FEMIC inverse code user manual
(Updated March, 2015)

The FEMIC inverse code is used to invert small-loop frequency domain electromagnetic induction data. To start the code: Type start in the Matlab command window and hit 'Enter' or 'return' button. The FEMIC GUI will then appear (Figure 1). It consists of several input subsections that allow a user to load data, controls the inversion process and the final display. A brief description of the format of each of these inputs is follow:

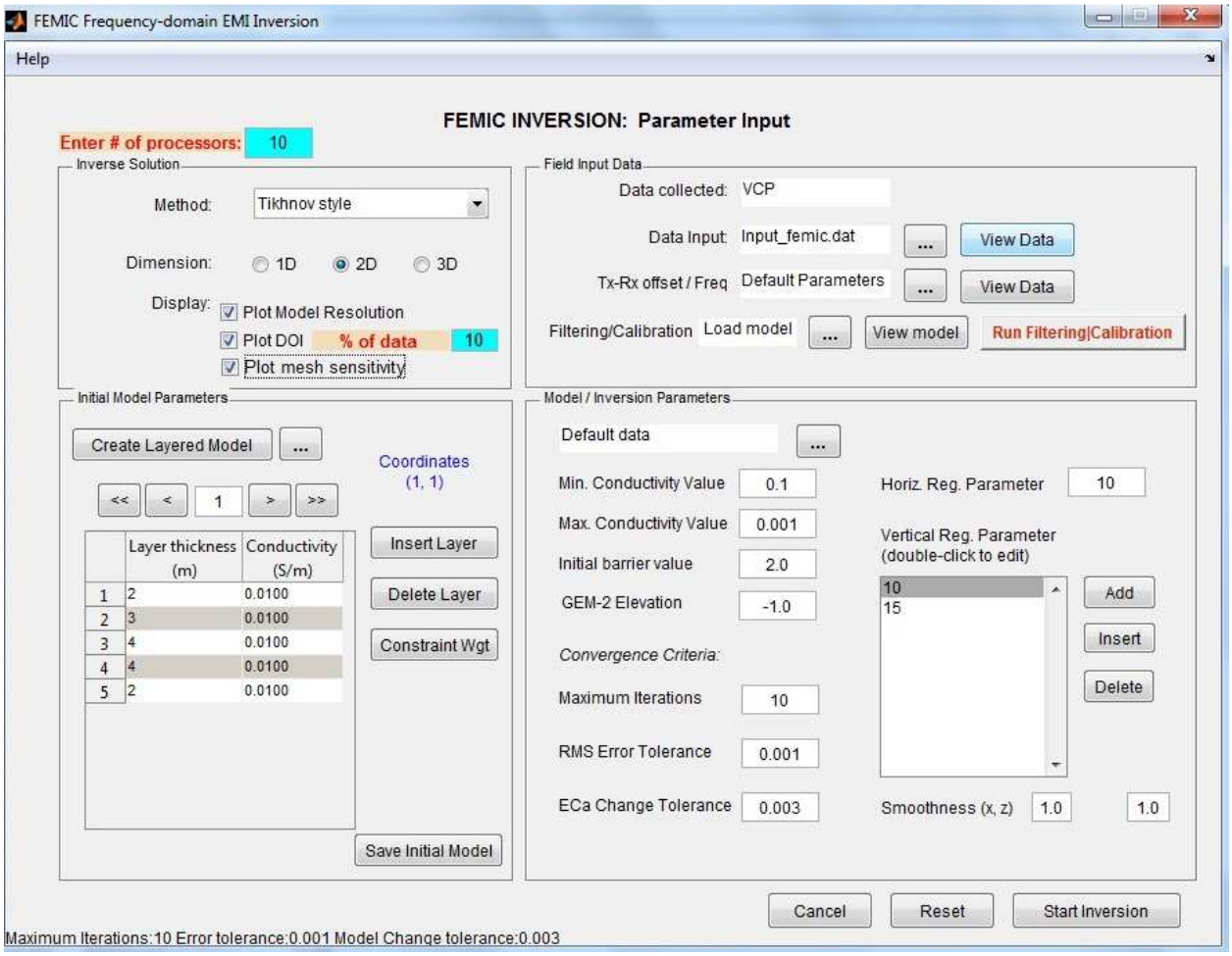


Figure 1: FEMIC GUI

1- Parallel computing: The user should type how many processors to use during the inversion process. In case a user provide a number bigger than the capacity of the used computer, an error massage shows up indicating the maximum allowed number of processors in that machine as shown in Figure 2.

