APPENDIX A

DGML Users Manual

Appendix A

DESIGN GROUND MOTION LIBRARY

DGML Version 2.0

Users Manual

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August 2009

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0. DISCLAIMER

DGML Version 2.0 (Release Date: August 2009) was developed based on knowledge believed to be accurate and reliable. Due to the possibility of human or mechanical error as well as other factors, this software is provided "as is" and the authors make no representation, express or implied, as to the accuracy, reliability, completeness, or timeliness of this software, and are not responsible for any loss or damages incurred by parties using this software.

The acceleration time history database used in DGML is the PEER-NGA strong-motion database, which was rotated to fault-normal and fault-parallel directions by a third party. Further QA/QC may be needed to ensure the quality of this database. Any comments, questions, bug reports regarding the DGML software and the Users Manual can be addressed to the authors of the program (email: dr.gangwang@gmail.com); bob.youngs@amec.com; maury.power@amec.com; lillian.li@amec.com).

1. INTRODUCTION

DGML Version 2.0 is an interactive software package that allows the user to select sets of strong ground motion acceleration time histories that are representative of design ground motions. The user specifies the design ground motions in terms of a target response spectrum and the desired characteristics of the earthquake ground motions in terms of earthquake magnitude, source-to-site distance and other general characteristics. The DGML tool then selects acceleration time histories from the PEER-NGA database for rotated fault-normal and fault-parallel acceleration time histories that satisfy the user-specified selection criteria and provide good fits to the target response spectrum.

DGML Version 2.0 has been developed based on the capability of Matlab's Graphic User Interface (GUI) (Matlab ® version 7.2). The software was compiled using Matlab Compiler ® into a stand-alone program so that it can be executed in any Windows PCs independent of Matlab environment.

Several features of DGML Version 2.0 are highlighted as follows:

***Graphic User Interface*:** GUI provides a user-friendly interface for data input and processing. The user's operation involves checking boxes, selecting pop-up menus, and pushing buttons. There are numerous features that are designed to facilitate easy usage. One example is the software can automatically retrieve previously specified input data.

***Interactive Plotting*:** Results in each step can be visualized in real time, and results from different sets of input parameters can be easily compared. The software provides a list of the selected records with important information. By clicking the list, users can visually inspect the response spectrum, acceleration/velocity/displacement time-history of each individual record for each component.

Flexibility: The DGML Version 2.0 provides users flexibility to exercise different criteria to select the design records. Users have the options to scale or not to scale the records; to select the record according to the geometric mean of fault normal and fault parallel components or

according to a single component. The user can choose to select records with pulses or without pulses. The number of output records can be user-specified, and users have the capacity to manually select and adjust the results to meet their specific requirement. In addition to the features provided in the previous release, DGML version 2 provides a supplementary search engine to allow users to search the database by NGA numbers, earthquake names, and station names. The new search engine gives users flexibility to inspect any record in the database.

Easy Output: DGML version 2 provides easy ways to output search results, plots and tables. The software can automatically generate a "Target Spectrum Report" and a "Search Result Report" and save them into text files or csv (Comma Separated Values) files. The DGML reports summarize search criteria, scale factors, scaled spectra of selected records, and other record information, and they can be opened by Microsoft Excel. The response spectra plots and time history plots can be exported into figure files of different formats. Finally, files containing acceleration time histories of selected records can be saved for each project.

Efficiency: The algorithm of the DGML Version 2.0 package is robust and efficient. The search engine can scan and sort the NGA database within a few seconds.

Extendibility: The DGML Version 2.0 package is directly connected to the NGA flatfile and strong motion database, so it can be easily upgraded to accommodate future development of the NGA database.

2. GETTING STARTED

2.1 DGML 2.0 DVD PACKAGE

The DGML Version 2.0 DVD contains the compiled executable DGML program, PEER-NGA rotated fault normal/fault parallel dataset, and electronic version of DGML report and User's Manual. The directory structure of the released DVD is shown on Figure 1.
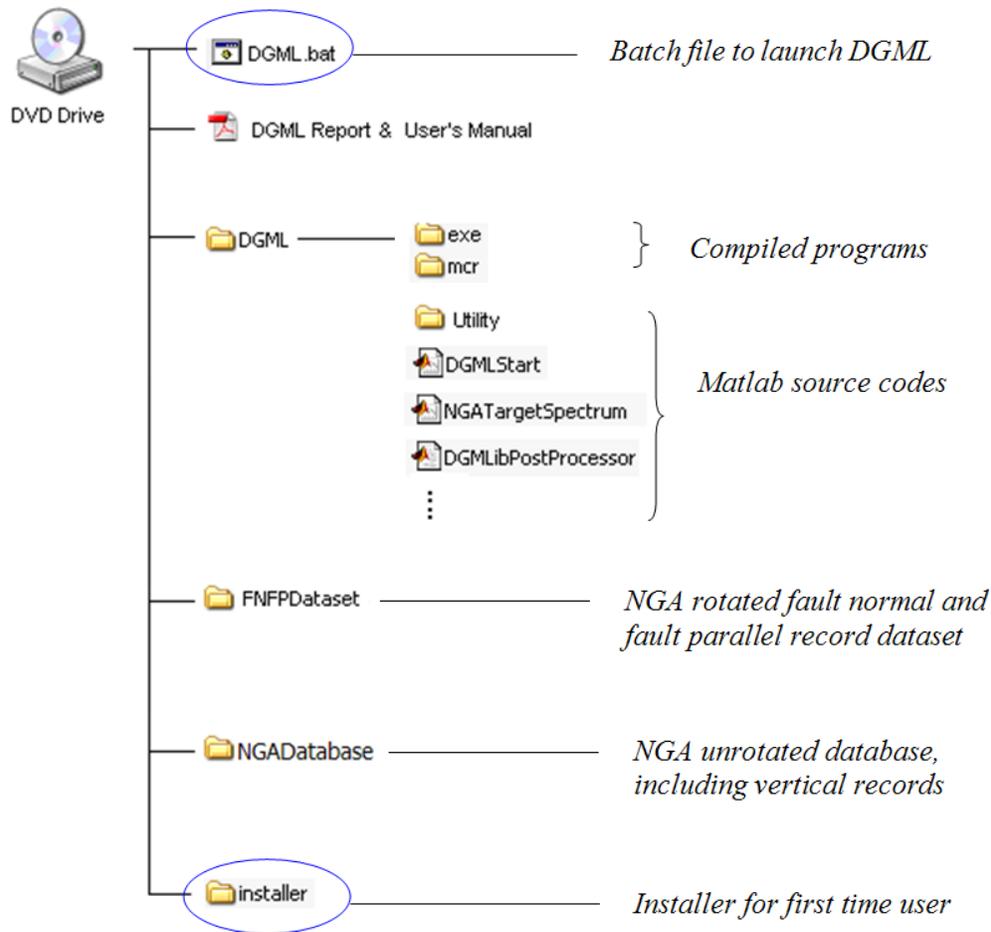
Figure 1: Directory Structure on DGML Version 2.0 DVD Package

The batch file "DGML.bat" is used for users to launch the DGML graphic interface. Although DGML source codes are written in Matlab® (v7.2), they are compiled using Matlab Compiler® (v7.10) to create a stand-alone executable program that does not require Matlab. The compiled DGML programs are located in "**DVD Drive:\DGML\exe**" directory. "**DVD Drive:\DGML\mcr**" contains expanded files from "Matlab Component Runtime (v7.10)", which are required to run the compiled program.

DGML source codes contain all *.m files, *.fig files in "**DVD Drive:\DGML**" directory and all files in "**DVD Drive:\DGML\Utility**" subdirectory. DGML can also be executed directly in Matlab environment from **DVD Drive:\DGML\DGMLStart.m**

The NGA rotated fault normal/fault parallel acceleration record dataset is also contained in the DVD. It is stored in the "**DVD Drive:\FNFPDataset**" directory. The NGA original (unrotated) database is stored in the "DVD Drive:\NGADatabase\" directory. These records can be viewed by a text editor.

IMPORTANT NOTES FOR THE FIRST TIME USER

*DGML Version 2.0 is designed to run directly on the DVD drive. User should have administrator privilege to run DGML, since it involves operation to write files (very minimum but necessary) on the local disk. Once the program starts, DGML automatically creates a directory on the user's local disk to store intermediate files and output files. This directory is named "**C:\DGML**". It is safe to delete "**C:\DGML**" directory and files after running the program.*

For the first-time user to run DGML, user needs to install Visual C++ 2005 Redistributable Package first if the package is not already installed in the local machine. Otherwise, DGML.bat cannot be properly executed. DGML is written in Matlab language and was compiled through Matlab Compiler v7.6 to create a stand-alone program, which requires this new installation procedure.

*The installer is located in "DVD:\installer\" directory. For 32-bit CPU (applies to most Pentium, Athlon, AMD CPUs etc. in **most personal computers**), run **vcredist_x86.exe**, For 64-bit CPU (eg. super-computers, stations, servers etc..), run **vcredist_x64.exe**. The Microsoft Visual C++ 2005 Redistributable Package installs runtime components of Visual C++ Libraries required to run applications developed with Visual C++ on a computer that does not have Visual C++ 2005 installed. The file does not do any harm to the user's computer. User only needs to install Visual C++ 2005 Redistributable Package once.*

The program is best viewed on a 15- inch or bigger screen with resolution 1280 by 1024 pixels. Graphic quality may deteriorate under other lower resolution settings.

2.2 START DGML

To start DGML Version 2.0, double click the batch file "**DVD Drive:\ DGML.bat**" to launch the program from the DVD. The start window will show up as Figure 2. Click the "START" button to start the program.
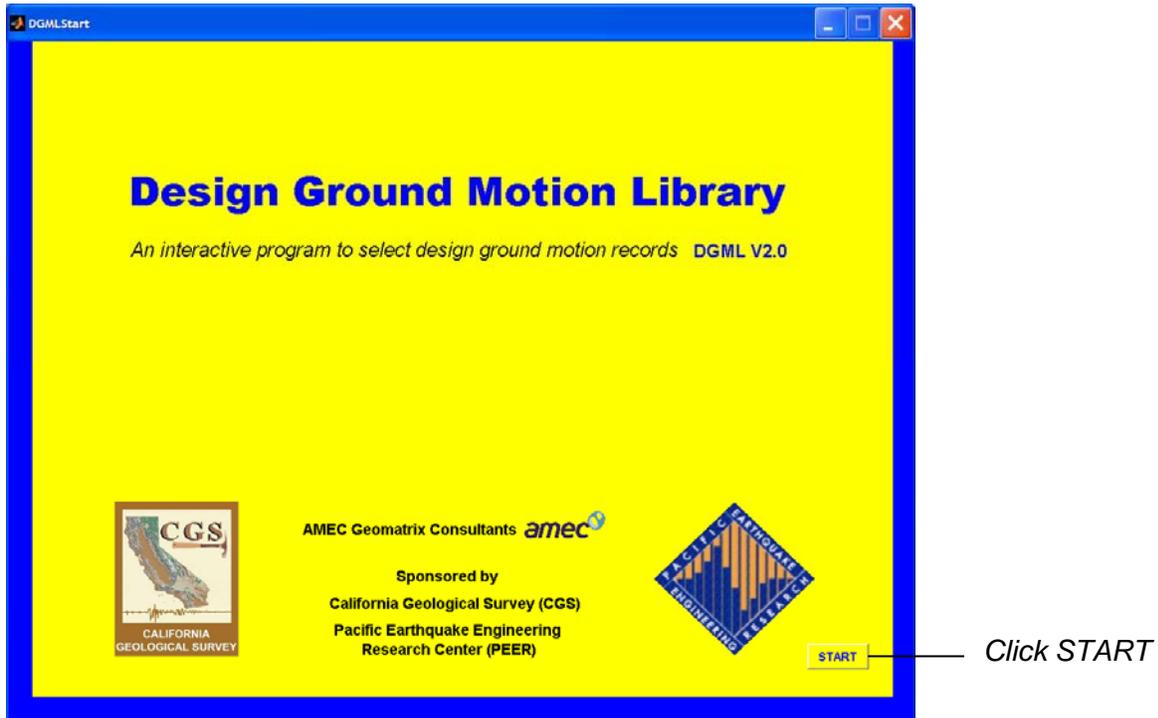
Figure 2: DGML Start Window

2.3 DGML BASIC STEPS

There are two basic steps in the use of the DGML software. Step one is the creation of the target response spectrum. The process of creating the target spectrum is described in Section 3.0 of the Users Manual. Step two is to search the PEER-NGA database for recordings that satisfy user-specified selection criteria and whose response spectra are similar to the target spectrum. Section 4.0 of the Users Manual describes the process of specifying selection criteria and developing sets of acceleration time histories. A user can inspect each ground motion record to finalize the selection.

3. CREATE TARGET SPECTRUM

The TARGET SPECTRUM window is shown in Figure 3. The window contains the following main parts: (1) Select Spectrum Model; (2) PEER-NGA Spectrum; (3) User Defined Spectrum; (4) Code Specification; (5) Plot Control panel; (6) Spectrum plot; (7) Explanation of notations; (8) Save Target Spectrum button; (9) Go to Next Step to Perform DGML Search.
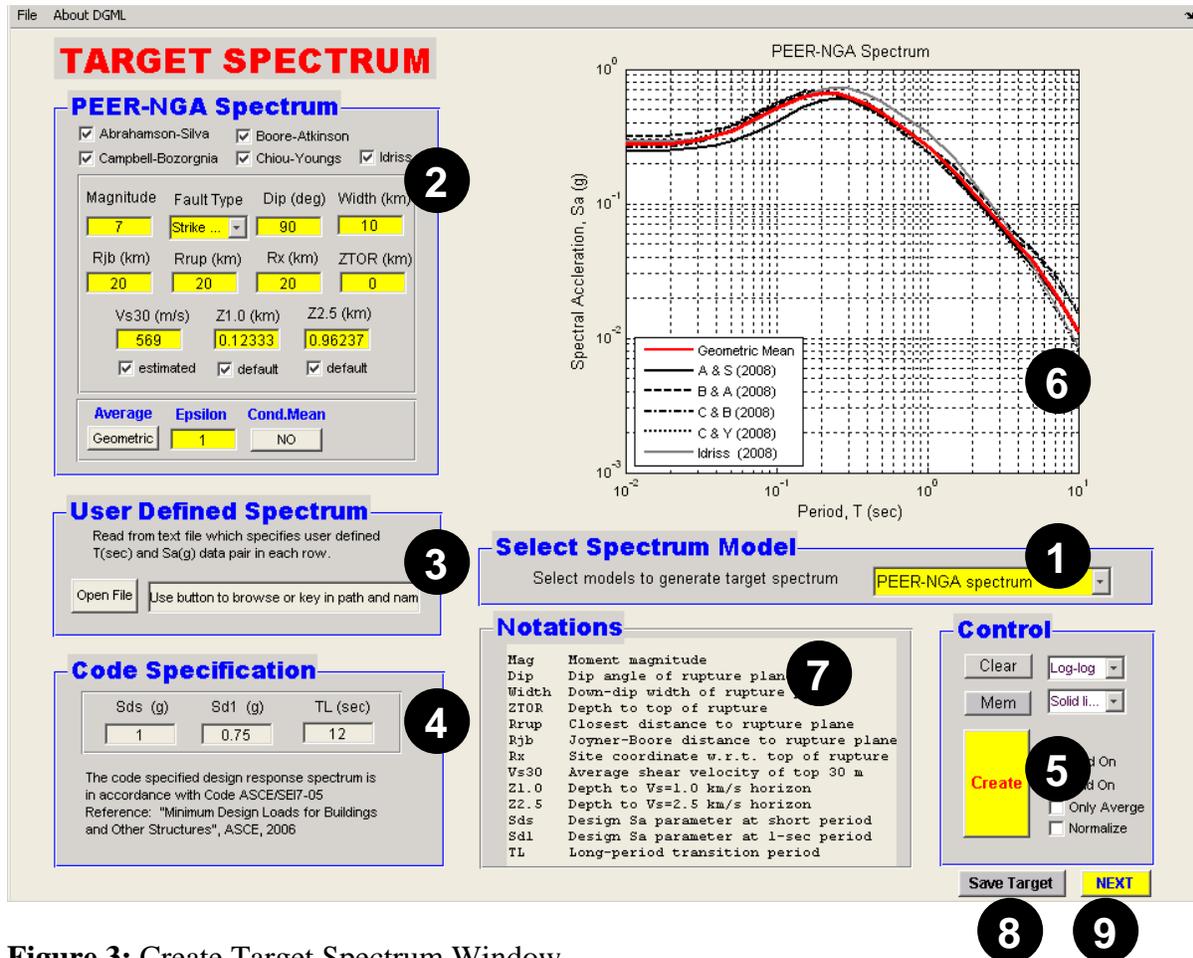
Figure 3: Create Target Spectrum Window

3.1 SELECT SPECTRUM MODEL

The first step is to select the spectrum model to generate the target spectrum. Three options are available by mouse-clicking the drop menu at location (1) in Figure 3:

(1) PEER-NGA spectrum;
(2) User defined spectrum;
(3) ASCE/SEI Standard 7-05 code specified spectrum.

Once a spectrum model is selected, the corresponding panel for parameter input will be highlighted in yellow color.

Click drop menu to select spectrum models
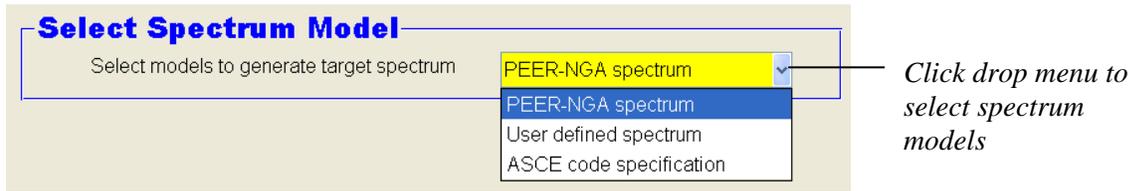
Figure 4: Selection of Spectrum Model

3.2 PEER-NGA SPECTRUM

The "PEER-NGA Spectrum" model creates a target response spectrum using the PEER-NGA ground motion models published in the February, 2008 issue of *Earthquake Spectra*. Five NGA empirical models are employed in DGML Version 2: Abrahamson-Silva (A&S, 2008), Boore-Atkinson (B&A, 2008), Campbell- Bozorgnia (C&B, 2008), Chiou-Youngs (C&Y, 2008a), and Idriss (2008). The spectrum is defined for a specific scenario earthquake defined in terms of magnitude, distance, style of faulting, and site conditions as specified in the PEER-NGA ground motion models. This option is selected by clicking the drop menu and selecting "PEER-NGA spectrum" option. The panel shown at location (2) in Figure 3 allows the user to input the necessary parameters to generate a PEER-NGA spectrum. An expanded view of this input panel is shown in Figure 5. The required input parameters are described below.

Check box to select NGA model(s), see Sec 3.2.1.

Input boxes to enter NGA model parameters, see Sec. 3.2.2

Input boxes to specify number of standard deviations, see Sec .2.3

Click button to specify method of averaging selected NGA models, see Sec. 3.2.1

Click button to enable or disable use of conditional mean method, see Sec. 3.2.3

Input box to specify the period of conditional mean method, see Sec. 3.2.3

Figure 5: Input Panel for Creating a PEER-NGA Spectrum

3.2.1 Select PEER-NGA Ground Motion Models

Use check boxes to select the PEER-NGA ground motion models to be used. The user has the option to use any single, or any combination, of these NGA models, except that the Idriss (2008) model is not applicable to cases where V_{S30} is less than 450m/s, or fault type is normal or normal oblique faulting. In such cases, DGML will automatically not select the Idriss (2008) model. If the Idriss (2008) model is selected by the user and is applicable for the conditions specified by the user (i.e. Vs30>=450m/s and strike slip faulting or reverse or reverse oblique faulting), then the Idriss model will be used.

If more than one model is selected, the user can further specify the resulting average target spectrum to be the arithmetic or the geometric mean of the spectra produced by the selected models.

The arithmetic mean of *n* spectra is defined as follows

$$SA(T) = \frac{1}{n}\left(\sum_{i=1}^{n} SA_i(T) \right)$$

where $SA_i(T)$ is the spectrum produced by model *i*; The geometric mean of spectra can be viewed as the arithmetic mean of the logarithm-transformed values (i.e., the arithmetic mean of the logarithms), and then using exponentiation to return the logarithm values to the natural scale actual values. The geometric mean of *n* spectra is defined as follows

$$\ln SA(T) = \frac{1}{n}\left(\sum_{i=1}^{n} \ln SA_i(T) \right) \quad \text{or} \quad SA(T) = \exp\left(\frac{1}{n} \sum_{i=1}^{n} \ln SA_i(T) \right)$$

3.2.2 Ground Motion Model Input Parameters

Depending on the PEER-NGA ground motion models selected, the user must enter up to twelve parameters in the data input boxes to construct the response spectrum. Parameters required by each ground motion model are listed in Table 1. DGML will only display the necessary parameters according to the model selection specified by the user.

Table 1: Parameters for PEER-NGA Ground Motion Models

	A&S	B&A	C&B	C&Y	Idriss	Explanations
Magnitude	✓	✓	✓	✓	✓	Moment magnitude of the earthquake
Fault Type	✓	✓	✓	✓	✓	Types of fault mechanism. Options are: (1) Strike Slip; (2) Normal or Normal Oblique; (3) Reverse or Reverse Oblique
Dip (deg)	✓		✓	✓		Dip angle of rupture plane
Width (km)	✓		✓	✓		Down-dip width of rupture plane
Z_{TOR} (km)	✓		✓	✓		Depth to top of rupture plane
R_{JB} (km)	✓	✓	✓	✓		Joyner-Boore distance to rupture plane
R_{Rup} (km)	✓		✓	✓	✓	Closest distance to rupture plane
R_X (km)	✓			✓		Site coordinate w.r.t. top of rupture
V_{S30} (m/s)	✓	✓	✓	✓	✓	Average shear wave velocity of top 30 m
estimated	✓			✓		Specifying V_{S30} is estimated or measured
$Z_{1.0}$ (km)	✓			✓		Depth to V_S=1.0 km/s horizon
$Z_{2.5}$ (km)			✓			Depth to V_S=2.5 km/s horizon
Epsilon	✓	✓	✓	✓	✓	Number of standard deviations away from the median spectrum
T_eps	✓	✓	✓	✓	✓	The period upon which conditional mean spectrum is conditioned

Remarks:

1. Magnitude, Fault Type, Dip, Width and Z_{TOR} are parameters that define the seismic source. R_{JB}, R_{Rup}, R_X define different types of distance measures from the site to the fault rupture. V_{S30}, $Z_{1.0}$ and $Z_{2.5}$ are used to describe the site condition.

