Inversion setup SCI

In this document we will show how to set up a Spatially Constrained Inversion (SCI) in the Aarhus Workbench for helicopter TEM data. This is a 1D inversion constrained both along and across the flight lines. Ones the preliminary inversions with Laterally Constrained Inversion (LCI) are over, the results have been inspected and the processing result is satisfactory, the final inversion should be done as a Spatially Constrained Inversion (SCI). This usually involves a smooth model inversion and in some cases a layered model inversion as well. If relevant a-priori exist additional inversions might also be done with added a-priori.

AGS Aarhus GeoSoftware

Step by step guide

1. Select data for inversion

Select the AEM data node that should be inverted, go to the Inversion ribbon and click New (spatially constrained).

Here we need to select the data sources. That is the AEM data nodes that we want to include in the inversion. For each data source we then set the settings on the right side. These should all be familiar from the similar settings for LCI.

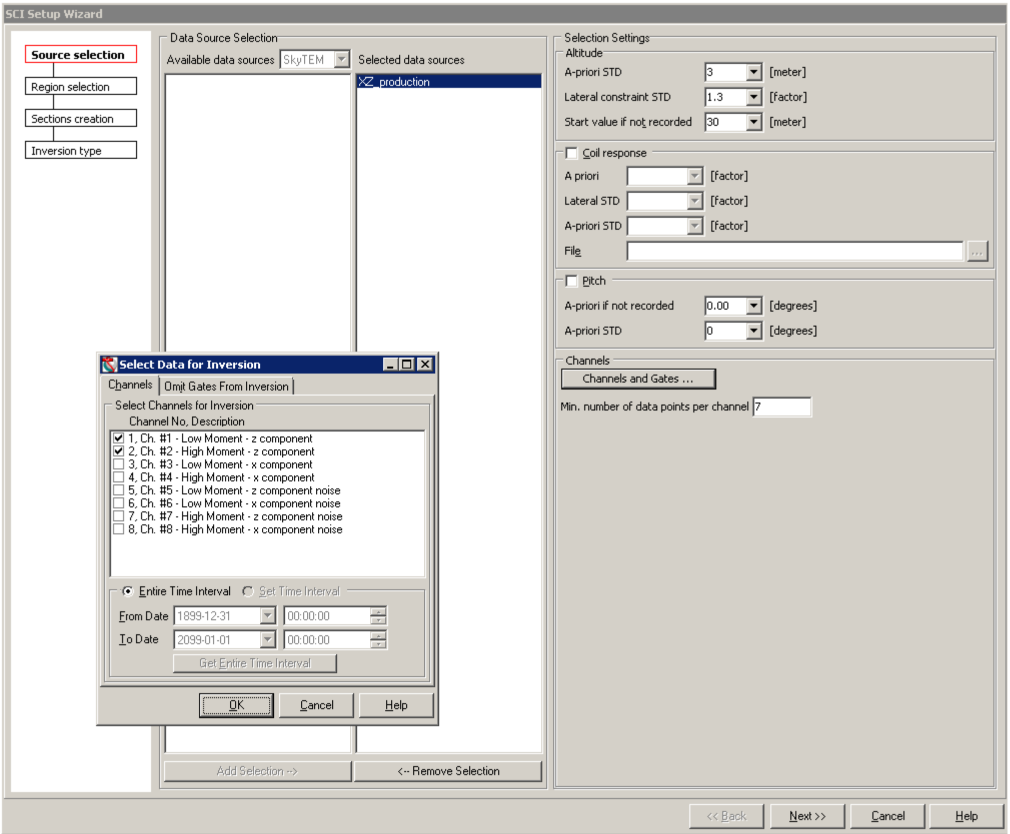

Figure 1. Source selection. Channels and gates have been opened for one of the sky nodes.

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

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

More importantly we have channels and gates. Just as for LCI we here select the channels and gates we want to include. For SkyTEM we often have two moments (low and high moment) that we want to invert as one model. Unlike for LCI we always select the entire time interval. Instead we will have the option to limit the inversion to an area later. Also in here we have the option to 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.

Finally, we have the minimum number of data points per channel. This should be used to omit soundings with very few data points.

Remember that these settings should be set for each data source and may need to be different for each of them.