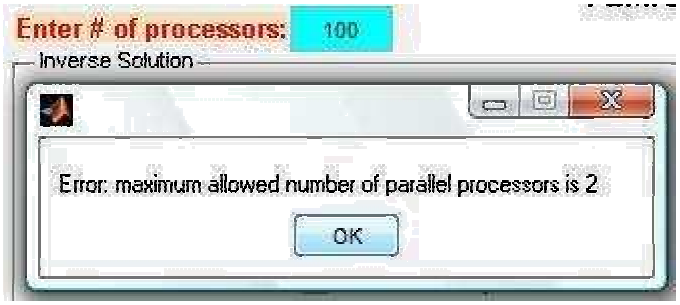


Figure 2: Parallel computing input/error

2- Field input data panel: The input data section consists of the following four inputs as shown in Figure 3:

a- Collected data type: Refers to the coil configuration and it is automatically assigned based from the supplied data input file.

b- Data input file: The user requires preparing/uploading a data input file with extension *.dat using a specific format as shown in Figure 3. The data file should only contain numeric values and consists of 8 columns arranged as follow:

- x – location: Locations of the soundings along the x direction
- y-location: Locations of the soundings along the y-direction.
- z-location: Elevation of each sounding. The current code version assumes that all soundings have zero elevations.
- Sounding_id: Numeric ID of each sounding. Different data within each sounding should be assigned the same number.
- Frequency: List of frequencies used during data acquisition.
- STD error: standard deviation of each measurement.
- Coil configuration: Enter 1 for VDM, 2 for HDM, or 3 for both configurations.
- List of measured apparent conductivity values at all soundings

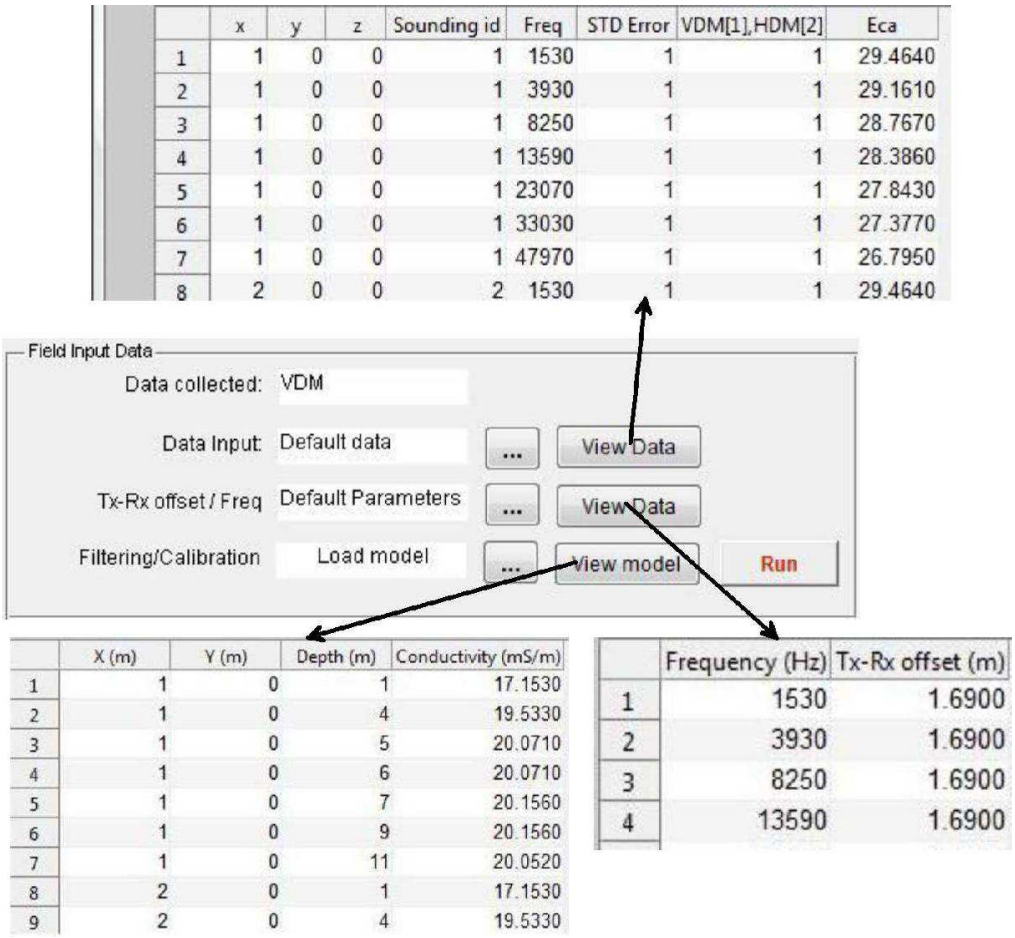
c- Tx-Rx offset: The user requires uploading a *.dat file that consists of two columns as shown in figure 3;