2. Definition of R_{JB}, R_{Rup}, and R_X are shown in Figure 6 for strike-slip faulting and for reverse or normal faulting with the site on the hanging-wall and the foot-wall side. Rrup is the closest distance to the rupture plane; R_{JB} is Joyner-Boore distance defined as the closest horizontal distance to the trace of the rupture that is vertically projected to the ground surface. R_{Rup} and R_{JB} are always non-negative numbers. Please note that R_X is the horizontal coordinate of the site with respect to the top of the rupture. For a reverse or normal fault, if the site is on the hanging wall side, R_X is a positive value; if the site is on the footwall side, R_X is a negative value. Therefore, DGML does not provide a separate hanging wall flag, instead, the sign of R_X is used to indicate a hanging wall condition for a reverse or normal fault. For a strike-slip fault, it does not matter whether R_X is positive or negative.

3. Parameters $Z_{1.0}$ and $Z_{2.5}$ specify the depths at which the shear wave velocity reaches 1.0 km/s and 2.5km/s at the site, respectively. A user can specify the values of $Z_{1.0}$ and $Z_{2.5}$ directly as shown in the following check boxes. The "default" checkboxes will be automatically unchecked once a user keys in numbers.

 user-specified $Z_{1.0}$ and $Z_{2.5}$ values

4. Default values of $Z_{1.0}$ and $Z_{2.5}$ can also be used by checking the "default" checkboxes. Empirical relationships are used to estimate $Z_{1.0}$ value based on V_{S30}, and the default values are automatically displayed in the text boxes thereafter.

 use default values of $Z_{1.0}$ and $Z_{2.5}$

A&S model uses the following empirical equations to estimate $Z_{1.0}$, where the unit of $Z_{1.0}$ is in km, and V_{S30} is in m/s.

$$Z_{1.0} = \begin{cases} \exp(6.745)/1000 & \text{if} & V_{S30} < 180 \, m/s \\ \exp(5.394 - 4.48*1n(V_{S30}/500))/1000 & \text{if} & V_{S30} > 500 \, m/s \\ \exp(6.745 - 1.35*1n(V_{S30}/180))/1000 & \text{if} & 500 \, m/s \geq V_{S30} \geq 180 \, m/s \end{cases}$$

C&Y model uses the following relationship to estimate $Z_{1.0}$,
$$Z_{1.0} = \exp(28.5 - 3.82/8 *1n(V_{S30}^8 + 378.8^8))/1000$$

Please note the difference of empirical correlations used by A&S and C&Y, where the estimate of $Z_{1.0}$ from C&Y is always smaller than that from A&S. If both A&S and C&Y models are specified in DGML, the above relation is used accordingly for each model. For simplicity, DGML only displays $Z_{1.0}$ values estimated by A&S model, but different $Z_{1.0}$ values are used as the default for C&Y model. Parameter $Z_{2.5}$ is used only by C&B model. Default value of $Z_{2.5}$ is determined based on the value of $Z_{1.0}$. If $Z_{1.0}$ is specified by the user, the following relation is used to estimate $Z_{2.5}$ based on $Z_{1.0}$ (both in units of km)

$$Z_{2.5} = 0.519 + 3.595 * Z_{1.0}$$

Otherwise, DGML estimates $Z_{1.0}$ first using relationship proposed by A&S, and then $Z_{2.5}$ is estimated using above equation.

5. It is the user's responsibility to ensure the input parameters are correct. The DGML does NOT check the consistency of the input data.

(a) Strike slip faulting   (b) Reverse or normal faulting, hanging-wall site

(c) Reverse or normal faulting, foot-wall site
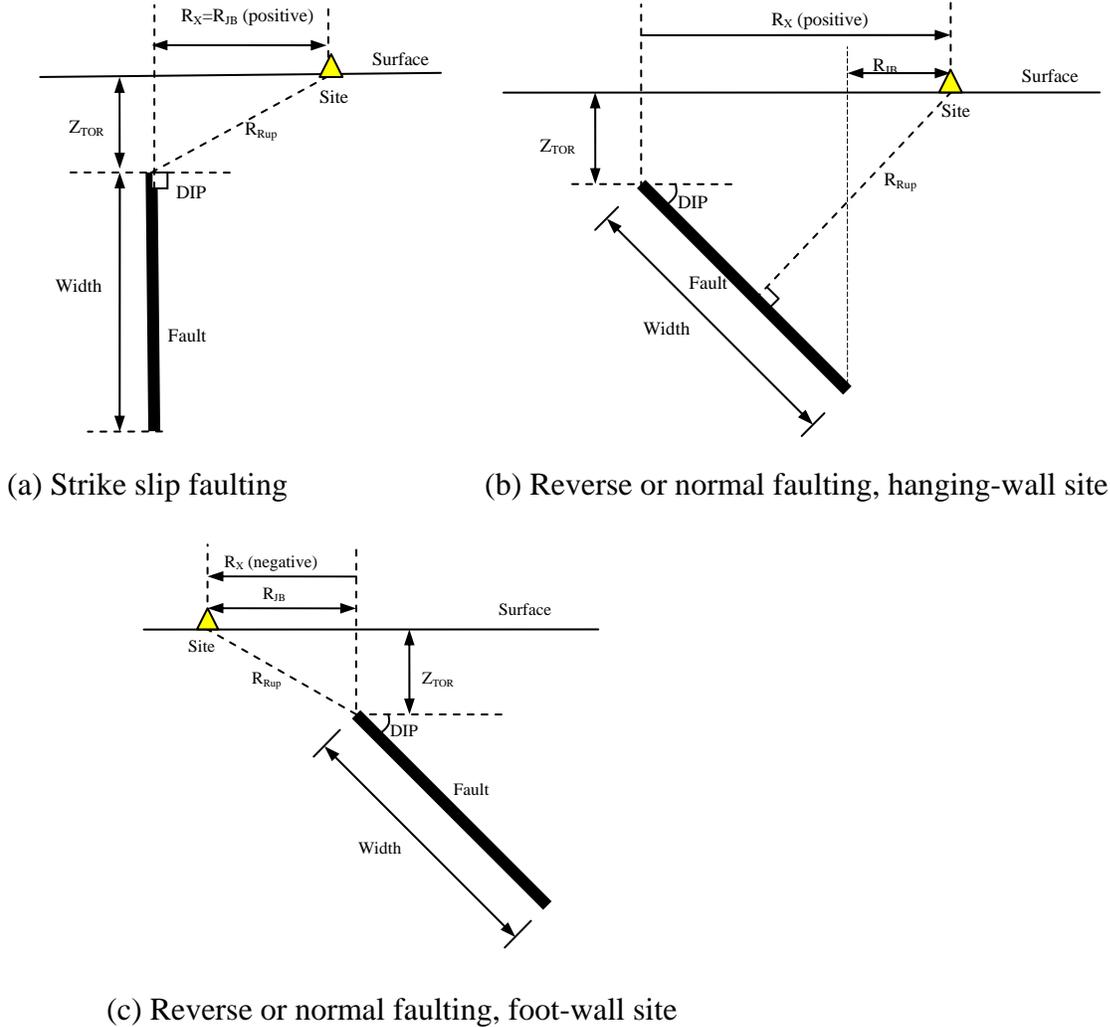
Figure 6: Definition of Fault Geometry and Distance Measures

3.2.3 Number of Standard Deviations and Conditional Mean Spectrum

The PEER-NGA ground motion models provide relationships for the median ground motion amplitude (mean value in log space) and for the aleatory variability about the median value. The aleatory variability is defined as the standard deviation of the natural log of the spectral acceleration. **Parameter epsilon is used to define the number of standard deviations away from the median represented by a particular ground motion level.** For example, the 84th-percentile spectrum is a spectrum where the ground motion levels are one standard deviation above the median at all spectral periods (epsilon = 1.0).

The user has two options for incorporating aleatory variability in the target spectrum developed from the PEER-NGA models. The first option is to use a constant value of epsilon at all spectral periods (e.g. epsilon=1.0 for an 84th-percentile spectrum). The second option is to develop a conditional mean spectrum (Baker and Cornell, 2006) in which the user specifies the value of epsilon at a specific spectral period and the correlation model developed by Baker and

Jayaram (2008) is used to compute the expected value of epsilon at other spectral periods.

(1) Constant Epsilon Spectrum

The constant epsilon spectrum is constructed by specifying a single value of epsilon for all periods (e.g. an 84th-percentile spectrum). To construct the constant epsilon spectrum the user provides the desired epsilon value and disables the method of conditional mean spectrum, as shown in Figure 7.

Click the button to "NO" to disable conditional mean method

Enter the Epsilon value
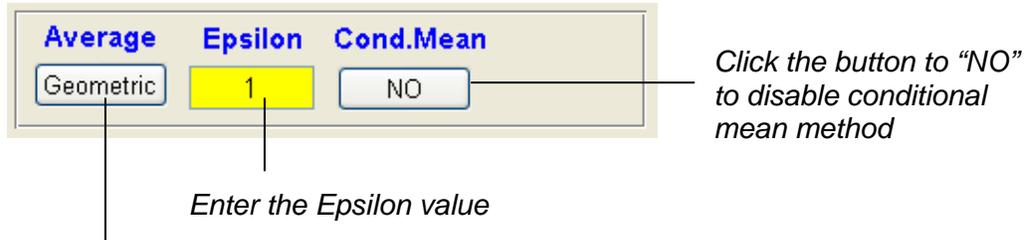
Click to choose between "geometric mean" or "arithmetic mean" of selected NGA model spectrum

Figure 7: Constructing a Constant Epsilon Spectrum.

Figure 8 shows examples of constant epsilon spectra generated using the average of five NGA models and epsilon = 0, 1, and 2. Model parameters are specified as shown in Figure 5. Epsilon is changed to be 0, 1 and 2 for each case as shown in Figure 8. The three cases are plotted together in the same graph for easy comparison, by using "Hold on" button and "change color of lines menu" provided in the Control Panel, see **Sec. 3.5.**
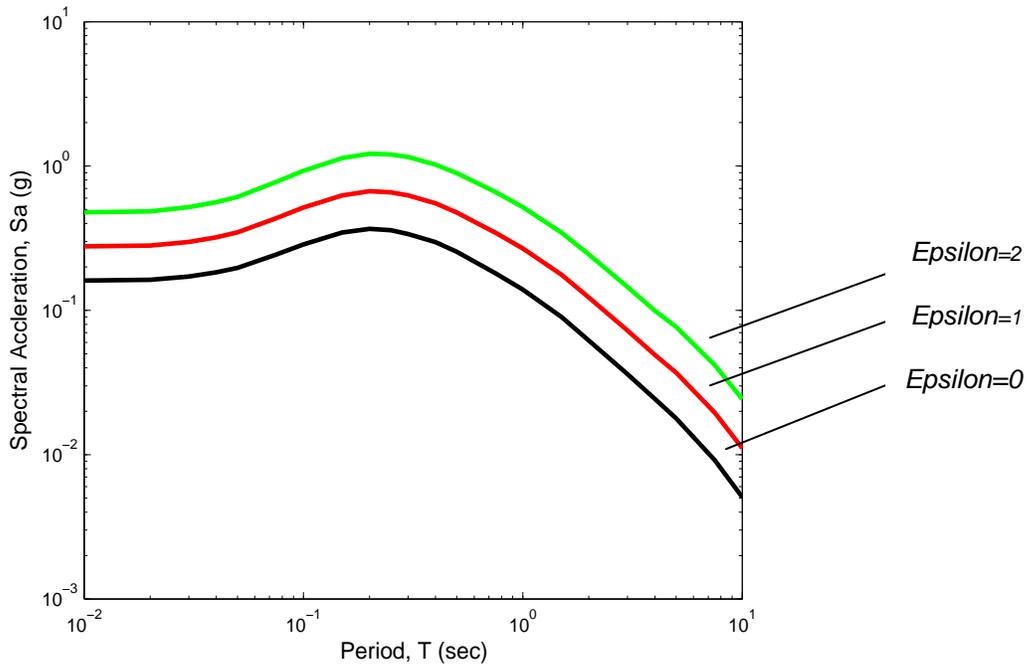
Figure 8: Example of Constant Epsilon Spectrum

(2) Conditional Mean Spectrum (CMS)

A conditional mean spectrum can be constructed using NGA models and the correlation coefficient model by Baker and Jayaram (2008) (see text of the report for a complete description). The inputs needed to construct a conditional mean spectrum are shown in Figure 9.

Figure 9: Input Needed to Construct a Conditional Mean Spectrum

Figure 10 shows an example of a conditional mean spectrum (CMS) created for an epsilon value of 1.0 at a spectral period of 0.5 seconds. Model parameters are specified as shown in Figure 5 using input parameters for the CMS are the same as shown in Figure 9. The solid black line shows the generated CMS for epsilon=1 and T_eps=0.5 sec. Constant epsilon spectra for epsilon=0, 1, as shown previously in Figure 8, are also plotted in Figure 10 for comparison with the CMS.

The value of epsilon may be selected in a variety of ways. One approach would be to use the results of epsilon deaggregation from a PSHA calculation. Alternatively, the user may specify a target spectral acceleration at T_eps and then enter trial values of epsilon until the resulting average conditional mean spectrum matches the target value.
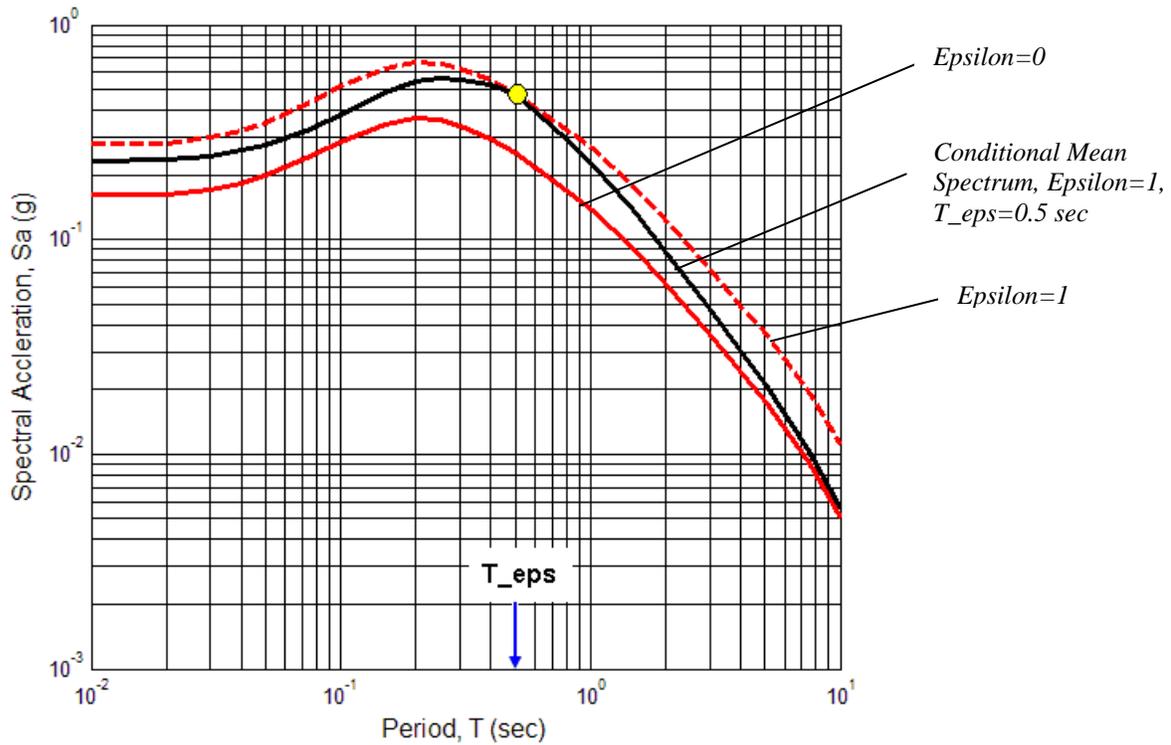
Figure 10: Example of Conditional Mean Spectrum

3.3 USER-DEFINED SPECTRUM

A user-defined spectrum is any target response spectrum the user wishes to use. It may represent a uniform hazard spectrum from a PSHA or a scenario earthquake spectrum created using other ground motion models. **There is no limit for the number of spectral periods and spectral acceleration values that may be entered.**

Select a "user-defined spectrum" model by clicking the drop menu (Location ① in Figure 3) and select a "user-defined spectrum" option.

Figure 11: Selecting a User-Defined Spectrum Model

3.3.1 Creating and Loading a User Defined Spectrum File

A file containing a user defined spectrum is created using a text editor. An example file is shown in Figure 12.

```
# User Specified Spectrum
# T(sec)   Sa(g)
# ------------------------------------
0.01      0.54
0.02      0.54186
0.075     0.8481
0.1       1.01966
0.2       1.31426
0.3       1.3162
0.5       1.10297
1         0.74228
1.5       0.5379
2.0       0.40813
3         0.24773
4         0.16592
10        0.05
```

Comment lines are the lines that contain any characters (as long as it is not pure numbers)

Data field, each line contains spectral period (T) and spectral acceleration (SA) data in pairs, separated by blanks or tabs. There is no limit for the number of data that maybe entered.

Figure 12: Example of User-Defined Spectrum File

DGML provides two methods to load a user-defined spectrum. (1) Click the "Open File" button to select from directory. The following figure shows an example:

Select the directory that contains the user-defined spectrum file

Click "Open File" button

Figure 13: Selecting a User-Defined Spectrum File From the File Menu

or (2) key in complete path and name of the file in the window box. The following is an example:
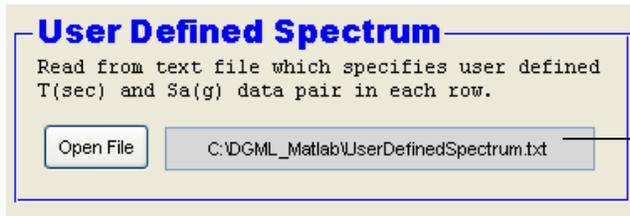
Type the complete path and name of the file, and hit "Enter" on keyboard

Figure 14: Direct Input of the File Name and Path for a User-Defined Spectrum

3.3.2 Generate User Defined Spectrum

Click **Create** button in **Control Panel**, and the user defined spectrum will be plotted in the plotting area, as shown in Figure 15.
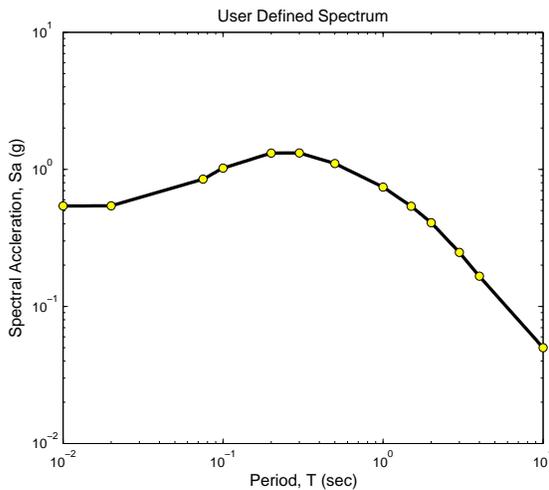
Figure 15: Plot of User-Defined Spectrum Using Data Listed in Figure 12.

3.4 CODE SPECTRUM

The code specified design response spectrum is in accordance with ASCE Standard ASCE/SEI 7-05 specified in the "Minimum Design Loads for Buildings and Other Structures", published by the American Society of Civil Engineers, 2006. The code specification requires three points to construct the spectrum, as follows: site-adjusted short period (0.2 sec) spectral acceleration (S_{DS}), site-adjusted one-second period (1.0 sec) spectral acceleration (S_{D1}), and the transition period (T_L) between constant spectral velocity and constant spectral displacement regions of the spectrum. These parameters are illustrated in Figure 16.
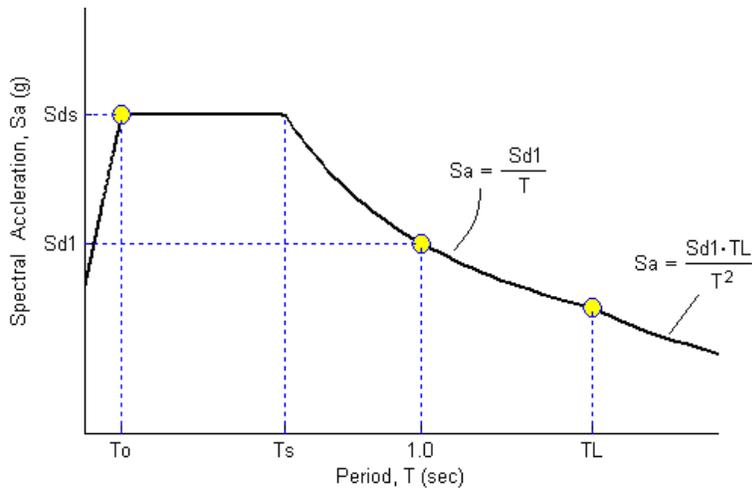
Figure 16: ASCE/SEI 7-05 Code Spectrum

The procedures, equations, and parameters for constructing each branch of the spectrum are given in ASCE Standard ASCE/SEI 7-05.

Example:

Step 1: To activate the function to generate a target spectrum according to the code specification, users need to select the spectrum model by selecting "ASCE code specification" from the menu at location ① in Figure 3.

Figure 17: Selecting the ASCE Code Spectrum Model

An illustration will appear in the plotting area to explain the symbols of the spectrum as specified by the code.

Step 2: Key in Sds (g), Sd1 (g), TL (sec) in the Input Windows for the Code Spectrum
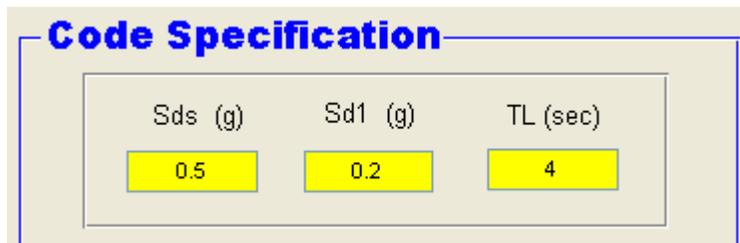
Figure 18: Input Needed to Construct a Code Spectrum.

Step 3: Press the **Create** Button at **Control** panel.