2. Region selection

We then click next. We then get to the region selection. Here we can either include all the data in the inversion or we can choose only to invert data within a region. We simply choose select on map and drag a selection of what we want to include. We then click next.

There is one other option. Before starting the inversion setup one can draw polygons on the map with the relevant area to invert, one can then select the data within the polygon from here.

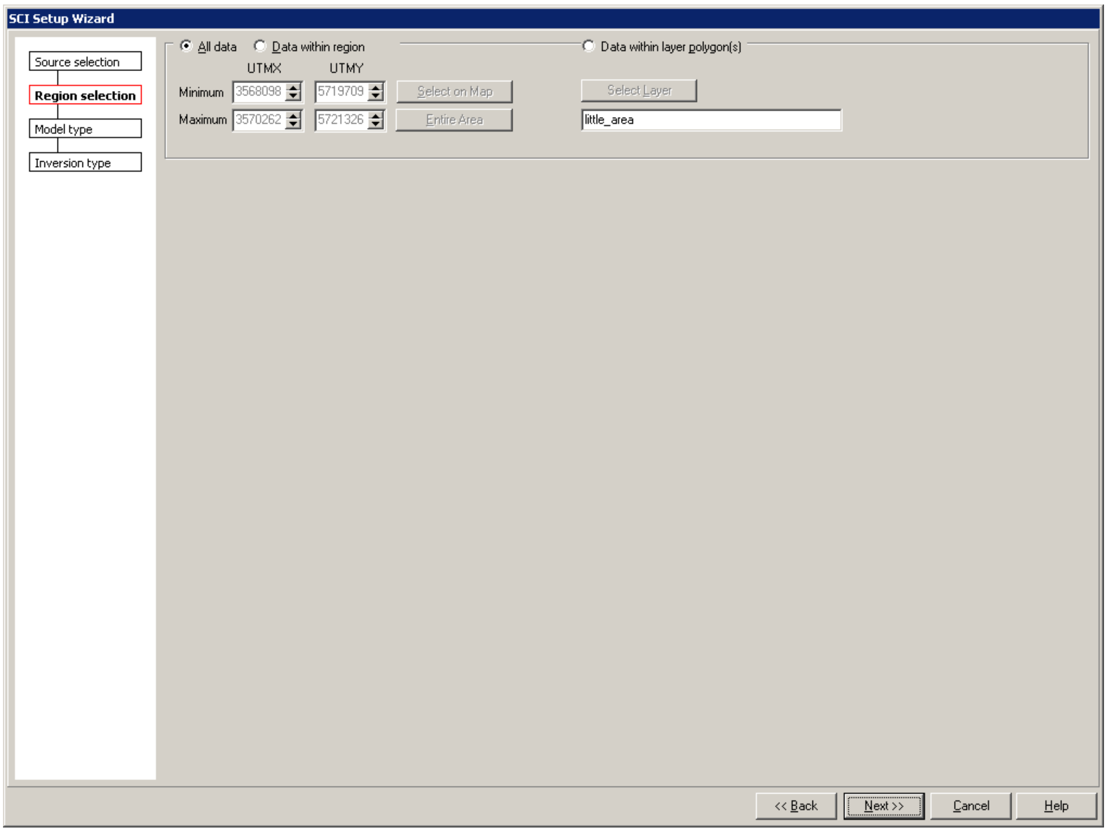

Figure 2. Region selection.

3. Model selection

Now we get to the model type selection. Here we have two options, we can use the manual selection to setup a smooth or layered model to be defined under inversion type. Or we can use a previous smooth model inversion result as a starting point for a layered model inversion. To do the later one also need to select the inversion node with the smooth inversion result and then use the layer estimation tool to find the right amount of layers. Try a few different number of layers, click fit models and look at the model fits. Then select the model with the number of layers that doesn't decrease the model fit much more than the similar model with one less layer.

