User Manual for CALM

Software: CALM

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download link: https://github.com/zhyy2020/CALM

The modelling of converted shear wave data is an important subject of ocean bottom seismometer (OBS), which is beneficial for revealing the characteristics of subsurface structures. Realization of rapid, automatic and comprehensive modeling of this data is demanded by relevant researchers. This article shows a software CALM (standing for Converted wAve veLocity Modelling), which provides a graphical user interface that can analyze the conversion mode and assist in the automatic simulation of shear wave velocity structure. The software is written in Python (Python3.7) and can run on multiple platforms.

This user manual mainly introduces the main system functions and routine processes of the conversion shear wave simulation software, and is used to guide relevant researchers to use the software correctly and efficiently. For more details, users are recommended to refer to the paper.

1. Installation and dependencies

Users can generate the executable files using software package tool, such as cx-Freeze (https://pypi.org/project/cx-Freeze/). Then the executables can run on different platforms. If users intend to run the program from the source code directly, platform Anaconda (https://www.anaconda.com/products/individual) is recommended, which has already embedded necessary libraries such as matplotlib. Program RAYINVR

(http://terra.rice.edu/department/faculty/zelt/rayinvr.html) should be installed in advance.

2. Modules

2.1 Model visualization

This module is designed for visualization of velocity models and subsequent plotting. The parameters in this module are:

“v.in”: Directory of the given Vp model.

“Layer Number”: The number (integer) of layers contained in the velocity model.

“Distance Min (km)”: The minimum value of model distance.

“Max (km)”: The maximum value of the model distance.

Three buttons are also provided:

“Select”: This button calls a dialog for directory selection.

“Parse”: This button launches the parsing of velocity model form file “v.in”.

“Visualize”: This button is clicked to plot the parsed velocity model in plot display area.

“Erase”: This button is clicked to erase the current plot in display area.

2.2 Analysis module:

This module is used for interactive analysis of conversion modes and interfaces. Two manners of parameters assignment are supported in this module. The first one is through filling into the entries manually, and the second is graphical selection in velocity model displayed. And two analysis patterns are also provided, which are single-position and spatial-variation, respectively. The results are printed in the text output and expressed as curve graphs in display area.

“Vp1”: Velocity of compressional wave (Vp) in incident medium.

“Vs1”: Velocity of shear wave (Vs) in emergent medium.

“Density 1”: Density in incident medium.

“Vp2”: Vp in medium 2.

“Vs2”: Vs in medium 2.

“Density2”: Density in emergent medium.

Note that the physical property parameters are of the selected points.

“Angle Min”: Minimum value of incident angles.

“Angle Max”: Maximum value of incident angles.

“Step”: The angle “step” along with “Angle Min” and “Angle Max” defines the set of incident angles used in analysis.

Button:

“Select Interface”: This button activates the graphical selection of physical property parameters flanking the target interface. After the interface is selected, the selection status is invalid.

“Mode Analy.”: When this button is clicked, the program carries out single-position analysis for conversion efficiency.

“Mode Varia.”: This button activates the spatial-variation analysis for conversion efficiency.

“Visualize”: This button plots the corresponding curve graph about the conversion mode analysis in the plot display.

Radio button “Single Site.” or “Spac. Varia” is used for switching between single-position and spatial-variation analysis.

2.3 Search parameters assignment

This module defines the basic files used and range of search. When the program is running, multiple intermediate files are generated. Therefore, separate folders are needed to store the results. This module is capable to carry out model search in three target layers simultaneously, which entails target layer number, search range and step. Initial setting of Poisson’s ratio is also requisite. Two search modes are supported in this module, which are “Layer mode” and “Block mode”, respectively. A convertor is also provided for conversion between Vp/Vs ratio and Poisson’s ratio. A progress bar is also provided to indicate the remaining time of model search.

“Layer1 Vp/Vs ratio Min”, “Max” and “Step” forms the search range of layer 1.

“Layer2 Vp/Vs ratio Min”, “Max” and “Step” forms the search range of layer 2.

“Layer3 Vp/Vs ratio Min”, “Max” and “Step” forms the search range of layer 3.

“Layer1 No”, “Layer 2 No” and “Layer3 No” define the target layers in search.

“Test Folder” defines the folder storing resulting files of the current search.

“Reduced Vel.(km/s)” is the reduced velocity used in plotting travel-times.

“Vp/Vs ratio” and “Poisson’s ratio” are entries used in convertor. “==>” and “<==” marks the direction of convertor.

“Layer Pois. ratio”: Entry for initial Poisson’s ratios of all layers used in model search, the values are separated by comma.

Radio button “Layer Mode” and “Block Mode” switches the search mode.

“Block Min 1” and “Block Max 1” delimit the search range of layer 1 in block mode.

“Block Min 2” and “Block Max 2” delimit the search range of layer 2 in block mode.

“Block Min 3” and “Block Max 3” delimit the search range of layer 3 in block mode.

Note that layer 1, 2 and 3 can be the same in block mode.

“Data Directory” is the directory containing necessary data files used in ray-tracing, such as travel-time files. This entry can be filled by file selection dialog (button “select”) or manual input.

After all necessary parameters are set, “Run” can be clicked to start a new model search.

2.4 Model evaluation

This module is used for evaluation of all modes searched, and finding the most appropriate one. The quality of model is assessed by the travel-time misfit and number of phases traced. This module provides corresponding parameter (“Chi2_share”) regulating relative contribution of misfit and traced number to model assessment.

“Prefix”: The common filename prefix of results.

“Chi2_share”: The parameter regulating the relative contribution of travel-time fitting and traced number to model assessment (scoring).

When “Chi2_share” is set, “Evaluate” button can be clicked to launch the model evaluation and the results will ne printed on the text display area. And “Plot Phases

traced” can be clicked to display the ray-tracing and travel-time fitting of the selected model.

2.5 Text output module (area)

A shared output area for different procedures in analysis and modelling is anchored at the bottom of GUI, which is oriented for displaying basic information during running.

2.6 Plot display module (area)

The GUI of CALM also integrates a display area for showing velocity model and interactive analysis of conversion mode analysis. Additionally, plot of ray-tracing and travel-time fitting can be shown on it.

3. Reference workflow

3.1 Plot the initial velocity (Vp) model in plot display area.

3.2 Analyze the conversion modes at each interface in the model. This step is highly recommended as it provides quantitative indication for determining conversion modes and interfaces.

3.3 Determine the reasonable conversion modes and interfaces. Then specify the layers or blocks to be searched, set the lower, upper bound and search step of the Vp/Vs ratios according to geological limitation.

3.4 With the bound and step parameters, the main program defines the set of models for ray-tracing of converted S-waves.

3.5 Run model search in the set.

3.6 Scoring functions of the models searched are calculated to determine the most appropriate model in model evaluation.

3.7 Consider the results and determine whether to continue the search or explore the other layers or blocks. Return to 3.3.

3.8 A reasonable Vp/Vs-ratio model, hence Vs model, is obtained when all layers and corresponding settings of Vp/Vs ratios are determined.

Note: Test data is provided for tryout when learning to use the software.