

# Ground motion selection for nonlinear response history analyses of concrete dams

Neal Simon Kwong  
[nealsimonkwong@berkeley.edu](mailto:nealsimonkwong@berkeley.edu)

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# **INTRODUCTION**

# Aim

1. Review fundamentals of ground motion selection and modification (GMSM)
2. Illustrate GMSM for three components of ground motion (GM)
3. Identify most important inputs to GMSM methodology

# Case study for illustration

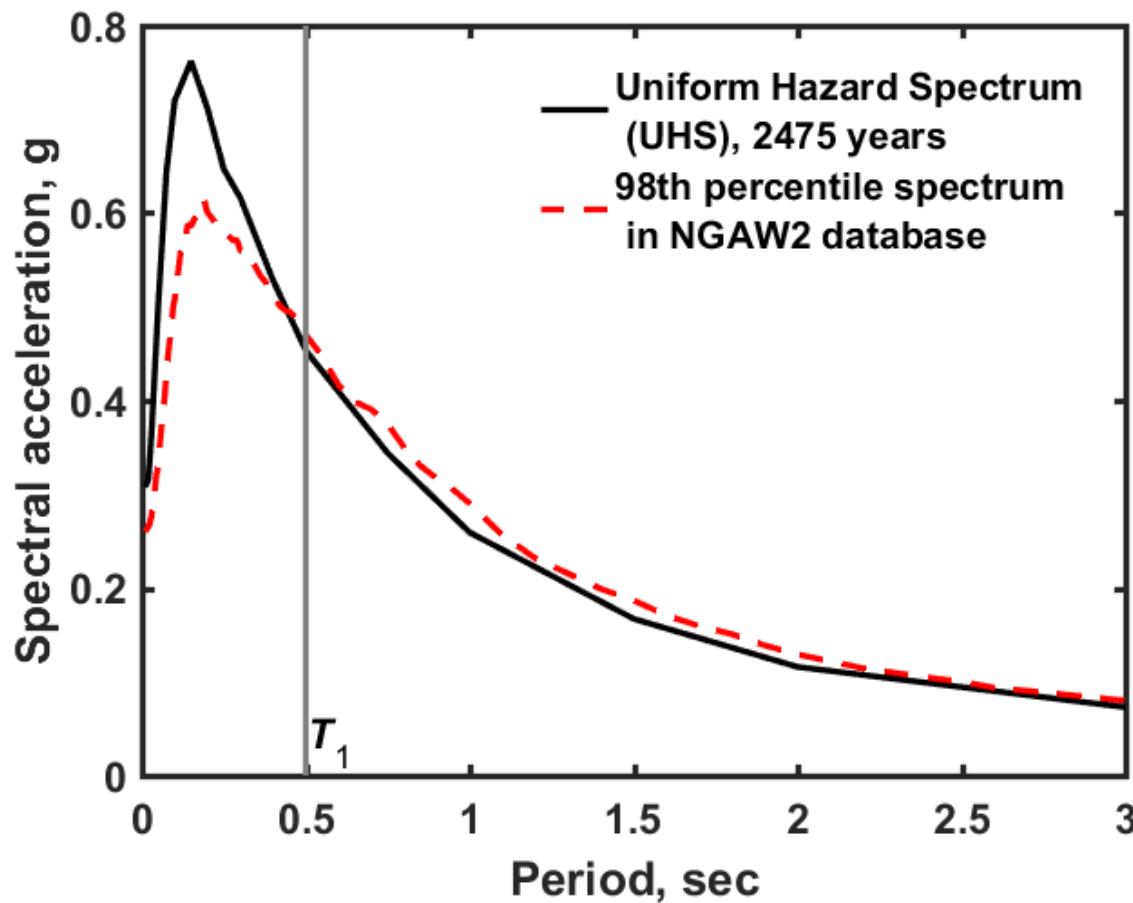
1. Structure with  $T_1 = 0.5$  sec
2. Site located in Davis, CA
3. Probabilistic seismic hazard analysis (PSHA)  
using OpenSHA with 2475-year return period
4. Recorded GMs from PEER NGAW2 database
5. GM selection algorithm using Matlab

# Other PSHA software

1. USGS Earthquake Hazards Program
2. OpenQuake
3. EZ-Frisk
4. QuakeManager
5. Proprietary software

# **GMSM FOR ONE HORIZONTAL COMPONENT OF GM**

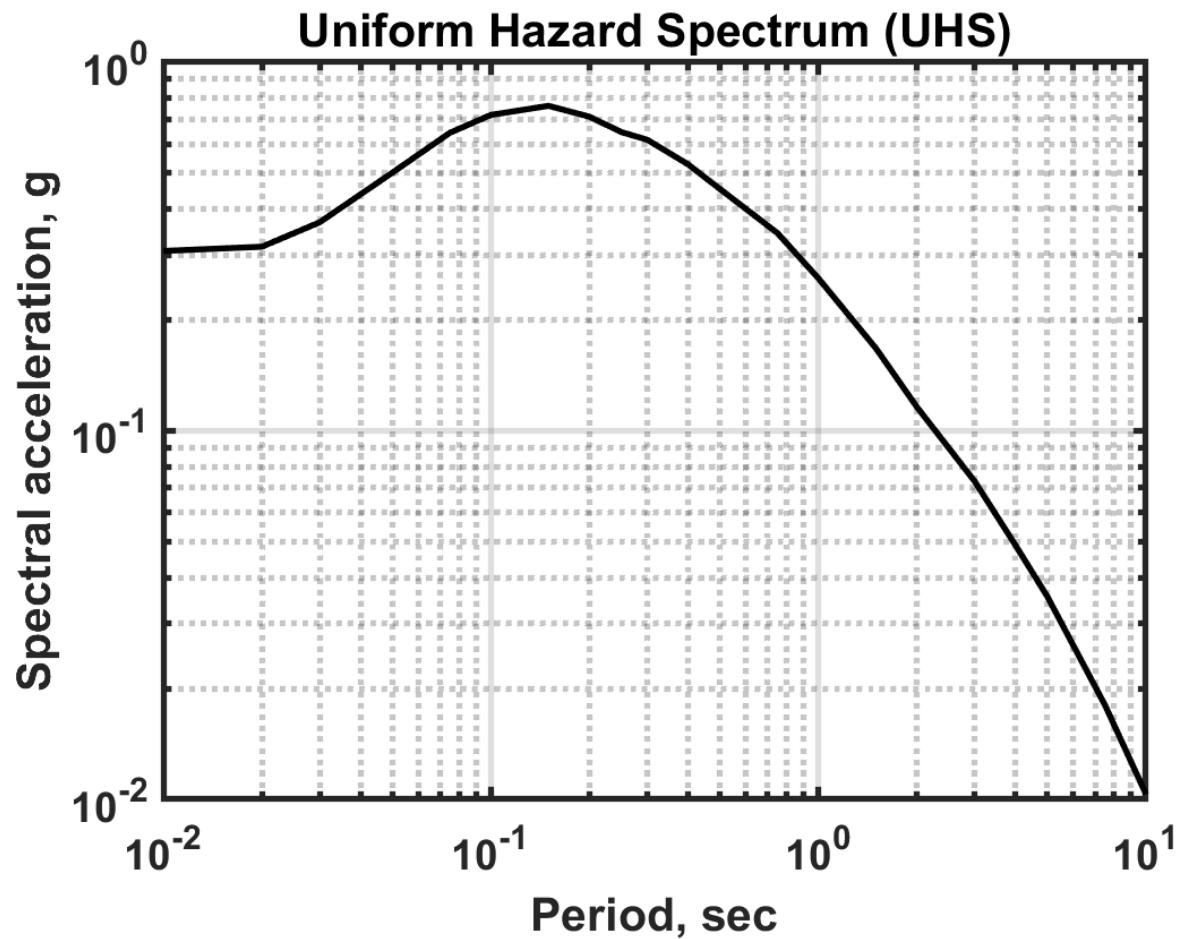
# The need for GMSM



# Fundamentals of GMSM

1. Target spectrum
2. Selecting and scaling GMs

# Target spectrum example



# Selecting and scaling GMs

1. Specify GMSM inputs
2. Select and scale GMs to match target
3. Confirm hazard consistency
4. Repeat GM selection with revised database if needed

# Specify GMSM inputs

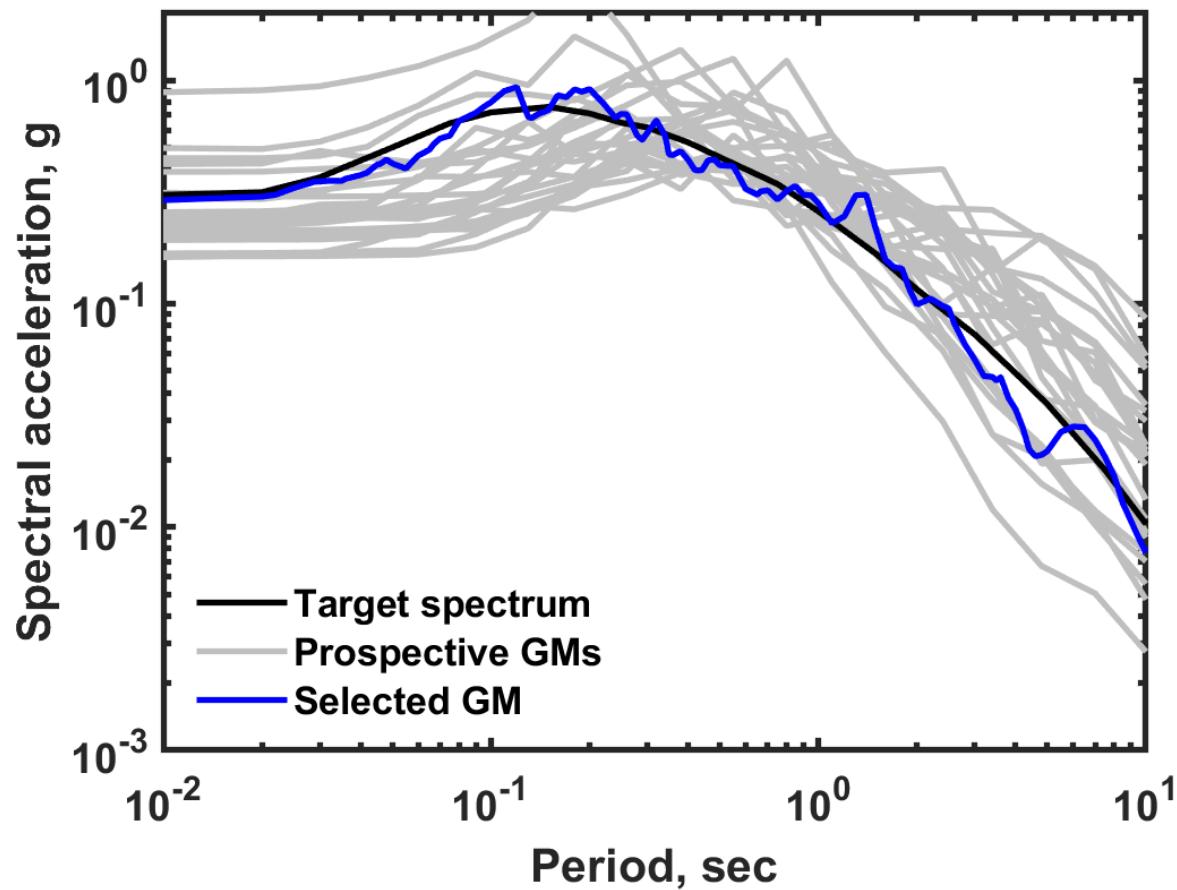
1. Database of prospective GMs (e.g., NGAW2)
2. Number of GMs to be selected (e.g., 11)
3. Limits on metadata (e.g., NGA RSNs,  $M$ ,  $R$ ,  $V_{s30}$ , etc.)
4. Limits on scale factors (SFs)

# Selecting GMs

- To compare response spectra, use sum-of-squared-differences (SSD):

$$SSD = \sum_{j=1}^{N_p} (\ln[SF \cdot A_0(T_j)] - \ln[A_{TS}(T_j)])^2$$

# Selecting GMs



# Scaling GMs

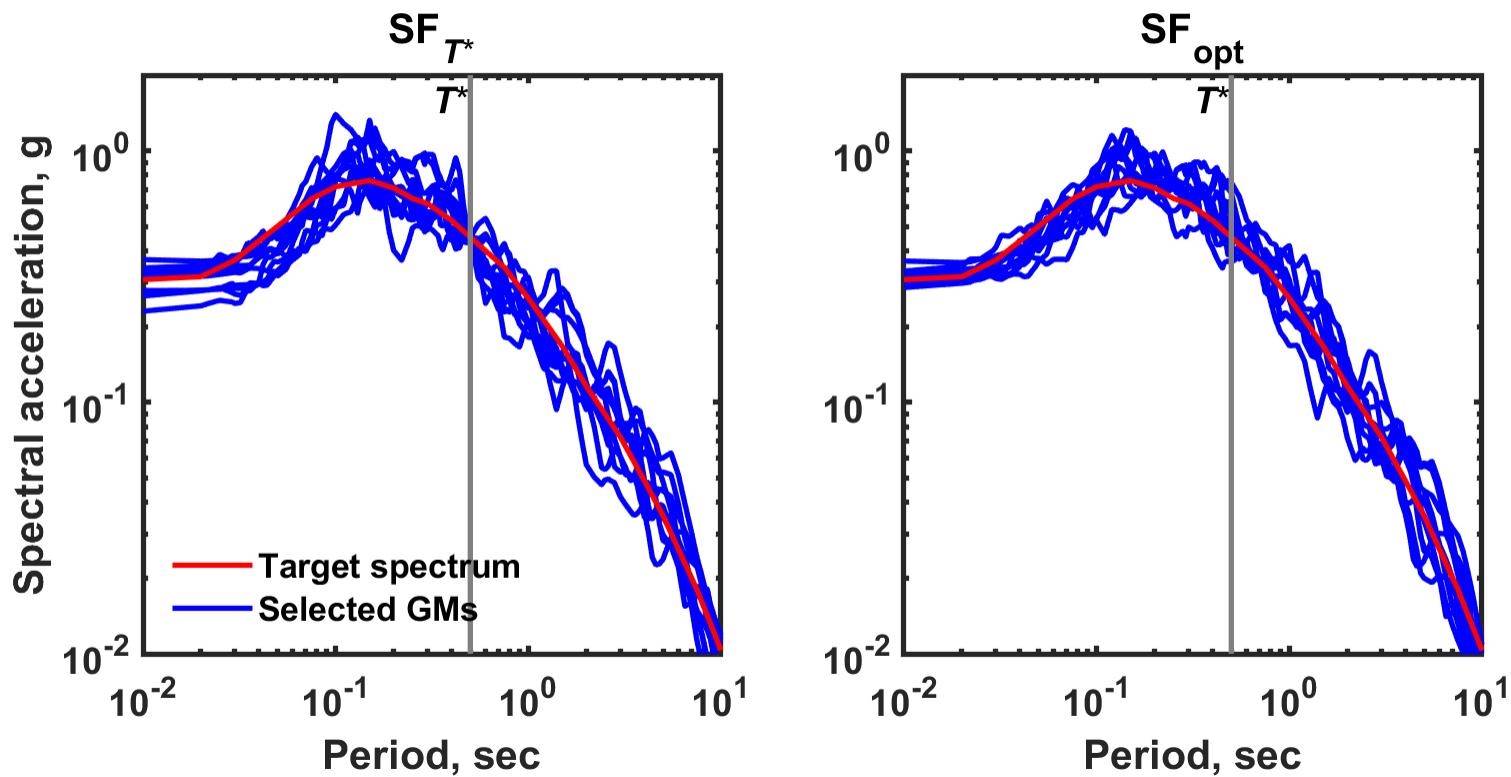
Single period  $T^*$

$$SF_{T^*} = \frac{A_{TS}(T^*)}{A_0(T^*)}$$

Range of  $N_p$  vibration periods

$$SF_{opt} = \left[ \prod_{j=1}^{N_p} \frac{A_{TS}(T_j)}{A_0(T_j)} \right]^{1/N_p}$$

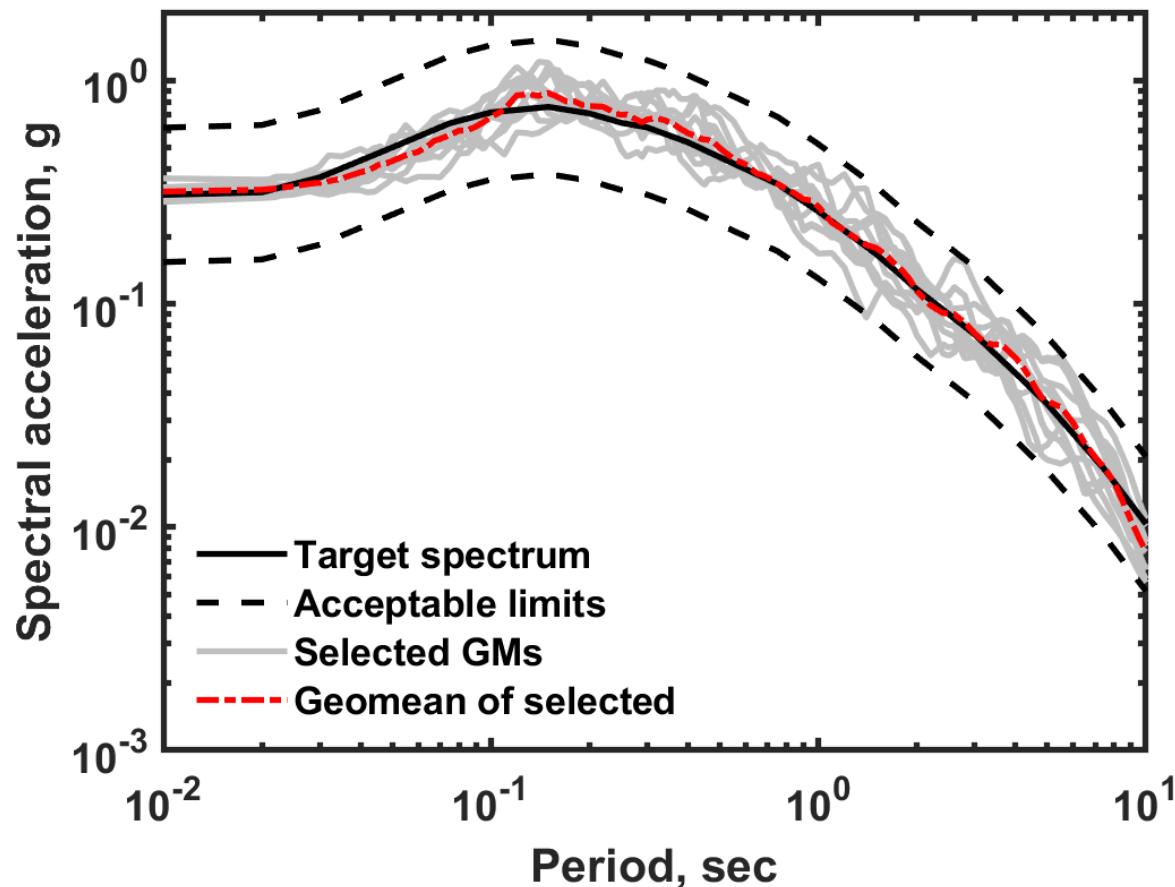
# Scaling GMs



# Confirming hazard consistency

- Standard deviation of logarithm of spectral acceleration,  $\sigma$ , approximately 0.7 units
- Multiplying target spectrum by  $\exp(1\sigma) \approx \exp(0.7) \approx 2$
- Acceptable limits defined by multiplying or dividing target spectrum by factor of two

# Confirming hazard consistency



# Repeat GMSM if needed

- Reasons for repeating:
  1. Selected ensemble is inconsistent with hazard
  2. Unable to retrieve time series
  3. Avoid one earthquake from dominating final selection
- Repeat using revised GM database with new RSNs

Previously, GMSM limited to:

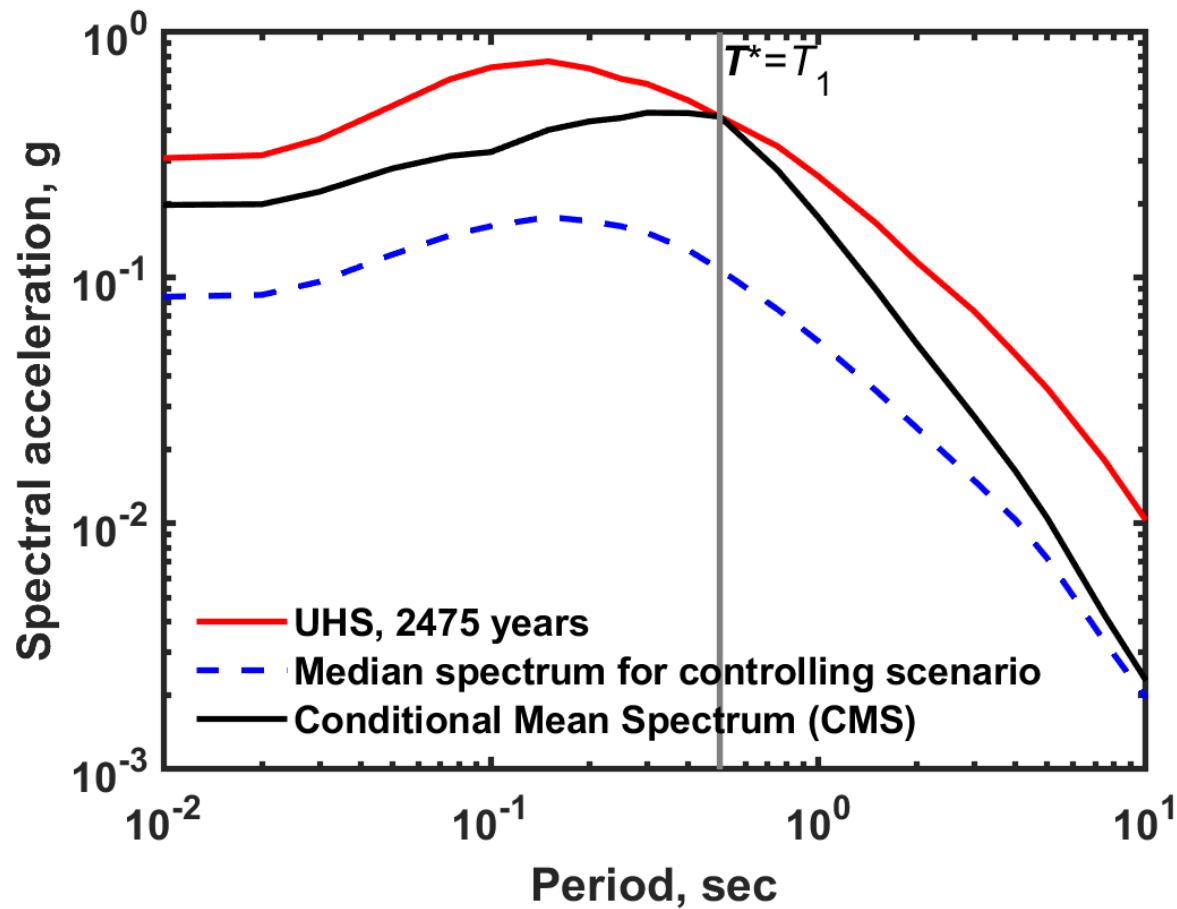
1. One component of GM
2. First-mode dominated structures

