LitMod2D_2.0 python GUI manual

Ajay Kumar *[1]

[1]Group of Dynamics of the Lithosphere, ICTJA-CSIC Barcelona, Spain , Email: ajay6763@gmail.com

August 2019

*SUBITOP (http://www.subitop.eu/home/)

1 Introduction

LitMod2D_2.0 is a finite element code which combines potential field, geochemical and seismological data to work out thermo-chemical structure of the lithosphere.
This document is a manual for a python based GUI to build the model where the user draws geometry of the bodies in the cross-section and associate physical properties to those bodies.

2 Installation

User can download or clone the package from `https://github.com/ajay6763/LitMod2D_2.0_package_dist_users.git`. You will have following directory structure.

```
LitMod2D_2.0_package_dist_users
├── Generator_Linux -- to generate material file
├── GUI -- includes the GUI in python
├── manual -- Manual for GUI use
├── Post_processing -- packages for post-processing
│   ├── flexure_tao
│   ├── Phase_diagrams
│   ├── RF
│   ├── Surface_wave_dispersion
│   └── Synthetic_Seismic_tomography
└── REAME.md
```

To setup Generator, follow the instructions in REAME.md file in the Generator_Linux directory.
Now we need to setup the GUI which essentially means we need to install python liberaries. Generally, Linux comes with installed python2.7 but in Windows you might have to install python2.7 (`https://www.python.org/getit/`). This GUI uses packages from python which do not come pre-installed with stand-alone python installation.This GUI is python2.7 compatible. All packages used here can be installed using "pip" a python package manager which can be easily installed in Windows or Linux distributions (`https://pip.pypa.io/en/stable/installing/`).

I would highly recommend to make a virtual python environment for this GUI and install the required liberaries in that environment. To set-up a python environment do following:

pip install virtualenv
virtualenv -p /usr/bin/python LitMod2D_2.0

Above command will make a LitMod2D_2.0 folder in the current folder with a dedicated python. Now you have to activate it by running following:

source ./LitMod2D_2.0/bin activate

Now stay here and navigate to the GUI folder and run the following command:

pip install -r requirements.txt

This should have you almost everything needed for the GUI.
Now everytime you have to run LitMod2D_2.0 you have activate this environment as explained above and run the GUI.

Once you have everything installed you need to add the LitMod2D to you your path.

3 How to make and work with models?

Before making model user should have following in the project folder:

- Sufrace observables (e.g., elevation, gravity, geoid height) in files. Each file separate for these observables should have three columns, first column being distance along the profile sampled according to the resolution you want (e.g., 2 km , 5 km), second column beinn the value of the observable, and the third being the error in the observable.
- Material files as two digit code name and contains pressure and temperature dependent thermoysical properties, which are genrated using the Generator module. To generate these files follow the README provided in the GENERATOR_Linux folder.

‘

To start the LitMod2D_2.0 go into GUI folder and run main.py (in Linux type " python main.py" in Windows you can double click on the main.py file), running which Fig. 1 will appear. Here you have three options. Build model option is to build a model from scratch. Load Model is to load a previously build model and the last option is about help.
*Note: In dialog boxes, put your mouse in a field and additional information will appear.

3.1 Build Model

Before building a model user should have a clear idea and sketch of the model user wants to build. User should know nodes along which different bodies will be connected. A model is build from top-to-bottom and left to right and every

