Seismic Analysis GUI Suite

User Manual

ResponseSpectrumGUI & **SpectraScalingGUI**

SDOF Earthquake Response Spectra and Ground Motion Scaling

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doc. Ing. Özgür Yurdakul, Ph.D.

Faculty of Transport Engineering
University of Pardubice

MATLAB-based seismic engineering software

Developed within the SIGMA Programme
M.ERA-NET Cofund / Technology Agency of the Czech Republic

Version 3.2 – April 2026

Contents

1 Introduction

This manual covers two companion MATLAB graphical user interface (GUI) tools for earthquake engineering analysis:

- `ResponseSpectrumGUI` — computes earthquake response spectra from ground motion records using three exact or numerically stable integration methods.
- `SpectraScalingGUI` — performs target-spectrum matching (ground motion scaling) in compliance with TBDY 2018 or EN 1998-1:2004 (EC8).

Both tools are self-contained single-file MATLAB applications requiring no additional toolboxes.

1.1 Requirements

- MATLAB R2020b or later (`uifigure` / App Designer support required)
- No additional toolboxes required

1.2 Acknowledgement

Note

These tools were developed within the framework of a project co-financed from the state budget by the **Technology Agency of the Czech Republic** under the **SIGMA Programme** within the **M.ERA-NET Cofund**.

1.3 License

2 ResponseSpectrumGUI

2.1 Overview

`ResponseSpectrumGUI` computes pseudo-spectral acceleration (S_a, PSa), pseudo-spectral velocity (S_v, PSv), and spectral displacement (S_d) response spectra from earthquake acceleration records. The equation of motion solved for each SDOF oscillator of natural period T is:

$$\ddot{u}(t) + 2\xi\omega_n\,\dot{u}(t) + \omega_n^2\,u(t) = -\ddot{u}_g(t) \tag{1}$$

where $u(t)$ is the relative displacement, ξ is the viscous damping ratio, $\omega_n = 2\pi/T$ is the undamped natural circular frequency, and $\ddot{u}_g(t)$ is the ground acceleration record.

The spectral quantities are defined as:

$$S_d(T,\xi) = \max_t |u(t)| \tag{2}$$

$$\mathrm{PSv}(T,\xi) = \omega_n\,S_d \tag{3}$$

$$\mathrm{PSa}(T,\xi) = \omega_n^2\,S_d \tag{4}$$

Note

PSa and PSv are *pseudo* quantities obtained via the ω_n relationship and coincide with the true spectral velocity and acceleration only for lightly damped systems ($\xi \leq 0.20$). For $\xi = 5\%$ the error is negligible for engineering purposes.

2.2 Getting Started

```
>> ResponseSpectrumGUI
```

The GUI opens in **1D mode** (narrow window, one spectrum column). Switching to 2D mode widens the window to display three columns: E-W, N-S, and Geometric Mean.

2.3 GUI Layout

2.3.1 Control Panel (left)

All input controls are in the left panel titled *Ground Motion Files*. Table 1 lists every control and its function.

Control	Description
Mode dropdown	`1D - Single Direction` or `2D - Two Directions + GM`. In 1D mode only one spectrum column is shown; in 2D mode E-W, N-S, and Geometric Mean columns are computed and displayed simultaneously.
Browse... button	Opens a file browser to load a ground motion file. Accepts `.txt`, `.csv`, `.at2`, `.dat`. Automatically detects Δt from PEER AT2 headers or uniform time column.
File text area	Displays the loaded filename.
E-W / N-S dropdowns	Visible in 2D mode only. Select which column of the file contains the E-W and N-S components (`Col 2`, `Col 3`, ...). Column 1 is always the time axis and is not selectable.
Direction dropdown	Visible in 1D mode with a multi-column file. Selects which acceleration column to use.
Damping ratio ξ	Viscous damping ratio (dimensionless). Default: 0.05 (5%).
$t_{\min}$ (s)	Lower bound of the spectral period axis. Default: auto-filled from Δt.
$t_{\max}$ (s)	Upper bound of the spectral period axis. Default: auto-filled from record duration $(N-1)\Delta t$.
dt (s)	Time step of the record. Auto-detected; edit if needed (0 triggers auto-detect).
N pts	Number of log-spaced period points at which the spectrum is evaluated. Default: 2000.
Acceleration units	Units of the acceleration values in the file: `m/s`^{2}, `cm/s`^{2}, or `g`. Internal computations always use m/s^2.
Integration method	One of three methods (see Section 2.7). Default: Newmark-β.
Overlay all three	When checked, all three methods are plotted on the same axes using blue / red / green lines for comparison.
Use same axis limits	(2D mode only) When checked, applies a common y-axis limit to PSa, PSv, Sd, and the ground acceleration axes across all three columns. Unchecking restores MATLAB auto-scaling.
COMPUTE SPECTRUM	Runs the selected method and plots results.
Export CSV	Saves the computed spectrum to a CSV file. In 2D mode all three columns (E-W, N-S, GM) are exported with labelled headers.
Save All Figures	Exports all four axes rows (PSa, PSv, Sd, ground acceleration record) to a PNG or PDF file at 300 dpi.