Step 4: A target spectrum is then generated in the plotting area as illustrated in Figure 19.
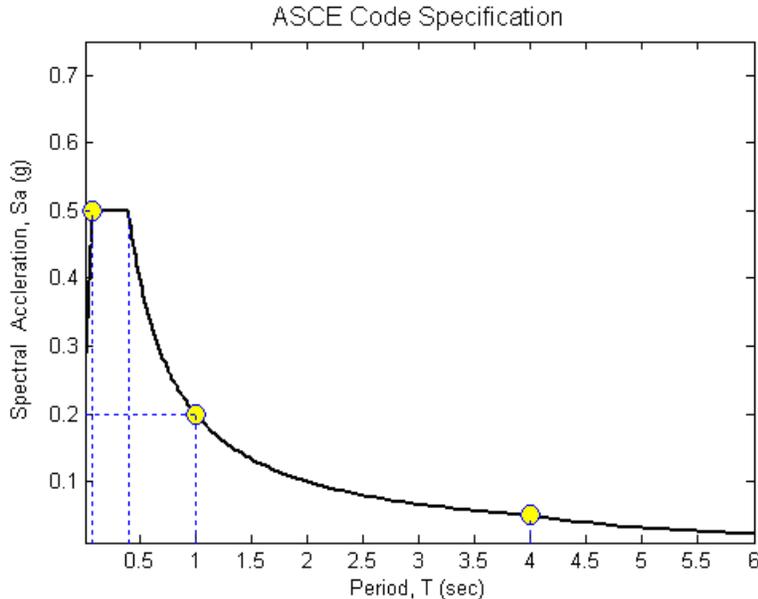
Figure 19: ASCE/SEI 7-05 Code Spectrum Created Using the Values Listed in Figure 18.

3.5 CONTROL PANEL

The control panel is used to provide options for automatic data input and plot adjustment. Figure 20 displays the layout of the control panel, and each of the functions will be described in the following:

(1) "**Create**" button is used to create and plot the target spectrum using current spectrum model and parameters.

(2) "**Clear**" button and "**Mem**" button are designed for automatic data input. Clicking "Clear" button will fill in "0" in all input boxes of Figure 5. Clicking "Mem" button will automatically fill in all input boxes of Figure 5 with data from the previous run.

(3) Drop menus in the right side of the panel are used to control the plot of the target spectrum: drop menu **A** to change the plot axis, e.g. from log-log plot to linear plot; drop menus **B** and **C** to select the color and style of the lines to be plotted.

(4) "Hold On" checkbox allows a new graph to be plotted on top of the previous plot for easy comparison. If Hold On box is checked, the plot will be displayed in the plot window without erasing the previous plot. If Hold On box is unchecked, each time the new plot is created, the previous one is erased. "Grid On" checkbox is to display the grid lines on the plot window. "Only Average" checkbox, if checked, displays only the average spectrum on the plot window if more than one PEER-NGA model is used. "Normalized" checkbox, if checked, will plot the normalized target spectrum (normalized with respect to PGA).

Clear: *Click to clear all input data boxes*
Mem: *Click to automatically refill all input data boxes*

Click to change plot axis

Click to change style of lines

Click to change color of lines

Click to Create target spectrum

Hold On: *Check to allow the next plot to superimpose on the previous one*
Grid On: *Check to show grid lines on the plot*
Only Average: *Check to only plot the average spectrum if more than one PEER-NGA models is selected.*
Normalize: *Create target spectrum normalized with respect to PGA*

Figure 20: The Control Panel

3.6 SAVE TARGET SPECTRUM

3.6.1 Save Target Spectrum Report

DGML Version 2 allows users to output the generated target spectrum in .csv format (Comma Separated Variables file) or .txt (ASCII file) by clicking "Save Target" button in the lower right side of the window, as shown in Figure 21. The CSV format file can be directly opened by Microsoft Excel or any text editor, providing the most convenient way for data export.

Figure 22 demonstrates a DGML automatically generated target spectrum report using parameters prescribed in Figure 5. In this file, the parameters that are used in generating the target spectrum are listed. In this example, the V_{S30} value is annotated as "estimated", and default values of $Z_{1.0}$ and $Z_{2.5}$ for A&S, C&Y and C&B model are reported separately. Spectrum values by individual NGA model together with the mean spectrum are listed for periods of 0.01, 0.02, 0.03, 0.04, 0.05, 0.075, 0.1, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5, 0.75, 1, 1.5, 2, 3, 4, 5, 7.5, and 10 seconds.

For a code-specified target spectrum, only the periods and spectrum values are reported. The exported values are interpolated at period intervals that are evenly spaced in log space, with 100 points per decade.
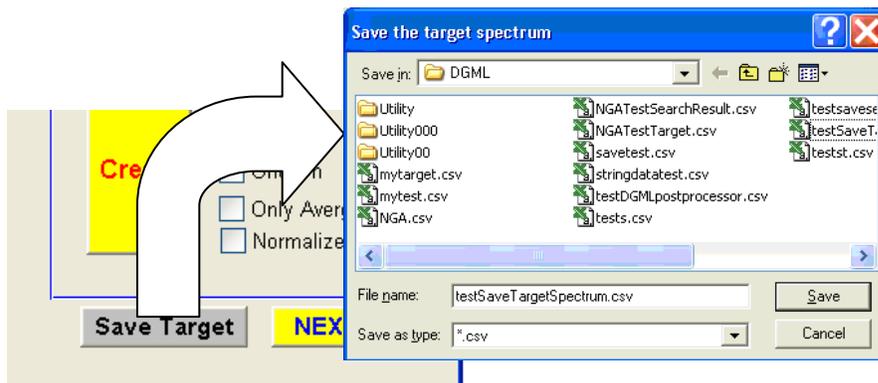
Figure 21: Click "Save Target" Button to Save Target Spectrum

Figure 22: Example of DGML Target Spectrum Report

3.6.2 Save Target Spectrum Plot

The spectrum plot can be saved to the disk as figure files. <u>Right click</u> mouse on the plot area, and a "Save Plot As" box will show up. <u>Left click</u> the box to pop up a window, select the proper directory, and enter the name of the graphic file to save. The plot can be saved as .bmp, .jpg, .tiff, .eps, or pdf format by selecting the proper "Save as type". Figure 23 illustrates the steps to save the spectrum plot.
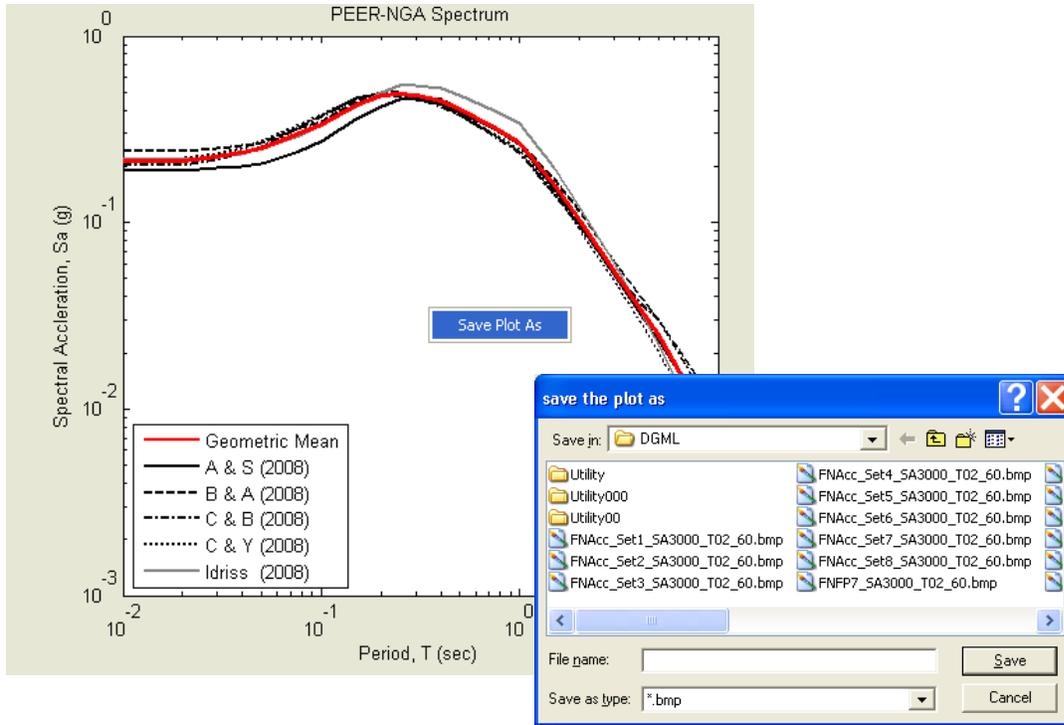
Figure 23: Save DGML Target Spectrum Plot

4. SEARCH NGA DATABASE

The DGML SEARCH ENGINE window contains eight main parts, as labeled in Figure 24: (1) Search Engine to specify the record acceptance criteria and perform search over NGA database; (2) Specification of Weight Function used for scaling records; (3) Spectra plotting window; (4) Weight Function plot; (5) Acceleration/ Velocity/ Displacement time history plotting of a selected record; (6) Ground motion record information output list; (7) Graphic control panel for line styles and display of ground motion components; (8) Buttons to accept, reject individual record, save the search results and selected acceleration time history files.
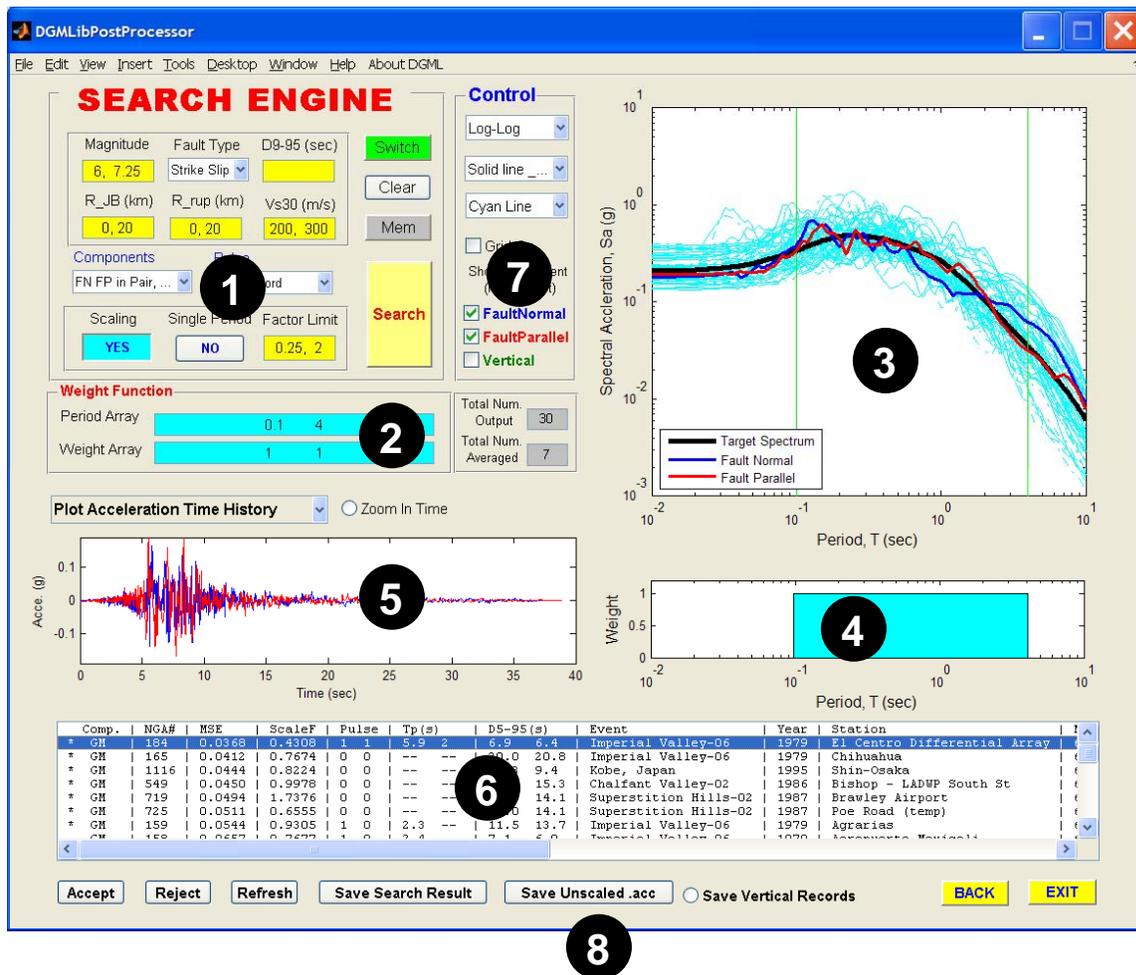
Figure 24: DGML Search Engine Window

4.1 SWITCH BETWEEN MAIN AND SUPPLEMENTARY SEARCH ENGINES

DGML Version 2 provides two types of search engines. Figure 25 illustrates the switch between two search engine interfaces by clicking "Switch" button. The main search engine searches the database according to the specified acceptable ranges for the characteristics of the recordings (e.g. the appropriate magnitude, distance range etc, termed as "acceptance criteria").

The <u>supplementary search engine</u> searches the database according to specified NGA sequence numbers, event names, and station names. The two search engines are described in the following sections. <u>By default</u>, DGML displays the main search engine.
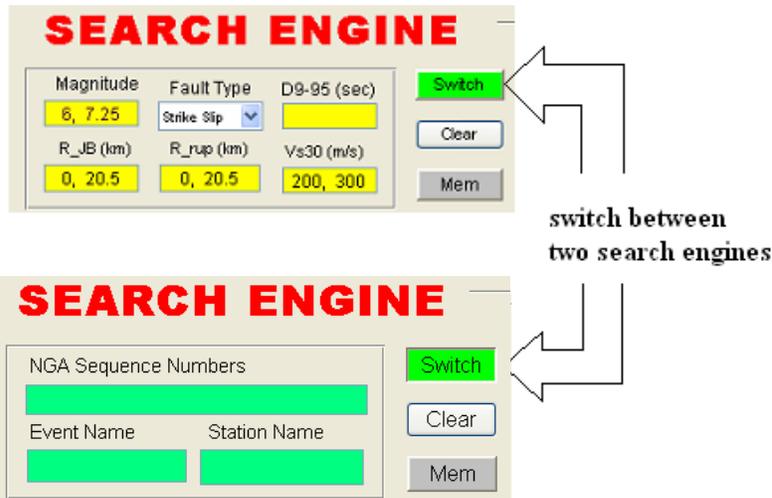
Figure 25: Switch between Main and Supplementary Search Engines

4.2 MAIN SEARCH ENGINE: SEARCH ACCORDING TO ACCEPTANCE CRITERIA

The acceptance criteria for recordings are entered in the search engine data boxes shown in Figure 26 (location 1 in Figure 24). As described below, acceptance criteria are specified by indicating the allowable range or restriction for the parameters listed in Table 2. Any recording satisfying these criteria will be passed on to the second stage of comparison with the target spectrum.

Data field input format

- The range of acceptable values for a recording parameter is entered into the data box with a **yellow** background color. The acceptance range is specified by the minimum and the maximum values. The minimum and maximum values should be delimited by a **comma** or **space**. For example:

- An input box in yellow colors can be left **BLANK** if **no** search restriction is imposed on that data field. For example:

Switch the search engine

Drop menu or text box to specify the minimum and maximum values of the search restriction, see Table 2

Press button to perform the search

Text box to specify the number of output, see Table 2

Specify scaling method and weight function, see sec. 4.4
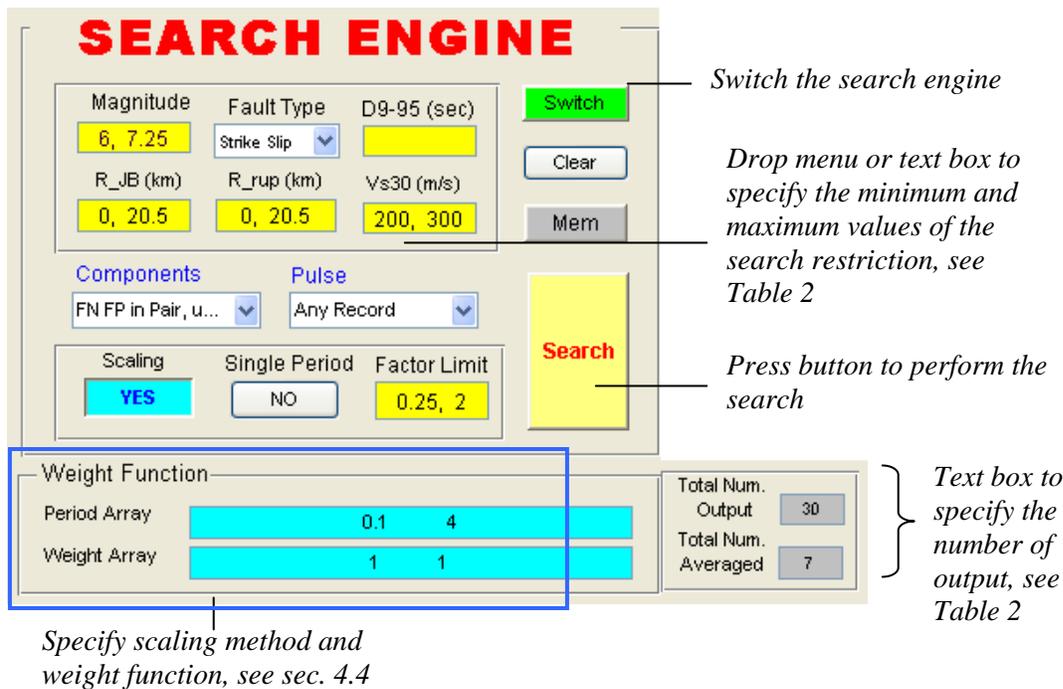
Figure 26: Main Search Engine (Default) User Interface.

Table 2: Parameters for DGML Search Engine

Data Field	Explanations
Magnitude	Restrict range of moment magnitude, input in the format of [min, max] or leave as blank for no restriction.
Fault Type	Types of fault mechanism. Options are: (1) All types of fault; (2) Strike Slip; (3) Normal or Normal Oblique; (4) Reverse or Reverse Oblique; (5) Combination of (2, 3); (6) Combination of (2,4); (7) Combination of (3,4).
D5-95(sec)	Restrict range of the significant duration of the records, input in the format of [min, max], or leave as blank for no restriction. The duration is defined as the time needed to build up between 5 and 95 percent of the total Arias intensity.
R_JB (km)	Restrict range of Joyner-Boore distance, input in the format of [min, max], or leave as blank for no restriction.
R_rup (km)	Restrict range of closest distance to rupture plane, input in the format of [min, max], or leave as blank for no restriction.
Vs30 (m/s)	Average shear wave velocity of top 30 meters of the site.
Components	Restrict the directional component of the records to search. Options are: (1) Use fault normal and fault parallel in pair, and use geometric mean of fault normal and fault parallel components for spectral matching; (2) Use only fault normal component; (3) Use only fault parallel component; (4) Use arbitrary component, either fault normal or fault parallel, regardless of the direction.

Data Field	Explanations
Pulse	Restrict the pulse characteristics of the searched record. Options are: (1) Any record; (2) Only pulse-like record; (3) No pulse-like record.
Factor Limit	Restrict range of scale factors, input in the format of [min, max], or leave as blank for no restriction. The parameter is applicable only if "scaling" button is "YES" and "single period" button is "NO" (i.e. the records are scaled, but are not scaled to a single period).
Ts (sec)	The period whose target spectral value all records are scaled to. The parameter is applicable only if "scaling" button is "YES" and "single period" button is "YES" (i.e. the records are scaled, but are scaled only to a single period).
Period Array	A real number sequence of periods used to specify the weight function. The number sequence is in ascending order between [0.01, 10].
Weight Array	A real number sequence of weights used to specify the weight function. The number sequence is in one-to-one correspondence to that of the Period Array.
Total Num. Output	Specify the total number of records to display in the "ground motion record information display window". If the number of qualified records is less than the specified number, the Total Num. Output will be reset to the maximum possible. Please note that the current version of DGML only displays at most up to 200 records. The restriction is necessary to avoid abuse of the software.
Total Num. Averaged	Specify the total number of record spectra to compute the average spectra. The number will be automatically reset to the maximum possible if the total output record number is less.

4.3 SUPPLEMENTARY SEARCH ENGINE: SEARCH ACCORDING TO NGA NUMBERS ETC.

Supplementary Search Engine is a new feature in DGML Version 2, which allows users to search, scale, and rank the records according to specified NGA sequence numbers, event name, or station name. This feature is particularly useful for users to inspect any particular record, especially convenient to fine-tune the search results from the Main Search Engine.

NGA sequence number is a unique number assigned to each pair of FN/FP records in the NGA flatfile. The sequence number can combine with the "Components" drop menu to specify which components are specified, and "Pulse" drop menu for specification of pulse characteristics. The NGA sequence number should be positive numbers, except that if the "Components" is chosen to be "Any Component, Either FN or FP", one needs to distinguish between the FN and FP components of the record which have the same NGA sequence number. In this case, positive numbers represent fault normal component, and negative numbers represent fault parallel component. For example, in the case that the "Components" menu is chosen to be "Any Component, Either FN or FP", the NGA sequence input of "-179, 719" specifies two single-component records: FP component from NGA #179 record, and FN component from NGA #719 record. Please note that, as explained in the DGML report, some records have been removed from the DGML database so those records are not searchable.

NGA sequence numbers can be input using the following formats: (1) number array separated by comma, eg. "1, 2, 3, 4, 5". (2) number range delimited by colon, eg. "1:300" specifies NGA number range from #1 to #300. (3) combination of format (1) and (2), eg. "1:100, 200, 300" specifies NGA numbers from #1 to #100, and #200, #300. DGML will automatically eliminate any duplicate numbers in the NGA sequence number input.

Event Name and Station Name require string input. The input string should be contained in the list of event names and station names as specified in NGA flatfile. For example, if user wants to search all "Imperial Valley" records, he can input "Imperial Valley" (input the string inside quotation marks), or "imperial valley", or "Imperial", or simply "Imp". The DGML uses exact character matching to search the records, but it won't distinguish upper- or lower-case letters.

The input boxes can be left as blank, which imposes no restriction in that field. If more than one input field is filled in, the search results are the logical "<u>AND</u>" of these multiple conditions.