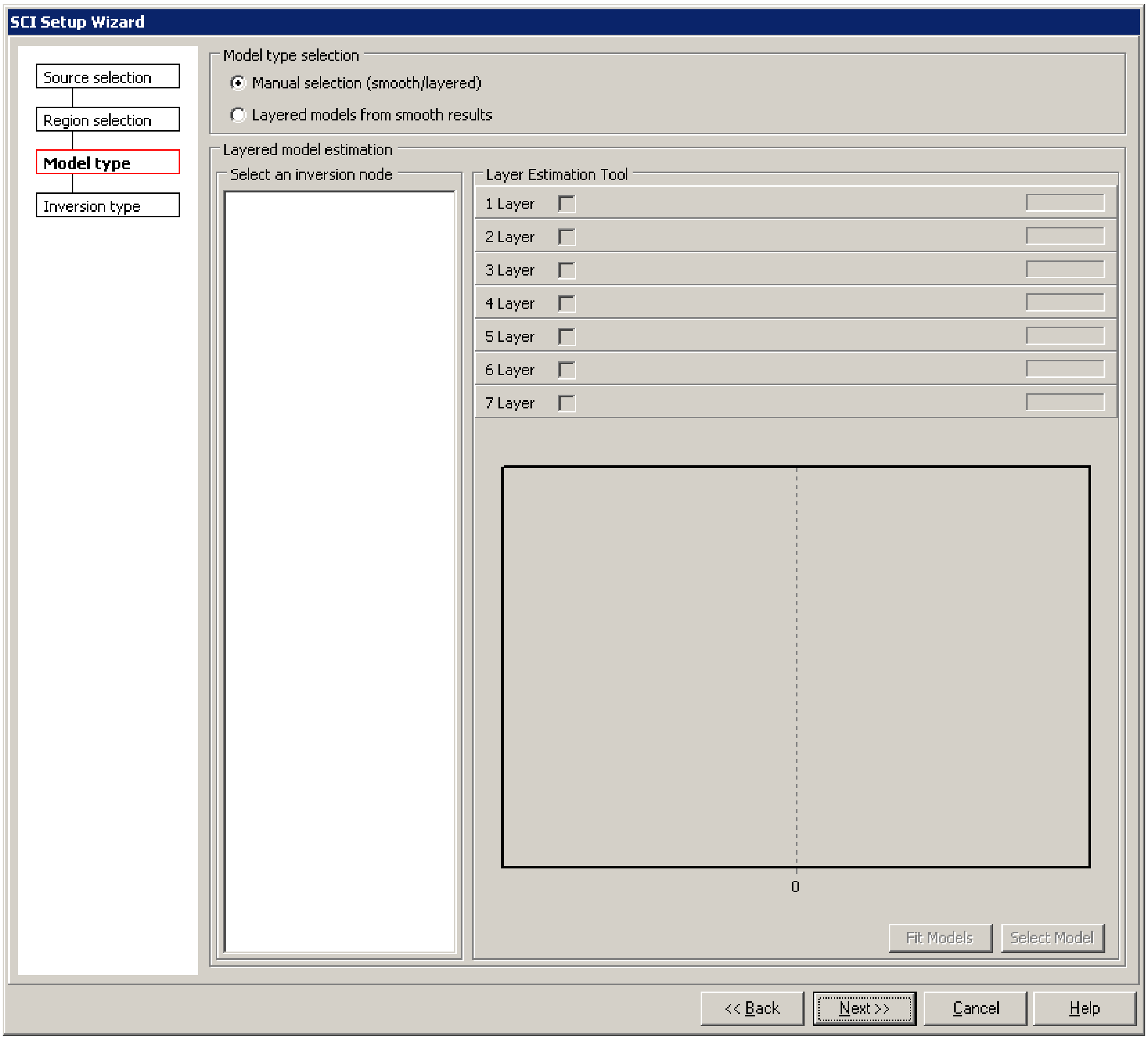

Figure 3. Model type.

4. Inversion model setup

Next we get to inversion type the actual inversion setup. We should start by giving names to the SCI node and SCI inversion node that we are going to create.

Right below that we have the option to set the inversion to run when the inversion node has been created. SCI nodes are stored in separate databases and it can take quite a while to create them, so it is very practical to have this option to run it automatically ones it has been build. For some SCI however we want to add additional a-priori from grids and so on, in those cases we need to be able to setup the inversion and then make a-priori adjustments before we actually run it.

Everything else in here is very similar to the LCI setup.

We need to decide 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 can load or save our settings, and there are also some suggested settings for typical setups.

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.

