User Manual for Scenario Spectra (2017) Program - Version0

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Introduction

The scenario spectra program performs the selection of a set of scenario spectra and assigns rates of occurrence to them such that the computed hazard curves using the selected scenario spectra and their rates of occurrence match, within a tolerance, the target hazard curves for a frequency range of interest. The analysis can be performed for either horizontal or vertical components or both components simultaneously. The scenario spectra program is designed to minimize the number of unique scenario spectra selected and reuses the same spectra with different scaling factors and rates of occurrence. The outcome is typically a set of several hundreds of scenario spectra of which a fraction is unique (typically less than 100). The calculated hazard using these spectra along with their rates of occurrence matches, within a tolerance, the target vertical and/or horizontal UHS curves at a range of hazard levels and periods. The outline of the program is as follows:

- Read a control input file, vertical and horizontal target UHS files, vertical and horizontal CMS files, and assigned flatfiles (files that contain empirical ground motion response spectra and their metadata). These input files specify input parameters and the set of UHS curves, CMS curves anchored at the reference period T_o specified in the input file, standard deviations of the CMS curves, and correlation coefficients of the ground motion across spectral periods. The input data (UHS, CMS, sigma, correlation coefficients) are interpolated (log-log or log-linear interpolation) to the spectral periods of the ground motion in the flatfiles.
- Discard the response spectra that don't satisfy the ranges assigned by the user in terms of magnitude, distance, V_{S30}, duration, PGV, acceptable instrument location, and usable frequency range.
- Select candidate scenario spectra for each hazard level that fall within 2.5 x $\sigma_{CMS}(T, T_0)$ of the vertical and/or horizontal CMS curves anchored to the corresponding UHS curves at the reference period T_o. The residual of the horizontal and/or vertical spectral accelerations of each candidate spectrum with respect to the horizontal and/or vertical CMS in natural logarithm units must not be larger than 0.15 at all spectral periods.
- From the candidate scenario spectra at each hazard level except for the lowest hazard level, select a subset N (N is assigned by the user) that has the best likelihood of capturing the horizontal and vertical conditional mean spectra and the variability around them. The lowest hazard level is only used for setting rates of occurrence.

- Using all the N subsets of scenario spectra (N_{total}), find the set of unique scenario spectra (N_{unique}) and scale them to be uniformly distributed in log space between each 2 consecutive UHS curves at the reference period T_o. A previous version of the program used all the N subsets of scenario spectra scaled to the ground motion halfway between each 2 consecutive UHS curves. This, however, resulted in pinching of the scenario spectra at the reference period. The current approach leads to a total of N_{unique} *(N_{levels} -1) scenario spectra that have different scaling factors.
- Initial equal rates of occurrence are assigned to the scenario spectra (N_{total}) at each hazard level based on the annual rates of exceedance of the 2 neighboring UHS curves. These rates of occurrence are changed numerically for each scenario spectrum in multiple iterations such that the misfits of the calculated horizontal and/or vertical hazard curves with respect to the target hazard curves are minimized in the frequency range of interest. Remove the scenario spectra that have very low (insignificant) rates of occurrence and consolidate duplicate spectra that have the same scaling factors.
- Write output summary file, scenario spectra metadata, vertical and/or horizontal hazard files, and UHS files.

Input Files

The input files to the scenario spectra program consist of the following:

- Control file that specifies the parameters of the run
- Files (1 file if a single component is used; 2 files if both horizontal and vertical components are used) containing the design horizontal and/or vertical UHS curves.
- Files (1 file if a single component is used; 2 files if both horizontal and vertical components are used) containing the CMS curves anchored at the reference period specified in the control file. The standard deviations and correlation coefficients used in the computation of the CMS curves are also included in these file.
- Horizontal and/or vertical flatfiles.

Input files should be kept in the same format as specified in the companion example case to avoid errors in the runs. These formats are specified below.

Control File

Title	Text line.
Run_Flag	Flag to run horizontal case (flag = 1), vertical case (flag = 2), or both vertical and horizontal case (flag = 0).
T_o	Reference period at which the CMS curves are anchored to the UHS. The value of this reference period is not critical to the results. A reference period around the middle of the period range used for strict matching of the target UHS curves is reasonable.
T_1, T_2	Period range used for the initial selection of scenario spectra and whereby loose matching to the UHS curves is performed outside T_{1Match}, T_{2Match} (See below). The given UHS curves and spectra in the flatfiles need to cover this period range.
T_{1Match}, T_{2Match}	Period range for strict matching of the UHS curves.
M_{min}, M_{max}	Magnitude range for selecting candidate spectra. Response spectra of time series with magnitude outside this range are discarded.
DistFlag	Flag to specify whether Rrup or Rjb is used to define the distance range in the next line. Use 1 for Rrup, 2 for Rjb.
D_{min}, D_{max}	Distance (Rrup or Rjb) range for selecting candidate spectra. Response spectra of time series with distance outside this range are discarded.
V_{S30min}, V_{S30max}	V_{S30} range for selecting candidate spectra. Response spectra of time series with shear wave velocities outside this range are discarded.

