TEMcompany

tTEM

USER MANUAL

Ver.1.2.1

TABLE OF CONTENTS

1. INTRODUCTION

1.1 What does the user manual contain

This user manual contains technical and theoretical specifications for the tTEM ground-based TEM system. It serves the purpose of introducing the tTEM system to the user regarding what needs to know before, during and after the field survey. It covers the tTEM components, the mechanical setup, which software to use and how, tips for when the user is about to plan a survey, what files and parameters are being used during a survey and how to proceed with the acquired data, from transferring them to their processing.

1.2 The Transient Electromagnetic Method

The measurements are made by transmitting a direct current through the transmitter coil. This results in a static primary magnetic field. The current is shut off abruptly, which induces an electrical field in the surroundings (Figure 1). In the ground, this electrical field will result in an electrical current which again will result in a magnetic field, the secondary field. As time passes, the resistance in the ground will weaken the current (which is converted to heat), and the current density maximum moves downwards and outwards leaving the current density still weaker. In a conductive ground, the current diffuses more slowly down into the ground compared to a resistive ground where the currents will diffuse and decay fast.

The decaying secondary magnetic field is vertical in the middle of the transmitter coil, and an electro motoric power is induced in the receiver coil - a voltage – and this is the signal, which is measured as a function of time in the receiver. Just after the current in the transmitter coil is turned off, the current in the ground will be close to the surface, and the measured signal reflects primarily the conductivity of the top layers. At later times the current will run deeper in the ground, and the measured signal contains information about the conductivity of the lower layers. Measuring the current in the receiving coil will therefore give information about the conductivity as a function of depth – this is often called a sounding.

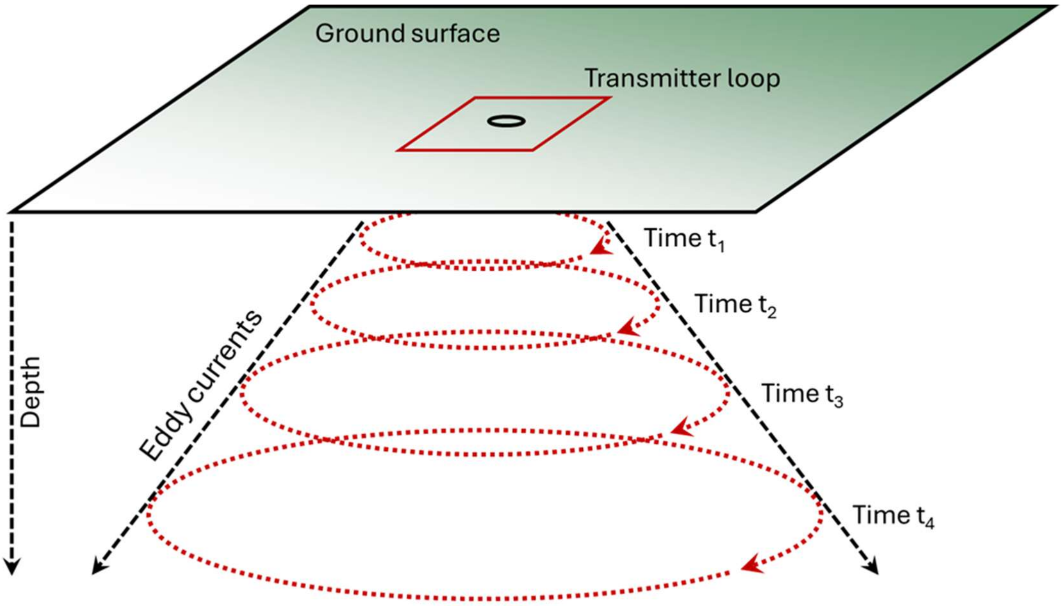


Figure 1. Principal sketch of the TEM method

2. TTEM SYSTEM – COMPONENTS

List of tTEM parts

The following list of items is needed to run the tTEM system.

Type	Name	Amount	Description
Electronics	tTEM unit	1	Transmitter & Receiver Unit
	RCS20	1	Receiver Coil
	TX Battery	1	Suitcase with 12 V, 100 Ahr Battery
	Tablet	1	Android Tablet with remote desktop app
	RRC2054-2	1	Battery for receiver side of the tTEM unit
Cables	Power cable	1	Power cable for powering up TX from Battery
	Tx coil*	1	Transmitter coil
	Tx coil lead in⁺	1	Lead in cable from TX to Transmitter coil
	Tx coil adapter	1	Adapter only for the 333 Tx coils
	Receiver cable⁺	1	Cable from RCS20 to Tx (1 mounted & 1 spare)
Mechanical	Tx Platform	1	Platform for the TX coil
	Rx Platform	1	Platform for the RCS20
	tTEM wings*	4	Wings for Tx platform and for Tx coil
	ATV platform	1	Platform for equipment on ATV

* Wings and transmitter coils need to be compatible. Similarly, TX coil lead-in and receiver cable need to be the same length.

3. TTEM – MECHANICAL ASSEMBLY GUIDE

The equipment requires some preparation before going to the field for first time.

Coolant in TX unit

When receiving a tTEM system the coolant reservoir in the Tx unit will be empty and must be filled with coolant suited for aluminum before powering up. To fill coolant in the reservoir:

- Power on the Tx unit.
- Use the filler bottle (lab-type plastic squeeze bottle) and fill it with coolant.
- To open the reservoir, unscrew the front bolt in the top of the reservoir (see arrow in Figure 2) using an Umbraco/Hex/Allen type key.
- Fill the reservoir using the filler bottle.
- Run the pump by pushing the bypass button seen in Figure 2. This will circulate the pump and empty the reservoir, allowing you to fill coolant again in an iterative approach.

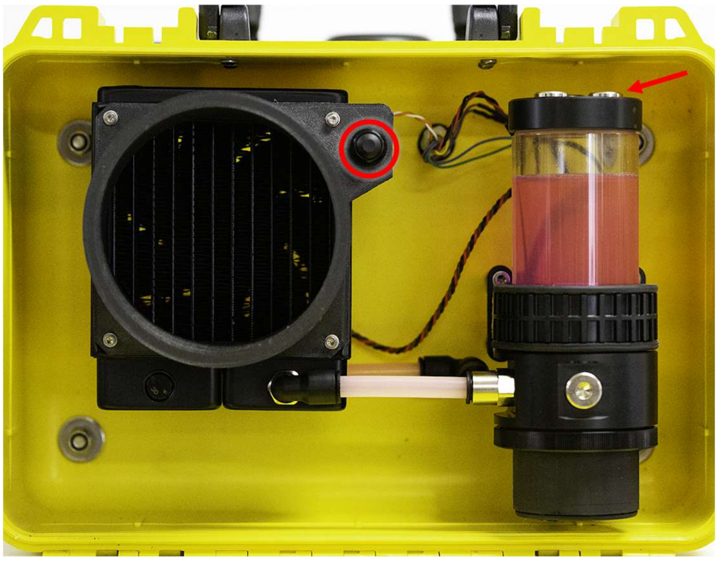


Figure 2. Coolant compartment of TX unit with bypass button indicated in red circle.

Notes

- It takes around ½ liter (0.22 gallons) and 2-3 fillings before the system and reservoir are full.
- Coolants suited for aluminum are found in every auto parts store.
- If using a coolant concentrate, follow the instructions for dilution ratio.
- The coolant concentrate should be diluted using distilled water.

- If you are in doubt about concentration, a higher dilution is generally better.

How to mount Receiver coil RCS20

The Receiver coil is easily mounted on the Rx platform (1) using the 8 bolts screwed in the runners – four on each side. Then place the receiver coil and insert the 8 bolts through platform into the runners.

Figure 3. Mount Receiver Coil RCS20

Connecting receiver cable to receiver platform

The receiver cable must be connected through the white plastic bracket as seen in Figure 4.

Figure 4.Connecting receiver cable to receiver platform and RCS20

4. TTEM – FIELD OPERATION GUIDE

A field crew of two people is recommended to operate the tTEM system efficiently.

The workflow for performing a tTEM survey at one location goes through the following steps:

1. Field assembly
   a. tTEM wings
   b. tTEM Tx coil
   c. tTEM equipment in ATV platform
2. Powering on the tTEM unit.
3. Operate the app to collect data.
4. Run the survey.
5. De-mobilize the system.

4.1 Field assembly

This section covers the required steps for when the system is in the field and needs to be set up for measuring.

tTEM Wings

- The wings have a “This side up” text on the wingtips.
- The wings should be inserted all the way in, until the grey part is no longer visible.

Notes

- *For new systems this may require a bit of jiggling to get the wing in.*
- *All wings are identical.*

Figure 5. Insert tTEM wings.

tTEM Tx coil

How the complete setup of the Tx coil and Tx lead-in cable must look like is shown in Figure 6. To set it up follow the steps below:

- Start by rolling out the Tx lead-in. The connector should be placed towards the ATV (**OBS! Do NOT connect it yet to the Tx unit.** See "Powering on the tTEM unit.). Attach the soft shackle in the front left runner and put the connectors on top of the wing.
- Start placing the Tx coil. The black box needs to be placed on the front left wing. Attach it to the wing in the way where the sign "UP" it is facing upwards.
- The **blue tape** indicates the Tx coil side that goes after the **front left wing**.
- There is a pair of **black heat shrinks** on either side of each wing.
- When the Tx coil is correctly setup, tighten it using the black cleat on the front (towards the ATV) of the coil
- Connect the Tx coil to the TX coil lead-in.
- Once mounted, the system should resemble the one shown below in Figure 6.
- If the Tx coil is a multiturn coil (333 or 443) the adapter provided is required to be used. Plug the adapter into the tTEM unit and then the lead-in.

Notes

When putting the Tx coil on, it is preferable if there are two people helping each other.

Figure 6. Example of tTEM2 system with 331 Tx coil.

Figure 7. How to operate a cleat. In the beginning the rope is loose (top), bring the rope beneath the black cleat and towards up and tighten it (middle). After lock the rope by bringing it downwards to the left side of the black cleat (bottom).

Figure 8. Tx coil adapter for Multiturn Tx coils (333 or 443).

tTEM equipment on ATV platform

Place the equipment in the matching position to the ATV platform (see Figure 9).

- Connect receiver cable to Tx unit.

Notes

- On some ATV platforms the battery position is rotated.
- Tx coil lead-in needs to have some slack/extra cable between the mounting point of the ATV and the Tx unit.

Figure 9. Back side of ATV platform with equipment, on newer platforms the battery is rotated 180 degrees.

4.2 Powering on the tTEM unit.

To turn on the tTEM unit:

- Insert one RRC 2054 in the tTEM unit (wait 5 seconds before connecting the Tx battery).
- Close the case and place it upright (handles pointing up).

- Connect the tTEM unit to the Tx battery via the power cable.
- Press the power button. The two battery LED indicators should light up.
- When LED lights are lit up, connect the Tx coil lead-in to the Tx.

The third LED light is GPS lock indicator.

- Blinking if receiving GPS signal.
- Off if not receiving GPS signal.

Notes

- Powering on and getting GPS lock takes a few minutes.
- There is a USB C connector on the board, which is used only for debugging the system and should NOT be used for anything else.

4.3 Operate tTEM controller app to collect data

When field setup is completed, tTEM controller app can be operated to start the survey. Open the app and follow the steps below:

- Make a New Project (or continue an existing one).
- Select Protocol.
- Add a background map, if available.

For more information on the tTEM controller app, see section 5.

4.4 De-mobilize the system

- Turn-off tTEM PC from the tTEM Controller app and press the power button on the tTEM unit.
- Disconnect cables and put protection caps on the plugs.
- Disassemble the tTEM Tx coil, tTEM wings and the equipment from the ATV platform.

To avoid dirt in the plugs, do not drag the plugs on the ground.

5. TTEM CONTROLLER APP

Installing the tTEM Controller App

The tTEM system is controlled by the tTEM Controller app which is preinstalled on the supplied tablet. The app can also be downloaded from iOS and android app stores at:

https://www.temcompany.com/products/software-product-downloads/

Connecting to the tTEM unit

- Make sure that the tTEM unit is turned on. It needs to run for a few minutes to set up the tTEM Wi-Fi.
- From the tablet **connect to the tTEM** Wi-Fi network.
  Wi-Fi name: tTEM_0### (ID of the tTEM instrument).
  Password: 0102030405060708
- Open the tTEM Controller app. If it is properly connected it will display the controller interface as shown in Figure 10.

Figure 10. tTEM controller start screen where campaign is chosen. Create a new campaign, continue the last campaign or open an older, existing campaign.

tTEM Controller App – Create project

To start a new project, fill in the fields shown in Figure 11 as explained below:

- **Make "New Project"**
    - Insert "**Project Name**" (Provide a name for the project i.e. Aarhus - **mandatory**).
    - Insert "**Description**" (**optional**).
    - Insert "**Operator Name**" (i.e. name initials of the tTEM user - **mandatory**).
    - **Select Map** (select background map i.e. json, pgw, or png format - **optional**).
    - **Select Protocol** (select the protocol that matches with the transmitter coil that is being used e.g. Protocol_tTEM_331_RC20_50Hz.sts - **mandatory**).

