How to import AeroTEM data

In this document we will show how to create a new workspace and import AeroTEM data in preparation for AeroTEM 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 AeroTEM 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 AeroTEM 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 AeroTEM 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.
GPSPosition1	3 Reals	Position of the 1st GPS device on the frame.	Req.
		All device positions are described in X, Y and Z [m] with origin at the center of the transmitter coil and with z positive downward.	
		For AeroTEM the corrections based on the device positions usually have been done before the import of the data, so to avoid doing them a second time, all devices other than receiver are falsely placed at origin.	
AltimeterPosition1	3 Reals	Position of the 1st altimeter on the frame.	Req.
InclinometerPosition1	3 Reals	Position of the 1st Inclinometer on the frame.	Req.
RxCoilPosition1	3 Reals	Position of the Z receiver coil on the frame.	Req.

The device positions should be confirmed, but they are normally not changed for different AeroTEM systems.

2. [General] section – Transmitter loop definitions.

Keyword	Type	Description	
LoopType	Real	LoopType used by AarhusInv when inverting the data. This is usually 7 for AeroTEM. It describes a rectangular loop detailed with the TXLoopSides entry below The transmitter loop used by the AeroTEM instrument is not a rectangle and could in principle be more accurately described through a segmented loop setup. The important thing here however is the area that always is included in the AeroTEM instrument description and not the exact shape and corner points of the frame which usually isn't included.	Req.
TxLoopSides	2 Real	Side lengths of a rectangular loop. [m] The lengths must be set so that the area match the area of the transmitter loop.	Req.
NumberOfTurns	Integer	Number of Tx-loop turns used.	Req.

The TxLoopSides and NumberOfTurns depend on the exact AeroTEM 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/0587666478/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.	Req.

		The waveform description for AeroTEM is unusual in the sense that the waveform can change slightly from one sounding to the next, all other systems define a fixed waveform in the geometry file, but for AeroTEM this waveform is usually just a placeholder with the average waveform while the actual sounding specific waveforms are imported from the data file.	

The waveform definition for AeroTEM 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. Often the actual gate times stay the same for a given AeroTEM system, but to use the sounding specific waveforms it will be necessary to adjust the zero time of the gates. It is normally not important for the modeling how the zero time have been defined, there are different conventions for different systems. It is only important that it is done in the same way for both the gates and the waveform for the same system. When using the sounding specific waveforms however, it matters as the gate times need to be shared by all soundings while the waveforms can be written out individually for each sounding in the inversion files. This makes it natural to set the zero time to be at TxOff average and then adjust the gate times accordingly.	Req.

The gate times table will usually only need to be updated the first time it is used for a given AeroTEM 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 AeroTEM	Req.
GateFactor	Real	Calibration factor shift of dB/dt values [factor]. This is rarely used for AeroTEM	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 AeroTEM 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.	Req.

		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". (http://www.hgg.geo.au.dk/Papers_EndNote/0587666478/CHRISTIANSEN2011.pdf)	
UniformDataSTD	Real	Relative uniform STD for all dB/dt gates. 0.05 = 5%	Req.
RepFreq	Real	Repetition frequency.	
TxAppoximateCurrent	Real	Approximate transmitter current. This must be within 25% of the actual current, else soundings with extreme values will be removed during the processing. If the voltage data has been normalized with the current, this value should be set to 1.	Req
ReceiverPolarizationXYZ	String	Receiver polarization. This can be X, Y or Z. The usual setup is to have it as Z.	Req.

The Channel1 sections will usually not have to be changed much, but it should still be confirmed. The most important values here are RepFreq with the repetition frequency of the system.

