

# SEISMOGRAPH

Quick Start Guide (B)

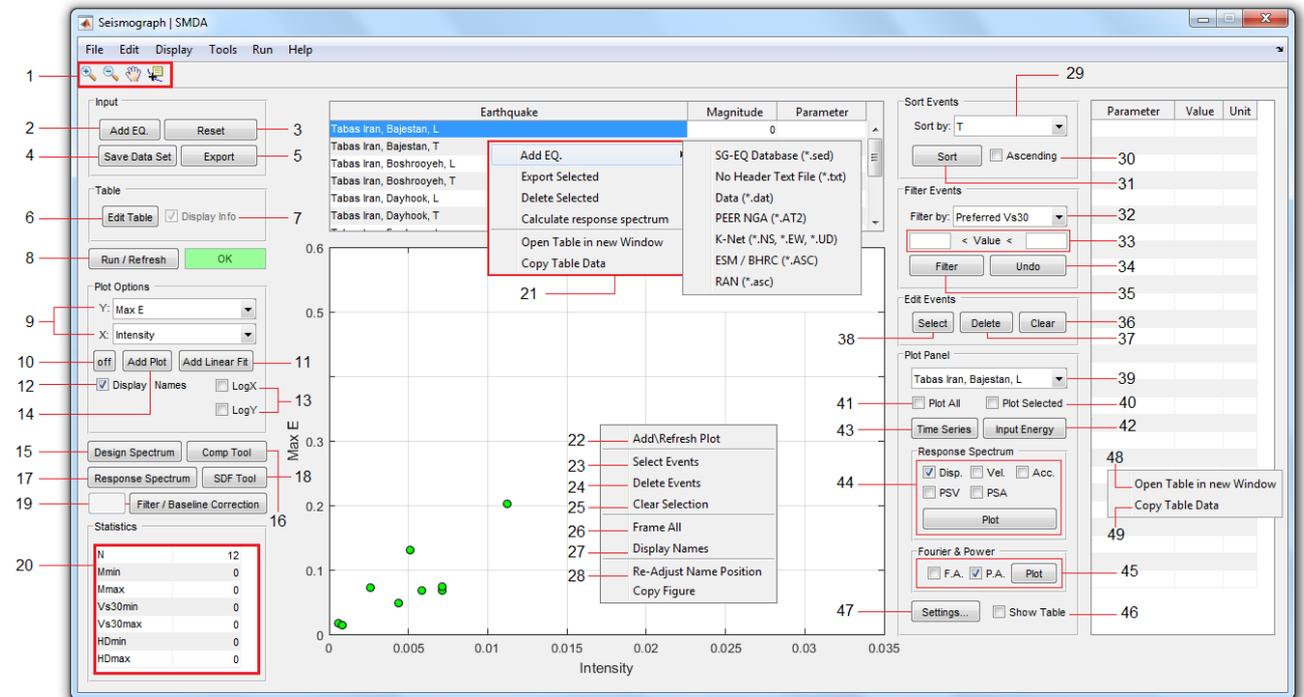
**SMDA** (v9.0)

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## 1. Main Window



### 1. Main Toolbar, including the following tools:

1. **Zoom in**
2. **Zoom out**
3. **Pan**
4. **Datacursormode** (enables selecting a point on the plot and opens a data tip displaying its coordinates)
2. Add new record<sup>1</sup>(s) to the current database.
3. Create a new project.
4. Save current database as new file. (\*.sed)
5. Save selected records from the table to text file (\*.txt). Filenames will be automatically determined using the earthquake name and the record station.
6. Use this button to view and edit all record's information in a table.
7. Enable this checkbox to see all available information for the selected record in a panel on the right-side of the main window:

<sup>1</sup> Available File Formats: \*.sed / \*.txt, \*.acc, \*.cor / \*.dat / \*.AT2 / \*.NS / \*.EW / \*.UD / \*.ASC / \*.mat

Click on any parameter from this list to display it in the main table. Selected parameters are added to the third column of the main table. Conversely, if you select multiple records from the main table, their parameters will be added to this table.

Depth	Depth of earthquake
Vs30	Average shear wave velocity at the upper 30-m depth
Ep. Dist.	Distance from the recording site to the epicenter
Hp. Dist.	Distance from the recording site to the hypocenter.
<a href="#">PGA</a>	Peak acceleration of ground motion
<a href="#">PGV</a>	Peak velocity of ground motion
<a href="#">PGD</a>	Peak displacement of ground motion
Power	Area of the PSD Function
Intensity	Maximum of the PSD Function
FA Area	Area of the Fourier Amplitude
Amax	Maximum of the Fourier Amplitude
Ca	$\int_{-\infty}^{\infty} a(t)^2 dt$
Vmax	Maximum of the Fourier Amplitude for Velocity
Cv	$\int_{-\infty}^{\infty} v(t)^2 dt$
<a href="#">Max E</a>	Maximum of total input energy per unit mass
<a href="#">T</a>	The period at which <b>Max E</b> OCCURS
Max Et	Maximum credible total input energy
Tt	The period at which <b>Max Et</b> occurs
Duration	Total duration
U Duration	Uniform duration
B Duration	Bracketed duration
S Duration	Significant duration
S/s Ratio	The ratio of the area below the PSDF to its maximum value (which is an indicative of the frequency range)
Et/E Ratio	The ratio of the maximum possible value of the energy to its maximum actual value
Tt/T Ratio	-
<a href="#">PGV/PGA</a>	-
<a href="#">Arias Intensity</a>	$\frac{\pi}{2g} \int_{-\infty}^{\infty} a(t)^2 dt$

Parameter	Value	Unit
Depth	5.75	km
Vs30	324.57	m/s
Ep. Dist.	74.66	km
Hp. Dist.	74.88	km
<a href="#">PGA</a>	0.10553	g
<a href="#">PGV</a>	13.298	cm/s
<a href="#">PGD</a>	7.633	cm
Power	0.11527	
Intensity	0.011224	
FA Area	3.5287	m/s <sup>2</sup>
Amax	1.039	m/s
Ca	1.7643	m <sup>2</sup> /s <sup>3</sup>
Vmax	0.43597	m
Cv	0.050566	m <sup>2</sup> /s
<a href="#">Max E</a>	0.20152	m <sup>2</sup> /s <sup>2</sup>
<a href="#">T</a>	0.5	s
Max Et	0.51852	m <sup>2</sup> /s <sup>2</sup>
Tt	2.4073	s
Duration	34.98	s
U Duration	1.6792	s
B Duration	16.42	s
S Duration	19.48	s
S/s Ratio	10.2698	
Et/E Ratio	0.38863	
Tt/T Ratio	0.2077	
<a href="#">PGV/PGA</a>	0.1285	s
<a href="#">Arias Intensity</a>	0.28261	m/s

8. Use this button to calculate and store the computational data. When the calculation is completed for all records, the status bar will turn into green. If the computational data is not available for a number of records, the number of these records will appear in the status bar with a minus sign. In this case you can continue the calculation for the same number of records using the Continue option from the Run menu.

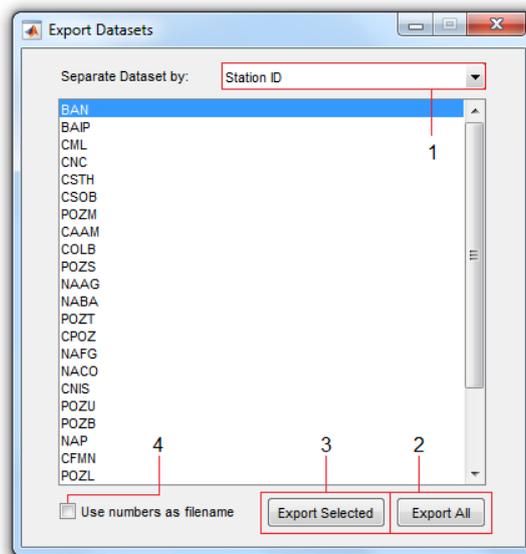
9. Select the desired quantities for the X and Y axis of the graph from these menus.
10. By default, when you select a record from the main table, its time histories are displayed. Using this button, you can switch the X-Y plot on or off.
11. Use this button to fit a Linear Regression model to the current plot data
12. Enable this checkbox to display name of the all records on the chart. (If some of the events are selected using options **23** or **38**, only names of those events will be displayed)
13. Enable these checkboxes to use a logarithmic scale for X or Y axis.
14. Use this button to add the selected plot (defined by options **9**).
15. Design Spectrum Tool
16. Records Comparison Tool
17. Response Spectrum Tool
18. SDOF Analyzer Tool
19. Filtering and Baseline Correction Tool
20. Some statistical information about the database is available in this table. (Including number of records, maximum and minimum magnitudes, maximum and minimum shear wave velocity, and maximum and minimum hypocentral distance)
21. **Table right-click Menu**, including shortcut for options **2** (Add new record), **5** (Save selected records), **37** (Delete selected records) and **17** (Response Spectrum Tool).

*Axes Right-click menu
<ol style="list-style-type: none"> <li>22. Add plot using the selected quantities for the X and Y data (same as button <b>10</b>)</li> <li>23. Select records on the chart</li> <li>24. Delete selected records</li> <li>25. Clear current selection</li> <li>26. Frame all data in the chart (After zooming in, you can use this option to return to full view)</li> <li>27. Display name of all (or selected) records on the chart. (same as checkbox <b>12</b>)</li> <li>28. Re-adjust the position of record's names</li> </ol>

29. To sort the table data, you need to select the desired quantity from the list. (Selecting any parameter from this list will replace it in the third column of the main table)
30. Enable this checkbox to sort the table data (by the selected quantity) in ascending order.
31. If checkbox **30** is disabled, this button will sort the table data in descending order. (default order)
32. To filter the table data, you need to select the desired quantity from this list. (Selecting any parameter from this list will replace it in the third column of the main table)
33. Enter the range of the desired quantity in these fields. (**Note:** Cannot filter by non-numeric quantities)
34. Use this button to restore filtered data.
35. Use this button to apply the filter. (**Note:** It is not possible to sort filtered data. If needed, sort before filtering.)
36. This button is used to clear the current selection.
37. Use this button to permanently delete selected records from the chart. (as well as from the table)
38. Use this button to select records on the chart.
39. Name of the selected record (when only one record is selected from the table) is displayed here.
40. If this checkbox is enabled, functions of the section **42** to **45** will be plotted for all selected records. You can select desired records from the table or select them on the chart. (**Note:** To avoid graphic issues, limit the number of selected records to 20)
41. If this checkbox is enabled, the selected function will be plotted for all available records. (**Note:** To avoid graphic issues, the function will be plotted only for the first 20 records)
42. Display the input energy per unit mass for selected record(s).
43. Display Acceleration, Velocity and Displacement time histories for selected record(s).
44. Enable the desired functions ( $S_d/S_v/S_a/PS_v/PS_a$ ) to be plotted using the Plot button.
45. Enable the desired functions (Fourier/Power Amplitude) to be plotted using the Plot button.

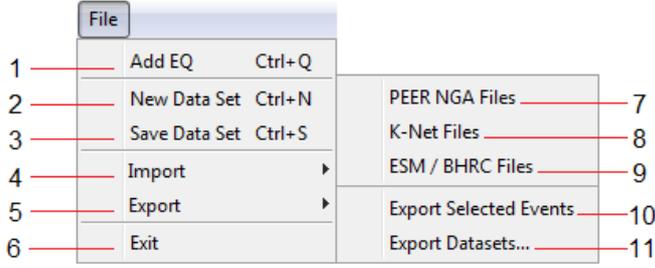
46. If this checkbox is enabled, the data corresponding to each function of the section **42** to **45** will also be displayed in a table. By displaying the table, its data will be automatically copied to the clipboard. (**Auto Copy** feature)
47. Use this button to change the calculation settings for the functions of sections **42** to **45**.
48. Display table data in a new window
49. Copy table data into clipboard

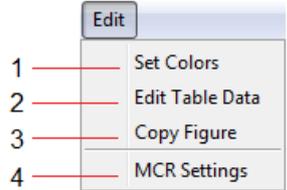
## 1.1 Dataset Export Tool

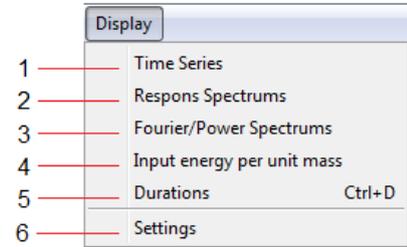


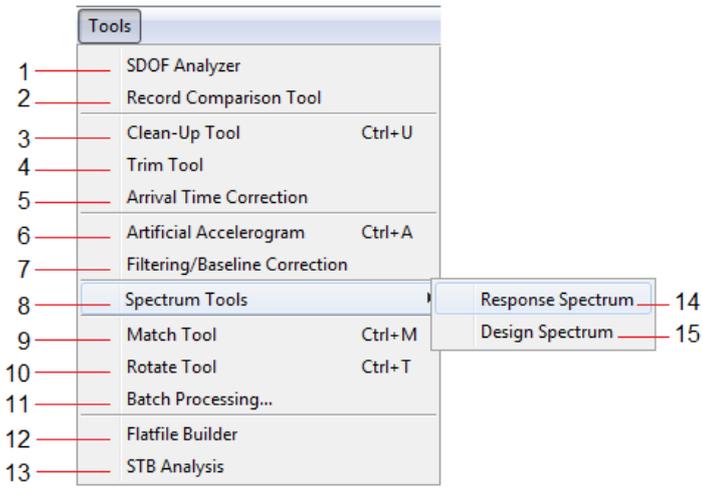
1. From this popup menu, you can sort and export the records based on Earthquake (Name), Station ID, Station Name, Component, or Magnitude.
2. Export all datasets from the list according to the selected separation method (e.g., by Station ID, Earthquake, etc.).
3. Exports only the datasets you have highlighted in the list.
4. If checked, the exported files will be named using numerical indices instead of their names (as shown in the list).

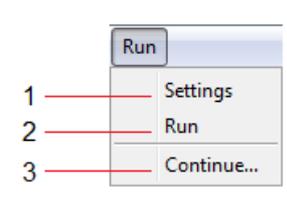
## 2. Menu Bar

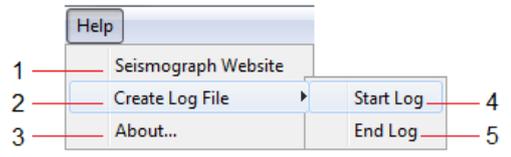
File	
	
<ol style="list-style-type: none"> <li>1. Add new record(s) to current database</li> <li>2. Create a new project</li> <li>3. Save current database as a new file (*.sed)</li> <li>4. Import multiple records from PEER, K-Net or BHRC database</li> <li>5. Export selected records <u>from the table</u> to text files (*.txt)</li> <li>6. Exit the application</li> </ol>	
Import	
<ol style="list-style-type: none"> <li>7. PEER Acceleration file (*.AT2)</li> <li>8. K-Net Records (*.NS / *.EW)</li> <li>9. ESM / BHRC files (*.ASC)</li> </ol>	
Export	
<ol style="list-style-type: none"> <li>1. Export selected records from the table to text files (*.txt)</li> <li>2. Dataset Export Tool</li> </ol>	

Edit	
<ol style="list-style-type: none"> <li>1. Assign custom color to different magnitudes in the database</li> <li>2. View and edit all records' information in a table</li> <li>3. Copy current axes to a new figure</li> <li>4. Access to MATLAB Runtime settings</li> </ol>	

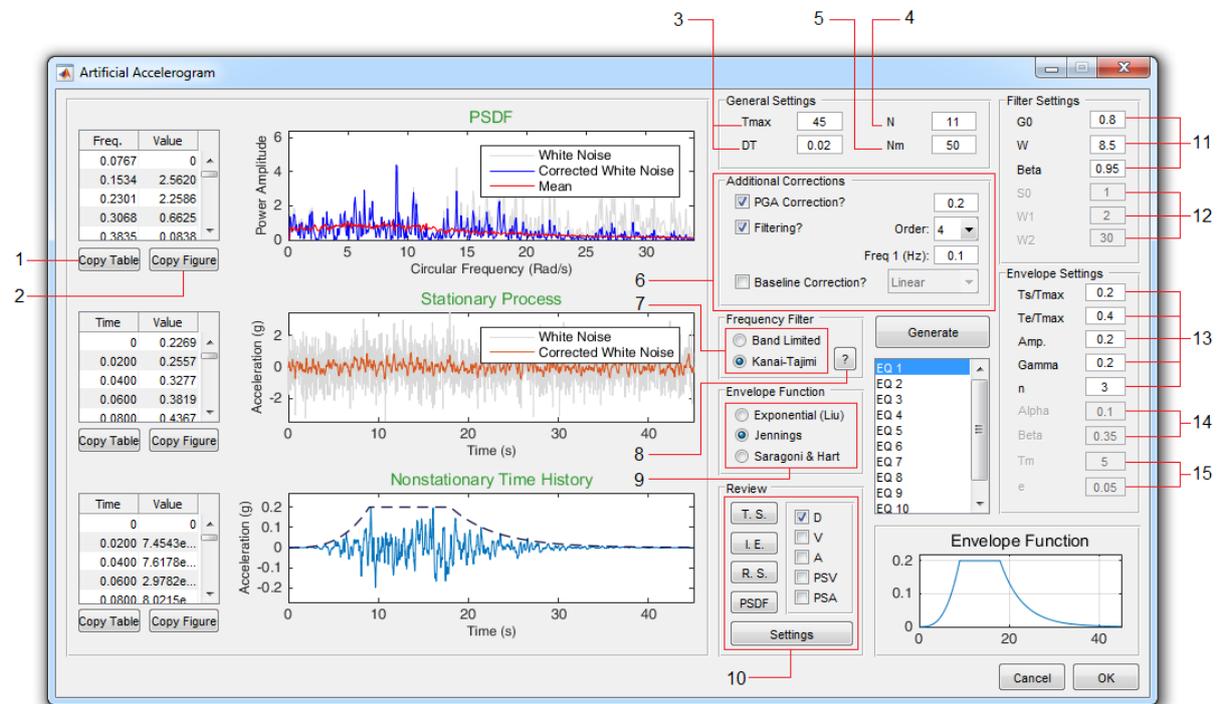
Display	
<ol style="list-style-type: none"> <li>1. Display the Acceleration, Velocity, and Displacement time histories</li> <li>2. Display the various Response Spectra (<math>S_d/S_v/S_a/PS_v/PS_a</math>)</li> <li>3. Display Fourier amplitude and power spectra</li> <li>4. Display the input energy per unit mass</li> <li>5. Duration Tool (to determine the various durations of the ground motion)</li> <li>6. Access to the calculation settings for the above functions</li> </ol>	