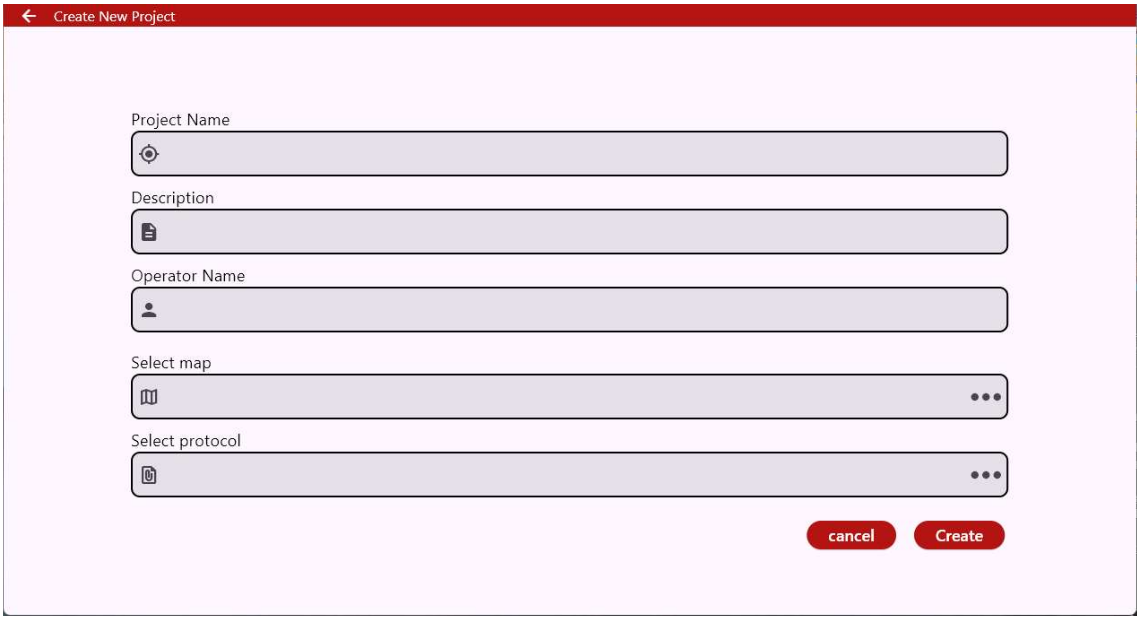


Figure 11. Fill the requested fields to create a new project.

Notes

- To copy the background map to the tTEM unit use the **TEM Data Manager** app to upload the files from the local PC to the "Maps folder" using the "Upload" button (Figure 20).

- The size of the file of the map must not exceed 20 Mb. The map needs to be copied to in the tTEM unit before starting the project.
- Maps can be created in free access software e.g. QGIS.
- Imported maps will show up in alphabetically order, first maps and then lines and points.
- If no background map has been selected, a default map from Open-StreetMap will be used.
- When changing the transmitter coil (e.g. from 331 to 333) after setting up the project with the correct protocol, the tTEM computer needs to be re-started to apply the settings. If a project is created with a wrong protocol, e.g. using a 331 coil, but the project is created with a 333 coil, then a new project with the correct protocol must be created by repeating the above step.
- When the tTEM is connected to both tTEM controller App and TEM Data Manager it can be turned off only from the TEM Data Manager. Turn-off button on tTEM controller App is being disabled at that time to prevent mistakenly turning off the instrument and potential failure in the internal hardware.

tTEM Controller App – Continue project

To continue the same project press "Continue". Alternatively, if a project was made previously press "Open Existing Project" and a window with all the available projects will be displayed to select the desired project (Figure 12).

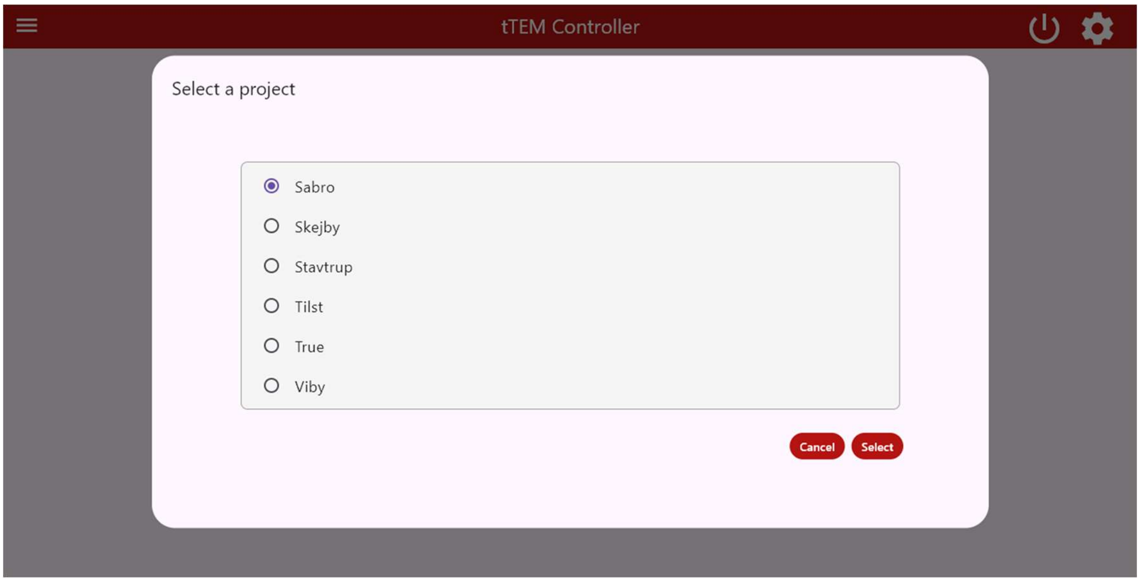


Figure 12. Select an existing project.

Starting Screen

When the project is launched, the starting screen will appear (Figure 13).

- The main view displays a map with your current location marked.

Note: *If the default OpenStreetMap does not load, the unit likely needs internet access. Use the Support option in the Main Menu (☰) to connect to an external Wi-Fi or mobile hotspot. Once online, open your project and zoom in/out to prompt the map to load correctly.*

- Left panel: Line number, Speed, Data, Temperature, HM current and GPS status indicators to inform the user during the survey.
- Middle panel: Map with driven lines. Imported shapefiles and pictures can be displayed.
- Right panel: Incoming data in tab "Data". "Map settings" in "GIS" tab. System information in "Info" tab.

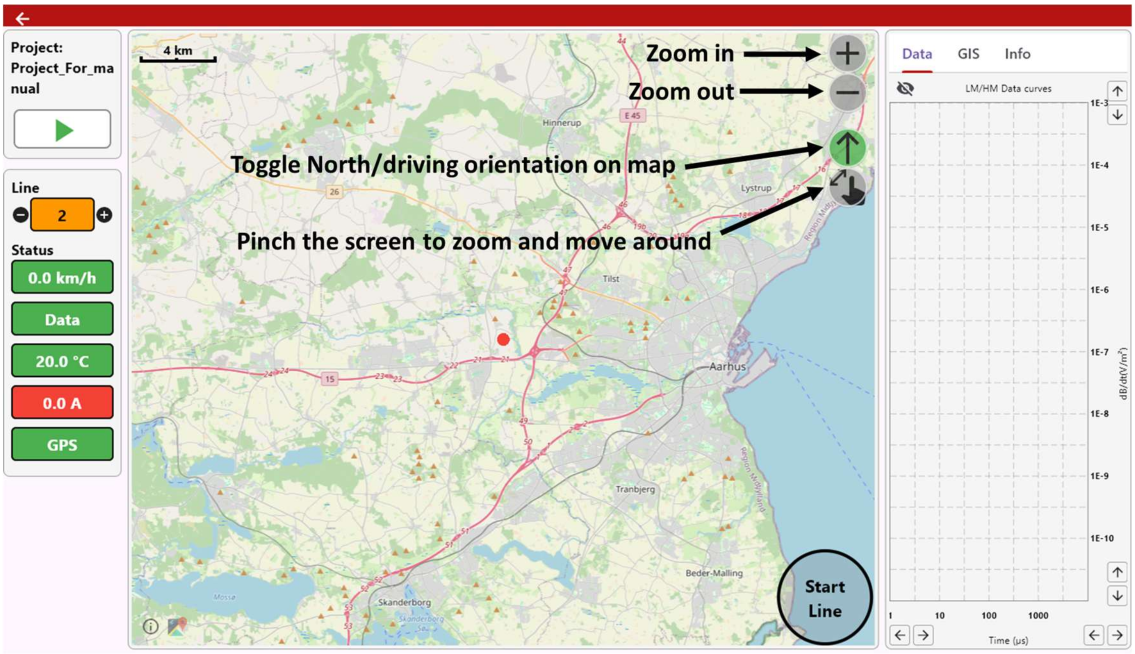


Figure 13. Starting screen interface.

tTEM Controller App – Operate

To start collecting data, press Run (top left corner). Then the transmitter will begin to transmit current.

- Start Line, press when the geometry of the system is straight.
- End Line, press before the geometry of the system is not straight (i.e. before turning).
- Pressing anywhere on the screen will start and end line.

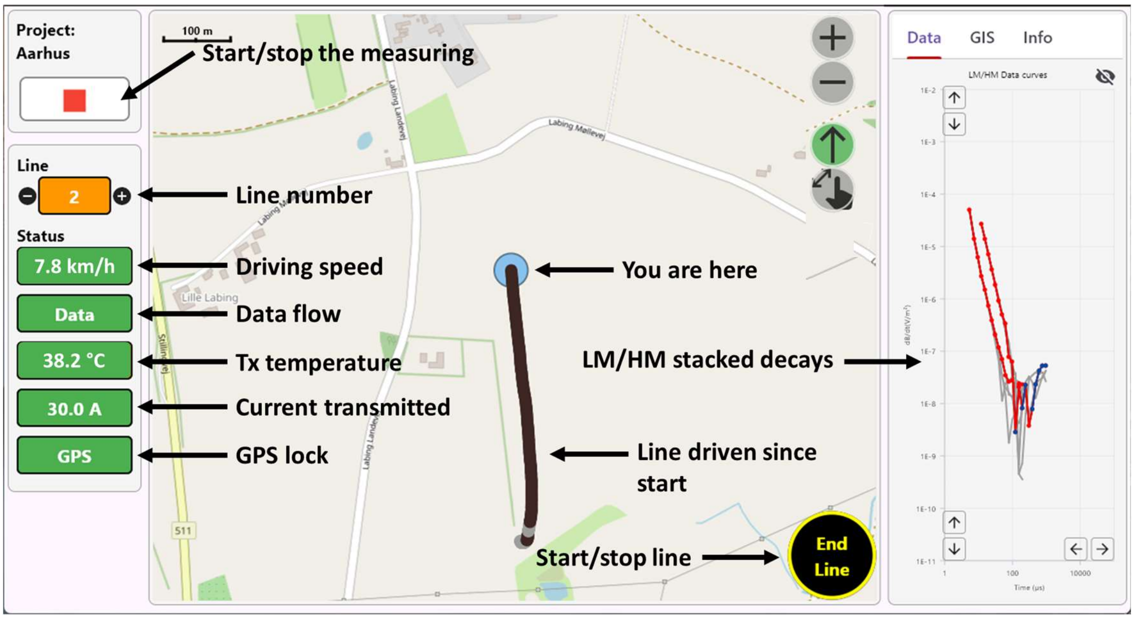


Figure 14. tTEM controller display.

tTEM Controller App – GIS & Info

The “Map settings” (Figure 16) can be changed under GIS tab, as well as the “GIS settings”.

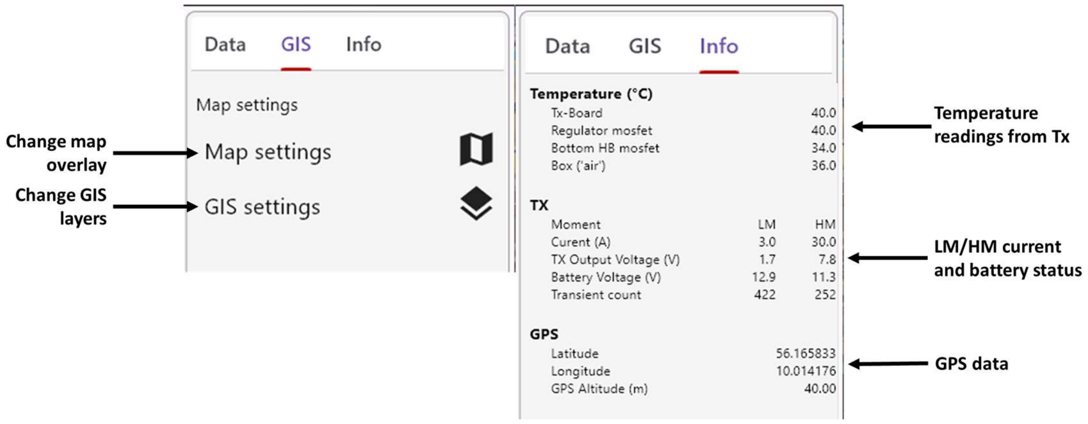


Figure 15. Showing the GIS tab with options.