Table 1: ResponseSpectrumGUI control panel elements.

2.3.2 Plot Area (right)

The right side contains up to three columns of axes (1D: one column; 2D: three columns):

Row (bottom→top)	Content	Unit	Colour
Ground acceleration	a_g vs. time t	g	dark grey
S_d	Spectral displacement	cm	(per column)
PSv	Pseudo-spectral velocity	cm/s	(per column)
PSa	Pseudo-spectral acceleration	g	(per column)

In 2D mode the three columns are coloured: E-W in blue, N-S in red, Geometric Mean in purple.

2.4 Ground Motion File Formats

The file reader (`read_gm_matrix`) handles three layouts automatically:

Format	Structure	Detection rule
PEER AT2	Header containing `NPTS= ...DT= ...` then plain acceleration values	Scans first 30 lines for keywords; Δt read from header
Multi-column	Column 1 = time, columns 2+ = accelerations	First column checked for uniform positive spacing (CV $< 1\%$); Δt = mean of differences
Single-column	Plain acceleration values, one per row or multiple per row	All numbers concatenated; Δt must be entered manually

Tip

For PEER NGA-West2 flat files in AT2 format (`.at2`) the header is read automatically and no manual Δt entry is needed.

Warning

For plain single-column files with no header, the auto-detected Δt defaults to 0.01 s and a warning is issued. Always verify the Δt field after loading.

2.5 Column Selection in Multi-Channel Files

When a file with ≥ 3 columns is loaded, column labels `Col 2`, `Col 3`, ... appear in the direction dropdowns (Column 1 is always time).

- **1D mode**: one dropdown selects the active column.
- **2D mode**: two independent dropdowns select E-W and N-S; E-W $\neq$ N-S is enforced.

2.6 2D Mode and Geometric Mean

In 2D mode the geometric mean spectrum is computed point-by-point as:

$$S_a^{\mathrm{GM}}(T) = \sqrt{S_a^{\mathrm{EW}}(T) \cdot S_a^{\mathrm{NS}}(T)} \tag{5}$$

and analogously for PSv and S_d. This definition corresponds to the RotD50 lower bound and is consistent with the geometric mean used in ASCE 7 and EN 1998-1 ground motion selection procedures.

2.7 Integration Methods

Three methods are implemented, all vectorised over the full period array simultaneously for computational efficiency. Each requires only $(N_{\text{steps}} - 1)$ time loop iterations regardless of the number of periods requested.

2.7.1 Newmark-β Method (Default)

Standard Reference

Reference: Newmark, N.M. (1959). "A Method of Computation for Structural Dynamics." *Journal of the Engineering Mechanics Division*, ASCE, 85(EM3), 67–94.

Parameters: $\beta = 1/4$, $\gamma = 1/2$ (average acceleration, unconditionally stable, second-order accurate). The effective stiffness and load per unit mass are:

$$\hat{K} = \omega_n^2 + a_0 + 2\xi\omega_n a_1 \tag{6}$$

$$\hat{P}_{n+1} = -\ddot{u}_{g,n+1} + (a_0 + 2\xi\omega_n a_1)\, u_n + (a_2 + 2\xi\omega_n a_4)\, \dot{u}_n + a_3\, \ddot{u}_n \tag{7}$$

where the constants for $\beta = 1/4$, $\gamma = 1/2$ are: $a_0 = 4/\Delta t^2$, $a_1 = 2/\Delta t$, $a_2 = 4/\Delta t$, $a_3 = 1$, $a_4 = 1$.