- Inter coil spacing during data acquisition.
- Corresponding frequency value at a given coil spacing.

d- Filtering/Calibration: The user requires uploading a conductivity model file to calibrate the measured EM raw data. That file consists of four columns as follow:

- X-location: Locations of the sampled conductivity values along the x direction.
- Y-location: Locations of the sampled conductivity values along the y direction.
- Depth: Depth of the sampled conductivity values.
- Conductivity: list of sampled conductivity values at all locations.

To view the model, click on “View model” button. To run the calibration and filtering process, click on “Run Filtering/Calibration” button. The calibrated and filtered data automatically replace the original EM raw data. A message indicating the success of the process appears after pressing on the run button.



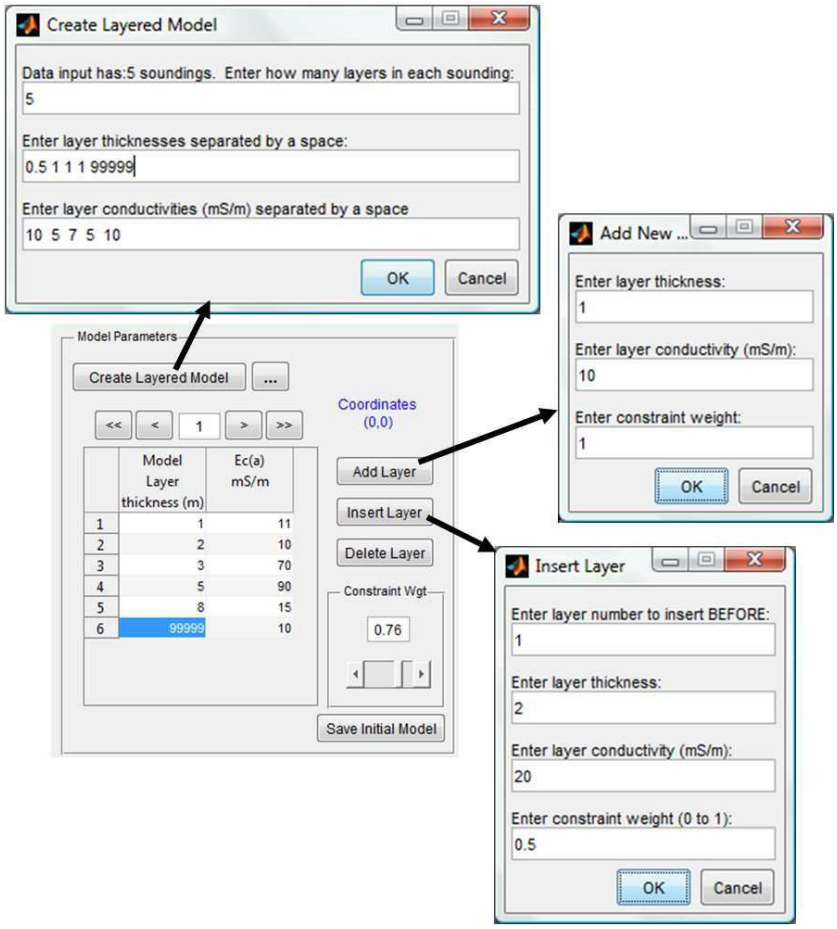
	x	y	z	Sounding id	Freq	STD Error	VDM[1],HDM[2]	Eca
1	1	0	0	1	1530	1	1	29.4640
2	1	0	0	1	3930	1	1	29.1610
3	1	0	0	1	8250	1	1	28.7670
4	1	0	0	1	13590	1	1	28.3860
5	1	0	0	1	23070	1	1	27.8430
6	1	0	0	1	33030	1	1	27.3770
7	1	0	0	1	47970	1	1	26.7950
8	2	0	0	2	1530	1	1	29.4640

