	-34.95	2745.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-51.21	274.77	-41.27	3286.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-58.07	223.13	-48.13	3911.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-65.63	191.95	-55.69	4620.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-73.92	157.46	-63.98	5495.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-84.71	122.21	-74.77	6578.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-97.11	77.46	-87.17	7828.000	55.00	64.94
	1001	288728.00	3843201.40	0.00	-110.43	33.76	-100.49	9245.000	55.00	64.94
	1001	288727.90	3843202.40	1.00	-15.83	2435.74	-5.87	818.000	55.10	65.06
	1001	288727.90	3843202.40	1.00	-20.19	1499.09	-10.23	974.000	55.10	65.06
	1001	288727.90	3843202.40	1.00	-23.42	939.36	-13.46	1151.000	55.10	65.06

Figure 16 – EmaxAIR stand-alone CDI output file; format option A

Option B

There is one XYZ file written *for each* flightline in the data. The format is consistent with Geosoft “Line XYZ” so that the data can quickly be gridded using spline gridding and viewed using Geosoft software. The Line Header records have a line number that is a composite of the actual flightline number and the station being processed, so for example “Line 10000_00002” corresponds to flightline 10000 station 2.

An example of this format is shown in [Figure 17](#).

X : is the distance from the start of the flightline.

Y : is the depth below surface, -ve down.

Conduct_mS_per_m : is the conductivity in mS/m.

RL : is the depth relative to the RL datum (eg. sea level), -ve down.

East : is the easting.

North : is the northing.

Time_usec : is the channel delay time in microseconds of the processed point.

TxAlt : is the Tx altitude above the ground surface.

TxRL : is the Tx height relative to the RL datum (eg. sea level), -ve down.

Option C

This is a variant of option B, and is essentially identical except that;

- an additional column containing the flightline number has been added.
- the Line Header records are commented out.
- all flightlines are written to a single file.

An example of this format is shown in [Figure 17](#).

The columns are identical to Option B, but with the addition of a “Line” column in the first position.

Option D

This option is intended for users who want output as Geosoft “array channel” format.

All flightlines are written to a single file.

An example of this format is shown in [Figure 17](#).

Line : is the flightline number

Distance : is the distance from the start of the flightline.

X : is the easting.

Y : is the northing.

TxAlt : is the Tx altitude above the ground surface.

TxRL : is the Tx height relative to the RL datum (eg. sea level), -ve down.

then followed by grouped columns;

Depth1, Depth2, ... : depth below surface, -ve down, for successive channels.

Cond1, Cond2, ... : conductivity (mS/m) for successive channels.

Time1, Time2, ... : delay time for successive channels.

RL1, RL2, ... : depth relative to the RL datum (eg. sea level), -ve down, for successive channels.

Comments on the output files

Coordinates East, North (X,Y columns in Options A & D) will differ from the input coordinates if POSLAG is set to +1 or -1.

Distance is the along-line distance. Distance is measured from the first station recorded in the input file for each flightline. For this reason it is recommended that the input file is pre-sorted on flightline and active coordinate (E or N) so that the distance is always measured from same end of all flightlines. If the input file is in the original order as supplied by the contractor (typically sorted on flightline and fiducial, the order in which the aircraft flew the survey) then the Distance will typically be measured from alternating ends of flightlines.

RL is the inferred elevation of the conductivity: $RL = TXRL - ALT + DEPTH$

Note that values for DEPTH (below surface) used in this formula are negative downwards.

RL is output as zero if the transmitter elevation (TXRL) is not included in the data file.

Output file names are derived from the root name of the parameter file.

For example if the parameter file specifies is MySurvey.PAR then the output files will be named;