# Conditional Mean Spectrum (CMS)

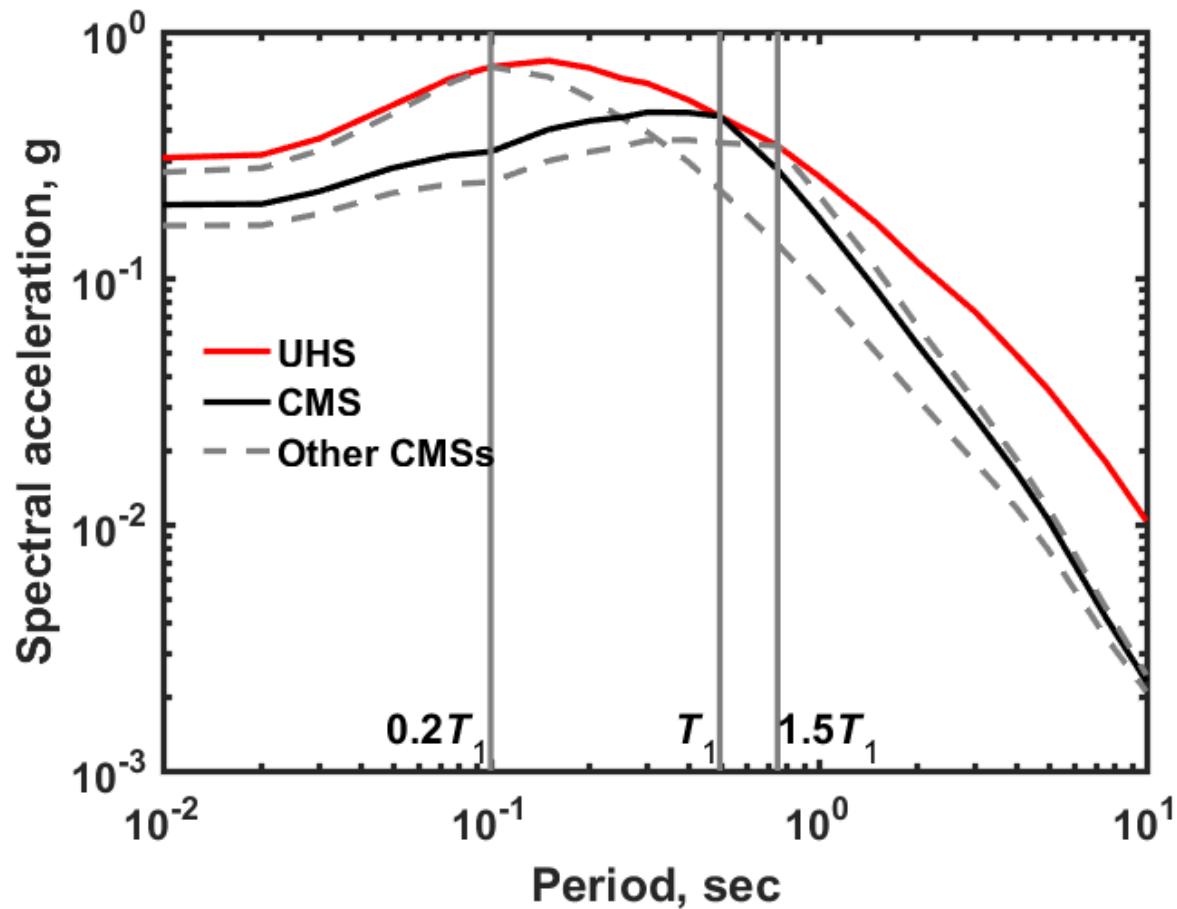
- Alternative target to UHS (Baker & Cornell 2006, Baker 2011)
- More representative of recorded GMs

$$\begin{aligned} A_{CMS}(T, T^*) \\ = A_m(T) \cdot \exp[\varepsilon_H(T^*) \rho_{H,H}(T^*, T) \sigma(T)] \end{aligned}$$

# Conditional Mean Spectrum (CMS)



# Multiple CMSs to avoid underestimation

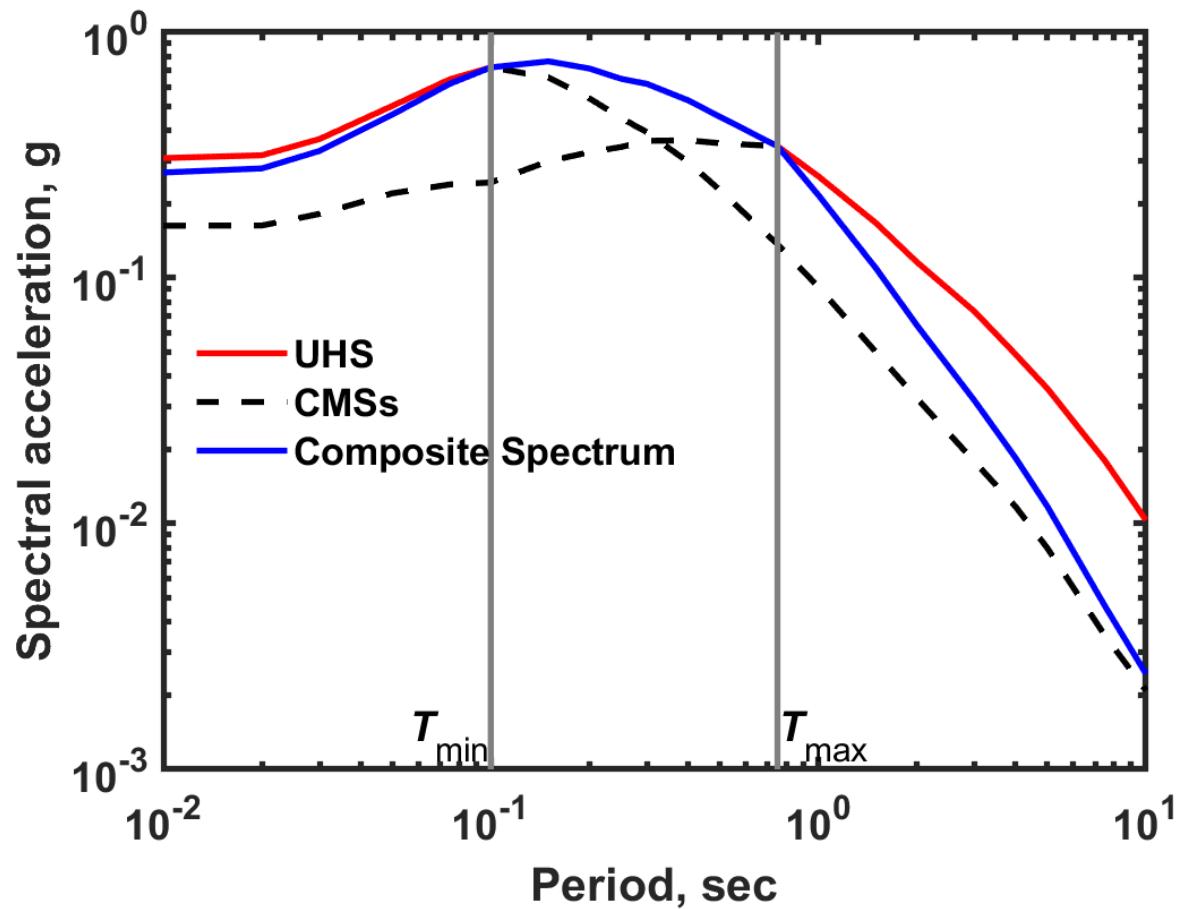


# CMS-UHS Composite Spectrum

- Replaces multiple CMSs with single target
- Significantly reduces computational effort
- Combines features from CMS and UHS:

$$A_{Composite}(T) = \begin{cases} A_{CMS}(T, T_{min}) & T \leq T_{min} \\ A_{UHS}(T) & T_{min} < T \leq T_{max} \\ A_{CMS}(T, T_{max}) & T \geq T_{max} \end{cases}$$

# CMS-UHS Composite Spectrum



# **GMSM FOR THREE COMPONENTS OF GM**

# Nonlinear response history analysis (RHA) of dams requires:

1. Three orthogonal components of GM
2. Consideration of multiple modes of vibration

# Composite Spectrum

1. Same target spectrum for each individual horizontal (H) component of GM, defined by RotD50
2. Considers modes via  $T_{min}$  and  $T_{max}$

# Including the vertical (V) component

1. Scale corresponding V component by same scale factor, or
2. Determine target spectrum for V component of GM

# Target spectrum for V component

## Extra inputs

1. Ground motion prediction models (GMPMs) for V component of GM
2. Correlation model for H and V components of GM

## Outputs

1. Hazard curves
2. UHS
3. CMSs
4. Composite Spectrum

# GMPMs for H component

## NGA-West2 Ground Motion Model for the Average Horizontal Components of PGA, PGV, and 5%-Damped Linear Acceleration Response Spectra

Kenneth W. Campbell,<sup>a)</sup> M.EERI, and Yousef Bozorgnia,<sup>b)</sup> M.EERI

We used an expanded PEER NGA-West2 database to develop a new ground motion prediction equation (GMPE) for the average (RotD50) horizontal components of PGA, PGV, and 5%-damped linear pseudo-absolute acceleration response spectra at 21 periods ranging from 0.01 to 10 s. In addition to those terms included in our now superseded 2008 GMPE, we include a more-detailed hanging-wall model, scaling with hypocentral depth and fault dip, regionally independent geometric attenuation, regionally dependent anelastic attenuation and site conditions, and magnitude-dependent aleatory variability. The NGA-West2 database provides better constraints on magnitude scaling and attenuation of small-magnitude earthquakes, where our 2008 GMPE was known to be biased. We consider our new GMPE to be valid for estimating RotD50 from shallow crustal continental earthquakes in an active tectonic domain for rupture distances ranging from 0 to 300 km and magnitudes ranging from 3.3 to 7.5–8.5, depending on source mechanism.

## NGA-West2 Equations for Predicting PGA, PGV, and 5% Damped PSA for Shallow Crustal Earthquakes

David M. Boore,<sup>a)</sup> Jonathan P. Stewart,<sup>b)</sup> M.EERI, Emel Seyhan,<sup>c)</sup> M.EERI, and Gail M. Atkinson,<sup>d)</sup> M.EERI

We provide ground motion prediction equations for computing medians and standard deviations of average horizontal component intensity measures (IMs) for shallow crustal earthquakes in active tectonic regions. The equations were derived from a global database with  $M$  3.0–7.9 events. We derived equations for the primary  $M$ - and distance-dependence of the IMs after fixing the  $V_{S30}$ -based nonlinear site term from a parallel NGA-West2 study. We then evaluated additional effects using mixed effects residuals analysis, which revealed no trends with source depth over the  $M$  range of interest, indistinct Class 1 and 2 event IMs, and basin depth effects that increase and decrease long-period IMs for depths larger and smaller, respectively, than means from regional  $V_{S30}$ -depth relations. Our aleatory variability model captures decreasing between-event variability with  $M$ , as well as within-event variability that increases or decreases with  $M$  depending on period, increases with distance, and decreases for soft sites. [DOI: 10.1193/070113EQS184M]

# GMPMs for V component

## Vertical Ground Motion Model for PGA, PGV, and Linear Response Spectra Using the NGA-West2 Database

Yousef Bozorgnia,<sup>a)</sup> M.EERI, and Kenneth W. Campbell,<sup>b)</sup> M.EERI

We summarize the development of the NGA-West2 Bozorgnia-Campbell empirical ground motion model (GMM) for the vertical components of peak ground acceleration (PGA), peak ground velocity (PGV), and 5%-damped elastic pseudo-absolute acceleration response spectra (PSA) at vertical periods ranging from 0.01 s to 10 s. In the development of the vertical GMM, similar to our 2014 horizontal GMM, we used the extensive PEER NGA-West2 worldwide database. We consider our new vertical GMM to be valid for shallow crustal earthquakes in active tectonic regions for magnitudes ranging from 3.3 to 7.5–8.5, depending on the style of faulting, and for distances as far as 300 km from the fault. [DOI: 10.1193/072814EQS121M]

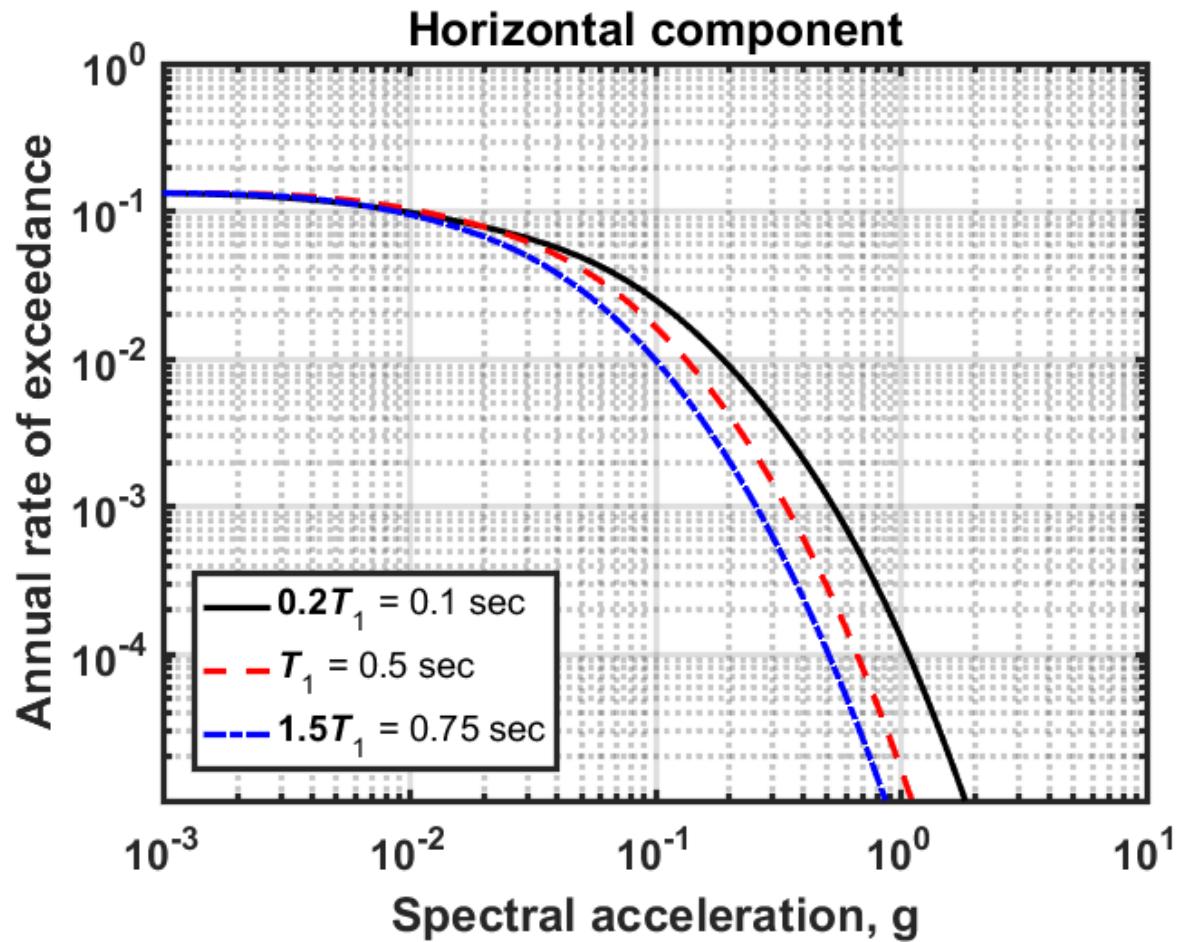
## Ground Motion Prediction Equations for the Vertical Ground Motion Component Based on the NGA-W2 Database

Zeynep Gülerce,<sup>a)</sup> M.EERI, Ronnie Kamai,<sup>b)</sup>

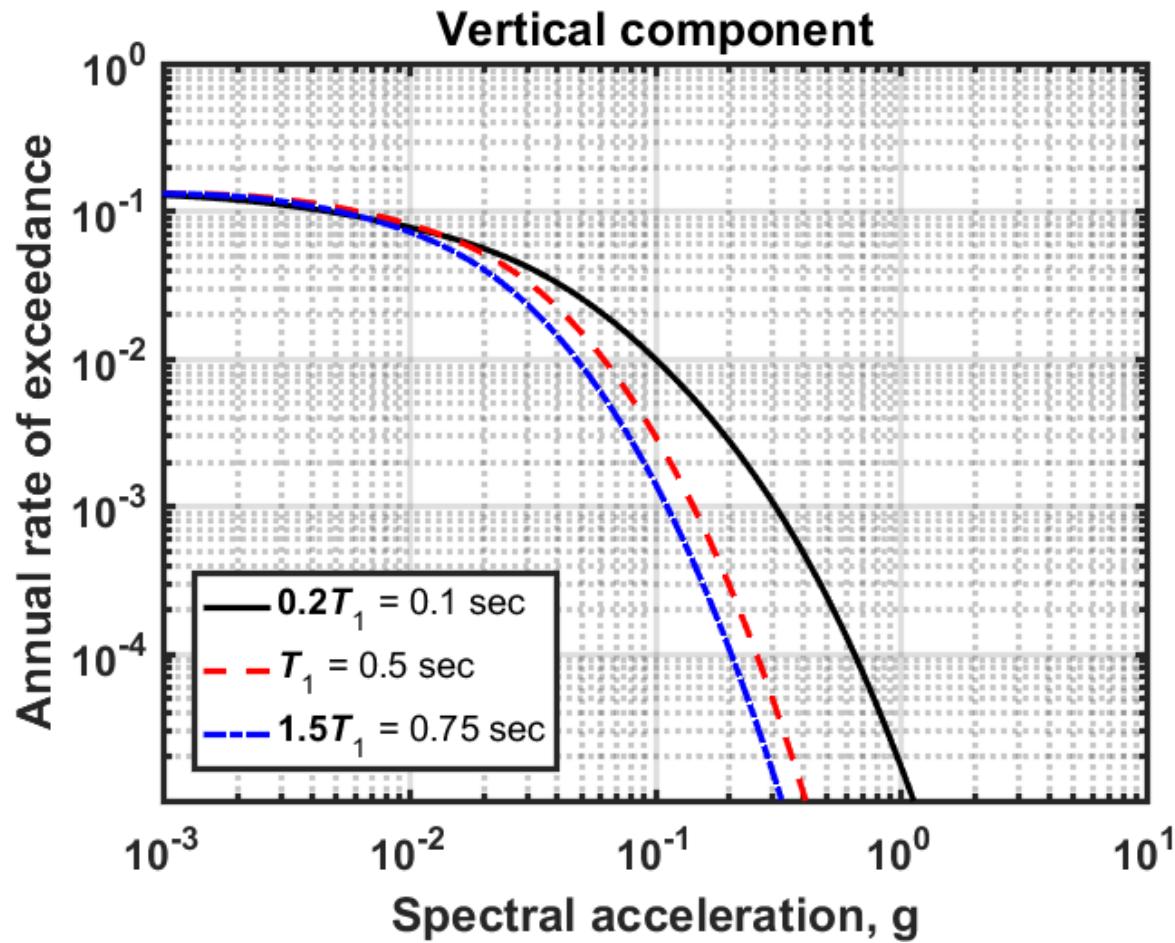
Norman A. Abrahamson,<sup>c)</sup> M.EERI, and Walter J. Silva,<sup>d)</sup> M.EERI

Empirical ground motion models for the vertical component from shallow crustal earthquakes in active tectonic regions are derived using the PEER NGA-West2 database. The model is applicable to magnitudes 3.0–8.0, distances of 0–300 km, and spectral periods of 0–10 s. The model input parameters are the same as used by Abrahamson et al. (2014) except that the nonlinear site response and depth to bedrock effects are evaluated but found to be insignificant. Regional differences in large distance attenuation and site amplification scaling between California, Japan, China, Taiwan, Italy, and the Middle East are included. Scaling for the hanging-wall effect is incorporated using the constraints from numerical simulations by Donahue and Abrahamson (2014). The standard deviation is magnitude dependent with smaller magnitudes leading to larger standard deviations at short periods but smaller standard deviations at long periods. The vertical ground motion model developed in this study can be paired with the horizontal component model proposed by Abrahamson et al. (2014) to produce a V/H ratio. For applications where the horizontal spectrum is derived from the weighted average of several horizontal ground motion models, a V/H model derived directly from the V/H data (such as Gülerce and Abrahamson 2011) should be preferred. [DOI: 10.1193/121814EQS213M]

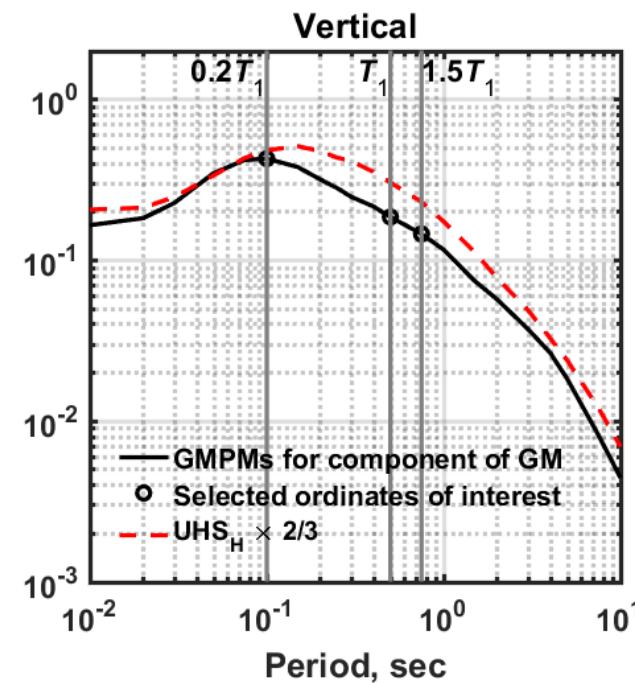
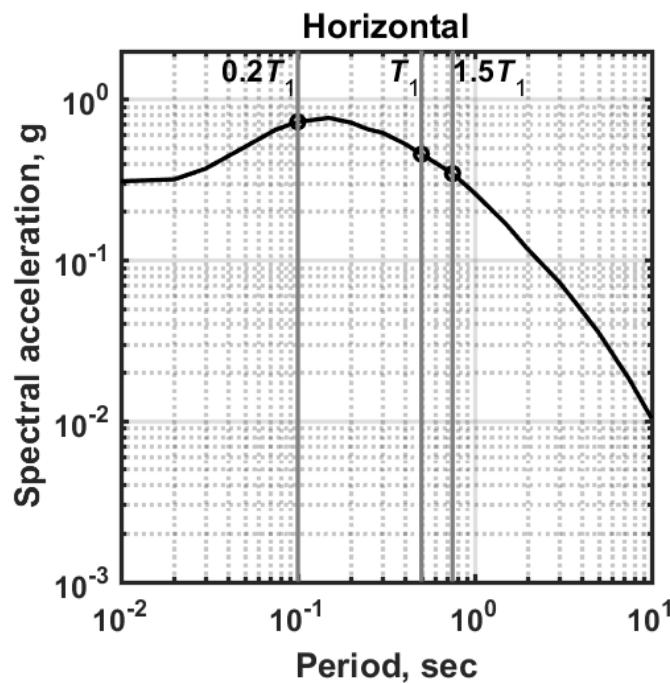
# Hazard curves



# Hazard curves



# Uniform hazard spectra



# Target spectrum for V component

## Extra inputs

1. Ground motion prediction models (GMPMs) for V component of GM
2. Correlation model for H and V components of GM

## Outputs

1. Hazard curves
2. UHS
3. CMSs
4. Composite Spectrum

# Correlation between H and V

Bulletin of the Seismological Society of America, Vol. 96, No. 1, pp. 215–227, February 2006, doi: 10.1785/0120050060

## Correlation of Response Spectral Values for Multicomponent Ground Motions

by Jack W. Baker and C. Allin Cornell

**Abstract** Ground-motion prediction (attenuation) models predict the probability distributions of spectral acceleration values for a specified earthquake event. These models provide only marginal distributions, however; they do not specify correlations among spectral accelerations with differing periods or orientations. In this article a large number of strong ground motions are used to empirically estimate these correlations, and nonlinear regression is used to develop approximate analytical equations for their evaluation. Because the correlations apply to residuals from a ground-motion prediction, they are in principle dependent on the ground-motion prediction model used. The observed correlations do not vary significantly when the underlying model is changed, however, suggesting that the predictions are applicable regardless of the model chosen by the analyst. The analytical correlation predictions improve upon previous predictions of correlations at differing periods in a randomly oriented horizontal ground-motion component. For correlations within a vertical ground motion or across orthogonal components of a ground motion, these results are believed to be the first of their kind.

The resulting correlation coefficient predictions are useful for a range of problems related to seismic hazard and the response of structures. Past uses of previous correlation predictions are described, and future applications of the new predictions are proposed. These applications will allow analysts to better understand the properties of single- and multicomponent earthquake ground motions.