	X (m)	Y (m)	Depth (m)	Conductivity (mS/m)
1	1	0	1	17.1530
2	1	0	4	19.5330
3	1	0	5	20.0710
4	1	0	6	20.0710
5	1	0	7	20.1560
6	1	0	9	20.1560
7	1	0	11	20.0520
8	2	0	1	17.1530
9	2	0	4	19.5330

	Frequency (Hz)	Tx-Rx offset (m)
1	1530	1.6900
2	3930	1.6900
3	8250	1.6900
4	13590	1.6900

Figure3: Description of the required file formats for the field data input panel

3. Initial model parameters: This section allows the user to enter a reference model during the inversion as well as any available priori information. The user can simply click on "Create Layered model" to create a homogenous starting model for all soundings. The starting models for all soundings are automatically assigned constraint weights of 0 for each layer/conductivity value within each sounding. The constraint weight, which adjusts how the inverted model deviates from the reference model, varies from 0 to 1. A value of '0' means no constraint, whereas a value of '1' indicates that the reference values will be hard constraint during the inversion. The user can modify the reference model and constraint weights of any soundings simply by clicking on 'Add layers' or insert layers as shown in Figure 4.



Figu re 4: Initial model parameters panel.

4. Model/Inversion parameters

The inversion parameters can be entered directly in this section or loaded from an input *.dat file. The input file should have a single column that contains the following para meters:

- Min. parameter: Minimum conductivity value used in a solution during the inversion (scalar).
- Max. parameter: Maximum conductivity value (scalar).
- Bar: Parameter for the positivity barrier function (scalar).
- Muh: Horizontal regularization parameter (scalar or vector).
- Muv: Vertical regularization parameter (scalar or vector).
- max iterations: Maximum number of inversion iterations.
- err tol: Convergence criteria for changing errors.
- eca tol: Tolerance on changes to conductivity.
- Sx: smoothness parameter in x-direction.
- Sy: smoothness parameter in y-direction.
- Sz: smoothness parameter in z-direction.

5. Inversion solution: The user in this section requires selecting:

- Dimension of the problem: Either 1D, 2D or 3D inversion.
- Display: The user may want to add a sensitivity plot, model resolution or show the maximum DOI within the inverted conductivity model, by selecting the appropriate radio button. The sensitivity and resolution plots will be displayed in addition to the regular inversion plots. The DOI estimation is based on the approach described by Oldenburg and Li (1999).

6. 2D Synthetic Examples:

Here we simulate anomalous body having conductivity value of 0.02 S/m and buried in a homogenous host medium with conductivity of 0.01 S/m (Figure 2). The inversion results and image appraisal analyses are shown in Figure (3). The anomalous body recovered fairly well. The estimated maximum DOI matches the bottom boundary of the anomalous body. The model resolution image shows regions within the model domain that are controlled by the data (bright colored regions) and by the inversion constraints (dark blue regions). This input data for this synthetic example are located inside the “synthetic example” folder located within the code main folder.