MySurvey.OUT	general program output.
MySurvey.CDI	output data, format option A : results for the whole survey.
MySurvey_1010.XYZ	output data, format option B : results for flightline 1010 only.
MySurvey_1020.XYZ	output data, format option B : results for flightline 1020 only.
	...etc... for all flightlines.
MySurvey_line_channel.DAT	output data, format option C : results for the whole survey.
MySurvey_array.DAT	output data, format option D : results for the whole survey.

```

/ -----
/ The format of this file is consistent with Geosoft XYZ.
/ "Line" headers refer to STATIONS on the current flightline.
/ Data columns are:
/ Distance Depth Conduct_mS_per_m RL East North Time_usec TxAlt TxRL
/ X Y Conduct_mS_per_m RL East North Time_usec TxAlt TxRL
Line 10000_00001
0.00 -3.64 149.09 0.00 499964.29 6599964.29 13.000 120.00 0.00
0.00 -5.22 289.71 0.00 499964.29 6599964.29 40.000 120.00 0.00
0.00 -6.76 351.34 0.00 499964.29 6599964.29 67.000 120.00 0.00
0.00 -8.03 390.41 0.00 499964.29 6599964.29 93.000 120.00 0.00
0.00 -9.68 434.30 0.00 499964.29 6599964.29 133.000 120.00 0.00
0.00 -12.03 482.79 0.00 499964.29 6599964.29 200.000 120.00 0.00
0.00 -14.79 528.17 0.00 499964.29 6599964.29 293.000 120.00 0.00
0.00 -18.20 571.76 0.00 499964.29 6599964.29 427.000 120.00 0.00
0.00 -22.34 606.84 0.00 499964.29 6599964.29 613.000 120.00 0.00
0.00 -27.23 633.87 0.00 499964.29 6599964.29 867.000 120.00 0.00
0.00 -33.58 633.87 0.00 499964.29 6599964.29 1213.000 120.00 0.00
0.00 -40.11 656.59 0.00 499964.29 6599964.29 1680.000 120.00 0.00
0.00 -48.57 656.59 0.00 499964.29 6599964.29 2307.000 120.00 0.00
0.00 -61.05 606.72 0.00 499964.29 6599964.29 3147.000 120.00 0.00
0.00 -75.10 571.10 0.00 499964.29 6599964.29 4267.000 120.00 0.00
0.00 -92.20 530.95 0.00 499964.29 6599964.29 5747.000 120.00 0.00
0.00 -114.76 477.18 0.00 499964.29 6599964.29 7680.000 120.00 0.00
0.00 -143.80 418.21 0.00 499964.29 6599964.29 10187.000 120.00 0.00
0.00 -181.56 353.84 0.00 499964.29 6599964.29 13427.000 120.00 0.00
0.00 -244.29 264.95 0.00 499964.29 6599964.29 17627.000 120.00 0.00
Line 10000_00002
14.14 -3.64 149.09 0.00 499974.29 6599974.29 13.000 120.00 0.00
14.14 -5.37 279.84 0.00 499974.29 6599974.29 40.000 120.00 0.00
14.14 -6.96 338.66 0.00 499974.29 6599974.29 67.000 120.00 0.00
/ -----
/ The format of this file is consistent with Geosoft XYZ.
/ "Line" headers refer to STATIONS on the current flightline - but in this file they are COMMENTED OUT and retained
/ Data columns are:
/ Line Distance Depth Conduct_mS_per_m RL East North Time_usec TxAlt TxRL
/ Line X Y Conduct_mS_per_m RL East North Time_usec TxAlt TxRL
/Line 10000_00001
10000 0.00 -3.64 149.09 0.00 499964.29 6599964.29 13.000 120.00 0.00
10000 0.00 -5.22 289.71 0.00 499964.29 6599964.29 40.000 120.00 0.00
10000 0.00 -6.76 351.34 0.00 499964.29 6599964.29 67.000 120.00 0.00
10000 0.00 -8.03 390.41 0.00 499964.29 6599964.29 93.000 120.00 0.00
10000 0.00 -9.68 434.30 0.00 499964.29 6599964.29 133.000 120.00 0.00
10000 0.00 -12.03 482.79 0.00 499964.29 6599964.29 200.000 120.00 0.00
10000 0.00 -14.79 528.17 0.00 499964.29 6599964.29 293.000 120.00 0.00
10000 0.00 -18.20 571.76 0.00 499964.29 6599964.29 427.000 120.00 0.00
10000 0.00 -22.34 606.84 0.00 499964.29 6599964.29 613.000 120.00 0.00
10000 0.00 -27.23 633.87 0.00 499964.29 6599964.29 867.000 120.00 0.00
10000 0.00 -33.58 633.87 0.00 499964.29 6599964.29 1213.000 120.00 0.00
10000 0.00 -40.11 656.59 0.00 499964.29 6599964.29 1680.000 120.00 0.00
10000 0.00 -48.57 656.59 0.00 499964.29 6599964.29 2307.000 120.00 0.00
10000 0.00 -61.05 606.72 0.00 499964.29 6599964.29 3147.000 120.00 0.00
10000 0.00 -75.10 571.10 0.00 499964.29 6599964.29 4267.000 120.00 0.00
10000 0.00 -92.20 530.95 0.00 499964.29 6599964.29 5747.000 120.00 0.00
10000 0.00 -114.76 477.18 0.00 499964.29 6599964.29 7680.000 120.00 0.00
10000 0.00 -143.80 418.21 0.00 499964.29 6599964.29 10187.000 120.00 0.00
10000 0.00 -181.56 353.84 0.00 499964.29 6599964.29 13427.000 120.00 0.00
10000 0.00 -244.29 264.95 0.00 499964.29 6599964.29 17627.000 120.00 0.00
/Line 10000_00002
10000 14.14 -3.64 149.09 0.00 499974.29 6599974.29 13.000 120.00 0.00
10000 14.14 -5.37 279.84 0.00 499974.29 6599974.29 40.000 120.00 0.00
10000 14.14 -6.96 338.66 0.00 499974.29 6599974.29 67.000 120.00 0.00
/ -----
/ The format of this file is consistent with Geosoft ARRAY CHANNEL XYZ.
/ Data columns are:
/ 1 2 3 4 5 6 7 8 9 10
/ Line Distance X Y ALT TXRL Depth1 Depth2 Depth3 Depth4
10000 0.00 499964.29 6599964.29 120.00 0.00 -3.64 -5.22 -6.76 -8.03
10000 14.14 499974.29 6599974.29 120.00 0.00 -3.64 -5.37 -6.96 -8.24
10000 28.28 499984.29 6599984.29 120.00 0.00 -3.64 -5.51 -7.14 -8.44
10000 42.43 499994.29 6599994.29 120.00 0.00 -3.64 -5.64 -7.29 -8.60
10000 56.57 500004.29 6600004.29 120.00 0.00 -3.64 -5.75 -7.41 -8.75
10000 70.71 500014.29 6600014.29 120.00 0.00 -3.64 -5.85 -7.51 -8.87
10000 84.85 500024.29 6600024.29 120.00 0.00 -4.11 -6.07 -7.64 -8.98
10000 98.99 500034.29 6600034.29 120.00 0.00 -4.11 -6.12 -7.71 -9.07
10000 113.14 500044.29 6600044.29 120.00 0.00 -4.11 -6.16 -7.79 -9.16
10000 127.28 500054.29 6600054.29 120.00 0.00 -4.11 -6.20 -7.85 -9.23
10000 141.42 500064.29 6600064.29 120.00 0.00 -4.11 -6.23 -7.91 -9.29
10000 155.56 500074.29 6600074.29 120.00 0.00 -4.11 -6.27 -7.97 -9.35
10000 169.71 500084.29 6600084.29 120.00 0.00 -4.11 -6.30 -8.02 -9.40
10000 183.85 500094.29 6600094.29 120.00 0.00 -4.11 -6.33 -8.05 -9.44
10000 197.99 500104.29 6600104.29 120.00 0.00 -4.11 -6.36 -8.09 -9.48
10000 212.13 500114.29 6600114.29 120.00 0.00 -4.11 -6.37 -8.11 -9.49
10000 226.27 500124.29 6600124.29 120.00 0.00 -4.11 -6.37 -8.12 -9.50
10000 240.42 500134.29 6600134.29 120.00 0.00 -4.11 -6.36 -8.10 -9.48
10000 254.56 500144.29 6600144.29 120.00 0.00 -4.11 -6.33 -8.05 -9.43
10000 268.70 500154.29 6600154.29 120.00 0.00 -4.11 -6.28 -7.99 -9.37

```

Figure 17 – EmaxAIR stand-alone XYZ output files; format options B,C,D

5. Sample Data

5.1 Sample Data – Bull Creek

Some sample data for various airborne systems is provided for checking and testing EmaxAIR operation and output results. See subdirectories under;

(32-bit operating systems) C:\Program Files\Fullagar\EmaxAIR\

(64-bit operating systems) C:\Program Files (x86)\Fullagar\EmaxAIR\

Since EmaxAIR v3 parameter files have been slightly different to those used previously in v2, however the newer versions of EmaxAIR are backward compatible with these older v2 format *.par files.

For illustration these are the Tempest sample files generated using the v3 *.par file;

The CDI section is shown in [Figure 18](#). (see also [Figure 24](#))

	<i>file name</i>
<i>EmaxAIR input data file</i>	samp__tempest.dat
<i>EmaxAIR input parameter file</i>	samp_v3_tempest.par
<i>EmaxAIR output CDI data file, format option A</i>	samp_v3_tempest.CDI
<i>EmaxAIR output containing general program run information</i>	samp_v3_tempest.OUT
<i>EmaxAIR output XYZ data file, format option B, flight line 10022</i>	samp_v3_tempest_10022.xyz
<i>EmaxAIR output XYZ data file, format option C</i>	samp_v3_tempest_line_channel.DAT
<i>EmaxAIR output XYZ data file, format option D</i>	samp_v3_tempest_array.DAT
<i>plotted output for flight line 10022 (with sharpening - see Figure 18)</i>	samp_v3_tempest_10022_plot.png