Figure 27 illustrates an example using the supplementary search engine to search and scale all "Imperial Valley" event from NGA #1-#3000, using geometric mean spectra of FN FP components. The search results in 49 records, and the number is automatically displayed in "Total Num Output" box. In this case, "Total Num Output" is not controlled by the user. Please note that DGML limits the maximum number of output to be less than 200 to avoid abuse of the program. "Total Num. Averaged" is set by the user.
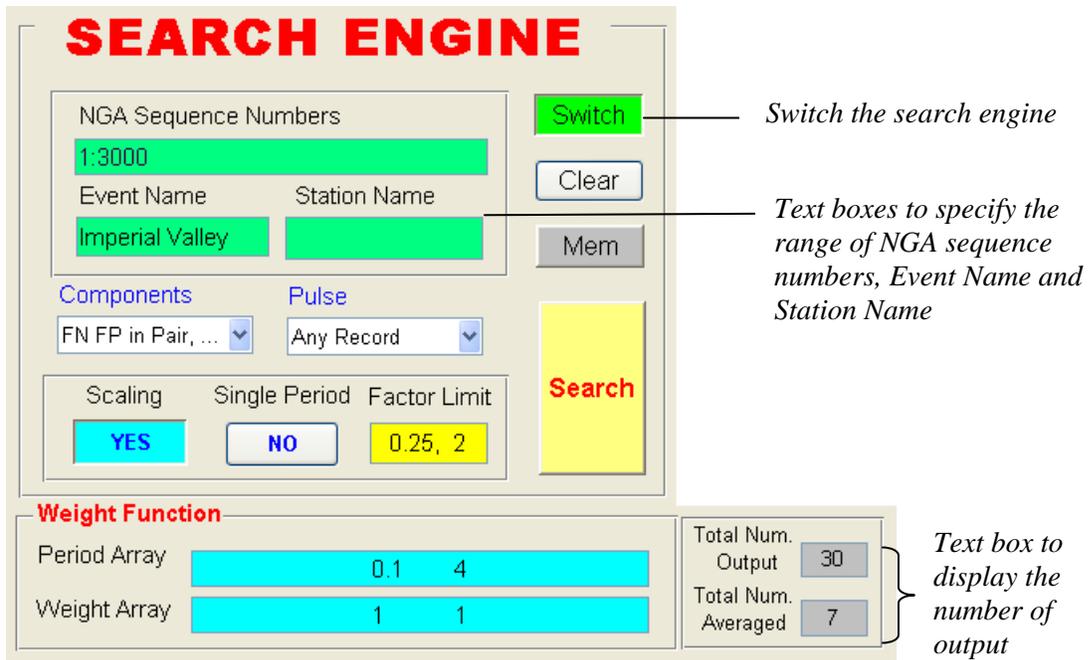
Figure 27: Supplementary Search Engine User Interface.

4.4 SPECIFY SCALING METHOD AND WEIGHT FUNCTION

The degree of similarity between the target and recording spectra is measured by the mean squared error between the two spectra. The user has several options for scaling the recordings before computation of the mean squared error. These are described in the following section.

4.4.1 Scaling the Records

Record scaling in the DGML is accomplished by applying a linear scale factor that does not alter the relative frequency content of the acceleration time history, and thus does not change the shape of the response spectrum of the time history. Two options are provided for scaling the records to match the target response spectrum. The user also has the option to use unscaled records.

(1) Scale the record to match the target spectrum over a period range

In this approach the record (or pair of records) is scaled by a factor that minimizes the mean squared error between the spectrum (spectra) of the scaled record(s) and the target spectrum. Calculation of the mean squared error is described in the main text of the DGML report.

Specify the max and min of scale factors. Leave the box blank if scale factor is not restricted

Click to YES   Click to NO
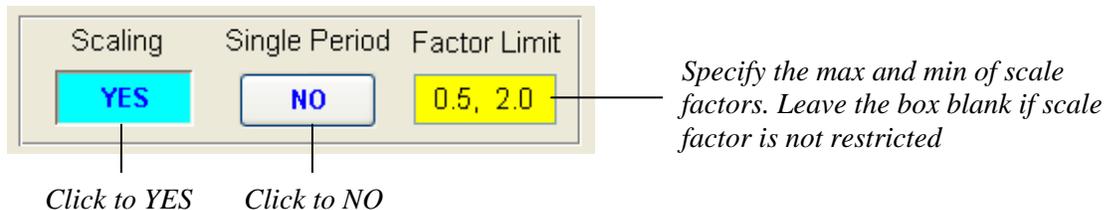
Click the *Scaling* button to "YES", the *Single Period* button to "NO", and specify the limits on scale factors, if desired. In this scheme, the scale factor is computed to minimize the weighted squared residuals between the scaled record and the target spectrum (see Section 2.3.2 of the report). Specification of the weight function is described in Section 4.4.2 of this manual. If the range (minimum, maximum) of scale factor is specified by the user, and the computed scale factor is greater (or less) than the specified maximum (or minimum), then the scale factor takes the maximum (minimum) value. If the factor limit is left blank, no restriction is imposed on the scale factor. The above example limits the minimum scale factor to 0.5, and maximum scale factor to 2.0.

(2) Scale the records to match the target spectrum to a single period

In this approach, the records are scaled to match the target spectrum at a specific spectral period, called *Ts* (sec). In this scheme, the scale factor (*f*) is computed such that the record spectrum matches the target spectrum at the single period *Ts*, i.e.,

$$f = \frac{SA^{t\arg et}(T_s)}{SA^{record}(T_s)}$$

The mean squared error is computed for the scaled record as described in Section 2.3.2 of the report.

To scale the records to match the target spectrum to a single period of *Ts*, click *Scaling* button to "YES", *Single Period* button to "YES", and specify the *Ts* value as follows,

Specify the period to which all the records are scaled.

Click to YES   *Click to YES*
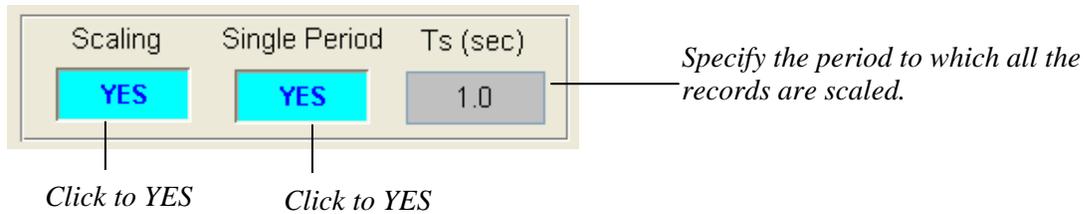
The above example shows all records are to be scaled to match the target spectrum at period 1.0 sec.

(3) No scaling

The third option is to consider only unscaled records. The mean squared error between the spectrum (spectra) of the recordings and the target is computed as described in Section 2.3.2 of the main report with the scale factor set to 1.0.

Click to NO, and all other fields become invisible

Click *Scaling* button to turn off scaling method. Original records are used in this case.

4.4.2 Weight Function (Period Array and Weight Array)

A weight function is used to compute the scale factor for scaling option 1 in Section **4.4.1** and in the computation of the mean squared error for all scaling options. We emphasize that the user needs to specify the weight function even if the records are to be scaled to match the target spectrum at a single period, or if there is no scaling at all. In the last two cases, although the weight function is not involved in computing the scale factors, it is used to compute the mean squared error to order the results with respect to degree of similarity of target spectrum and spectra of recordings.

The user needs to specify *Period Array* and *Weight Array* to construct the weight function. The *Period Array* or the *Weight Array* each has at least two data points. The *Period Array* is a period sequence (T_1, T_2, … T_n) in ascending order between [0.01,10], with each element delimitated by space or comma. The *Weight Array* data set is a sequence of non-negative numbers that have a one-to-one correspondence to the *Period Array* data set, and thus shall have the same number of elements (W_1, W_2, … W_n). Weights beyond the range of the *Period Array* are automatically set to zero.

In DGML, the weight function specified by Period Array and Weight Array is discretized by linearly interpolating over evenly-spaced discrete period points in log scale. To maintain sufficient accuracy, one log-cycle is discretized by 100 points. Therefore, there are 301 discrete period points (end-points included) in total to range from 0.01-10 sec. The weight function only

represents relative weights assigned to various discrete periods and are normalized in the program such that the summation of the weight function over discrete period points equals unity. Therefore, the absolute value of the weight function is immaterial.

The following three examples illustrate input of the weight function and the visualization produced by the DGML software.

Example 1
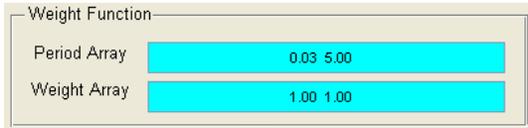
Equal weight between period 0.03 sec. to 5.0 sec.
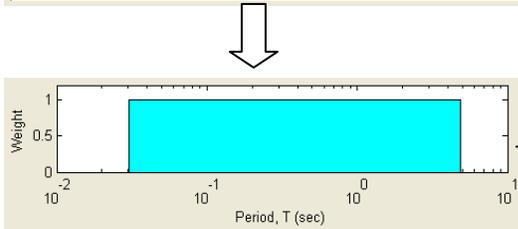
The weight function is visualized in Area 4 of Figure 24 when the Search button in Figure 26 is pressed.

Example 2
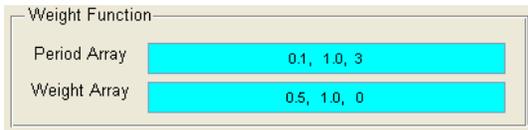
More weight is put on the short period range (0.1-1 sec) than long period range (1-3 sec)
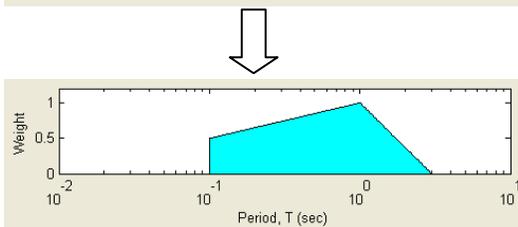
Example 3
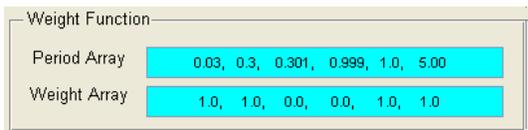
Discrete weight on the short period range (0.03-0.3 sec) and long period range (1-5 sec). Because the Period Array needs to be a monotonically increasing sequence, step function should be approximated by a very steep ramp, as illustrated.
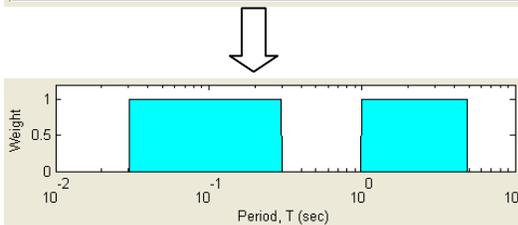
Figure 28: Examples of Specifying Weight Function

4.5 PERFORM THE SEARCH

4.5.1 Search for Records and Calculate Average Spectrum

Once the search restriction, scaling method and weight function are specified, press "*Search*" button to perform the search.

Press button to perform the search

Text box to specify the number of output
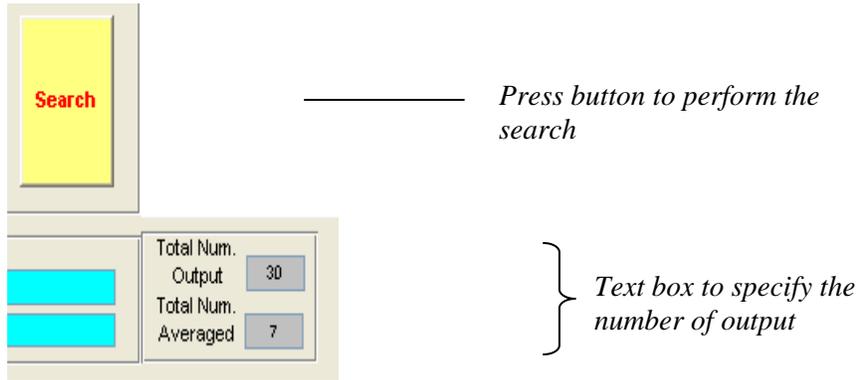
A progress bar will appear and shows the size of the data bin that satisfies all the specified search restrictions, and specified number of records for output.
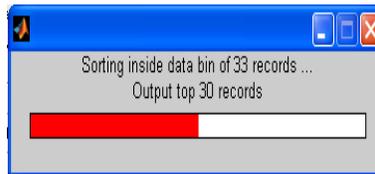
The progress bar shows there are total of 33 available records that satisfy the acceptance criteria specified in the Search Engine Panel. The best 30 (specified in *Total Num. Output* box) records will be displayed for inspection, and the best 7 records (specified in *Total Num. Averaged* box) are used to compute the average spectrum. If the total number of records that satisfy the acceptance criteria is less than the value of *Total Num Output* specified by the user, the value of *Total Num Output* is automatically reset to the maximum number of acceptable recordings in the database. **DGML restricts the display of outputs up to 200 records** to avoid abuse of the program.

The spectra for all 30 output recordings will be displayed in the spectrum plot window together with the average spectrum. Both the geometric mean and algebraic mean of the selected number of spectra are plotted against the target spectrum, see Figure 29 for an example.
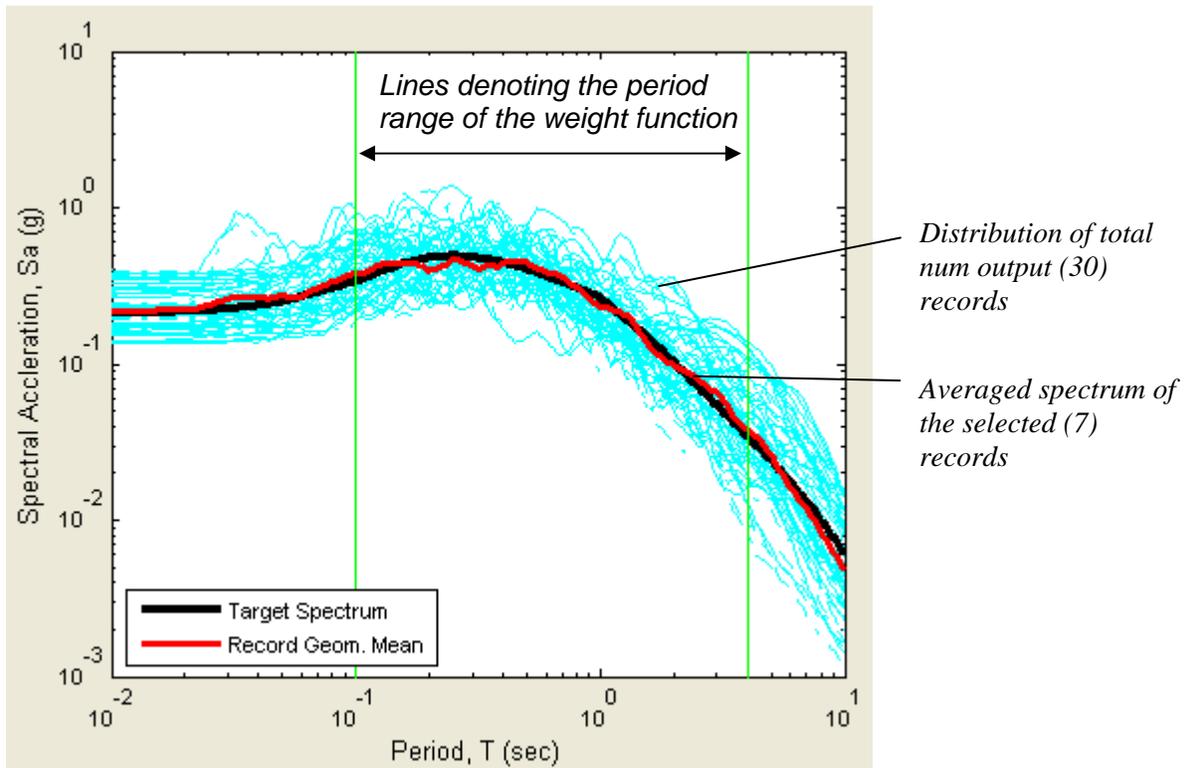
Figure 29: Example of Average Spectrum of Selected Records

4.5.2 List the Search Result

DGML lists the search results in the *output list window* for the total number of output records specified by users. The record list is ranked in order of increasing MSE.

Individual Record Information

Figure 30: Output List Window

Since user has specified *Total Num Averaged* (=7), the first 7 records (NGA #s 184, 165, 1116, 549, 719, 725, 159) in the list are selected to compute the average spectrum, **with an asterisk (*) shown in front of each selected record**. The user can manually add or reject an individual record from the list of output records. See sec. 4.6.4.

```
      Comp. | NGA# | MSE    | ScaleF | Pulse | Tp(s)   | D5-95(s) | Event              |
  *   GM    | 184  | 0.0368 | 0.4308 | 1  1  | 5.9  2  | 6.9  6.4 | Imperial Valley-06 |
  *   GM    | 165  | 0.0412 | 0.7674 | 0  0  | --  --  | 20.0 20.8| Imperial Valley-06 |
  *   GM    | 1116 | 0.0444 | 0.8224 | 0  0  | --  --  | 13.3 9.4 | Kobe, Japan        |
  *   GM    | 549  | 0.0450 | 0.9978 | 0  0  | --  --  | 11.2 15.3| Chalfant Valley-02 |
  *   GM    | 719  | 0.0494 | 1.7376 | 0  0  | --  --  | 13.5 14.1| Superstition Hills-02 |
  *   GM    | 725  | 0.0511 | 0.6555 | 0  0  | --  --  | 13.0 14.1| Superstition Hills-02 |
  *   GM    | 159  | 0.0544 | 0.9305 | 1  0  | 2.3  --  | 11.5 13.7| Imperial Valley-06 |
```

Figure 31: Close-up of Output List Window

The listed information for each record is tabulated in Table 3.

Table 3. Listed Record Information of DGML Search Result

*	The asterisk (*) is used to designate the record is selected to compute the averaged design spectrum.
Comp.	Component indicator: FN: Record of fault normal (FN) direction FP: Record of fault parallel (FP) direction GM: Record of both FN and FP directions; use geometric mean of two components.
NGA#	NGA number. A unique number assigned to each NGA record for identification purposes.
MSE	Computed Mean Squared Error (MSE) of the selected record with respect to the target spectrum.
ScaleF	Scale factor of the record computed by DGML
Pulse	Pulse Indicator: binary code to indicate if the unscaled record has velocity pulse. 0 for non-pulse-like record 1 for pulse-like record If the search is for two components in pair, the pulse indicator is shown for both components. The first binary is for fault normal record, and the second binary is for fault parallel record.
Tp (sec)	The period of the velocity pulse. No number is assigned for a non-pulse record. If the search is for two components in pair, pulse periods (if any) for both FN and FP components are given in order.
D5-95 (sec)	Significant duration, the time needed to build up between 5 and 95 percent of the total Arias intensity. If the search is for two components in pair, durations for both FN and FP components are given.
Event	Name of the earthquake event
Year	Year of earthquake
Station	The unique name of strong-motion station
Mag.	Moment magnitude of earthquake
Mechanism	Type of Fault Mechanism. Available mechanisms are: Strike-Slip, Normal, Normal-Oblique, Reverse, Reverse-Oblique.

Rjb (km)	Joyner-Boore distance to rupture plane
Rrup (km)	Closest distance to rupture plane
V_{S30} (m/s)	Average shear velocity of top 30 m
Low. Freq. (Hz)	The recommended lowest usable frequency for the record. (see Footnote (1) below)
Horiz. Acc. File Name or FN Acc. File Name FP Acc. File Name	The horizontal acceleration time history record file name in \FNFPDataset\ directory. If the search is for FN/FP components in pair, the file names for both FN FP components are given (labeled as "FN Acc. File Name" and "FP Acc. File Name", respectively).
Vertical Acc. File Name	The vertical acceleration time history record file name in \NGADatabase\ directory. If the vertical file is missing, the file name is displayed as "nonexistent".

4.6 SELECTION AND EVALUATION OF RECORDS

4.6.1 Highlight an Individual Record

The response spectrum and acceleration, velocity, and displacement time histories for scaled individual records can be easily visualized in DGML, providing users the capacity to inspect the records in greater detail. The user can simply click on the record line in the list window, and the selected record line will be highlighted. The following example shows a particular record (NGA#165) selected. Record #165 is ranked 2nd in terms of closeness of the spectrum shape to the target spectrum, where geometric mean of the FN and FP components (Comp.=GM) are used to calculate the scale factor and MSE. The scale factor (ScaleF) is computed to be 0.7674. The pulse indicator shows that both components of this record is not pulse-like (Pulse=0 for both FN FP component).

Click to highlight an individual record

Figure 32: Highlight an Individual Record on the Output List

Footnote (1): The recommended lowest usable frequency is related to filtering of a record by the record processing organization to remove low-frequency (long-period) noise. Filtering results in suppression of ground motion amplitudes and energy at frequencies lower than the lowest usable frequency such that the motion is not representative of the real ground motion at those frequencies. It is a user's choice on whether to select or reject a record on the basis of the lowest usable frequency. Because of the suppression of ground motion at frequencies lower than the lowest usable frequency, it is recommended that selected records have lowest usable frequencies equal to or lower than the lowest frequency of interest.