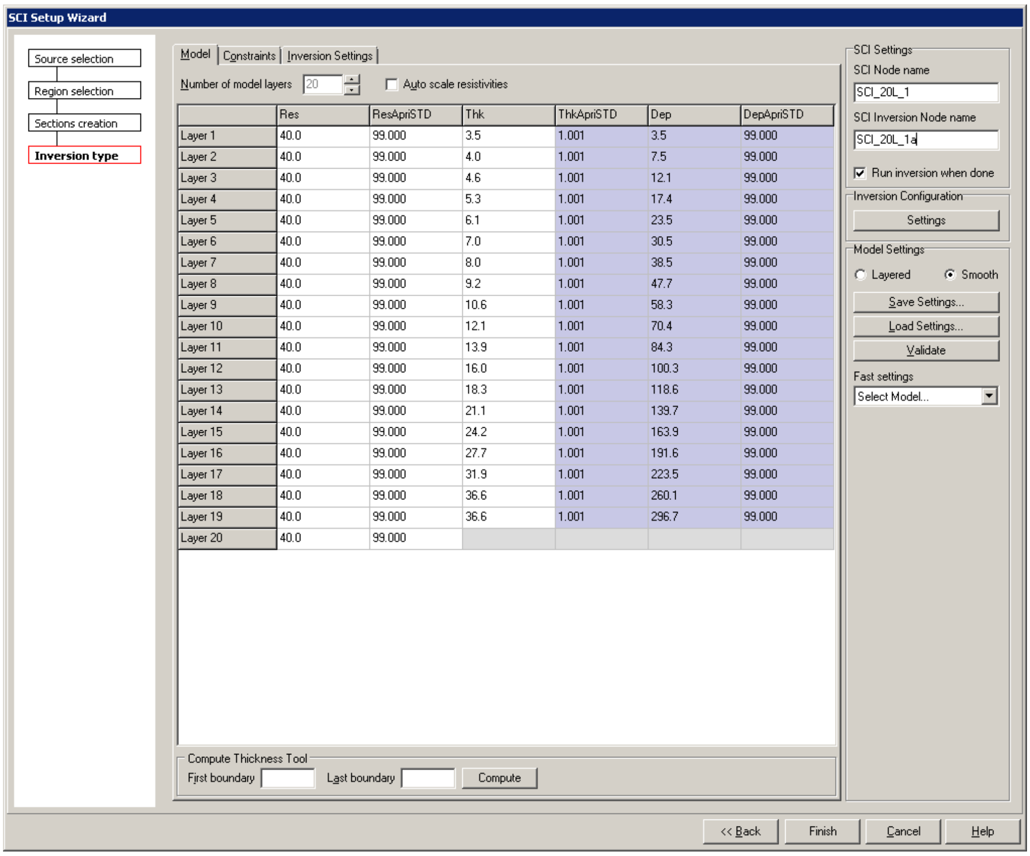

Figure 4. Inversion type – Model description tab.

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 1 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 is not constrained unless additional a-priori is being applied.

5. 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. For SCI that translate into relative stronger constraints across flight lines compared along flight lines. The default value is 0.75.

