

How to import GroundTEM data

In this document we will show how to create a new workspace and import GroundTEM data in preparation for GroundTEM data quality control and data processing.

We will go through the creation of the 3 import files. The geometry file, the data file and the xyz format file. Then we create a new workspace and go through the actual import of the GroundTEM data.

The geometry file

The first import file we need is the geometry file, also referred to as the gex file. This is a text format (.gex) file that describes the system parameters of the used GroundTEM system. It includes the geometry of the frame, the placement of the instruments, the transmitter waveform, time gate specifications, and so on. Everything that is needed to allow accurate modeling of the system in the inversion.

The geometry file consists of a [General] section and a [Channel1] section. Within each section, related entries have been grouped together, often using a comment line to describe the group. This is not required, the entries just need to be within the right section, but it does improve the readability of the geometry file. Comment lines are indicated with a “/”.

Below we will go through an example GroundTEM geometry file using tables to explain the different keywords within each group. The type can be a string or a specific number of integers or reals. The description details how the keyword is used. The last column shows if the keyword is required (Req.) or optional (Opt.).

In general, we use SI-units for the keyword values. The unit for the different keyword values are stated in brackets [].

1. [General] section – Device positions.

Keyword	Type	Description	
Description	String	Line that can be used to describe the geometry file.	Opt.
DataType	String	Here the keyword GroundTEM is used to control what the importer should look for in the geometry file. The coordinate system is for instance using a different device position origin for GroundTEM than it is for airborne systems.	Req.
GPSPosition1	3 Reals	<p>Position of the 1st GPS device on the frame.</p> <p>All device positions are described in X, Y and Z [m] with origin on the ground at the center of the transmitter coil and with z positive downward.</p> <p>GPSPosition1 is used to correct the recorded GPS positions for the x,y displacement from origin at the center of the transmitter as part of the processing. If this correction already has been done to the import file values, it is necessary to use a false “at the center of the transmitter” device position here. The z coordinate of GPSPosition1 is not used.</p>	Req.

RxCoilPosition1	3 Reals	Position of the Z receiver coil on the frame.	Req.
TxCoilPosition1	3 Reals	Position of the transmitter coil on the frame. Per definition its x and y coordinates will be zero.	Req.

The GPSPosition1, RxCoilPosition1 and TxCoilPosition1 may need to be updated, but they are often not changed much for a given GroundTEM system.

2. [General] section – Transmitter loop definitions.

Keyword	Type	Description	
LoopType	Real	LoopType used by AarhusInv when inverting the data. This can be either 72 or 73. Both describe a segmented loop detailed with the TxLoopArea and TxLoopPoint entries below. The difference is that the 73 variant uses the inverse Laplace transform instead of the Fourier transform that has been used with the legacy 72 variant. For inversions using waveform and filters it doesn't matter for the result which is used.	Req.
TxLoopArea	Real	Area of the Tx-loop [m ²]. This area must match the area of the polygon described by the TxLoopPoint entries below.	Req.
TxLoopPoint1 .. TxLoopPointN	2 Reals	X and Y [m] coordinates for the N corners of the loop. Counterclockwise order. The last point connects back to the first point.	Req.
NumberOfTurns	Integer	Number of Tx-loop turns used.	Req.

The TxLoopArea, TxLoopPoints and NumberOfTurns depend on the exact GroundTEM system and may need to be updated.

3. [General] section – Low pass filter characteristics of the receiver coil(s).

Keyword	Type	Description	
RxCoilLPFilter1	2 Reals	Low pass filter characteristics of the Z receiver coil. The first value is the order of the filter. A value of -1 is used for no filter and a value of 0.99 is used for a Gaussian. filter. The second value is the cut-off frequency [Hz]. If the values are unknown and cannot be measured, they can usually still be estimated by looking at how the inversion fits the early gates using a few different low pass filters. For more about the effect of the filters see the article "Christiansen, A. V., E. Auken, and A. Viezzoli, 2011, Quantification of modeling errors in airborne TEM caused by inaccurate system description, Geophysics, 76, 1, F43-F52". (http://www.hgg.geo.au.dk/Papers_EndNote/3986773044/CHRISTIANSEN2011.pdf)	Req.