4.6.2 Highlight Response Spectrum of an Individual Record

By specifying suitable options in the "*Control*" panel, the **scaled** response spectrum of an individual record can be highlighted in the *Spectrum Plot Window*. Figure 33 shows the graphic control to highlight the *scaled* fault-normal (in blue color), fault-parallel (in red color) and vertical (in green color) response spectra for record NGA#165. Please note that the vertical component is scaled using the same scale factor that was obtained for the horizontal components.
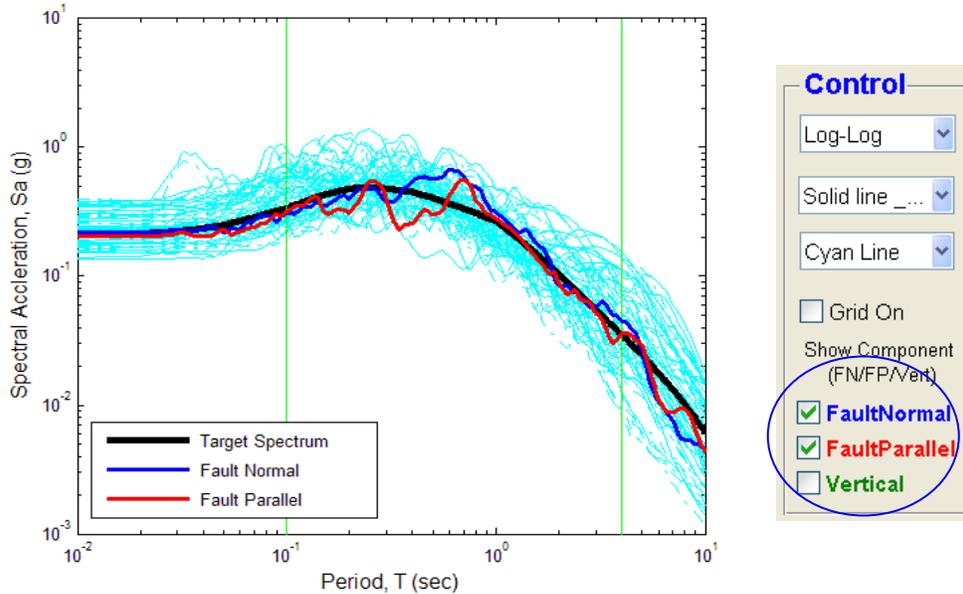
(a) Graphic control to highlight fault-normal and fault-parallel spectrum of selected record
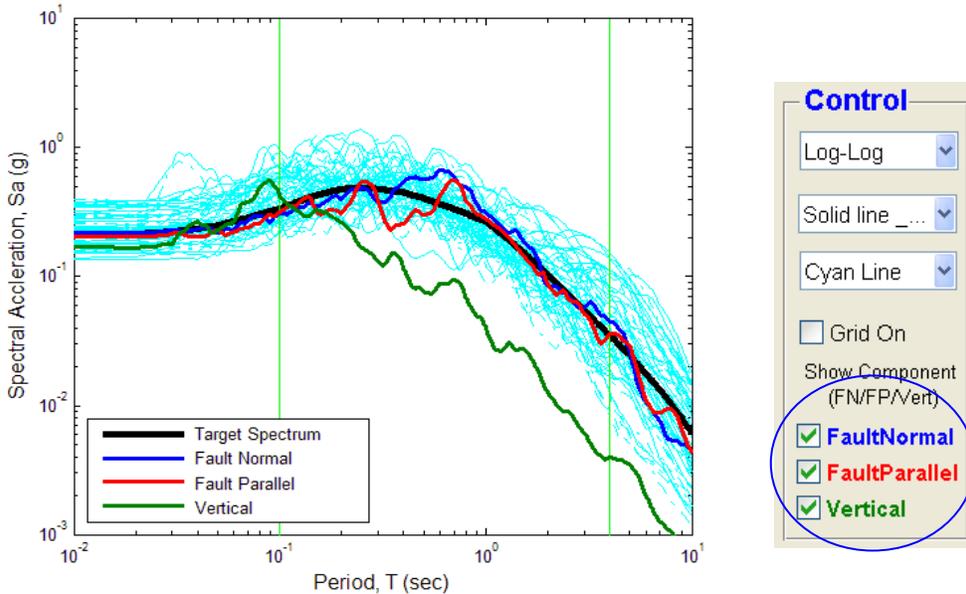
(b) Graphic control to superimpose vertical response spectrum

Figure 33: Highlight the Response Spectrum of an Individual Record

4.6.3 Highlight Time History of an Individual Record

Once an individual record is highlighted, the **scaled** acceleration/velocity/displacement time history is automatically plotted in *Time History Plot Window*. One can select the drop menu to plot acceleration or velocity or displacement time history. Check boxes in the **Control** panel give users the option to display fault-normal (in blue color), fault-parallel (in red color) and vertical (in green color) components. Figure 34 shows the *scaled* time histories for a highlighted record (NGA#165 in this case).
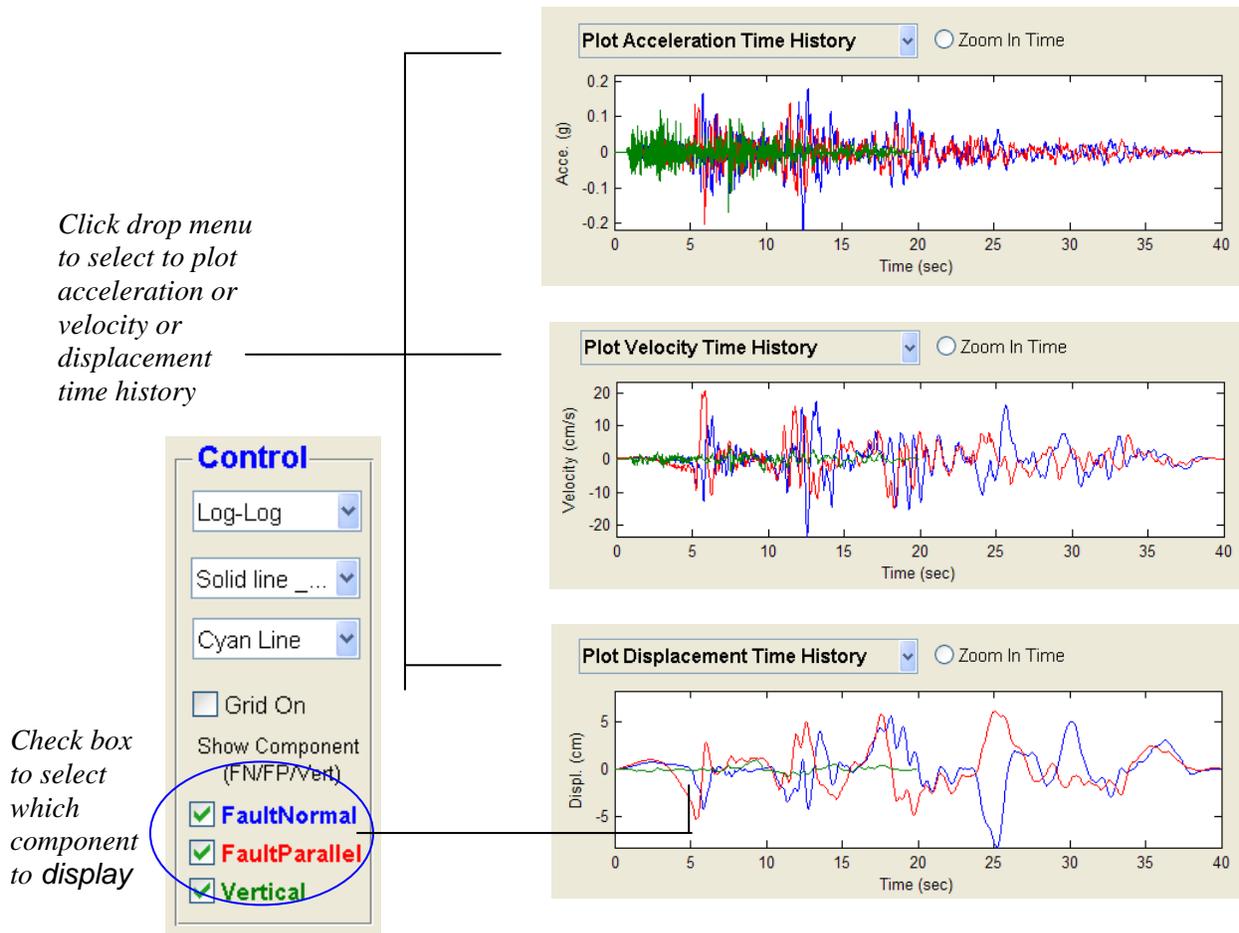
Figure 34: Plot of the Scaled Acceleration/Velocity/Time History of an Individual Record in Fault Normal, Fault Parallel and Vertical Directions

4.6.4 Zoom In Time Function for Examining the Time History of an Individual Record

The "Zoom In Time" function is provided to help the user inspect the details of the time history plot. The function can be activated by selecting the option "Zoom In Time". As shown in Figure 35, an input box appears to prompt input in the form of "min, max". The example shows

that the acceleration time history is zoomed in between 5-7 seconds. To zoom out, one can input blank in the input box, or click the "Zoom In Time" to deactivate the function.
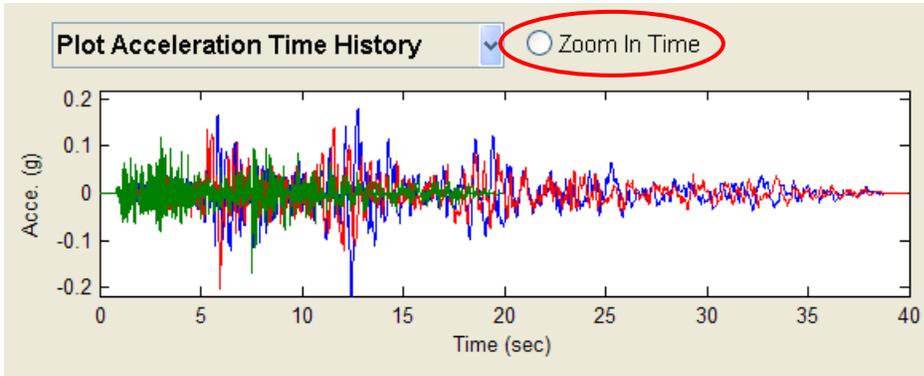
(a) Click on radio button "Zoom In Time" for the input box to appear.
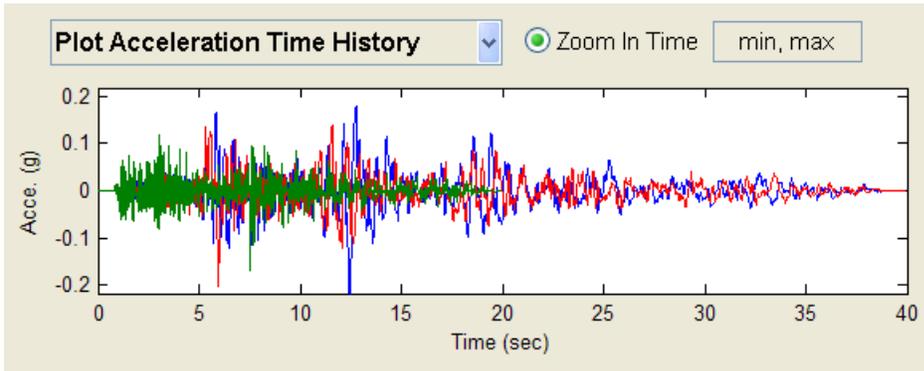
(b) It is prompted to input data pair in the format of [min, max]
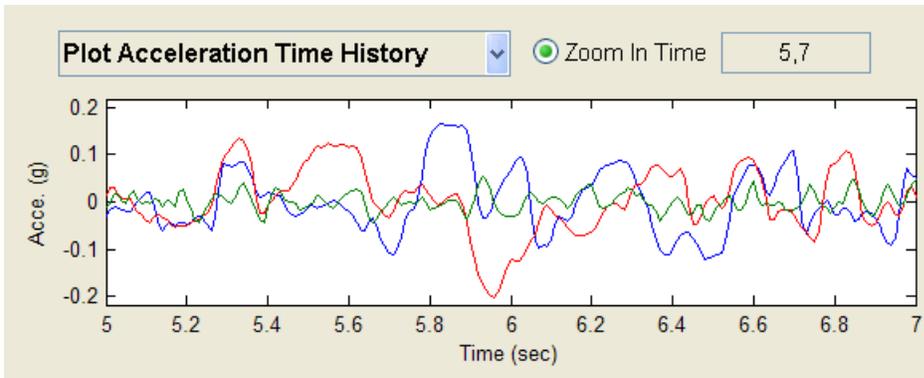
(c) Key in the time range to zoom in. The acceleration time history zooms in between 5-7 seconds in this example.

Figure 35. Zoom In Time History Plot

4.6.5 Accept or Reject an Individual Record

The user has the option to remove or add an individual record from the selected list by using "Accept" and "Reject" button. First, mouse-clicking the record in the list window highlights the individual record. If the asterisk (*) shows the record is currently in the selected list, then clicking Reject button removes the record from the list, and the asterisk (*) is also removed in the front to signify the record was rejected. Similarly, clicking the Accept button will add the highlighted record into the selected list, and the asterisk (*) symbol appears in the front after the operation. The average spectrum of the selected list is automatically updated after each "Accept" or "Reject", however, one can always check the updated spectrum using the "Refresh" button. The steps of operation are illustrated in Figure 36.

Click to highlight the individual record

Star is removed from the front to show the record is rejected

Click Reject to remove the record from selected list

Star appears in the front to show the record is added

Click Refresh to see the average spectrum of the updated selected list.

Highlight record and click Accept to add the record from selected list

Figure 36: Steps to Accept or Reject an Individual Record

4.7 GRAPHIC CONTROL

4.7.1 Graphic Control Panel

The graphic control panel provides the functionality to manipulate the spectrum plot and the time history plot. Basic functions of the control panel are summarized in Figure 37.
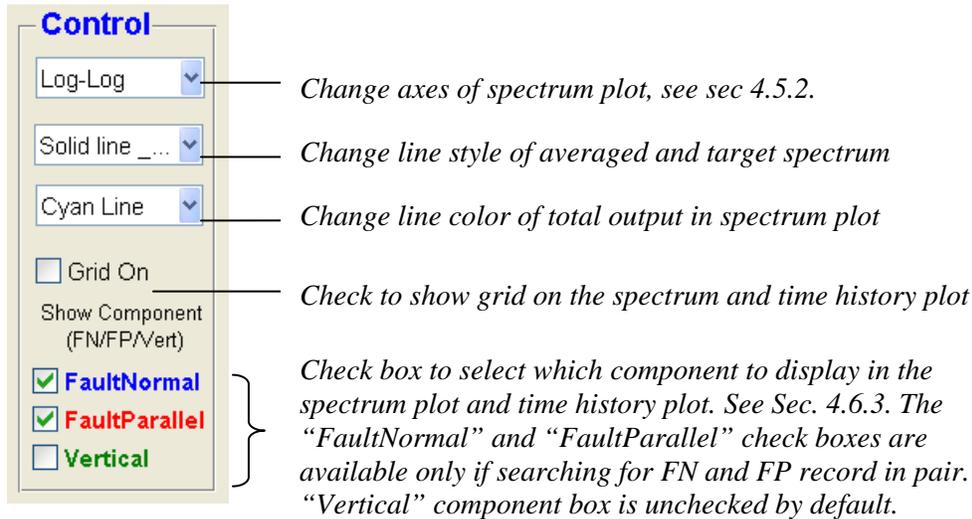
Figure 37: Graphic Control Panel

4.7.2 Change Plot Axes

The axes of the spectrum plot can be changed from log scale to linear scale by selecting options in the drop menu. The following plots in Figure 38 illustrate four options available to change the axes of a same plot.
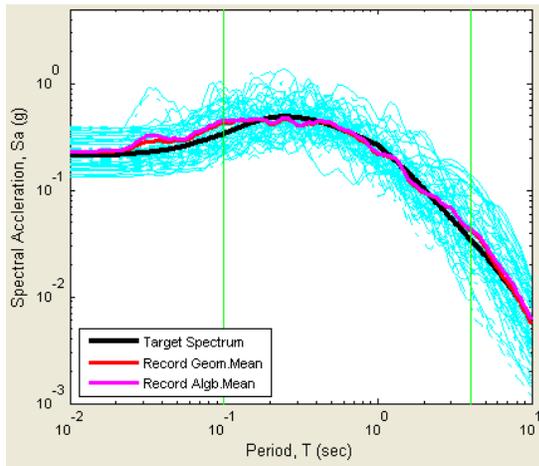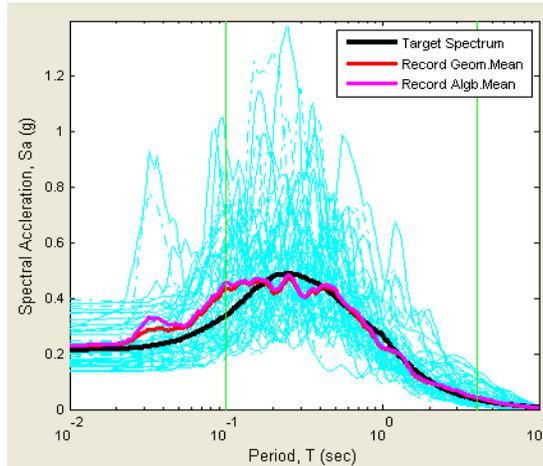
(a) log-log axes   (b) semilogx axes
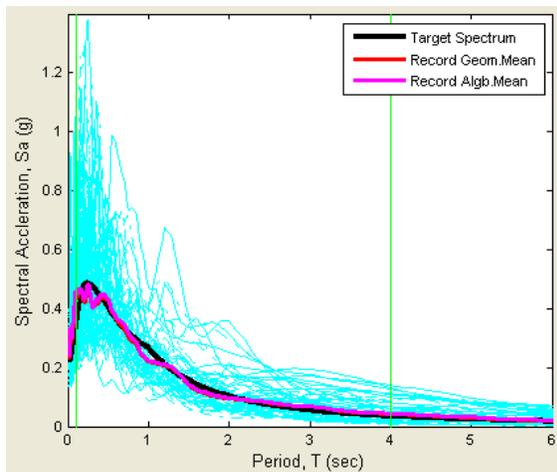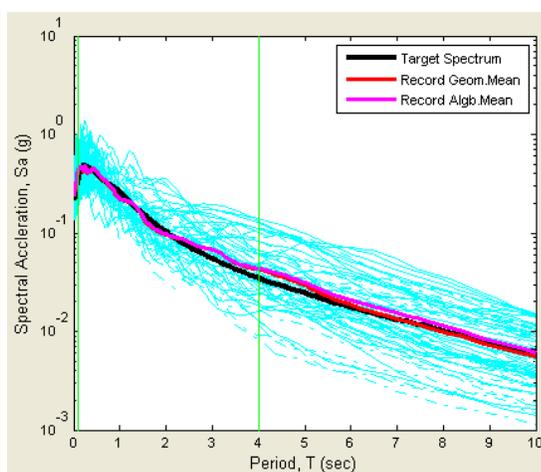
(c) linear axes   (d) semilogy axes

Figure 38: Example of Four Options to Change Plot Axes

4.8 SAVE DGML SEARCH RESULT

4.8.1 DGML Search Report

The DGML search criteria and summary of the selected records can be exported by clicking "Save Search Result" button (cf. Figure 39). If "Save Vertical Records" button is selected, the corresponding vertical component information will be exported together with the horizontal components. A pop-up window allows the user to specify the file name and file type ("csv" or 'txt' format). "cvs" (Comma Separated Variables) file format is preferred since it can be opened using Microsoft Excel, or any text editor.
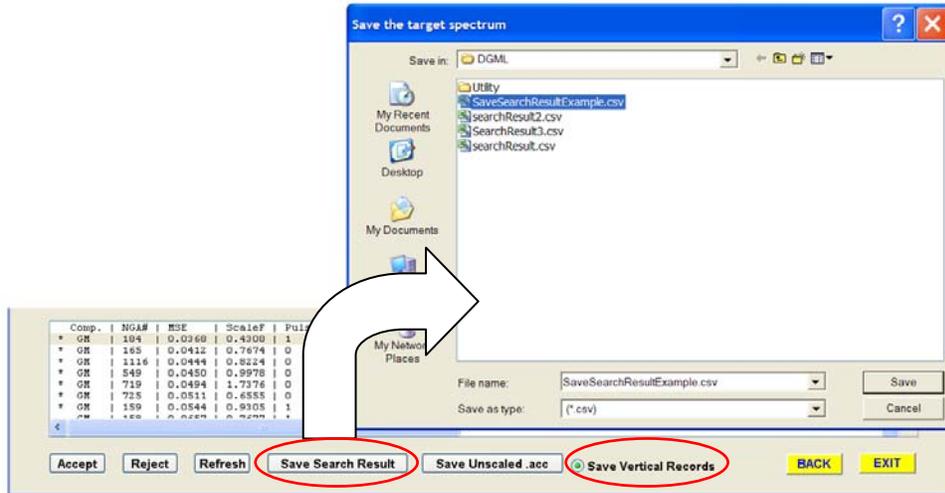
Figure 39: Save DGML Search Result

Microsoft Excel - SaveSearchResultExample.csv

File Edit View Insert Format Tools Data Window Help Adobe PDF

T47 = 0.3151

Design Ground Motion Library (DGML ver.2) Time History Search Report 05-Apr-2009

Summary of DGML Search Criteria
Magnitude: 6 - 7.25
Fault Type: Strike Slip
D9_95: Not specified
RRUP =0 - 20 (km)
RJB = 0 - 20 (km)
Vs30 = 200-300 (m/s)
Component: FN/FP in Pair
Pulse: Not Specified
Records Are Scaled and The Scale Limit is [0.25-2]
Period Array: 0.1   4
Weight Array: 1 1

Summary of Properties of Selected Horizontal Records

Comp.	NGA#	MSE	ScaleF	Pulse	Tp(s)	D5-95(s)	Event	Year	Station	Mag	Mechanis	Rjb(km)	Rrup(km)	Vs30(m/s	Low.f
* GM	184	0.0368	0.4308	1 1	5.9 2	6.9 6.4	Imperial V	1979	El Centro	6.53	Strike-Slip	5.1	5.1	202.3	
* GM	165	0.0412	0.7674	0 0	-- --	20.0 20.8	Imperial V	1979	Chihuahu	6.53	Strike-Slip	7.3	7.3	274.5	
* GM	1116	0.0444	0.8224	0 0	-- --	13.3 9.4	Kobe- Jap	1995	Shin-Osak	6.9	Strike-Slip	19.1	19.1	256	
* GM	549	0.045	0.9978	0 0	-- --	11.2 15.3	Chalfant V	1986	Bishop - L	6.19	Strike-Slip	14.4	17.2	271.4	
* GM	719	0.0494	1.7376	0 0	-- --	13.5 14.1	Superstitio	1987	Brawley A	6.54	Strike-Slip	17	17	208.7	
* GM	725	0.0511	0.6555	0 0	-- --	13.0 14.1	Superstitio	1987	Poe Road	6.54	Strike-Slip	11.2	11.2	207.5	
* GM	159	0.0544	0.9305	1 0	2.3 --	11.5 13.7	Imperial V	1979	Agrarias	6.53	Strike-Slip	0	0.7	274.5	

Note: Rjb and Rrup in square brackets are estimated values.

