Inversion setup LCI

In this document we will show how to set up a Laterally Constrained Inversion (LCI) in the Aarhus Workbench for helicopter TEM data.

LCI is a 1D laterally constrained inversion along the survey lines.

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Step by step guide

1. Select data for inversion

Select the processing node that should be inverted, go to the Inversion ribbon and click Invert Data. Here we need to select the channels and the time interval we want to include in the inversion. For SkyTEM we often have two moments (low and high moment) that we want to invert as one model. Usually we want the entire time interval, but being able to invert just a small interval certainly has its use.

Additionally, we have a few practical time saving options here behind the other tabs. We can submit multiple inversions at ones from the same AEM data node. We can also omit gates from the inversion. If we have chosen not to remove an early gate during the processing and then later find that it should have been removed, we can instead omit it from the inversions here. Simply select the channel and write in the gates to be omitted.

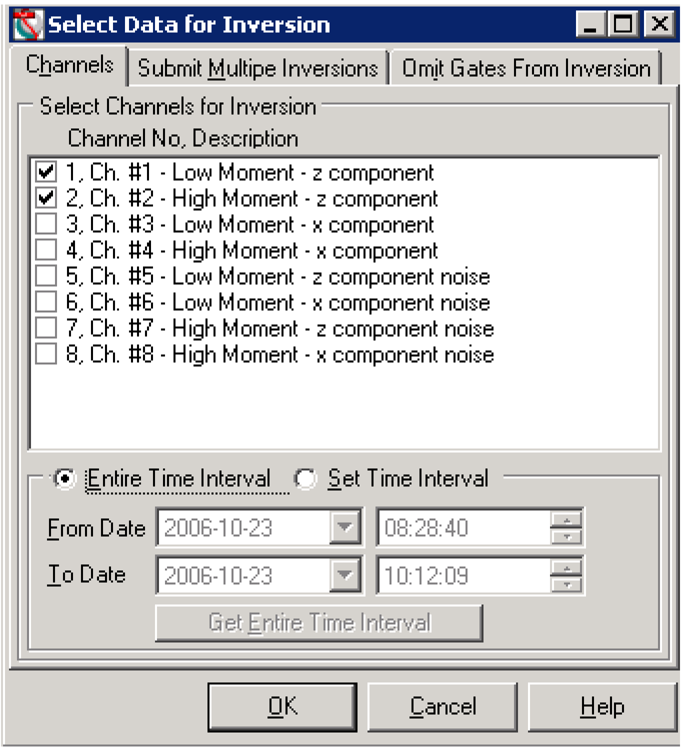

Figure 1. Select Data for Inversion.

2. Model setup

Now we get to the actual inversion setup. The first thing we need to decide is what kind of model we are going to invert with. Usually we start with a smooth model, thereby making fewer assumptions, and only later move to a layered model. We will focus on the smooth model here, and only glance over the differences for the similar layered model.
We can save and load our settings, and there are also some suggested settings for typical setups. We will now go through the each of the tabs here for the inversion setup.

Under the model tab we have a description of the model. Some of these columns will be locked with the derived values or values required for the type of model we have chosen. These columns have been given a grey color. Starting from the top we can change the number of layers, and either auto scale the resistivities or give a starting resistivity of each layer. If all layers should have the same value, this can be done by clicking on the column header.

The starting thickness of each layer can be given in the same way. For smooth models however we often use layers with thicknesses that increase logarithmically. This is conveniently done with the compute thickness tool below the model description where we just put in first and last layer boundary and let it calculate the layers.

Finally, on this tab we can give a priori standard deviation values for the resistivity, thickness and depth of each layer. These standard deviations are given as factors. To set a factor to say 1.1 would set the first standard deviation interval to go from the starting value divided by 1.1 to the starting value multiplied by 1.1. A standard deviation of 1.001 is fixed and a standard deviation of 99 is not constrained.
For the smooth model the thickness is by definition fixed. For the layered model both resistivity and thickness are not constrained unless additional a-priori is being applied.