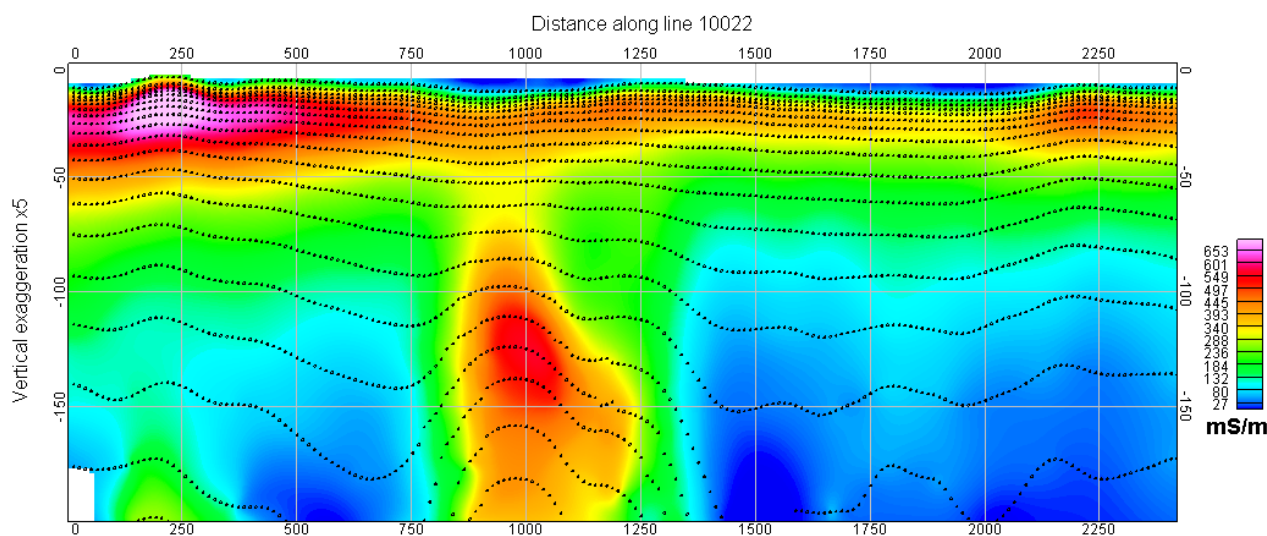


Figure 18 – Conductivity-depth section for flight line 10022.

If you want to do some test runs using the sample data, to avoid write permission problems do not try and run it in the Program Files directory. Instead copy it to a temporary folder on your data drive first and run your tests from there.

(Bull Creek data courtesy of Exco Resources)

6. Support

For support please contact:

technical and installation queries :

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7. Appendices

7.1 Choosing SDMIN0

SDMIN0 provides a floor on the standard deviation; it only starts to have an effect if it's larger than the standard deviation computed using PCERR. Therefore a change in SDMIN0 with PCERR fixed will only affect later channels.

Your choice of SDMIN0 should be guided by what you think is the noise level in the data. *It is expressed in the same units as the data read from the input file.*

Choosing a value that is too high may result in EmaxAIR settling on conductivity-depth solutions that are not as good as they could be. This is the situation shown in the example on the **left** of [Figure 19](#) where some decays show sharp changes in depth compared to adjacent decays. Here the conductivity-depth solutions are perfectly valid according to the SDMIN0 value specified. In addition the depth extent of the section is significantly reduced because otherwise healthy data is rejected by the high SDMIN0 value.

Choosing a value that is too low allows genuinely noisy data to be processed and results in a much greater depth extent of the section, as shown on the **right** of [Figure 19](#).

The optimum SDMIN0 value for the sample data shown in [Figure 19](#) is somewhere between the two examples plotted; a value of 0.001 removes the sharp changes in depth evident in the left section, but prevents the excess of noisy data beginning to appear at the deeper parts of the right section.

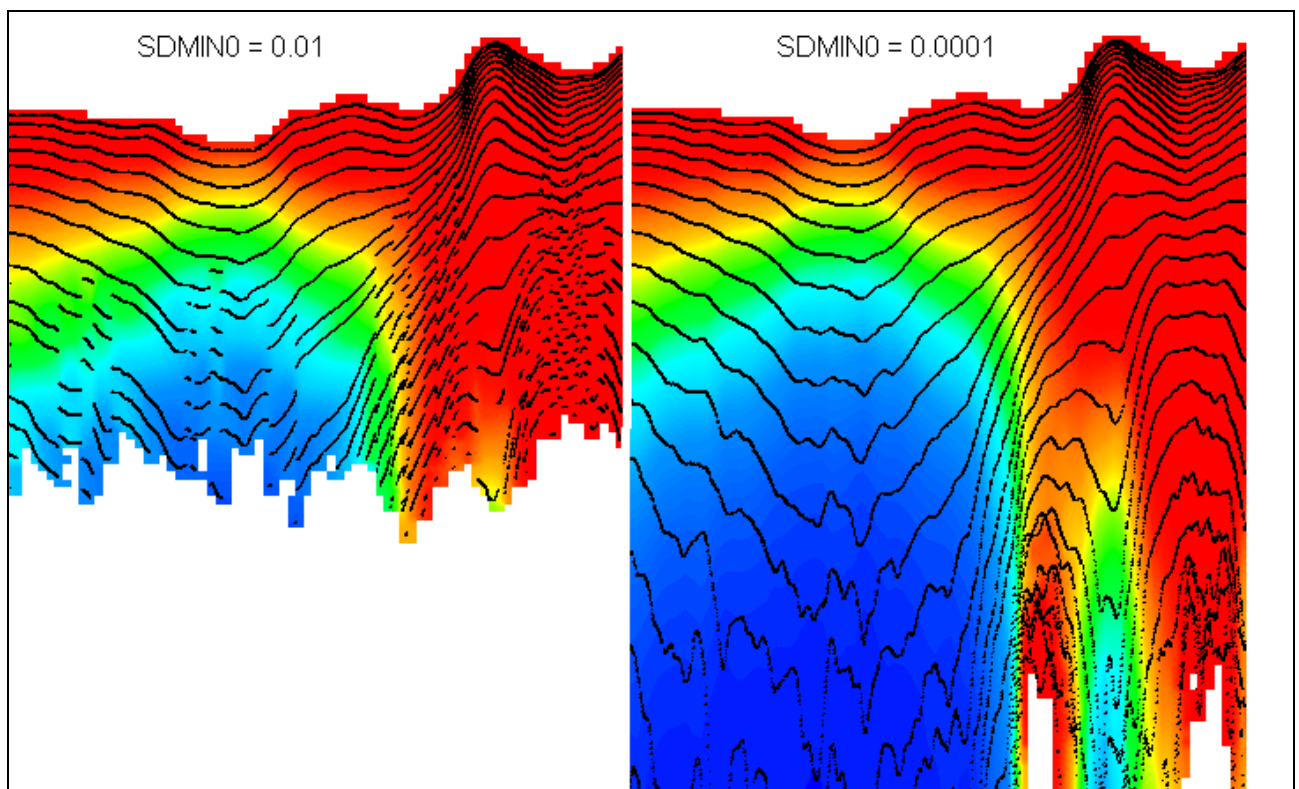


Figure 19 – Choosing a value for SDMIN0.

7.2 Reciprocity

For some systems it is possible to use the principle of “reciprocity” and interchange the Tx and Rx in order to process data. In this situation the Tx is treated as if it were the Rx, and vice versa.

This approach was needed, for example, with **HeliTEM** data when using EmaxAIR v5.10b or earlier, or when using Maxwell v5.16.71.25319 or earlier. In a HeliTEM survey the Rx is *ahead of and above* the Tx, therefore the sign convention used by EmaxAIR (**Figure 2**) requires the vertical separation parameter X0 to be negative. These older versions of software did not handle negative X0 values with EmaxAIR processing.

Figure 20 shows the general parameters required to define the Tx and Rx positions and separations for (left) the normal case with Tx and Rx in their actual position, and (right) when reciprocity is used to interchange the Tx and Rx definitions during processing.

The X0 and DEL0 parameters are defined as positive when the Rx is behind and below the Tx.