The displacement is recovered as $u_{n+1} = \hat{P}_{n+1}/\hat{K}$ and the state is updated via the Newmark predictors.

2.7.2 Nigam-Jennings Exact Method

Standard Reference

Reference: Nigam, N.C. & Jennings, P.C. (1969). "Calculation of Response Spectra from Strong-Motion Earthquake Records." *Bulletin of the Seismological Society of America*, 59(2), 909–922.

This is the method used by **SeismoSignal** and most professional spectrum calculation codes. The ground acceleration is assumed to vary *linearly* between consecutive time steps, leading to an analytically exact closed-form recursion for the state vector $\{u_n, \dot{u}_n\}$:

$$\begin{bmatrix} u_{n+1} \\ \dot{u}_{n+1} \end{bmatrix} = \mathbf{A} \begin{bmatrix} u_n \\ \dot{u}_n \end{bmatrix} + \mathbf{B} \begin{bmatrix} \ddot{u}_{g,n} \\ \ddot{u}_{g,n+1} \end{bmatrix} \tag{8}$$

State transition matrix A: Let $\omega_d = \omega_n \sqrt{1-\xi^2}$ (damped natural frequency), $E = e^{-\xi\omega_n \Delta t}$, $S = \sin(\omega_d \Delta t)$, $C = \cos(\omega_d \Delta t)$:

$$\mathbf{A} = \begin{bmatrix} E\left(C + \dfrac{\xi}{\sqrt{1-\xi^2}} S\right) & \dfrac{E\,S}{\omega_d} \\ -\dfrac{E\,\omega_n}{\sqrt{1-\xi^2}} S & E\left(C - \dfrac{\xi}{\sqrt{1-\xi^2}} S\right) \end{bmatrix} \tag{9}$$

Forcing matrix B (corrected piecewise-linear exact): Let $\overline{EC} = (A_{11} + A_{22})/2 = E\cos(\omega_d \Delta t)$ (exact). Then:

$$B_{11} = \frac{A_{11}}{\omega_n^2} + \frac{2\xi(\overline{EC}-1)}{\Delta t\,\omega_n^3} - \frac{A_{12}(1-2\xi^2)}{\Delta t\,\omega_n^2} \tag{10}$$

$$B_{12} = -\frac{1}{\omega_n^2} - \frac{2\xi(\overline{EC}-1)}{\Delta t\,\omega_n^3} + \frac{A_{12}(1-2\xi^2)}{\Delta t\,\omega_n^2} \tag{11}$$

$$B_{21} = \frac{A_{21} + (1-A_{11})/\Delta t}{\omega_n^2} \quad \text{(note: } A_{11}\text{, not } A_{22}\text{)} \tag{12}$$

$$B_{22} = \frac{A_{11}-1}{\Delta t\,\omega_n^2} \quad \text{(note: } A_{11}\text{, not } A_{22}\text{)} \tag{13}$$

Warning

A common implementation error in the Nigam-Jennings **B** matrix is substituting A_{22} where A_{11} is required in B_{21} and B_{22}, and omitting the $2\xi(\overline{EC}-1)$ correction in B_{11}/B_{12}. These errors produce errors exceeding 400% at $T = 2$ s for typical records and are corrected in the present implementation (verified numerically against the exact analytical solution for a constant-acceleration input).

2.7.3 Duhamel's Integral (Recursive Convolution)

Standard Reference

Reference: Clough, R.W. & Penzien, J. (1993). *Dynamics of Structures*, 2nd ed., McGraw-Hill, §4-2.