The RxCoilLPFilter1 may need to be confirmed.

4. [General] section – Waveform definitions.

Keyword	Type	Description	
WaveformPoint01 ... WaveformPointN	2 Reals	Time [s] and normalized amplitude [0;1] for each of the N waveform points. The waveform must start and end at 0 amplitude. The waveform description for GroundTEM can be quite detailed, far more so than it is really needed. As there is a slight performance cost for each waveform point, it is not recommended to use more than 30 or so waveform points. The used description should preserve the total area below the waveform and the exact shape of the waveform close to the ramp down. The exact shape of the earlier part of the waveform is less important.	Req.

The waveform definition for GroundTEM may need to be confirmed.

5. [General] section – Gate time definitions.

Keyword	Type	Description	
GateTime01 .. GateTimeN	3 Reals	Center [s], Open [s] and Close [s] times for each of the N gate. In the included example the zero time is set to be, at the begin of the ramp down. This is not a requirement for the modeling, but the zero time does have to be identical for the gates and the waveform.	Req.

The gate times table will usually only need to be updated the first time it is used for a given GroundTEM system, but it should always be confirmed.

6. [Channel1] sections – Settings.

Keyword	Type	Description	
GateTimeShift	Real	Calibration time shift of gatetimes [s]. This is rarely used for GroundTEM	Req.
GateFactor	Real	Calibration factor shift of dB/dt values [factor]. This is rarely used for GroundTEM	Req.
RemoveInitialGates	Integer	Automatic disable time gate 1 to RemoveInitialGates in the processing.	Req.
PrimaryfieldDampingFactor	Real	Primary field damping factor used in the modeling of the data. This cannot be set to 0. It is related to the low pass filter characteristics of the receiver coil and the efforts that have been made to remove the primary field from the voltage data for this GroundTEM	Req.

		<p>system. Often it would not be reasonable to model the primary field at full strength. In practice a damping factor of 0.1 is often used for a nearly removed primary field.</p> <p>For more about the effect of this damping factor on the filters see the article “Christiansen, A. V., E. Auken, and A. Viezzoli, 2011, Quantification of modeling errors in airborne TEM caused by inaccurate system description, Geophysics, 76, 1, F43-F52”.</p> <p>(http://www.hgg.geo.au.dk/Papers_EndNote/3986773044/CHRISTIANSEN2011.pdf)</p>	
UniformDataSTD	Real	Relative uniform STD for all dB/dt gates. 0.05 = 5%	Req.
RepFreq	Real	Repetition frequency.	
TxApproximateCurrent	Real	<p>Approximate transmitter current. This must be within 25% of the actual current, else soundings with extreme values will be removed during the processing.</p> <p>If the voltage data has been normalized with the current, this value should be set to 1.</p>	Req
ReceiverPolarizationXYZ	String	Receiver polarization. This can be X, Y or Z. The usual setup is to have it as Z.	Req.

The Channel1 section will usually not have to be changed much, but it should always be confirmed. The most important values to update here is RepFreq with the repetition frequency of the system.

It can also sometimes be relevant to use a slightly higher UniformDataSTD for the gates and it can also on occasion be relevant to use RemoveInitialGates to automatically disable the earliest gates in the processing.