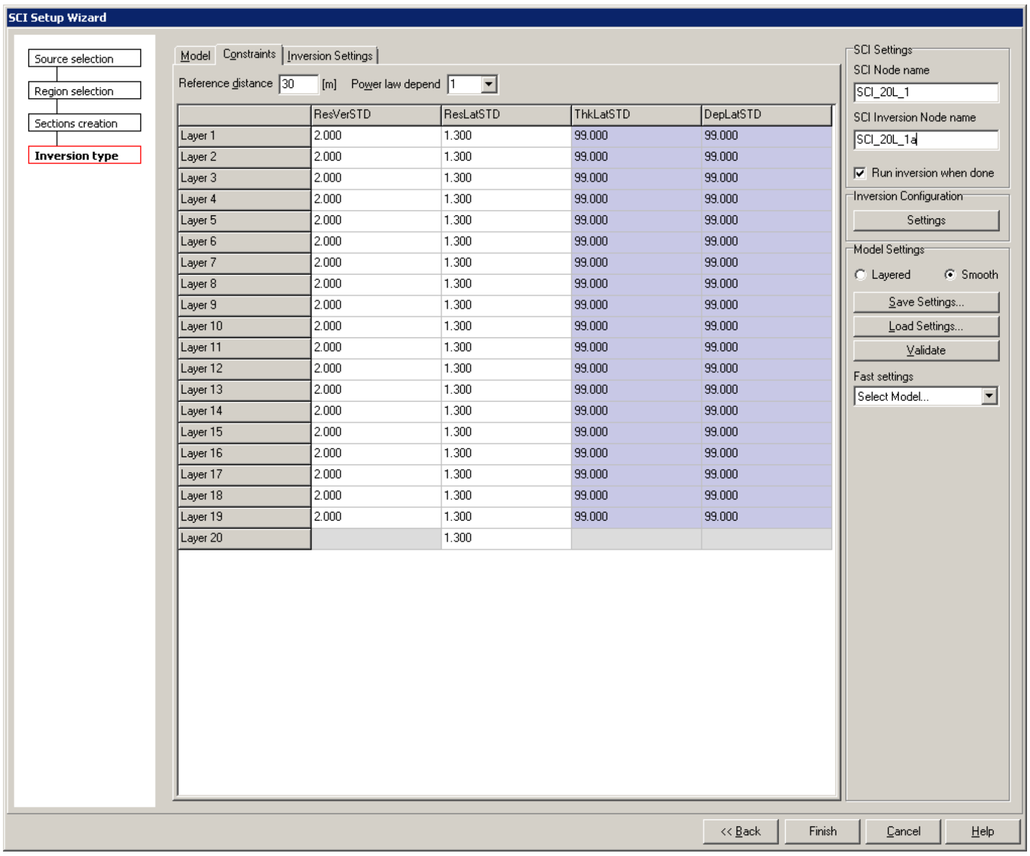

Figure 5. Inversion type – Constraints description tab.

Now we get to the actual constraints. Keep in mind that 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 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 layers for neighboring models are usually, for sedimentary environments, set to a factor between 1.1 and 1.6. Other geologies 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.

6. Inversion settings and run inversion

Under the inversion settings tab we have a few settings related to the inversion. There is the number of parallel processes to be used. This number can however also be changed during the inversion. It is also here that we set it to calculate depth of investigation as part of the inversion.

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. In some cases, however, it might be relevant to go into few optional settings place under inversion configuration. These will be covered in a different document however.

Now we just press finish. The SCI node and SCI inversion node is then created. This includes a rebuild of the database. After the rebuild it will then either start the Scembi directly or, if we did not set it to run inversion when done, we will have the option of doing so later by selecting the SCI inversion node and then clicking invert data on the inversion ribbon. The Scembi controls the inversion runs independently of the Workbench just as the Embi for LCI inversions. That means we can close the workspace and the Aarhus Workbench if we need to. The Scembi only need to have access to the databases. This allows us to run multiple instances of Scembi and even do so on different computers as long as all have access to the databases on a shared hard drive.