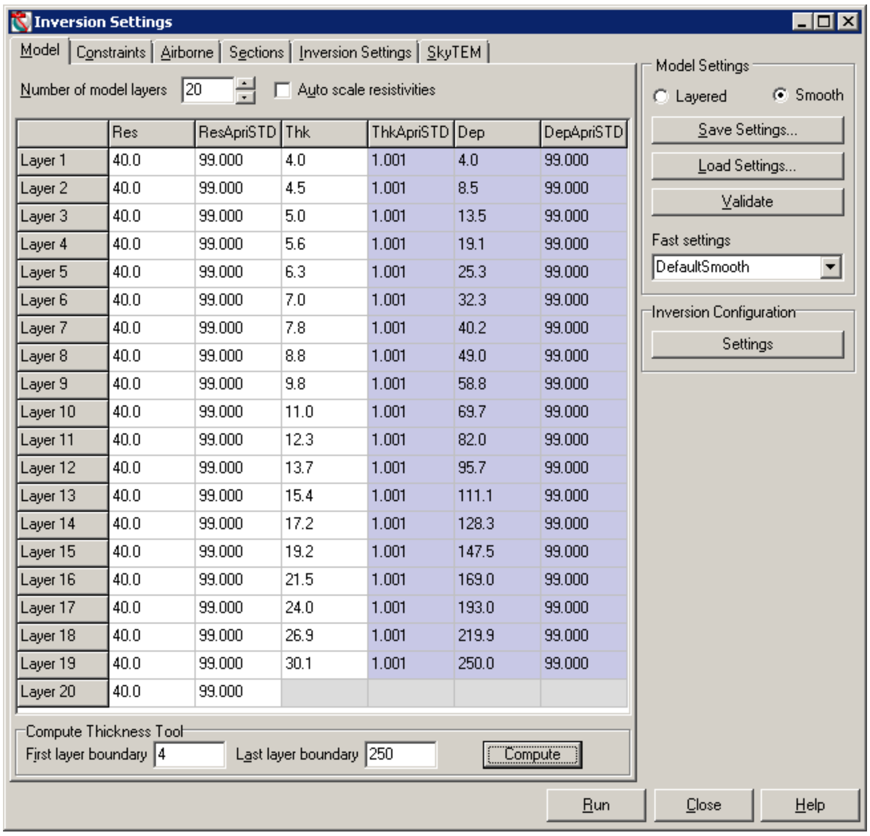

Figure 2. Inversion Settings – Model description.

3. Constraints

Under the constraints tab we have a description of the constraints. These constraints are again given as factors and work similar to the standard deviations, but for the lateral constraints they also get scaled by the distance between the models.

We give a reference distance that should reflect the average model separation. The constraints should then represent the expected variation in the geophysical models for that distance. Note that the scaling is not done for models closer than the reference distance.

It is possible to adjust the power law dependence of the function used to scale the constraints between models. A lower value of the power law dependence means that the constraint strength decreases slower with model separation. The default value is 1.

Now we get to the actual constraints. Keep in mind that the constraints primarily affect the resistivities and thicknesses that are poorly resolved in the data.

We have the vertical constraints on the resistivities of the model. For the smooth model vertical constrains on the resistivities should be set to a factor between 1.5 and 3. These constraints

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stabilize the inversion and reduce overshoot and undershoot typical of smooth models. A low value here results in a smother model. A high value here causes the deeper poorly determined layers to mainly be affected by the starting resistivity and information from the lateral constraints of neighboring models. For the layered model these constraints are by definition not constrained.

The lateral constraints on the resistivities between the same layer for neighboring models are usually, for sedimentary environments, set to a factor between 1.1 and 1.6. Other users might require lateral constraints to be set looser, i.e., with a value >2.

The lateral constraints on the thicknesses and depths of the same layer for neighboring models are by definition not constrained for a smooth model. For a layered model however, the lateral constraints on the depths should be set to a factor between 1.05 and 1.6. These values are relative to the depth, so it is often advisable to make them progressively tighter towards the bottom.