Tools	
<ol style="list-style-type: none"> <li>1. SDOF Analyzer</li> <li>2. Record Comparison Tool</li> <li>3. Clean-Up Tool (Ctrl+U)</li> <li>4. Trim Tool</li> <li>5. Arrival Time Correction</li> <li>6. Artificial Accelerogram (Ctrl+A)</li> <li>7. Filtering/Baseline Correction</li> <li>8. Spectrum Tools</li> <li>9. Match Tool (Ctrl+M)</li> <li>10. Rotate Tool (Ctrl+T)</li> <li>11. Batch Processing...</li> <li>12. Flatfile Builder</li> <li>13. STB Analysis</li> </ol>	
<ol style="list-style-type: none"> <li>1. SDOF Tool (dynamic analysis of SDF systems)</li> <li>2. Record Comparison Tool</li> <li>3. Records Clean-Up Tool (remove initial Rest time)</li> <li>4. Record Trim Tool</li> <li>5. Arrival Time Correction Tool</li> <li>6. Artificial Earthquake Tool (synthetic accelerogram)</li> <li>7. Filtering and Baseline Correction Tool</li> <li>8. Spectrum Tools</li> <li>9. Spectral Matching Tool</li> <li>10. Rotate Tool</li> <li>11. Batch Processing Tool</li> <li>12. FlatFile Builder Tool</li> <li>13. Station-Based Analysis Tool</li> </ol>	<p style="text-align: center;"><b>Spectrum Tools</b></p> <ol style="list-style-type: none"> <li>14. Response Spectrum Tool</li> <li>15. Design Spectrum Tool</li> </ol>

Run	
<ol style="list-style-type: none"> <li>1. Access to the Run settings</li> <li>2. Calculate the computational data for all records</li> <li>3. Calculate the computational data only for the remaining records</li> </ol>	

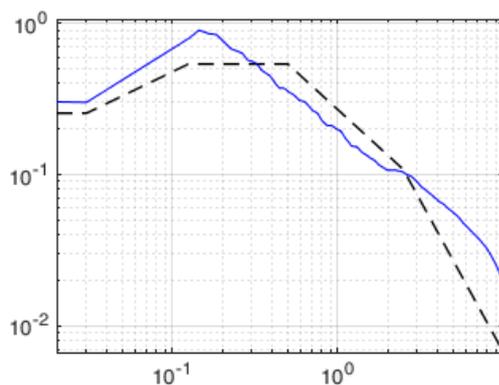
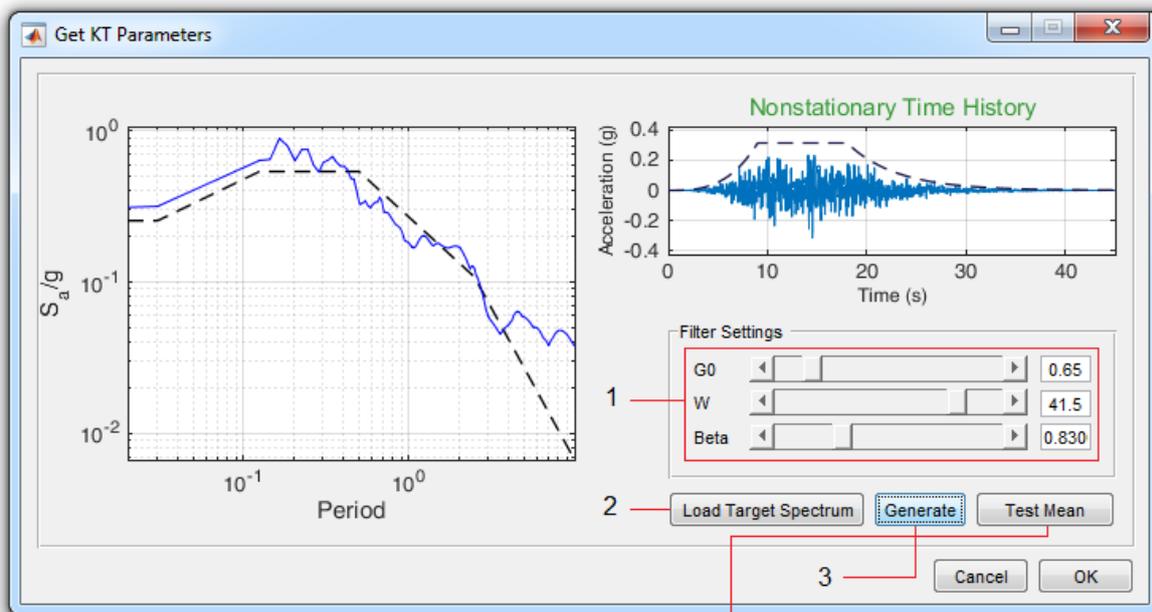
Help	
<ol style="list-style-type: none"> <li>1. Visit the product page on the website</li> <li>2. Create a Log file for bug report</li> <li>3. View description of the current version of the software</li> </ol>	
Create Log file	
<ol style="list-style-type: none"> <li>4. Start writing the Log file</li> <li>5. Stop writing the Log file (it is saved the in the software's installation folder).</li> </ol>	

### 3. Artificial Accelerogram Tool



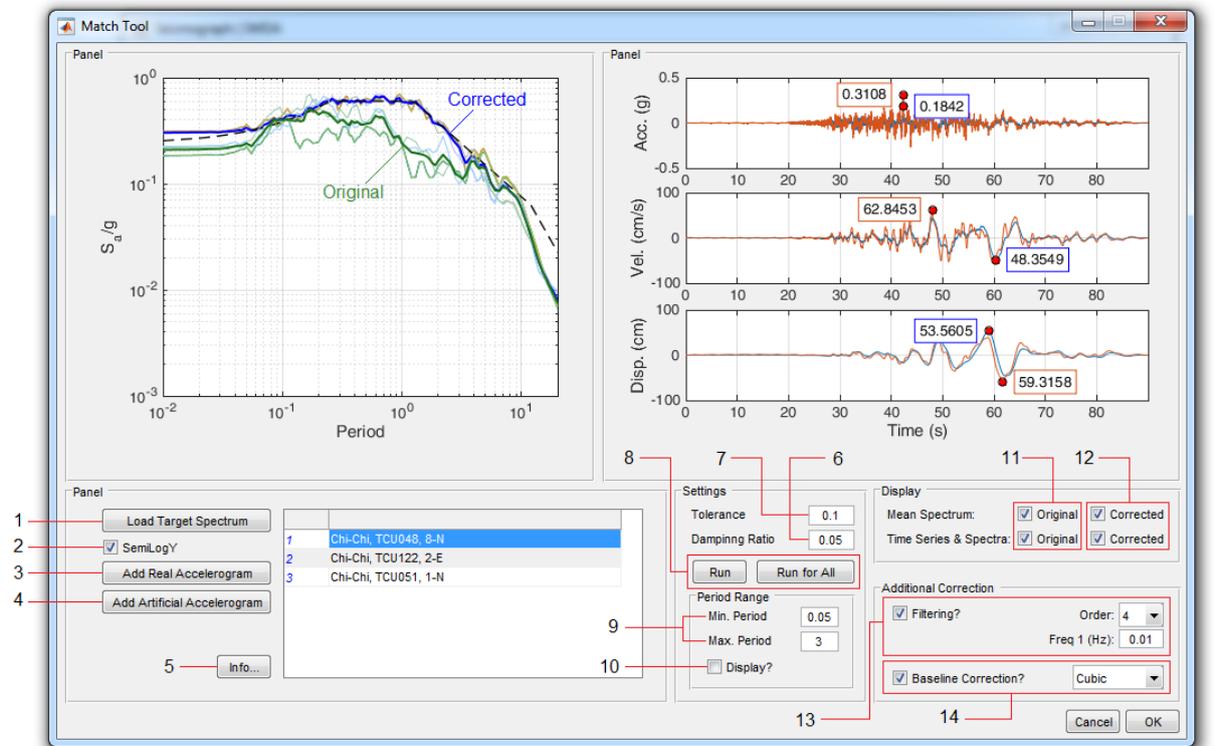
1. Copy table data into the clipboard.
2. Use this button to make a copy of the axes corresponding to this table in a new figure.
3. Duration and time step of the synthetic accelerogram.
4. Number of required artificial accelerograms to be generated.
5. Number of records for calculating Mean of the PSD Function for the synthetic accelerogram. (it is displayed on the first chart in red color)
6. To apply additional corrections (PGA Correction, Highpass Filtering and Baseline Correction) just enable its checkbox from this section.
7. Select the type of frequency filter.
8. Use this button to determine parameters of Kanai-Tajimi filter in accordance with a target spectrum.
9. Select the type of envelope function.
10. Use this section to review results and plot various response diagrams for selected Accelerogram. (Including: Time Series, Input Energy, Response Spectra and Power spectrum)
11. Kanai-Tajimi filter parameters. ( $\omega$  and  $\beta$  are the parameters of the overlaying soil deposits and  $G_0$  is the constant spectral intensity of the rock motions.)

12. Band-limited filter parameters. ( $S_0$  is the constant spectral intensity and  $\omega_1$  and  $\omega_2$  are the bounding frequencies over which the frequency content has non-zero value.)
13. Define parameters for Jennings envelope Function.
14. Define parameters for Exponential envelope Function.
15. Define parameters for Saragoni & Hart envelope Function.



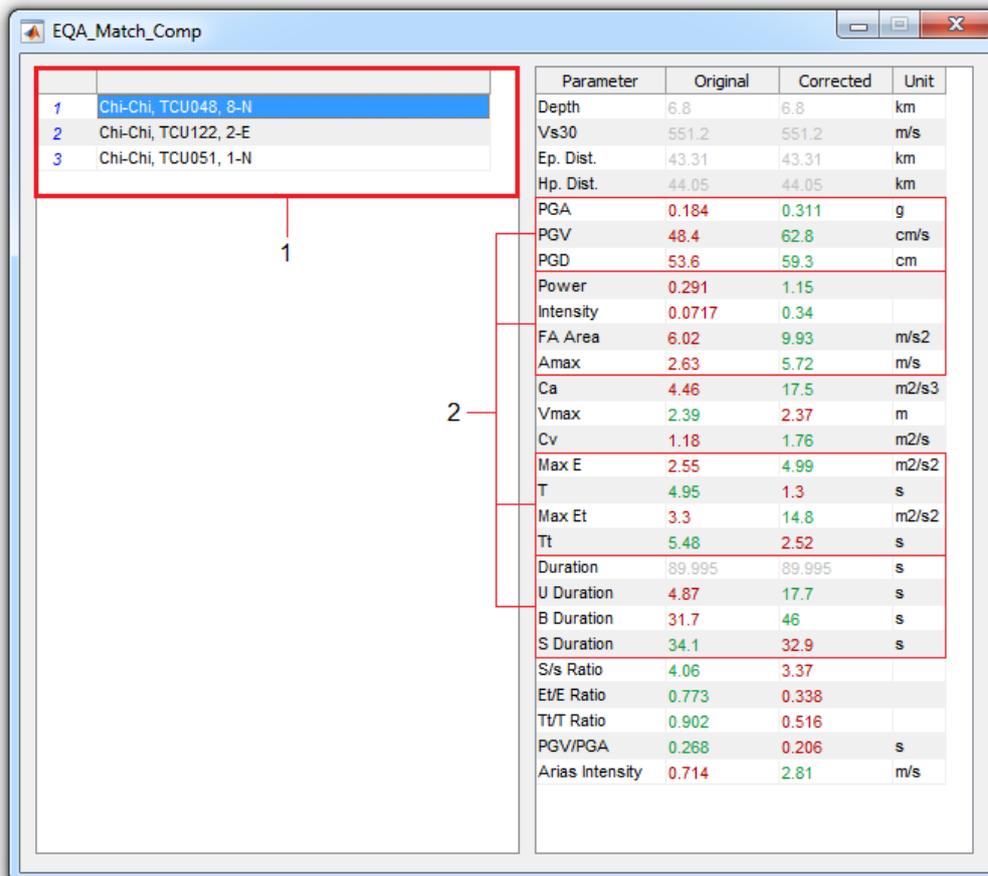
1. Use the sliders to change the parameters so that the resulting spectrum is most consistent with the target spectrum.
2. Use this button to load the target spectrum from a \* .txt file.
3. Use this button to generate a new accelerogram.
4. Use this button to ensure the average response spectrum matches the target spectrum properly.

## 4. Match Tool



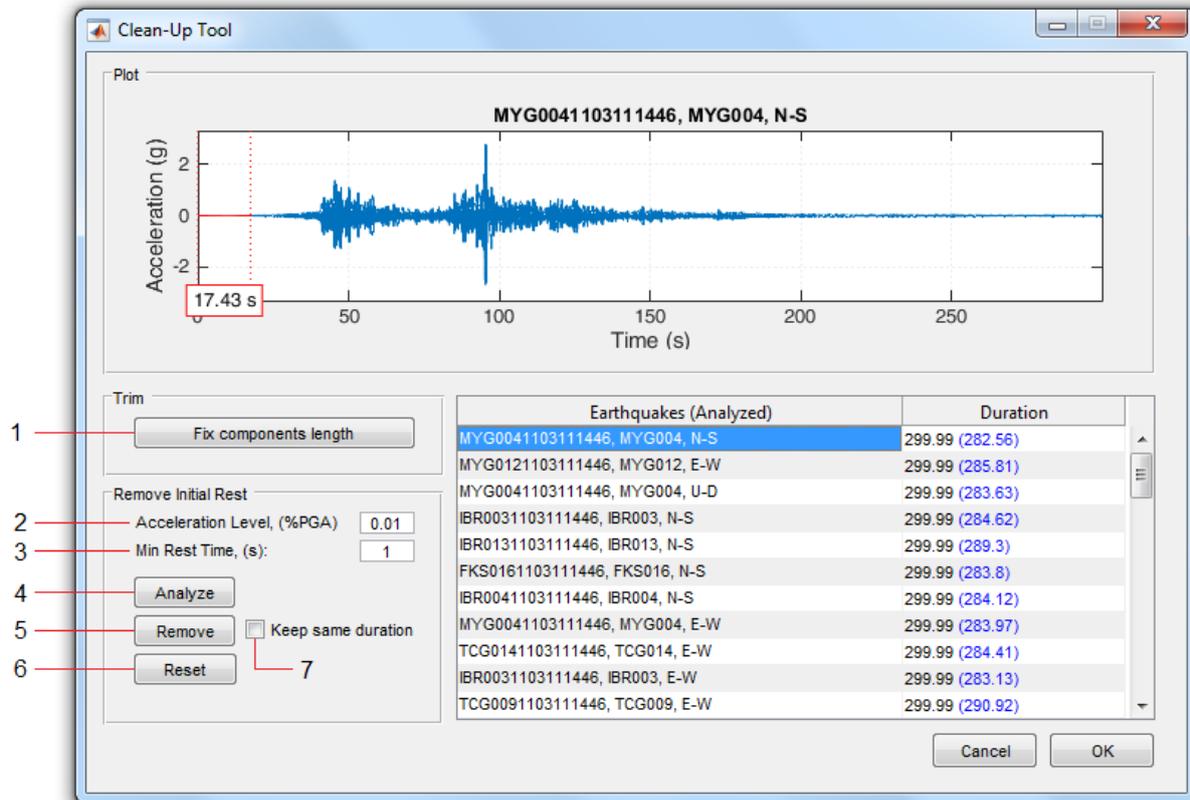
1. Use this button to call the target range from a \*.txt file.
2. Use these options to convert graph axes from linear to logarithmic.
3. Use this button to load recorded accelerograms.
4. If the required number of recorded ground motions is not available, use this button to generate simulated ground motions.
5. Use this button to compare the properties of original and modified records.
6. The damping ratio to calculate the response spectrum. (If changed, all response spectra need to be recalculated.)
7. Acceptable tolerances for convergence of response spectra.
8. Use these buttons to apply the spectral matching for the selected record or all records.
9. Enter the Period Range over which the spectral matching should be applied.
10. Enable this checkbox to display the Period Range on the chart.
11. Enable this checkbox to display uncorrected time histories, response spectra and mean spectrum.
12. Enable this checkbox to display corrected time histories, response spectra and mean spectrum.