The relative displacement is expressed as the Duhamel convolution:

$$u(t) = -\frac{1}{\omega_d}\int_0^t \ddot{u}_g(\tau)\, e^{-\xi\omega_n(t-\tau)} \sin[\omega_d(t-\tau)]\, \mathrm{d}\tau \equiv -\frac{I_2(t)}{\omega_d} \tag{14}$$

The cosine (I_1) and sine (I_2) components are updated recursively using a *trapezoidal* (piecewise-constant mean) approximation of $\ddot{u}_g$:

$$I_1^{n+1} = E\big(I_1^n C - I_2^n S\big) + \frac{f_{\text{avg}}}{\omega_n^2}\big[\xi\omega_n(1-EC) + \omega_d ES\big] \tag{15}$$

$$I_2^{n+1} = E\big(I_1^n S + I_2^n C\big) + \frac{f_{\text{avg}}}{\omega_n^2}\big[\omega_d(1-EC) - \xi\omega_n ES\big] \tag{16}$$

where $f_{\text{avg}} = (\ddot{u}_{g,n} + \ddot{u}_{g,n+1})/2$. This piecewise-constant quadrature assumption distinguishes the Duhamel implementation from the piecewise-linear assumption of Nigam-Jennings.

2.7.4 Method Comparison

Method	**Stability**	**Order**	**Δt assumption**
Newmark-β	Unconditional	2nd	Avg. acceleration
Nigam-Jennings	Exact	Exact	Piecewise linear
Duhamel	Unconditional	≈2nd	Piecewise constant

Tip

For typical earthquake records with $\Delta t \leq 0.02$ s the three methods agree to within $< 1\%$ for 5% damping. Use the **Overlay all three methods** checkbox to verify agreement for your specific record.

2.8 Outputs

2.8.1 On-screen status panel

After computation the bottom-left label reports:

- Computation time (seconds)
- Damping ratio used
- In 1D: `max PSa = X.XXXX g @ T = X.XXX s`
- In 2D: peak PSa and corresponding period for each of E-W, N-S, and GM

2.8.2 CSV export columns

Column name	Content
`T_s`	Period (s)
`PSa_g` / `PSa_EW_g` / `PSa_NS_g` / `PSa_GM_g`	PSa (g)
`PSv_cms` / ...	PSv (cm/s)
`Sd_cm` / ...	S_d (cm)

2.9 Limitations

- Linear SDOF analysis only (no inelastic or degrading systems)
- PSa/PSv are pseudo-quantities; for $\xi > 20\%$ use true spectral values
- Geometric mean requires exactly two matched E-W + N-S components
- Duhamel uses trapezoidal quadrature; accuracy degrades for very large Δt
- The period axis is log-spaced; $T = 0$ (PGA) is not included (reported separately in the status panel from the record's peak ground acceleration)

2.10 Troubleshooting

Issue	Solution
dt defaults to 0.01 s	File has no recognisable header and no uniform time column. Enter Δt manually in the dt field.
2D mode requires ≥ 2 *columns*	File has only one acceleration column. Use two separate files or a multi-column file.
E-W and N-S must differ	Both direction dropdowns point to the same column. Select different columns.
Flat or zero spectrum	Check that the acceleration units are correct. A record stored in cm/s^2 loaded as m/s^2 will produce a spectrum 100× too small.
Three methods disagree strongly	Δt is too large relative to the shortest period. Reduce t_{min} or use a record with smaller Δt.

3 SpectraScalingGUI

3.1 Overview

`SpectraScalingGUI` performs target-spectrum matching of ground motion records by computing per-record scale factors (SFs) that minimise the least-squares deviation between the scaled mean spectrum and a user-supplied target design spectrum over a prescribed period range. The tool fully implements the requirements of:

- **TBDY 2018** (Turkish Building Earthquake Code, 2018), §2.4
- **EN 1998-1:2004** (Eurocode 8), §3.2.3.1, §4.3.3.4.3

3.2 Getting Started

```
>> SpectraScalingGUI
```

The GUI opens with three tabs on the left panel and a plot axes on the right.