# Correlation between H and V

- Need correlation models for wide range of vibration periods
- Overcome using GM models for vertical-to-horizontal (V/H) ratios

# GM models for V/H ratios

## Site-Specific Design Spectra for Vertical Ground Motion

Zeynep Gülerce,<sup>a)</sup> M.EERI, and Norman A. Abrahamson,<sup>b)</sup> M.EERI

This paper contains ground-motion prediction equations (GMPEs) for the vertical-to-horizontal spectral acceleration (V/H) ratio, and the methods for constructing vertical design spectra that are consistent with the probabilistic seismic hazard assessment results for the horizontal ground motion component. The GMPEs for V/H ratio consistent with the horizontal GMPE of Abrahamson and Silva (2008) are derived using the Pacific Earthquake Engineering Research Center's Next Generation of Ground-Motion Attenuation Models (PEER-NGA) database (Chiou et al. 2008). The proposed V/H ratio GMPE is dependent on the earthquake magnitude and distance, consistent with previous models, but it differs from previous studies in that it accounts for the differences in the nonlinear site-response effects on the horizontal and vertical components. This difference in nonlinear effects results in large V/H ratios at short spectral periods for soil sites located close to large earthquakes. A method to develop vertical design spectra dependent on the horizontal component uniform hazard spectrum that accounts for the correlation between the variability of the horizontal ground-motion model and the variability of the V/H ratio ground-motion model is proposed. [DOI: 10.1193/1.3651317]

## Ground Motion Model for the Vertical-to-Horizontal (V/H) Ratios of PGA, PGV, and Response Spectra

Yousef Bozorgnia,<sup>a)</sup> M.EERI, and Kenneth W. Campbell,<sup>b)</sup> M.EERI

We present a ground motion model (GMM) for the vertical-to-horizontal (V/H) ratios of peak ground acceleration, peak ground velocity, and 5%-damped pseudo-acceleration response spectra at periods ranging from 0.01 s to 10 s. The V/H GMM includes formulations for the median V/H ratio and for the aleatory within-event, between-event, and total standard deviations. The V/H model is based on the GMMs we have developed for the vertical and “average” horizontal components of ground motion using a mathematical formulation that accounts for the correlation between these two components. We validated the V/H model against the NGA-West2 empirical database. We consider our V/H model to be valid for worldwide shallow crustal earthquakes in active tectonic regions for moment magnitudes ranging from 3.3 to 8.5, depending on the style of faulting, and for fault rupture distances ranging from 0 km to 300 km. Our V/H model incorporates period-dependent effects of magnitude saturation, style of faulting, hypocentral depth, fault-rupture dip, geometric attenuation, regionally dependent anelastic attenuation and site response, hanging-wall geometry, and magnitude-dependent between-event and within-event aleatory variabilities. The V/H ratios predicted from the model show a strong dependence on spectral period and site response. [DOI: 10.1193/100614EQS151M]

# Correlation between H and V

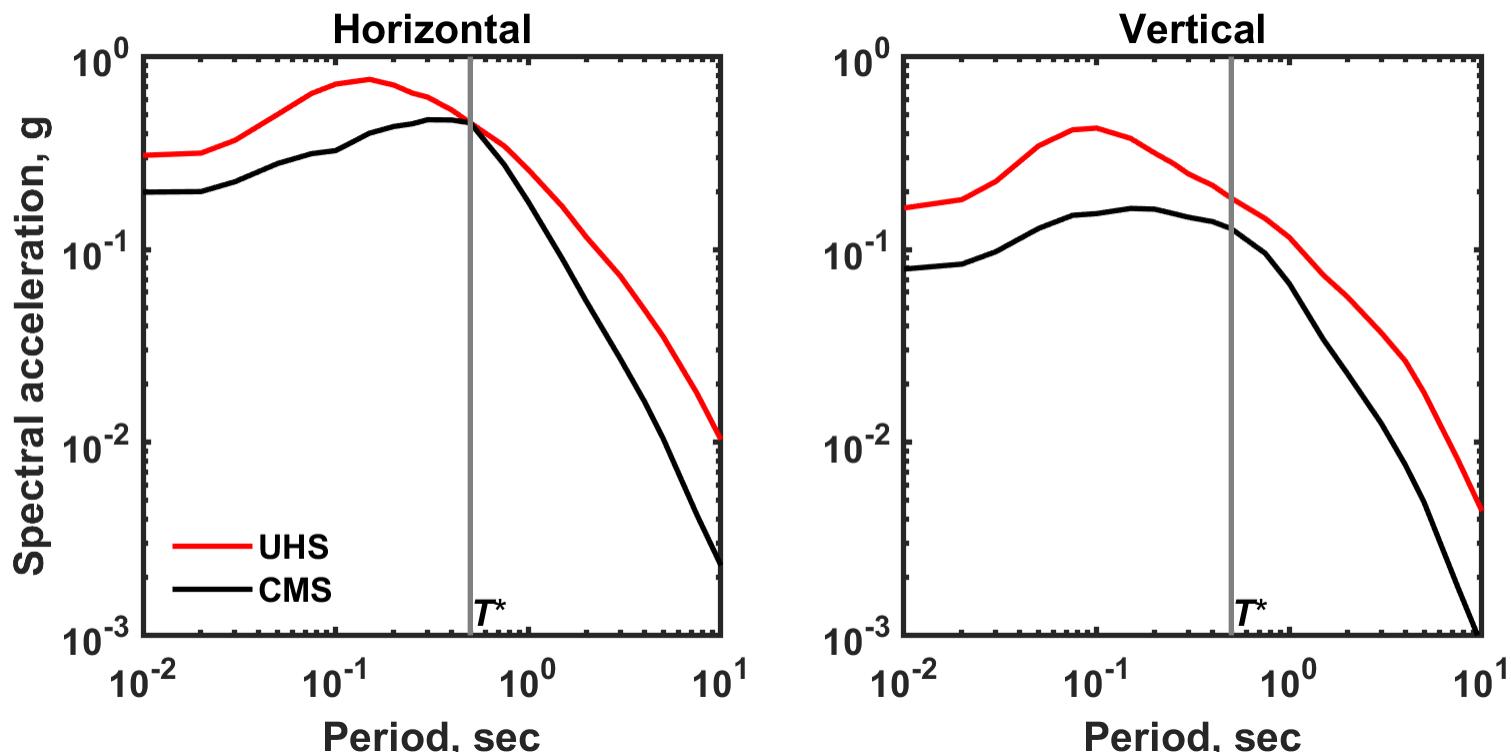
$$\rho_{H,V}(T_a, T_b) = \frac{\sigma_H(T_b)\rho_{H,H}(T_a, T_b) + \sigma_{V/H}(T_b)\rho_{H,V/H}(T_a, T_b)}{\sqrt{\sigma_H^2(T_b) + \sigma_{V/H}^2(T_b) + 2\rho_{H,V/H}(T_b, T_b)\sigma_H(T_b)\sigma_{V/H}(T_b)}}$$

# Multicomponent CMS

For  $k$ th component of GM ( $k=H$  or  $V$ ):

$$A_{k,CMS}(T, T^*) \\ = A_{k,m}(T) \cdot \exp[\varepsilon_H(T^*) \rho_{H,k}(T^*, T) \sigma_k(T)]$$

# Multicomponent CMS



# Multicomponent Composite Spectrum

For  $k$ th component of GM ( $k=H$  or  $V$ ):

$$A_{k,Composite}(T) = \begin{cases} A_{k,CMS}(T, T_{min}) & T \leq T_{min} \\ \bar{A}_{k,UHS}(T) & T_{min} < T \leq T_{max} \\ A_{k,CMS}(T, T_{max}) & T \geq T_{max} \end{cases}$$

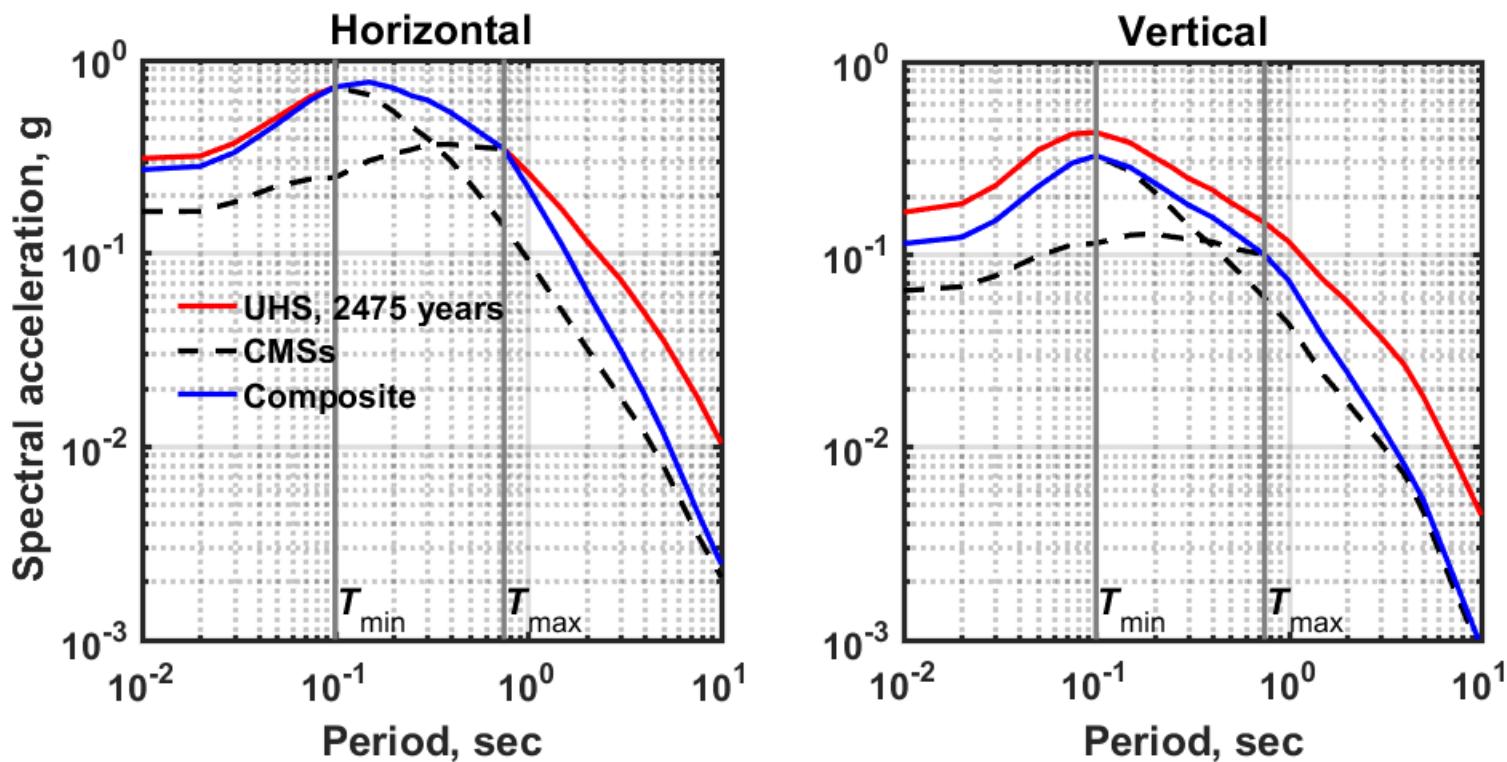
# Multicomponent Composite Spectrum

$$\bar{A}_{H,UHS}(T) = A_{H,UHS}(T)$$

$$\begin{aligned}\bar{A}_{V,UHS}(T) &= A_{V,m}(T, \theta_e) \cdot \exp[\varepsilon_H(T)\rho_{H,V}(T, T, \theta_e)\sigma_V(T, \theta_e)] \\ &\approx A_{V,m}(T) \cdot \exp[\varepsilon_H(\bar{T})\rho_{H,V}(T, T)\sigma_V(T)]\end{aligned}$$

$$\bar{T} = \sqrt{T_{min} \cdot T_{max}}$$

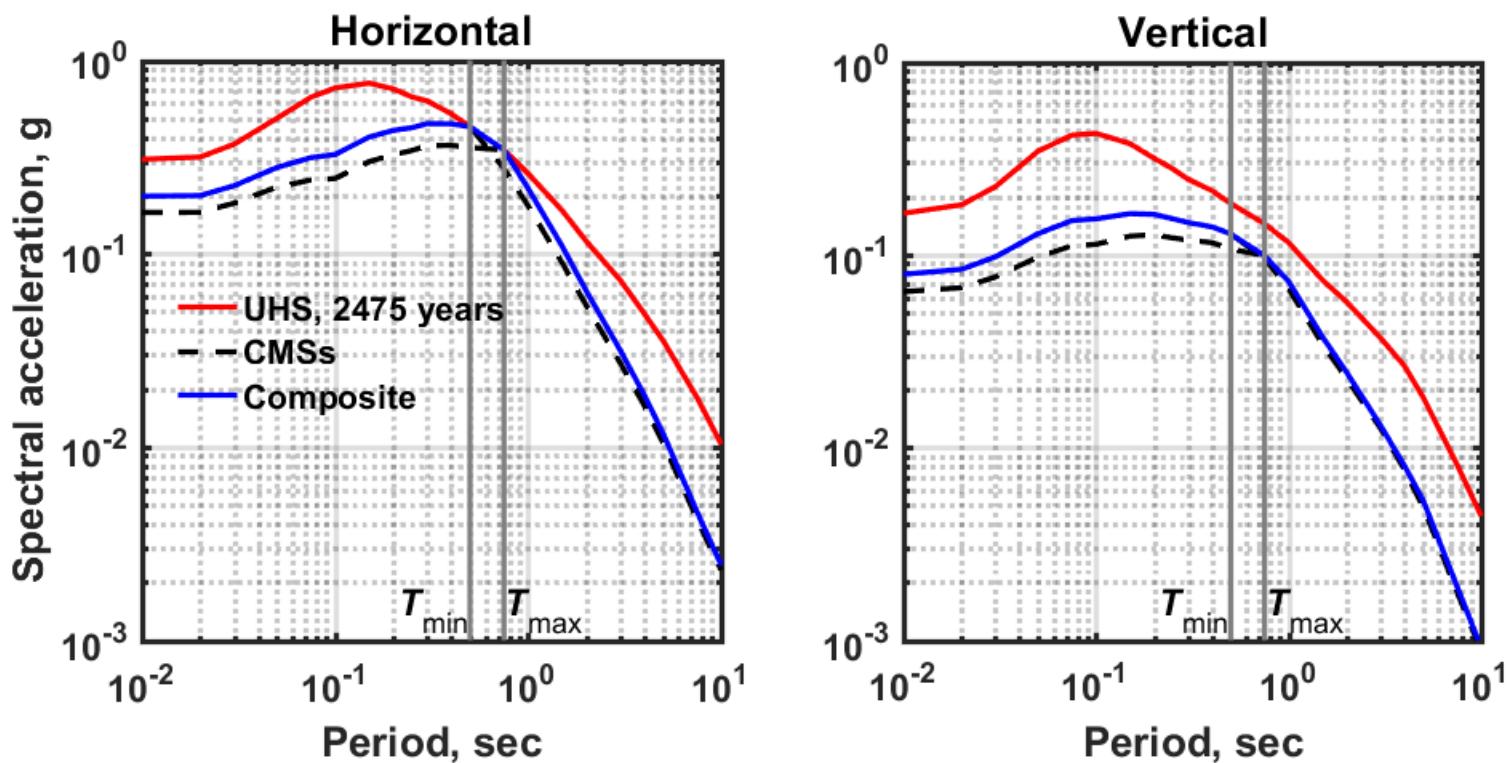
# Multicomponent Composite Spectrum



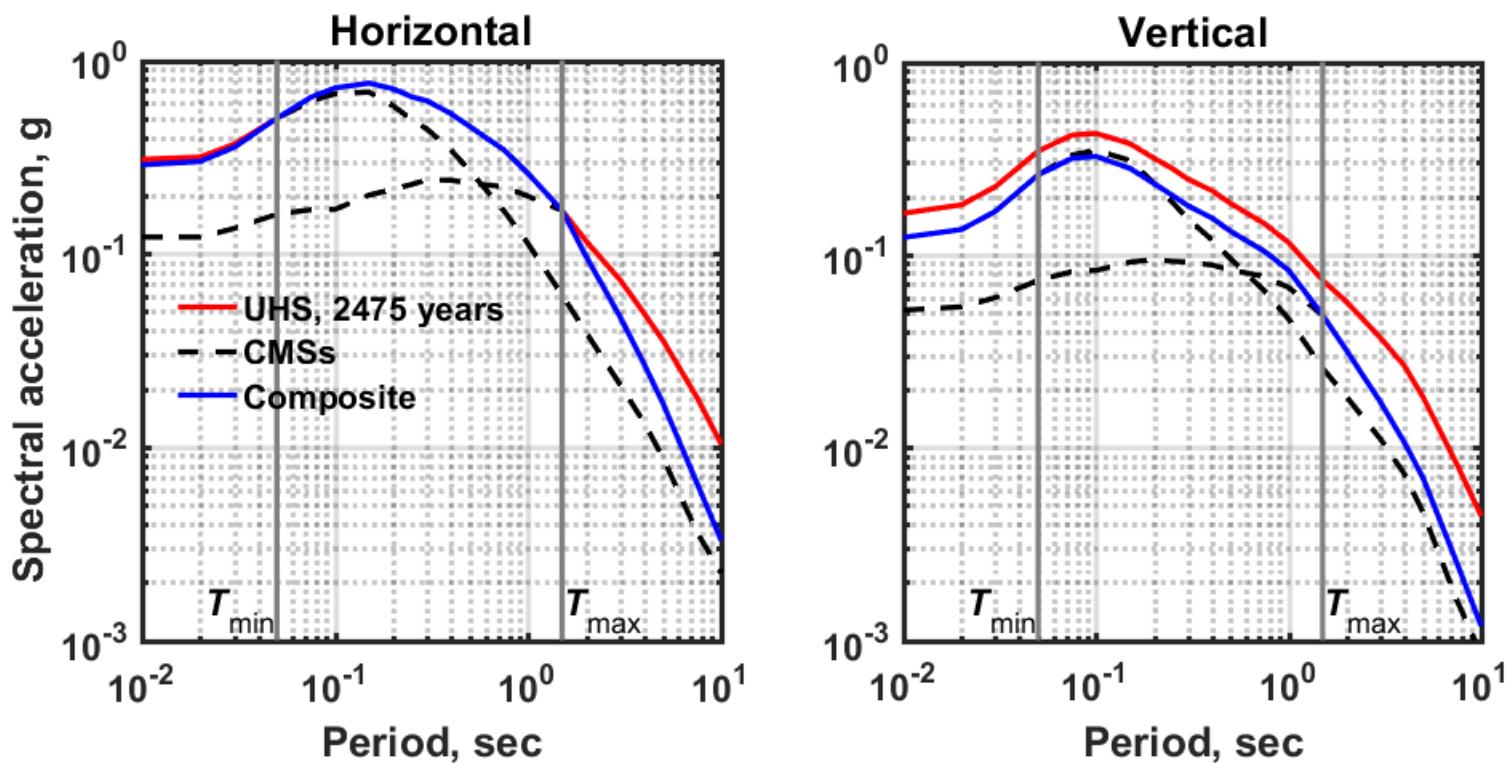
# Vibration periods $T_{min}$ and $T_{max}$

1. When close, approximately CMS
2. When far apart, approximately UHS

$$T_{min} = T_1 \text{ and } T_{max} = 1.5T_1$$



$$T_{min} = 0.1T_1 \text{ and } T_{max} = 3T_1$$



# **SELECTING GMS TO MATCH MULTICOMPONENT TARGET SPECTRUM**

# Summary of steps

1. Specify GMSM inputs
2. Scale and select GMs to match target
3. Confirm hazard consistency
4. Repeat GM selection with revised database if needed

# Extra GMSM inputs

1. Same or different SFs for V components
2. Relative importance of H component

Relative importance of H component,

$$0 \leq w_H \leq 1$$

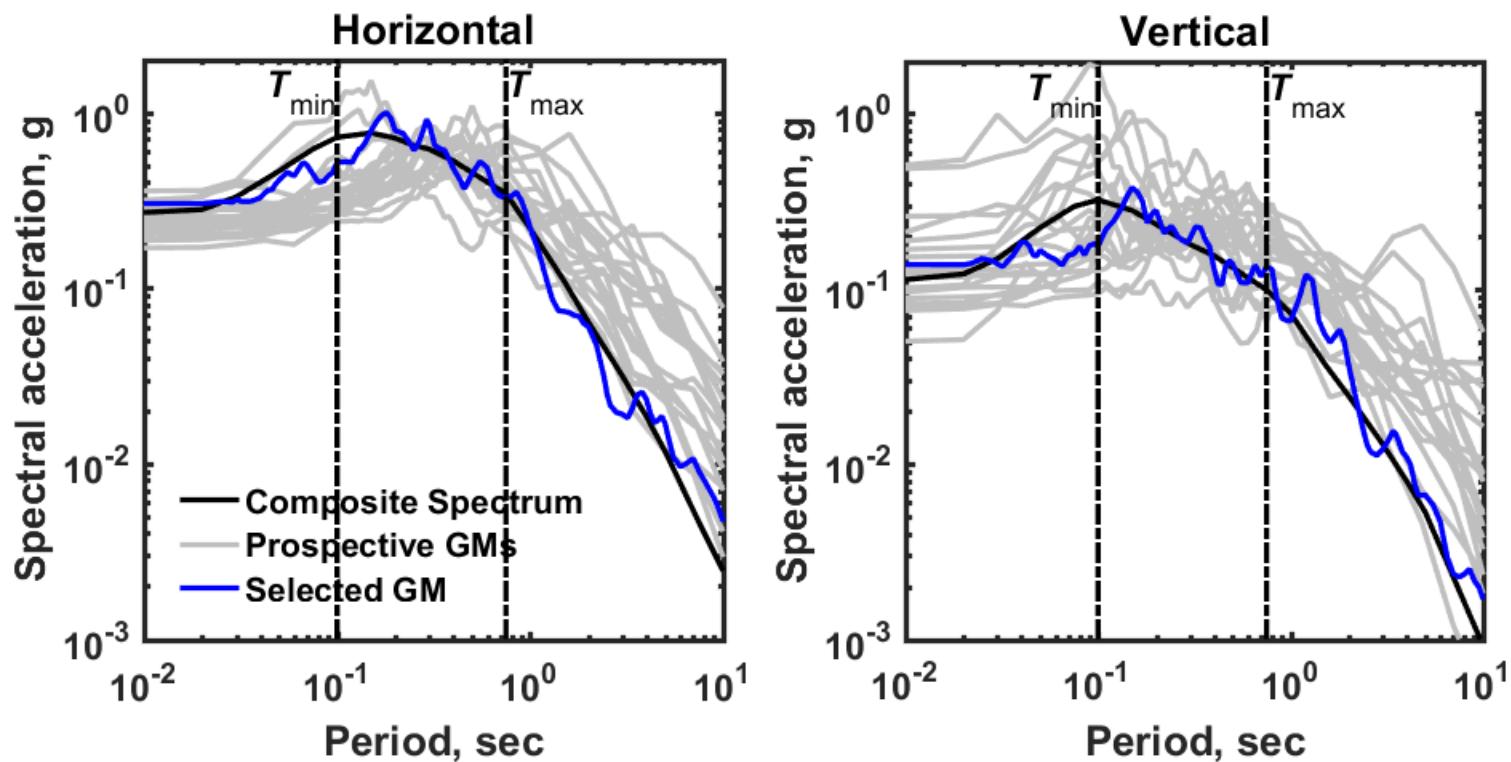
- For  $k$ th component of GM ( $k=H$  or  $V$ ):

$$SSD_k = \sum_{j=1}^{N_p} (\ln [SF_k \cdot A_{k,0}(T_j)] - \ln [A_{k,TS}(T_j)])^2$$

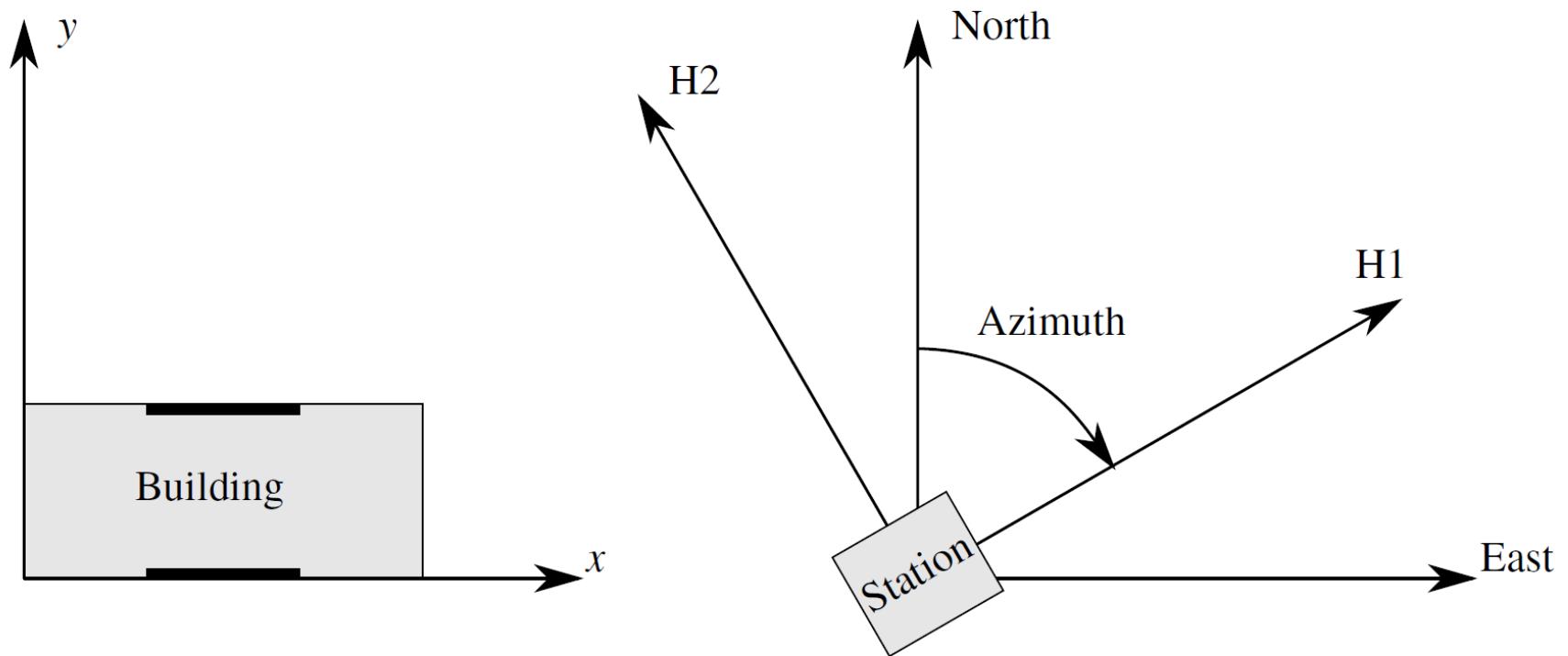
- For both H and V components of GM:

$$SSD_{combined} = \textcolor{red}{w_H} SSD_H + (1 - \textcolor{red}{w_H}) SSD_V$$