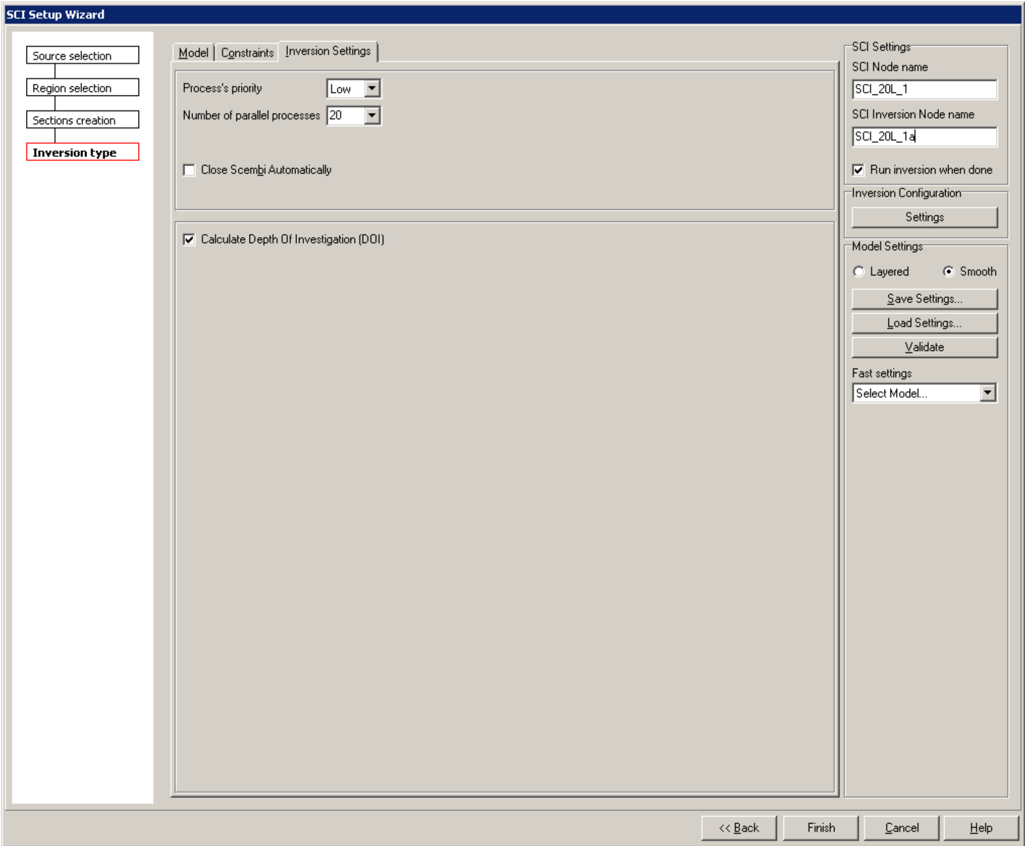

Figure 6. Inversion type – Inversion settings tab.

Scembi inverts everything, plotting the residual of the inversion as it finished it, and then it returns the results to the database. There is a status bar and a log with detailed information.

At the end of each run the database is being rebuilt. This will cause Scembi to not respond while the rebuild is happening. For large datasets, this can easily take several hours, so be patient. If we want to confirm that the rebuild is happening, we do have the option to go to the workspace folder on the hard drive. The log also exists as a simple txt file in the SCI folder there.

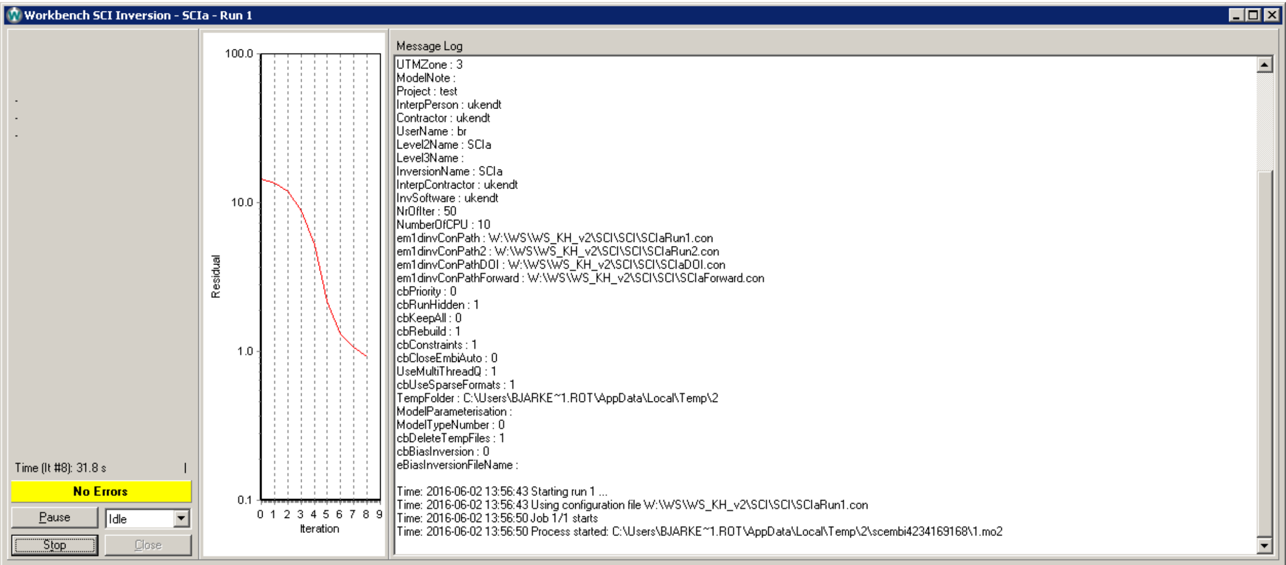

Figure 10. Example Scembi.