Scaled Spectral Acceleration of Selected Horizontal Records

Comp.	NGA #	Scale Fac	PGA (g)	PGV (cm/	PGD (cm	Period(s)	0.01	0.02	0.022	0.025	0.029	0.03	0.032	0.035	0.
* GM	184	0.4308	0.1854	23.8384	14.1387	Sa (g)	0.1858	0.1883	0.1898	0.191	0.1941	0.1944	0.197	0.1981	0.1
FN	184	0.4308	0.1797	25.6716	16.684	Sa (g)	0.1804	0.1841	0.1857	0.1881	0.1916	0.1926	0.1972	0.2012	0.2
FP	184	0.4308	0.1912	22.136	11.9817	Sa (g)	0.1913	0.1925	0.1941	0.194	0.1966	0.1963	0.1968	0.195	0.1
* GM	165	0.7674	0.2108	21.9872	7.0496	Sa (g)	0.2122	0.2119	0.2121	0.2131	0.2195	0.2225	0.2244	0.216	0.2
FN	165	0.7674	0.2181	23.3332	8.2857	Sa (g)	0.2193	0.2195	0.2199	0.2197	0.2279	0.2301	0.2294	0.2225	0.2
FP	165	0.7674	0.2038	20.7189	5.998	Sa (g)	0.2053	0.2046	0.2047	0.2067	0.2115	0.2152	0.2194	0.2097	0.2
* GM	1116	0.8224	0.1851	29.1134	6.6064	Sa (g)	0.1856	0.1855	0.1856	0.1857	0.186	0.1861	0.1862	0.1865	0.1
FN	1116	0.8224	0.1535	24.641	7.2115	Sa (g)	0.1537	0.154	0.1541	0.1542	0.1545	0.1546	0.1547	0.1551	0.1
FP	1116	0.8224	0.2231	34.3975	6.0521	Sa (g)	0.2241	0.2235	0.2235	0.2237	0.2239	0.224	0.2241	0.2243	0.2
* GM	549	0.9978	0.2159	19.9979	6.8059	Sa (g)	0.2161	0.2172	0.2189	0.2209	0.2208	0.2189	0.2342	0.2403	0.2
FN	549	0.9978	0.2309	20.7182	6.0201	Sa (g)	0.231	0.2323	0.2326	0.2339	0.2341	0.233	0.2497	0.2576	0.2
FP	549	0.9978	0.2018	19.3027	7.6943	Sa (g)	0.2021	0.2031	0.2059	0.2087	0.2083	0.2055	0.2196	0.2242	0.2
* GM	719	1.7376	0.244	28.1429	12.1034	Sa (g)	0.2482	0.2516	0.254	0.2579	0.2665	0.2685	0.2711	0.2741	0.
FN	719	1.7376	0.2759	25.9252	9.4218	Sa (g)	0.2785	0.2869	0.2887	0.2932	0.3023	0.3029	0.3055	0.3176	0.3
FP	719	1.7376	0.2158	30.5503	15.5483	Sa (g)	0.2211	0.2207	0.2234	0.2269	0.2349	0.238	0.2406	0.2365	0.2
* GM	725	0.6555	0.2236	19.3138	7.3141	Sa (g)	0.2261	0.2252	0.2263	0.2268	0.228	0.2311	0.234	0.2392	0.
FN	725	0.6555	0.2048	18.5791	6.5274	Sa (g)	0.2075	0.2057	0.206	0.2073	0.2097	0.2124	0.2124	0.2149	0.2
FP	725	0.6555	0.2441	20.0775	8.1956	Sa (g)	0.2464	0.2466	0.2486	0.2481	0.248	0.2515	0.2578	0.2662	0.2
* GM	159	0.9305	0.2615	30.125	6.9544	Sa (g)	0.2641	0.2968	0.3164	0.4263	0.679	0.7109	0.8595	0.8008	0.8
FN	159	0.9305	0.2898	50.0578	13.8163	Sa (g)	0.293	0.3572	0.3691	0.5036	0.6892	0.7311	0.9397	0.8601	0.9
FP	159	0.9305	0.2359	18.1293	3.5005	Sa (g)	0.238	0.2467	0.2711	0.3608	0.6689	0.6913	0.786	0.7456	0.7

Scaled Spectral Acceleration of Selected Vertical Records

Comp.	NGA #	Scale Fac	PGA (g)	PGV (cm/	PGD (cm	Period(s)	0.01	0.02	0.022	0.025	0.029	0.03	0.032	0.035	0.
Vert	184	0.4308	0.3047	8.8899	4.9846	Sa (g)	0.3069	0.3527	0.3576	0.4328	0.433	0.4213	0.4245	0.4915	0.5
Vert	165	0.7674	0.1675	3.9212	0.9804	Sa (g)	0.1711	0.1678	0.1699	0.1723	0.1827	0.1769	0.2128	0.2289	0.2
Vert	1116	0.8224	0.0483	5.249	1.7769	Sa (g)	0.0486	0.0487	0.0488	0.0489	0.049	0.049	0.0492	0.0496	0.0
Vert	549	0.9978	0.1401	6.7005	2.2366	Sa (g)	0.1435	0.1597	0.1738	0.1921	0.2159	0.24	0.2942	0.3915	0.4
Vert	719	1.7376	NaN	NaN	NaN	Sa (g)	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	Na
Vert	725	0.6555	NaN	NaN	NaN	Sa (g)	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	Na
Vert	159	0.9305	0.7767	9.43	4.6331	Sa (g)	0.7851	1.13	1.233	1.4209	3.0754	3.447	3.9127	3.0618	3.3

Note: vertical records use the same scale factors from their corresponding horizontal components

Scaled Average Spectral Acceleration of Selected Horizontal Records

						Period(s)	0.01	0.02	0.022	0.025	0.029	0.03	0.032	0.035	0.
Target Spectrum (Horizontal)						Sa (g)	0.2137	0.2146	0.2167	0.2196	0.223	0.2239	0.2264	0.23	0.2
Geometric Mean Spectrum of Selected Horizontal Records						Sa (g)	0.218	0.2226	0.2258	0.2368	0.2558	0.2592	0.269	0.2689	0.2
Arithmetic Mean Spectrum of Selected Horizontal Records						Sa (g)	0.2197	0.2253	0.2293	0.2462	0.2842	0.2912	0.3123	0.3092	0.3

Note: Horizontal Components with star (*) in front are used to compute the mean spectra

SaveSearchResultExample

Figure 40: An Example of DGML Search Report

Figure 40 illustrates an example of the DGML search report (named as SaveSearchResultExample.csv in this case) opened by Microsoft Excel. The search report features the following data blocks:

(1) *Summary of DGML search criteria.* All user-defined search criteria are listed in this data field, including the magnitude range, fault type, specified D9-95 range, specified R_{rup} and R_{jb} ranges, specified V_{S30} range, component specification, pulse characteristics, scale factor limit, period array and weight array.

(2) *Summary of Properties of Selected Horizontal Records.* The same information in the DGML output list window is reported only for selected records (these marked with stars). The reported properties of each selected record are: Component Indicator, NGA number, Mean Squared Error (MSE), Scale Factor, Pulse Indicator, Pulse Periods, D5-95 duration, Event Name, Year, Station Name, Magnitude, Fault Mechanism, R_{JB}, R_{Rup}, V_{S30}, recommended lowest usable frequency, and the acceleration record file names. Please note that if R_{JB} or R_{Rup} is in a squared bracket, it indicates that the value is absent in NGA Flatfile. The reported value was estimated by Chiou and Youngs (2008b).

(3) *Scaled Spectral Acceleration of Selected Horizontal Records*. For each selected record listed in data field (2), their component indicator, NGA number, scale factor, *scaled* PGA, PGV, PGD values and *scaled* spectra acceleration values are reported in this data field. The scaled spectra acceleration values are reported for the following periods (in seconds):

0.01	0.02	0.022	0.025	0.029	0.03	0.032	0.035	0.036	0.04
0.042	0.044	0.045	0.046	0.048	0.05	0.055	0.06	0.065	0.067
0.07	0.075	0.08	0.085	0.09	0.095	0.1	0.11	0.12	0.13
0.133	0.14	0.15	0.16	0.17	0.18	0.19	0.2	0.22	0.24
0.25	0.26	0.28	0.29	0.3	0.32	0.34	0.35	0.36	0.38
0.4	0.42	0.44	0.45	0.46	0.48	0.5	0.55	0.6	0.65
0.667	0.7	0.75	0.8	0.85	0.9	0.95	1	1.1	1.2
1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2.5	2.6	2.8	3	3.2	3.4	3.5	3.6	3.8	4
4.2	4.4	4.6	4.8	5	5.5	6	6.5	7	7.5
8	8.5	9	9.5	10					

If the search component is "FN/FP in Pair", the spectra values of the Geometric Mean (GM) spectra and Fault Normal (FN), Fault Parallel (FP) are all listed separately. If the search component is "FN" or "FP", only the spectra values of FN or FP component are listed.

(4) *Scaled Spectral Acceleration of Selected Vertical Records.* The data block is available only if "Save Vertical Records" button is selected. The data block lists the same information for vertical component as is in data field (3).

(5) *Scaled Average Spectral Acceleration of Selected Horizontal Records*. The data field reports the target spectrum (horizontal) values, and both geometric mean spectrum and arithmetic mean spectrum of selected horizontal records (see definitions of geometric mean and arithmetic mean of spectrum, Section 3.2.1 of Users Manual). Please note that the reported

target spectrum is re-interpolated to the same period sequence as used in data field (3), therefore, the values may be slightly different from user's original input.

4.8.2 Save Acceleration Time History Files

DGML (version 2) allows users to save the selected acceleration time history file. **Please note that the saved time history file contains <u>unscaled</u> original data as in the PEER NGA database**. The steps are illustrated in Figure 41.

Step (1): user clicks to highlight the record to be saved. By default, only horizontal time history files will be saved. One must check "Save Vertical Records" button if the corresponding vertical time history file is to be exported.

Step (2): click "Save Unscaled .acc" button. A pop-up window allows the user to specify the save directory and file name. The pop-up window shows a default file name assigned by DGML using the convention of "FilePath.Filename" as was used in the PEER NGA database to distinguish records that might have the same file name but different file paths in the database. If the search component is set as "FN/FP in Pair", the pop-up window will show up sequentially for each of the FN and FP acceleration time history file, and for the vertical file in the last if "Save Vertical Records" button is checked.
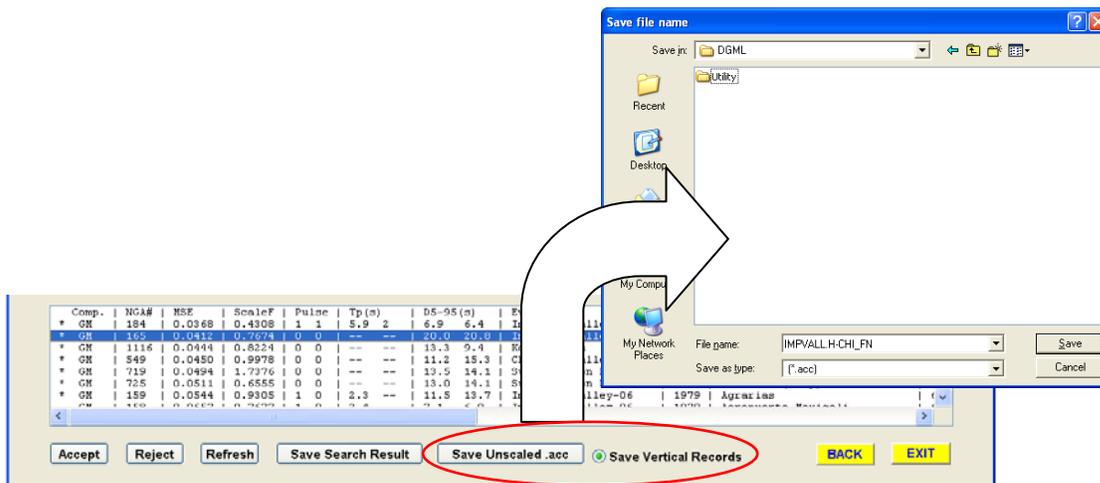

Figure 41: Save Acceleration Time History Files

4.8.3 Save the Plot

Both spectrum and time history plots can be saved to the disk as figure files. The steps are illustrated in Figure 42. Step (1): <u>Right click</u> mouse on the plot area, and a "Save Plot As" box will show up. Step (2): <u>Left click</u> the box to pop up a window, select the proper directory, and enter the name of the graphic file to save. The plot can be save as .bmp, .jpg, .tiff, or .eps format.
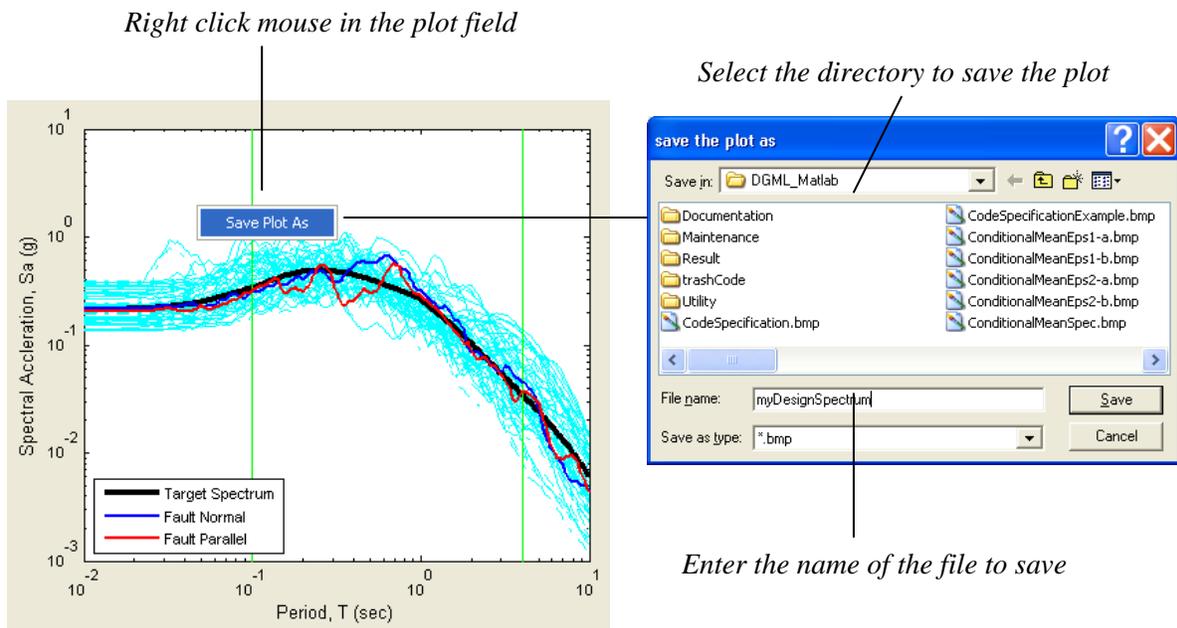
Figure 42: Steps to Save the Plot

5. DGML EXAMPLES

Examples are provided below to illustrate the major steps in selecting suitable ground motion records using the DGML. The examples are served mainly for the purpose of demonstration and not for the purpose of any practical application.

5.1 RECORD SELECTION AND MODIFICATION

Step 1. Developing the Target Spectrum

The site selected for the example is Site Class D at a location in San Francisco approximately 10 km from the San Andreas fault. The structure was assumed to be a medium- to high-rise building having a significant period range of 0.3 to 3 seconds. The design response spectrum is a Code spectrum, and the following steps are needed to construct the spectrum.

(1) *Select Spectrum Model*: Choose "ASCE code specification" from the drop menu.

Figure 43: Select Spectrum Model

(2) *Specify Spectrum Parameters*: By referring to the design ground motion maps and provisions of ASCE standard ASCE/SEI 7-05, parameters Sds, Sd1, and TL needed to construct the code design spectrum are obtained as follows, where equations, figures, maps, and tables refer to ASCE (2006):

Maximum Considered Earthquake parameters:
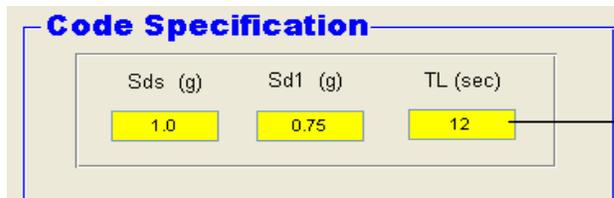Ss=1.5g (Map, p. 214), Fa= 1.0 (Table 11.4-1), Sms=1.5g (Eq.11.4-1)
S1=0.75g (Map, p.216), Fv=1.5 (Table 11.4-2), Sm1=1.125g (Eq. 11.4-2)

Design earthquake parameters:
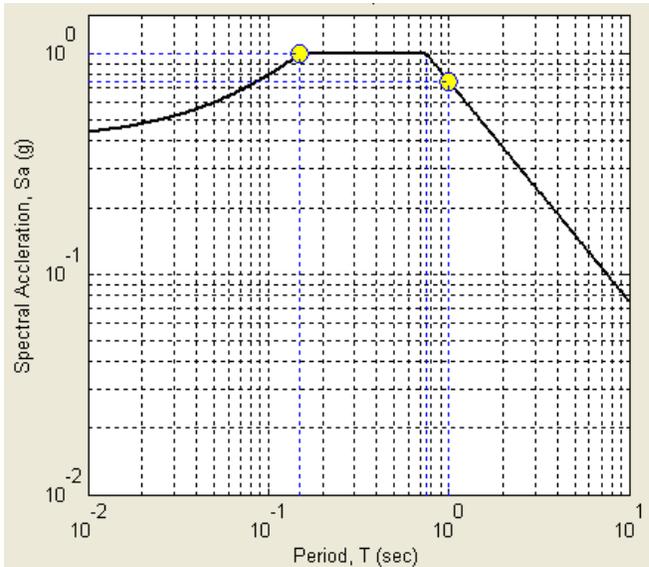Sds=2/3*Sms=1.0g   (Eq. 11.4-3)
Sd1=2/3*Sm1=0.75g (Eq. 11.4-4)
TL=12 sec   (Fig. 22-16)

Enter Parameters for the Code Spectrum

Figure 44: Specify Spectrum Parameters

(3) ***Create the Target Design Spectrum***: Press "Create" button in the Control Panel to create the target spectrum, which is shown in the spectrum plot window as follows:
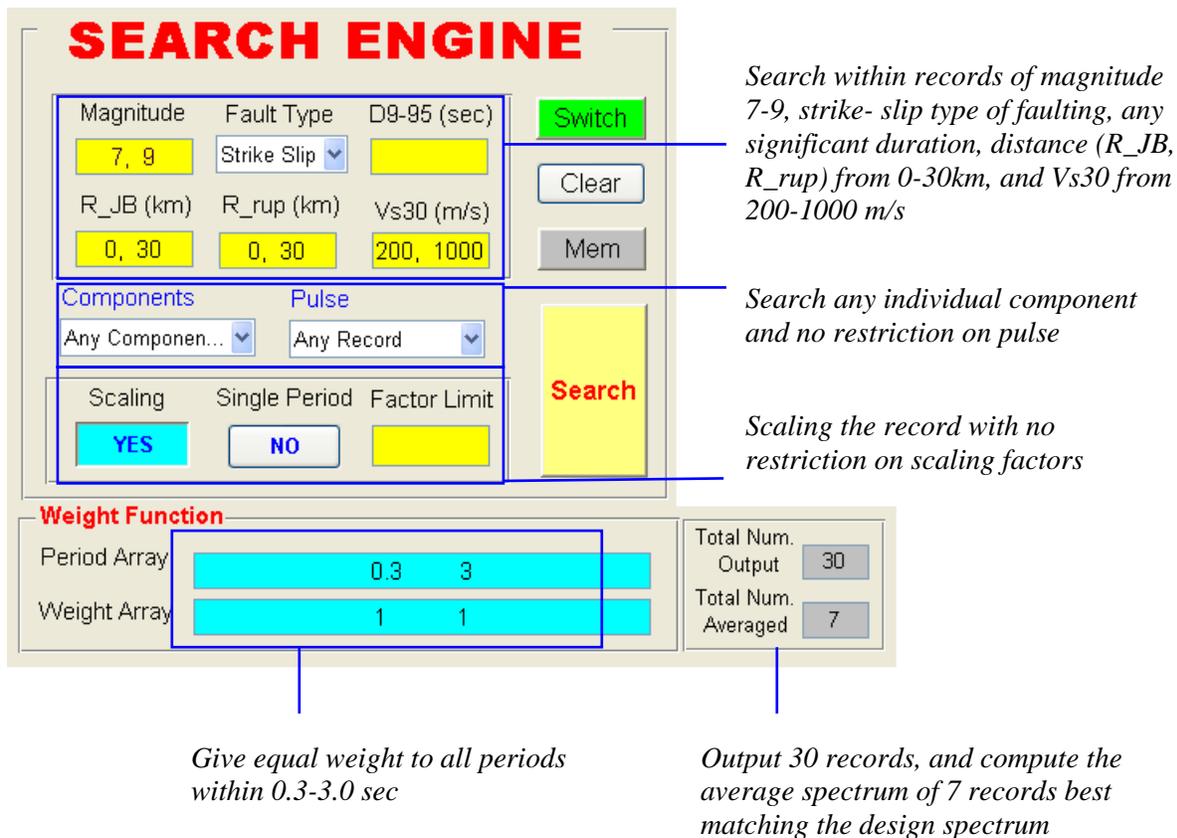

Figure 45: The Target Design Spectrum

Press **NEXT** button to proceed to the next step.

Step 2. Defining the Search Criteria

The USGS web site, http://earthquake.usgs.gov/research/hazmaps, was used to deaggregate the site ground motion hazard. At 1-second period, the dominant contributor to the hazard was an earthquake of approximately magnitude 7.8 occurring on the San Andreas fault. For purposes of the example, the search was restricted to recordings from strike-slip (SS) earthquakes of magnitude 7 and higher occurring within 30 km of the site. A wide range of V_{S30} limits and no restrictions on significant duration (D_{5-95}) or on scale factor were utilized in order to capture a sufficiently large set of potential records for examination and scaling and matching of recorded spectra to the Code spectrum within the significant period range. It is noted that although specifying the site V_{S30} and site class is essential in developing the design response spectrum, it is not so important in selecting records because the search will rank the records with respect to their match to the design spectrum. It was assumed that matching would be to the Code spectrum rather than to a conditional mean spectrum. Equal weight was given to matching at all periods within the significant period range (0.3-3 sec). It was also assumed that for the structural analyses, only individual horizontal components were required rather than FN/FP pairs. No restrictions were placed for searching on whether the record should or should not have pulses. The display of search criteria is shown in Figure 46.

Search within records of magnitude 7-9, strike-slip type of faulting, any significant duration, distance (R_JB, R_rup) from 0-30km, and Vs30 from 200-1000 m/s

Search any individual component and no restriction on pulse

Scaling the record with no restriction on scaling factors

Give equal weight to all periods within 0.3-3.0 sec

Output 30 records, and compute the average spectrum of 7 records best matching the design spectrum

Figure 46: Specify the Search Criteria

Step 3. Searching for Records

Press "Search" button in the Search Engine. The progress bar shows there are 46 records that satisfy the search criteria.
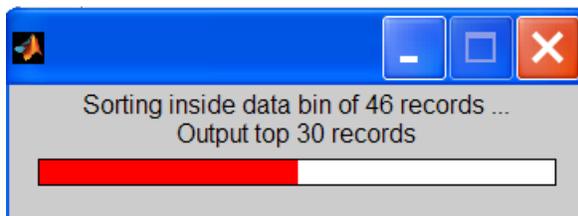
Step 4. Inspect, Evaluate, and Finalize the Search Result

As shown in Figure 46, the search was set up to output 30 records and computes the average spectrum for the 7 records that best match the Code spectrum. Scroll down the list bar in the list window to see information on all 30 output records, as shown in Figure 47. Clicking on an individual record allows one to examine the spectrum and acceleration/ velocity/ displacement time history of that record.