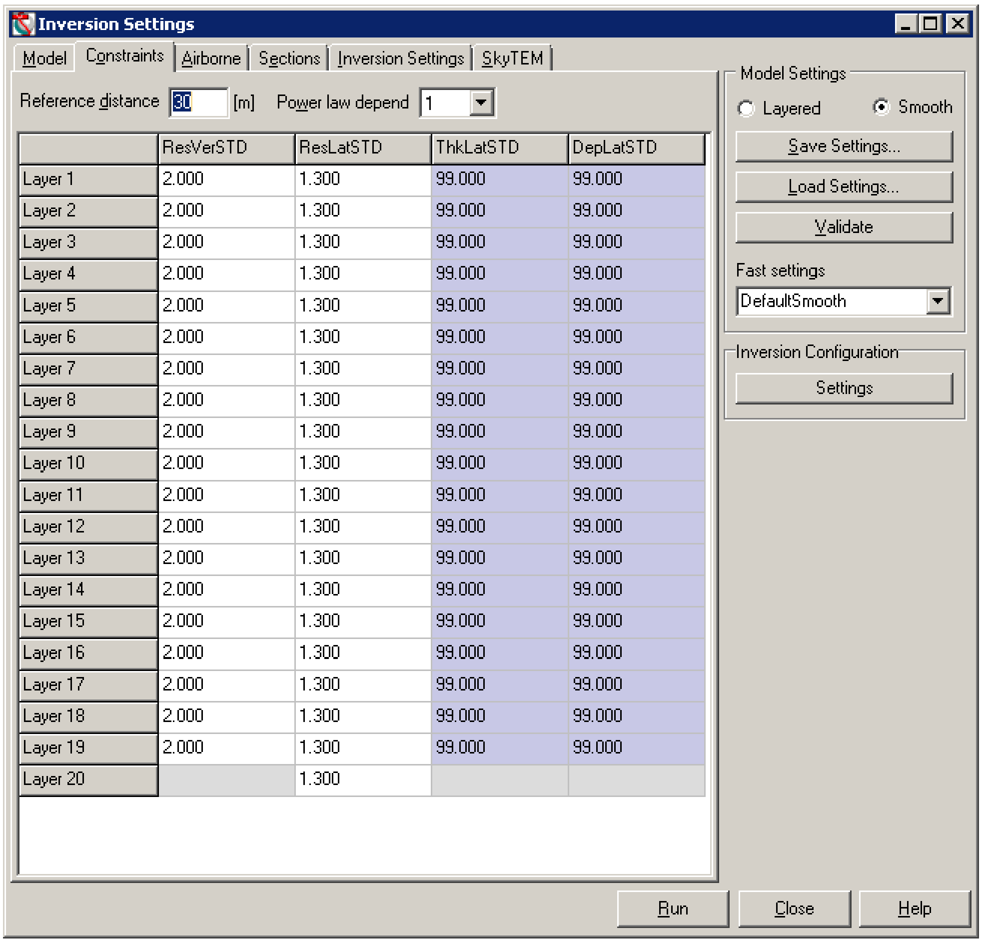

Figure 3. Inversion Settings – Constraints description.

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4. Airborne settings (only for airborne data)

Under the airborne tab we have some flight altitude settings. There is an a-priori value to use if nothing was recorded, like it can happen over water. There is an a-priori standard deviation in meters with the uncertainty of the altitudes. And finally there is a lateral standard deviation as a factor. This last one is again scaled with the reference distance.

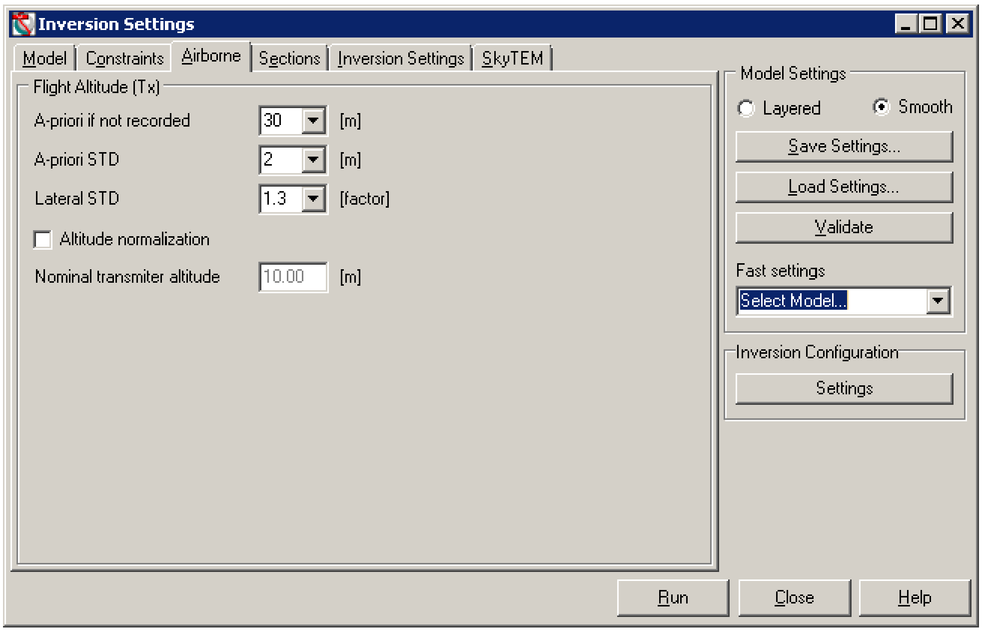

Figure 4. Inversion Settings – Airborne tab.