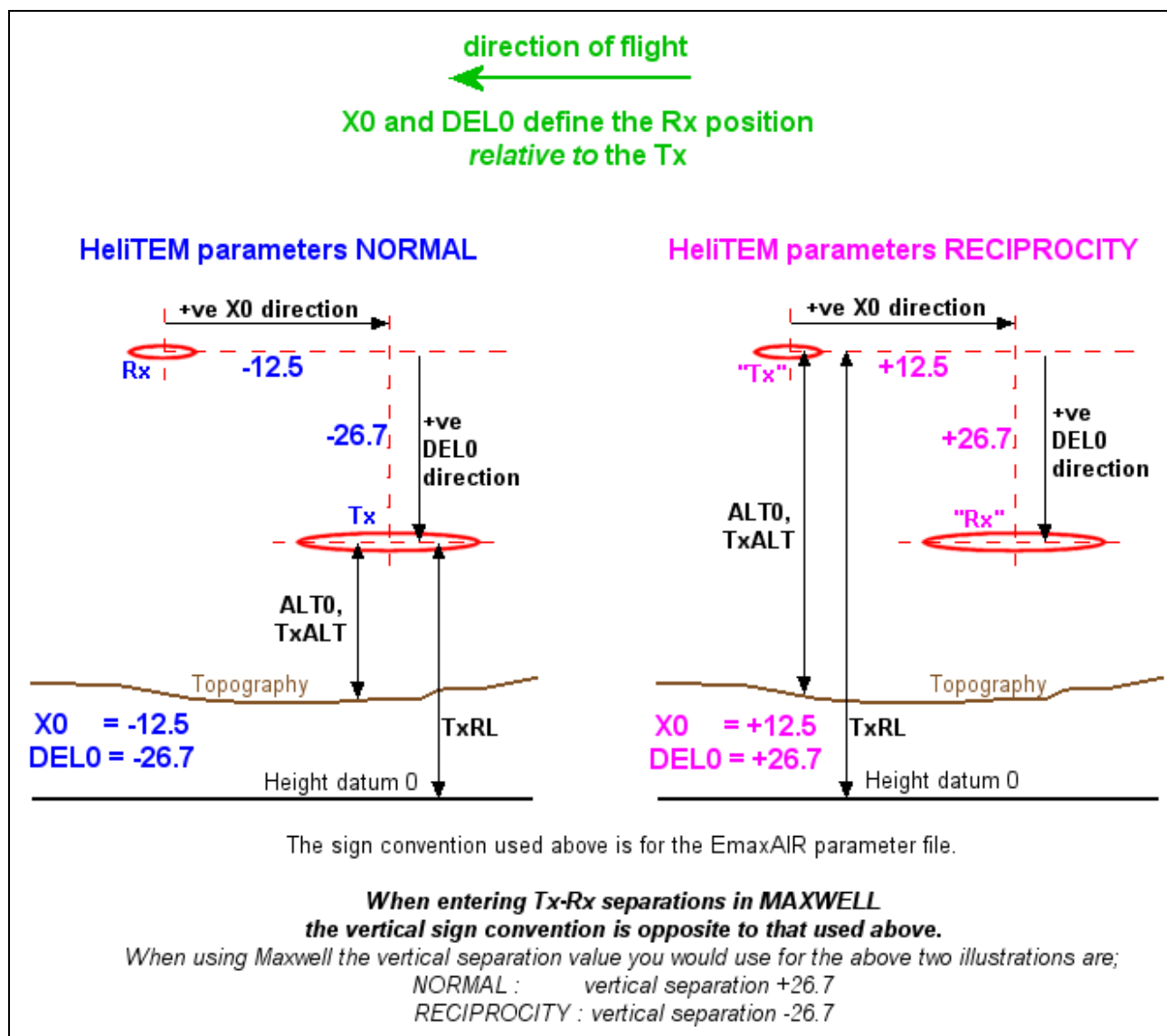


Figure 20 - Reciprocity of Tx and Rx.

7.3 Using the correct Height for TEMPEST surveys

These comments can apply in a general sense to any system, but they apply in particular to the TEMPEST system and its final data. TEMPEST surveys usually include “HPRG corrected” e/m data which has been corrected for variations in **Height**, **Pitch** and **Roll** of the transmitter/receiver **Geometry** [corrections based on Green’s (1998) apparent dipole depth method].

EmaxAIR uses altitude in the conductivity calculations. Normally the altitude for each station is read from a column in the input data file. However HPRG data has typically been corrected to a constant 120m altitude and therefore the altitudes contained in the input data file column do not apply (those altitudes only apply to *non*-HPRG data). Incorrect CDI data will be generated if the incorrect height is used by EmaxAIR, and this will cause errors that are particularly noticeable in shallower parts of the CDI sections.

For HPRG data processing prior to EmaxAIR v5.39 the user needed to create an extra column in the input data file containing the HPRG constant altitude. The parameter “**ALTO_flag**” has been introduced so that the extra altitude column is no longer required; instead if ALTO_flag = 1 then EmaxAIR will use the nominal survey altitude set in parameter ALTO as the constant altitude for processing the whole survey.

Figure 21 shows HPRG data processed with the *incorrect* altitude (ALTO_flag = 0; using actual altitudes read from the data file) illustrating some shallow and abnormally high erroneous conductivities. **Figure 22** shows the same data processed with the *correct* altitude (ALTO_flag = 1; using constant altitude defined by parameter ALTO).

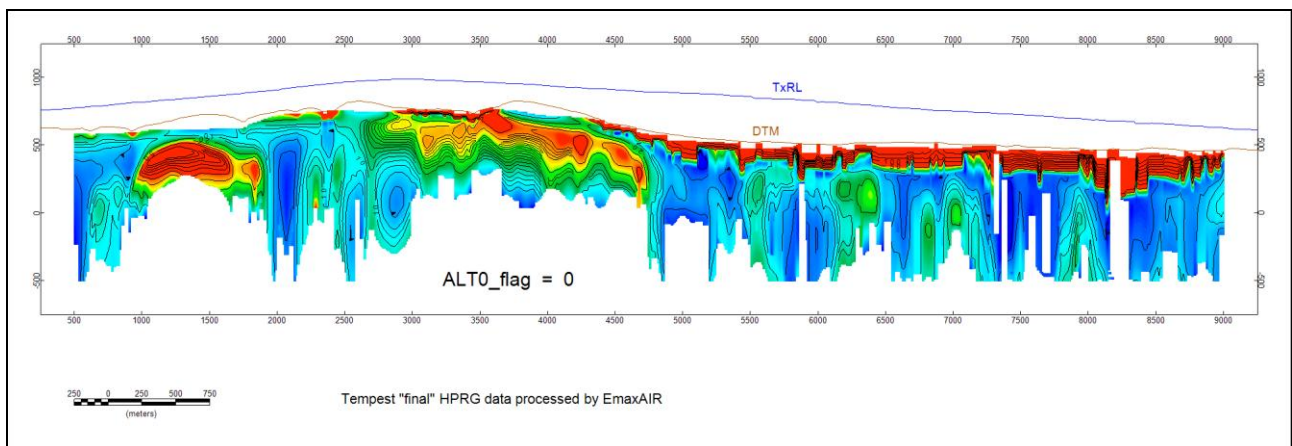


Figure 21 – TEMPEST example, HPRG data processed with variable (measured) altitude.