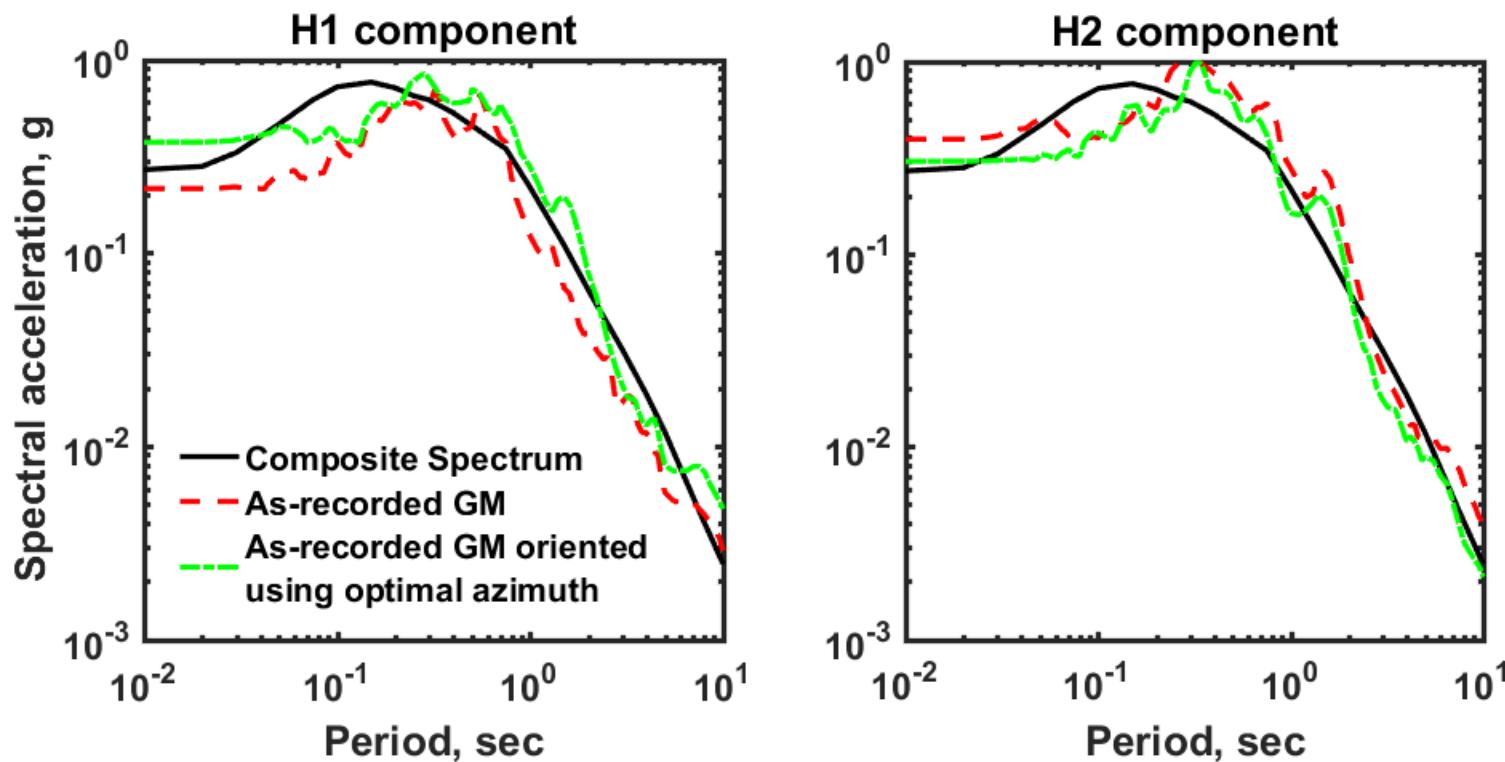
# Selecting GMs with $SSD_{combined}$



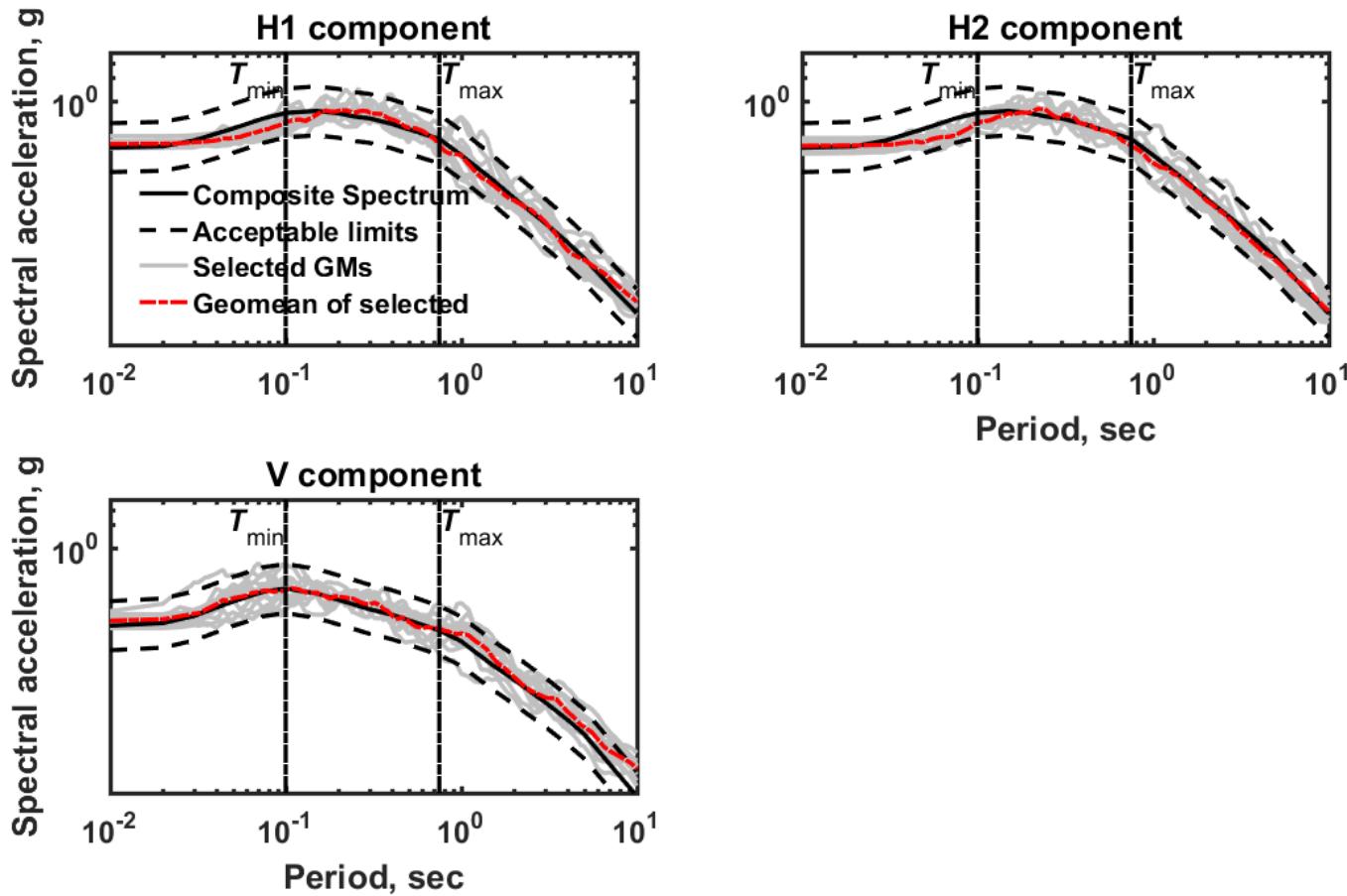
# Orienting bidirectional GMs



# Determining optimal azimuth



# Confirming hazard consistency



# Final selection of multicomponent GMs

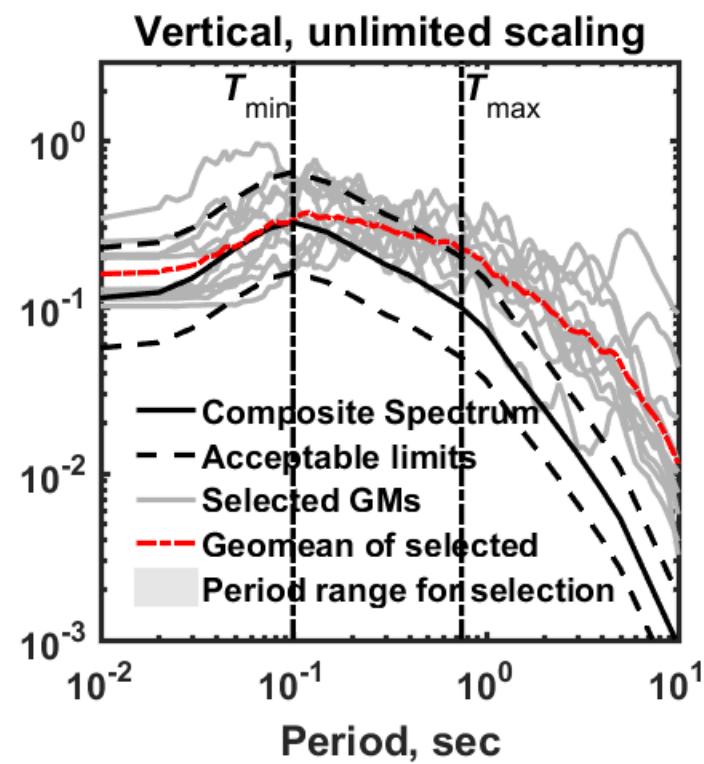
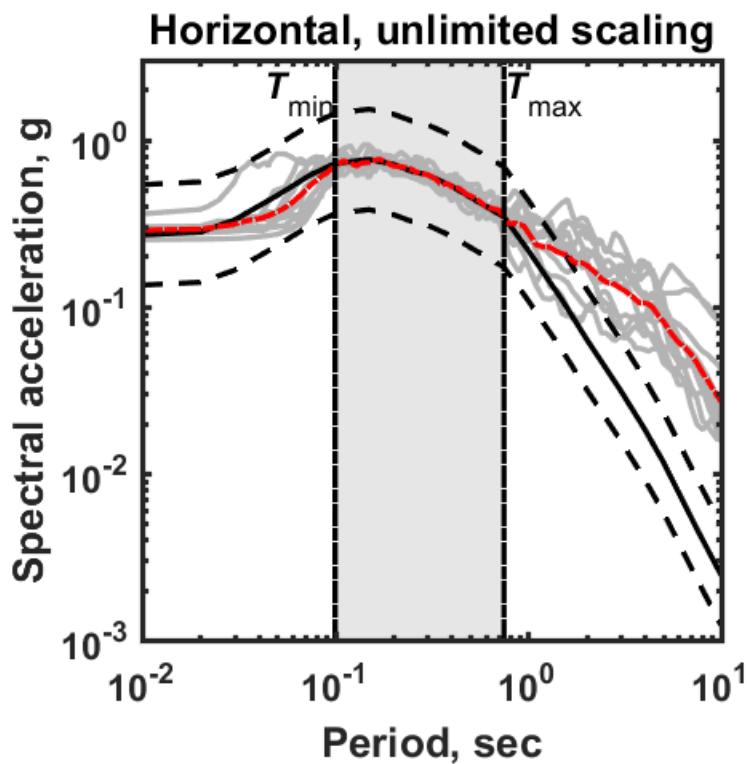
<b>NGA RSN</b>	<b>SF<sub>H</sub></b>	<b>SF<sub>V</sub></b>	<b>Angle for CCW rotation of H components (°)</b>
2623	2.05	2.05	18
2981	3.54	3.54	16
3000	3.48	3.48	60
3002	3.68	3.68	77
3188	2.58	2.58	23
4153	2.18	2.18	15
4212	0.93	0.93	7
5292	3.68	3.68	28
5652	1.07	1.07	2
5672	1.25	1.25	49
5811	1.97	1.97	90

# **DISCUSSION OF GMSM INPUTS**

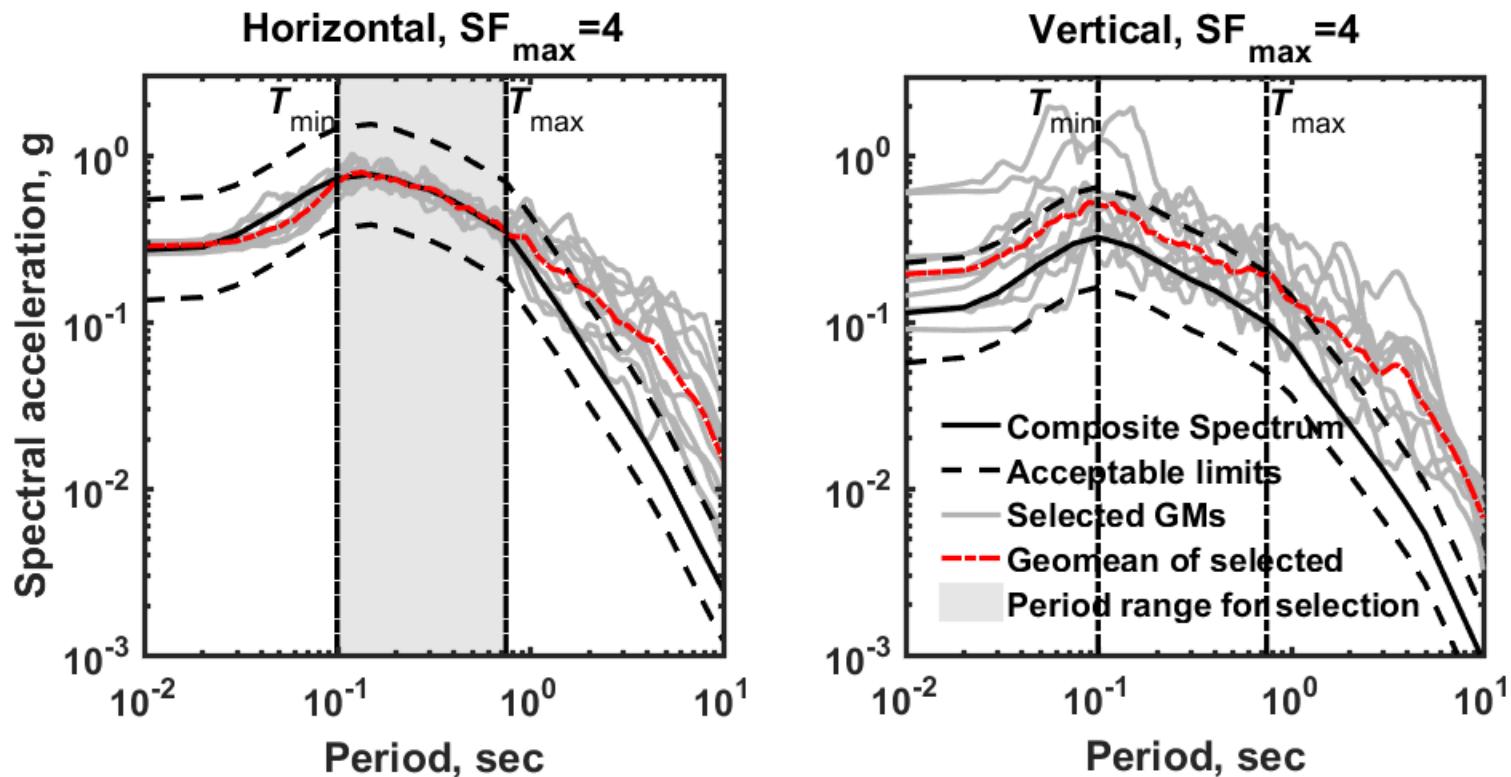
# Most important GMSM inputs

1. Period range for selecting GMs
2. Limits on SFs
3. Relative importance of H component  $w_H$

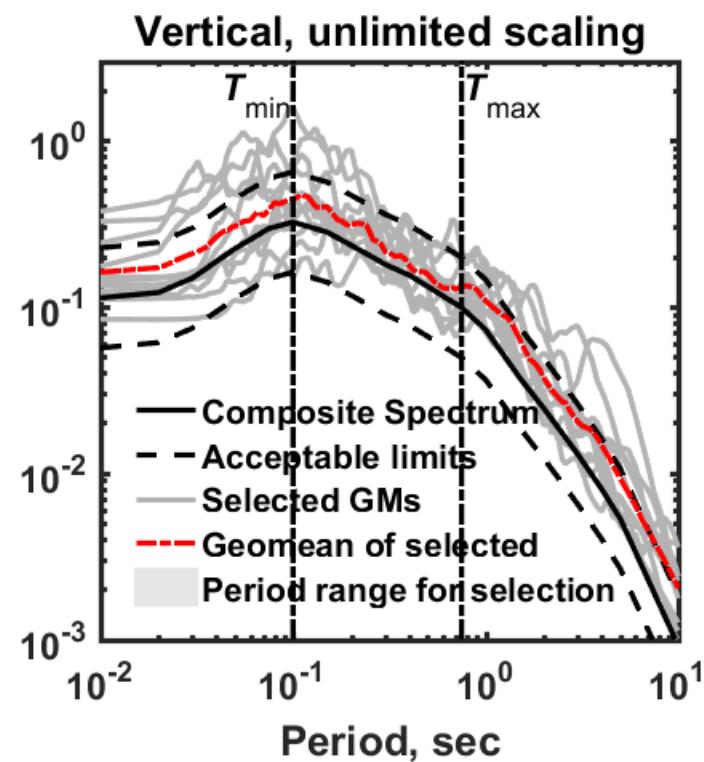
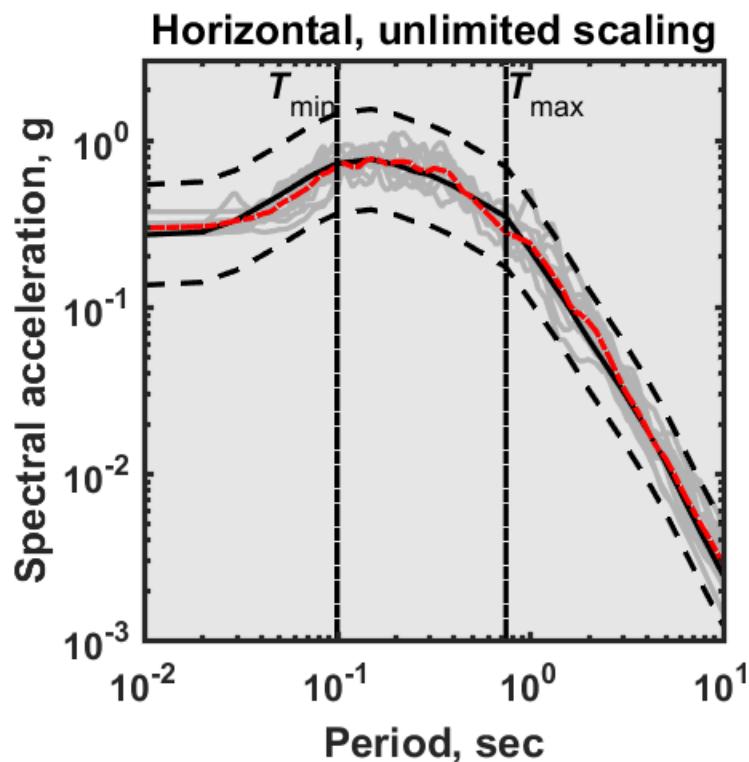
# Limits on scale factors