It can 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 AeroTEM the key database fields we are looking for in the xyz file columns, possible with slightly different names, are:

Line number
UTMX
UTMY
Topography
Transmitter Altitude
Gate_01
…
Gate_xx

To use sounding specific waveforms, we also need the waveform description with times in ms and with the same zero point as the waveform and gate times:

TxOnTime
TxPeakTime
TxOffTime

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 yyyyy/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 EPGS or coordinate system and datum of the data. We need to know the unit of the Voltage data. V, mV, μV, nV, pV and fV are all supported. And finally, we need to know the used normalization. Rx area [V/m^2] (sometimes instead expressed as [T/s]), Current and Rx area [V/Am^2}, Tx effective area and Rx area [V/m^4] or Current, Tx effective area and Rx area [V/Am^4] 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 AeroTEM 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).
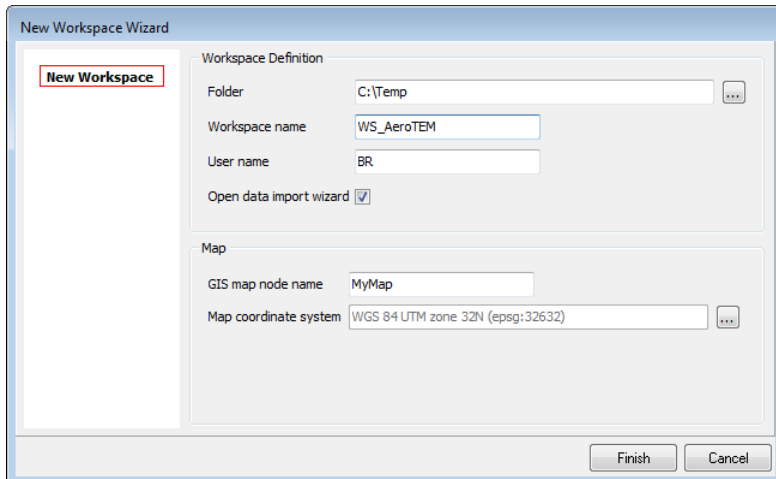
Figure 1. Create the Workspace.

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 Airborne Data tab and select Airborne TEM Processing (AeroTEM).
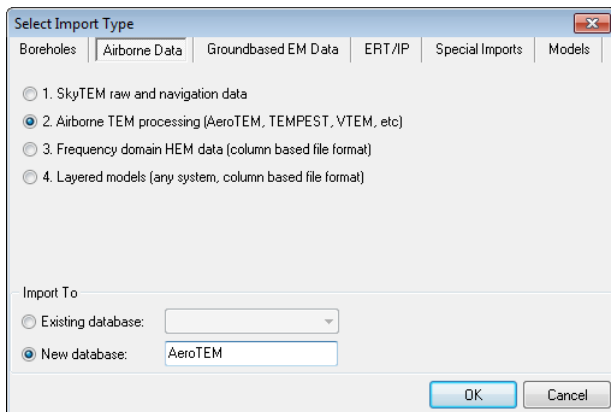

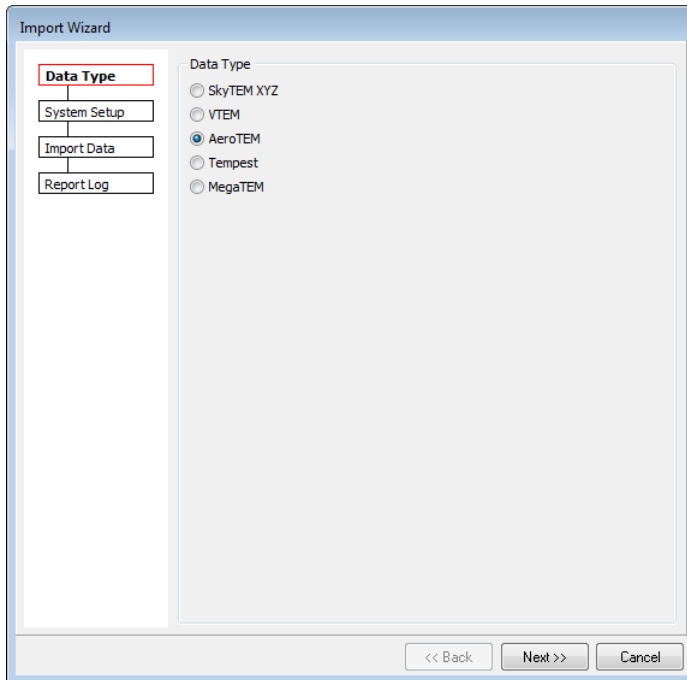Figure 2. Select the Airborne TEM importer.