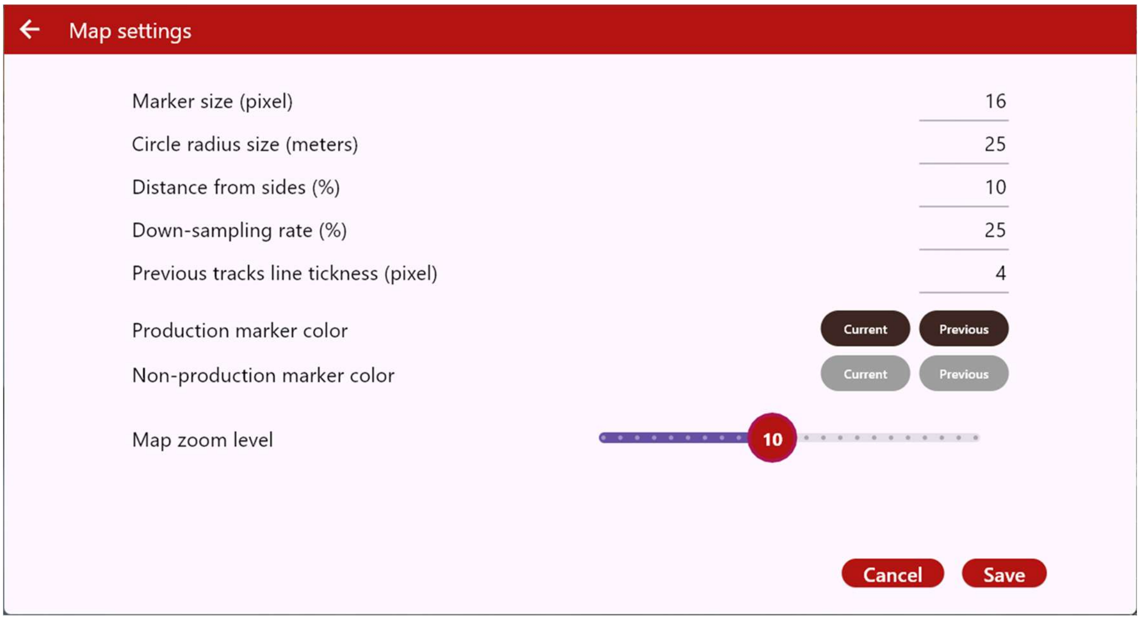


Figure 16. Options for map settings.

Supported filetypes for background maps/images & shapes

Coordinate system

tTEM Controller app supports the commonly used **EPSG3857** (WGS 84 / Pseudo-Mercator) and **EPSG4326** (WGS 84) Coordinate Reference Systems (CRS). These CRSs are used for example by Google Maps, OpenStreetMap, Bing ArcGIS, ESRI, QGIS* etc.

In **EPSG3857** the coordinates are in meters and use Mercator projection while **EPSG4326** uses latitude and longitude for coordinates. Both CRS' are based on World Geodetic System 1984.

*The suggested software is QGIS since it is an open-source software.

Background maps and images

The tTEM Controller app supports .png and .jpg files with World files. World files contain georeferenced information for the image and must have the same name as the image file name. Extension will be .pgw for PNG and .jgw for JPG file (i.e. image.pgw & image.jgw).

In QGIS, before exporting, make sure that the correct CRS has been selected. From the top of the menu bar select first "Project" then "Import/Export" and "Export Map to Image" to export map as image.

Make sure that "Append georeferenced information (embedded or via world file)" checkbox has been selected. This is needed to create a world file that contains georeferenced information for the created image.

Shapes (points, lines, polygons)

The tTEM Controller app supports .geojson alone.

To export shapes from QGIS, right click on the shape layer in Layers section of QGIS, and select "Export" then "Save Features As…". In the dialog window, select CRS ("EPSG: 4326 – WGS 84" or "EPSG:3857 – WGS 84 / Pseudo-Mercator").

Each layer should be in its own file.

Upload Map Files to tTEM instrument

See Download and upload data section for more information on how to upload the created files.

Premium features and real-time inversion

If you have access to the Premium features package, you will have access to the real-time inversion option in the tTEM Controller app. It is designed to provide immediate insights into your subsurface data while you're still in the field. As data is collected, the instrument will automatically perform a preliminary 1D inversion using a smooth model. When measuring along a line, will result in the display of pseudo-2D sections by interpolating the individual 1D models — giving you a quick overview of lateral variations. The app provides insight into the depth of investigation (DOI).

Figure 17. Real-time inversion tab. A pseudo-2D resistivity section of several 1D interpolated models is shown along the surveyed line.

Real-time inversion Troubleshooting

There are two common situations where an inversion model may not appear:

1. **A gray model is displayed**

The grey model bar is a dummy bar, that is displayed when the inversion process is running, but the automatic processing rejects too much data for the inversion to be able to run. This usually indicates that the collected data is poor quality, possibly due to noise, couplings, induced polarization, 3D effects or something else. The relevant log file will display the following message:

Sapi.InversionThread: Lupus inversion returned error {type: ValueError, message: Not enough data points, has 0, expect at least 5}

2. The inversion window is completely blank

This typically points to a problem with the inversion function itself, rather than the data. This can happen due to the following reasons

a) **Inversion is turned off** – Go to the **Settings** and make sure inversion is enabled (Figure 18).

b) **License issue -** The instrument does not have a Premium Functionality License, or it has expired. Check the expiry date under the **About** section. Contact support@temcompany.com for information on how to get it re-newed.

c) **Inversion process not running –** If the above two are fine, then contact support@temcompany.com for help.

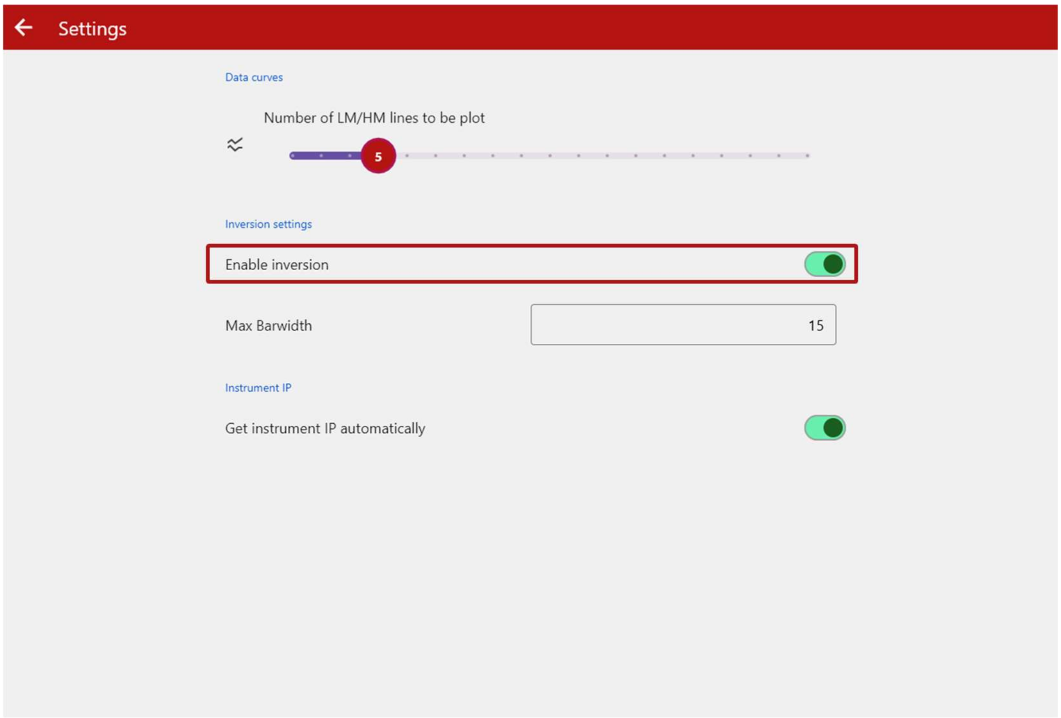


Figure 18. Enable/Disable inversion option in Settings menu.

6. SURVEY

General

- Do not connect/disconnect plugs/cable while recording data.
- Do not connect/use damaged plugs or cables. For repair/replace options contact TEMcompany or reseller. Minor damage on Tx coil can often be repaired with insulation tape.
- Do not connect plugs if the inside is wet or dirty.
- To clean the equipment, use a wet cloth with soap for the tTEM instrument, the RCS20 and the cables (Tx coil, receiver cable, power cable). Use air pressure (if available) and/or a spatula to remove mud and dirt from the platforms.

Survey Packing

- Create a check list with all the items needed for the field. Use it to make sure you bring everything back when you return.
- Batteries charged (RRC battery, 100 Ah battery and tablet). It is recommended to either have a power bank connected to the tablet or charge the tablet directly from ATV.
- If possible, bring a spare RX-cable. In case of damaged cable , the fieldwork can continue.
- A toolbox might be helpful to do a field-repair while on a survey. Recommended items to include are a 30 mm wrench, a cleaning spray for connectors, screwdrivers with different heads, a multimeter, duct tape and extra zip ties.

Survey

Before starting up the ATV and driving, there are some pointers and things to be aware of listed below.

- ***If something breaks, it is going to be a cable***.

    This is of course an exaggeration, but true in many cases. When driving, and especially turning, keep an eye on the cables between the ATV and Tx platform (this means the Tx coil lead-in as well as the Rx cable). The cables will be more under tension when turning, and it is very important learn just how tightly you can make the turns.

- ***Watch your speed and watch your equipment.***

  The tTEM system is, including ATV, almost 20 m (66 ft) long. Whenever you are driving in tight quarters, around corners etc., look back and keep an eye on the system. Even though it is tempting to open the throttle on the ATV, please do not. The faster you drive (>20 km/h (12 mph)), the more difficult it will be to stop or correct your course. Remember to look at the RCS20 platform as well, as it tends to get tangled in trees, bushes etc. This happens due to inattentiveness and because the system is almost 20 m (66 ft) long, the turns must be large enough.

- ***Setup of instruments and cables must be checked***

  Check if the cables are coiled or have any loops. Make sure the distances are correct – if there is excess cable there is risk of creating loops.

Notes

- Do not charge the batteries if the battery or ambient temperature is below 0 °C (32 °F).
- Do not charge the battery if the battery temperature is below 0 °C (32 °F).
- Each day before driving a quick tightening of all bolts should be performed.
- Keeping the equipment clean and tidy without mud and dirt helps with its reliability.
- Check all cables and ropes for fraying and excessive wear. This includes the connectors.

6.1 Survey Troubleshooting

Apart from the normal dB/dt decays that can be seen during a survey, there are few cases where their shape changes. The parameters that cause these changes are described below.

How it appears	Cause	Solution/ What to do
Not smooth decays in the noise level (Figure 19, A)	Receiver cable is not connected to the TX	Connect the receiver cable to the TX.
Flatish decays (Figure 19, B)	RCS20 is not connected to the receiver cable	Connect the RCS20 to the receiver cable.
Signal level is low for both LM and HM & sign change can be seen either in both moments or only in HM (Figure 19, C)	High resistive areas are with chargeable layers and may produce this type of response. The system operates properly and there is no need for further action.	In case of doubt, move to a different area with less resistive subsurface or with a known response from previous measurements and check the shape of the decays.
Decays with several fluctuations-spikes	Capacitive coupling. It can be seen when crossing buried cables.	Move further away from the area and check the shape of the decays.
Last gates have very low signal (0 dB/dt) (Figure 19, E)	Defective Receiver cable	Change Receiver cable and test if the shape of the decays remains the same.
Last gates have very low signal (0 dB/dt) (Figure 19, E)	Defective RCS20 lead in	Check the RCS20 lead-in if it has been pulled and if there is any damage in the connection.
First gates in LM have a small “step” behavior (Figure 19, G)	Multiturn Tx coil has been plugged in without the Tx coil adapter.	Plug the Tx coil adapter and then the Tx lead-in.