5. Sections

Under the sections tab we set the length of the sections of soundings being inverted together. The larger the sections the more memory and CPU intensive the inversion will be. The default value is 100.000 to take all data in one section. The value should not be higher but can be set to lower values. The max sounding gap is used to force the inversion setup to cut a section into two if it includes a large gab that would cause those two parts of the section to be largely independent anyway.
Force continuous models means that the starting model is constrained to the final model from the previous section. In the past we were limited to only run with one processor when using this option, that is no longer the case, so this option is now always used.

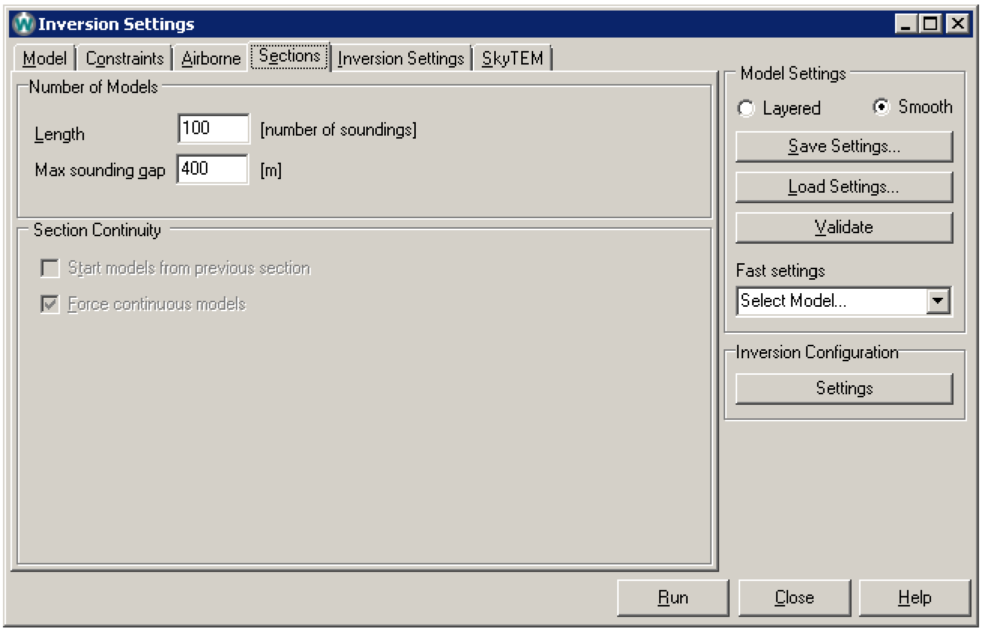

Figure 5. Inversion Settings – Sections tab.

6. Inversion settings

Under the inversion settings tab we have a few settings related to the inversion. There is the number of parallel processes to be used. There is the minimum number of data points. This should be used to omit soundings with very few data points. And finally it is also here that we can set it to calculate the depth of investigation as part of the inversion.

Under the SkyTEM tab we have some special settings for inverting with x-component data or coil response correction. We will skip those. For other airborne TEM data types there can be other tabs with settings specific to that data type that then needs to be filled out.

Normally we would now be ready to run the inversion. We should perhaps save the settings into a file with save settings, but everything is also stored in the registry database. For some inversion, it might be relevant to go into a few optional settings place under inversion configuration. These will be covered in a different document however.

Now we just press Run. This launches the Embi that controls the inversion independently of the Workbench. That means we can close the workspace and the Aarhus Workbench if we need to. The Embi only need to have access to the database. This allows us to run multiple instances of Embi and even to do so from different computers as long as all have access to the databases on a shared hard drive.