The data file

The second file we need for the import is the raw data file, also referred to as the xyz file. This is a space delimited column file in text format (.xyz). Often the data will be made available as a Geosoft database from where one then can extract the text file with the relevant parts of the data. For GroundTEM the key database fields we are looking for in the xyz file columns, possible with slightly different names, are:

Line number
 UTMX
 UTMY
 Topography
 Gate_01
 ...
 Gate_xx (possible both for the X and Z channels)

If the data has not been normalized by the current, we will need to look for that in a column:

Current

It is possible to add columns with:

Date
 Time

They are however not required, one can enter a sounding distance and import with a dummy date and time instead. For date `yyymmdd` and `yyyy/mm/dd` formats are supported. For time `hh:nn:ss`, `hh:nn:ss:zzz`, `hh:nn:ss.zzz`, `hh:nn:ss.zz`, `hhnnss.z` and number of seconds formats are supported.

It is also possible to import in a few extra columns and plot them in the processing. These miscellaneous columns will not affect the inversions, but it can still sometimes be practical to have easy access to them in the processing.

In the above the line numbers are unusual in the sense that they don't have to be imported as a column. They can also be imported from Geosoft xyz files where they are placed between blocks of columns.

Related to the data file we also need to know the EPSG or coordinate system and datum of the data. We need to know the unit of the Voltage data. V, mV, μ V, nV, pV and fV are all supported. And finally, we need to know the used normalization. Rx area, Current and Rx area, Tx effective area and Rx area or Current, Tx effective area and Rx area are all supported.

The xyz format file

The third and final file we need for the import is the xyz format file, also referred to as the alc file. This is a text format (.alc) file with just two columns. It is used to map the different columns of the data file into the corresponding database fields used by Aarhus Workbench. The first column is the largely fixed list of database fields such as `utmx` and `utmy`, the second column holds the column numbers of the columns that will be read from the data file into those database fields.

For everything other than line number a -1 means that nothing will be read to this database field, for line number a -1 means the data file should be treated as a Geosoft xyz file with the line number between blocks of columns.

This alc file can either be edited by hand from an existing file, or it can be done using the editor found in the importer. The editor is quite useful when making changes to the import gates column numbers, but minor adjustments can just as easily be done by hand before starting the import.

With this we have all the necessary import files and can start using Aarhus Workbench.

Create a new workspace and import the GroundTEM data

Now we can open the Aarhus Workbench and select New to create a new workspace. Select a folder for the workspace, add names and select the map coordinate system (EPSG).

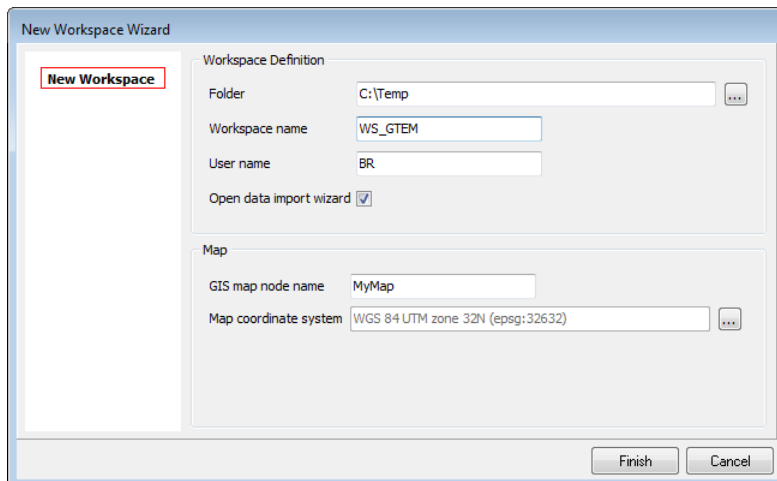


Figure 1. Create the Workspace.

When the workspace has been created, go to the database explorer and select Import on the database ribbon to start the import. If the open data import wizard checkbox was checked before, this wizard will open automatically. Now set the importer to import to a new database and fill out a name. Then go to the Groundbased EM Data tab and select Ground based towed TEM (xyz).