Dur_{min}, Dur_{max}	Duration range for selecting candidate spectra. The type of duration is not defined at this point in the program. The definition of this duration should be the same as the one in the flatfiles.
PGV_{min}, PGV_{max}	Peak ground velocity range for selecting candidate spectra.
AI_{min}, AI_{max}	Arias intensity range for selecting candidate spectra.
N	Number of scenario spectra to select per hazard level.
nMonte	Number of Monte Carlo realizations for selecting the subset of scenario spectra per hazard level that best spans the variability around the CMS.
nFit, delta	Number of iterations on the rates of occurrence of scenario spectra. Fractional change in the rates of occurrence.
maxAdj	Maximum change (Rate Initial/Rate Final) in rates of occurrence allowed. Scenarios with Rate Initial/Rate Final > maxAdj are discarded.
Text	Text line.
UHSh_file	Name of the horizontal or vertical UHS file.
UHSv_file	Name of the vertical UHS file. This line is only needed when *Run_Flag* is set to 0.
CMSh_file	Name of the horizontal or vertical CMS file.
CMSv_file	Name of the vertical CMS file. This line is only needed when *Run_Flag* is set to 0.
Horiz_flatfile	Name of horizontal or flatfile containing ground motion metadata and spectral acceleration.
$Vert\_flatfile_i$	Name of vertical flatfile. This line is only needed when *Run_Flag* is set to 0.
Text	Text line.

The following lines specify the names of output files generated by the program.

Outputfile_sum	Name of output file containing the main input and output parameters (summary file).
Outputfile_1	Name of output file containing the list of scenario spectra metadata, their rates of occurrence and their vertical and horizontal scaling factors.

Outputfile_2H Name of output file containing the list of scaled scenario spectra for the horizontal or vertical component.

Outputfile_2V Name of output file containing the list of scaled scenario spectra for the vertical component. This line is only needed when *Run_Flag* is set to 0.

Outputfile_3H Name of output file containing the computed and target horizontal or vertical hazard curves.

Outputfile_3V Name of output file containing the computed and target vertical hazard curves. This line is only needed when *Run_Flag* is set to 0.

Outputfile_4H Name of output file containing the computed and target UHS curved for the horizontal or vertical component.

Outputfile_4V Name of output file containing the computed and target UHS curved for the vertical component. This line is only needed when *Run_Flag* is set to 0.

Outputfile_5 Name of output file containing the names of the unique scenario spectra.

Horizontal and Vertical FlatFiles

The horizontal and vertical pairs of flatfiles should have the same format. All metadata in the flatfiles are the same for the same database. The spectral acceleration values are the only different entries in the 2 flatfiles. Any missing or unknown metadata or spectral acceleration values should be reported as -999 in the flatfiles.

Title Text line.

nPer Number of spectral periods asides from PGA, PGV, and PGD.

T1, T2,… List of the values of the nPer spectral periods in the flatfile.

RSN, EQID… Header line.

Vertical columns have entries based on the NGA-West flatfile and definitions. They have the following format. For further descriptions, refer to the NGA-West flatfile documentation.

RSN Unique record sequence number assigned to each spectrum in the flatfile.

EQID Unique ID assigned to each earthquake in the flatfile.

SSN Unique station sequence number assigned to each earthquake in the flatfile.

Mag Moment magnitude of earthquake.

Dip Dip angle of the fault plane in degrees (dip between 0 and 90 degrees).

Rake	Rake is the angle measured in degrees on the fault plane counterclockwise from the reference strike direction to the average slip direction (values between -180 and 180 degrees).
Rrup	Closest distance from the recording site to the rupture plane in km.
Rjb	Joyner and Boore distance in km. It is the shortest horizontal distance from the recording site to the vertical projection of the rupture plane.
Repi	Distance from the recording site to the epicenter in km.
Rhypo	Distance from the recording site to the hypocenter in km.
Rx	Horizontal distance from the top of rupture measured perpendicular to fault strike in km.
SrcAz	Source to site azimuth in degrees. It is the angle measured clockwise from the fault strike direction to the direction connecting the site and the site's closest point on the surface projection of top edge of fault. It is a hanging wall/footwall indicator. If SrcAz is positive, the site is on the hanging wall; otherwise it is on the footwall.
V_{S30}	Average shear-wave velocity in top 30m of site profile in m/sec.
GMX's C1	First letter of Geomatrix's classification indicating instrument housing, structure type and instrument location. Refer to NGA-West documentation for more information.
GMX's C2	Second letter of Geomatrix's classification indicating mapped local geology. Refer to NGA-West documentation for more information.
GMX's C3	Third letter of Geomatrix's classification indicating geotechnical subsurface characteristics. Refer to NGA-West documentation for more information.
Dur	Duration in sec.
AI	Arias intensity in the unit of length per time.
fmin	Recommended lowest useable frequency for the average horizontal component or for the vertical component.
PGA	Peak ground acceleration in g.
PGV	Peak ground velocity in cm/sec.
PGD	Peak ground displacement in cm.
T0.010S, *T0.020S,...*	Pseudo-spectral accelerations in g. This column is repeated for the number of spectral periods *nPer*.