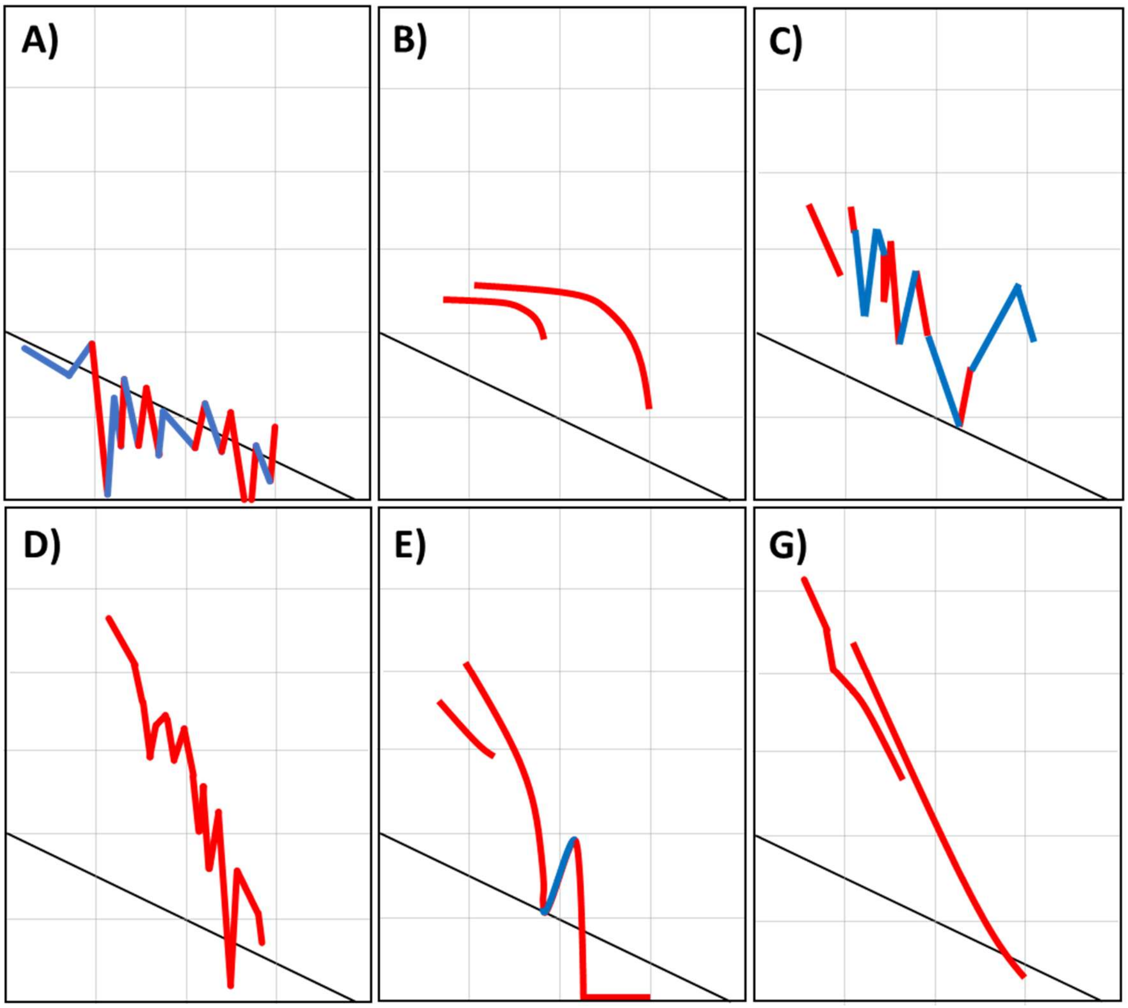


Figure 19. Different decay shapes. A) Only the noise level, B) Flat'ish decays C) Decays with low signal levels and sign change (only in HM in this example), D) Decays with several fluctuations-spikes, E) Last gates have very low signal (0 dB/dt).

7. DOWNLOAD AND UPLOAD DATA

The recorded data is downloaded/copied from the unit to a PC using the *TEM Data Manager* program. *TEM Data Manager* is available on TEMcompany's website (https://www.temcompany.com/products/software-product-downloads/). This section is written for version 2025.2.0.7.

Connecting to tTEM2 Wi-Fi

The first step is connecting the *Local PC* to the Wi-Fi of the unit. To do so:

- Insert the batteries into the tTEM2 unit and turn it on.
- From the *Local PC* connect to the unit's Wi-Fi network. Wi-Fi name: tTEM2_0###, Password: 0102030405060708

TEM Data Manager

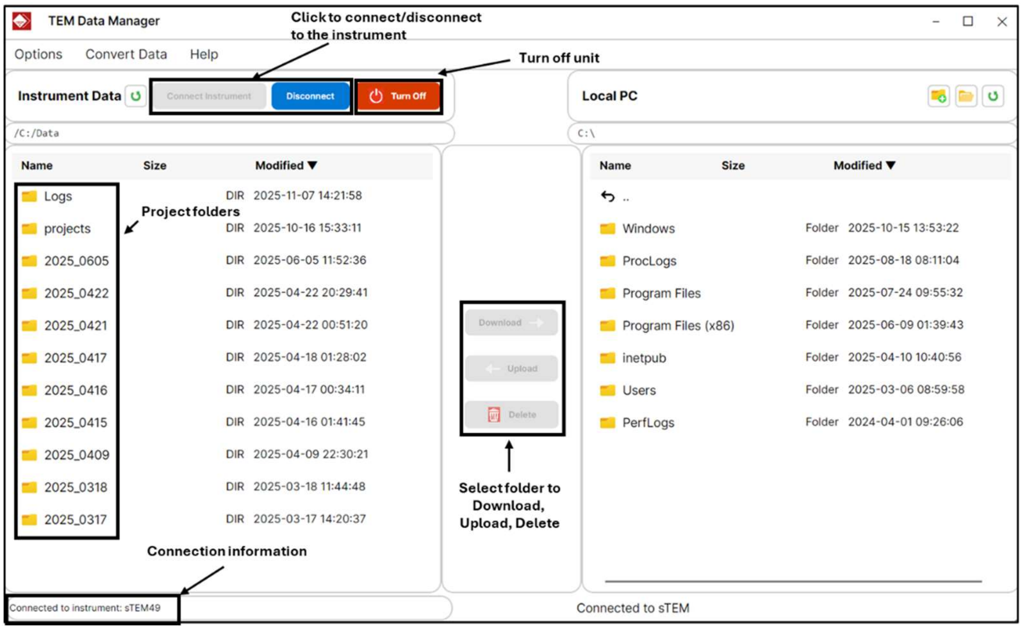


Figure 20. Steps for copying data from unit to Local PC (after connecting to the instrument).

To copy data from Instrument to Local PC

- Press *Connect to Instrument* to display the data folders on the unit
    - The TEM data on the instrument is sorted in main folders named by (yyyy_mmdd)
- Select main- or sub-folder(s) to copy to Local PC and set a target folder on the Local PC.

- Turn off the Instrument PC from the Controller app before turning off the unit.

Note
- Folders/files with date/time names are named using UCT-time (GPS date/time).
- Before deleting data from the instrument, verify that the data files are copied to your Local PC.

Additional options in TEM Data Manager

Figure 21 illustrates several additional menus available in the TEM Data Manager application:

- **Connection Settings** – The default setting is "Automatic", which connects to the instrument currently paired with your device. This option should not be changed unless specifically advised by support.
- **Instrument Info** – Displays key information about your unit, including the MAC address, firmware/SAPI/node versions, and license expiration date. This information is particularly useful when contacting support, as it helps us identify your system.
- **Connect Instrument to External Wi-Fi** and **Show TeamViewer ID** – These two options are primarily used to enable remote support. To allow our support team to access your unit, first connect the instrument to the internet, then share the TeamViewer ID provided in this menu.

Figure 22 illustrates the Update menu, which provides several important maintenance and configuration options:

- **Upload Protocol** – Displays a list of all current protocols. From here, you can delete outdated protocols or upload new ones. This action should only be performed if specifically advised by support.
- **Update Calibration** – Each protocol relies on calibration factors that are unique to the system configuration. These values are preset by our team and should not be modified unless instructed to do so by support.
- **Update SAPI / Firmware / License** – These options are used when software updates, firmware upgrades, or license renewals are required. If

any of these updates are necessary, our support team will provide detailed instructions and the required files.

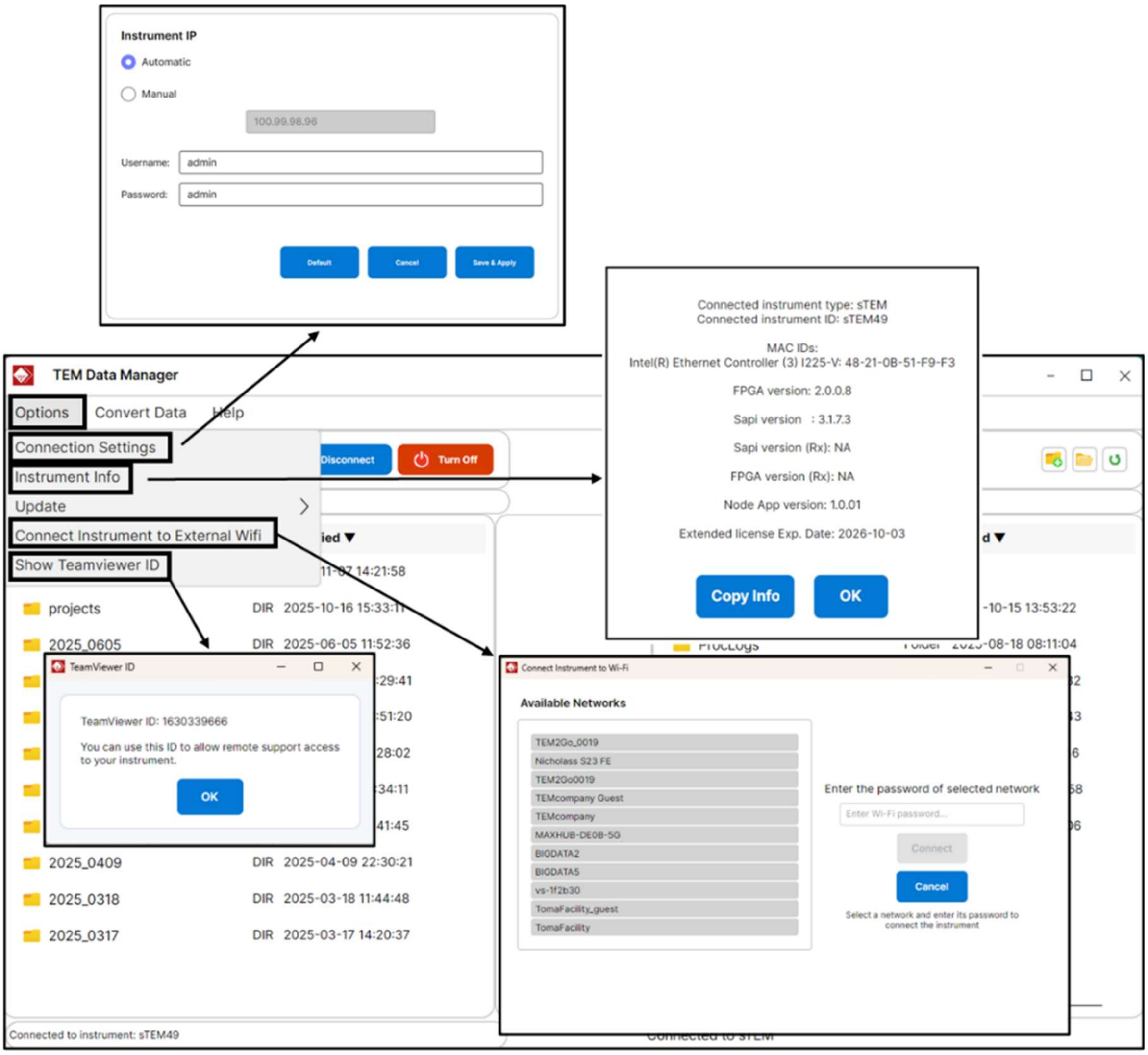


Figure 21. General Options menu.

Additionally, the program includes a **Convert Data** option (Figure 23), which allows you to convert acquired data into various output formats according to your needs. Supported formats include XYZ files and formats compatible with TEMImage and AGS Workbench. Data can be converted either upon download (while connected to the unit) or after download (using locally stored data, no active connection required).

Finally, the **Help** menu includes a **Version Info** section, where you can verify whether your application is up to date.

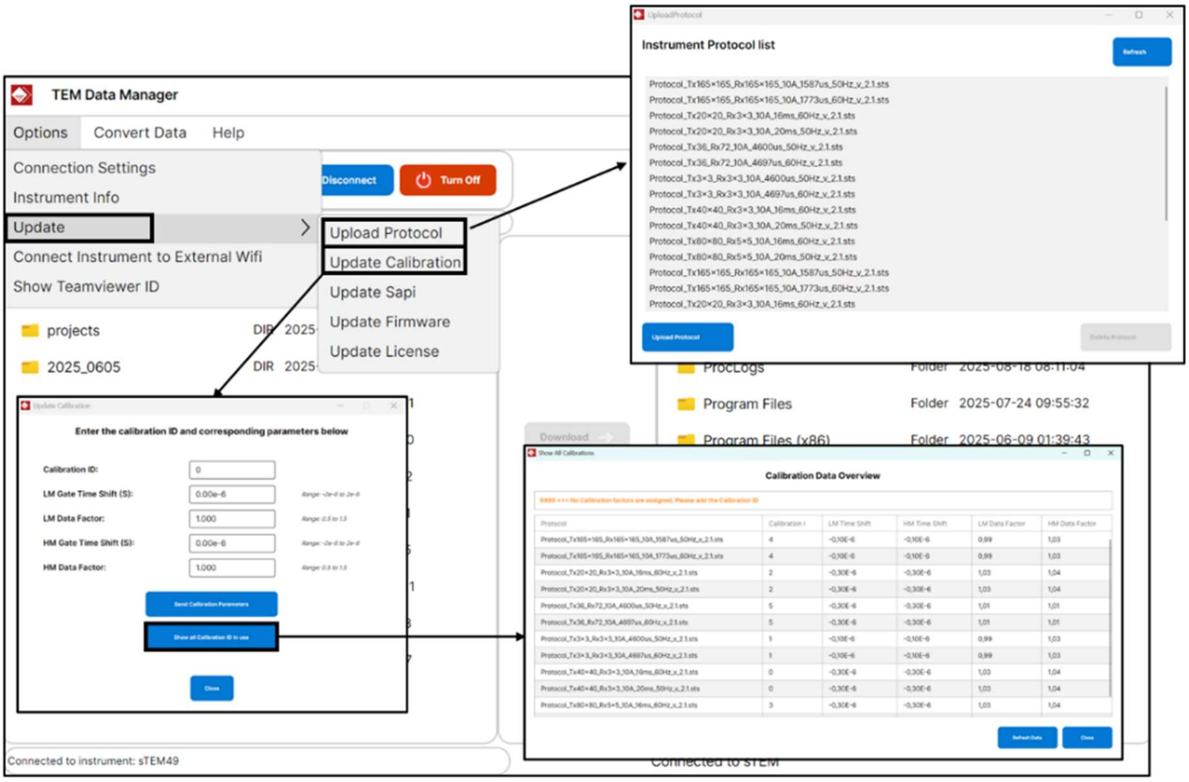


Figure 22. Update menu in TEM Data Manager.