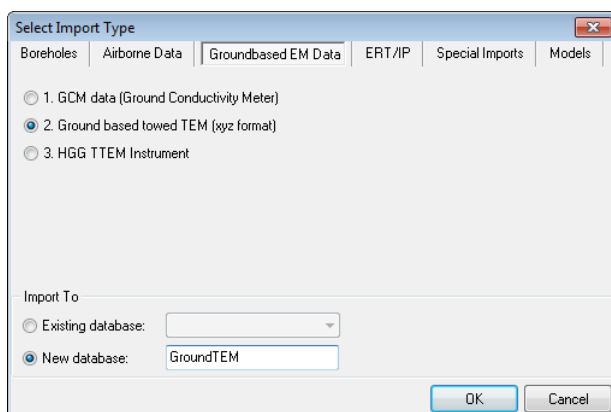


Figure 2. Select the Ground based towed TEM importer.

This launches the importer. Here we need to create the dataset and import the geometry file with the system setup. First name the dataset, then make sure that the right coordinate system has been set, and finally point the geometry file.

In addition to this, it is possible to set several labels related the data processing and the used height system and reference model. None of this affects the inversion of the data, it is just labels in the database.

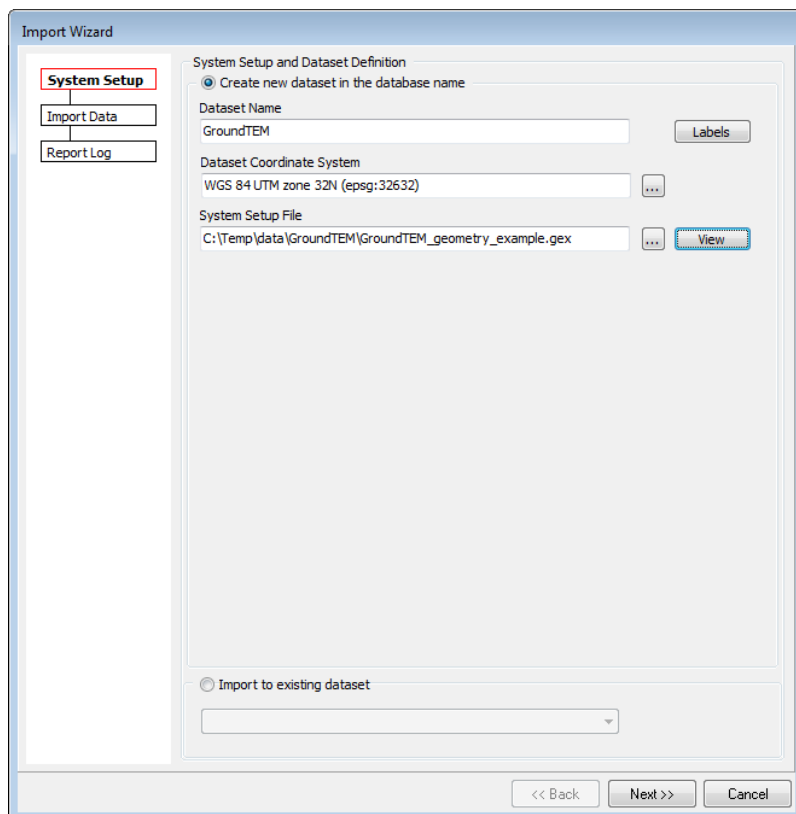


Figure 3. Create the dataset and import the geometry file.

Now we can import the data to the dataset. Point to the xyz file with the data. Then point to the xyz format file with the information about how the data from xyz file should be imported. It is here that it is possible to edit the xyz format file. The editor is great for changing the columns of the gates, but for other minor edits we can also easily update the column numbers directly in the file.

We often don't have the times in the data file. Then the time settings can be used to set an artificial starting point with a sounding distance, so that the data can be imported with dummy times.

Under unit settings we need to fill in the voltage unit and the data normalization. If the data has not been normalized by the current, we need to set the Transmitter peak current to be read from the data file. If the data has been normalized by the current, instead use a nominal value of 1.

It is possible, but in general not recommended, to skip the log form and go directly to automatic processing by pointing to a processing settings file here.