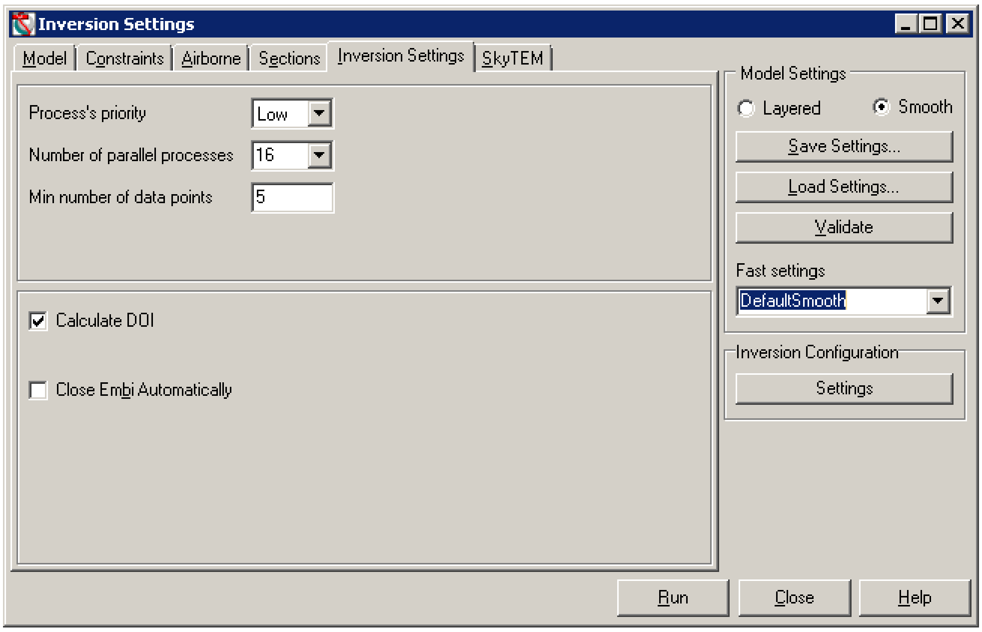

Figure 6. Inversion Settings – Inversion Settings tab.

Embi inverts each section in turn, plotting the residual of the sections as it finished them, and then it returns the results to the database. There is a status bar and a log with detailed information.

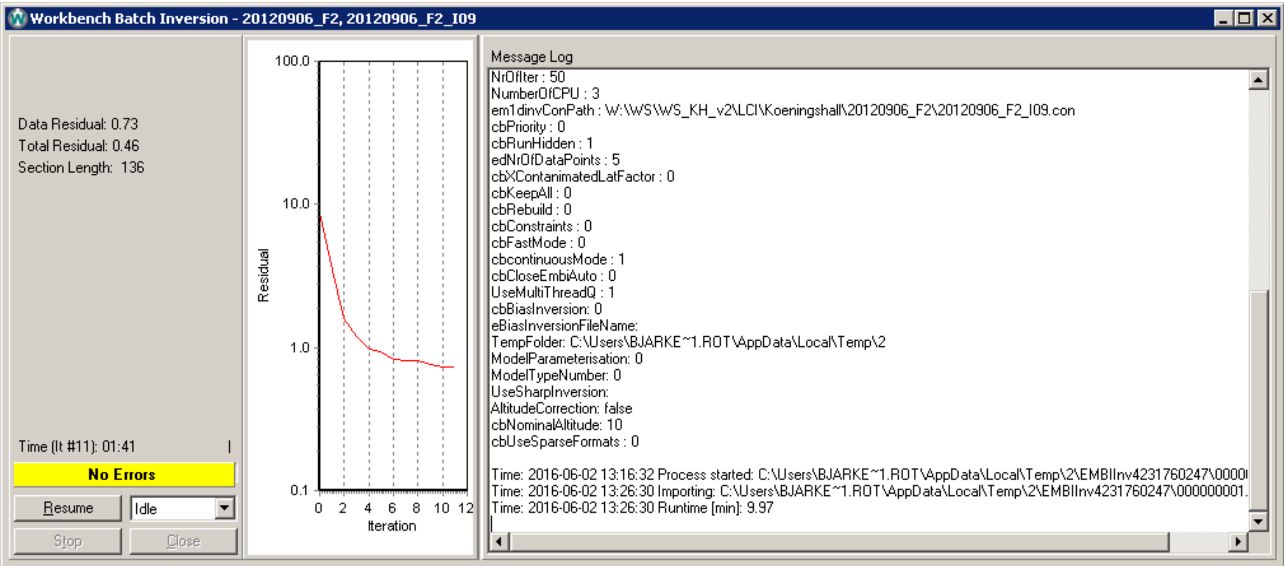

Figure 10. Example Embi.