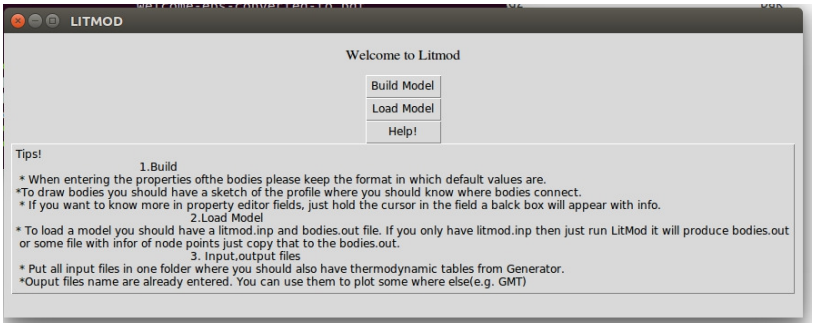

Figure 1: Welcome Page

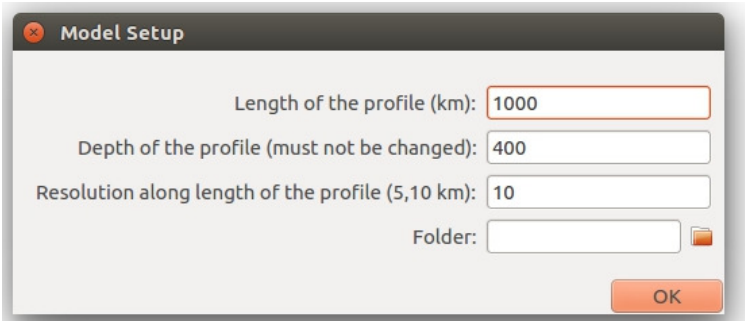

Figure 2: Model Setup

time user wants to exit and wants to save the model, user should close the model by clicking the close Model button on top right. After clicking close model click on the save option which will open a dialog box about some info about the model.

After user hits Build Model option a dialogue box appears (Fig. 2) asking for information about the model and another dialogue box asking for digitized file where you already have nodes of the bodies (e.g. digitized sketch, Moho depths,LAB depths; two coulmn, X (distance along profile, km) Y(depth, -ve, km)). This digitized file will be plotted in background and you can click on the plotted points.

**Note: Bodies are added from left to right

- **Start of the profile (km)**: This is the left most start point of profile(it can be negative too. In that case all the observable files should have same limits).
- **End of the profile(km)** : This the right most end point of profile.
- **Depth of the profile**: This the depth of the profile in km. It must be 400km, so it must not be changed.
- **Resolution along the profile**:resolution of the profile

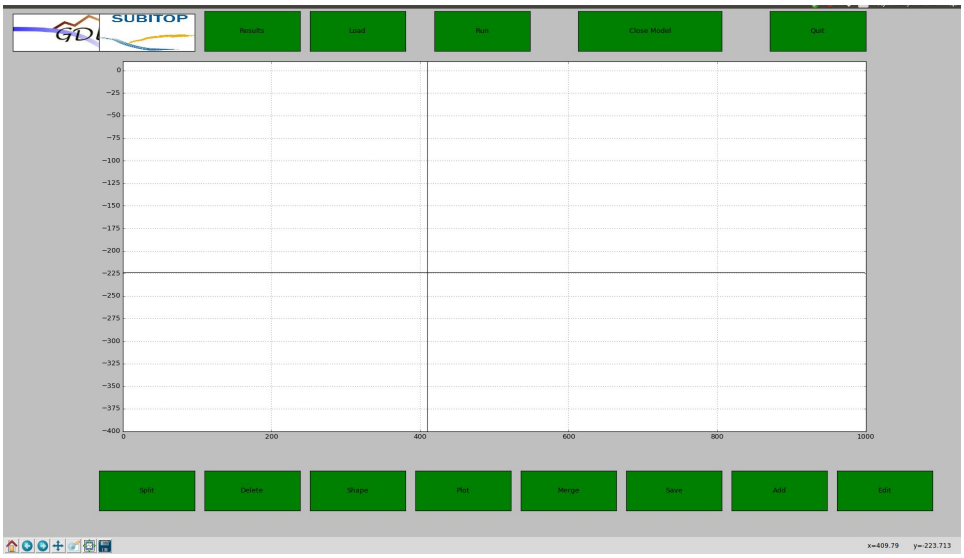

Figure 3: Build Model Window

- **Folder** : Here user selects the folder in which observable files are put and it becomes the working folder for LitMod2D_2.0. All the outputs files are stored in this folder.
  Tip: For each of your model you can make folder where you put all oberv-ables files, material files from Generator. Later you can load the model by browsing into this folder.