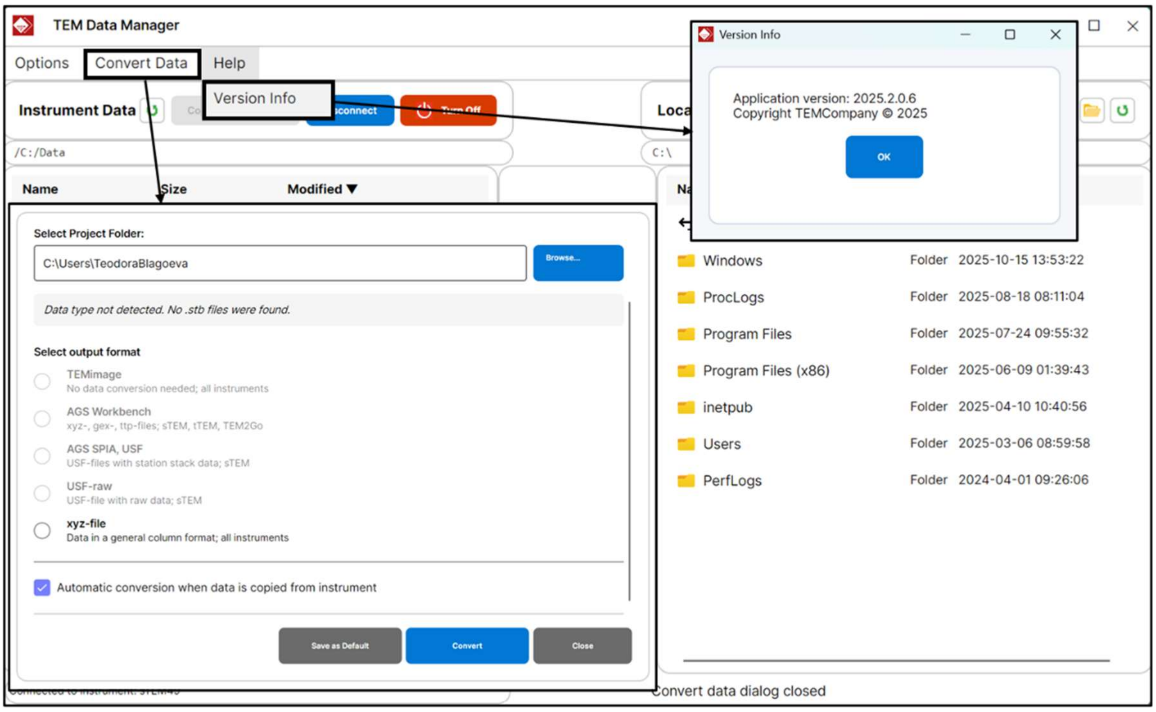


Figure 23. Convert data and Help menus.

8. TTEM IN EXTREME TEMPERATURE

8.1 Cold Weather (≤ 0 °C (32 °F)) – What to be aware of

Water/Coolant

In usual conditions (in ambient temperatures above 0 °C (32 °F)), the tTEM system needs to have 25% coolant and 75% water for its cooling system. In some cases, the coolant is already pre-mixed to these proportions, and no further dissolving is needed.

When the system is about to be used in an environment with lower temperatures than that, the coolant needs to be concentrated more than 25%, otherwise the system will freeze. Similarly, the pre-mixed coolants may need to be switched with another coolant that fits the warmer temperature ranges.

Check the coolant's manufacture information and respect/follow the instructions/limits for each coolant. The most efficient would be to find a coolant for both extreme cold and warm weather. If this is not possible, and the planned survey will take place in extremely different ambient temperature from the previous time, it is highly recommended to change coolant. This is due to the high risks that can lead when the concentration is not correct. For example, too high concentration risks severe temperature shutdowns (in ambient temperatures more than 30 °C (86 °F)) while too low concentrations risk freezing, and breakage of the cooling system (in ambient temperatures lower than 0 °C (32 °F)).

Runners

The runners are made from High Density Polyethylene (PEHD1000) which is known for low friction, anti-stick, abrasion, and its good impact resistance. However, this material can shrink when the temperature is below 0 °C (32 °F), making it difficult to do a field repair/change them in the field in these conditions (see Figure 24).

The recommendation in this case would be to do the repair/changing or the runners indoors or somewhere with room temperature. In this temperature the runners will "expand", reaching their initial shape, making it easier to attach them back to the system.

In other cases, where no need for field repair arises, it is important to know that the frozen runners have lower endurance range. That creates higher risk for breaking or damaging the runners than usual.

Figure 24. Example of shrank runners in extreme cold weather (-25 ºC).

Water hoses

Like all materials, the water hoses that are being used in the tTEM system have a temperature range which is around -5 ºC (23 ºF) to 40 ºC (104 ºF). When a survey needs to be held at a temperature lower than that the ordinary water hose will become brittle and fragile. Then, it will be easier for the hose to break apart and to not provide any more protection to the towing ropes and the cables that are inside them.

TEMcompany can provide another set of Tx coil and Receiver cables that has been made with a water hose suitable to extreme cold weather. In this case, we need to be contacted sufficient time before the planned survey, to ensure good delivery time of the cables.

8.2 Warm Weather (≥ 35 ºC (95 ºF))

To ensure the best operating conditions, make sure that the fan is not blocked. If the transmitter gets too hot, shading from the sun may be necessary.

Usually, premixed coolant is sufficient to keep the temperature low, but if the temperature is still rising dilute with distilled water.

If you still have problems with temperature, contact TEMcompany.

9. TOWING VEHICLE AND DISTANCE TEST

ATV types

The tTEM is a towed system, which requires a towing vehicle, but not all vehicles are equally suitable. The system is designed and optimized to be towed by an ATV/quad. The large metal frame of larger vehicles will affect the signal and make late time gates unusable. To accommodate larger vehicles, extended transmitter and receiver cables should be used.

Recommended vehicle type:

Can use standard and extended length cables

Not recommended types:




Cannot use standard length cables, but likely the extended length cables*

To verify the vehicle does not affect the data, an ATV distance test can be carried out

ATV distance test

The tTEM frame and sleds are built of non-conductive components to avoid coupling and bias signals. The ATV with the instrumentation is therefore placed approximately 3 meters (10 ft) away from the front of the transmitter frame to minimize interference. The tTEM system has been operating with different brands of ATVs.

If other types of pulling vehicles than an ATV are used, or by any doubt of possible interference from the towing vehicle, we recommend that an ATV distance test is conducted. The ATV distance test should be conducted where the earth signal is low (resistive ground) since minor ATV interference is detectible in this case.

1. Set up the system as normal, but place the instruments, in the normal layout, on the ground or on plastic boxes at the end of the towing rope, instead of on the back of the ATV.
2. Important: Make sure that the transmitter and receiver cables are separated by a minimum of ~40 cm (16 in) as when the instruments are mounted on the ATV.
3. Move the ATV far away (>30 m (100 ft)) and record one minute of data. Make a note of the line number/time interval. This is the Baseline response.
4. Move the ATV as close to the front of the transmitter frame as possible (0 m separation). Change the line number and record for one minute in this position with the ATV engine on.
5. Move the ATV in steps of ~0,5 m (60 in) away from the transmitter front towards the instrument boxes and record one minute of data at each ATV location and note line number, time, ATV separation at each position. Continue this procedure until the ATV is ~7 m (23 ft) away from the transmitter front. Remember to make a measurement at the normal ATV position.
6. End the sequence as stated with the ATV far away.
7. Import the data to Aarhus Workbench. Set the stack width to 40 s and turn off filters that eliminate data.
8. Plot the stacked data curve (AVE data) at the center time of the time interval for each ATV distance and compare them with the base line measurements.
9. You should observe that when the ATV is close to the frame the curve is disturbed, compared to the base line response.
10. If no systematic dissimilarities between the response at the normal ATV distance (and longer distances) and the base line response are observed, the ATV - TX-coil distance is sufficient for the specific ATV. You can evaluate the natural fluctuations of the TEM response by comparing the start and end baseline responses. Do not shorten the ATV-transmitter frame distance even if your test results show it is possible.

Extended RX cables and Tx coil lead in can be ordered.

10. REMOTE SUPPORT

If there is a need for remote support, the tTEM needs to be put online and TeamViewer ID needs to be passed on to TEMcompany support.

In some instances, support might also ask for a Sapi log to go though, all the above information can be found in the tTEM Controller app under options → support tab, Figure 25.

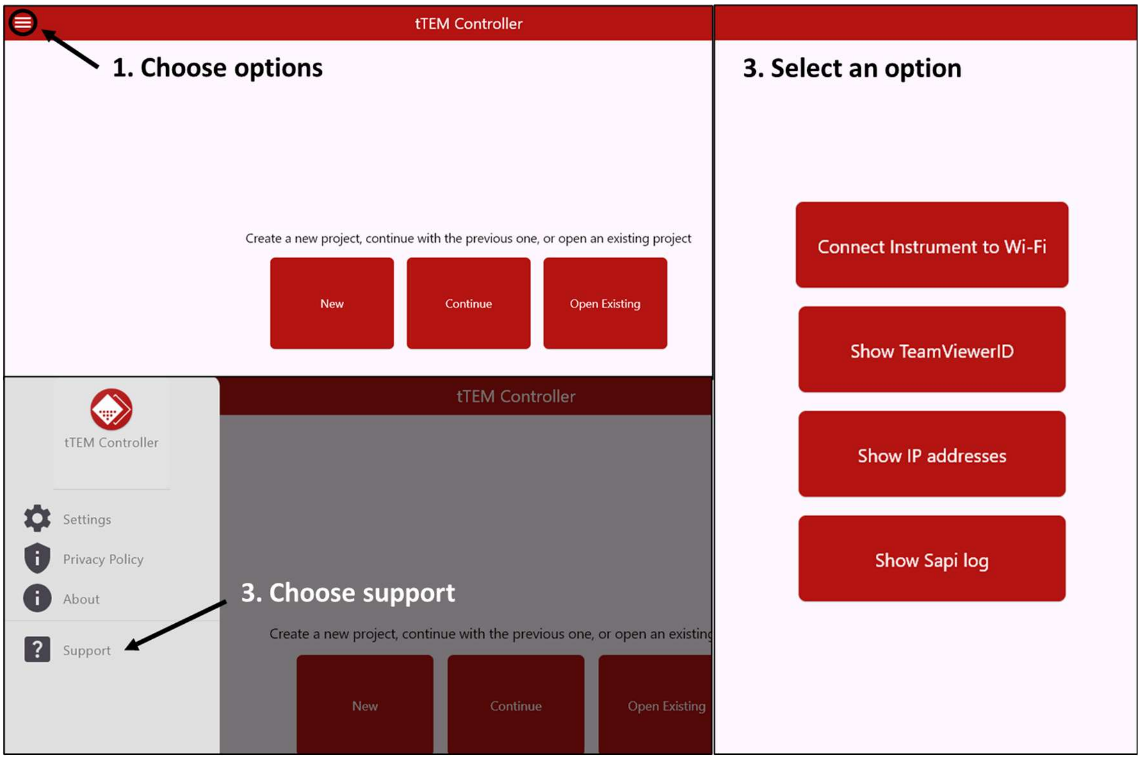


Figure 25 How to access information and get tTEM ready for support.

APPENDIX I:

1. TTEM DATA IN AARHUS WORKBENCH

After a successful survey is completed, the user should follow the steps mentioned in the guide below to import, process, visualize and report the collected data. The present guide consists of a brief walk through for that. However, the abilities of the software extend further, and it is not the subject of the present guide to cover it to that extent.

1.1 Import tTEM Data

"New Workspace Wizard"

Start "New Workspace Wizard". Select folder where the workspace (WS) will be saved. Provide a name and remember to check which coordinate system you should choose. Press finish and continue.