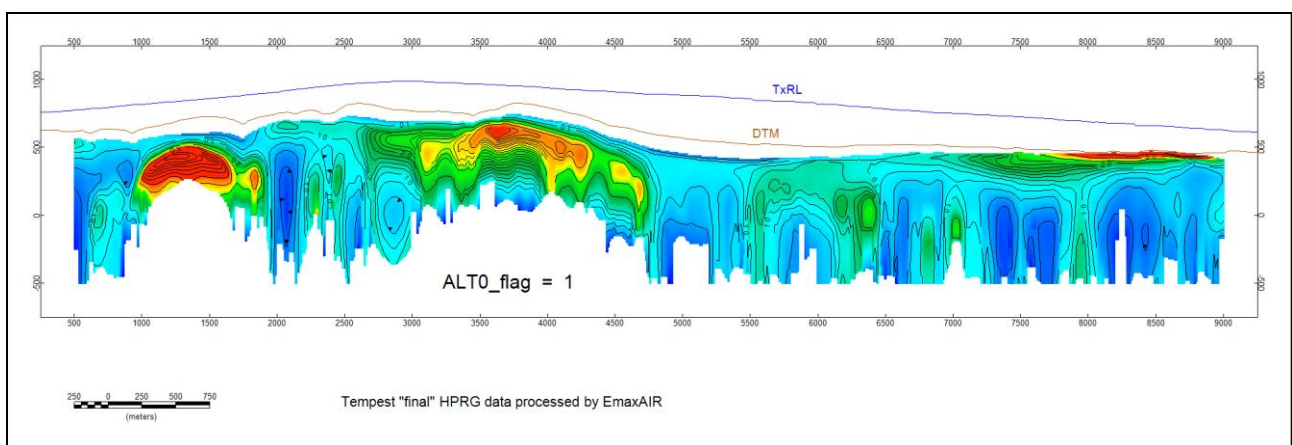


Figure 22 - TEMPEST example, processed with constant (ALTO) altitude.

Green, A., 1998, Altitude correction of time domain AEM data for image display and geological mapping using the Apparent Dipole Depth (ADD) method. *Exploration Geophysics*, **29**, 87–91.

Sattel, D. 2004, The resolution of shallow horizontal structure with airborne EM. *Exploration Geophysics*, **35**, 208–216.

7.4 The effect of “sharpening”

The effect of applying the sharpening option is illustrated in [Figure 23](#). This example is from ground-based coincident loop data, but the effect of applying sharpening to airborne data will be similar. The colour stretch is the same in both sharpened and unsharpened images.

The sharpened data (bottom image) illustrates the effect of this option wherein the gently-west-dipping conductive feature has been better defined. Sharpening can often define conductors more tightly, especially their upper boundaries (as seen particularly in the left of [Figure 23](#)).

Sharpening also has the tendency to enhance noise where present, typically at late times where signal is poor. A small example of this effect can be seen below at 2325E and a depth of 400m. Users should be aware of these kinds of artefacts which may be produced by the sharpening process.

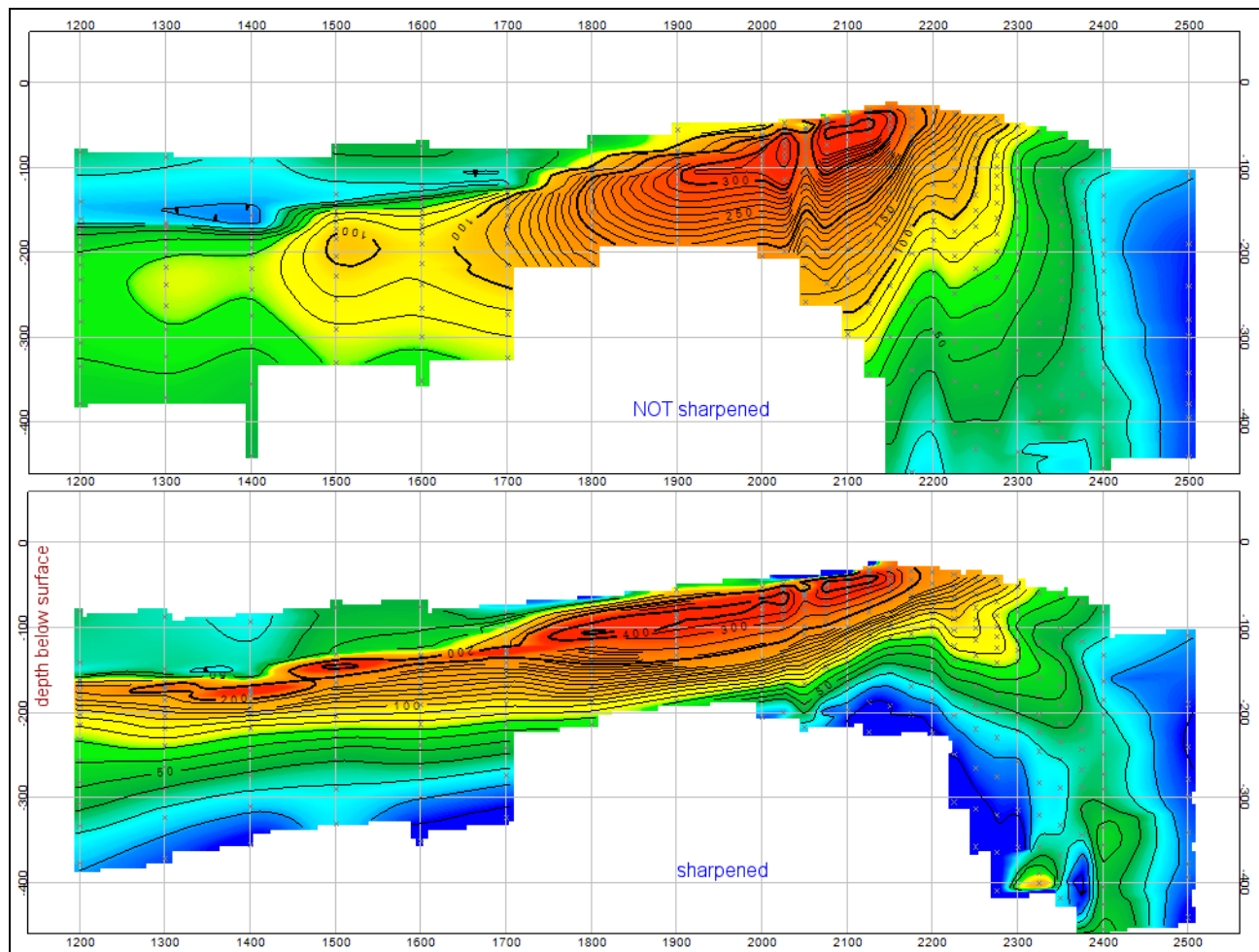


Figure 23 – Unsharpened (top) and normal sharpening (bottom).

7.5 C-sharpening (ISHARP=2) example and usage guidelines

C-sharpening creates a layered "model" extending up to the ground surface.

The input data for C-sharpening are the original apparent conductivities and depths computed by EmaxAIR. Depending on the ambient conductivity and the delay times, the first (shallowest) depth may be relatively large. In order to achieve the desired near-surface resolution, the user can insert additional layers between the first normal EmaxAIR depth, D1, and the ground surface; NUM_SPLIT is the number of extra layers to be inserted, and the interval between the first depth and the ground surface is divided into NUM_SPLIT+1 equal layers.

As NUM_SPLIT increases, convergence is usually achieved more quickly given the additional "unknowns" (degrees of freedom). Setting NUM_SPLIT is somewhat subjective, but there is a practical limit because the thickness of the extra layers becomes unreasonably small when NUM_SPLIT is large. The maximum permitted value of NUM_SPLIT is 10. If no acceptable solution is found after 19 iterations, the program terminates at the station in question and moves on to the next station.

NUM_SPLIT=0 is a valid choice, but the C-sharpening algorithm may have difficulty finding a satisfactory solution. The number of iterations required for convergence, ITERCS, is recorded in the output file. The assumed uncertainty of the apparent conductivity "data" submitted for C-sharpening is $\sim 0.5 \cdot (1 + \text{ITERCS})\%$.