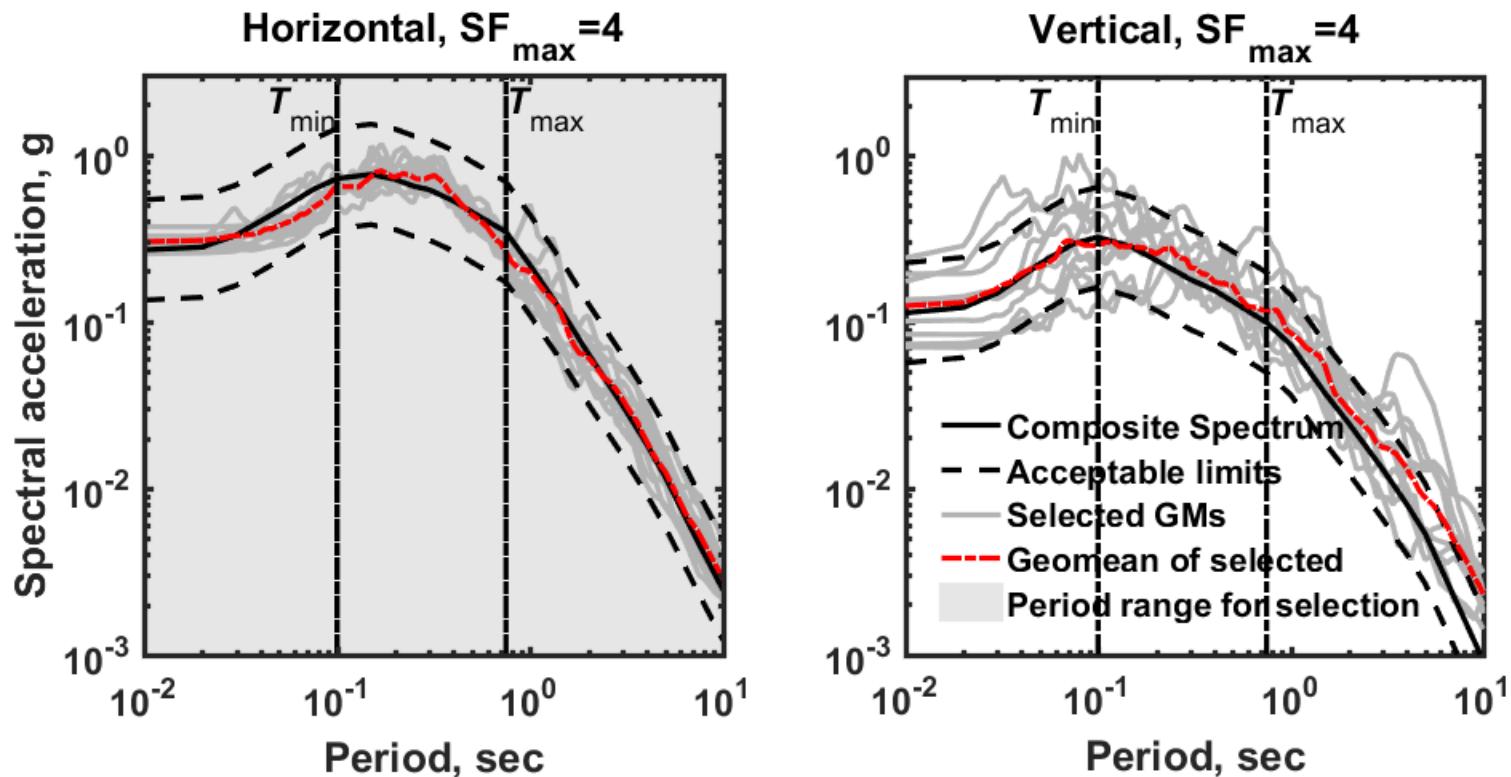
# Limits on scale factors



# Period range for selecting GMs

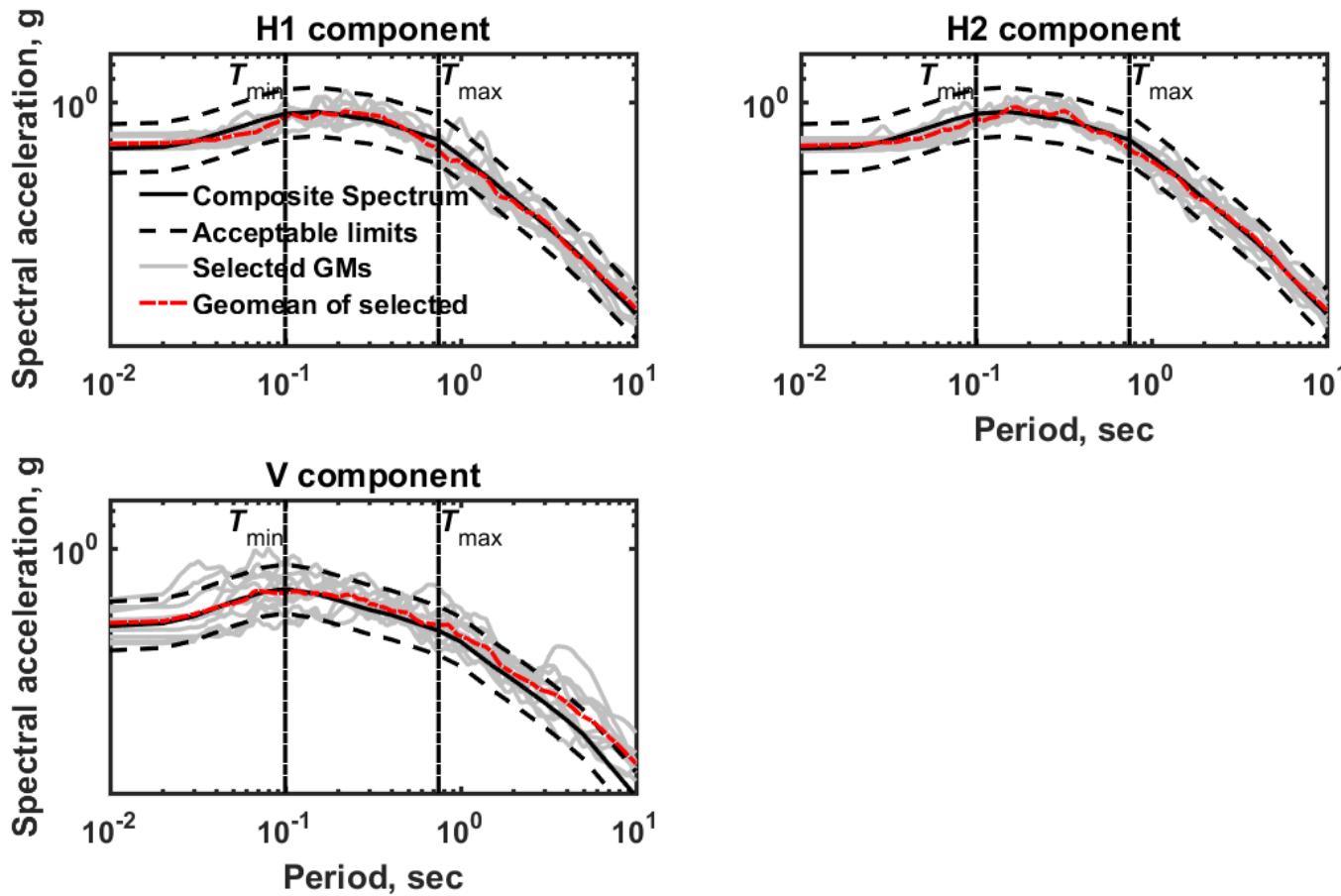


# Period range for selecting GMs



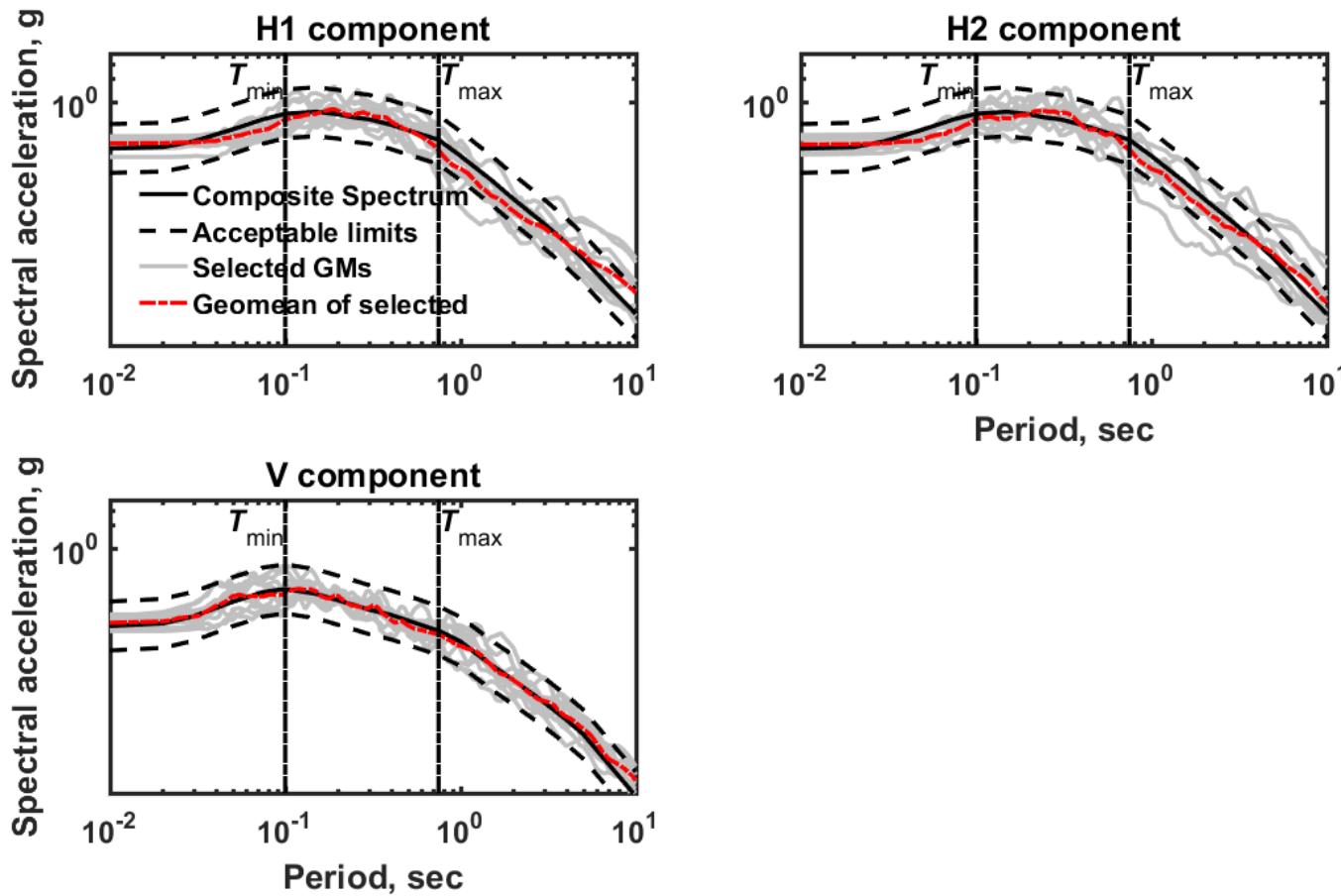
# Relative importance of H component:

$$W_H = 1$$



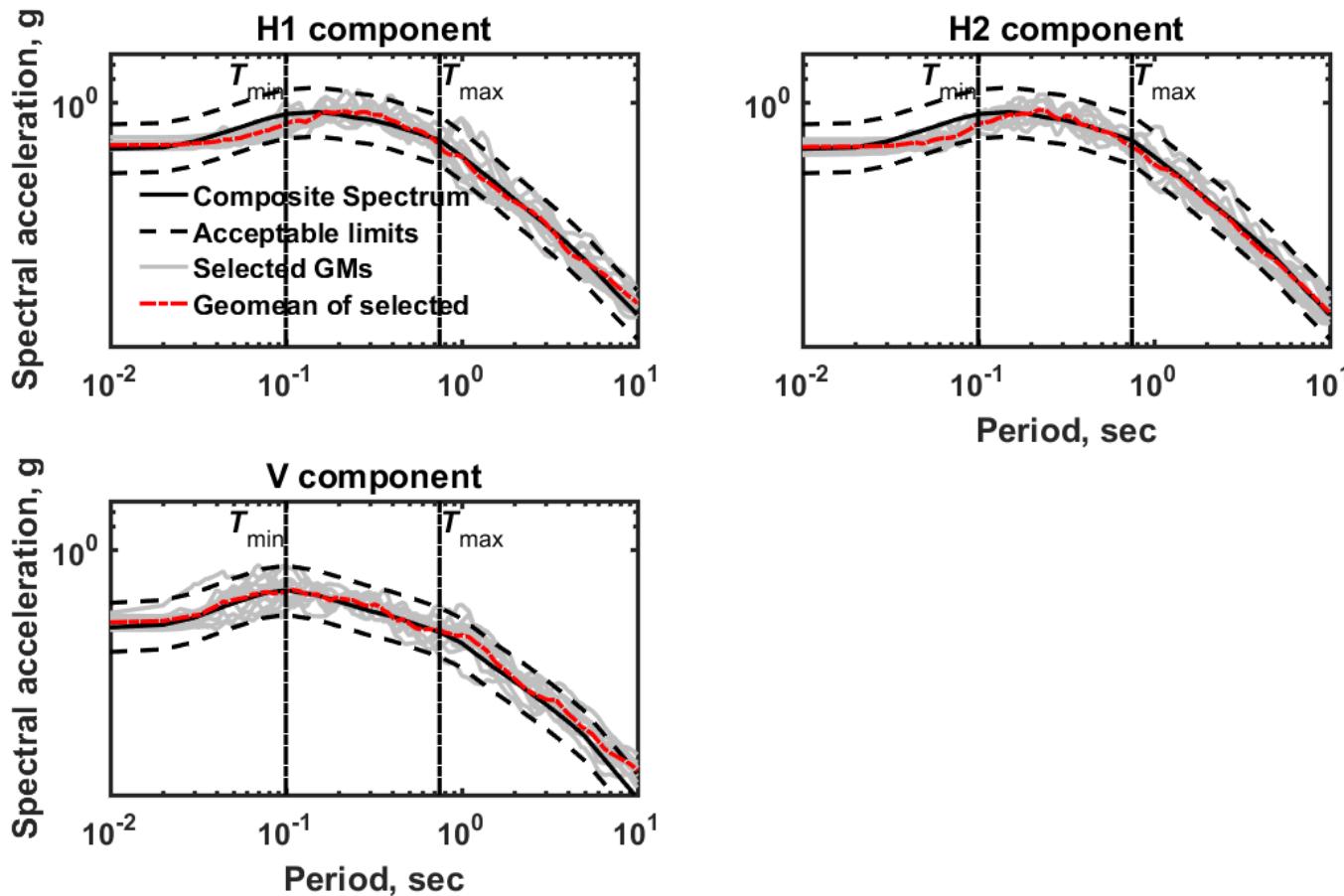
# Relative importance of H component:

$$w_H = 0$$



# Relative importance of H component:

$$w_H = 0.5$$



# Suggestions for GMSM inputs

1. Select GMs using a period range of 0.01 to 10 sec
2. Limit SFs within 0.25 to 4
3. Specify  $w_H$  as 0.5

# Less important GMSM inputs

1. Limits on metadata
2. Same or different SFs for orthogonal components of GM
3. Metric for comparing response spectra

# **CONCLUSIONS**

# Summary

1. To select multicomponent GMs, the V component must be included when:
  - a) Conducting PSHA
  - b) Determining the target spectrum
  - c) Implementing a selection algorithm

# Summary

2. Using the CMS-UHS Composite Spectrum reduces the number of multicomponent GMs to be selected, relative to multiple CMSs

# Summary

3. Hazard-consistent GMs can be obtained so long as:
  - a) A wide period range is used for selecting GMs
  - b) SFs are limited; both same and different SFs for V components are reasonable
  - c) Both H and V components are included in the selection process with  $w_H = 0.5$

# Further reading

- Baker, J. W. and Cornell, C. A., 2006. Spectral shape, epsilon, and record selection.  
*Earthquake Engineering and Structural Dynamics* **35**, 1077-1095.
- Baker, J. W., 2011. Conditional Mean Spectrum: Tool for ground-motion selection.  
*ASCE Journal of Structural Engineering* **137**, 331.

# Further reading

- Kwong, N. S. and Chopra, A. K., 2017. A Generalized Conditional Mean Spectrum and its application for intensity-based assessments of seismic demands. *Earthquake Spectra* **33**(1), 123-143.
- Kwong, N. S. and Chopra, A. K., 2018. Determining bi-directional ground motions for nonlinear response history analysis of buildings at far-field sites. *Earthquake Spectra* **34**(4), 1931-1954.

# Further reading

- Kwong, N. S. and Chopra, A. K., 2019.  
Selecting, scaling, and orienting three  
components of ground motions for intensity-  
based assessments at far-field sites.  
*Earthquake Spectra* (in review).

# **SUPPLEMENTARY MATERIAL**

# **FORMULATION USING V/H MODELS**

# CMS for V component of GM

$$\begin{aligned} & A_{V,CMS}(T, \varepsilon_H(T^*)) \\ &= A_{H,CMS}(T, \varepsilon_H(T^*)) \cdot \left[ \frac{V}{H}(T) \right]_m \\ &\cdot \exp[\varepsilon_H(T^*) \rho_{H,V/H}(T^*, T) \sigma_{V/H}(T)] \end{aligned}$$

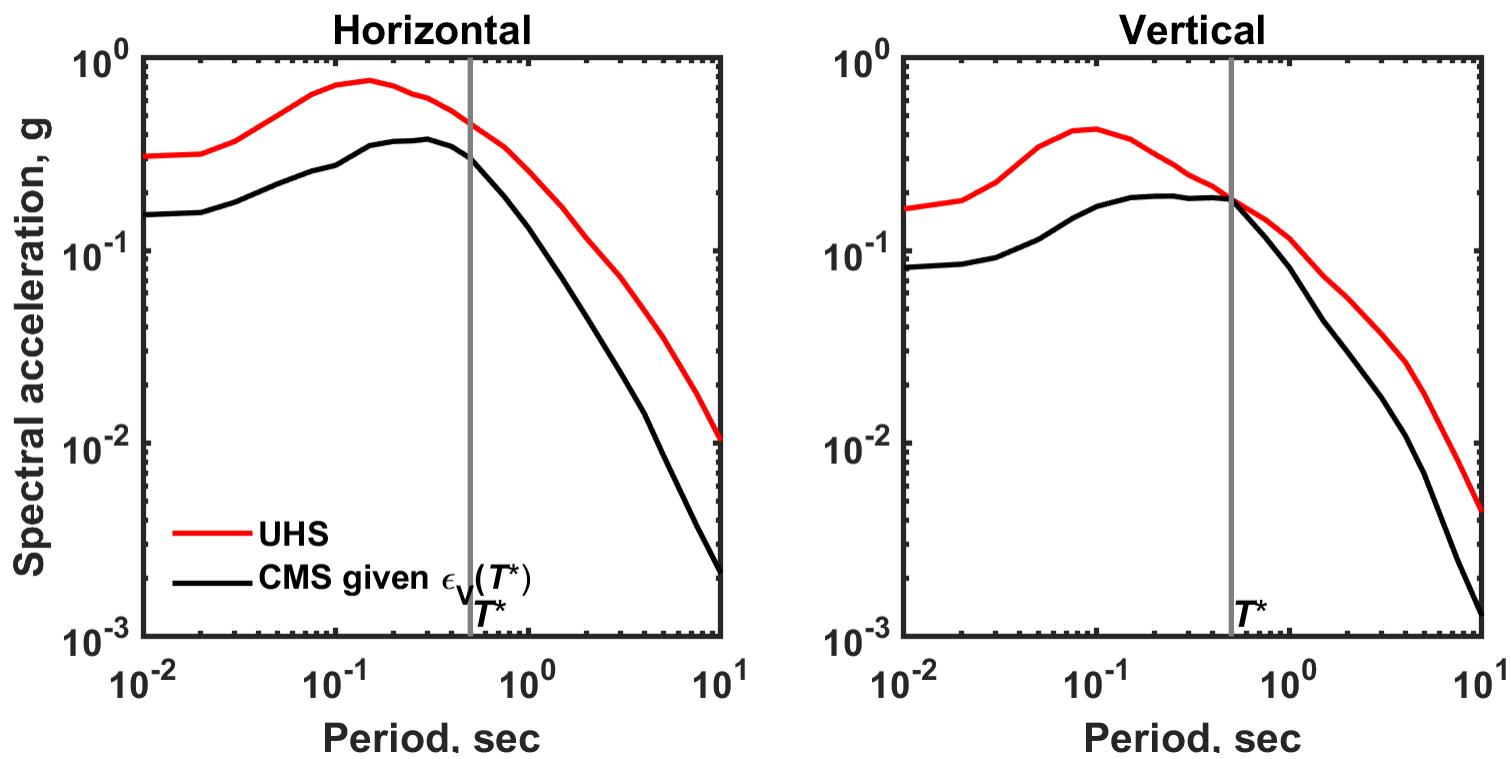
# **CONDITIONING UPON THE V COMPONENT OF GM**

# Multicomponent CMS

For  $k$ th component of GM ( $k=H$  or  $V$ ):

$$A_{k,CMS}(T, \varepsilon_V(T^*)) \\ = A_{k,m}(T) \cdot \exp[\varepsilon_V(T^*) \rho_{k,V}(T, T^*) \sigma_k(T)]$$

# Multicomponent CMS



# Multicomponent Composite Spectrum

For  $k$ th component of GM ( $k=H$  or  $V$ ):

$$A_{k,Composite}(T) = \begin{cases} A_{k,CMS}(T, T_{min}) & T \leq T_{min} \\ \bar{A}_{k,UHS}(T) & T_{min} < T \leq T_{max} \\ A_{k,CMS}(T, T_{max}) & T \geq T_{max} \end{cases}$$

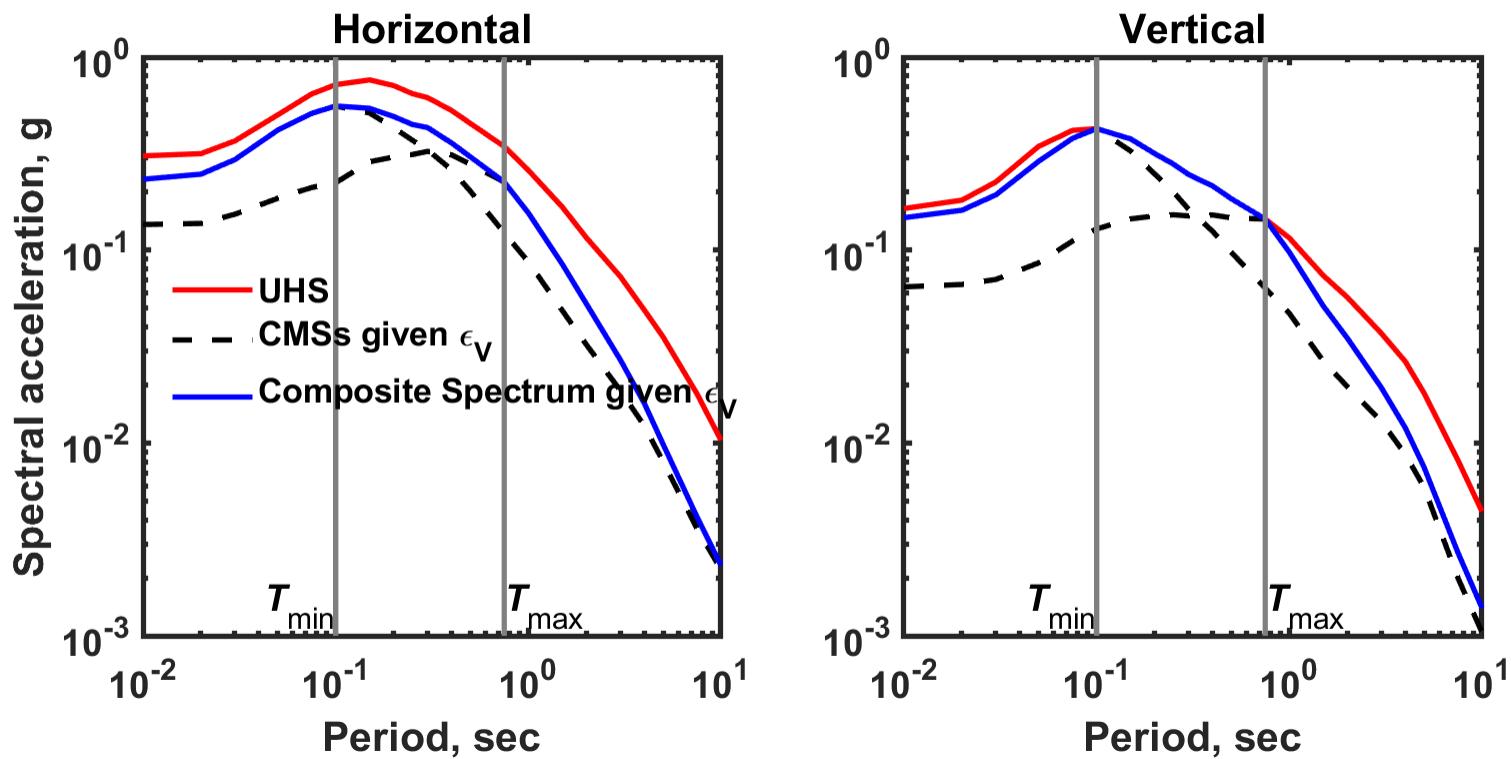
# Multicomponent Composite Spectrum

$$\bar{A}_{V,UHS}(T) = A_{V,UHS}(T)$$

$$\begin{aligned}\bar{A}_{H,UHS}(T) &= A_{H,m}(T, \theta_e) \cdot \exp[\varepsilon_V(T)\rho_{H,V}(T, T, \theta_e)\sigma_H(T, \theta_e)] \\ &\approx A_{H,m}(T) \cdot \exp[\varepsilon_V(\bar{T})\rho_{H,V}(T, T)\sigma_H(T)]\end{aligned}$$

$$\bar{T} = \sqrt{T_{min} \cdot T_{max}}$$

# Multicomponent Composite Spectrum



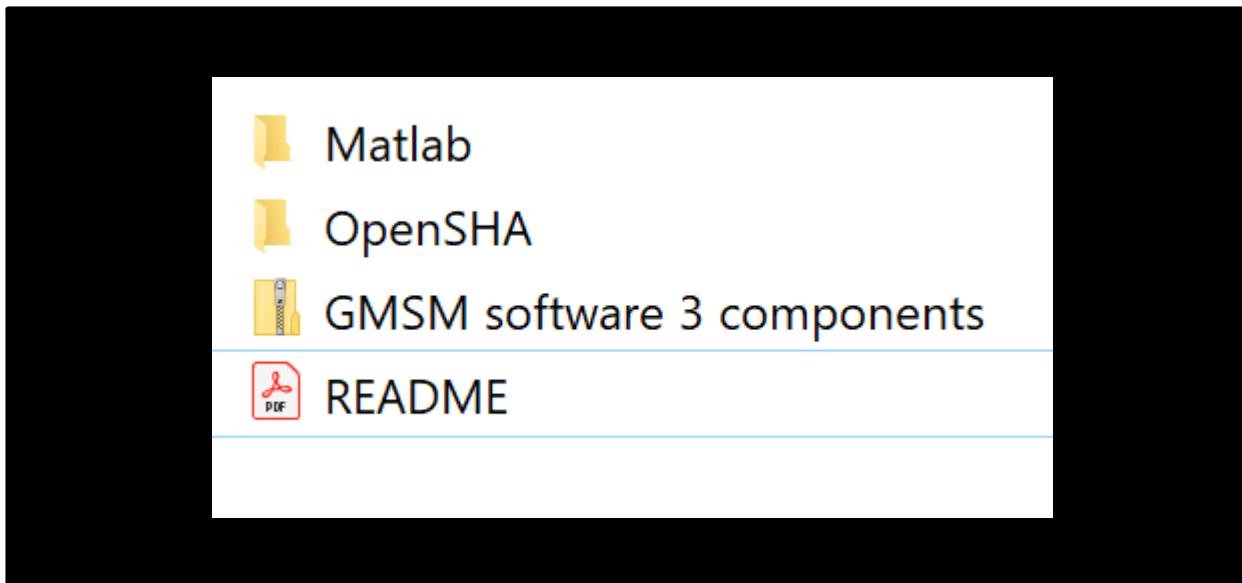
Neal Simon Kwong ([nealsimonkwong@berkeley.edu](mailto:nealsimonkwong@berkeley.edu))

# **ILLUSTRATIVE EXAMPLE**

# Electronic supplement

1. Software for conducting PSHA and implementing GMSM of three components is provided
2. Specific numerical example illustrated using OpenSHA and Matlab
3. Subsequent screenshots illustrate use of this software