13. Enable this checkbox to apply the highpass filter to the modified record.
14. Enable this checkbox to apply the baseline correction on the modified record.



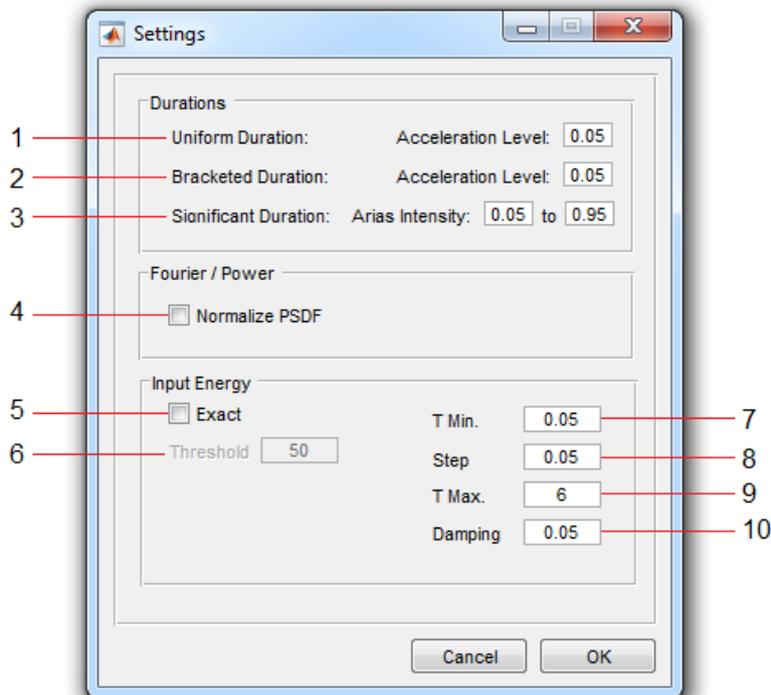
1. Select the desired record from this table. Various parameters for the original and modified record will be shown in the right-hand table. Modified record parameters will be shown in green, red and gray, respectively, if they are increased, decreased or unchanged.
2. Click on each parameter in this section to display the comparison chart for the original and modified record. (Including: acceleration, velocity and displacement time histories / Fourier amplitude spectra and power / energy curve / and different time durations)

## 5. Clean-Up Tool



1. Use this feature to fix the length of accelerograms (to be identical for different components of the same record)
2. Acceleration threshold for finding the initial rest time
3. Minimum duration to preserve before reaching to the acceleration threshold (i.e. the minimum rest time)
4. Use this button to analyze all records and identify the available rest times. (Total duration after removing the initial rest time will be displayed in the Duration column in blue color)
5. Remove initial rest time for the records identified in the previous step.
6. Use this button to undo all changes and restore the original records.
7. Enable this checkbox to keep same length for different components of the same record. (Alternatively, you can use the option 1 after removing the rest time.)

## 6. Run Settings

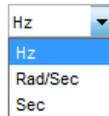


1. The acceleration threshold for calculating the Uniform Duration.
2. The acceleration threshold for calculating the Bracketed Duration.
3. The Arias intensity range for calculating the Significant Duration.
4. Enable this checkbox to use the normalized power spectral density function (with an area equal to 1) to calculate the related quantities.
5. If enabled, the input energy per unit mass for periods beyond the value specified in option **6** is calculate more accurately. (Obviously it takes more time to calculate input energy)
7. Minimum Period
8. Period increment
9. Maximum Period
10. Damping ratio

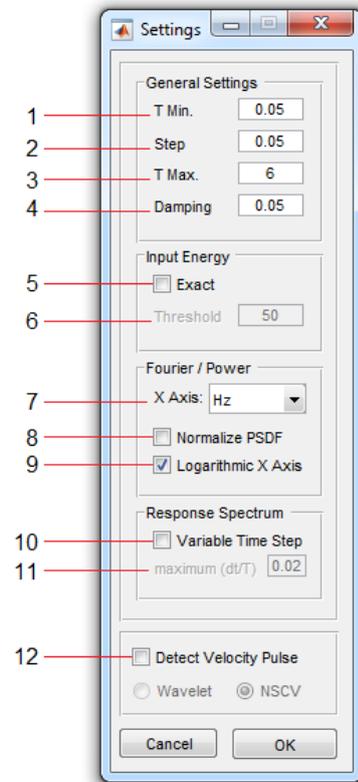
## 7. Spectrum Settings

1. Minimum Period
2. Period increment
3. Maximum Period
4. Damping ratio
5. Enable this checkbox to calculate the input energy per unit mass more accurately for periods beyond the value specified in option 6.

7. Determine the X-axis unit for the Fourier Amplitude and Power Spectrum:

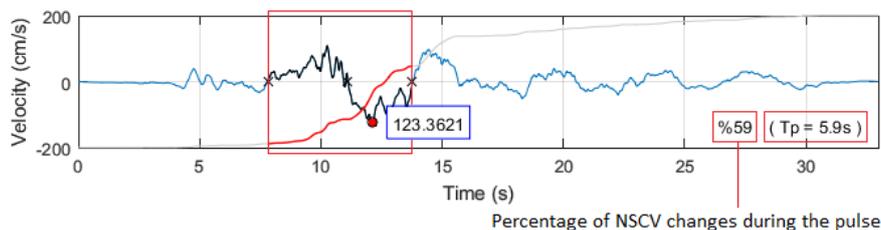
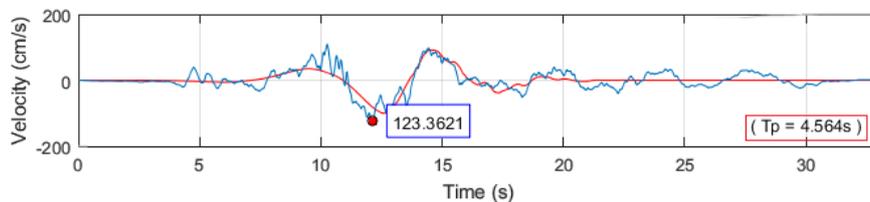


8. Enable this checkbox to use the normalized power spectral density function (in which the area under the curve – for positive frequencies – is equal to 1)

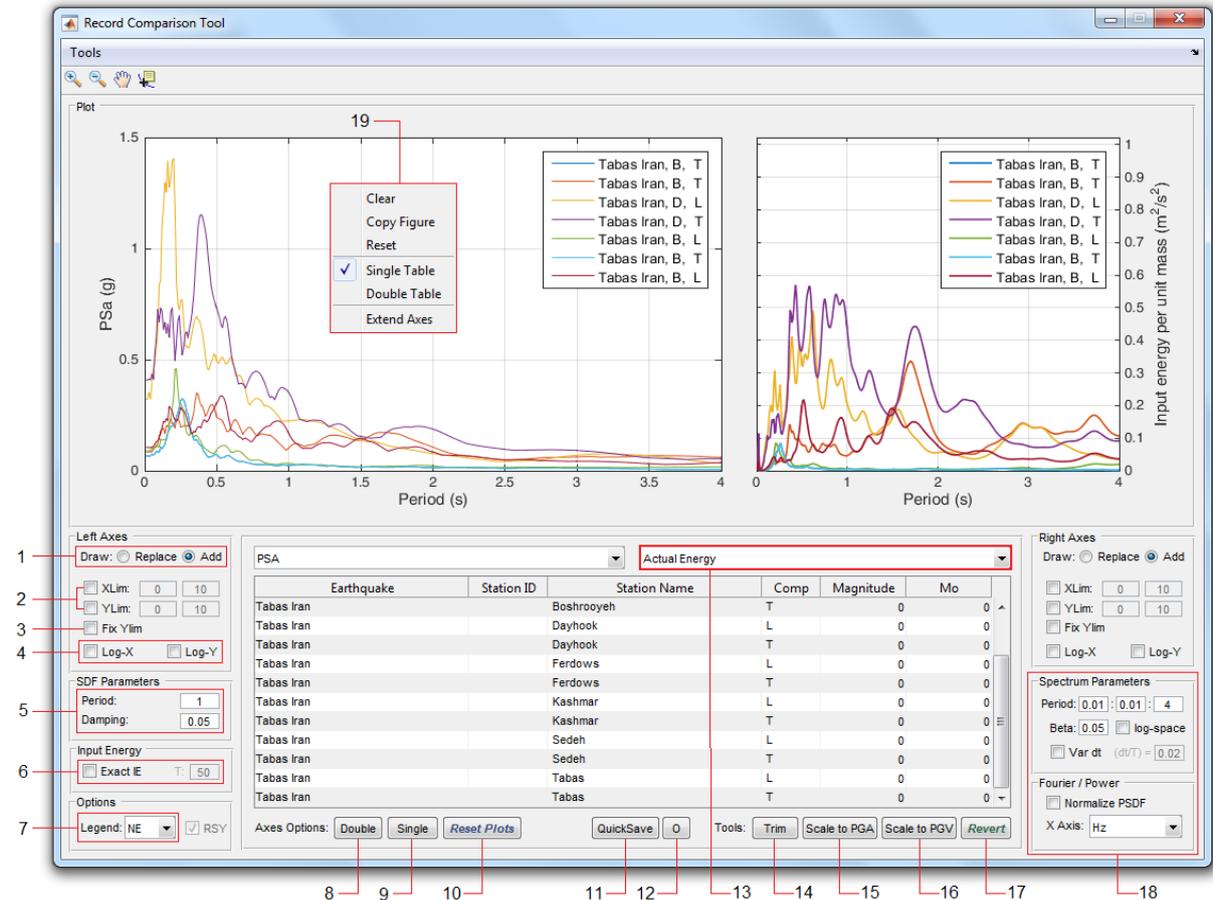


9. Use logarithmic scale for X-axis of the Fourier amplitude and power spectrum
10. Enable the use of variable time step. (more calculation time needed)
11. Maximum value for the ratio of record Time Step to Period (dt/T)
12. If this checkbox is enabled, the velocity pulse – if exists – will be detected on the velocity time history using the selected method:

- NSCV curve. (Appendix C of NIST GCR Report 11-917-1).
- Wavelet based method (Baker J.W. (2007). [1])



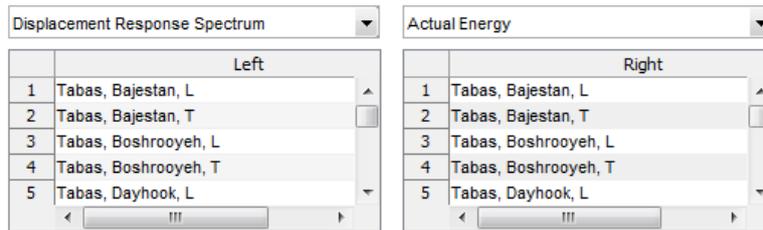
## 8. Record Comparison Tool



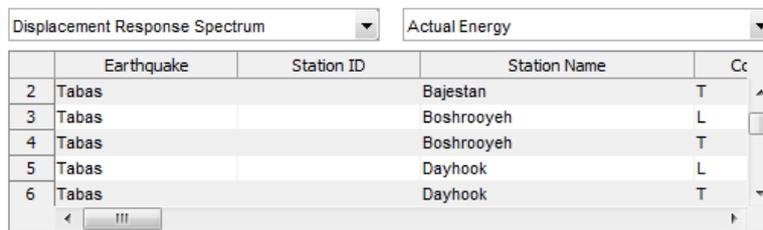
1. Use this option to control whether next plot is added to the current plot or replaces it.
2. Use this option to set the X and Y axis limits.
3. Enable this checkbox to keep a fixed value for the Y axis limits while adding new plots.
4. Enable this checkbox to use logarithmic scale for X and Y axis.

**Note:** The same above options are also available for the right-hand axes, from the Right Axes Panel.

5. Set the Period and Damping Ratio of the SDOF system on this panel. (required for response time history calculations)
6. Use this option to use more accurate method for calculating input energy per unit mass in long-period range.
7. Use this popup-menu to control the location of the legend.
8. This button allows you to use each panel (left or right) independently.

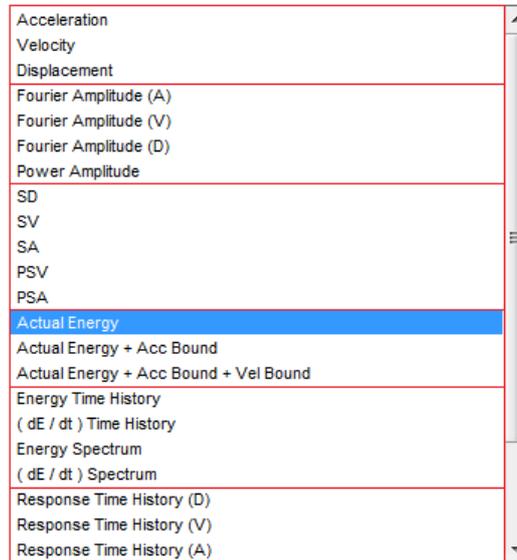


9. Use this button to plot both left and right charts for the selected record at the same time.



10. Use this button to clear all plots (both left & right axes)
11. Use this button to save the current plots (both left and right axes) to the \*.PNG file. You may be prompted to choose the Folder where the images will be stored.
12. Use this button to open the QuickSave folder.

13. Select the desired quantity from this menu to plot in the right axes. (The left-hand menu is used for the left axes)



14. Access to the record trimming tool

15. Use this button to scale records to any specific PGA level.

16. Use this button to scale records to the specified PGV level.

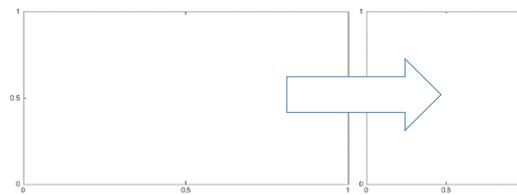
17. Use this button to restore records to their original state. (after scaling or trimming)

18. This Panel includes the following settings:

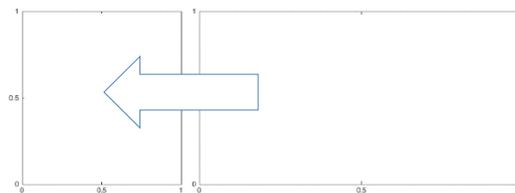
1. Period settings (Min, Max, Step size) and Damping Ratio for the response spectrum calculation.
2. Variable time step option and settings. (for the response spectrum calculation)
3. PSDF normalization option.

**19. Axes right-click Menu**, includes the following settings:

1. Clear the current axes (left or right).
2. Make a copy of the current axes in a new figure.
3. Reset all plots (both left & right axes)
4. Switch to Single Table mode (same as **9**).
5. Switch to Double Table mode (same as **8**).
6. Extend the width of selected axes:



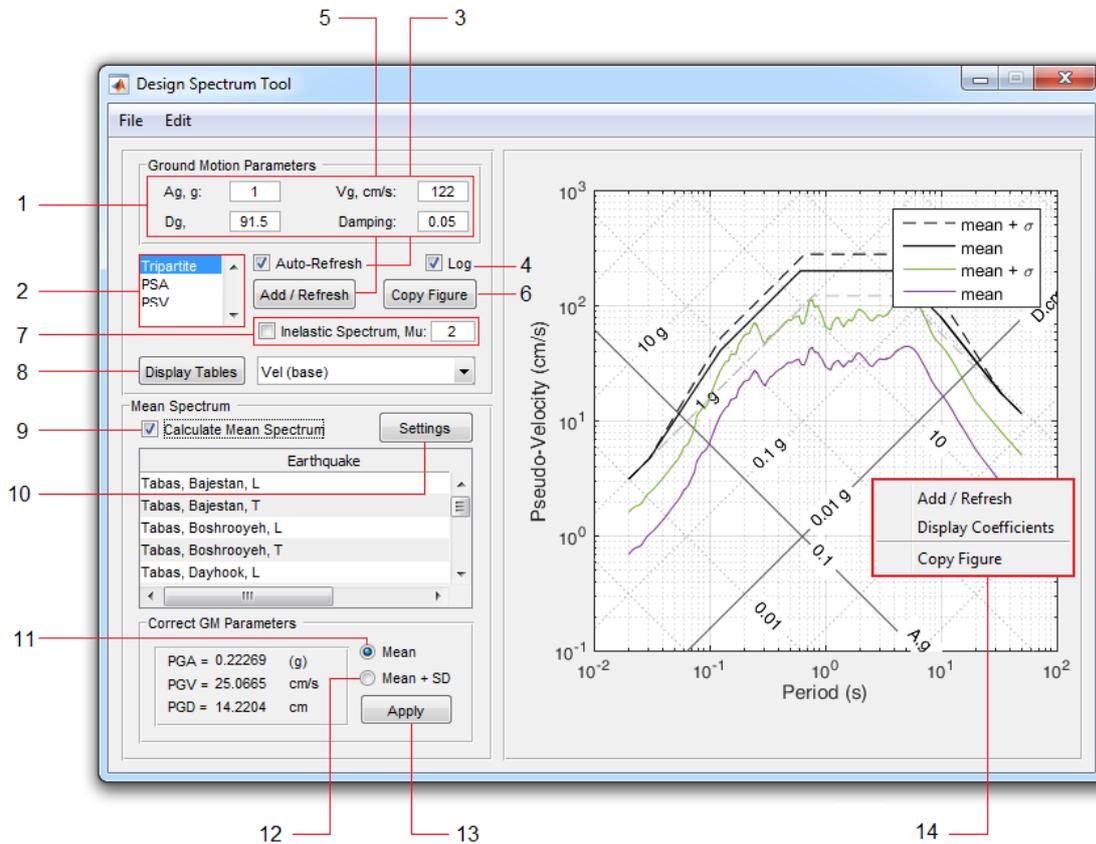
Extend right axes



Extend left axes

Tools Menu	
<ol style="list-style-type: none"> <li>1. Reset all plots (both left &amp; right axes)</li> <li>2. Save the current plots to the *.PNG file</li> <li>3. Select the QuickSave Folder</li> <li>4. Select the colormap for the lots</li> </ol>	