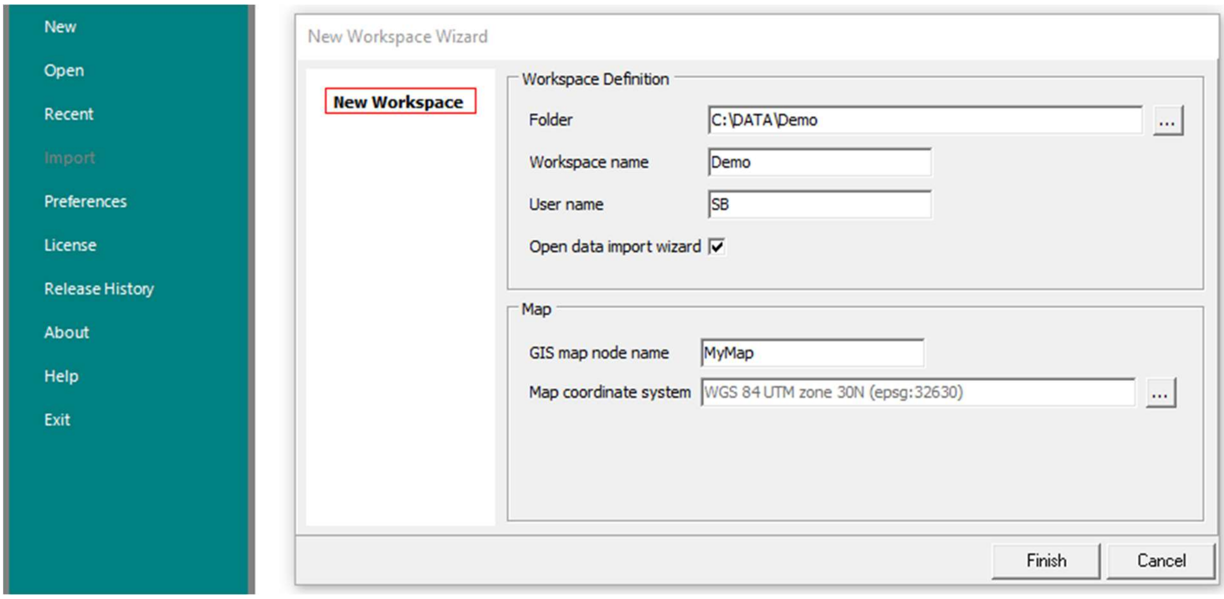


Figure 26. Start new Workspace.

Database Explorer

In the new WS, go to "Database Explorer" and select "Geophysical Database". Geophysical database is a file on the hard disk that contains the tTEM dataset(s) (all raw data). Later, if log data are available, one can import them to the Borehole Database which creates a file on the hard disk containing boreholes info (press F1 for more info about the type of log files that can be imported).

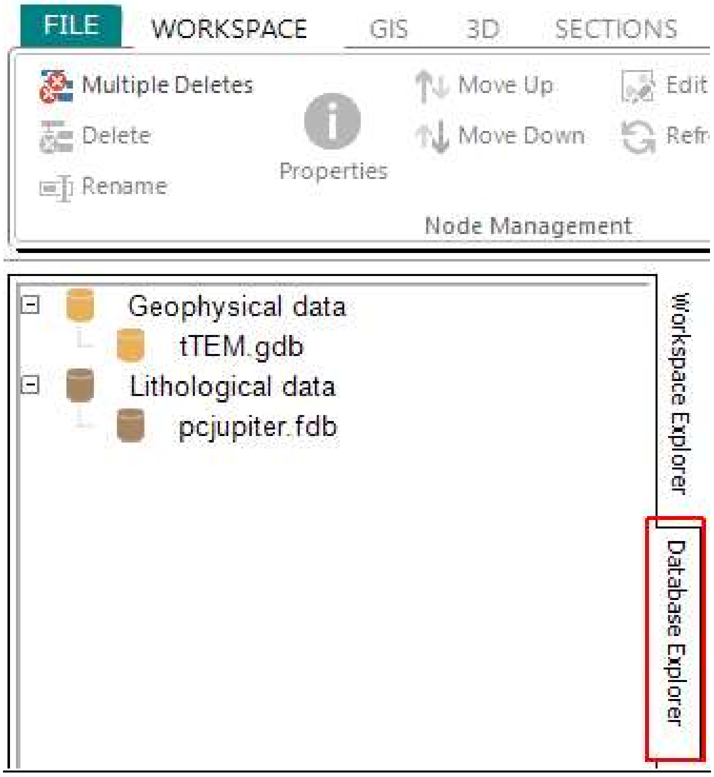


Figure 27. Database Explorer.

Select Import Type

To import tTEM data, select “Geophysical data” (1) and then “Import” (2). The “Select Import Type” will open, where the tTEM2 system (stb format) needs to be selected (3) and then the user selects either “Existing database” or “New database” (4). “New database” corresponds for when data from the first day of a survey are being imported, while “Existing database" corresponds when the second day of a survey is completed etc.

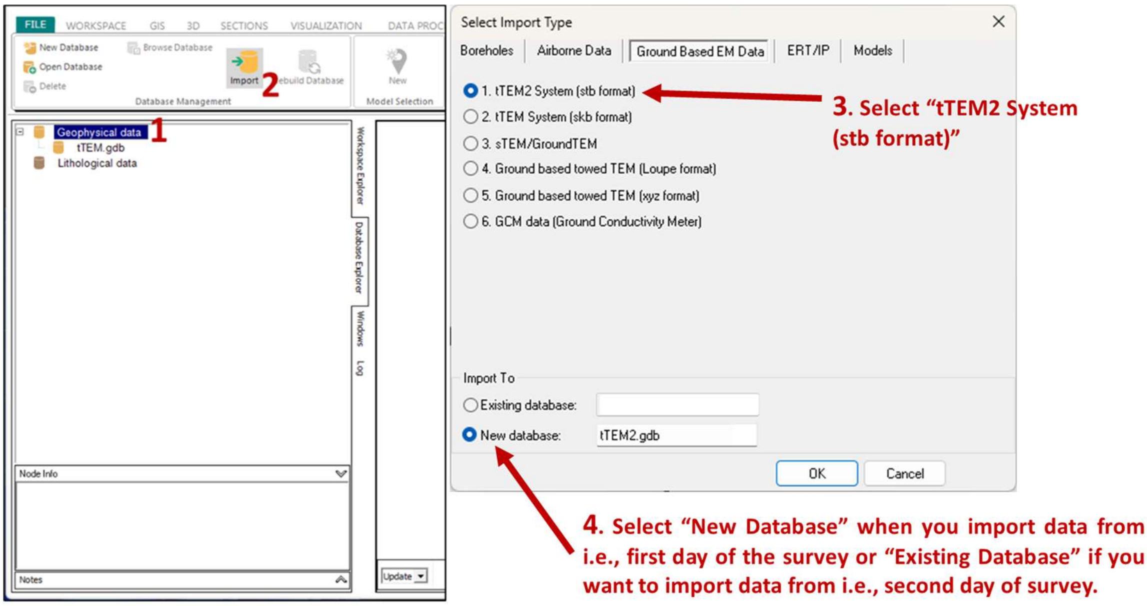


Figure 28. Import in a "New" or in an "Existing" Database.

tTEM Data Import-Define tTEM System Setup

In the next window point to the Data folder and to the Production (line) file (5) and then select "Create new dataset" or "Import to existing dataset" (6). After these steps select coordinate system (7) and then press "Import" (8).

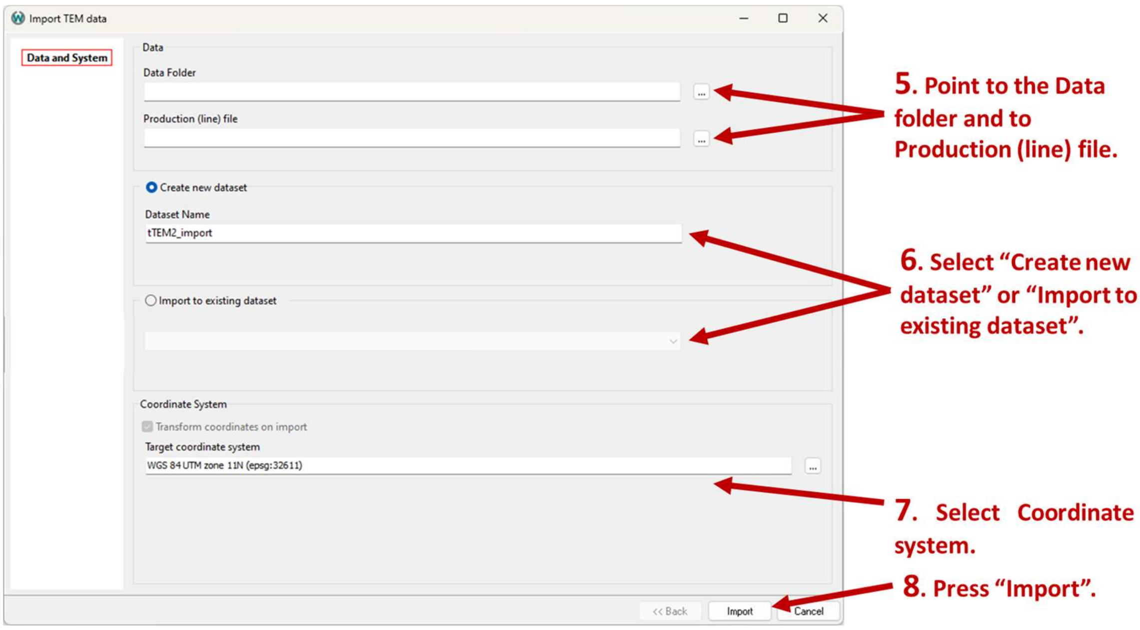


Figure 29. Import dataset into database.

1.2 Processing of tTEM Data

Two steps are required before starting the processing of tTEM data. Step 1 is to make a processing node and step 2 is to apply the desired processing settings.

Processing Setup

This step is for how to make a processing node. The user needs to select "Data Processing" tab and then on "Data" on the top left corner of the screen. When the "New Processing" tab opens, select Database name and processing type as "Towed TEM". Select the desired dataset on the next window and press "OK".

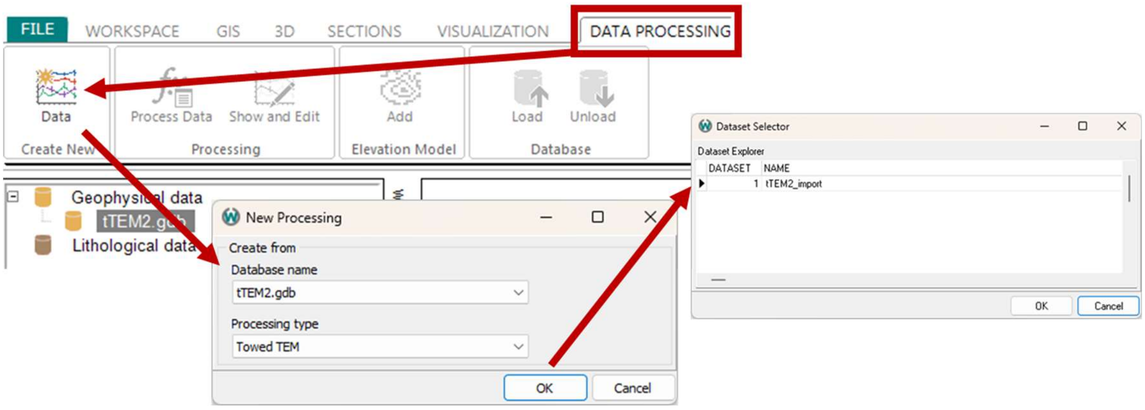


Figure 30. Processing node.

Lastly, the user needs to select time period for the new processing node. The option of auto split is given from Workbench by selecting "Create automatic intervals after _ hours gap". By selecting this option, the user can import data from a long survey i.e., 4 days, and split them into 4 processing nodes by putting 7 hours gap on the option mentioned above. By unclicking this option, the user can select manually which time intervals prefer to use for the new processing node.

We recommend selecting the entire interval and using the auto split option if more than one day of survey has been imported.

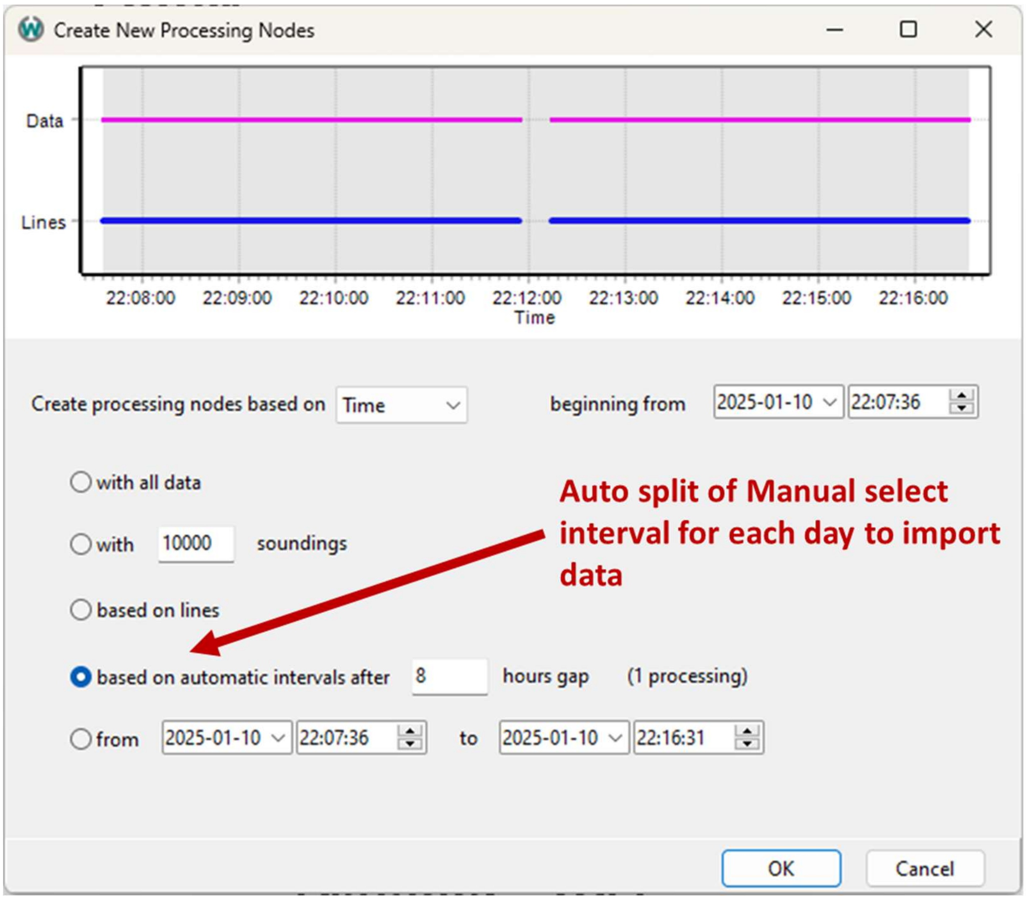


Figure 31. Selecting time period for the processing node.