After the user hits OK button build model window will appear (Fig. 3). Here the user has different option.

3.1.1 Add Body

Bodies are added from top to bottom, each body is drawn left to the right.To add a body press the add button on the window (Fig. 3) which will open a dialog box asking for information about the body (Fig. 4).
*Please note that format in which default values appear should be maintained.
Fields description

- **Name** : Name of the body. Just for your reference
- **Body number** : Index of the body starting from the top.
- **Material** :Type of material of the body
- **Body type**: if you are adding a body which is new, this option should be normal. If you are splitting a body change this option to split. If you are adding an anomaly, change this option to type of anomaly you are adding (thermal or seismic or from a file).

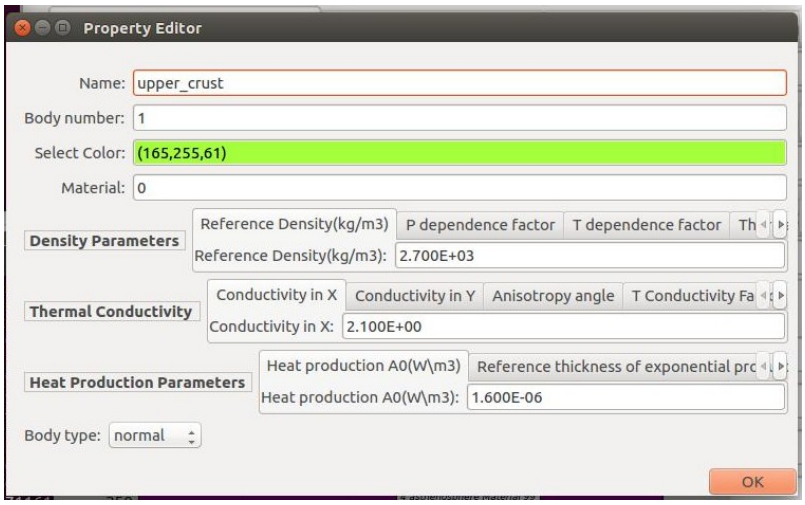

Figure 4: Body property editor

Once the user is done with adding properties user should hit OK and control will be back to the plotting area.

- **to add point**: Middle mouse click (Scroller)
- **to delete current point**: double left click.
- **to close body**: right click

3.1.2 Delete body

The user can delete the last body entered by clicking on the delete button. Let us say a user has drawn three bodies. To delete second body first user has to delete the third body. So essentially you can only delete the last entered body. If you want to delete a body inbetween, then you can use the merge function(see following sections).

3.1.3 Change shape of the bodies

To move,delete or add node points of the drawn bodies user can click on shape button. After clicking this button a separate plot will appear where all bodies will be drawn as points (In case you have anomalies in the model other than from a external file then seond window also appears where you can edit anomalouse bodies too). Now user can move these point by left click drag, to delete a point move the cursor on the point and then press 'd' key on the keyboard (sometimes there are more than one points so keep pressing 'd' untill the point is gone). To add a point go to the point and press 'i' key on the keyboard. After you are done changes can be saved with right click while the cursor is on the edit plot

window. Once you have saved changes close the window and come back to the main window and hit plot button which will update the changes. This function will only work after you have closed your model.
*Note: when you see the plot of the bodies (for anomalies) in separate window , you might see some lines connecting different bodies, just ignore them. To have clear idea keep main window where you added bodies in front of you along with this separate window

3.1.4 Edit properties

To edit properties of a body already drawn click on edit button and a dialog box will appear asking for the index of the body you want to edit.

3.1.5 Split body

This function allows the user to split a body into two (does not work for anomalous bodies). Let us say if you have a crustal body along a body and you want to have different density on the right side than the left side then you would use this option. To split this crustal body click on split body option and enter the asked information about the body and add point near the already existing node in the body and add points along the axis you want to split. The end point should be added close a an already existing point in the body. Once you are done then press right click. The follow the Shape change option instructions, adjust the nodes and refresh back in the main window.
*Note: If for some reasons split does not work then you can load model again and try to split it again.