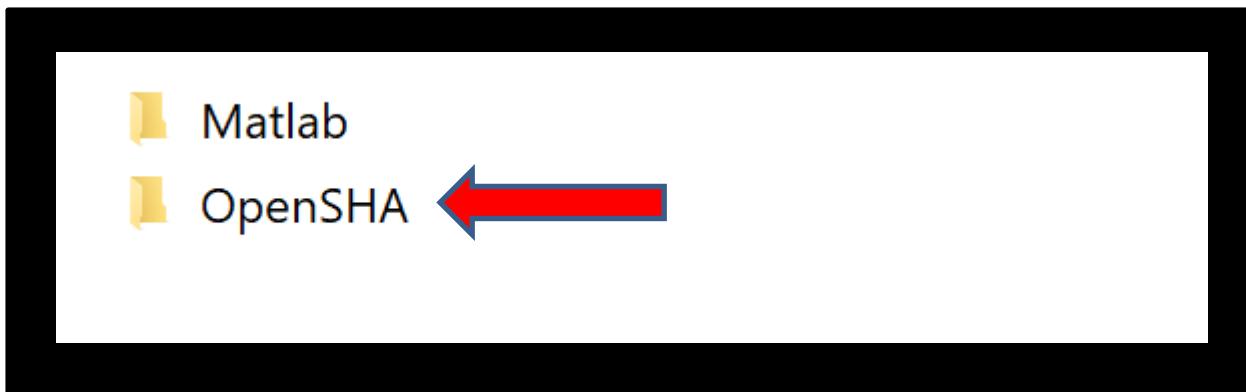
# README file



# Organization of files



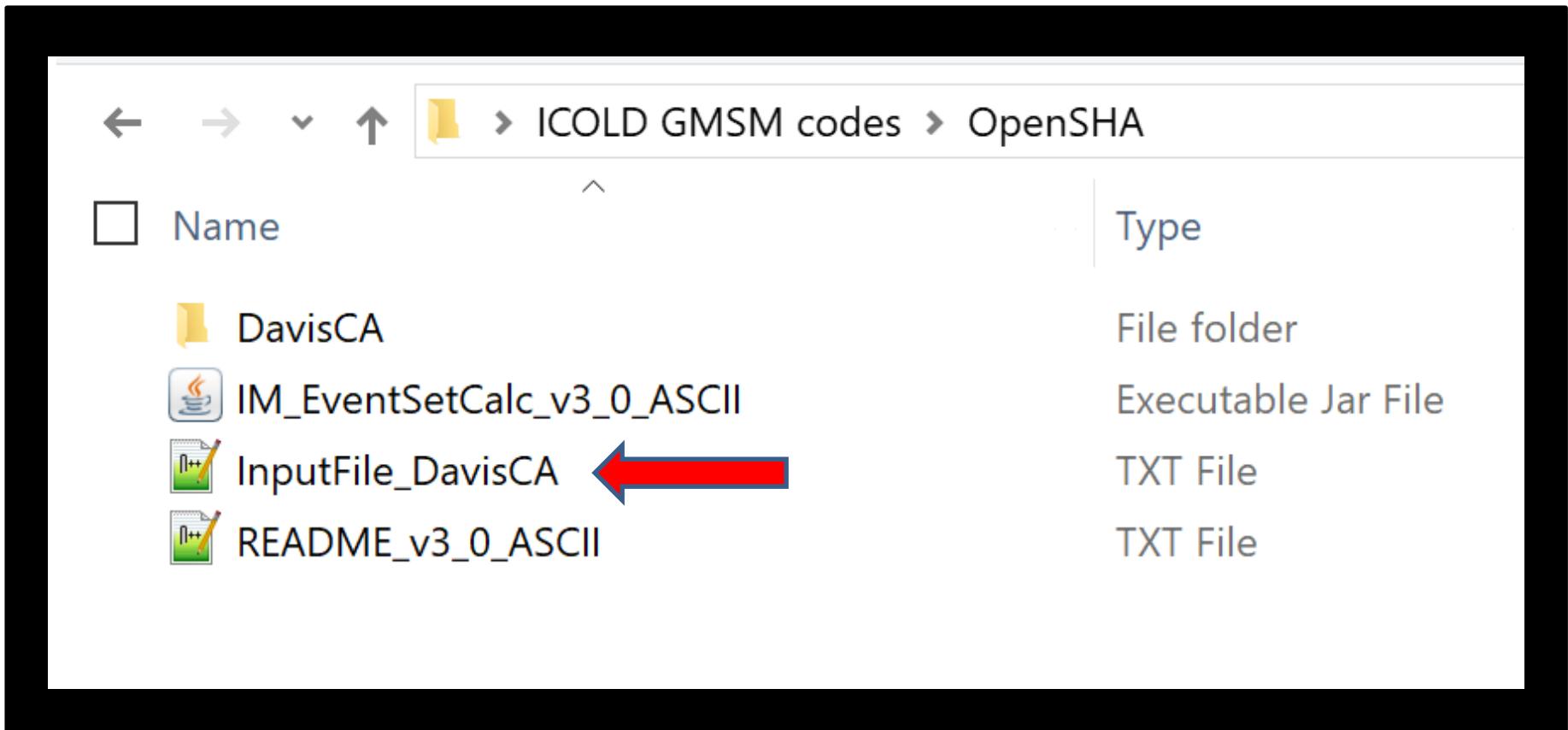
# Conduct PSHA



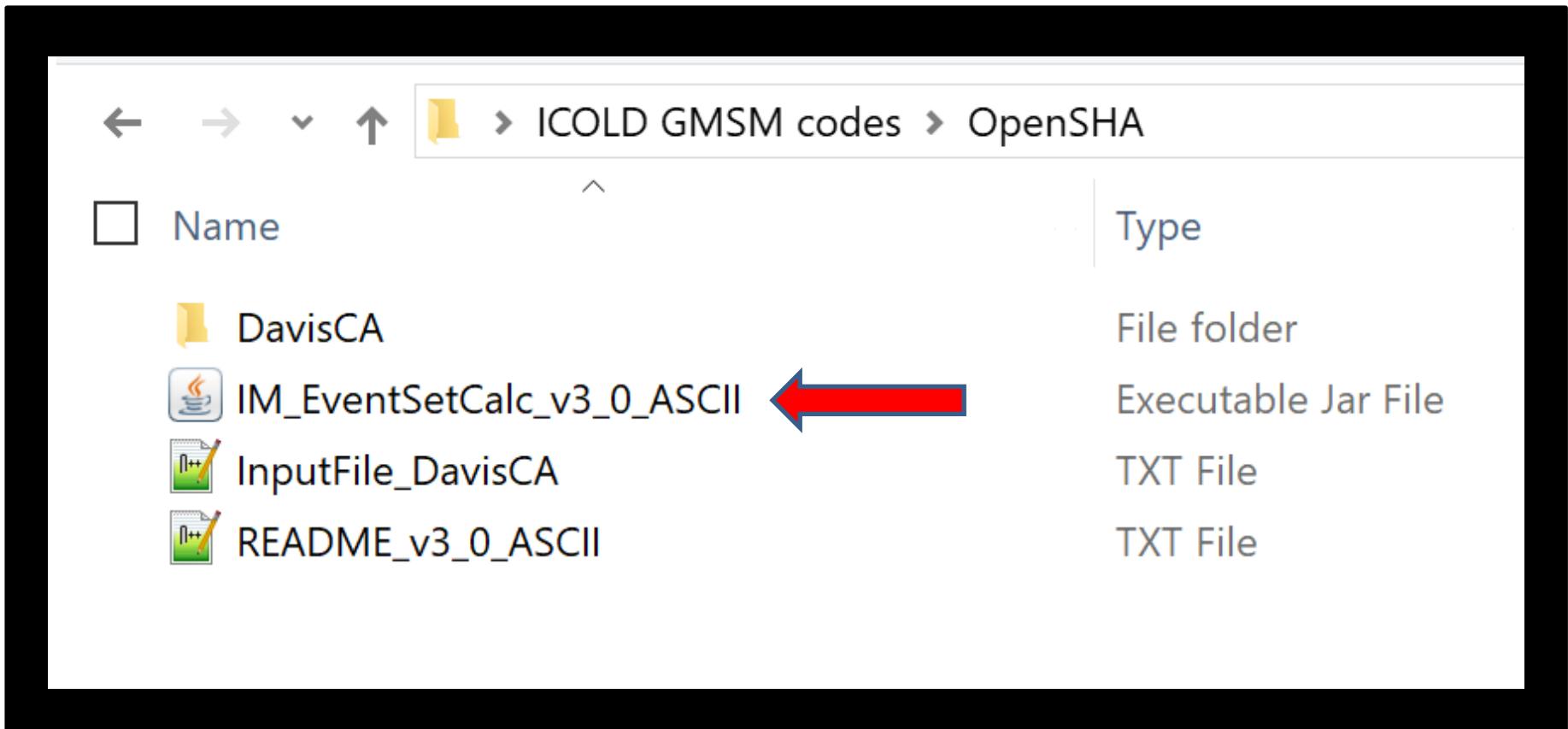
# PSHA instructions

Name	Type
DavisCA	File folder
IM_EventSetCalc_v3_0_ASCII	Executable Jar File
InputFile_DavisCA	TXT File
README_v3_0_ASCII	TXT File

# PSHA input



# Get earthquake rupture forecast



# PSHA output

Name	Type
DavisCA	File folder
IM_EventSetCalc_v3_0_ASCII	Executable Jar File
InputFile_DavisCA	TXT File
README_v3_0_ASCII	TXT File

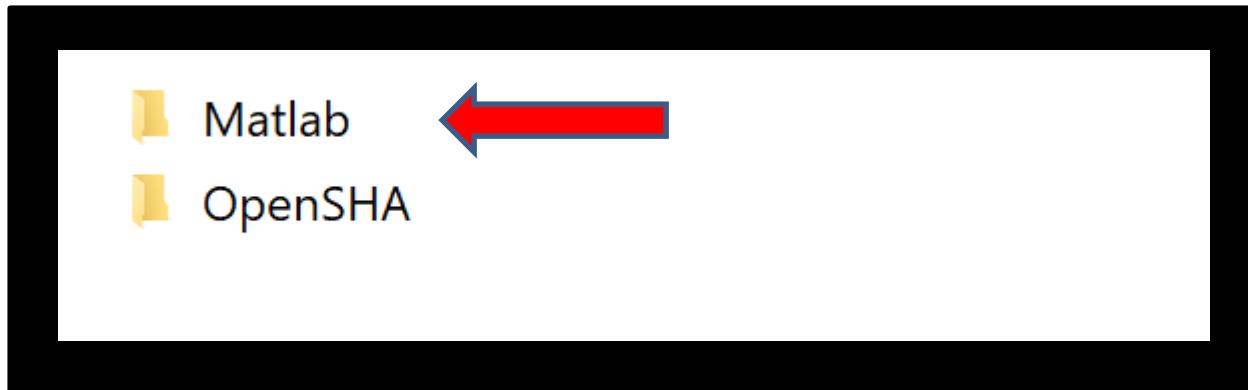
# Earthquake rupture forecast

Name	Type
src_rup_metadata	TXT File
rup_dist_jb_info	TXT File
rup_dist_info	TXT File
CB2014_SA_10.0	TXT File
CB2014_SA_7.5	TXT File

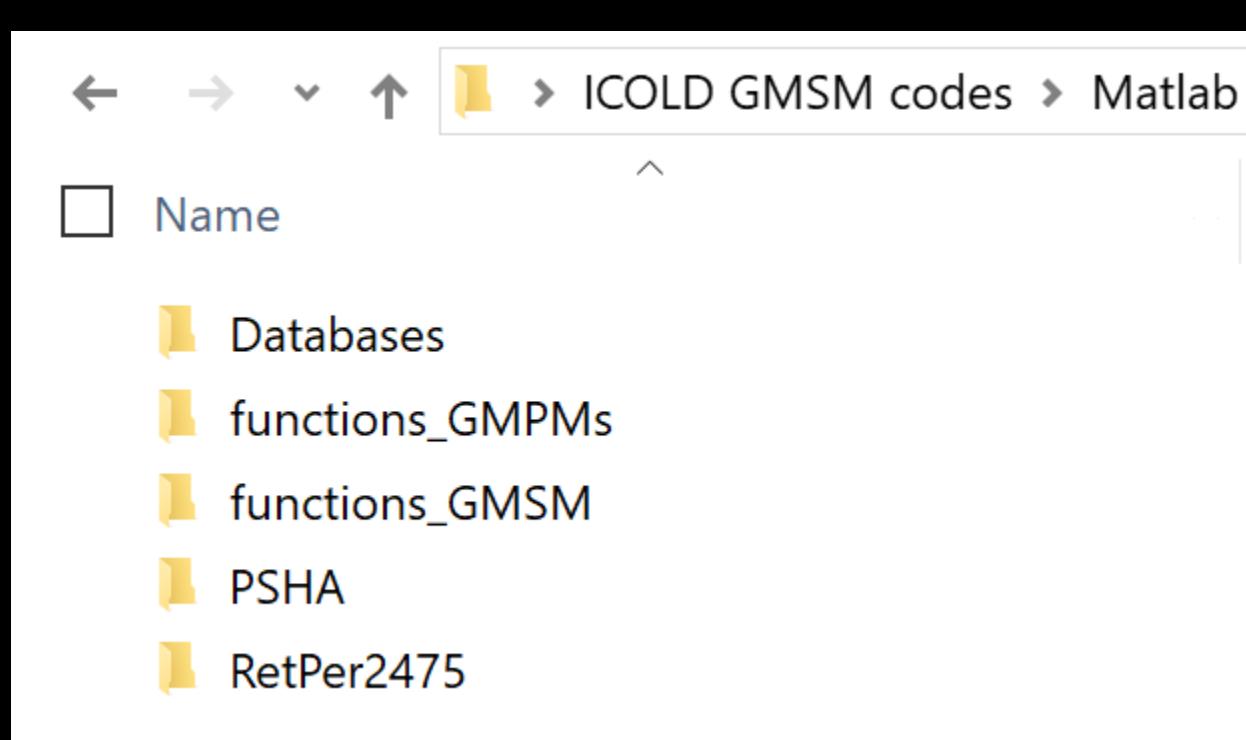
# Earthquake rupture forecast

1	62	0	4.7602345E-5	6.15	West Napa	(j10.wnapa)	1	Char		
2	62	1	7.34724E-5	6.2	West Napa	(j10.wnapa)	1	Char		
3	62	2	9.532828E-5	6.25	West Napa	(j10.wnapa)	1	Char		
4	62	3	1.03973085E-4	6.3	West Napa	(j10.wnapa)	1	Char		
5	62	4	1.6690134E-4	6.35	West Napa	(j10.wnapa)	1	Char		
6	62	5	1.8394268E-4	6.4	West Napa	(j10.wnapa)	1	Char		
7	62	6	1.909343E-4	6.45	West Napa	(j10.wnapa)	1	Char		
8	62	7	1.5632994E-4	6.5	West Napa	(j10.wnapa)	1	Char		
9	62	8	1.5528912E-4	6.55	West Napa	(j10.wnapa)	1	Char		
10	62	9	1.2892572E-4	6.6	West Napa	(j10.wnapa)	1	Char		
11	62	10	9.5518444E-5	6.65	West Napa	(j10.wnapa)	1	Char		
12	62	11	2.6116857E-5	6.7	West Napa	(j10.wnapa)	1	Char		
13	62	12	2.394538E-5	6.75	West Napa	(j10.wnapa)	1	Char		
14	62	13	1.8455432E-5	6.8	West Napa	(j10.wnapa)	1	Char		
15	62	14	1.1957169E-5	6.85	West Napa	(j10.wnapa)	1	Char		
16	63	0	5.1935338E-5	6.05	Quien Sabe	(bb.quiensabe)	1	Char		
17	63	1	8.016021E-5	6.1	Quien Sabe	(bb.quiensabe)	1	Char		
18	63	2	1.0400551E-4	6.15	Quien Sabe	(bb.quiensabe)	1	Char		
19	63	3	1.1343721E-4	6.2	Quien Sabe	(bb.quiensabe)	1	Char		