## 9. Design Spectrum Tool



1. Enter the base values for the acceleration, velocity, and displacement as well as the damping ratio. (required for constructing the design spectrum)
2. Use this listbox to select the desired plot to display. (tripartite plot / pseudo-acceleration response spectrum / pseudo-velocity response spectrum)
3. If this checkbox is enabled, by changing any of the base values (of the section **1**) the spectrum will be recalculated and plotted automatically. Otherwise, you need to click the **Add/Refresh** button (**5**) to calculate and plot the spectrum.
4. Enable this checkbox to use logarithmic scale for X and Y axis.
5. If checkbox **3** is disabled, then you need to use this button to re-calculate the spectrum after editing the base values of the section **1**.
6. Use this button to make a copy of the current axes in a new figure.
7. To add an inelastic response spectrum, enable this option and enter the desired ductility factor. ( $\mu$ )
8. Use this checkbox to display the spectral data in a table. Select the desired data type from the adjacent menu. By displaying the table, its data will be automatically copied to the clipboard. (**Auto Copy** feature)

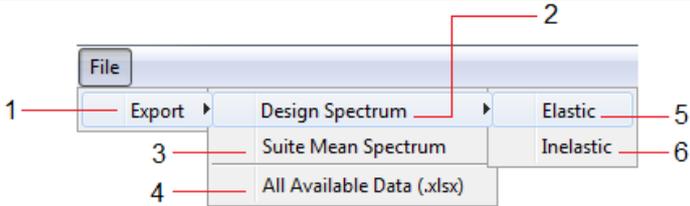
9. To construct a Design Spectrum compatible with the available database, enable this checkbox to compute the mean response spectrum for the suite of records.
10. Access to response spectrum settings (for the suite response spectrum calculation)
11. Select this option to calculate the design spectrum compatible with the mean response spectrum of the suite. (and click on the button **12** to apply the changes)

**Note:** In some cases, the match cannot be achieved correctly. In this case, you can modify the default period points ( $T_a = 1/33$ ,  $T_b = 1/8$ ,  $T_e = 10$  and  $T_f = 33$ ) using the *Period Adjustment Tool* (from the **Edit** menu.)

12. Select this option to calculate the design spectrum compatible with the mean-plus-one standard deviation of the suite response spectrum. (and click on the button **12** to apply)

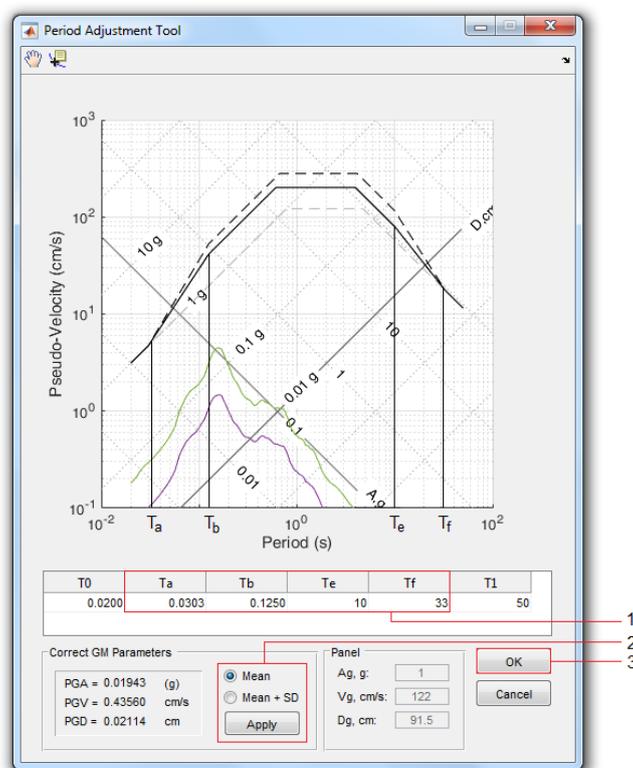
13. **Axes right-click Menu:** includes the following options:

1. Add/Refresh option
2. Display the Amplification Factors
3. Make a copy of the current axes in a new figure.

File	
	<ol style="list-style-type: none"> <li>1. Export existing data, including:                             <ol style="list-style-type: none"> <li>2. Design spectrum</li> <li>3. Suit mean spectrum</li> <li>4. Export all available data to Excel, including:                                     <ul style="list-style-type: none"> <li>• Suite Response Spectrums</li> <li>• <math>S_a</math> (Acceleration Design Spectrum)</li> <li>• <math>S_v</math> (Velocity Design Spectrum)</li> </ul> </li> </ol> </li> </ol>
Export Design Spectrums	
<ol style="list-style-type: none"> <li>5. Elastic spectrum</li> <li>6. Inelastic spectrum</li> </ol>	

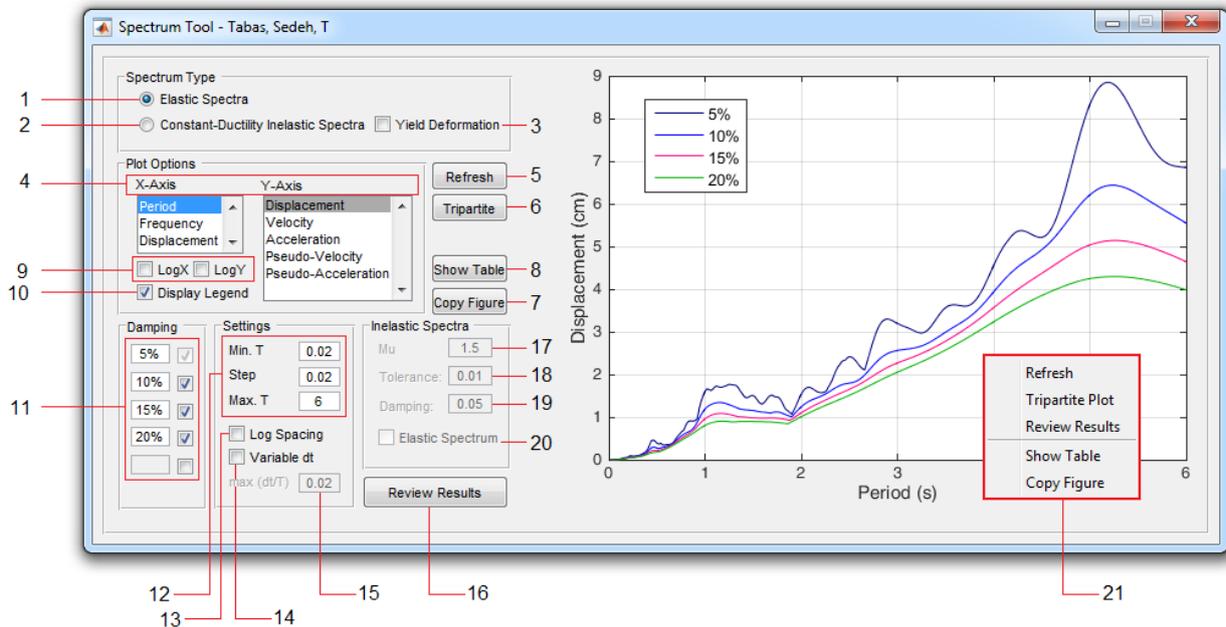
Edit	
<ol style="list-style-type: none"> <li>1. Copy current axes to a new figure</li> <li>2. Display the <u>Amplification Factors</u> used to calculate the design spectrum</li> <li>3. Period Adjustment Tool</li> <li>4. Access to response spectrum settings (for the suite response spectrum calculation)</li> </ol>	

### 9.1 Period Adjustment Tool



1. Modify the default period points ( $T_a = 1/33$ ,  $T_b = 1/8$ ,  $T_e = 10$  and  $T_f = 33$ ) using this table. (Note that first and last values are fixed.)
2. Use this panel to calculate the design spectrum compatible with the mean (or mean + SD) response spectrum of the suite. (and click on the apply button)
3. Click on OK button to confirm the changes and return to the previous window.

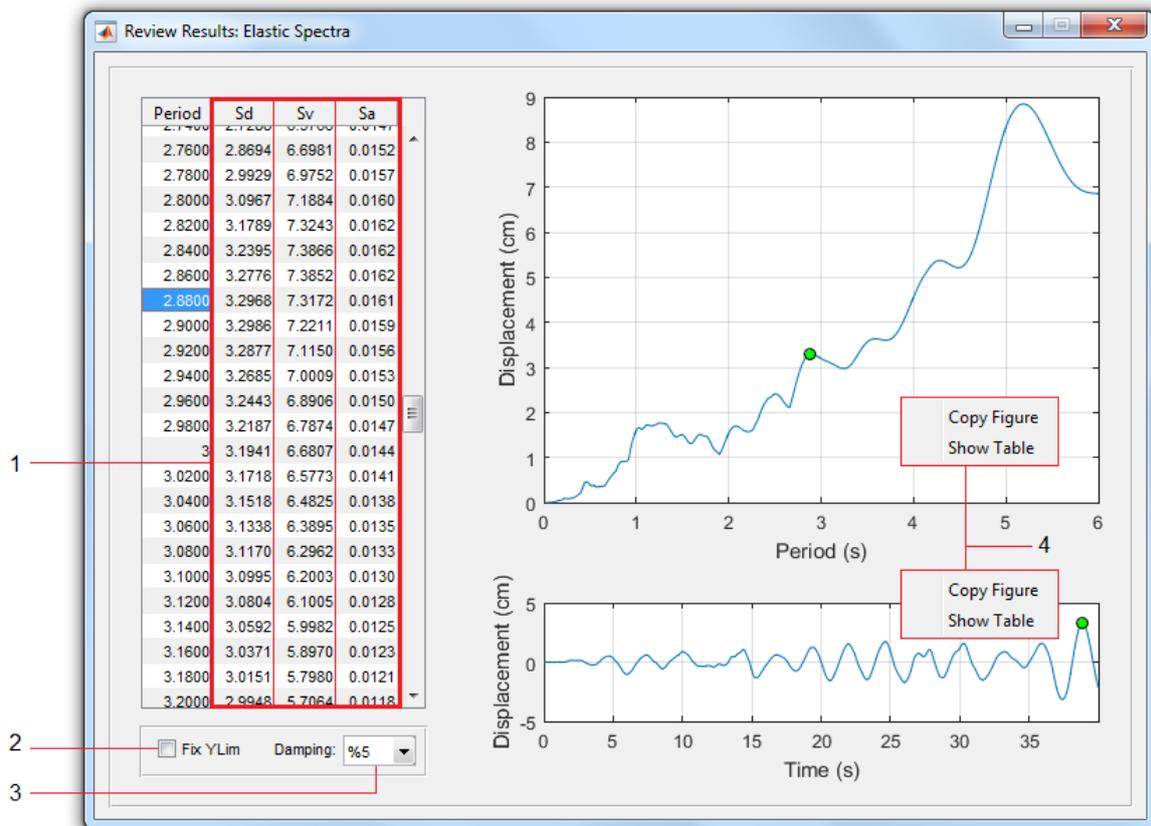
## 10. Response Spectrum Tool



4. Select this option to calculate the elastic spectrum.
5. Enable this option to calculate the inelastic spectrum based on the maximum response value. (In this case *PSA* and *PSV* are not available)
6. Enable this checkbox to calculate the inelastic spectrum based on the yield value. (In this case *SA* and *SV* are not available)
7. Use these listboxes to change the X and Y axis for the chart.
8. After changing any settings, you may need to use this button to recalculate the response spectrums.
9. Use this button to display the *Tripartite Plot*.
10. Use this button to make a copy of the current axes in a new figure.
11. Use this button to display spectral data in a table. Table data will be automatically copied to the clipboard. (**Auto Copy** feature)
12. Enable these checkboxes to use logarithmic scale for the X and Y axis.
13. Use this checkbox to show the legend on the chart.
14. Use this section to enter (up to 5) Damping Ratios (%) for calculating elastic response spectra.
15. Enter the minimum, maximum and increment step size to determine the periods in which the spectrum values are calculated.
16. Enable this checkbox to use equal logarithmic spacing to determine the periods in which the spectrum values are calculated.

17. Enable the use of a variable time step.
18. Maximum value for the ratio of record Time Step to Period (dt/T)
19. Use this button to review the analysis results.
20. Ductility Factor for inelastic response spectrum.
21. Acceptable tolerance for the Ductility Factor convergence.
22. Damping Ratio for calculating inelastic response spectrum.
23. Enable this checkbox to add the elastic response spectrum to existing inelastic spectrum.
24. **Axes right-click Menu**, includes the following options: Refresh, Tripartite Plot, Show Tables, Copy Figure and Review Results.

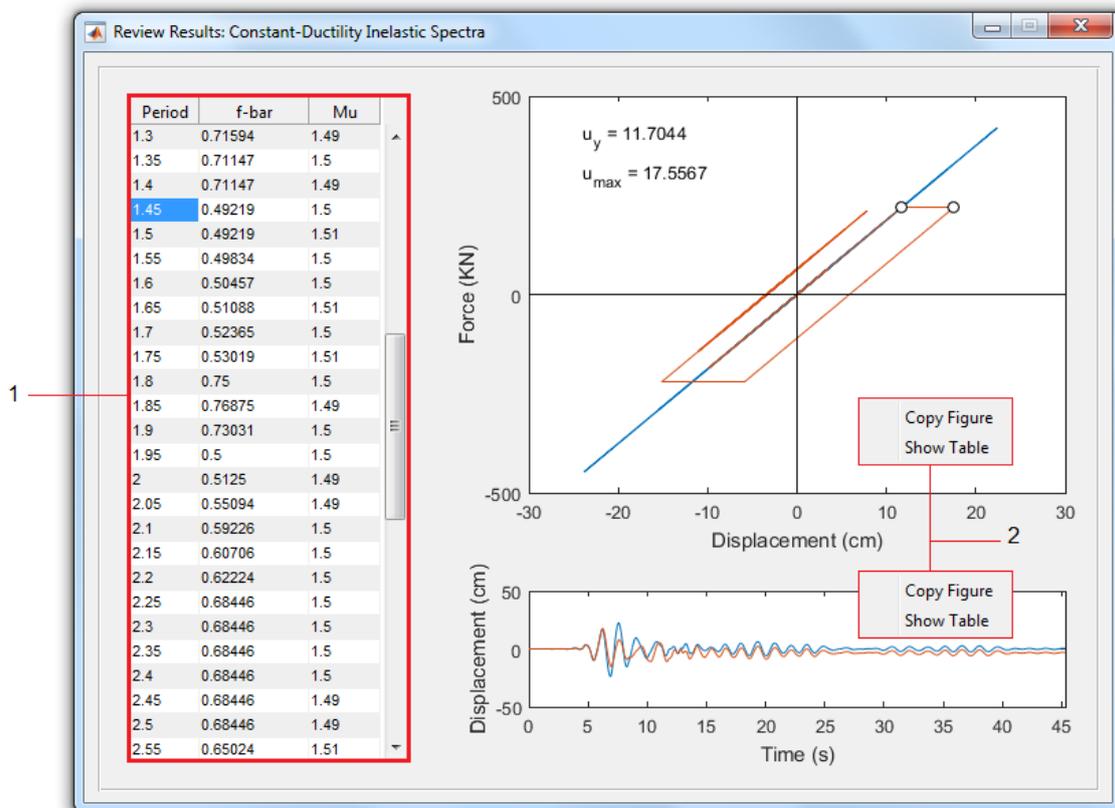
### 10.1 Review Elastic Spectra



1. Select each column from this table ( $S_d/S_v/S_a$ ) to plot its spectrum as well as the corresponding response time history.
2. Enable this checkbox to fix the Y-axis limit of the response time history plot.