Finally, we have the option of doing decimation on the data and skip some of the data during the import. Start the import by clicking Finish.

Import Wizard

System Setup | **Import Data** | Report Log

Load Files

XYZ file: C:\Temp\data\GroundTEM\GroundTEM_data_example.xyz [View]

XYZ format file: C:\Temp\data\GroundTEM\GroundTEM.alc [Edit]

Settings

Time

☐ Define start time: 14-07-2010 12:00:00

☐ Nominal speed: [] [km/h]

☐ Sounding distance: 0.1 [sec]

☒ Read from file

Time format: yyyy/mm/dd hh:mm:ss

Units

Voltage unit: $\mu V [1e-6]$

Data normalized: Current and Rx area

Transmitter peak current: ☐ data file ☒ nominal 1 [Amp]

Processing

☐ Skip Log form and launch automatic processing function

Processing settings file: []

Misc

Decimation: 1 (import every 1 sounding)

<< Back Next >> Cancel

Figure 4. Import the data.

Alc File Editor

Format file fields

- TxAltitude
- TxOffTime
- TxOnTime
- TxPeakTime
- TxPitch
- TxRoll
- TxRxHoriSep
- TxRxVertSep
- UTMX
- UTMY
- Gate_Ch01_begin
- Gate_Ch01_end
- STD_Ch01_begin
- STD_Ch01_end
- InUse_Ch01_begin
- InUse_Ch01_end
- Current_Ch01

XYZ File

Date	9	10	Gate_Ch01_01	Gate_Ch01_02	Gate_Ch01_03	Gate_Ch01_04
2018/08/20	10.200	33	828.038829	1136.026033	1210.288646	881.129342
2018/08/20	10.200	33	823.184998	1132.167788	1208.461427	848.487780
2018/08/20	10.200	33	828.662836	1137.189280	1210.013186	880.012173

Settings

Dummy Value: 999999

Number of channels: 1

File Version: 2

Help

Select a keyword on the left side list.

To delete a column header, just click on its name.
(Double click to delete all the gates from a channel).

Save Close

Figure 5. The alc file editor. For gates there is an option to click on the first gate and then the last gate, it can then fill out the gate column numbers of the gates in-between. To adjust an already existing gate setup, first click on begin and then any of the already assigned gates to reset the selection.

When everything has been imported check the log. If everything looks fine, it is time to create the AEM node. For that go to Data Processing and select Data (create new processing) and then select the database in the dropdown and processing type Towed TEM. Then there is a dataset selector where we just need to say ok and a name for the processing node that needs to be filled out, before the data node will be created.

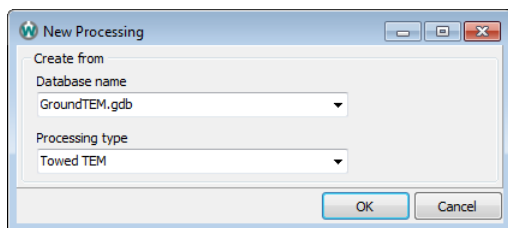


Figure 6. Create new data processing.

We will then be asked to also create a processing node. Here just click ones on each side of the data we want to include. If needed, click the button in the upper right corner of the form to reset. If the full dataset is very large or very dense, it is suggested to limit the size of the processing nodes. Larger nodes will be slower to work with in the processing. The more manual processing one expects to do, the more important it becomes to limit the size of the processing nodes. When doing so, it can be advantageous to enter the from and to times manually to get more exactly defined processing nodes that doesn't leave out any data. The create automatic interval feature is unfortunately not useful when using faked times.