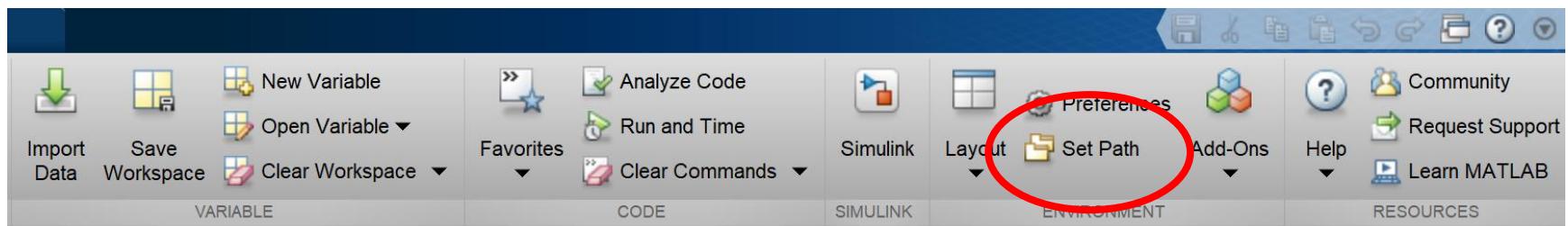
# Conduct PSHA with Matlab-GMPMs



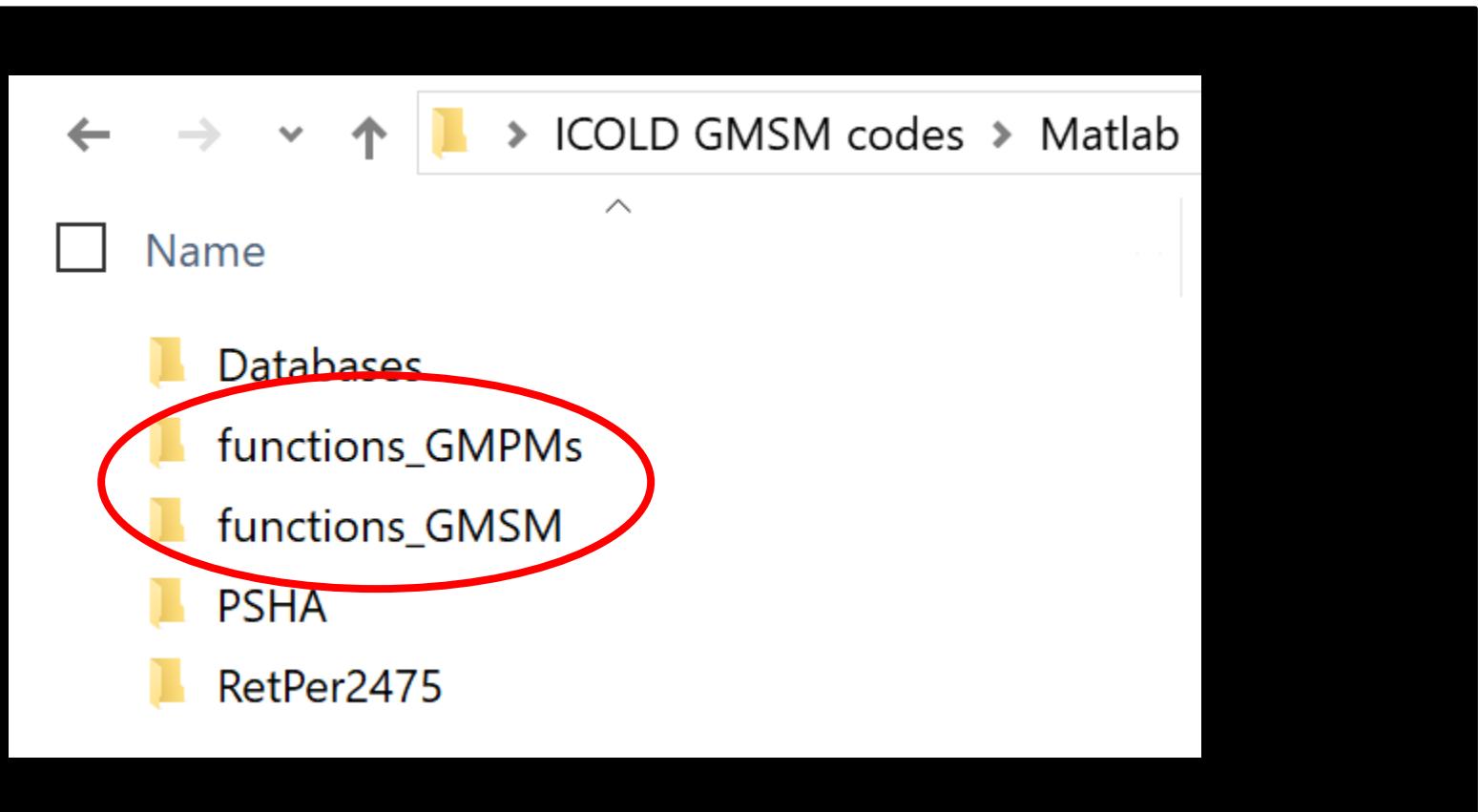
# Conduct PSHA with Matlab-GMPMs



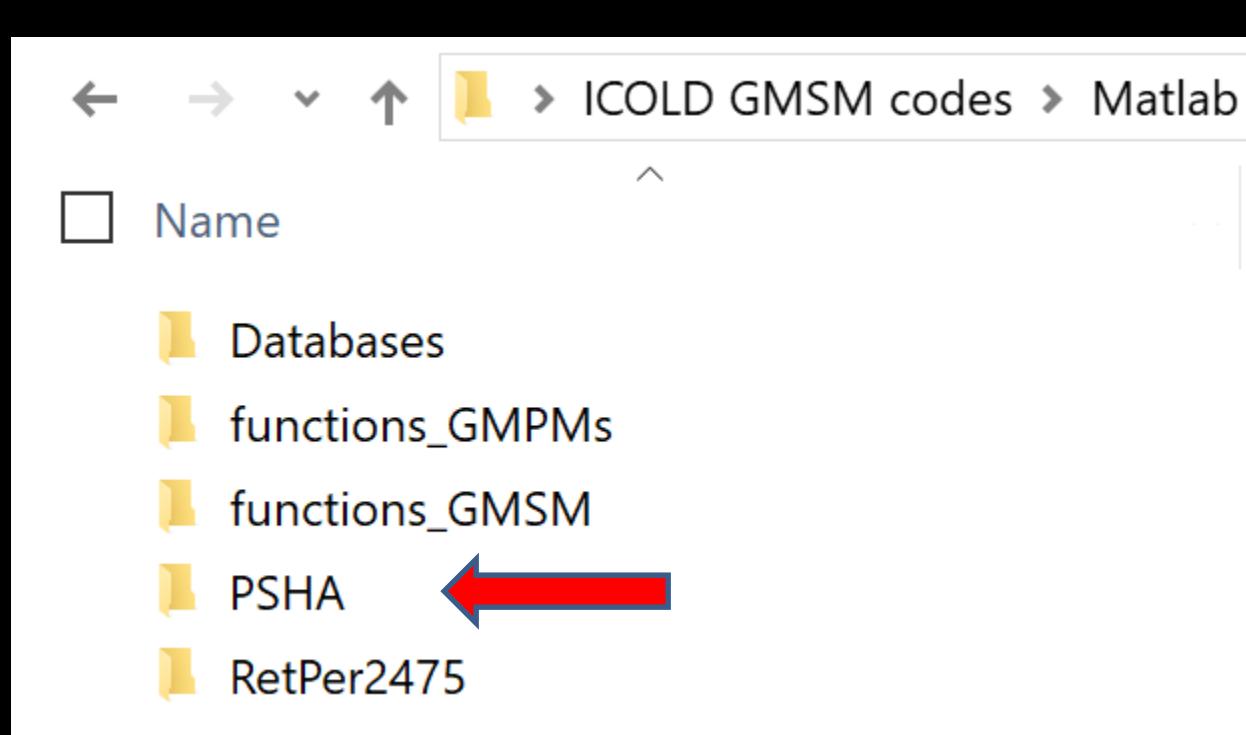
# Set path in Matlab



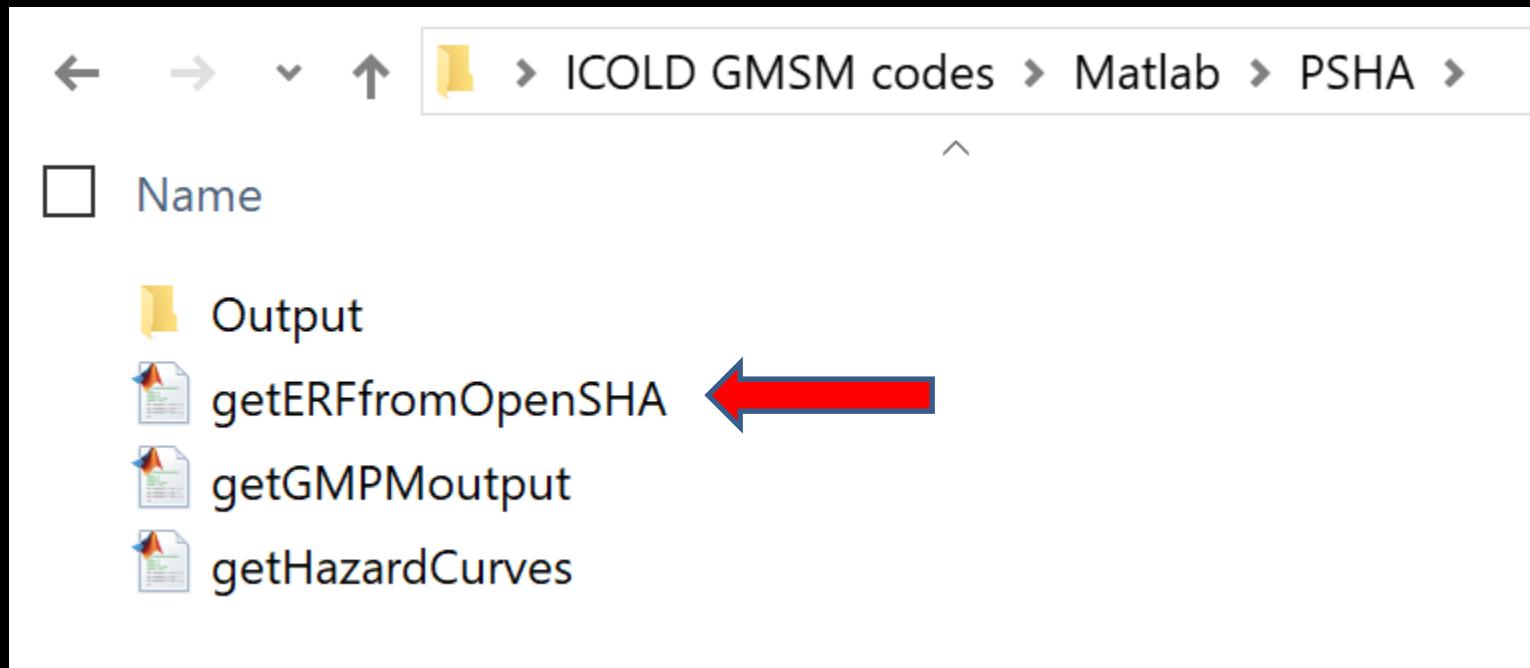
# Set path in Matlab



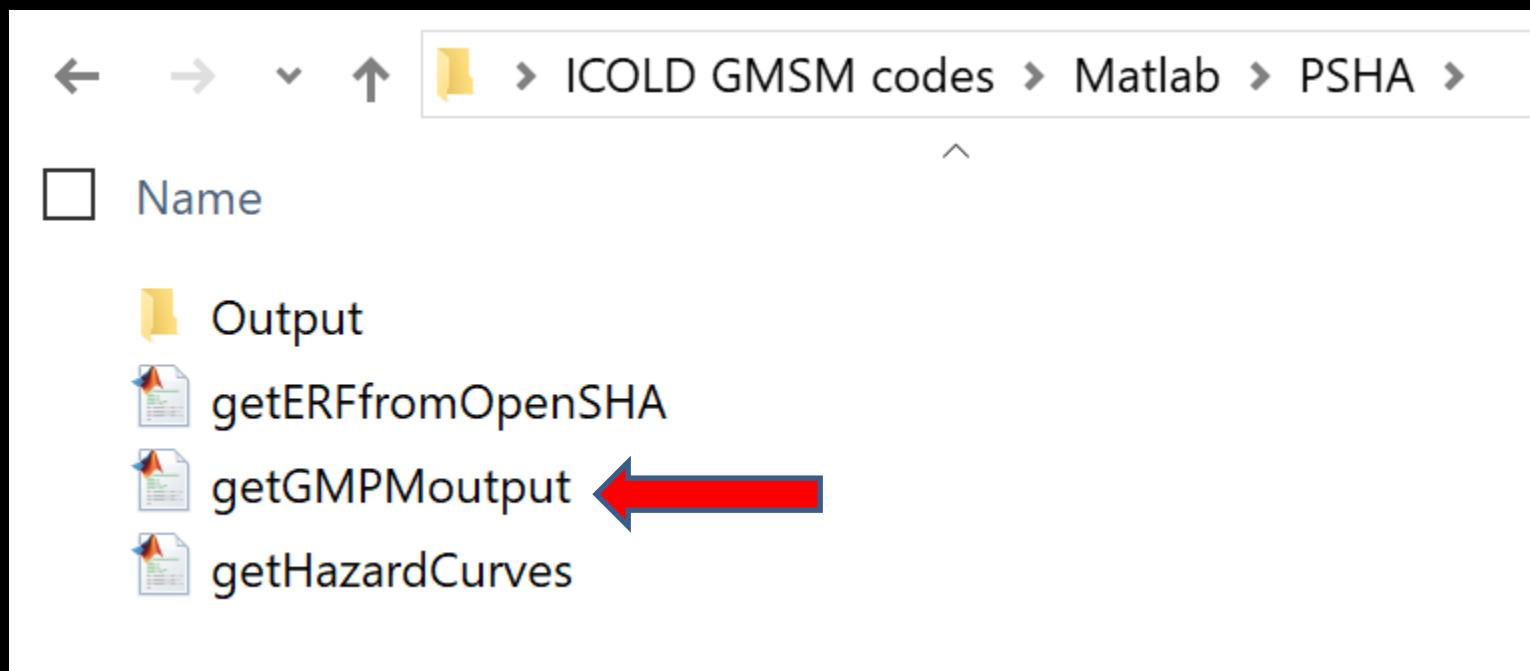
# Conduct PSHA with Matlab-GMPMs



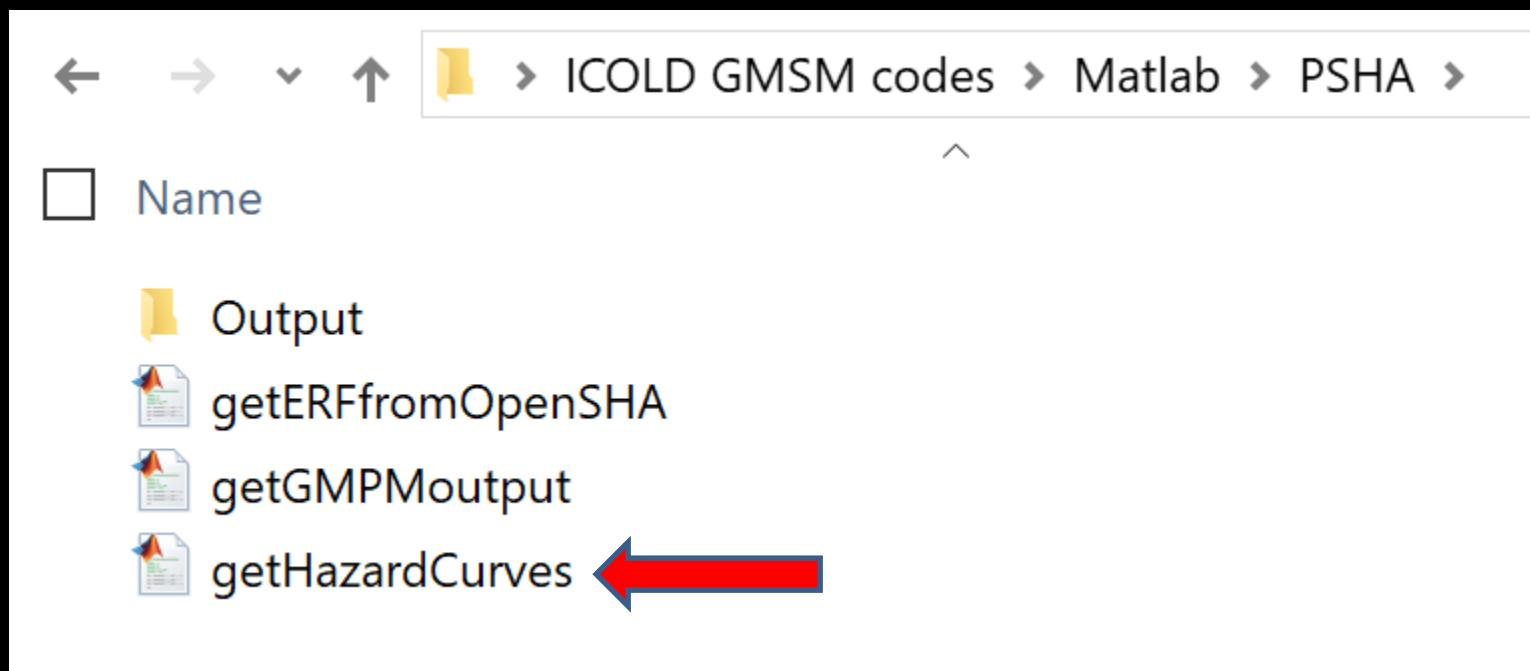
# Get earthquake rupture forecast



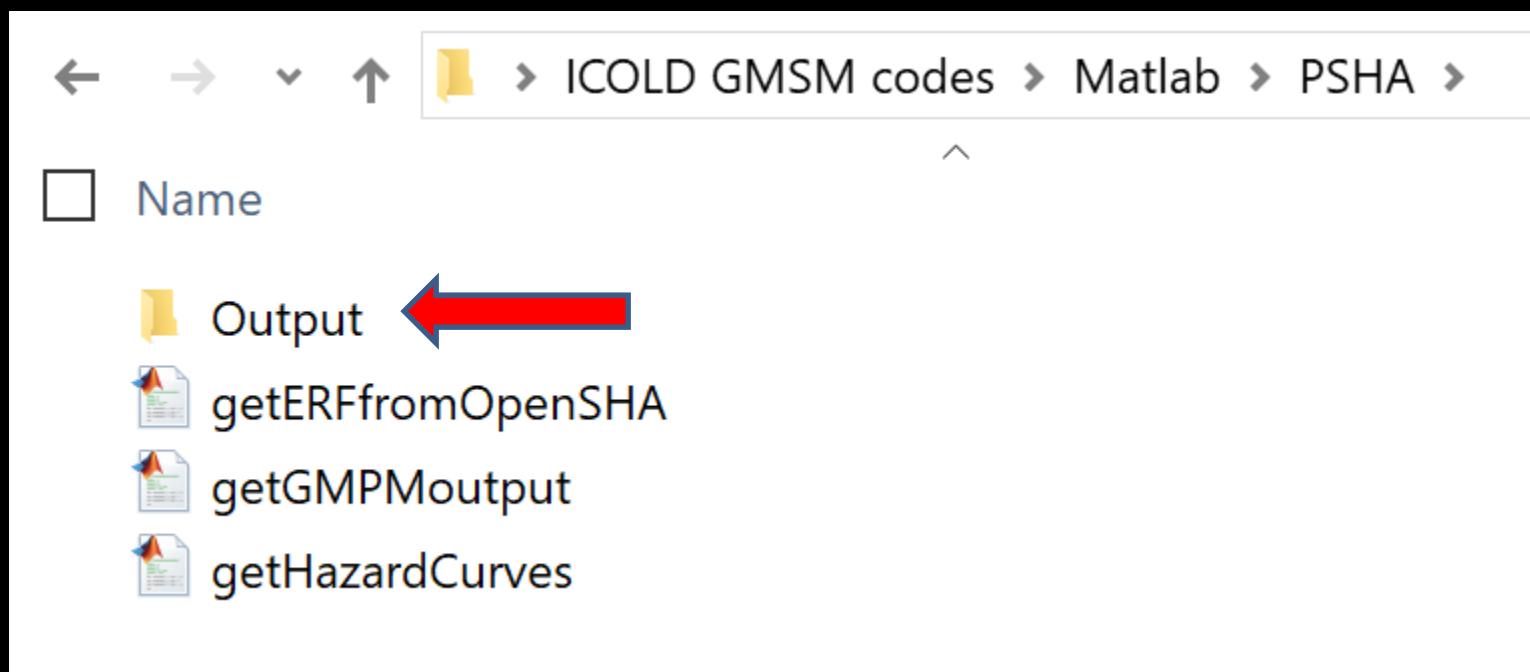
# Implement Matlab-GMPMs



# Compute hazard curves



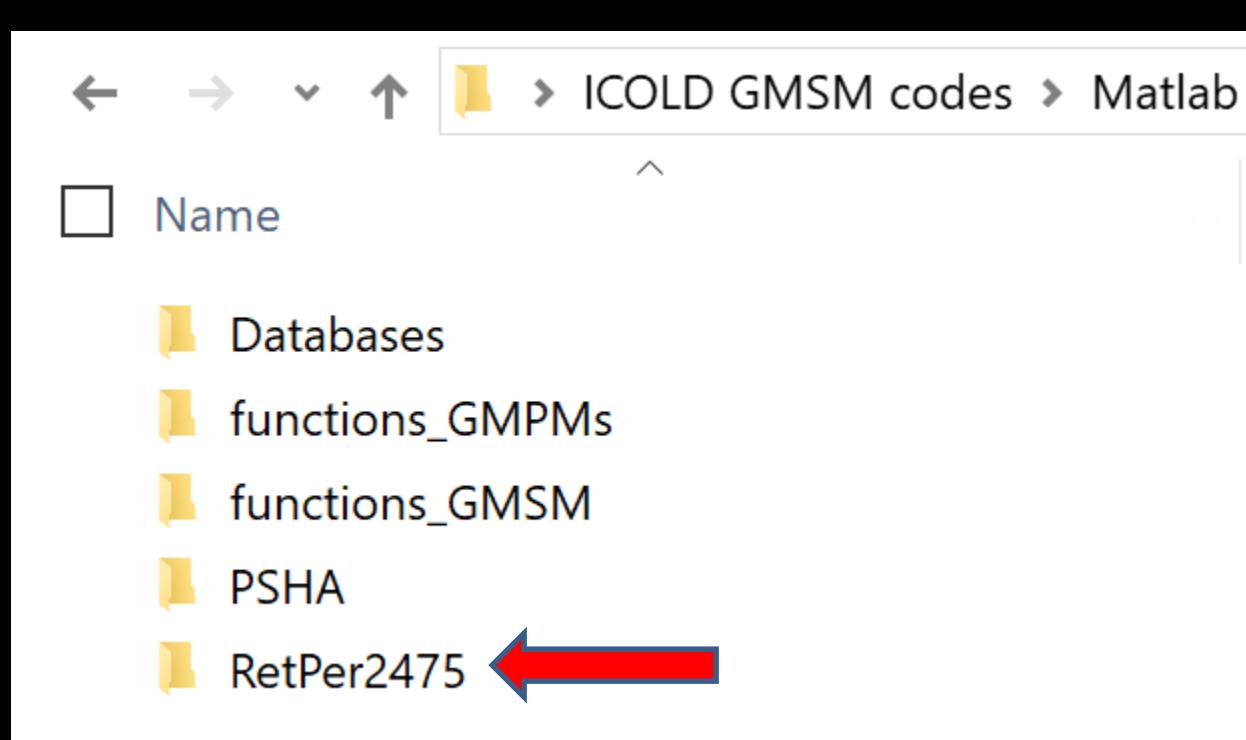
# PSHA output



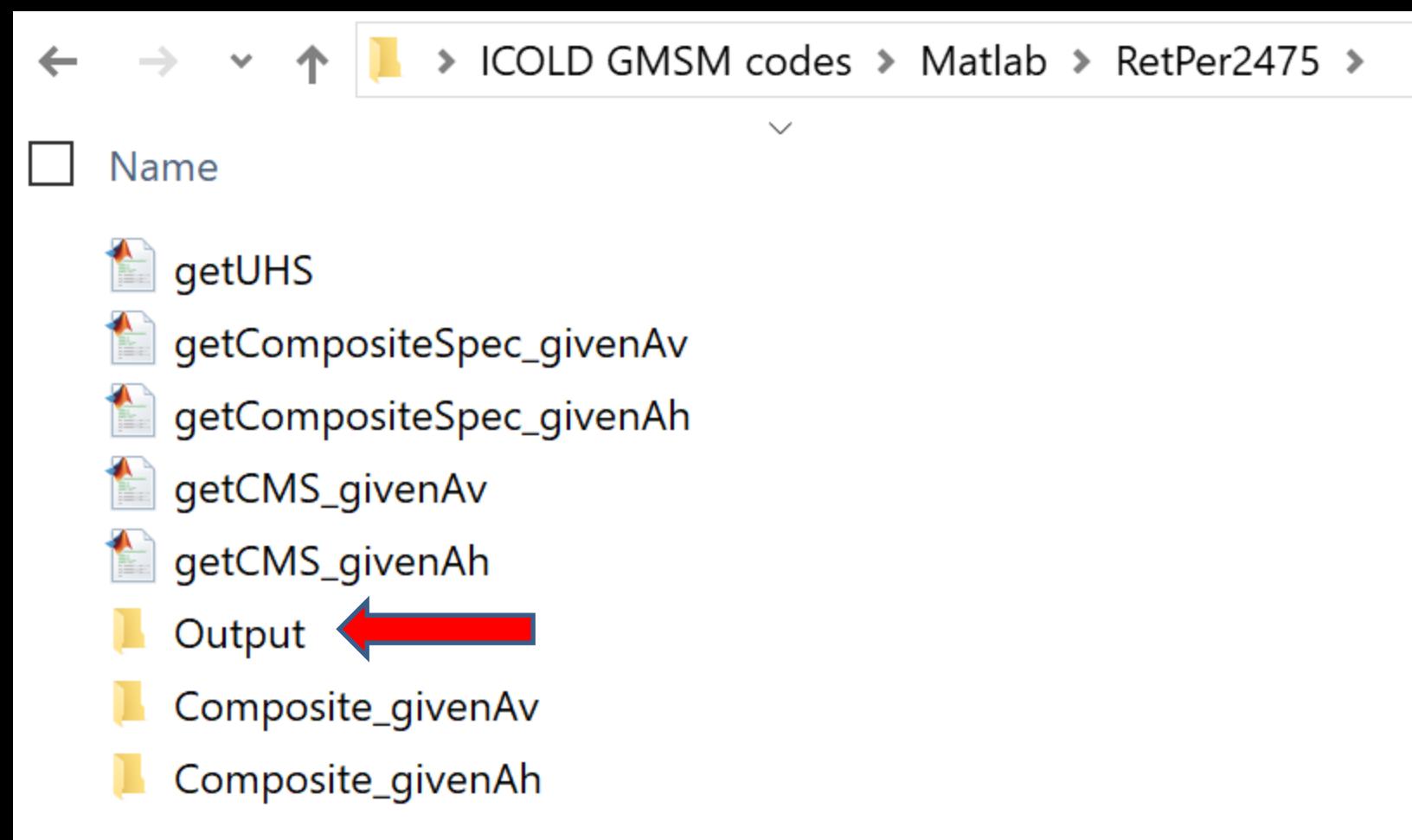
# PSHA output

Name	Type
GMPMout	MATLAB Data
hazCurves	MATLAB Data
OpenSHAout	MATLAB Data

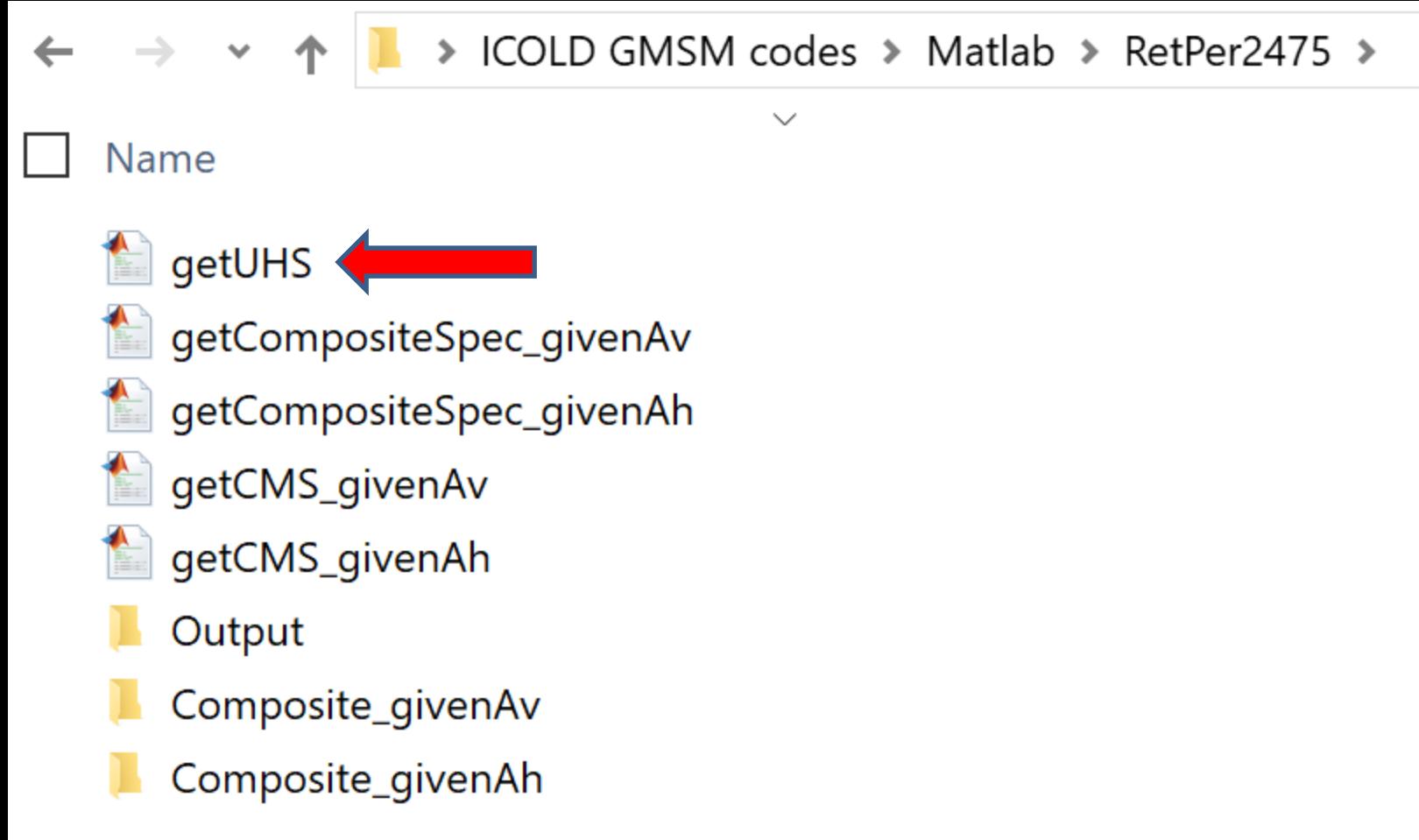
# Return period for target spectra



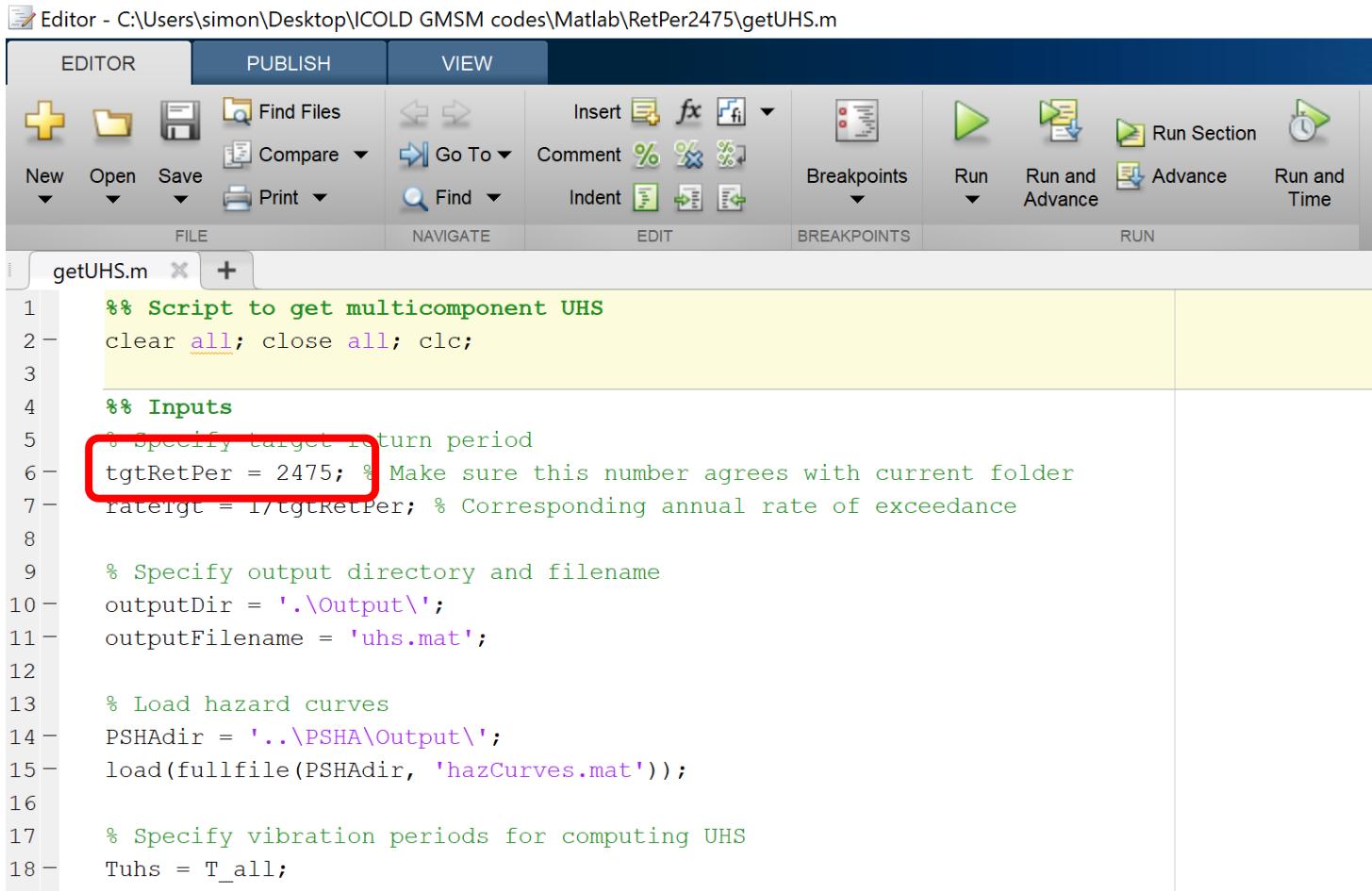
# Target spectra output



# Get UHS



# Get UHS

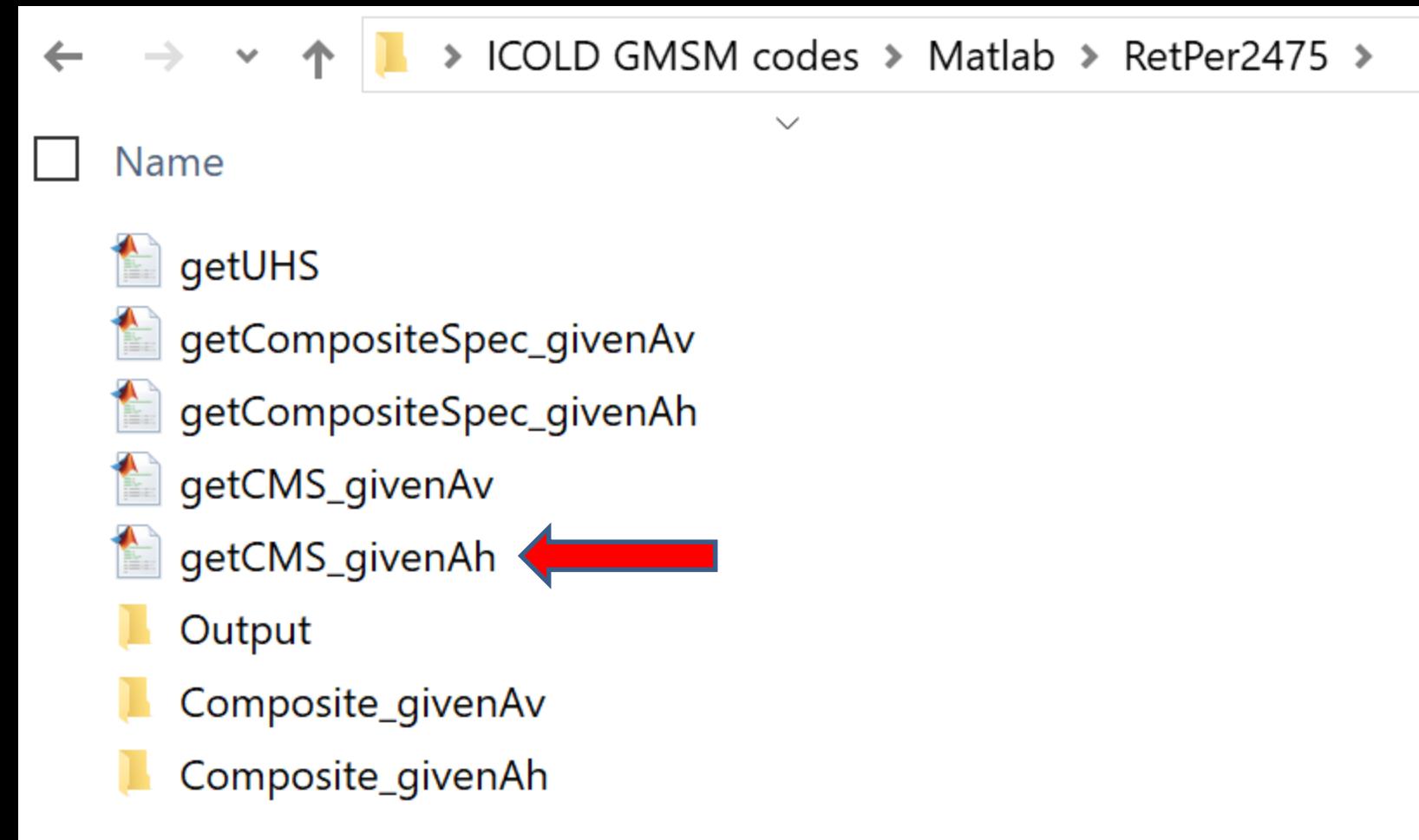


The screenshot shows a MATLAB Editor window titled "Editor - C:\Users\simon\Desktop\ICOLD GMSM codes\Matlab\RetPer2475\getUHS.m". The window has tabs for "EDITOR", "PUBLISH", and "VIEW". The "EDITOR" tab is selected. The toolbar contains icons for New, Open, Save, Find Files, Compare, Go To, Find, Insert, Comment, Indent, Breakpoints, Run, Run and Advance, Run Section, Advance, and Run and Time. The code editor displays the following MATLAB script:

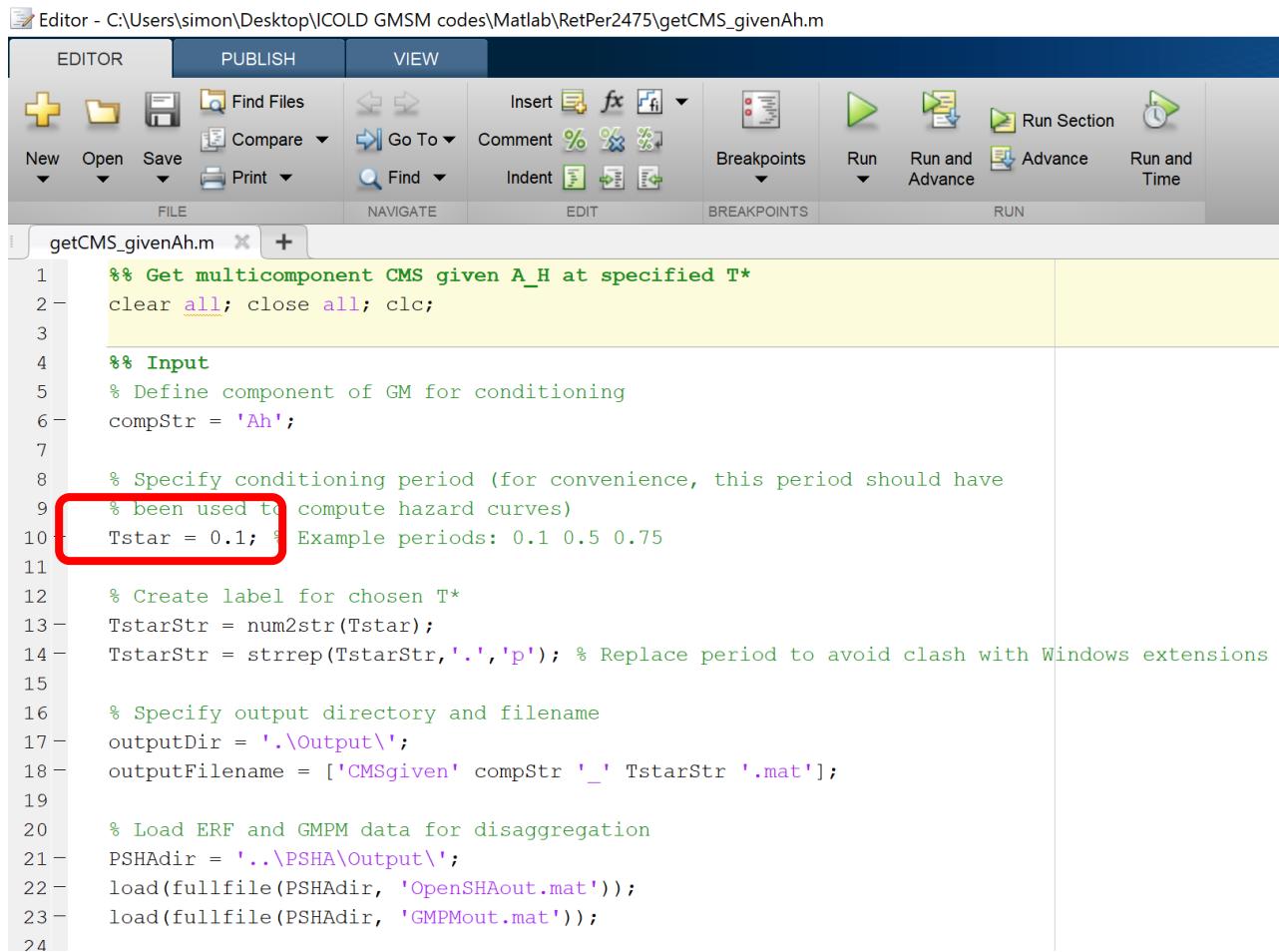
```
1 % Script to get multicomponent UHS
2 clear all; close all; clc;
3
4 %% Inputs
5 % Specify target return period
6 tgtRetPer = 2475; % Make sure this number agrees with current folder
7 ratetgt = 1/tgtRetPer; % Corresponding annual rate of exceedance
8
9 % Specify output directory and filename
10 outputDir = '.\Output\' ;
11 outputFilename = 'uhs.mat';
12
13 % Load hazard curves
14 PSHAdir = '..\PSHA\Output\' ;
15 load(fullfile(PSHAdir, 'hazCurves.mat'));
16
17 % Specify vibration periods for computing UHS
18 Tuhs = T_all;
```

The line of code "tgtRetPer = 2475;" is highlighted with a red rectangular box.

# Get CMSs



# Get CMS for $T_{min}$



Editor - C:\Users\simon\Desktop\ICOLD GMSM codes\Matlab\RetPer2475\getCMS\_givenAh.m

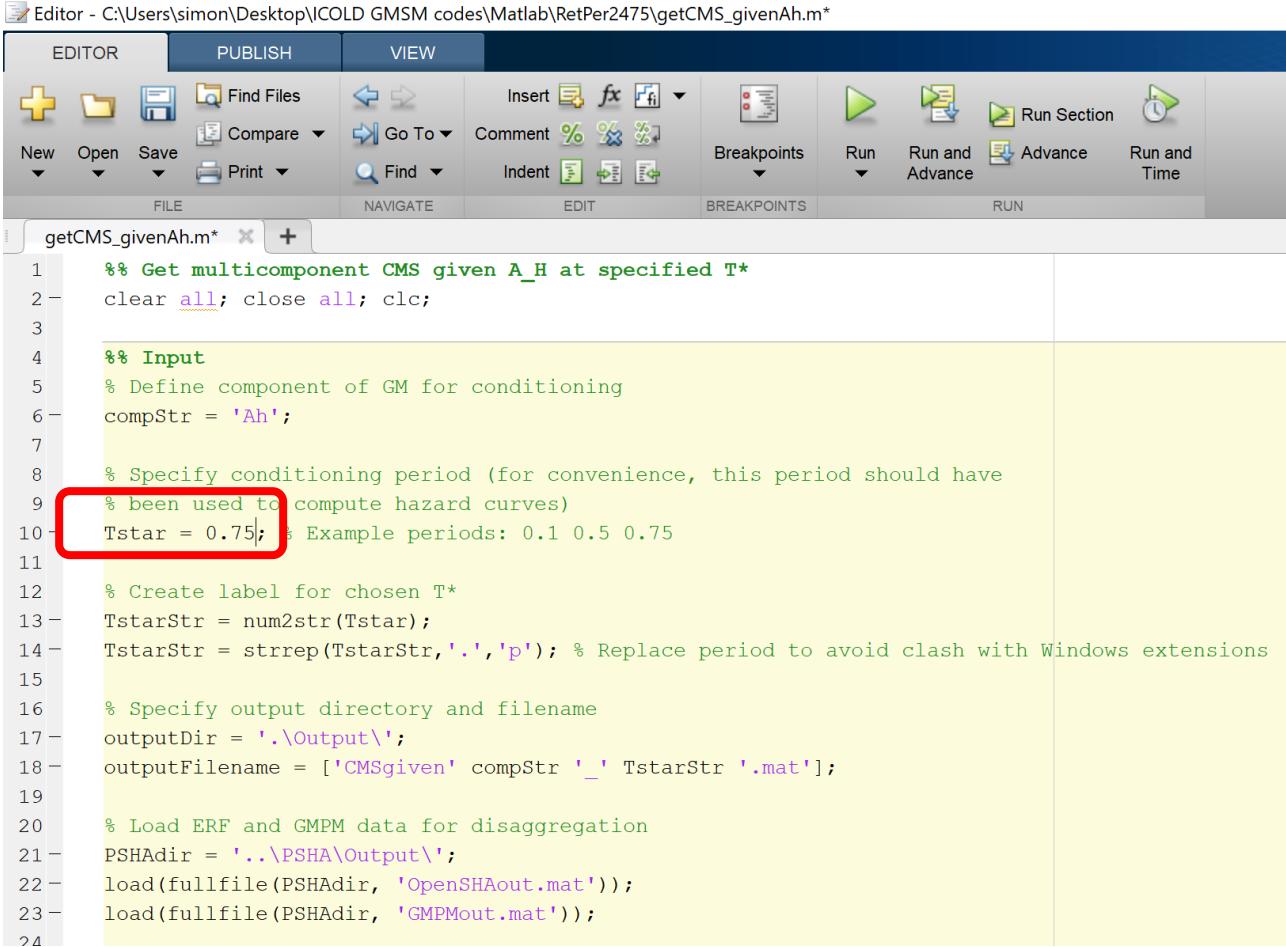
EDITOR PUBLISH VIEW

FILE NAVIGATE EDIT BREAKPOINTS RUN

getCMS\_givenAh.m

```
1 %% Get multicomponent CMS given A_H at specified T*