C-sharpening itself is formulated as an inverse problem, to derive estimates of the true conductivities from the EmaxAIR apparent conductivities. The greater ITERCS, the larger the final residuals between the EmaxAIR apparent conductivities (which can be regarded as "observed") and the apparent conductivities associated with the C-sharpened solution (which can be regarded as "calculated" apparent conductivities). In other words, the larger the ITERCS value, the poorer the fit.

The effect of processing the Bull Creek data (see also section [5.1 Sample Data – Bull Creek](#)) with different sharpening options is shown in [Figure 24](#). The C-sharpening processing used NUM_SPLIT=8.

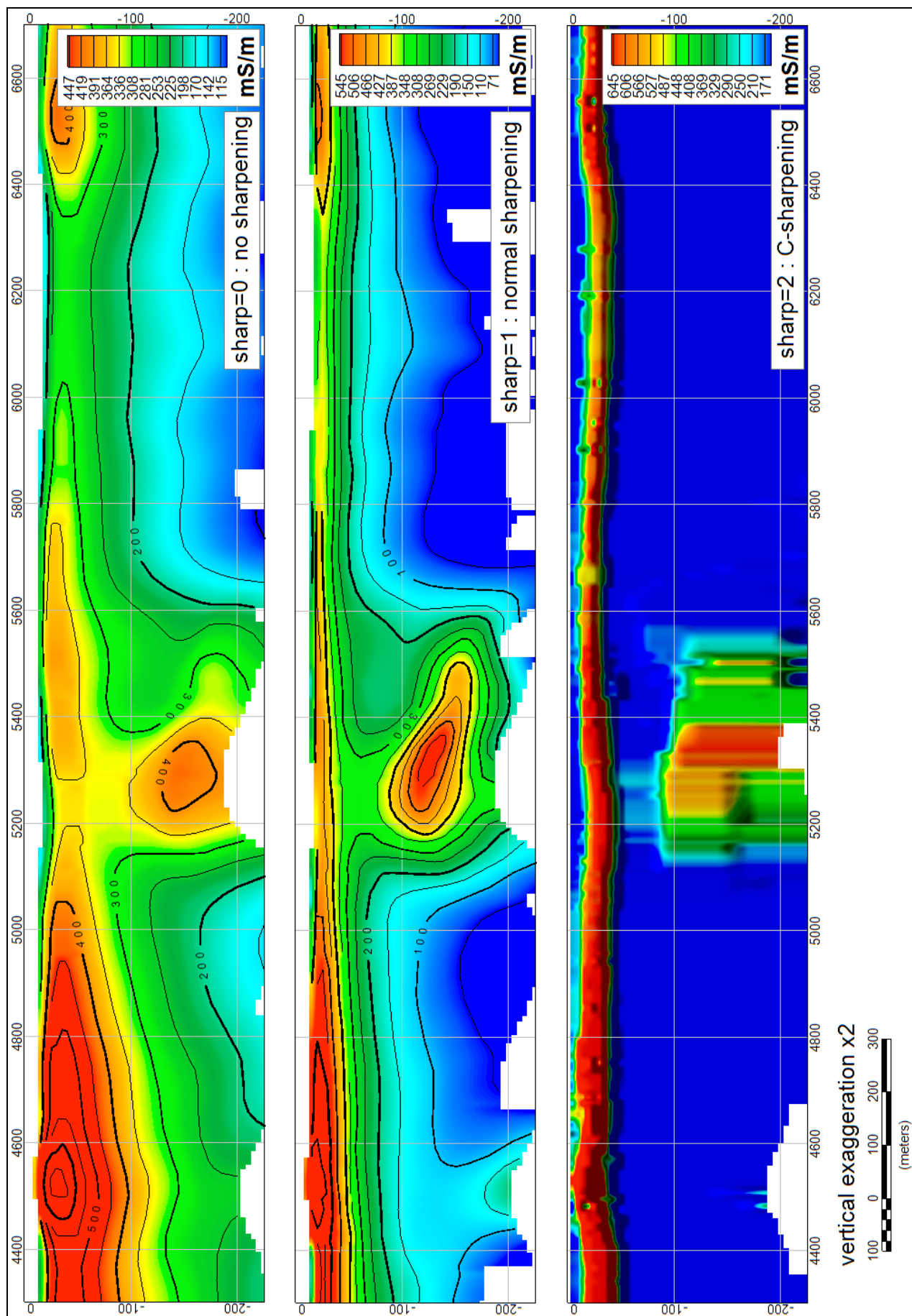


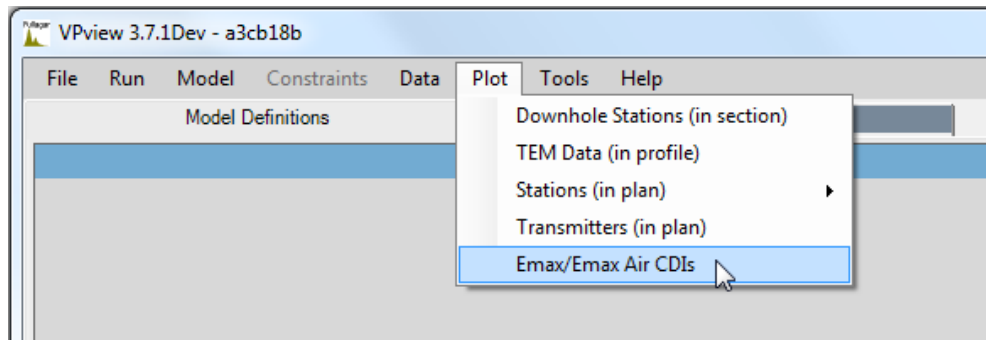
Figure 24 – Bull Creek example: comparison of sharpening options.

7.6 CDI output data use in VPview

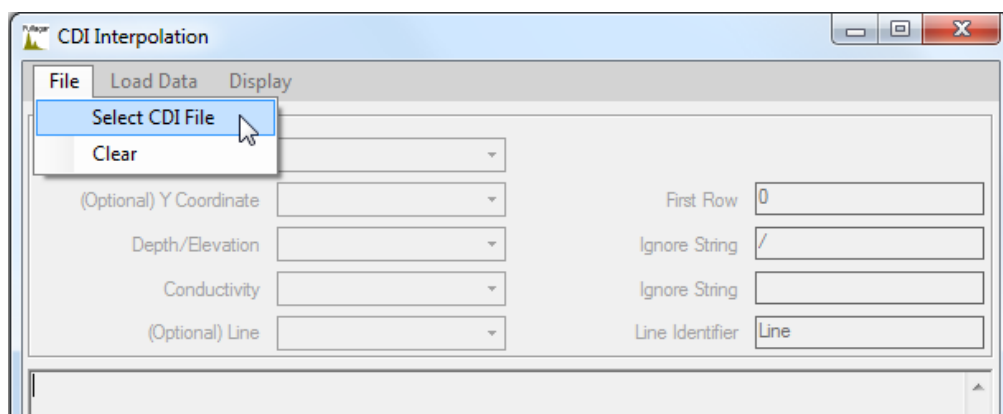
Output data written to a CDI-format file (see “Option A” in section 4.11 The output files) can be imported into VPview, a free graphical interface provided by Fullagar Geophysics for running the 3D inversion program VPem3D. This allows a preview display of selected flight line(s), but is also used to introduce the EmaxAIR CDI output data as the starting model for a 3D inversion run by VPem3d.