3.3 GUI Layout

3.3.1 Menu Bar

Menu item	Function
File → New	Clears all records, target, and project state
File → Open	Loads a previously saved `.mat` project file
File → Save	Saves the current project (overwrites if path known)
File → Save As	Saves to a new `.mat` file
Export → Figure	Exports the current plot to PNG, PDF, or EMF at 300 dpi

3.3.2 Tab 1: Target Spectrum

Control	Description
Standard	`TBDY 2018` or `EC8 EN 1998-1:2004`. Switching immediately updates the period range labels, axis markers, auto-scale window, and compliance check window throughout the GUI.
Load Target Spectrum	Browses for a CSV file containing the target design spectrum. A column-selector dialog allows choosing which column is period T and which is $S_a(g)$.
Target status label	Confirms file name and selected columns once loaded.
T_1 (s)	Fundamental building period. Required for scaling window computation and compliance check. Entering 0 hides the period markers.
Period markers	Once T_1 is entered, vertical dashed lines at $0.2T_1$, T_1, and the upper period bound ($1.5T_1$ for TBDY 2018; $2T_1$ for EC8) are drawn on the plot.
Plot Axis Limits	X min/max (s) and Y min/max (g) fields. Click **Apply Limits** to enforce; **Reset to Auto** to restore automatic scaling.

3.3.3 Tab 2: Ground Motions

Control	Description
Add CSV File(s)...	Multi-select browser for ground motion spectrum CSV files. For each file a dialog asks for the period column, S_a column, and component label (EW / NS / GM).
Remove Selected Row	Removes the highlighted row from the table.
Records table	Columns: *Record Name*, *SF* (editable), *Component*, *T col*, *Sa col*, *OK*.
Apply SFs and Re-plot	Reads any manually edited SF values from the table and redraws all spectra.
Auto-Scale (Least Squares)	Computes optimal SFs by least-squares minimisation over the standard's period window (see Section 3.4).
Reset All SFs to 1.0	Resets every record's SF to unity.

3.3.4 Tab 3: Results

Field	Content
Records loaded	Total number of records in the table
Target spectrum	Label of the loaded target file
Building T_1 (s)	Current value of T_1
$0.2T_1$ (s) / Upper T (s)	Period window boundaries (standard-dependent)
Min ratio (mean/target)	Minimum of $\bar{S}_a(T_i)/S_{a,\mathrm{tgt}}(T_i)$ over the window
Mean ratio (mean/target)	Mean of the ratio array
RMSE (g)	Root-mean-square error between mean and target
R^2	Coefficient of determination
EC8 §3.2.3.1.2(4)(c)	Visible only when EC8 is selected (see Section 3.6)
EC8 §4.3.3.4.3	Visible only when EC8 is selected (see Section 3.6)
Check Compliance	Recomputes and updates all Results fields
Export Results (CSV)	Saves scale factors and mean scaled spectrum to CSV

3.4 Auto-Scale Algorithm

For each record i, the optimal scale factor SF_i is found by ordinary least squares minimisation over the period window $[T_{\min}, T_{\max}]$:

$$\mathrm{SF}_i = \frac{\mathbf{S}_{a,i}^{\top}\,\mathbf{S}_{a,\mathrm{tgt}}}{\mathbf{S}_{a,i}^{\top}\,\mathbf{S}_{a,i}} \tag{17}$$

where $\mathbf{S}_{a,i}$ and $\mathbf{S}_{a,\mathrm{tgt}}$ are vectors of the record and target spectral values interpolated at 300 uniformly-spaced period points within the window. Scale factors are bounded to [0.1, 3.0].

The period window depends on the selected standard:

Standard	Lower bound	Upper bound
TBDY 2018	$0.2T_1$	$1.5T_1$
EC8 EN 1998-1:2004	$0.2T_1$	$2.0T_1$

3.5 Compliance Check Metrics

All metrics are computed from the *mean scaled spectrum* $\bar{S}_a(T) = \frac{1}{N}\sum_{i=1}^{N} \mathrm{SF}_i \cdot S_{a,i}(T)$ evaluated at 300 points within the scaling window:

$$\text{Min ratio} = \min_i \frac{\bar{S}_a(T_i)}{S_{a,\text{tgt}}(T_i)} \tag{18}$$

$$\text{Mean ratio} = \frac{1}{n_v}\sum_i \frac{\bar{S}_a(T_i)}{S_{a,\text{tgt}}(T_i)} \tag{19}$$

$$\text{RMSE} = \sqrt{\frac{1}{n_v}\sum_i [\bar{S}_a(T_i) - S_{a,\text{tgt}}(T_i)]^2} \tag{20}$$

$$R^2 = 1 - \frac{\sum_i [\bar{S}_a(T_i) - S_{a,\text{tgt}}(T_i)]^2}{\sum_i [\bar{S}_a(T_i) - \overline{S_{a,\text{tgt}}}]^2} \tag{21}$$

where n_v is the number of valid (non-NaN) interpolation points.