This launches the Airborne TEM importer. Select the AeroTEM importer.

Figure 3. Selecting the AeroTEM importer.

Here we need to create the new 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.
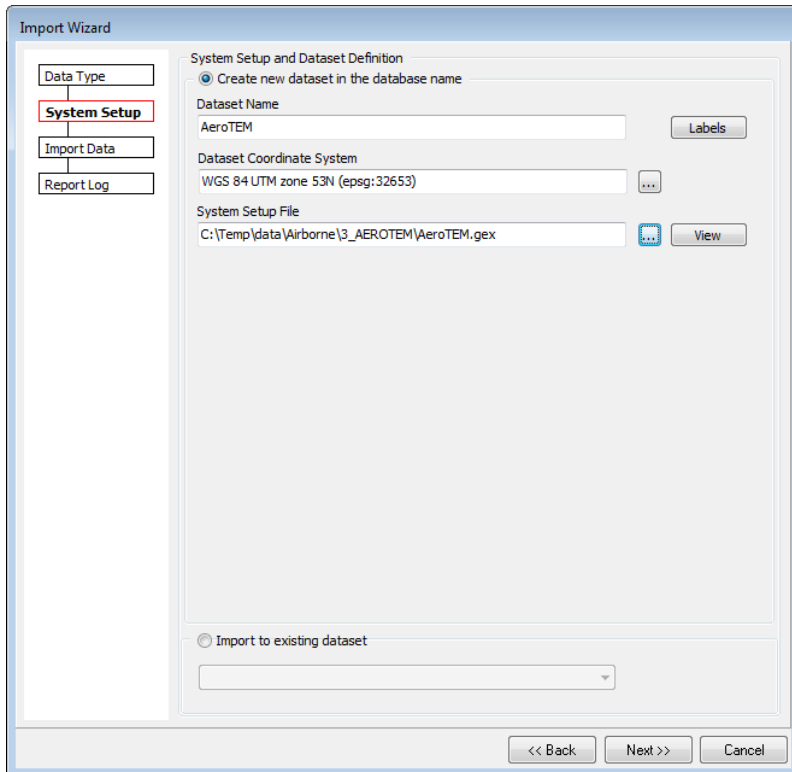
Figure 4. Create the dataset and import the geometry file.