3.1.6 Anomalies in the sublithosphere mantle

In this GUI anomalies (Composition,thermal,seismic) are added on top of the completely closed profile. You can edit the shape of these anomalies and properties (type and amount of anomaly) with shape and edit function respectively. These types of anomalies can be drawn in the profile.
There is another way to enter anomalies where you enter them in a file and you choose the file (For more information about this file refer to the LitMod2D_2.0_usage.pdf, supplied in this folder. Only seismic anomalies can be added in this way.
* Note that if you have selected anomalies in form of a file then all other anomalies (drawn on the profile) are not considered even if you have added them.

3.1.7 Save

When you are done with the profile and you have closed it by clicking on the Close model button, it can be saved by clicking on save button. After you click on the save button a window will appear asking for some more information.
You can choose observable filex, where you should have three columns with distance, data value, error. Total length and sampling of these observables

should be exactly same as that in your profile. One important thing is to have starting and end point of these observables data as that of start and end you choose to make your profile. After browsing the these file try to keep only the name of the input file try to delete the absolute path. Here making a folder for each of your model, which can be at any location in yout computer, helps keeping things in track.
Every time you save a model, a back-up of three files, 1. LitMod2D_2.0.inp 2. bodies_GUI.dat 3. bodies_GUI_envelops.out, with a date and time added. You can later rename these set of files and load them again.

3.1.8 Run model

To run a model first you have to save the model by clicking on the save button, but before that, your model should be closed. You should also put the observables file (topography, bougeur, geoid, free air, heat flux) and composition files (e.g. 80 81 88 99 etc) which you have associated with the bodies in your model, in the same folder .
Note:To run a model you should have LitMod2D_2.0 program executable for windows or linux based on your system. Executable for Linux is provided with the distribution . Name of these executables should be LitMod2D_2.0_V4_VS_Windows for windows and should be in LitMod2D_2.0_package folder and for Linux it should be in same folder with name LitMod2D_2.0_V4_VS_Linux.

3.1.9 Load Model

This option lets the user load previously build models. To load models user need three files, 1. LitMod2D_2.0.inp, which is a input file to the LitMod2D_2.0 program and 2. bodies_GUI.out , this file contains nodes point of the bodies in the model and color of the body and bodies_GUI_envelops.out. Units of nodes points in bodies_GUI.dat are in kilometers.
This option also allows you to restore changes while you are working. For instance if something goes wronge (e.g. split body , merge body) you can load last saved session and start from there again. You can also track this threes files saved in same folder at any time you have saved them, rename them and can load them again.

4 Post-processing toolbox

Post-processing toolbox contains a set of codes/scripts linking with outputs from LitMod2D_2.0 with other softwares. At this point is it counpled with "Computer programms in Seismology (CPS)" tool (Herrmann, 2013) and "tao-geo" (Garcia-Castellanos et al., 2002) software. It also includes scripts to produce stable phase and minerla assembalges in the profile. Installations of coupled softwares is explained below.

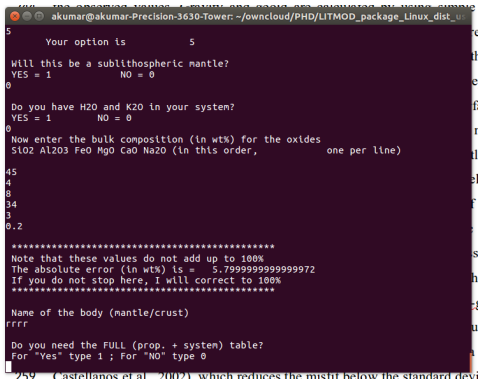

Figure 5: Generator console showing option to generate full property table.