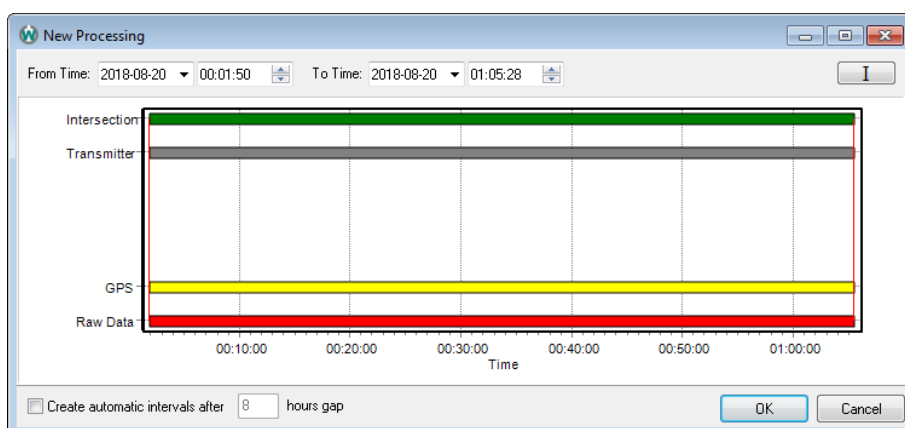


Figure 7. Processing node creation. Select the beginning and end of the data needed.

Lastly, we will be asked to give that node a name (this name must include a letter) and then we get to the processing filters. That will be covered in greater details later, for now just use default values. Note how the processing filters for Tilt and Altitude should remain unused for GroundTEM. This was the last part of the import.

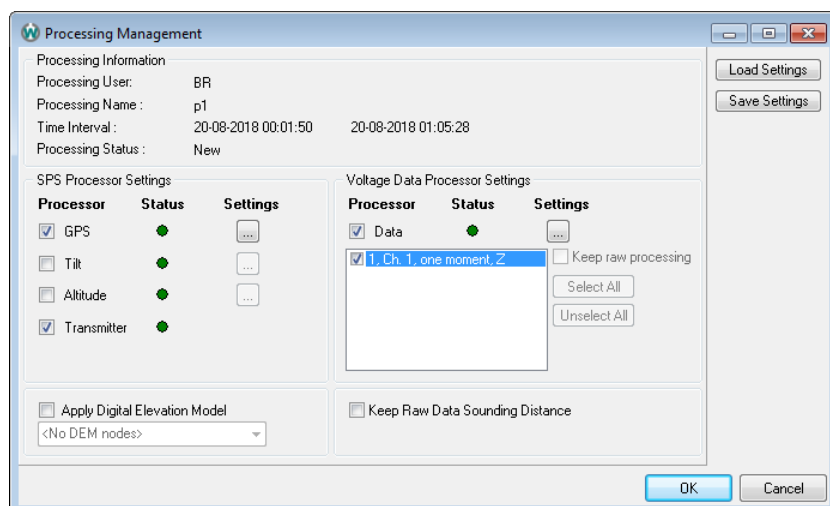


Figure 8. Processing filters with default settings for GroundTEM.

If it was necessary to cut the processing into multiple node, additional processing nodes should be made by selecting the data node and then selecting Process Data. This opens a window where we can select Create new processing node(s) which will return us to the Processing node creation. This is important as this allows us to create multiple processing nodes under the same data node rather than under a new data node.

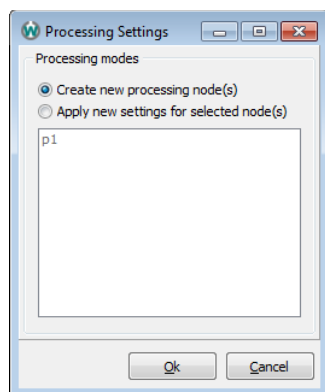


Figure 9. Creating additional processing nodes from the same data node.

All GroundTEM data from a survey should be imported through a single import, unless different geometry files make it necessary to split the survey into multiple imports. If additional GroundTEM data from the same survey need to be imported later, it is best done to a new database. There is an option to import to an existing dataset, but with GroundTEM data this will cause line number information for the already imported data to be lost in the process.