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.
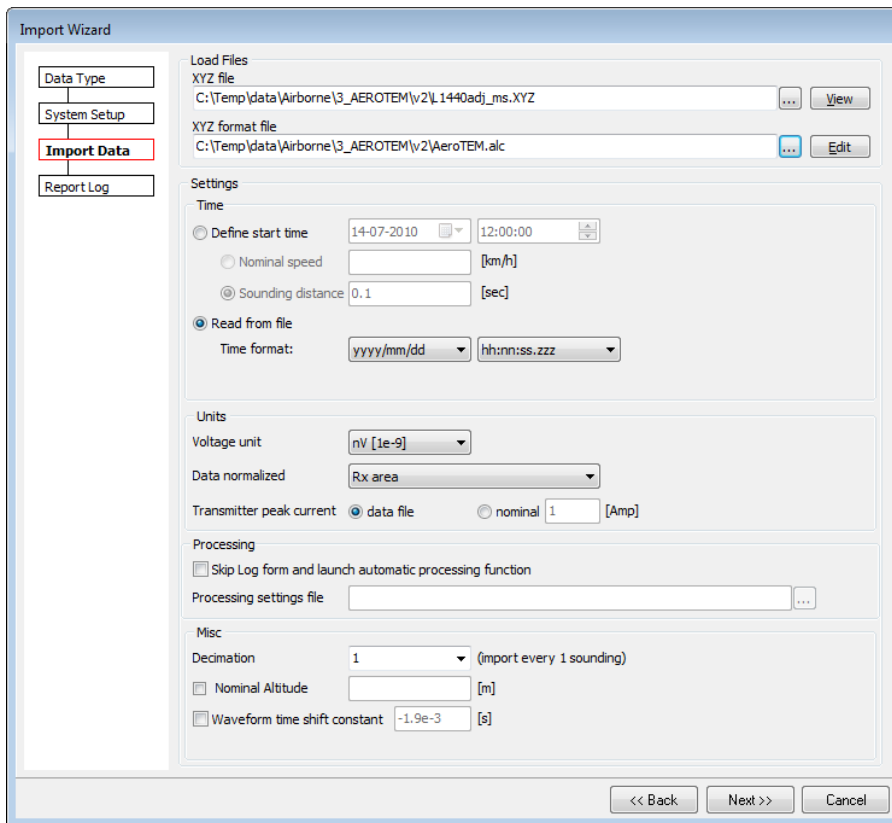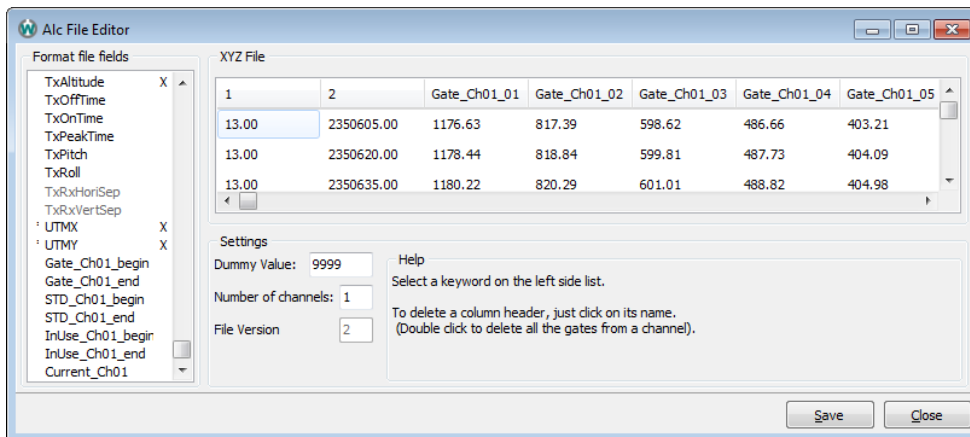
Figure 5. Import the data.

Figure 6. 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 data node. For that go to Data Processing and select Data (create new processing) and then select the database in the dropdown and processing type Airborne 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.
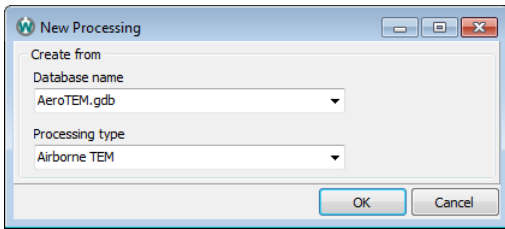
Figure 7. Create new data processing.