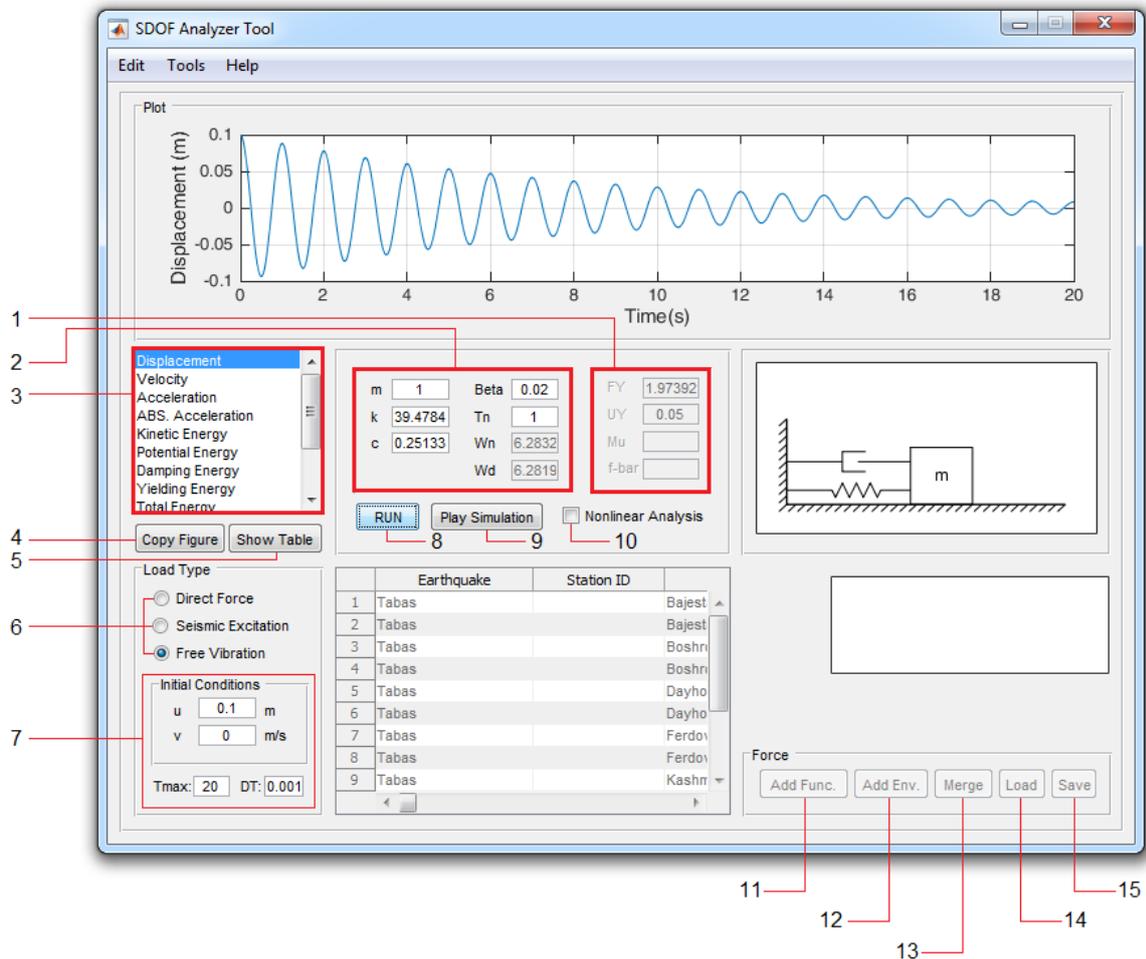
3. Select the desired Damping Ratio from this list.
4. **Axes right-click Menu**, includes the following options: Copy Figure and show table. (Table data will be automatically copied to the clipboard - **Auto Copy** feature)

## 10.2 Review Inelastic Spectra



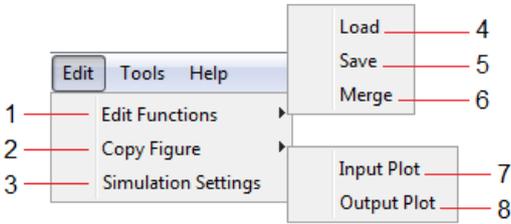
1. Select each row from this table to plot the response time history as well as the hysteresis loops (elastic and inelastic) for the selected period.
2. **Axes right-click Menu**, includes the following options: Copy Figure and show table. (Table data are displayed for the response time history or inelastic hysteresis loop. Data will be automatically copied to the clipboard - **Auto Copy** feature)

## 11. SDOF Tool

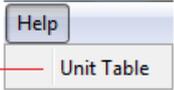


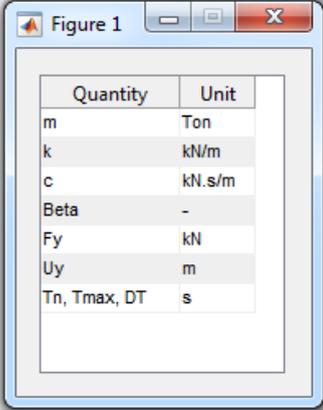
- Specify the system's non-linear (elasto-plastic) behavior using one of the following methods:
  - Enter the yield deformation ( $U_Y$ ) and the yield strength ( $F_Y$ ).
  - Enter only the desired value for the ductility factor.
  - Enter only the desired value for the normalized yield strength ( $\bar{F}_Y$ ).
- The SDOF system specifications (mass, stiffness, damping coefficient - or ratio - and the period) can be entered here.
- To display the system response, select the desired quantity from this list. By displaying each plot, its data will be automatically copied to the clipboard. (**Auto Copy** feature)
- Use this button to make a copy of the response axes in a new figure.

5. Use this button to display the current response data in a table. By displaying the table, its data will be automatically copied to the clipboard. (**Auto Copy** feature)
6. Select the type of analysis. (forced vibration / seismic excitation / free vibration)
7. If the free vibration analysis mode is selected, the initial conditions, time step and maximum analysis time can be determined from this section.
8. Use this button to perform the analysis.
9. Use this button to watch the simulation of the vibration. (press Esc to cancel)
10. To perform nonlinear analysis, enable this option and specify nonlinear parameters as described in paragraph 1.
11. Use this button to add a built-in function (harmonic, ramp or step) for forced vibration analysis mode.
12. Use this button to add an envelope to the existing function.
13. Use this option to merge two functions. (**Note:** They must have an identical time step)
14. Load function from a \*.txt file
15. Save the current function to a \*.txt file

Edit	
	
<ol style="list-style-type: none"> <li>1. Actions related to functions editing</li> <li>2. Copy current axes to a new figure</li> <li>3. Access to the simulation settings (Video Settings)</li> </ol>	
Editing Functions	
<ol style="list-style-type: none"> <li>4. Load function from a file (*.txt)</li> <li>5. Save current function to a file (*.txt)</li> <li>6. Access to the Merge Tool (used to combine 2 functions)</li> </ol>	
Copy figure	
<ol style="list-style-type: none"> <li>7. Copy <u>input</u> axes (load function / earthquake time history) to a new figure</li> <li>8. Copy <u>output</u> axes (response of the system) to a new figure</li> </ol>	

Tools	
<ol style="list-style-type: none"> <li>1. Display nonlinear parameters</li> <li>2. Access to Damping Calculator Tool</li> </ol>	 <p>A screenshot of the 'Tools' menu with two items: 'Display Nonlinear Parameters' and 'Calculate Damping'. Red lines with numbers 1 and 2 point to these items respectively.</p>

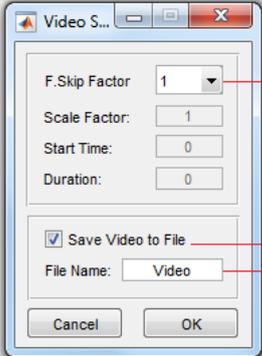
Help	
<ol style="list-style-type: none"> <li>1. Display the units of used quantities in a table.</li> </ol>	 <p>A screenshot of the 'Help' menu with one item: 'Unit Table'. A red line with the number 1 points to this item.</p>



A screenshot of a window titled 'Figure 1' containing a table of quantities and their units.

Quantity	Unit
m	Ton
k	kN/m
c	kN.s/m
Beta	-
Fy	kN
Uy	m
Tn, Tmax, DT	s

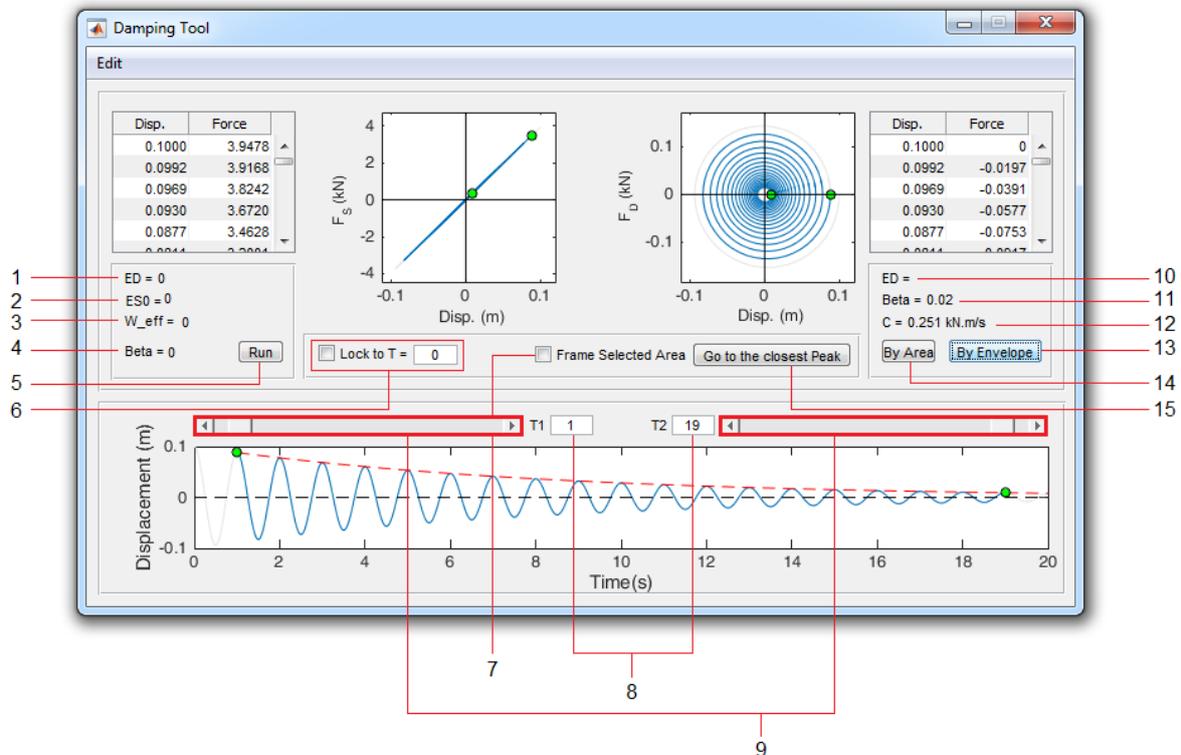
### 11.1 Video Settings



A screenshot of the 'Video Settings' dialog box with three red lines and numbers pointing to specific settings: 1 points to the 'F.Skip Factor' dropdown menu (set to 1), 2 points to the 'Save Video to File' checkbox (checked), and 3 points to the 'File Name' text box (containing 'Video').

1. Set the skip frame factor (useful to speed up when time step is too small)
2. Enable to save the video (\*.avi)
3. Set the default name for the SDOF simulation videos

## 11.2 Damping Tool

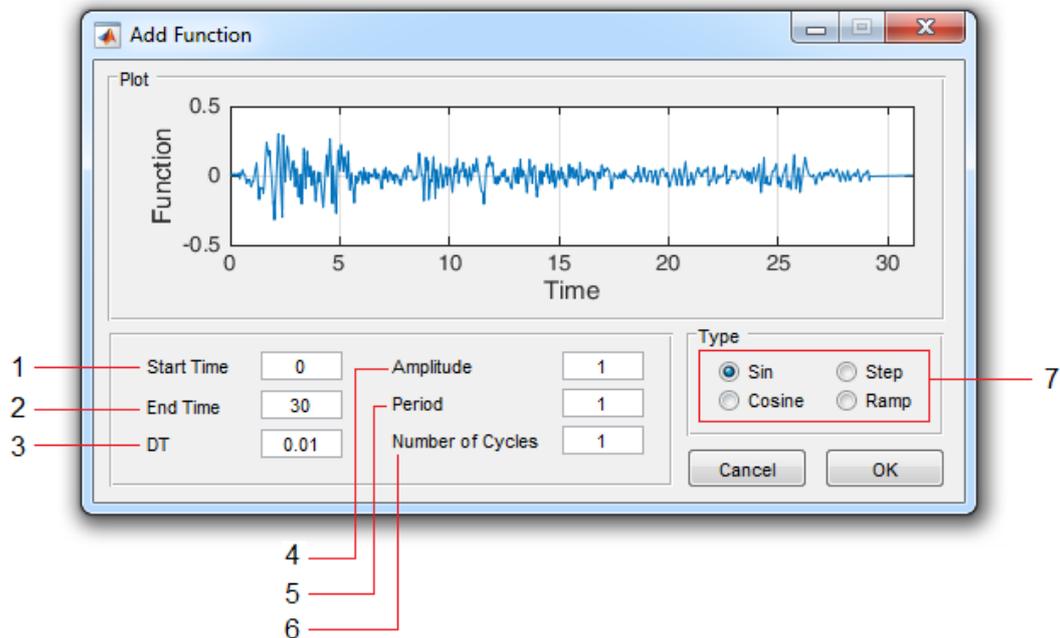


1. Dissipated Energy (energy loss)
2. Strain Energy
3. Effective frequency (frequency of the equivalent linear system)
4. Equivalent Viscous Damping Ratio
5. Use this button to calculate the Equivalent Viscous Damping for a nonlinear system.  
(**Note:** Before using, make sure to limit the calculation time range to one cycle of vibration using the checkbox **6**)
6. Use this option to limit the time range over which the damping calculation is performed.
7. When checkbox **6** is enabled, use this checkbox to display the limited area of the displacement response plot.
8. If checkbox **6** is disabled, you can enter the desired time range in these fields.
9. If checkbox **6** is disabled, you can change the desired time range using these sliders. If checkbox **6** is enabled, the sliders will move the desired range along the time axis, maintaining the selected duration.

10. Dissipated Energy
11. Damping Ratio
12. Damping Coefficient
13. Use this button to calculate damping using the free vibration analysis result.  
(Logarithmic Decrement Method)  
(**Note:** Before using, make sure to use button **15** to limit the calculation time range to the peak-to-peak interval of a few cycles of the *free vibration* diagrams.)
14. Use this button to calculate damping using the forced vibration result.  
(**Note:** Before using, make sure to limit the calculation time range to one cycle of the vibration using checkbox **6**)
15. Use this option to move the start and end of the calculation time range to the nearest adjacent peak.

Edit	
1. Copy Figure	
2.	Displacement-Spring Force diagram
3.	Displacement-Damper Force diagram
4.	Time history of Displacement response

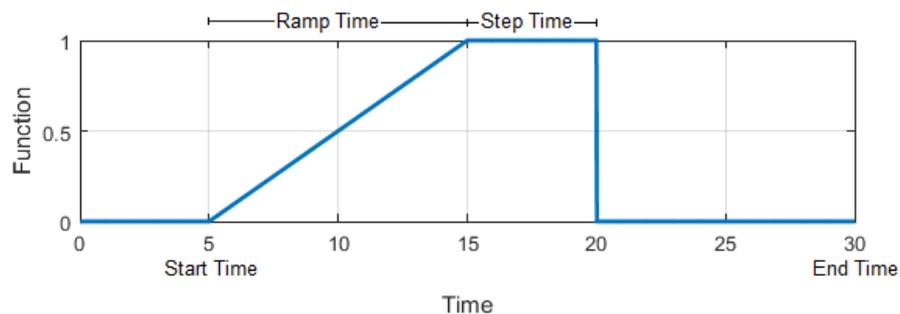
## 11.3 Add Function



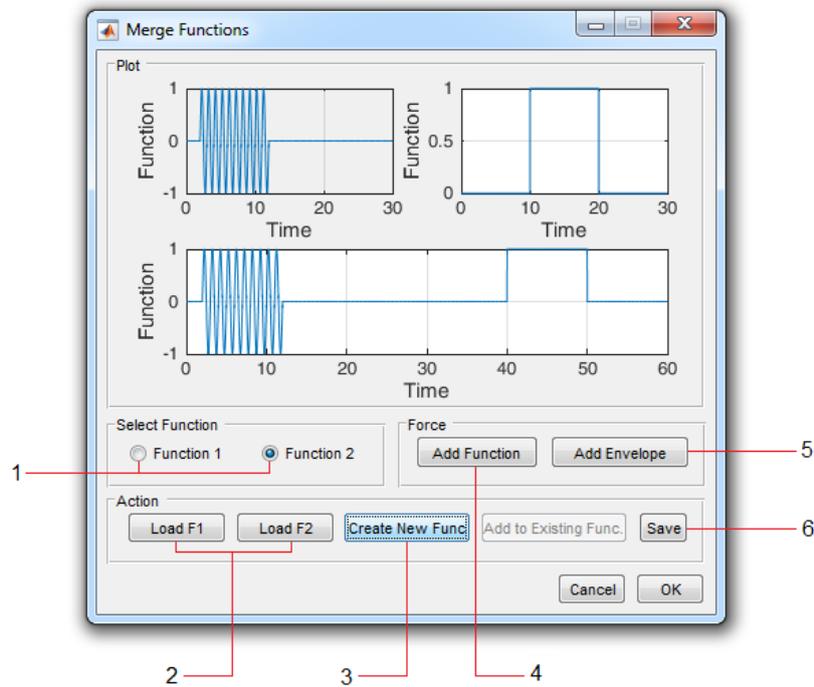
1. Function's start time
2. Function's end time (duration)
3. Time step
4. Maximum Function Value (Amplitude)
5. Period (for harmonic functions)
6. Number of cycles (for harmonic functions)
7. Select type of the function from this section.

**Note:** For the step function, textbox 6 is disabled and textbox 5 specifies the step duration.

**Note:** For the ramp function, textbox 5 specifies the ramp duration and textbox 6 is the duration of the constant section before the load fall to zero.