The series of images in [Figure 25](#) (a) to (f) below illustrate the importation of a CDI-format file, and the preview display of a line of conductivity-depth data.

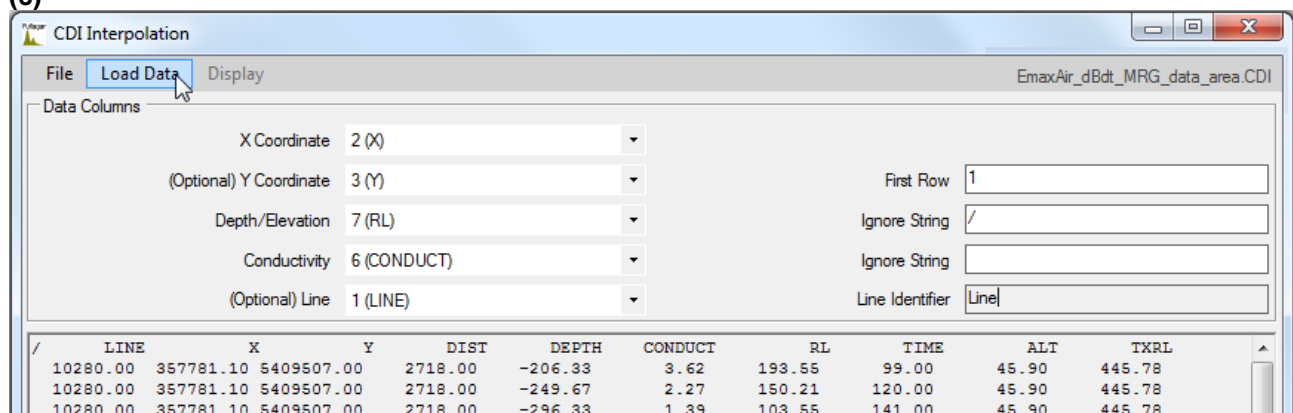
(a)



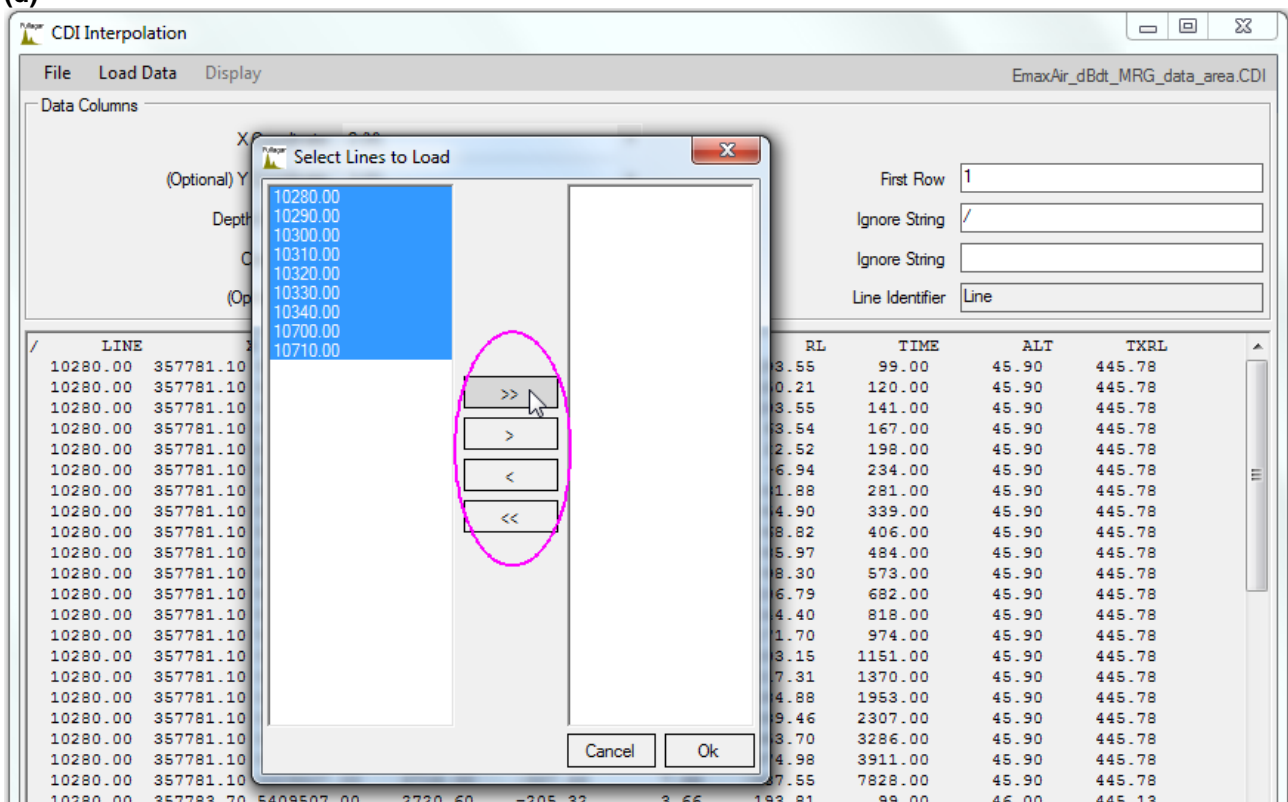
(b)



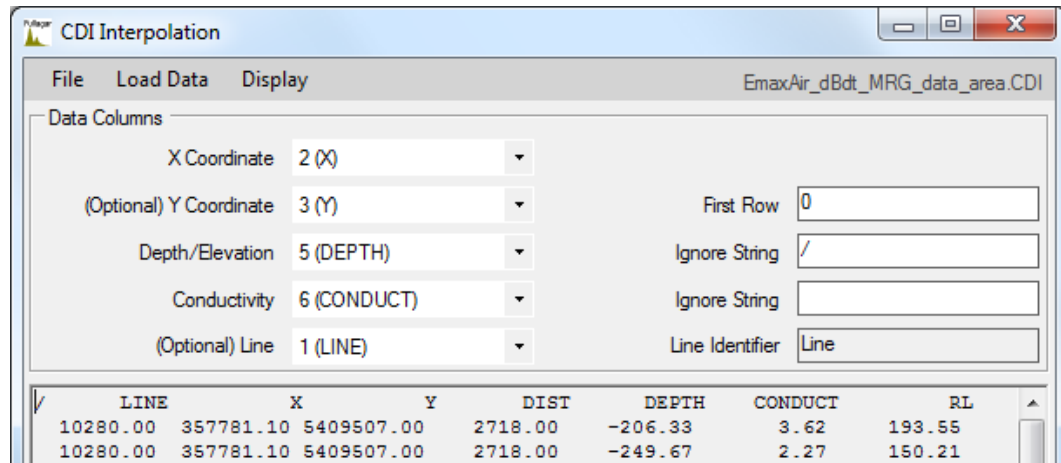
(c)



(d)



(e)



(f)