4.1 Passive Seismological data

Forward prediction of surface wave dispersion curves and reciever functions can be calculated from the seismic velocities distribution with depth at each node along the profile. This done by feeding in seismic velocities to CPS.
CPS can be easily downloaded and install from `http://www.eas.slu.edu/eqc/eqccps.html` and needs to in your path.

4.2 Flexutal Isostasy

Flexural isostasy is incorporated via "tao-geo" and can be downloaded and installed from `https://github.com/danigeos/tao-geo` and should be added in your path.

4.3 Stable phase and mineral assemblages

To do this user should have full property tables from the GENERATOR module. Opting for option "1" shown in 5 produces both full property material file along with simple material file with physical properties only. Full property material file contains information on stable pahse and mineral assemblages (weight percentage, volume percentage) along with the physical properties (density, seismic velocities). Simple material files, with material code '90,99..' are read in the LitMod2D_2.0 whereas full property material files named as '99_FULL etc.' are used to produce stable phase and mineral assemblages. Full property material files should be in the model directory.

First user should run "make_mineral_wise_files_full.sh". This produces mineral wise properties along the profile.

User can plot a property (e.g. weight%) of stable mineral at a distance point along the profile running 'phase_diagram_1D.py' 6 or depth distribution of individual minerals along the profile using 'phase_diagram_2D.py' 7

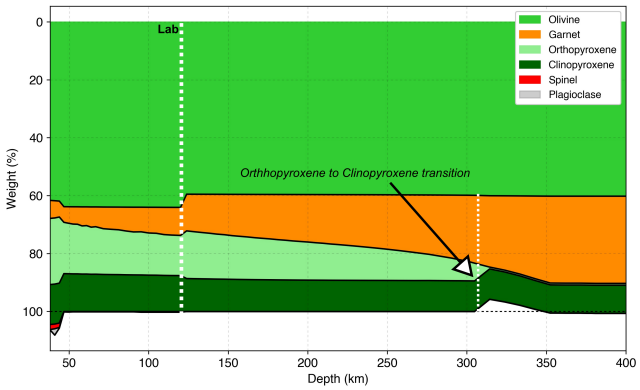

Figure 6: Example of stable mineral wt% distribution at a distance point.

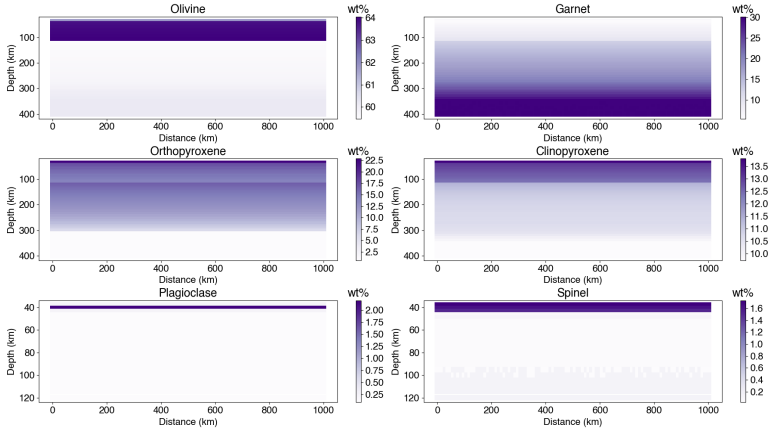

Figure 7: Example of stable mineral wt% distribution along a profile.

5 Miscellaneous

User can also use other functionality. They are listed below:

1. Values of coordinates are shown at the bottom right corner of the plot. It is useful to add points at specific positions.

2. You can zoom in at any area of the profile by clicking at the functions in the left bottom of the window. You can also go to the zoom mode by pressing 'o' on the keyboard. Then you can selet area to zoom in with mouse and navigate back and forth with arrow keys on the keyboard. It is useful for small area bodies.

3. To go back out of zoom mode you should press 'o' again.

4. You can drag the profile and to go to this mode you can press 'p' on the keyboard.

5. If you want to go straight to the initial level after zooming at different levels just press 'h' key on the keyboard.