AccFilename_H1	Name of the file containing the acceleration time series on the H1 component for this spectrum.
AccFilename_H2	Name of the file containing the acceleration time series on the H2 component for this spectrum.
AccFilename_V	Name of the file containing the acceleration time series on the vertical component for this spectrum.

UHS Files

The UHS file format is consistent with the format used in the HAZ45 post processor. Both horizontal and vertical UHS files should have the same format. This format is described below.

Dummy	Text line. This is repeated for lines 1 through 5.
Dummy, nLevel	Number of given hazard levels.
Dummy	Text line. This is repeated for lines 7 through 9.
HazLevel	Given hazard levels. This line is repeated for the assigned number of hazard levels.
Dummy	Text line.
Dummy, nPer	Number of spectral periods given to define the UHS.
Dummy	Text line. This is repeated for a total of 2 consecutive lines.
Per_UHS	Spectral periods used to define the UHS. This line is repeated to list all the nPer needed.
Dummy	Text line. This is repeated for a total of 4 consecutive lines.
Nb, Per, Sa_1, Sa_2,…	Dummy number, spectral period, spectral acceleration at this period and at the different hazard levels. This line is repeated for the number of spectral periods, *nPer*, to define the UHS curves for the different hazard levels.

CMS Files

The CMS file format is similar to the UHS file format. The hazard levels and period vector in the CMS file should be consistent with those defined for the UHS. Both horizontal and vertical CMS files should have the same format. This format is described below.

Dummy	Text line. This is repeated for lines 1 through 5.

Dummy, nLevel	Number of given hazard levels.
Dummy	Text line. This is repeated for lines 7 through 9.
HazLevel	Given hazard levels. This line is repeated for the assigned number of hazard levels.
Dummy	Text line.
Dummy, nPer	Number of spectral periods given to define the CMS.
Dummy	Text line. This is repeated for a total of 2 consecutive lines.
Per	Spectral periods used to define the CMS. This line is repeated to list all the nPer needed.
Dummy	Text line. This is repeated for a total of 4 consecutive lines.
Nb, Per, Sa_1, Sa_2,…	Dummy number, spectral period, spectral acceleration at this period and at the different hazard levels. This line is repeated for the number of spectral periods, *nPer*, to define the CMS curves for the different hazard levels.
Dummy	Text line. This is repeated for a total of 2 consecutive lines.
Nb, Per, Sa_1, Sa_2,…	Dummy number, spectral period, median spectral acceleration at this period and at the different hazard levels. This line is repeated for the number of spectral periods, *nPer*. Note that the median spectral accelerations are not used in the scenario spectra program.
Dummy	Text line. This is repeated for a total of 2 consecutive lines.
Nb, Per, $Sigma_1$, $Sigma_2$,…	Dummy number, spectral period, standard deviation (sigma) used to compute the CMS at this period and at the different hazard levels. This line is repeated for the number of spectral periods, *nPer*.
Dummy	Text line. This is repeated for a total of 2 consecutive lines.
Nb, Per, Rho_1, Rho_2,…	Dummy number, spectral period, correlation coefficient (rho) used to compute the CMS at this period and at the different hazard levels. This line is repeated for the number of spectral periods, *nPer*.

Output Files

A total of five (for a single-component run) to nine (for a two-component run) output files are produced by the scenario spectra program with names specified in the input file. The first output file is a summary file that lists the main input and output parameters. Output parameters include the average and maximum misfits between the calculated and target UHS and the spectral periods at which the maximum misfits happened. The total and unique numbers of scenario spectra are also listed.

The second output file is a scenario spectra file that lists the set of spectra needed to match the target UHS curves in the period range of interest along with their rate of occurrence and vertical and/or horizontal scaling factors. Metadata such as record sequence number, earthquake ID, magnitude, distance, duration and V_{S30} are also given.

The next output file contains the scaled spectral accelerations for the set of scenario spectra needed to match the UHS. This file contains the number of scenario spectra, number of periods, the spectral period vector and the rates and scaled spectral acceleration values for all the scenarios. If both horizontal and vertical components are used in the analysis, then the next output file will contain the scaled spectral accelerations for the vertical component.

The next output file lists the initial, computed and target hazard curves. This file contains the number of spectral periods, number of hazard levels, and the set of spectral periods, and the initial, final, and target hazard curved for the different hazard levels. If both horizontal and vertical components are used in the analysis, then the next output file will contain the hazard curves for the vertical component.

The next output file contains the computed and target UHS curves. This file contains the number of spectral periods, number of hazard levels, and the reference period used in the analysis. The sets of spectral periods, target and computed UHS values are then listed for the different hazard levels. If both horizontal and vertical components are used in the analysis, then the next output file will contain the hazard curves for the vertical component.

The last output file contains the list of filenames for the three components (H1, H2, and Up) for the unique set of scenario spectra.