Processing Settings

Processing Settings are the last step before the user starts to manually process the data. The user has the option to process data either on "Distance" or in "Time". It is recommended to use the "Default Settings".

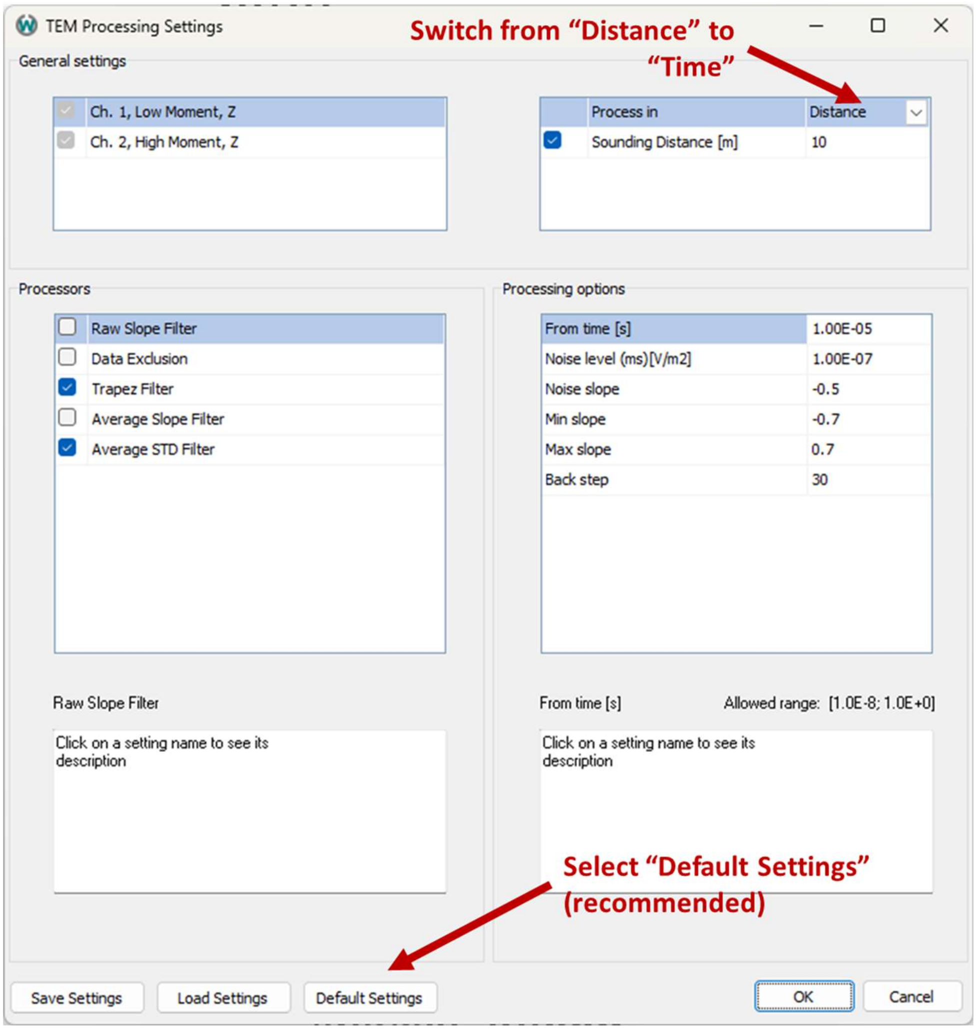


Figure 32. Processing settings.

Data Processing - First Step

Data Processing requires two steps and a few adjustments on the view setup. We recommend starting the processing by plotting the raw data of LM (top plot) and HM (middle plot) and speed and topography or current and speed on the AUX plot (bottom plot). After doing that, the user should check/inspect the quality of the data and remove/disable data affected from noise sources, from when the system was standing still (speed 0 m/s) and from turning points where the geometry of the system was not straight.

Good advices:

- Keep gates 2-5 from LM (maybe discard 2nd gate if it has many fluctuations).
- Keep gates 6-30 from HM.

- Check soundings (press "Shift" and then select data).
- Use the "Buffer" button or select "Line No" to navigate through time or Lines,
- Click "Update Edits" and "Save" often,
- See where you stand with the GIS feature of WB.

*To disable/enable data select them with the mouse and press Q or A proportionally.

*To switch between LM/HM – Raw/AVG use the right click and select the one you want to work on from "Data".

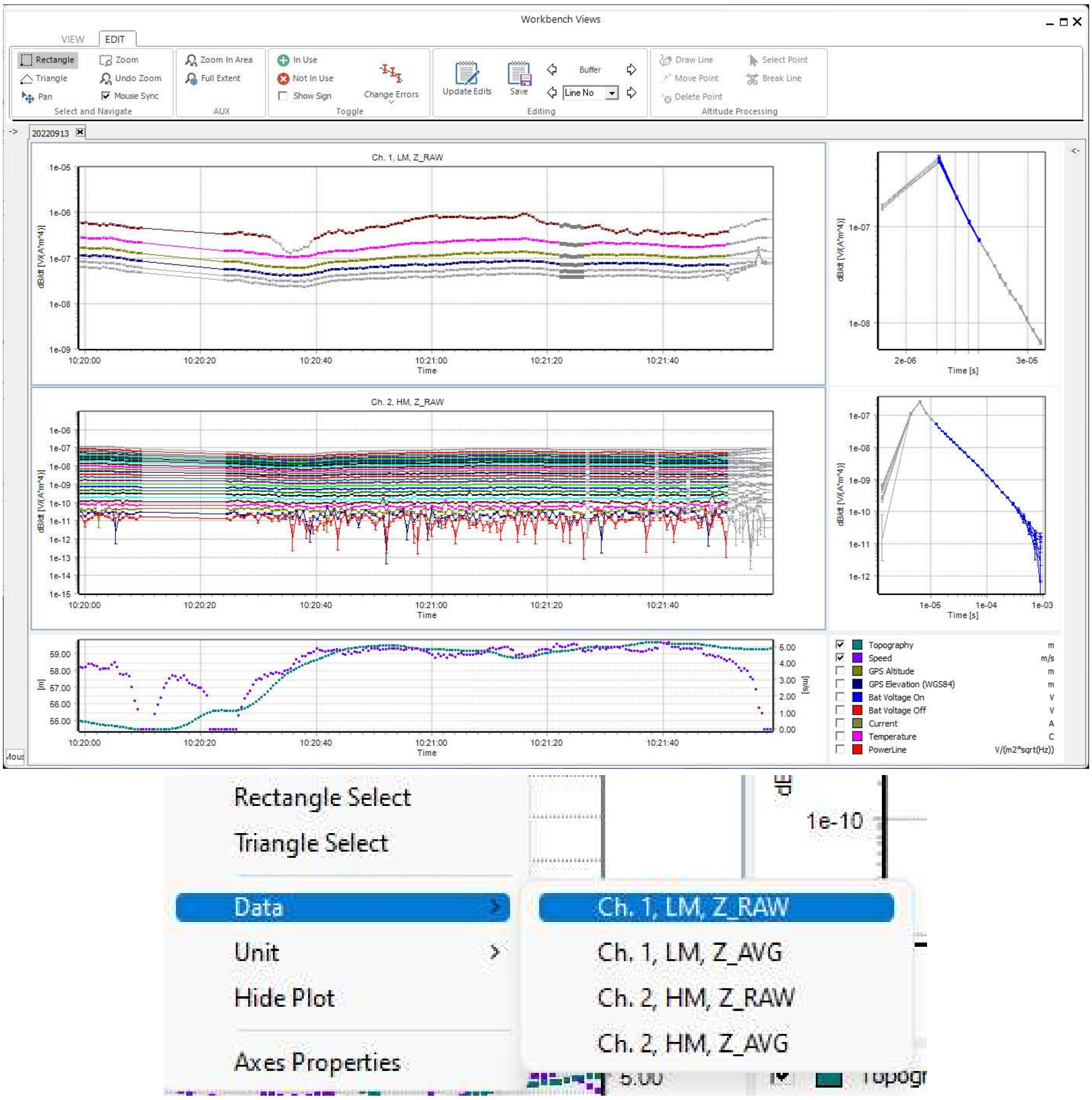


Figure 33. Processing window with Raw LM/HM (top). How to switch between LM/HM - Raw/AVG data.

Data Processing - Second Step

Second Step starts by inspecting the Averaged data (AVG). It is recommend doing it using HM data as a first approach. Change the view setup so there is HM raw data in the top plot, HM AVG data in the middle plot and keep the bottom plot as before. In this step it is necessary to check that excluded/included data from RAW agrees with what has been disabled/enabled on AVG. In case there are many mismatches, check LM raw and AVG and make the changes manually.

*You may need to enable data that has been removed automatically due to processing filters, but they are not disturbed by any coupling source, and they can still be used.

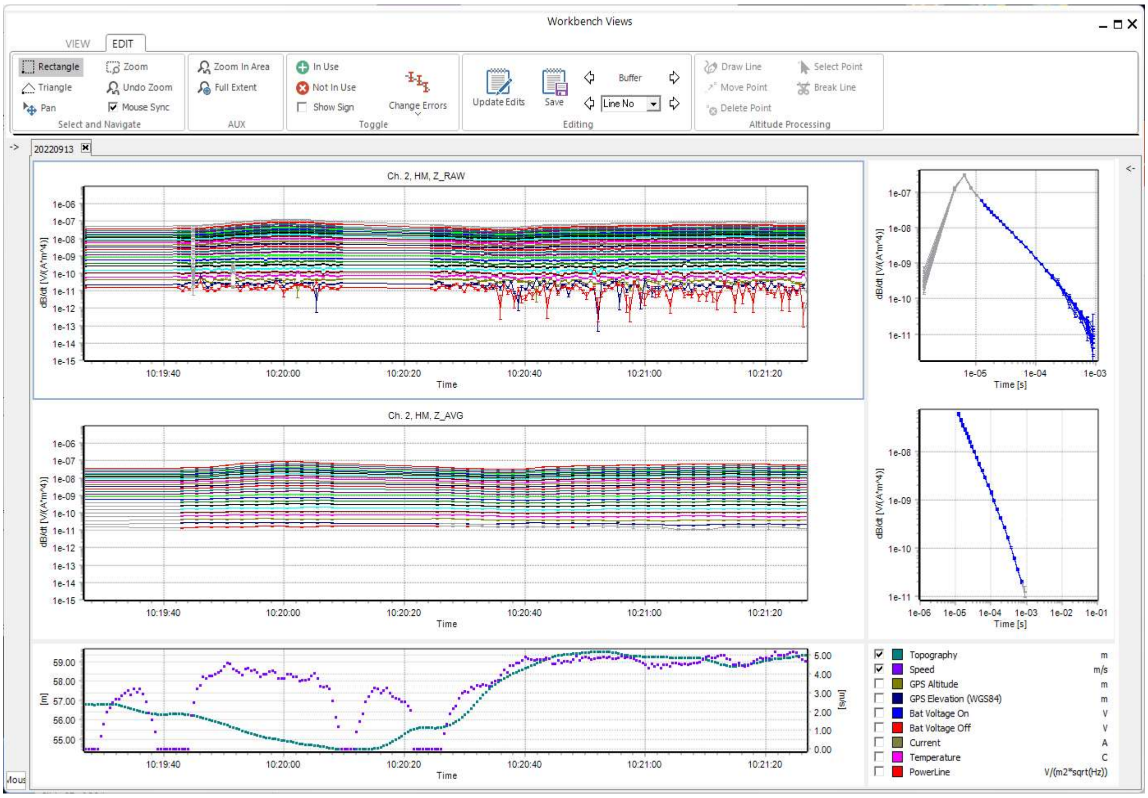


Figure 34. Processing window with AVG LM/HM.

2. VISUALIZATION OF TTEM DATA

The inverted model can be displayed in different ways. Below is a brief description of the most typical ways. The user is directed on the wiki page of Workbench for how to make each of these visualizations, by pressing "F1" under "Visualization tab".