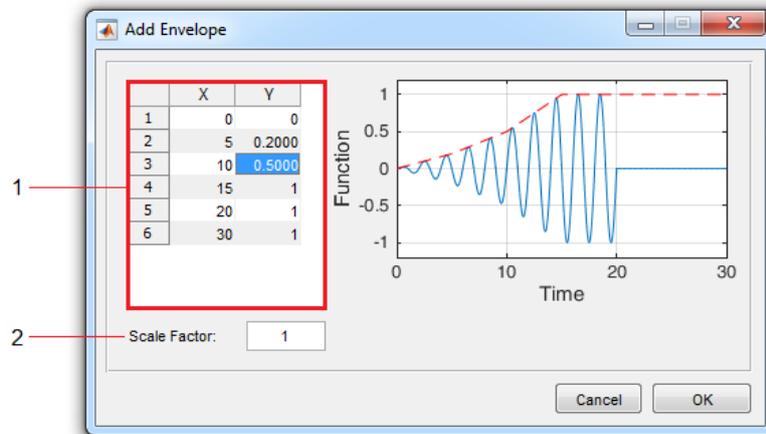


## 11.4 Merge Functions



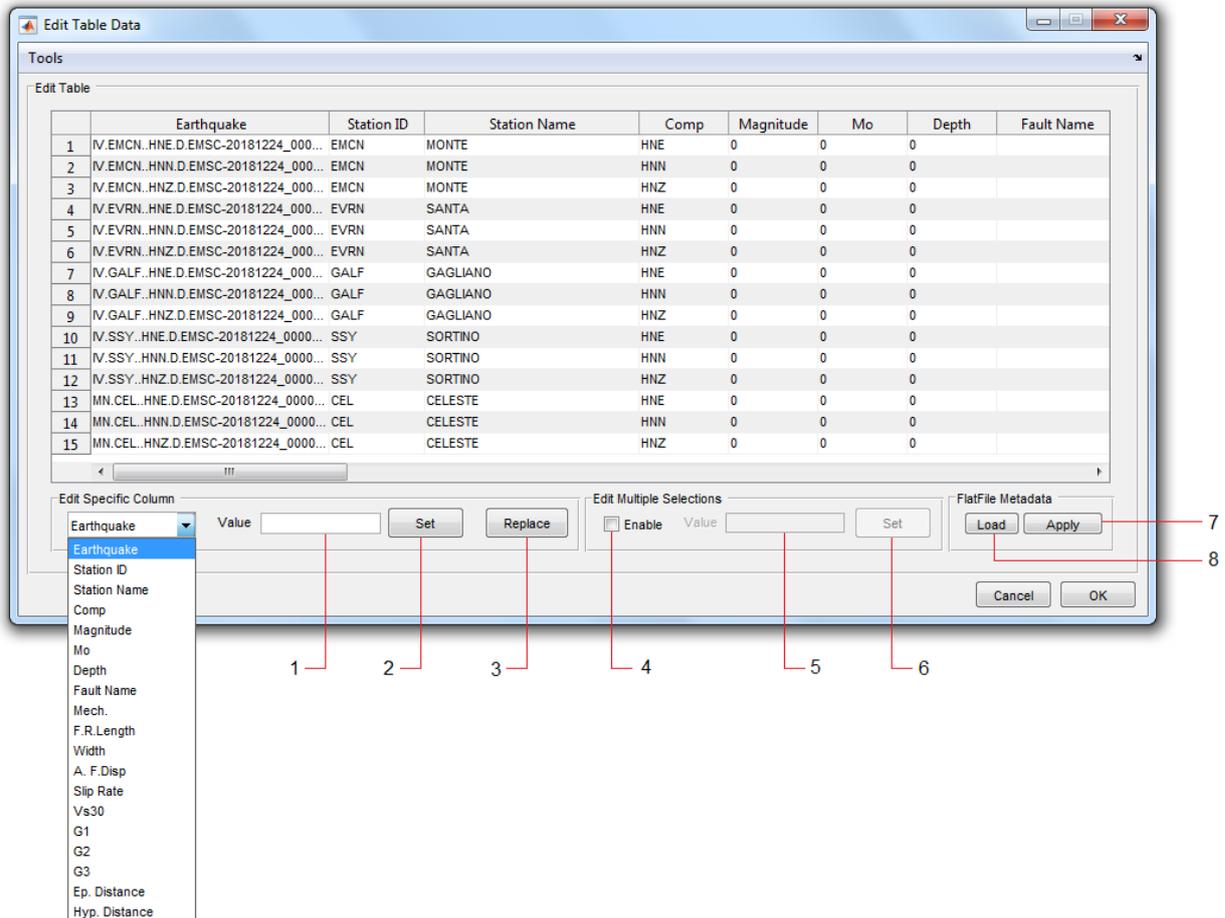
1. To add a built-in function, select the current function (1 or 2) from here.
2. Use these buttons Load the first or second function from a \*.txt file.
3. Use this button to combine the first and second functions. (**Note:** functions must have an identical time step)
4. Use this button to add a built-in function. (harmonic / ramp / step).
5. Use this button to add an envelope to the current function.
6. Use this button to save the created function.

## 11.5 Add Envelope



1. Use this table to edit the X and Y values for the envelope function.
2. Use this option to assign a specified number to all Y values.

## 12. Edit Table Data

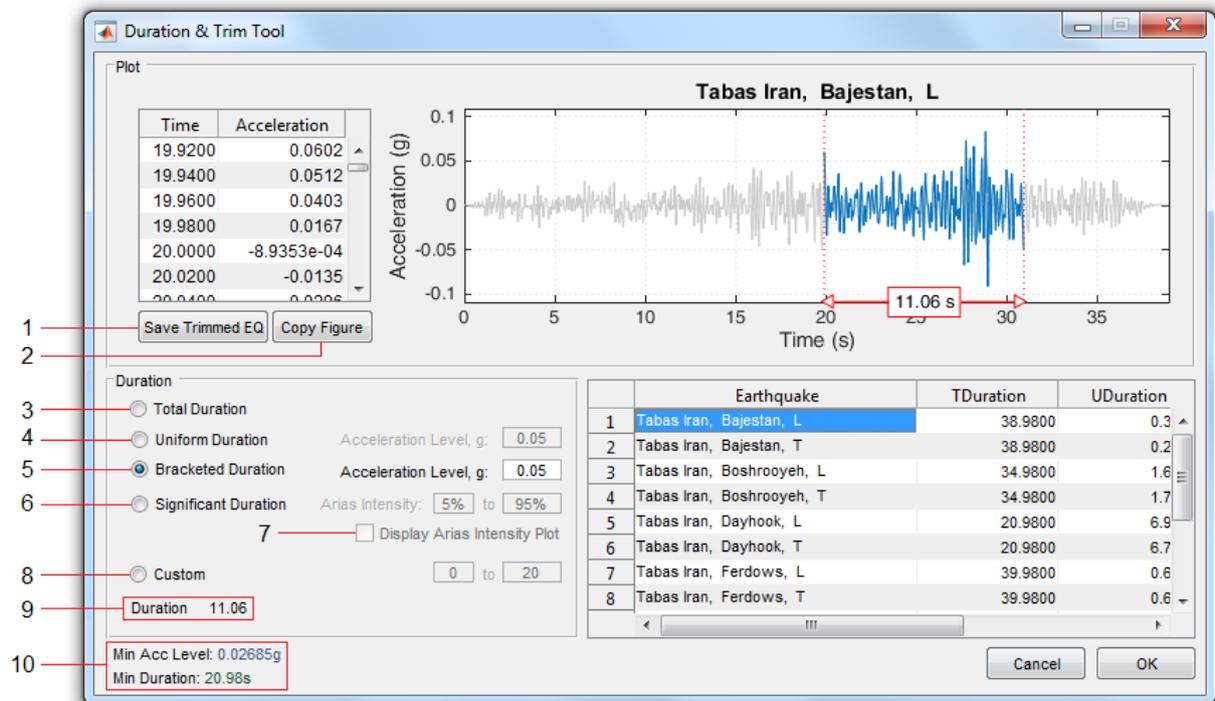


1. To change all values for a certain column of the table, select the name of column from the adjacent menu and enter the value in this textbox.
2. Use this button to assign the value entered in textbox **1** to the selected column.
3. Use this button to search and replace any pattern in the selected column.
4. To edit multiple cells of the table, enable this option and select the desired cells.
5. Enter the value you want to be replaced in the selected cells, in this textbox.
6. Use this button to assign the value entered in textbox **4** to the selected cells.
7. For the records taken from the PEER website, you can automatically get the information from the FlatFile. To do this, you need to load the FlatFile using this button. It is also possible to load the FlatFiles generated using the *FlatFile Builder Tool*.

8. When the FlatFile is loaded, you can use this button to automatically replace the available information into the database. (**Note:** If the provided NGA FlatFile is loaded, SMDA searches the FlatFile by the earthquake name, and the record's station. If you have changed these values in the dataset, the software will not be able to find the record from the FlatFile. For the other FlatFiles generated by the SMDA, the filename is used to find the matches)

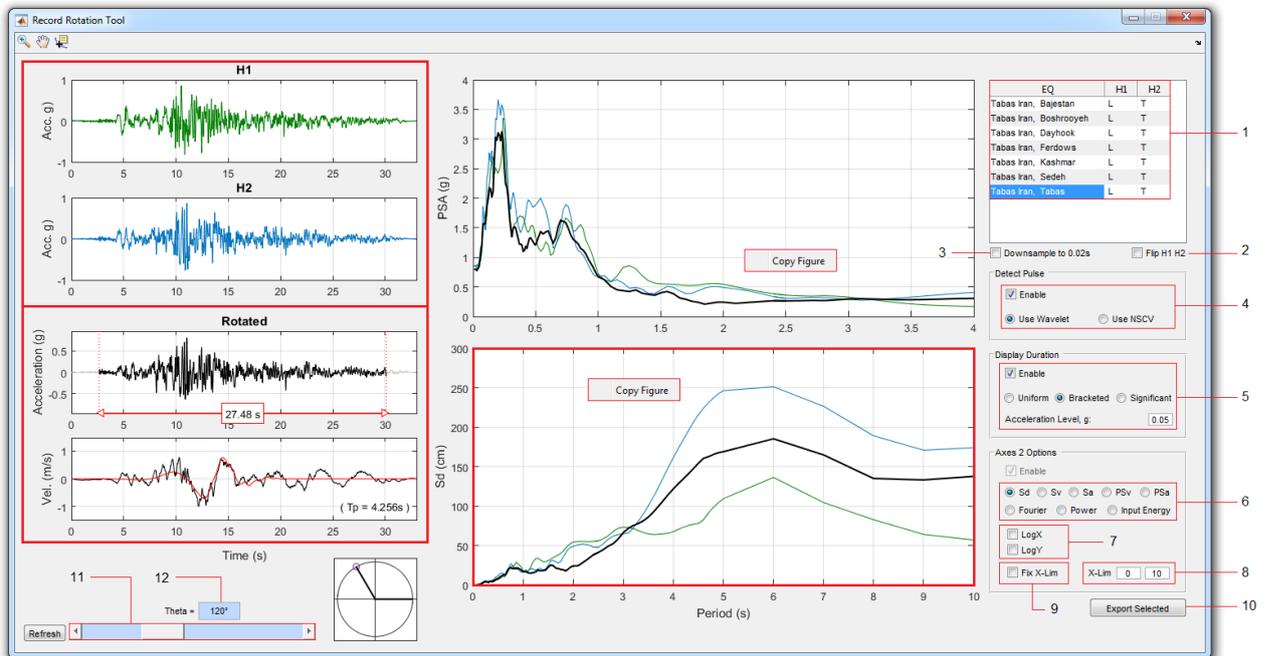
**Impotent:** Starting from the 2025 version, after loading accelerograms into the SMDA, the filenames are also stored in the dataset. This is necessary to keep some modules functional. If your dataset is created using a previous version of SMDA (which has the filenames assigned into the "Earthquake" field) you can use the *Fill FileName* feature from the **Tools** menu. However, you will be asked to enter the file extension.

### 13. Duration & Trim Tool



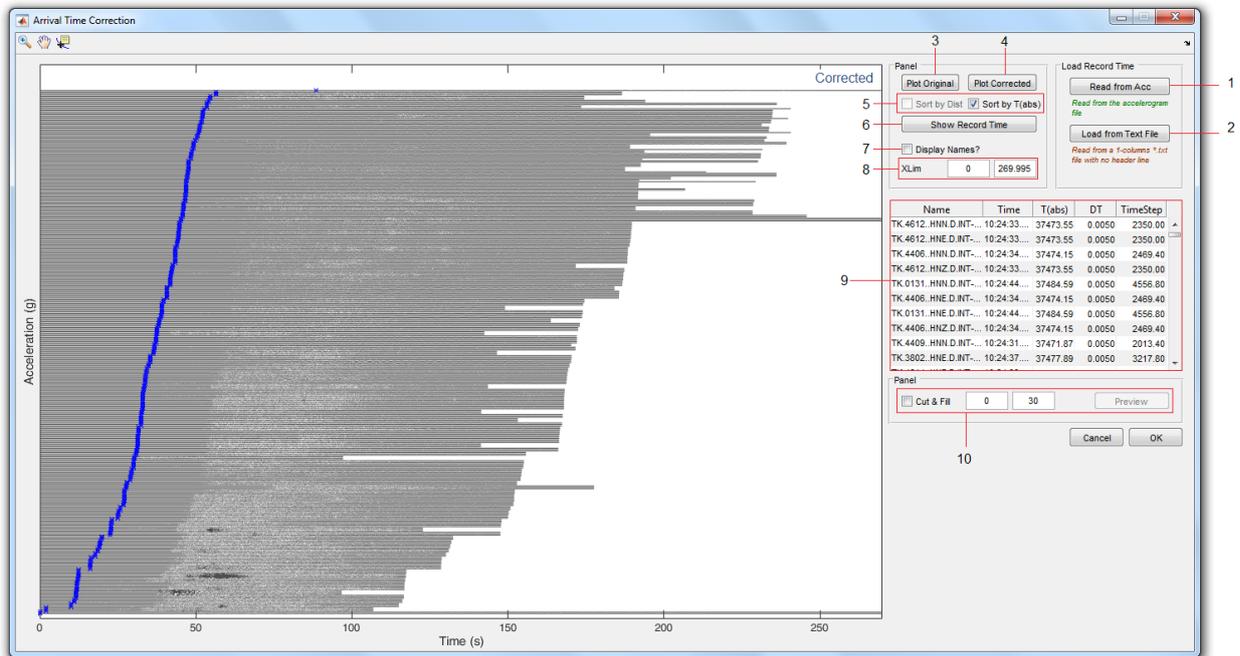
1. Save the currently selected Trimmed Record to a \*.txt file.
2. Use this button to make a copy of the current axes in a new figure.
3. Display Total Duration for the selected record (on the plot and in the textbox 9.)
4. Display the Uniform Duration for the selected record.
5. Display the Bracketed Duration for the selected record.
6. Display the Significant Duration for the selected record.
7. If this checkbox is enabled, the Arias Intensity plot will be displayed after calculating the Significant Duration.
8. This option allows specifying a custom range for trimming the records.
9. The calculated duration is displayed in this textbox.
10. Minimum available Acceleration Level and Duration is displayed here. You cannot use values larger than these levels for the trimming.

## 14. Accelerogram Rotation Tool



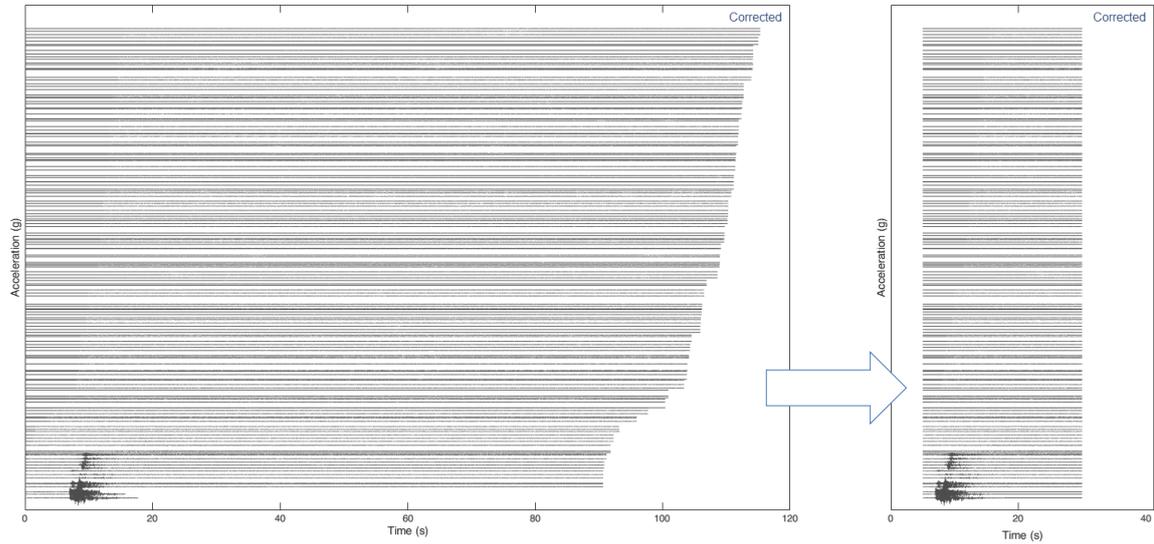
1. Detected pairs of horizontal accelerograms are displayed in this table. Select desired record to apply the rotation analysis.
2. Use this checkbox to reverse the order of horizontal components (H1 & H2)
3. To speed up the process, you can down sample input accelerograms to  $dt=0.02s$ .
4. Using this option, the Duration for the selected record will be displayed on the acceleration time history of rotated record (based on the selected method).
5. Using this option, the velocity pulse – if exists – will be displayed on the velocity time history of rotated record using the selected method.
6. You can change the type of graph displayed on the Axes 2 (the bottom axes). Axes 1 is reserved to display the PSA.
7. Enable these checkboxes to use logarithmic scale for the X and Y axis (applicable to the bottom axes).
8. Use this option to set the X axis limits (applicable to the bottom axes).
9. If enabled, X axis limits for the next plot are fixed to the values defined in previous step. Otherwise, it default x axis limits will be used.
10. Using this option, you can export the current rotated accelerogram to \*.txt format.
11. Use the slider to change the rotation angle.
12. You can directly enter the rotation angle in this textbox.