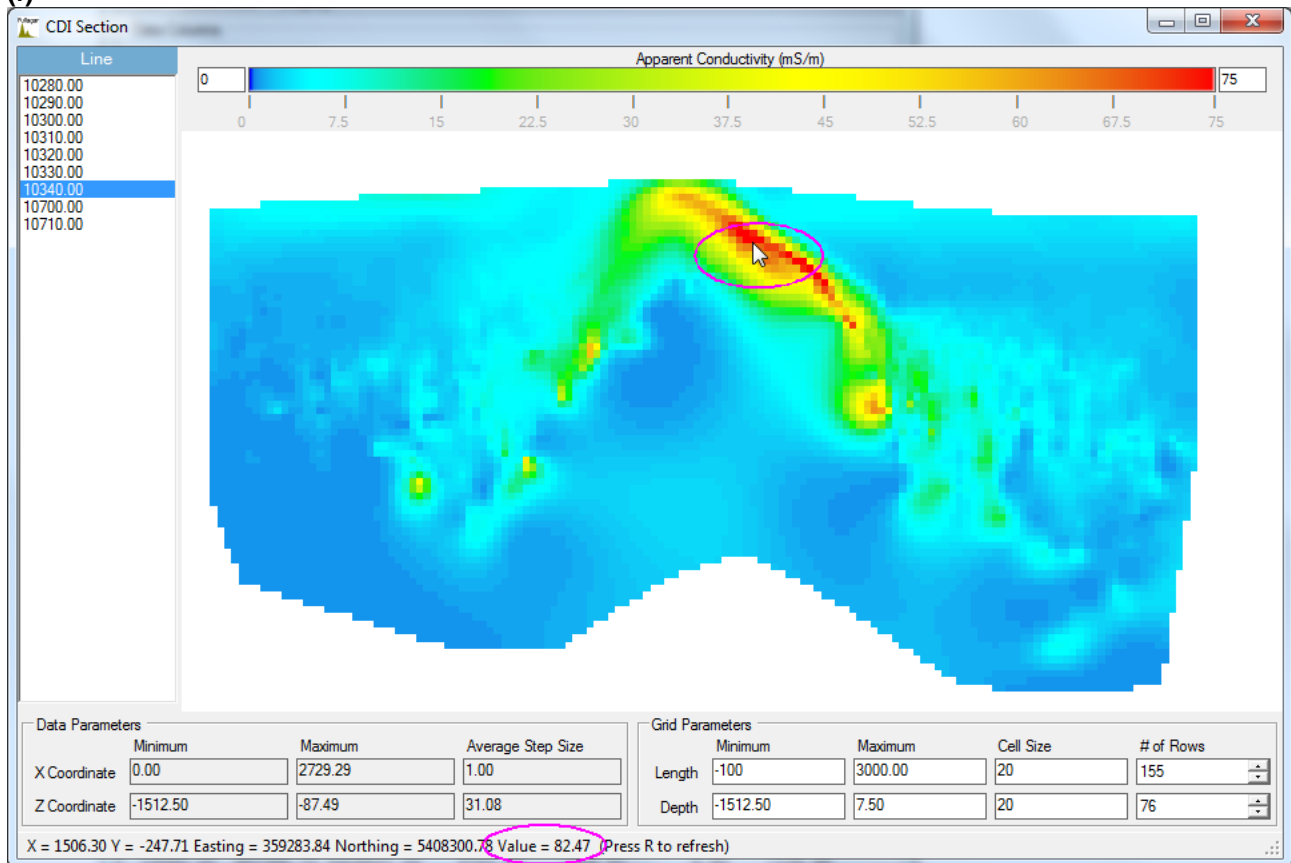


Figure 25 (a) to (f) – Loading EmaxAIR “CDI-format” output data into VPview.

7.7 Sharpening comparison: ISHARP = 1 and ISHARP = 11

Figure 26 shows a comparison of the 'normal' sharpening (above) available in previous versions of EmaxAIR and the modified sharpening (below) available with EmaxAIR version 5.60. This example is processed from HeliTEM² square waveform 6.25Hz Z component dB/dt data.

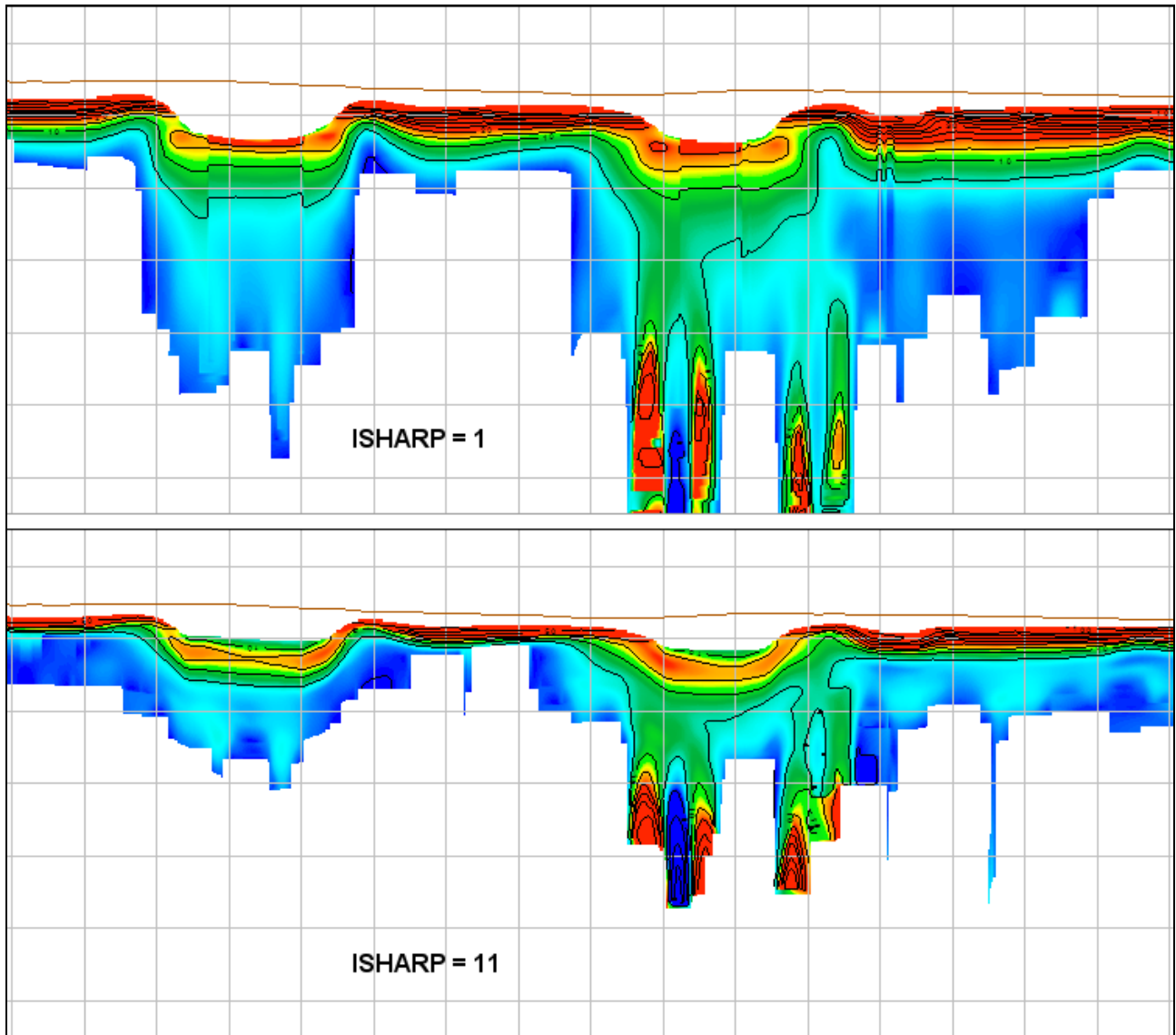


Figure 26 – Example of a HeliTEM survey processed with the original sharpening method (above) and the modified sharpening method (below).