Quality maps- Number of Data, Data Residual and Depth of Investigation

Quality maps can provide information regarding the data misfit, the depth of investigation and the number of data points. The former one shows the efficiency of the inversion (how well the data fitted). The values shown as data residual have been normalized with the data standard deviation. Thus, values below one translates to a fit within one standard deviation. The second one shows the estimated DOI for each inversion model, and the latter one holds the amount of data, indicating the S/N ratio on each sounding.

Mean Resistivity Maps

With Mean Resistivity Maps, horizontal slices all through the study are being created. They have uniform specified intervals, and their starting point can be the topography of the area (depth) or the distance from the sea level (elevation). Mean resistivity values for every horizontal slice are calculated from each model and interpolated to a regular grid.

Section/Profiles

Profiles are termed the vertical slices that have been picked through the study area. On each profile information can be added, such as inversion models, borehole data, elevation etc.

3. SURVEY REPORTING

In Aarhus workbench it is possible to generate a report including QC maps and themes. The first step is to create templates. This is done in Edit Template on the Visualization ribbon. After creating a Template, a New Report can be made where the Template is added. The user can make 2 templates, one for QC plots and Mean Resistivity Maps. In addition, a template for cross sections could be made. For further details Workbench Wiki page is helpful. Press F1 to open Wiki and then Workbench guides and then number 8: Report Tools Guides.

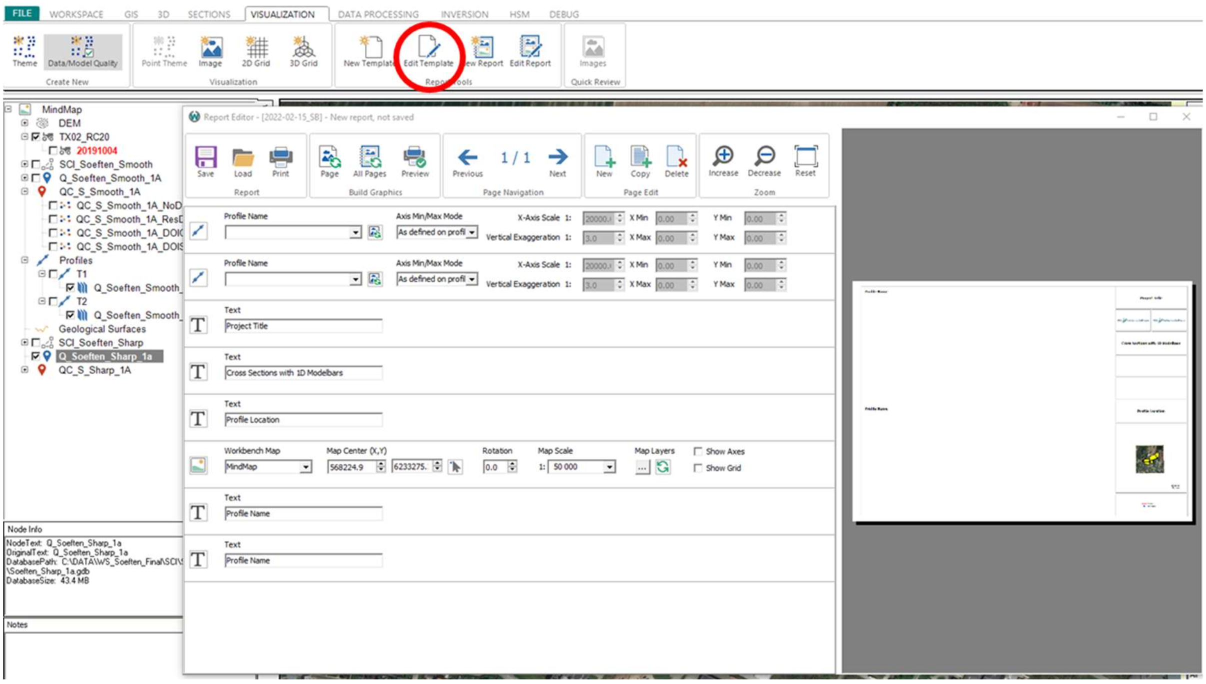
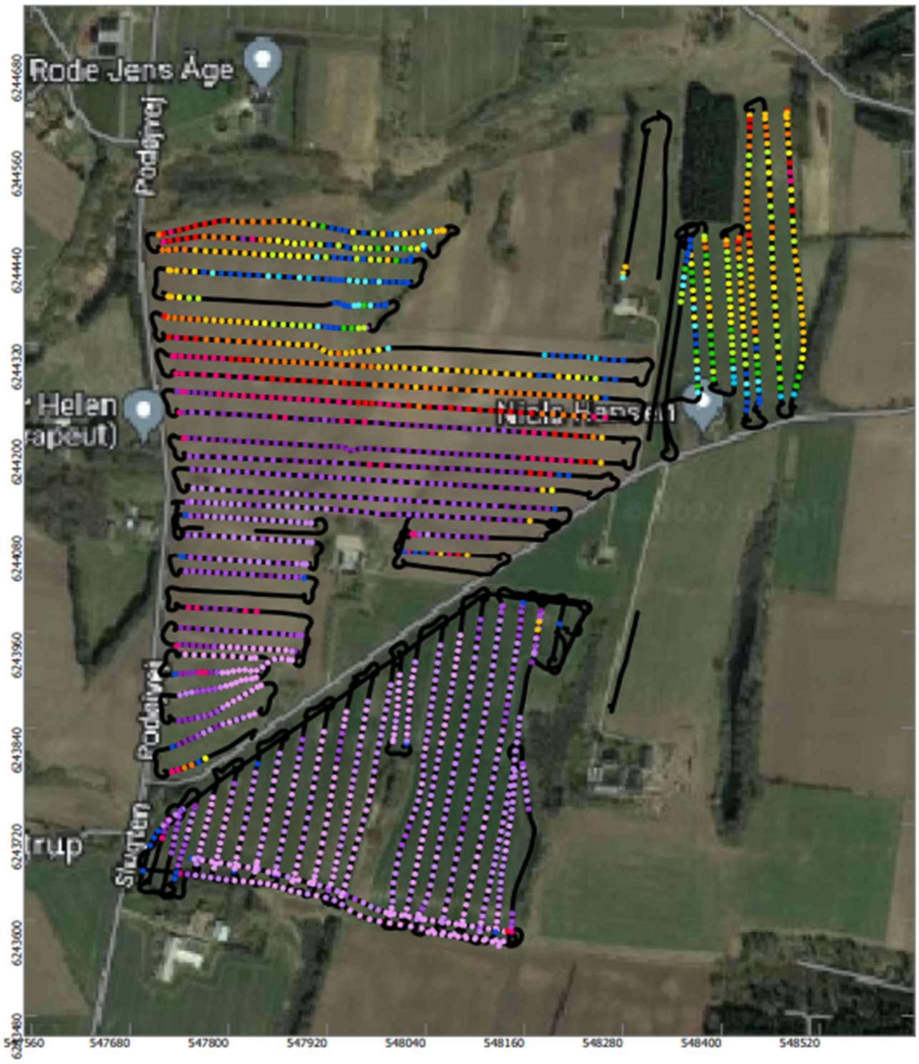


Figure 35. Interface for "New template" when making survey report from Workbench.



	Thorsoe, tTEM	Model, data residual Below one corresponds to a fit one standard deviation
		UTM Zone 32N WGS84 300 m

Figure 36. Example of Data residual map on report.

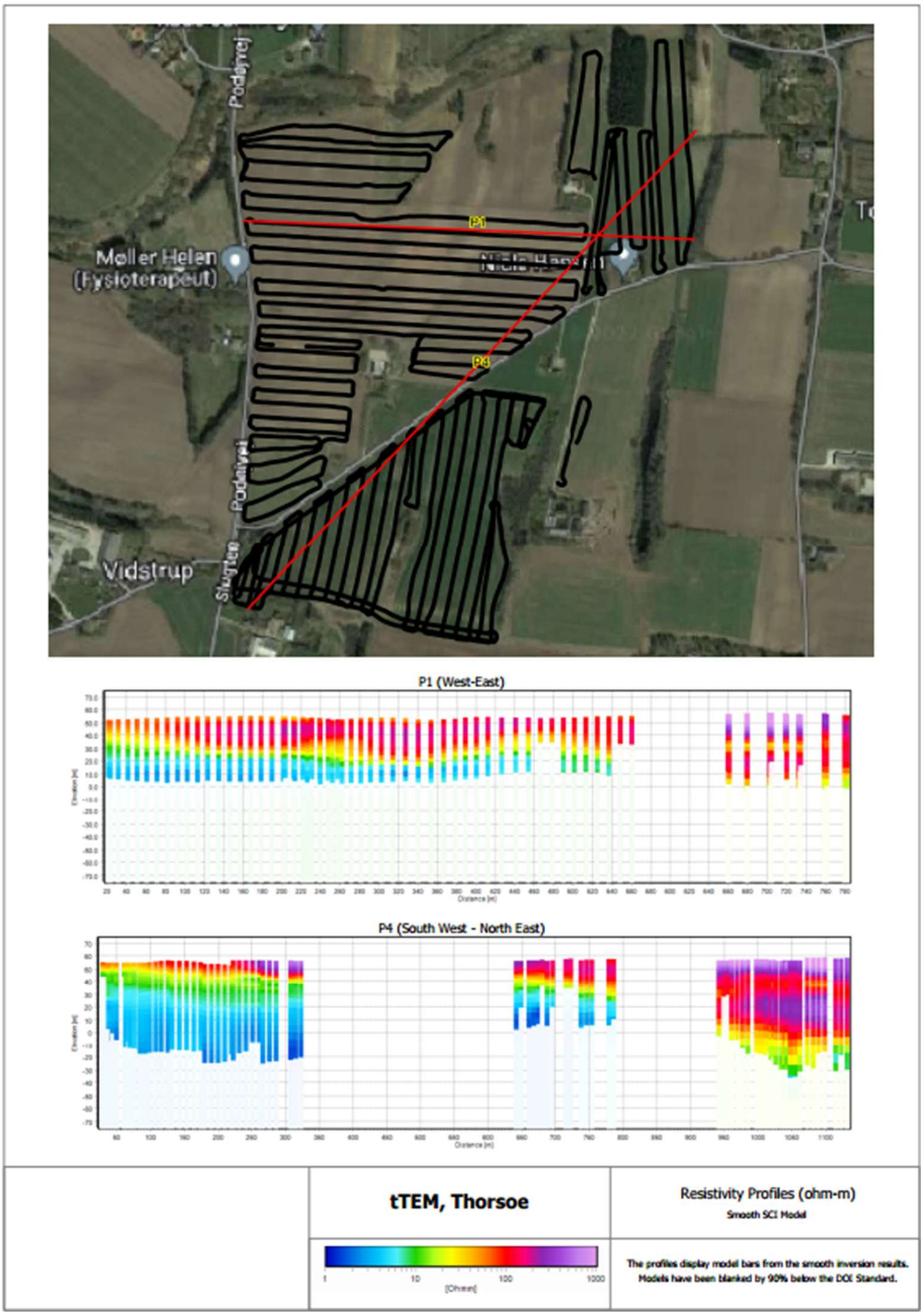


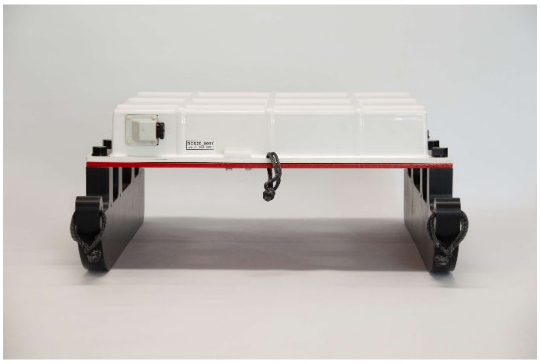
Figure 37. Example of Cross section on report.

APPENDIX II: COMPONENTS

Electronics

Tx unit

Battery Suitcase



Receiver Coil RS20

Tablet

RC-2054-2 TiB battery

Tx coil

Power cable

Receiver cable

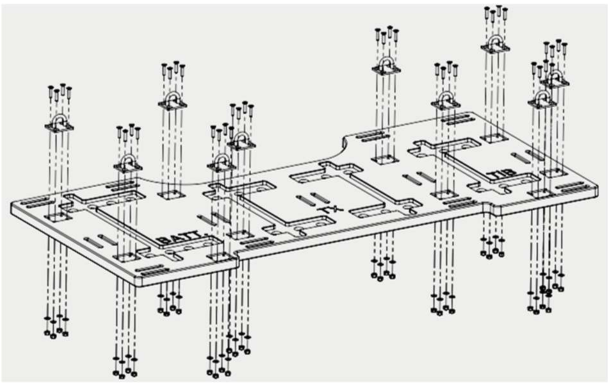
Adapter for Multiturn Tx coil (333, 443)

Mechanical

Tx platform

Rx platform

tTEM wings



ATV platform

Miscellaneous

RRC charger

ATV platform Mounting Kit

12 V Victron Battery Charger

Note: Switch off the Victron Battery Charger and then plug in the battery and set power to the charger to make sure it runs an analysis before charging. Be aware that depending on battery depletion it might take 6-8 hours to be fully charged for the 100 Ah battery.