## 15. Arrival Time Correction

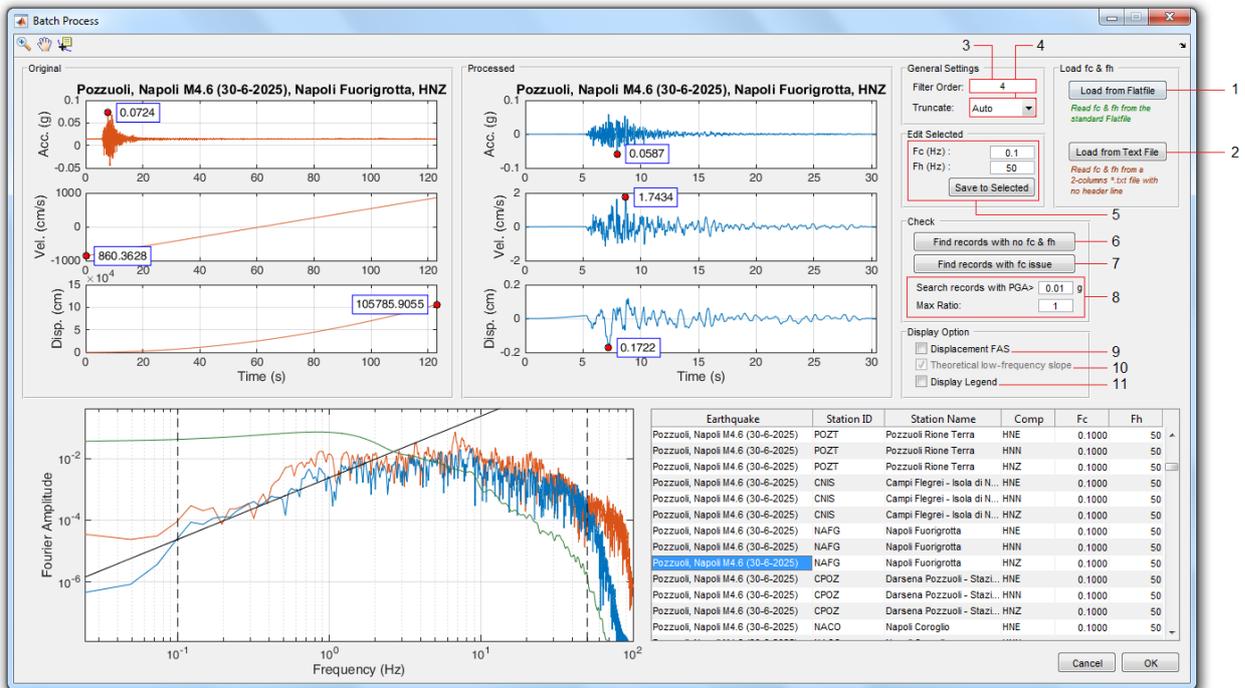


1. Use this button to read the record time directly from an accelerogram file.
2. Use this button to load record time data from a text file. The file should be a single-column .txt file without a header line.
3. Use this button to plot the original (uncorrected) accelerograms.
4. Use this button to plot the corrected accelerograms.
5. Use these checkboxes to to sort the record list either by distance (if distances are available in the dataset) or by absolute arrival time (after loading the record time)
6. Use this button to display the record times for the accelerograms on the graph (blue 'x' marker).
7. Using this checkbox you can set whether the names of the records are displayed on the plot or not.
8. Use this option to manually set the X-axis limits (time range) on the plot.
9. Table showing detailed information about each record, including: Record's Name, Record's Time, Absolute arrival time, Sampling interval (DT) and the Number of time steps that needs to be added at the start of each accelerogram (TimeStep)

10. Use this options to trim (cut) and fill the data within a specified time window. Define the start and end times (in seconds) and click on the Preview button to show the effect.



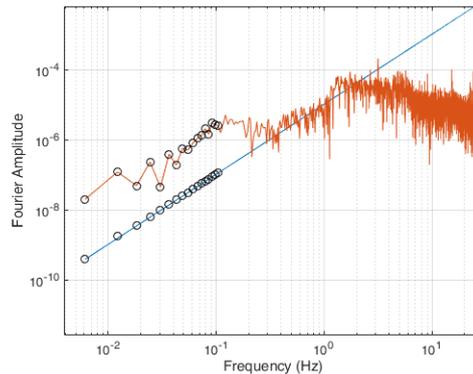
## 16. Batch Processing



1. Load filter cutoff frequencies (fc and fh) from a standard FlatFile. This option reads predefined filter settings for batch processing.
2. Load filter cutoff frequencies (fc and fh) from a two-column text file without a header. Use this to import custom frequency values for selected records.
3. Set the filter order, which determines the sharpness of the filter's transition band. Higher values produce steeper cutoffs.
4. Select how the filter truncation is handled. Available options are:
  1. **Auto:** Truncates on both ends.
  2. **Off:** no truncation.
  3. **End-Only:** Truncates the end of accelerogram. Useful when you have corrected the accelerograms for the arrival time.
5. Manually specify low (Fc) and high (Fh) cutoff frequencies (in Hz) for the selected record(s). Remember to "Save to Selected" to update the data in the table.
6. This feature searches and lists all records that currently lack defined cutoff frequencies in the Set Value window, allowing you to quickly enter incomplete data.

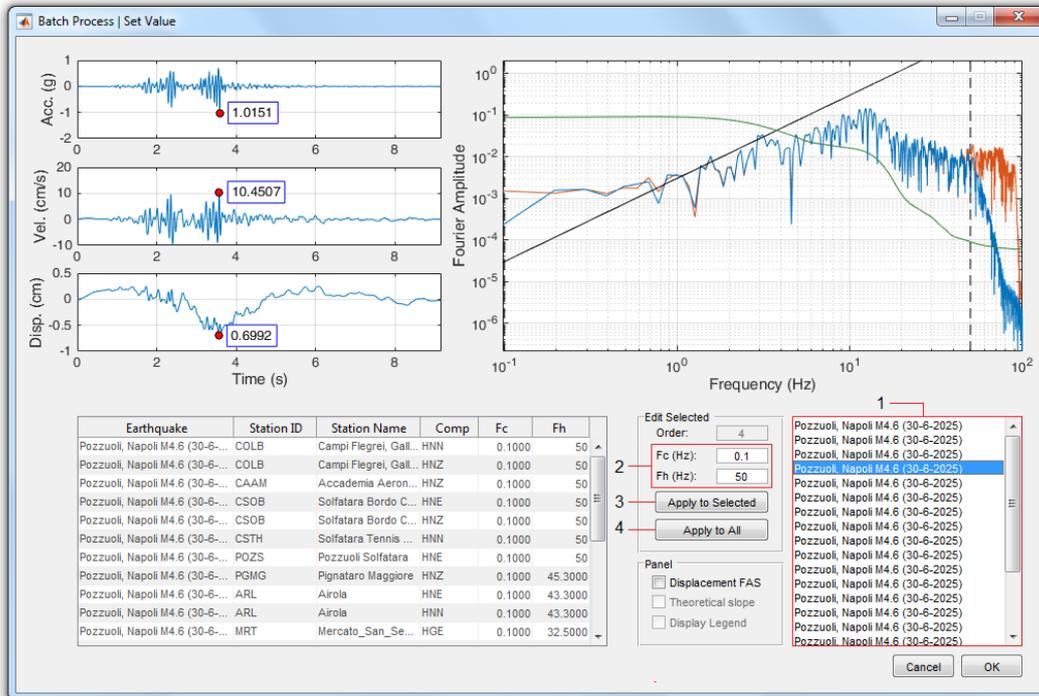
7. Find records with potentially problematic cutoff frequency values that may need adjustment.
8. Set a threshold to find records with PGA exceeding the specified value, and optionally filter by maximum ratio criteria, which tries to determine the deviation from the theoretical low-frequency slope:

$$\bar{r} = \frac{1}{N} \sum_{i=1}^N \ln \left( \frac{FA_i}{\tilde{f}_i^2} \right)$$



9. Enable to display of the Fourier Amplitude Spectrum (FAS) of displacement for the processed record.
10. Overlay the theoretical low-frequency slope (proportional to  $f^2$ ) on the Fourier spectrum.
11. Enable this checkbox to show the legend on the plot.

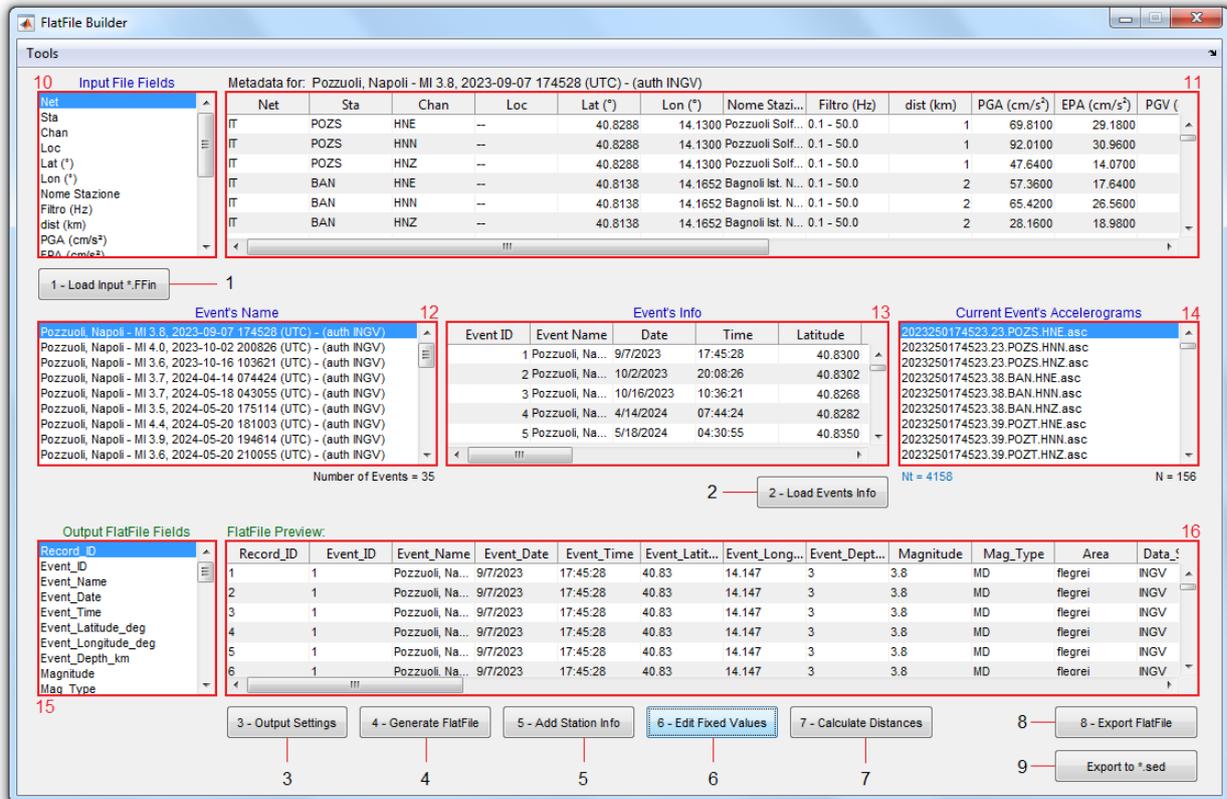
## 16.1 Batch Processing: Set Value Window



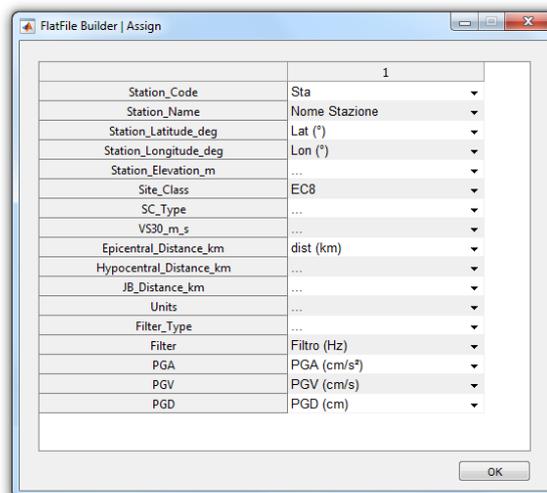
1. This listbox displays a list of selected earthquake records for editing.
2. Manually specify low ( $F_c$ ) and high ( $F_h$ ) cutoff frequencies (in Hz) for the selected record.
3. Use this button to apply the currently set filter parameters ( $F_c$ ,  $F_h$ ) only to the records you have selected in section 1.
4. Use this button to apply the filter parameters to every record in the list, regardless of selection.

**Note:** To use the Batch Processing Tool, all the three components must be available for all records in the dataset.

## 17. FlatFile Builder Tool



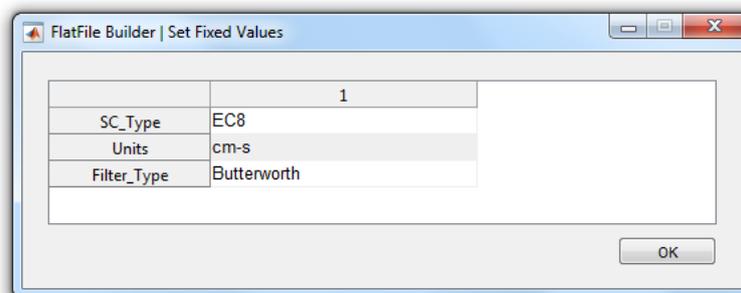
1. Use this button to load the input file (\*.FFin)
2. Use this button to load the Events Info file (\*.xls)
3. Use this button to assign the Input File fields (from listbox **10**) to the FlatFile fields (listbox **15**):



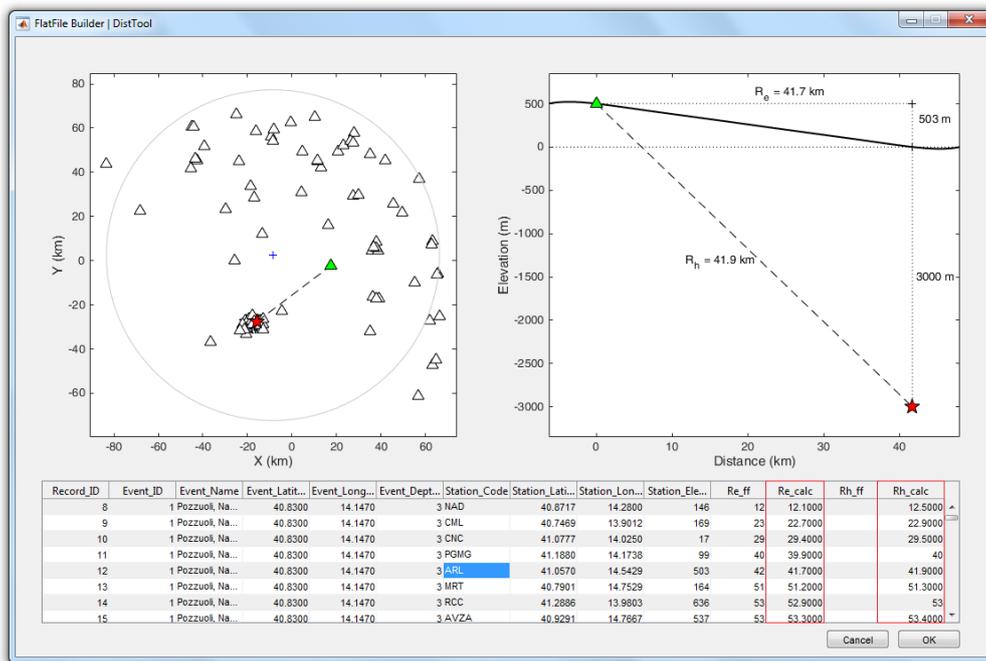
4. Use this button to generate the FlatFile. A preview of the FlatFile is displayed in the table **16**.
5. If you have additional information on the elevation and soil type of the stations, you can load it using this button. The accepted format is \*.xlsx file with 5 columns, as follows:

Station ID	Latitude	Longitude	Elevation (m)	Soil
AMSN	41.4684	13.3336	107	B
ARI	41.1546	15.0903	785	B
ARL	41.057	14.5429	503	B
ARR	41.1418	15.0819	639	B
ATI	41.6219	13.7948	439	B
ATN	41.6203	13.8012	472	A
AVHO	40.9221	14.7985	467	-
AVL	40.9228	14.787	422	B

6. Some values are constant across the entire FlatFile. You can set them using this button.



7. In case the epicentral and hypocentral distances are missing from the input files, you can use this option to automatically calculate them. SMDA calculates distances using the latitude and longitude coordinates and elevation of the station and the coordinates and depth of the earthquake hypocenter.