The best-matching 7 records are called **"Selected Records"**, with a star in the front for identification. Figure 47 shows the top 7 records (with * symbols) that are selected by DGML. However, the user has the capability to reject records from or add records to the list of selected records. The next step is to adjust the list of selected records and finalize the search result.
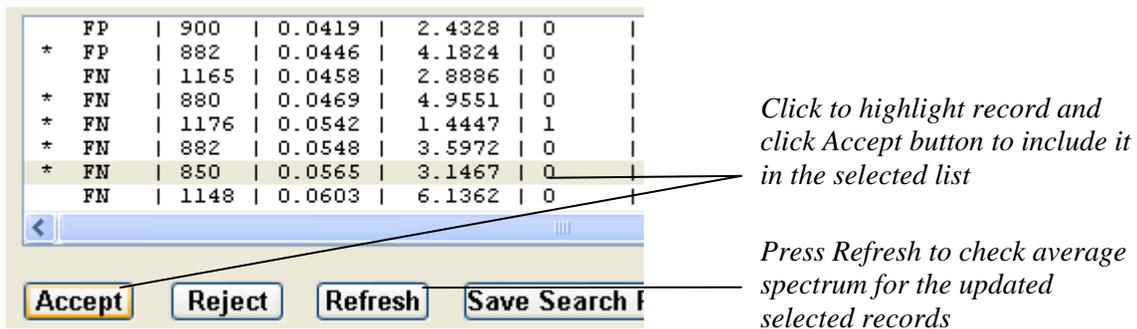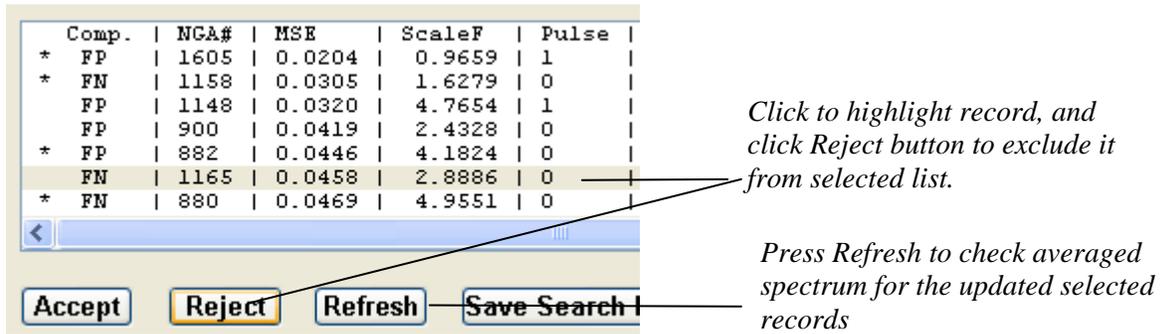
After inspecting the records, it was decided to reject records #FP1148, #FP 900, # FN 1165, and add records #FN882, #FN 1176, #FN 850 into the list of selected records. Figure 48 shows the operation to include or exclude an individual record. **Note that the selected records always have * symbol in the front.** The finalized 7 selected records are summarized in Table 4.

	Comp.	NGA#	MSE	ScaleF	Pulse	Tp(s)	D5-95(s)	Event	Year	Station
*	FP	1605	0.0204	0.9659	1	5.6	10.7	Duzce, Turkey	1999	Duzce
*	FN	1158	0.0305	1.6279	0	--	11.7	Kocaeli, Turkey	1999	Duzce
*	FP	1148	0.0320	4.7654	1	6.7	10.3	Kocaeli, Turkey	1999	Arcelik
*	FP	900	0.0419	2.4328	0	--	19.6	Landers	1992	Yermo Fire Station
*	FP	882	0.0446	4.1824	0	--	36.3	Landers	1992	North Palm Springs
*	FN	1165	0.0458	2.8886	0	--	15	Kocaeli, Turkey	1999	Izmit
*	FN	880	0.0469	4.9551	0	--	40.2	Landers	1992	Mission Creek Fault
	FN	1176	0.0542	1.4447	1	4.5	15.4	Kocaeli, Turkey	1999	Yarimca
	FN	882	0.0548	3.5972	0	--	37	Landers	1992	North Palm Springs
	FN	850	0.0565	3.1467	0	--	32	Landers	1992	Desert Hot Springs
	FN	1148	0.0603	6.1362	0	--	11	Kocaeli, Turkey	1999	Arcelik
	FN	879	0.0639	1.3167	1	5.1	0	Landers	1992	Lucerne
	FN	864	0.0648	1.5641	0	--	26	Landers	1992	Joshua Tree
	FN	881	0.0691	2.6821	0	--	32.1	Landers	1992	Morongo Valley
	FP	1165	0.0703	2.3389	0	--	13.2	Kocaeli, Turkey	1999	Izmit
	FP	1158	0.0710	1.1277	0	--	10.1	Kocaeli, Turkey	1999	Duzce
	FP	879	0.0748	2.3563	0	--	0	Landers	1992	Lucerne
	FP	1176	0.0773	1.5754	1	4.6	14.9	Kocaeli, Turkey	1999	Yarimca
	FP	1616	0.0798	16.2979	0	--	20.4	Duzce, Turkey	1999	Lamont 362
	FN	1613	0.0809	16.3877	0	--	18.9	Duzce, Turkey	1999	Lamont 1060
	FP	1611	0.0841	5.8687	0	--	15.2	Duzce, Turkey	1999	Lamont 1058
	FP	1613	0.0841	14.7757	0	--	12.5	Duzce, Turkey	1999	Lamont 1060
	FN	1605	0.0907	1.1212	0	--	10.9	Duzce, Turkey	1999	Duzce
	FN	1616	0.0943	12.7918	0	--	19.3	Duzce, Turkey	1999	Lamont 362
	FP	1787	0.0959	2.1522	0	--	11.2	Hector Mine	1999	Hector
	FP	850	0.1015	3.7581	0	--	31.8	Landers	1992	Desert Hot Springs
	FN	900	0.1238	2.0259	1	7.5	17.2	Landers	1992	Yermo Fire Station
	FP	880	0.1271	6.9522	0	--	34.7	Landers	1992	Mission Creek Fault
	FN	2114	0.1300	1.1102	0	--	25.4	Denali, Alaska	2002	TAPS Pump Station #10
	FP	864	0.1360	1.9355	0	--	27.2	Landers	1992	Joshua Tree

(continue to the graph below)

Mag	Mechanism	Rjb(km)	Rrup(km)	Vs30(m/s)	Low.freq(Hz)	Horiz. Acc. File Name	Vertical Acc. File Name
7.14	Strike-Slip	0.0	6.6	276.0	0.10	DUZCE/DZC FP.acc	DUZCE/DZC-UP.AT2
7.51	Strike-Slip	13.6	15.4	276.0	0.24	KOCAELI/DZC FN.acc	KOCAELI/DZC-UP.AT2
7.51	Strike-Slip	10.6	13.5	523.0	0.09	KOCAELI/ARC FP.acc	KOCAELI/ARCDWN.AT2
7.28	Strike-Slip	23.6	23.6	353.6	0.07	LANDERS/YER FP.acc	LANDERS/YER-UP.AT2
7.28	Strike-Slip	26.8	26.8	345.4	0.28	LANDERS/NPS FP.acc	LANDERS/NPS-UP.AT2
7.51	Strike-Slip	3.6	7.2	811.0	0.13	KOCAELI/IZT FN.acc	KOCAELI/IZT-UP.AT2
7.28	Strike-Slip	27.0	27.0	345.4	0.11	LANDERS/MCF FN.acc	LANDERS/MCF-UP.AT2
7.51	Strike-Slip	1.4	4.8	297.0	0.09	KOCAELI/YPT FN.acc	KOCAELI/YPT-UP.AT2
7.28	Strike-Slip	26.8	26.8	345.4	0.28	LANDERS/NPS FN.acc	LANDERS/NPS-UP.AT2
7.28	Strike-Slip	21.8	21.8	345.4	0.07	LANDERS/DSP FN.acc	LANDERS/DSP-UP.AT2
7.51	Strike-Slip	10.6	13.5	523.0	0.09	KOCAELI/ARC FN.acc	KOCAELI/ARCDWN.AT2
7.28	Strike-Slip	2.2	2.2	684.9	0.10	LANDERS/LCN FN.acc	LANDERS/LCN-UP.AT2
7.28	Strike-Slip	11.0	11.0	379.3	0.07	LANDERS/JOS FN.acc	LANDERS/JOS-UP.AT2
7.28	Strike-Slip	17.3	17.3	345.4	0.28	LANDERS/MVH FN.acc	LANDERS/MVH-UP.AT2
7.51	Strike-Slip	3.6	7.2	811.0	0.13	KOCAELI/IZT FP.acc	KOCAELI/IZT-UP.AT2
7.51	Strike-Slip	13.6	15.4	276.0	0.24	KOCAELI/DZC FP.acc	KOCAELI/DZC-UP.AT2
7.28	Strike-Slip	2.2	2.2	684.9	0.10	LANDERS/LCN FP.acc	LANDERS/LCN-UP.AT2
7.51	Strike-Slip	1.4	4.8	297.0	0.09	KOCAELI/YPT FP.acc	KOCAELI/YPT-UP.AT2
7.14	Strike-Slip	23.4	23.4	517.0	0.07	DUZCE/362 FP.acc	DUZCE/362-V.AT2
7.14	Strike-Slip	25.8	25.9	782.0	0.07	DUZCE/1060 FN.acc	DUZCE/1060-V.AT2
7.14	Strike-Slip	0.2	0.2	424.8	0.07	DUZCE/105 FN.acc	DUZCE/1058-V.AT2
7.14	Strike-Slip	25.8	25.9	782.0	0.07	DUZCE/106 FN.acc	DUZCE/1060-V.AT2
7.14	Strike-Slip	0.0	6.6	276.0	0.10	DUZCE/DZC FN.acc	DUZCE/DZC-UP.AT2
7.14	Strike-Slip	23.4	23.4	517.0	0.07	DUZCE/362 FN.acc	DUZCE/362-V.AT2
7.13	Strike-Slip	10.4	11.7	684.9	0.04	HECTOR/HEC FP.acc	HECTOR/HECVER.AT2
7.28	Strike-Slip	21.8	21.8	345.4	0.07	LANDERS/DSP FP.acc	LANDERS/DSP-UP.AT2
7.28	Strike-Slip	23.6	23.6	353.6	0.07	LANDERS/YER FN.acc	LANDERS/YER-UP.AT2
7.28	Strike-Slip	27.0	27.0	345.4	0.11	LANDERS/MCF FP.acc	LANDERS/MCF-UP.AT2
7.90	Strike-Slip	0.2	2.7	329.4	0.03	DENALI/ps10 FN.acc	DENALI/ps10-UP.AT2
7.28	Strike-Slip	11.0	11.0	379.3	0.07	LANDERS/JOS FP.acc	LANDERS/JOS-UP.AT2

Figure 47: DGML Search Result

```
    Comp. | NGA# | MSE    | ScaleF | Pulse |
*   FP    | 1605 | 0.0204 | 0.9659 | 1     |
*   FN    | 1158 | 0.0305 | 1.6279 | 0     |
    FP    | 1148 | 0.0320 | 4.7654 | 1     |
    FP    | 900  | 0.0419 | 2.4328 | 0     |
*   FP    | 882  | 0.0446 | 4.1824 | 0     |
    FN    | 1165 | 0.0458 | 2.8886 | 0     |
*   FN    | 880  | 0.0469 | 4.9551 | 0     |
```

[Accept] [Reject] [Refresh] [Save Search]

Click to highlight record, and click Reject button to exclude it from selected list.

Press Refresh to check averaged spectrum for the updated selected records

```
    FP    | 900  | 0.0419 | 2.4328 | 0     |
*   FP    | 882  | 0.0446 | 4.1824 | 0     |
    FN    | 1165 | 0.0458 | 2.8886 | 0     |
*   FN    | 880  | 0.0469 | 4.9551 | 0     |
*   FN    | 1176 | 0.0542 | 1.4447 | 1     |
*   FN    | 882  | 0.0548 | 3.5972 | 0     |
*   FN    | 850  | 0.0565 | 3.1467 | 0     |
    FN    | 1148 | 0.0603 | 6.1362 | 0     |
```

[Accept] [Reject] [Refresh] [Save Search]

Click to highlight record and click Accept button to include it in the selected list

Press Refresh to check average spectrum for the updated selected records

Figure 48: Modify the List of Selected Records and Re-average

Table 4. Selected Ground Motion Records

Comp.	NGA#	Scale Factor	Pulse	Tp (sec)	D5-95 (sec)	Event	Year	Station	Mag	Mechanism	Rjb (km)	Rrup (km)	Vs30 (m/s)	Low.Freq (Hz)
FP	1605	0.966	1	5.6	10.7	Duzce, Turkey	1999	Duzce	7.1	Strike-Slip	0	6.6	276	0.10
FN	1158	1.638	0	---	11.7	Kocaeli, Turkey	1999	Duzce	7.5	Strike-Slip	13.6	15.4	276	0.24
FP	882	4.182	0	---	36.3	Landers	1992	North Palm Springs	7.3	Strike-Slip	26.8	26.8	345	0.28
FN	880	4.955	0	---	40.2	Landers	1992	Mission Creek Fault	7.3	Strike-Slip	26.8	26.8	345	0.11
FN	1176	1.445	1	4.5	15.4	Kocaeli, Turkey	1999	Yarimca	7.5	Strike-Slip	1.4	4.8	297	0.09
FN	882	3.597	0	---	37	Landers	1992	North Palm Springs	7.3	Strike-Slip	26.8	26.8	345	0.28
FN	850	3.147	0	---	32	Landers	1992	Desert Hot Springs	7.3	Strike-Slip	21.8	21.8	345	0.07

For the seven selected records, significant duration (5 to 95% of Arias Intensity) ranged from 11 to 40 seconds with an average of about 26 seconds. The average is very close to the median value of about 27 seconds for a magnitude 7.8 earthquake at 10km distance based on the correlation of Kempton and Stewart (2006) in Table 1 of the main report. Two pulse records are included in the data set, with estimated pulse periods in the range of 4.5 to 5.6 seconds. Although pulse periods of these amplitudes are reasonable for a large-magnitude earthquake (see Figure 9 of the report), it could be desirable to have a record set with a wider range of pulse periods, or a larger number of pulse records, depending on the structural characteristics and response. The average spectrum for the seven selected records is shown in Figure 49, and the background shows the spectra of all 30 listed records. The averaged spectrum has a close match to the target spectrum in the significant period range of 0.3 to 3 sec. The acceleration, velocity, and displacement time histories of the selected records are shown in Figure 50.
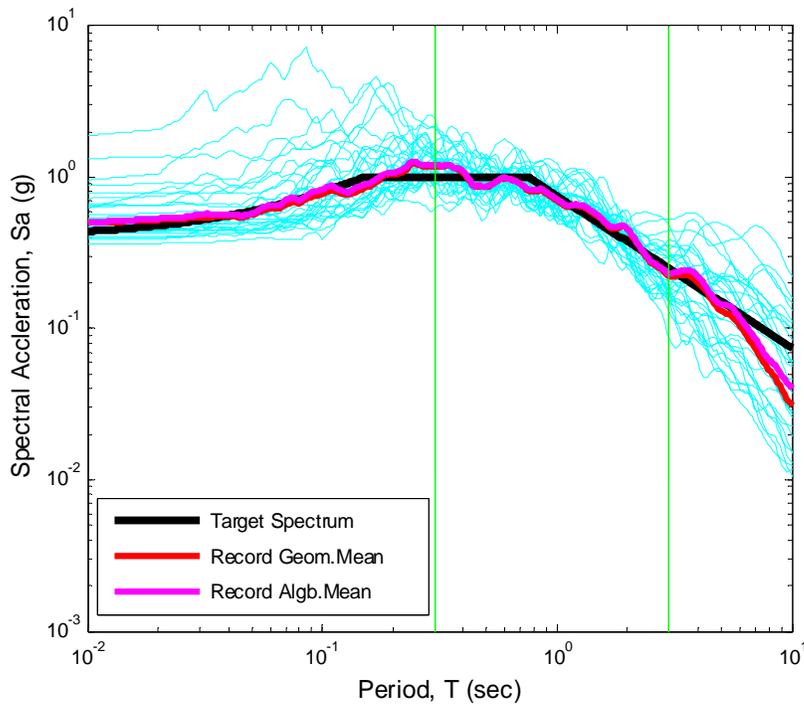
Figure 49: Average Spectrum of 7 Selected Records
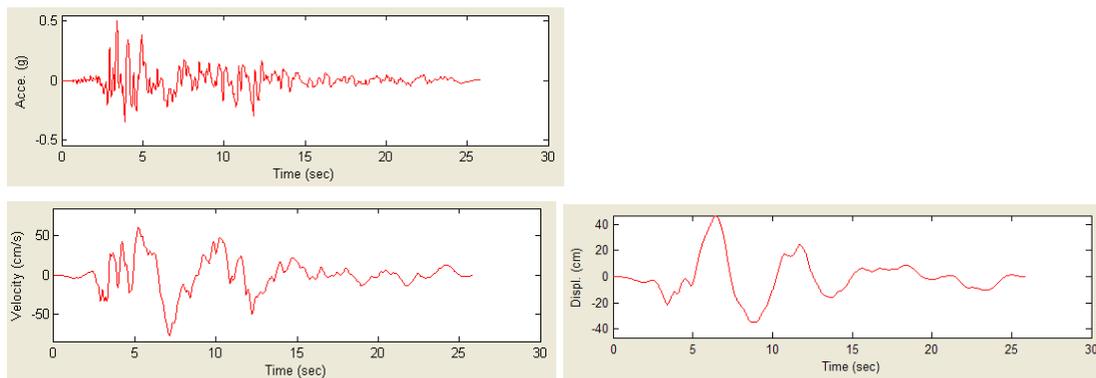
Record #FP 1605
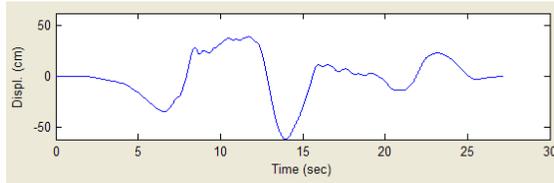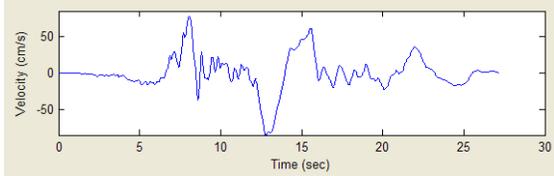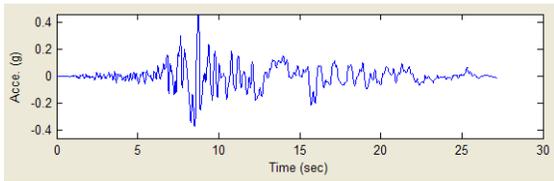
Record # FN 1158
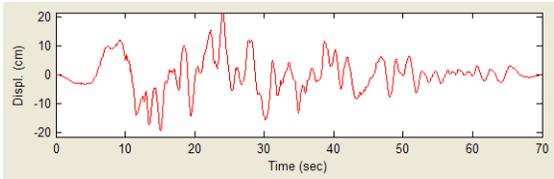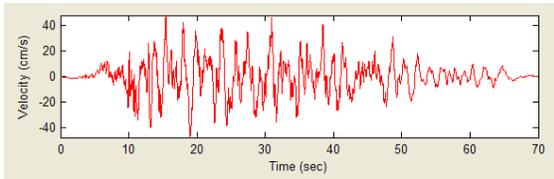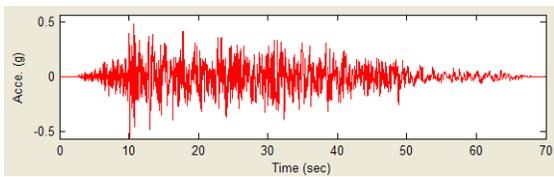
Record # FP 882
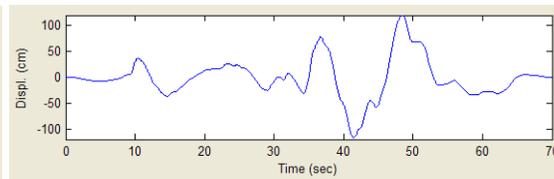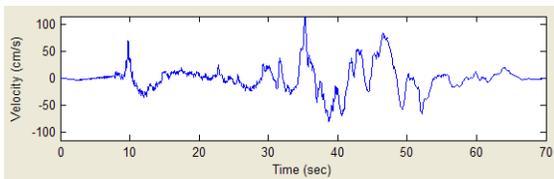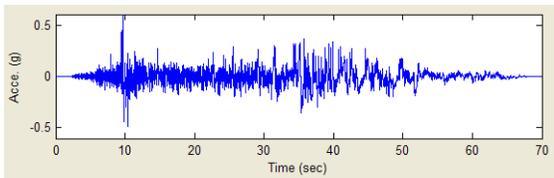
Record # FN 880
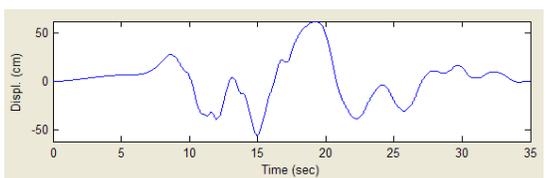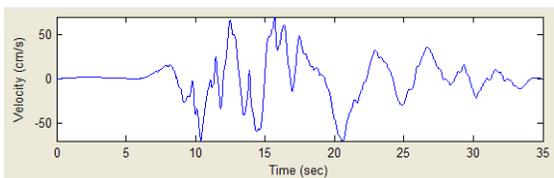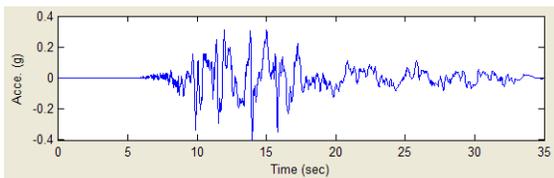
Record # FN 1176
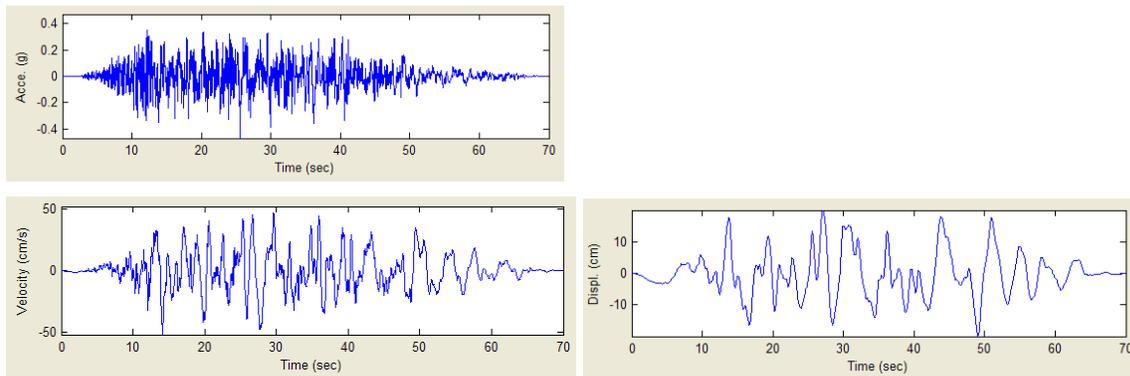
Record # FN 882
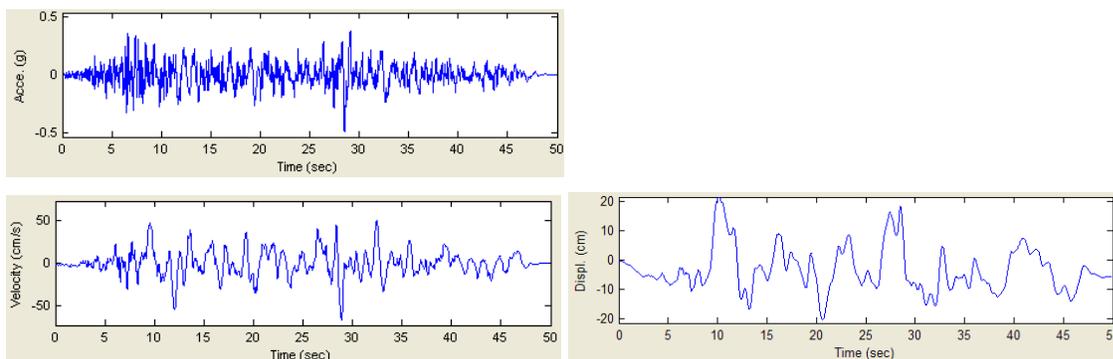
Record # FN 850

Figure 50: The Acceleration, Velocity and Displacement Time Histories of Selected Records

5.2 USE DGML SUPPLEMENTARY SEARCH ENGINE

The previous example illustrates the steps to use DGML's default search engine to select and modify ground motion records. In DGML Version 2, a supplementary search engine is provided to enhance the search capability, which is documented in Section 4.3 of this manual. The supplementary search engine is useful to inspect the properties of a set of records according to specified sequence of NGA numbers, and/or event name, station name.