Note

All four metrics are strictly computed *within* the standard's period window $[0.2T_1,\ 1.5T_1$ or $2T_1]$. Points outside this range are never included.

3.6 Standards Implementation

3.6.1 TBDY 2018

Standard Reference

Reference: TBDY (2018). *Türkiye Bina Deprem Yönetmeliği* (Turkish Building Earthquake Code).

In TBDY 2018 mode:

- Scaling window: $[0.2T_1,\ 1.5T_1]$
- Axis markers at $0.2T_1$, T_1, and $1.5T_1$
- The EC8-specific compliance rows in Tab 3 are hidden

3.6.2 EC8 EN 1998-1:2004

Standard Reference

References:

- EN 1998-1:2004, §3.2.3.1.2(4)(c) — 90% lower-bound rule on mean spectrum
- EN 1998-1:2004, §3.2.3.1.3 — recorded and simulated accelerograms
- EN 1998-1:2004, §4.3.3.4.3(3)–(4) — 3 vs. 7 design value rule

In EC8 mode:

- Scaling window: $[0.2T_1,\ 2.0T_1]$ per §3.2.3.1.2(4)(c)
- Axis markers at $0.2T_1$, T_1, and $2T_1$

90% lower-bound check (§3.2.3.1.2(4)(c)) The standard requires that *"no value of the mean 5% damping elastic spectrum, calculated from all time histories, should be less than 90% of the corresponding value of the 5% damping elastic response spectrum."* Formally:

$$\bar{S}_a(T_i) \geq 0.90\, S_{a,\mathrm{tgt}}(T_i) \quad \forall\, T_i \in [0.2T_1,\ 2T_1] \tag{22}$$

The GUI checks this at all 300 evaluation points and reports:

- **PASS** if zero points fall below the 90% bound
- **FAIL** + number of failing points if any violation exists

3 vs. 7 design value rule (§4.3.3.4.3(3)–(4))

N records	Design value	GUI report
$N \geq 7$	Mean response	N ≥ 7 → use MEAN response
$N < 7$	Maximum (envelope) response	N < 7 → use MAX (envelope) response

Warning

When $N < 7$ records are used, EN 1998-1:2004 §4.3.3.4.3(3) requires the *most unfavourable* value of the structural response quantity from all analyses to be used as the design value. This is more conservative than the mean and the GUI flags this condition in orange as a reminder to the analyst.

3.7 Plot Description

The right-side axes shows all spectra overlaid:

- **Target spectrum**: solid black line, linewidth 2.2
- **Individual scaled records**: coloured semi-transparent lines ($\alpha = 0.45$)
- **Mean scaled spectrum**: solid dark-red line, linewidth 2.0
- **90% of target (EC8 only)**: dashed grey line when EC8 is selected
- **Period markers**: solid blue vertical line at T_1; dashed blue lines at $0.2T_1$ and the upper bound

Tip

Run **Auto-Scale** first, then **Check Compliance**. If the EC8 90% check fails, consider adding more records or manually adjusting the SFs of records that are deficient in the failing period range.

3.8 CSV Export Format

The exported CSV file contains two blocks separated by a blank line:

```
Scale Factors
RecordName,ScaleFactor,Component
<name>,<SF>,<EW|NS|GM>
...

Mean Scaled Spectrum
T_s,Sa_mean_g
<T>,<Sa>
...
```

3.9 Limitations

- Records must be pre-computed spectra (CSV format); the tool does not compute spectra internally — use `ResponseSpectrumGUI` for that purpose
- Scale factor bounds are fixed at [0.1, 3.0]; these may be adjusted in the source if project requirements differ
- One component label per record; mixed EW/NS/GM records are each treated independently
- No inelastic spectrum compatibility check (elastic target only)
- No automatic pair-matching for bidirectional analyses (records must be organised by the user)