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.
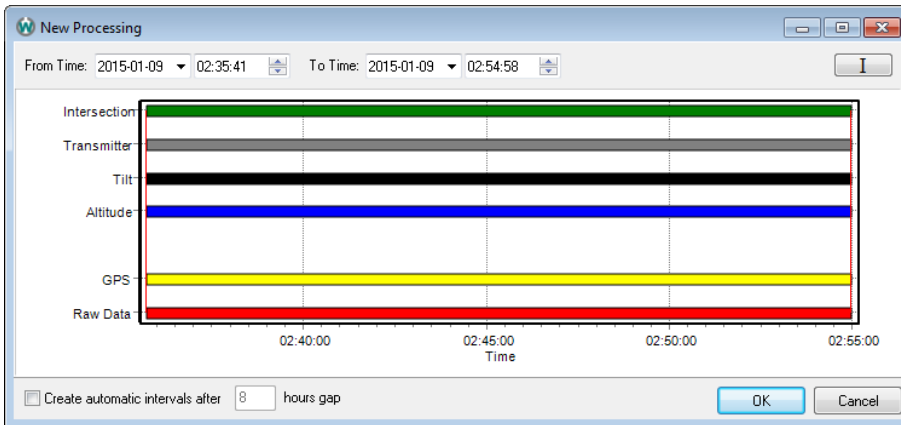

Figure 8. Processing node creation. Select the beginning and end of the data needed.

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. This was the last part of the import.
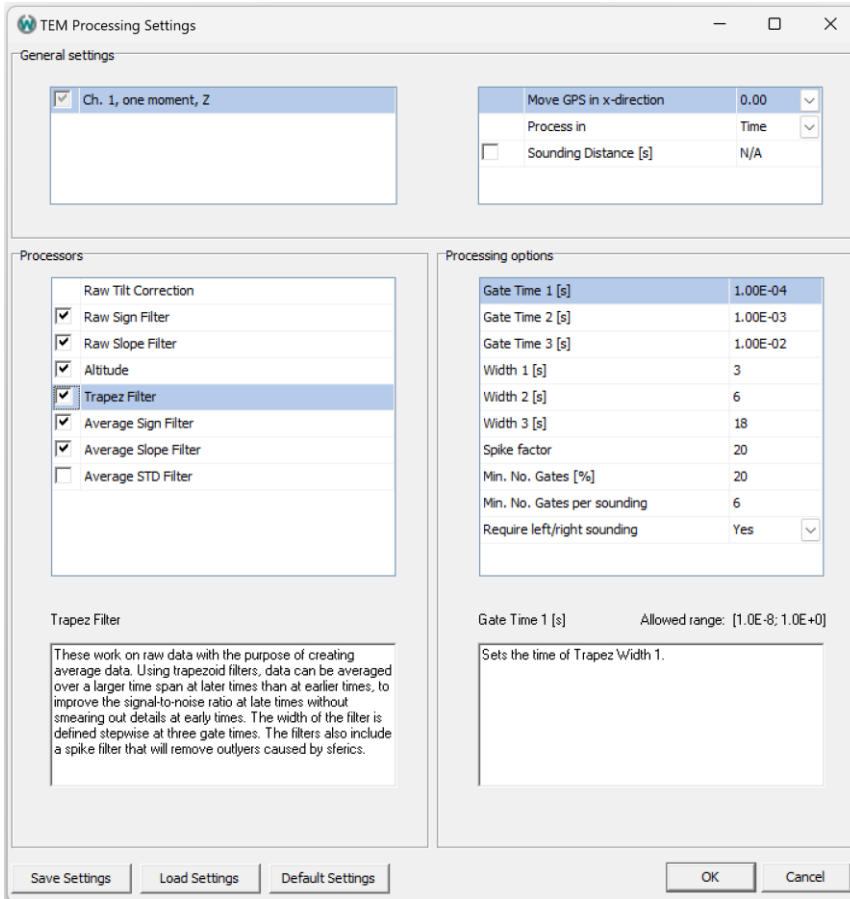
Figure 9. Processing filters with default settings.

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 open 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.
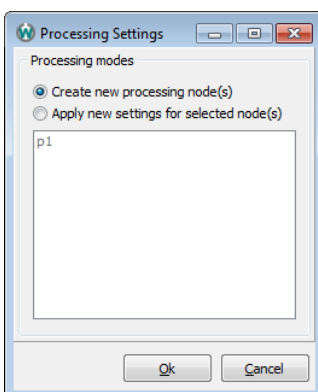

Figure 10. Creating additional processing nodes from the same data node.