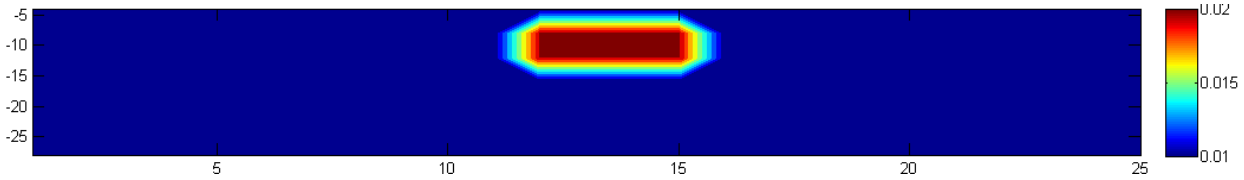


Figure 2: True model

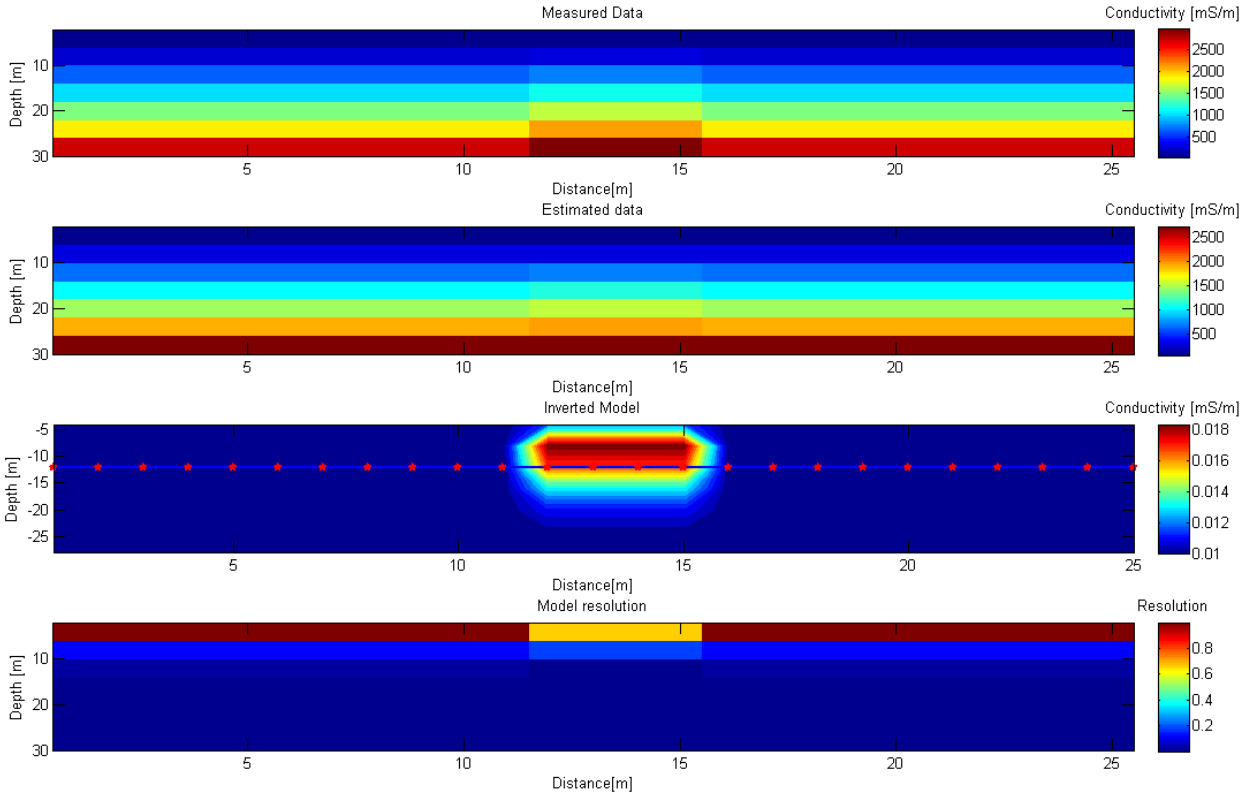


Figure 3: Inversion and image appraisal results of the synthetic example (a) synthetic data, (b) forward modeled data, (c) inverted model. The horizontal line denoted the maximum DOI, and (d) normalized model resolution image.