3.10 Troubleshooting

Issue	**Solution**
Period markers persist after changing T_1	Markers are cleared and redrawn on every plot refresh. If stale markers appear, click **Apply SFs and Replot** or change T_1 again to force a redraw.
Insufficient overlap warning	The record's period range does not cover the full scaling window. Check that records span at least $[0.2T_1,\ 1.5T_1]$ (TBDY) or $[0.2T_1,\ 2T_1]$ (EC8).
All SFs hit the 3.0 cap	Records are much softer than the target. Consider using a different record set or relaxing the period window.
EC8 compliance rows not visible	Select `EC8 EN 1998-1:2004` in the Standard drop-down on Tab 1. These rows are hidden in TBDY 2018 mode.
Saved project does not restore plot	Click **Apply SFs and Replot** after loading a project to regenerate the axes.

4 Using MATLAB Online

Both tools run without modification in MATLAB Online (browser-based). No installation is required.

4.1 Accessing MATLAB Online

4.1.1 Option A: Institutional Campus-Wide Licence (Recommended)

1. Go to `https://matlab.mathworks.com`
2. Sign in with your institutional email address (SSO)
3. If you do not yet have a MathWorks account, create one — the campus licence links automatically

Tip

Check eligibility at: `https://www.mathworks.com/academia/tah-support-program/eligibility.html`

4.1.2 Option B: Basic MATLAB Online

Create a free MathWorks account and access 20 hours/month of compute time with 5 GB MATLAB Drive storage. This is sufficient for typical seismic analysis sessions.

4.2 Running the Tools Online

1. Upload the `.m` file to MATLAB Drive using the Upload button
2. Type in the Command Window:

   ```
   >> ResponseSpectrumGUI
   ```

   or

   ```
   >> SpectraScalingGUI
   ```

3. The GUI opens inside the browser. All controls work identically to the desktop version.
4. Ground motion / spectrum CSV files can be uploaded to MATLAB Drive and browsed within the GUI's file dialogs.

Warning

MATLAB Online requires a stable internet connection. The GUI state and uploaded files are preserved in MATLAB Drive, but unsaved Command Window output may be lost if the connection drops.

5 Quick-Start Workflow

The recommended workflow for a complete spectrum compatibility analysis is:

1. **Compute spectra**: Load your ground motion records (acceleration time histories) into `ResponseSpectrumGUI`. Set $\xi = 5\%$, choose the appropriate Δt and units, run `COMPUTE SPECTRUM`, and export CSVs for each record.
2. **Prepare target**: Generate or obtain the design spectrum CSV (e.g. from TBDY 2018 §2.3 or EC8 Type 1/Type 2 elastic spectra).
3. **Load into SpectraScalingGUI**: Select the standard, enter T_1, load the target spectrum, then add the record spectra from Step 1.
4. **Auto-scale**: Click **Auto-Scale**. Inspect the plot and the compliance metrics on Tab 3.
5. **Verify compliance**: Click **Check Compliance**. For EC8 projects, confirm the 90% lower-bound check passes and note the 3 vs. 7 design value rule.
6. **Export**: Export results CSV (scale factors + mean spectrum) and the figure.

6 References

1. Nigam, N.C. & Jennings, P.C. (1969). Calculation of response spectra from strong-motion earthquake records. *Bull. Seism. Soc. Am.*, 59(2), 909–922.

2. Newmark, N.M. (1959). A method of computation for structural dynamics. *J. Eng. Mech. Div.*, ASCE, 85(EM3), 67–94.

3. Clough, R.W. & Penzien, J. (1993). *Dynamics of Structures*, 2nd ed. McGraw-Hill.

4. TBDY 2018. *Türkiye Bina Deprem Yönetmeliği* (TBDY 2018). Disaster and Emergency Management Presidency, Ankara. §2.4 (ground motion selection and scaling).

5. CEN (2004). *EN 1998-1:2004 – Eurocode 8: Design of structures for earthquake resistance – Part 1: General rules, seismic actions and rules for buildings.* European Committee for Standardization, Brussels. §3.2.3.1.2(4)(c), §3.2.3.1.3, §4.3.3.4.3(3)–(4).