All AeroTEM 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 data from the same survey need to be imported later, it should be imported into the same dataset. The only exception would be if parts of the survey was flown using a different geometry file, then import it into a new database. To import additional data of a different type, simply import it into a new database.

When importing to the same dataset, go into import as before. Since the database already exist we can adjust the Import To setting to points to the existing database.
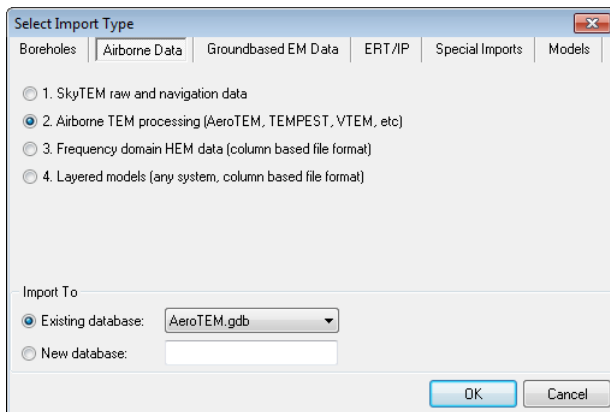

Figure 11. Importing to an existing database.

The dataset has also already been created, so we can select the import to existing dataset option and point the existing dataset. The rest is done just like before, just point to the new xyz file with the data. There is one little thing however that we need to remember here, if we are using an artificial starting point, one should move the date ahead here so that we don't import to the same time. When done additional processing node can be made just as described earlier.
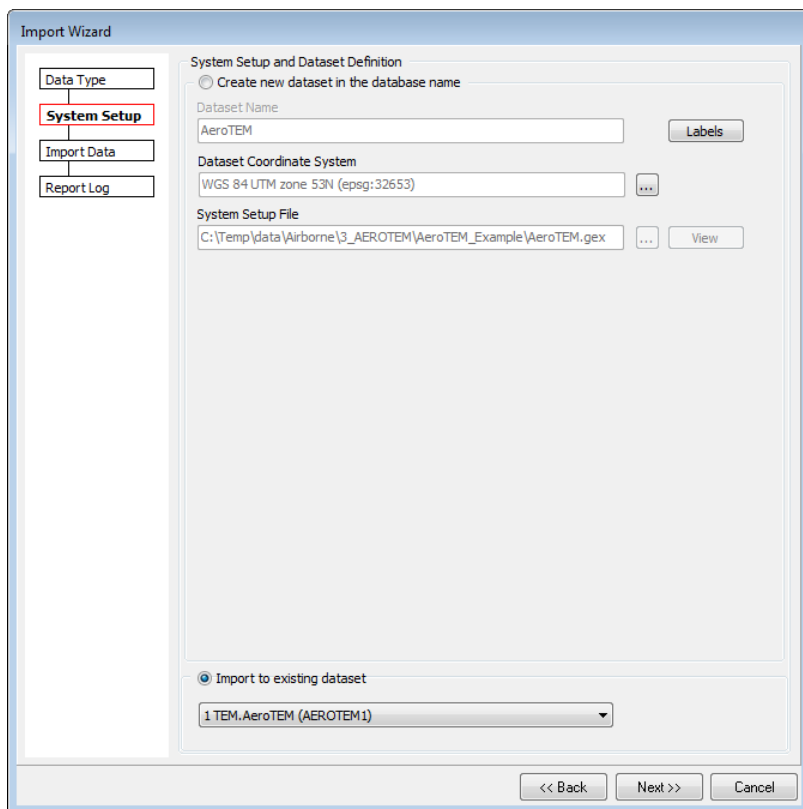
Figure 12. Import additional raw data to existing dataset.