Step 1. Switch to Supplementary Search Engine

Press "Switch" button to activate the Supplementary Search Engine. The user interface is shown in Figure 51.

Step 2. Search According to NGA Numbers

The final result from Example 5.1 can be easily reproduced using the Supplementary Search Engine. First, specify the NGA sequence numbers with the rule set in Section 4.3. The "Components", "Pulse", and other options also need to be set properly as shown in the Figure 51.

After pressing the "Search" button, only the specified seven records are displayed. The spectrum plots are shown in Figure 52, where the target spectrum, the average spectrum and each of the selected records are illustrated in colors. Please also notice the difference between Figure 52 with Figure 49, where the background in Figure 49 shows the spectra of all 30 listed records.

Step 3. Search According to Event Name

Assuming that the user particularly wants to include records from Northridge earthquake. one can use the Supplementary Search Engine to search records according to the "Event Name", as shown in Figure 53. All records with "Event Name" containing the key word "Northridge" will be searched and displayed.

Step 4. Modify Search to Include a Particular Record

The Supplementary Search Engine is also useful to add particular records into a group. Assume that after inspecting all "Northridge" records in Step 3, the user wants to include FP component of NGA #1057 record to replace the last record (FN NGA#850) used in Step 2. The task can be easily achieved by specifying an updated set of seven records by the "NGA Number Sequence" as shown in Figure 54, where 850 was replaced by -1057. The spectra for the updated set are shown in Figure 55.
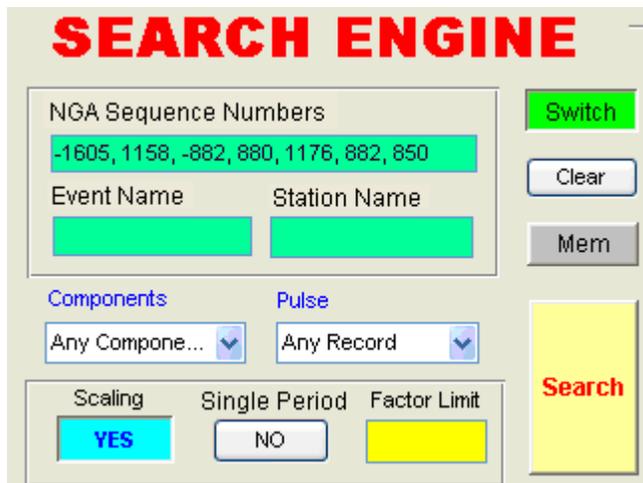
Figure 51: Search by NGA Sequence Using The Supplementary Search Engine
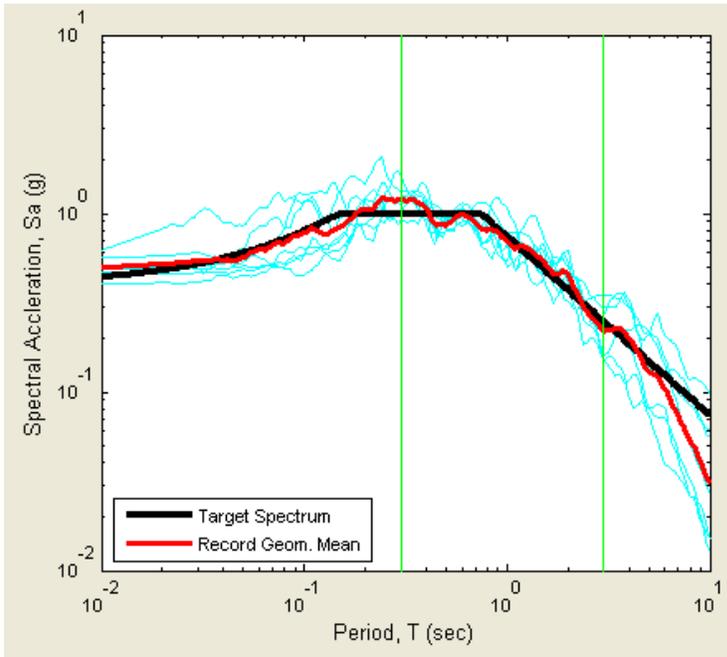
Figure 52: Plot Spectra of Selected 7 Records

Figure 53: Search by Event Name Using the Supplementary Search Engine

Figure 54: Update to Include the Northridge Record
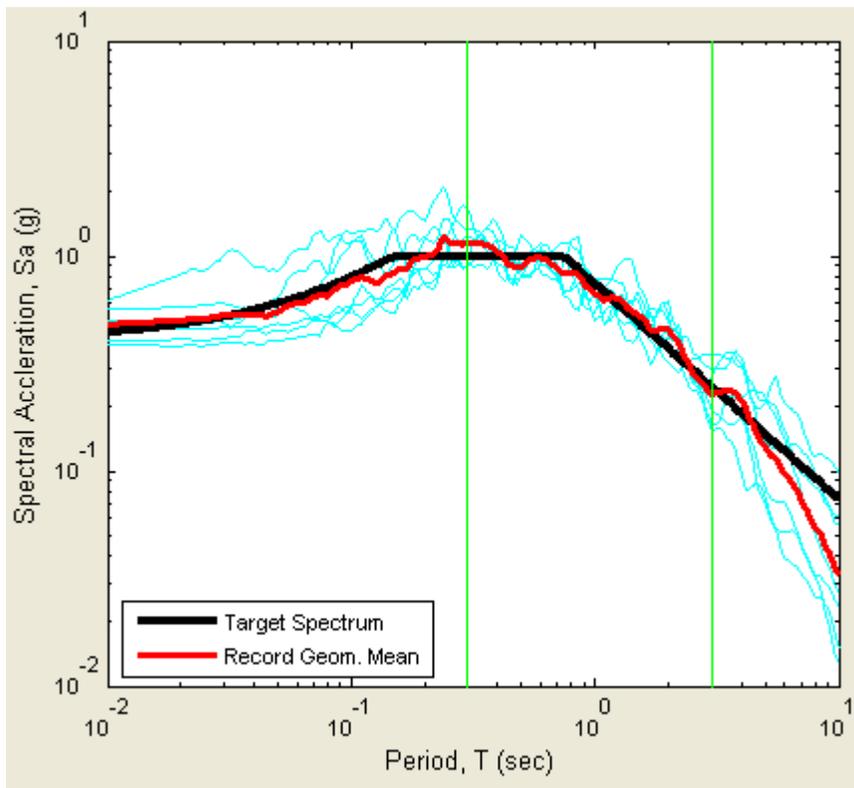
Figure 55: Plot Spectra of Updated 7 Records

6. DGML MATLAB SOURCE CODE

DGML was developed using Matlab ® version 7.2 Graphic User Interface (GUI). The DGML Matlab source codes were compiled into standalone executable so that no Matlab environment is required for common users. The DGML Matlab source codes are also provided in the DVD release. Advanced users can execute or modify the source codes in Matlab environment. The section provides brief descriptions of the DGML source codes for advanced programmers, and it can be skipped by common users. Relevant references on Matlab GUI programming should be consulted if necessary.

6.1 INTRODUCTION

The Matlab source codes are stored in "DVD:\DGML\" directory, with Matlab utility files stored in "DVD:\DGML\Utility\" directory. The utility files are Matlab .mat files that store pre-processed NGA database information, such as spectrum values, earthquake magnitudes and distances, etc. The utility files are called by DGML in real time, serving as input data for various subroutines. DGML can be updated by simply updating the utility files without re-compiling the whole system.

There are two types of source files under "DVD:\DGML\" directory. The *.fig files are Matlab figure files used to design the GUI layout, and *.m files are Matlab source files that provide the callback functions of the GUI objects and perform other operations. Brief descriptions of the source codes are given in Table 5.

Table 5. Descriptions of DGML Matlab Source Codes

Matlab Source Codes	Description
DGMLStart.fig	GUI layout of DGML Start page
DGMLStart.m	Main program of DGML Start GUI
NGATargetSpectrum.fig	GUI layout of Target Spectrum page
NGATargetSpectrum.m	Main program of Target Spectrum GUI
AS2008.m	Subroutine to compute Abrahamson and Silva (2008) NGA spectrum
BA2008.m	Subroutine to compute Boore-Atkinson(2008) NGA spectrum
CB2008.m	Subroutine to compute Campbell- Bozorgnia (2008) NGA spectrum
CY2008.m	Subroutine to compute Chiou-Youngs (2008) NGA spectrum
Idriss2008.m	Subroutine to compute Idriss (2008) NGA spectrum
ComputeEpsilon.m	Subroutine to compute correlation coefficient based on Baker & Jayaram (2008)

DGMLLibPostProcessor.fig	GUI layout of DGML Search Engine page
DGMLLibPostProcessor.m	Main program of DGML Search Engine
DGMLLibSearchEngine.m	Core code segment of DGML search engine.
ComputeAccVelDispTimeHistory.m	Subroutine to read in acceleration time history data from a file in NGA database, and compute the velocity and displacement time history.
fixPSlinestyle.m	Subroutine to fix the dashed line style in post script figure output

6.2 RUN DGML IN MATLAB

Beside running the pre-compiled program on DVD, DGML can be executed directly using Matlab ® version 7.2 or higher. By setting "DVD:\DGML\" as the working directory, DGML can be started by calling DGMLStart.m function as follows,

>> DGMLStart

6.3 VIEW GUI OBJECT CALLBACK FUNCTIONS

Matlab command "guide" can be used to open each GUI *.fig file. Type the following command in Matlab:

>> guide

The command will show existing GUI files that can be opened, as in Figure 56. For example, if one selects to click open "NGATargetSpectrum.fig", the GUI layout of "Target Spectrum" page will be shown in Figure 57. The GUI Layout of "Search Engine" page is shown in Figure 58. Developer can resize each GUI object (buttons, menus, etc.) by clicking and dragging. GUI programming is "event-driven", i.e., a user-defined call-back function will be invoked when a button is clicked, or a drop menu is selected and so on. To view the call-back function of a GUI object, one can right-click a GUI object, and the related object call-back functions can be selected from the pop-up menu. Figure 59 illustrates the procedure to view call back function of the "Create" button on NGATargetSpectrum.fig. Figure 60 shows the source code of the callback function when "Create" button is pressed.
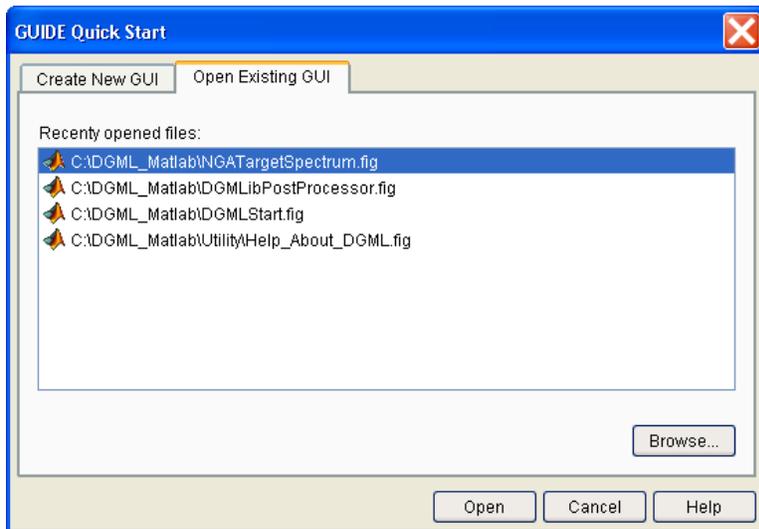
Figure 56: Use Matlab "Guide" Command to Open DGML GUI
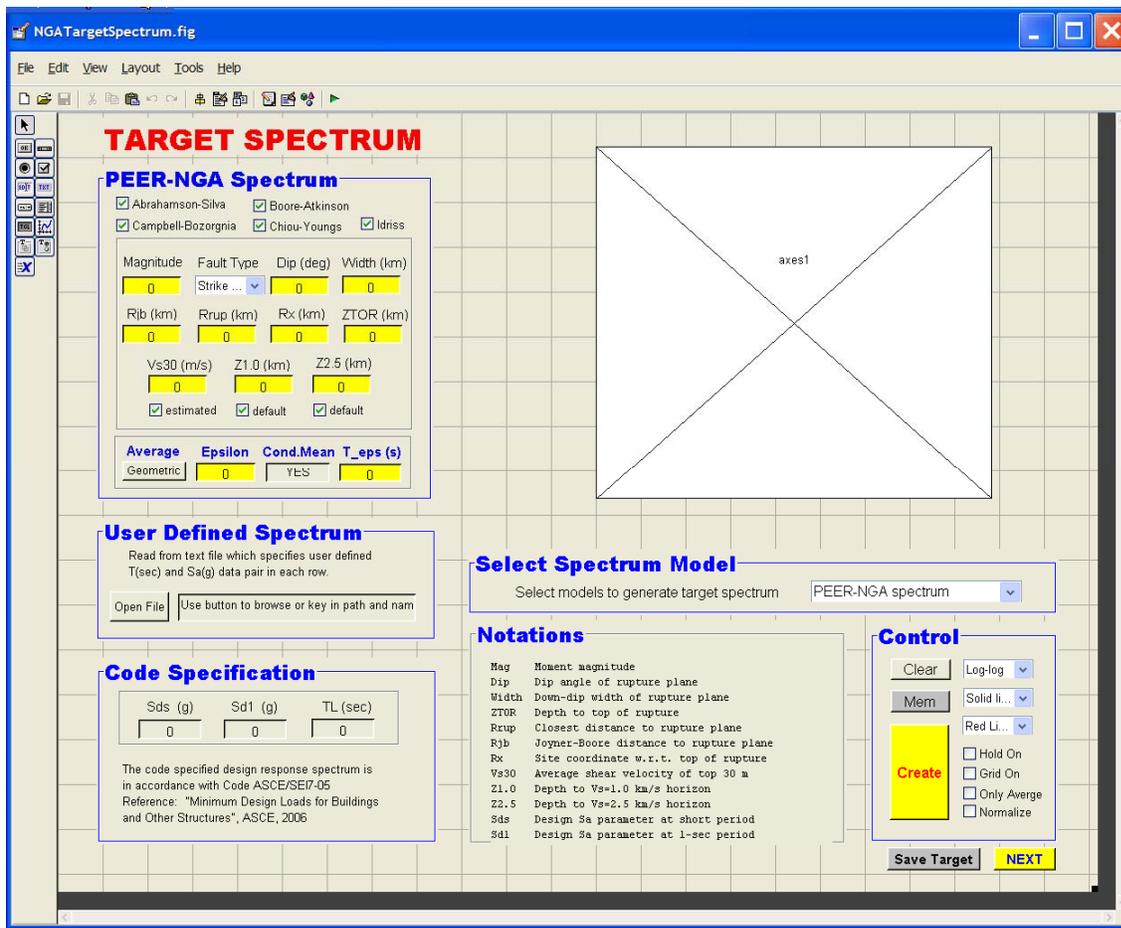
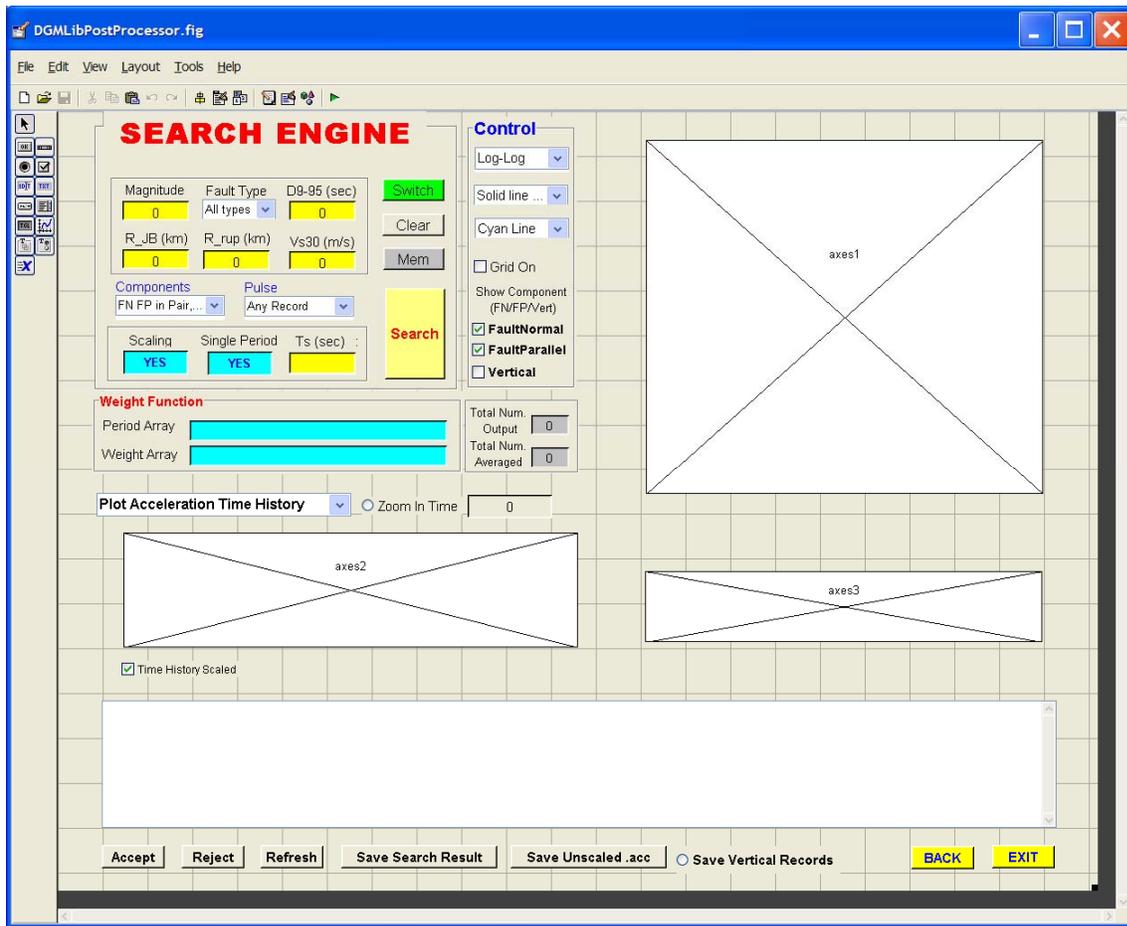

Figure 57: GUI Layout of "Target Spectrum" Page

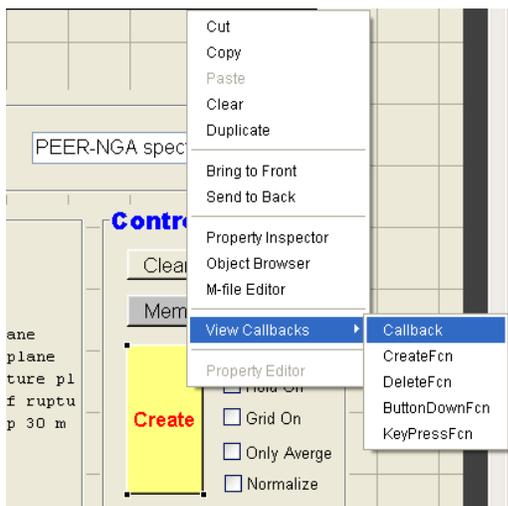**Figure 58:** GUI Layout of "Search Engine" Page

Figure 59: View Callback Functions of a GUI Object

Figure 60: Source Code of a Callback Function

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Summary of PEER-NGA Records Included in and Excluded from DGML Database (tables in electronic form on DVD)