8. Use this button to export the Flatfile. Two files will be generated: \*.xlsx and \*.mat. If required — by some SMDA modules — the latter one can be loaded to provide additional data.

**Note:** you will also be asked whether you want to export in SIMBAD format as well. However, it is only feasible if the accelerograms are already processed. Otherwise, you need to use the updater tool.

9. Use this button to quickly generate and save the SMDA dataset (\*.sed) files for both individual earthquakes and the entire Flatfile.

10. The input file fields are displayed in this listbox.

11. This table shows the metadata for the event currently selected from the listbox **12**.

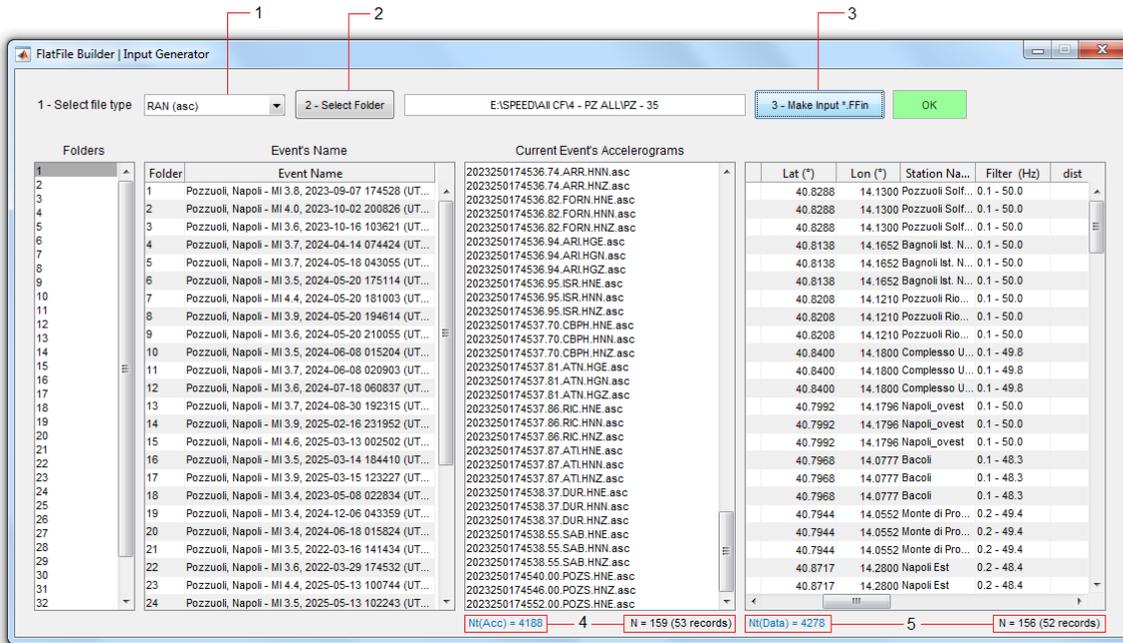
12. All available events are listed in this listbox.

13. The Event's Info data can be entered/edited from this table. The Event's Info can also be loaded from a \*.xlsx file. The accepted format is as follows:

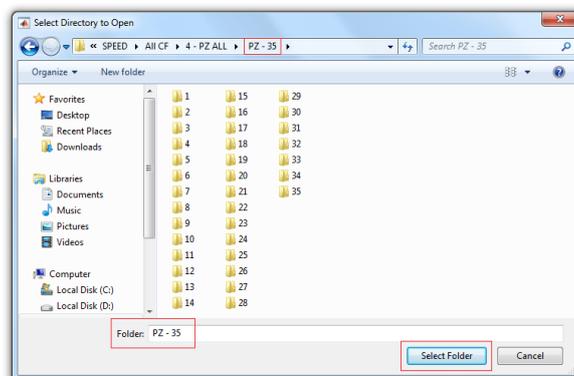
Event ID	Event Name	Date	Time	Latitude	Longitude	Depth (km)	Magnitude	Mag Type	Area	Data Source	Reference Fault	Focal Mechanism	Strike	Dip	Rake	Length (km)	Width (km)
1	Pozzuoli, Napoli M3.8	9/7/2023	17:45:28	40.83	14.147	3	3.8	MD									
2	Pozzuoli, Napoli M4.0	10/2/2023	20:08:26	40.83	14.149	3	4.0	MD									
3	Pozzuoli, Napoli M3.6	10/16/2023	10:36:21	40.82	14.142	2	3.6	MD									
4	Pozzuoli, Napoli M3.7	4/14/2024	07:44:24	40.82	14.136	3	3.7	MD									

14. List of the current event's accelerograms are displayed here.
15. The output FlatFile fields are displayed in this listbox.
16. A preview of the FlatFile is displayed in the table.

## 17.1 Input Generator

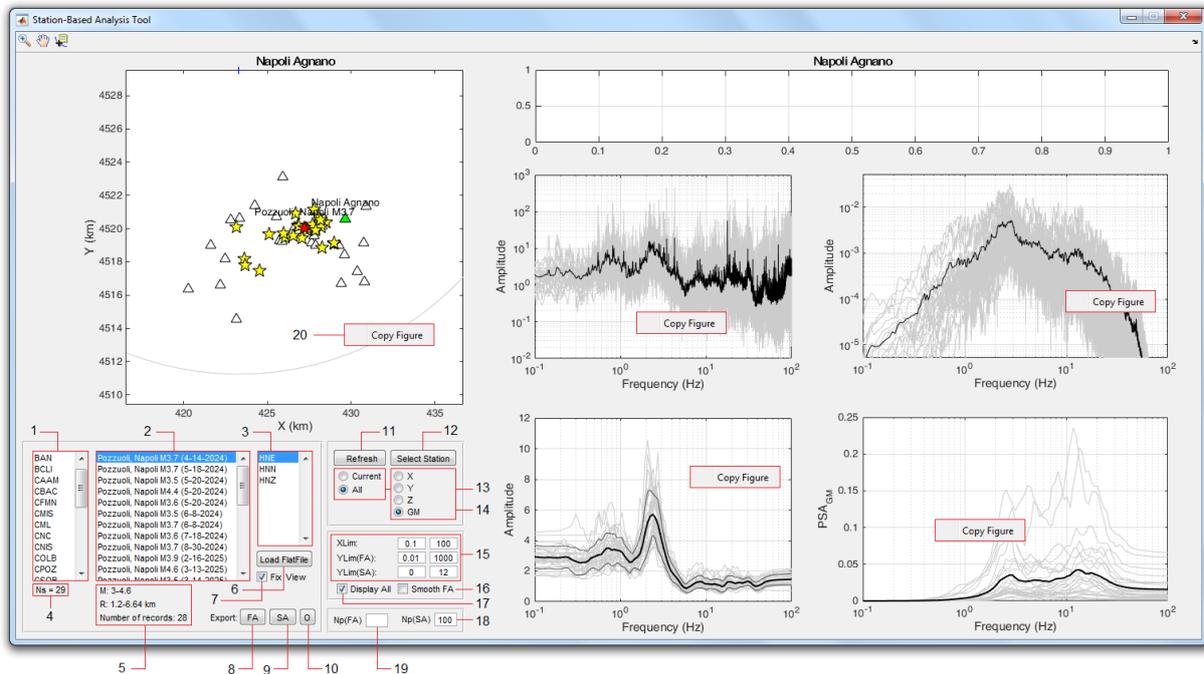


1. Select the file type from this popupmenu: RAN (\*.asc) / ESM (\*.asc) / K-Net (EW/NS/UD)
2. Select the folder that contains the accelerograms folder.



3. Click on this button to start generating input file for the Flatfile Builder (\*.FFin).
4. Here you can see the total number of accelerograms (in all folders), the number of accelerograms in current folder and the number of records. Make sure that there is 3 accelerograms (EW, NS and UD) per record in each folder.
5. If you have included a supplementary Excel file for the accelerograms, here you will find the total number of entries in the Excel files, as well as the data for the Excel in the current folder.

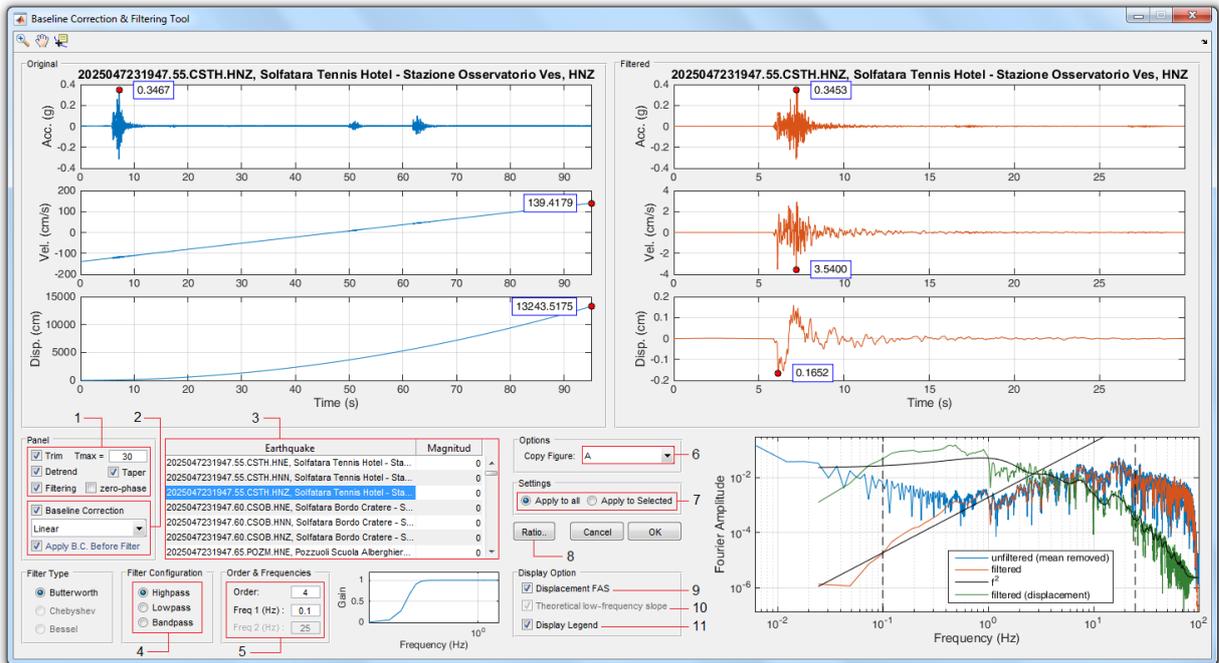
## 18. STB Analysis Tool



1. Here you can see all available stations.
2. This listbox lists all recorded seismic events associated with the selected station.
3. Available components are displayed here.
4. Total number of stations is displayed in this textbox.
5. Magnitude range, distance range and total number of events – recorded at the current station – is displayed in this panel
6. Using this button, you can load the FlatFile (Generated by SMDA) to visualize the location of stations and the recorded events on the map.
7. Enable this option to fix the current map view.
8. Use this button to export the Fourier Amplitude plot in \*.png format (QuickSave Feature). You may be prompted to select the folder in which the images will be stored.
9. Use this button to export the Spectral Acceleration plot in \*.png format.
10. Use this button to open the QuickSave folder.
11. Use this button to update the GUI plots and data after changing the current selections (i.e. options **13**, **18** and **19**).
12. If the FlatFile is already loaded, you can use this button to select the station directly on the map

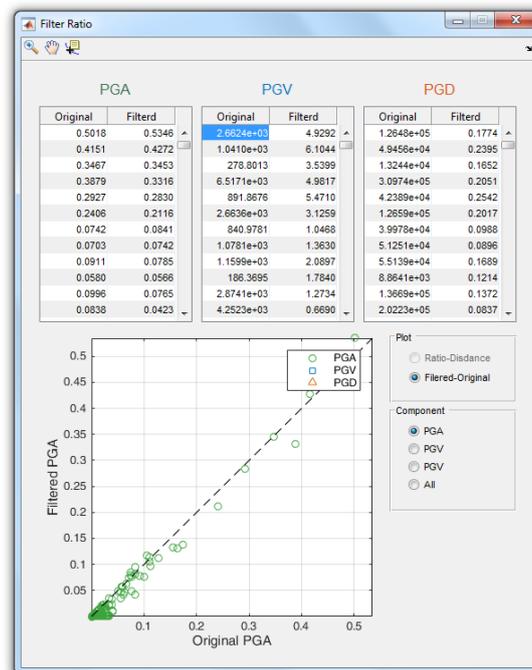
13. Use this panel to choose whether the H/V ratios are calculated for the currently selected event (listbox **2**) or for the all events at the current station.
14. Use this panel to select which component to plot (X, Y, Z, GeoMean).
15. Use these options to set the axis limits: Xlim (frequency) and Ylim (H/V ratio for FA or SA)
16. Enable this checkbox to smooth the Fourier Amplitude. (Note: avoid using a very large Np(FA) when this feature is active)
17. When the option **13** is set to "All", you can use this checkbox to hide the Fourier Amplitude or Spectral Acceleration plots for all events (the gray lines).
18. Np(SA) sets the number of points for Spectral Acceleration interpolation.
19. Np(FA) sets the number of points for Fourier Amplitude interpolation.

## 19. Baseline Correction and Filtering



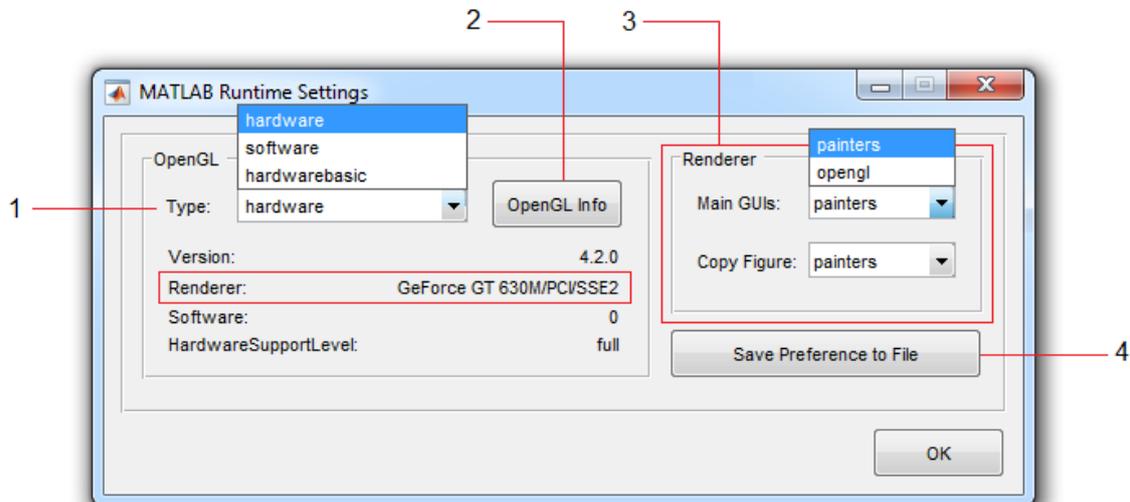
- From this panel you can enable the following basic processing functions:
  - Trim:** to shorten the length of accelerograms.
  - Deterend:** to remove the vertical shift from the acceleration time history.
  - Taper:** applies a ramp function at the start and end of the accelerogram to gradually bring it from zero to full amplitude and back to zero, preventing abrupt edges that could introduce artificial frequencies.
  - Filtering:** to apply the filter function to the acceleration time history
  - Zero-Phase:** enables zero-phase filtering, which applies the filter forward and backward to remove phase distortion while preserving the original signal's timing characteristics
- From this panel, you can enable baseline correction, choose the type (Linear, Quadratic, or Cubic), and specify whether it is applied before or after filtering.
- Select the accelerogram to display the preview of the processed and original time histories.
- From this panel, select the filter configuration (High-pass, Low-pass, or Band-pass).
- From this panel, set the filter order and define the low and high cutoff frequencies, which control the steepness of the filter and the range of frequencies that are preserved.

6. Use this popup menu to select and display a comparison between processed and original time histories for Acceleration, Velocity, or Displacement
7. Use this panel to choose whether to apply the current processing to all accelerograms or only the selected one
8. Use this option to display a comparison table for the original and filtered PGA, PGV, and PGD values. You can also plot filtered values against the original values, and—if distance data is available—plot the ratio as a function of distance.



9. Enable this checkbox to display the filtered Displacement Fourier Spectrum.
10. Enable this checkbox to overlay the theoretical low-frequency slope ( $f^2$ ) on the spectrum for comparison with expected behavior.
11. Enable this checkbox to show the legend on the plot.

## 20. MCR Settings



1. Select OpenGL Type. By default, *hardware* is used. If the graphics card driver is not updated there will be some graphic issues. In this case, switch to *software* OpenGL for the current session.
2. Display information about the OpenGL<sup>®</sup> implementation currently in use by the software, such as the version, renderer, and other features. If you don't see your graphics card in the renderer field, you will need to change the preferred graphics processor for the software. (See: [MCR Settings](#) for more information)
3. Select Default renderer for: Main software's GUIs as well as the Copied Figures.
4. Save current settings to an output file (which will be used next time when the software launches)

**Note:** if there is graphics card driver issue, you can launch program with the *software* version of OpenGL. You just need to download the preferences file (pref.xml) from the website and place it into the installation folder.

## REFERENCES

- [1] Baker, J.W., 2007. Quantitative classification of near-fault ground motions using wavelet analysis. *Bulletin of the seismological society of America*, 97(5), pp.1486-1501.

**SEISMOGRAPH**

earthquake engineering software