2 clear all; close all; clc;
3
4 %% Input
5 % Define component of GM for conditioning
6 compStr = 'Ah';
7
8 % Specify conditioning period (for convenience, this period should have
9 % been used to compute hazard curves)
10 Tstar = 0.1; % Example periods: 0.1 0.5 0.75
11
12 % Create label for chosen T*
13 TstarStr = num2str(Tstar);
14 TstarStr = strrep(TstarStr, '.', 'p'); % Replace period to avoid clash with Windows extensions
15
16 % Specify output directory and filename
17 outputDir = './Output';
18 outputFilename = ['CMSgiven' compStr '_' TstarStr '.mat'];
19
20 % Load ERF and GMPM data for disaggregation
21 PSHAdir = '../PSHA\Output';
22 load(fullfile(PSHAdir, 'OpenSHAout.mat'));
23 load(fullfile(PSHAdir, 'GMPMout.mat'));
```

# Get CMS for $T_{max}$

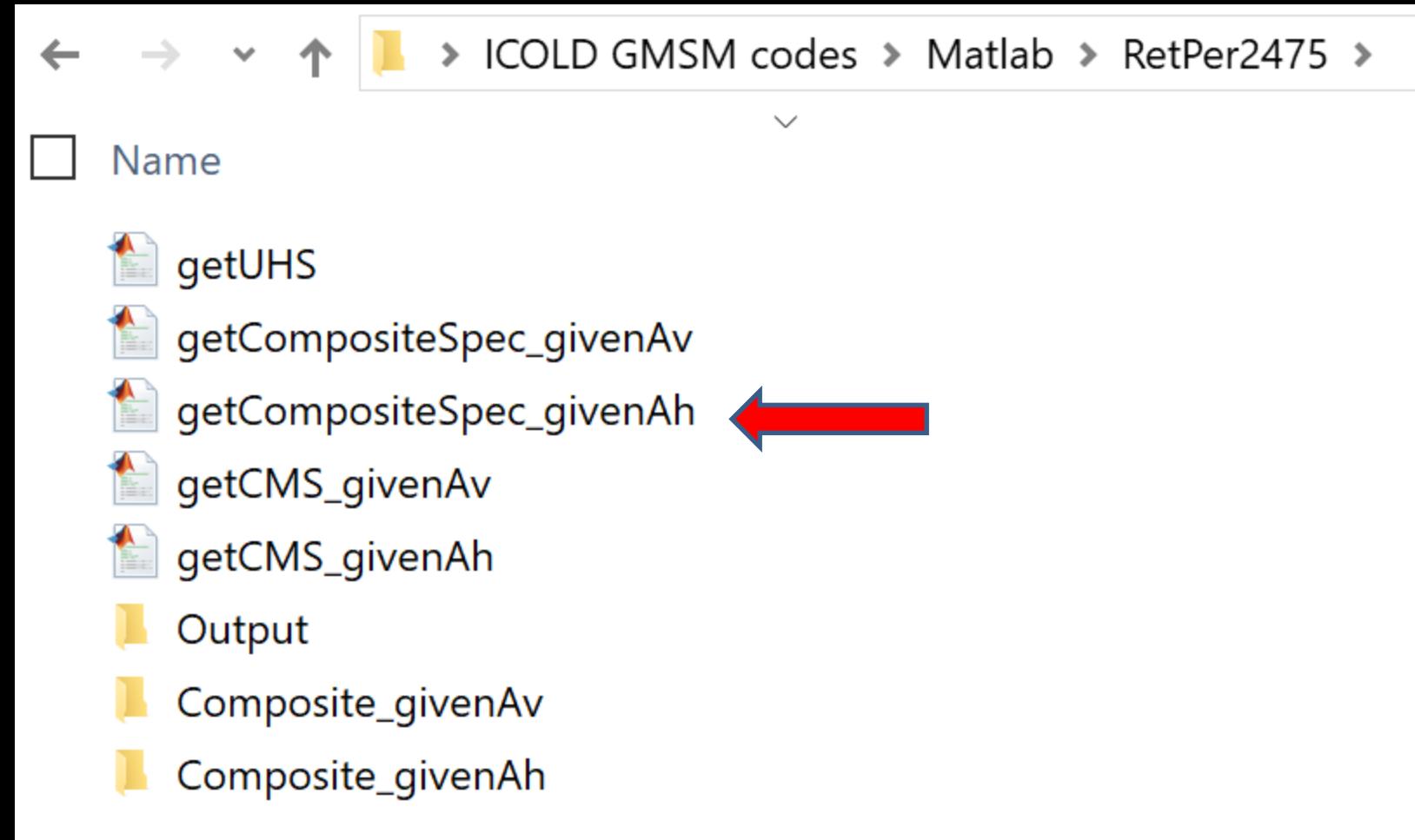


The screenshot shows the MATLAB Editor window with the title "Editor - C:\Users\simon\Desktop\ICOLD GMSM codes\Matlab\RetPer2475\getCMS\_givenAh.m\*". The menu bar includes "EDITOR", "PUBLISH", and "VIEW". The toolbar has icons for New, Open, Save, Find Files, Compare, Go To, Find, Insert, Comment, Breakpoints, Run, Run and Advance, Run Section, Advance, and Run and Time. The code editor displays the following MATLAB script:

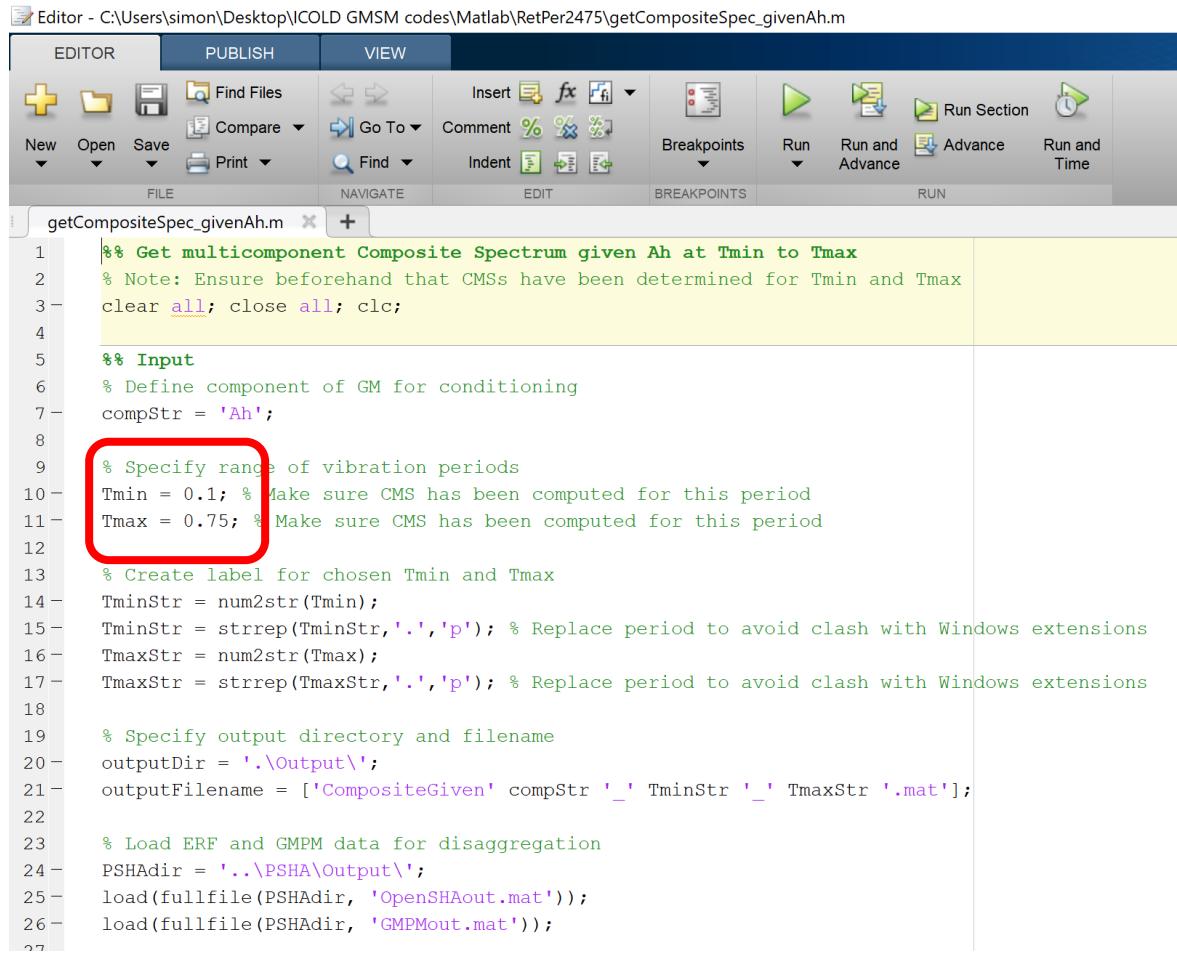
```
%> %% Get multicomponent CMS given A_H at specified T*
%> clear all; close all; clc;
%>
%> %% Input
%> % Define component of GM for conditioning
%> compStr = 'Ah';
%>
%> % Specify conditioning period (for convenience, this period should have
%> % been used to compute hazard curves)
%> Tstar = 0.75; % Example periods: 0.1 0.5 0.75
%>
%> % Create label for chosen T*
%> TstarStr = num2str(Tstar);
%> TstarStr = strrep(TstarStr,'.', '_'); % Replace period to avoid clash with Windows extensions
%>
%> % Specify output directory and filename
%> outputDir = '.\Output\' ;
%> outputFilename = ['CMSSgiven' compStr '_' TstarStr '.mat'];
%>
%> % Load ERF and GMPM data for disaggregation
%> PSHAdir = '..\PSHA\Output\' ;
%> load(fullfile(PSHAdir, 'OpenSHAout.mat'));
%> load(fullfile(PSHAdir, 'GMPMout.mat'));
```

The line `Tstar = 0.75;` is highlighted with a red rectangle.

# Get Composite Spectrum



# Get Composite Spectrum



Editor - C:\Users\simon\Desktop\ICOLD GMSM codes\Matlab\RetPer2475\getCompositeSpec\_givenAh.m

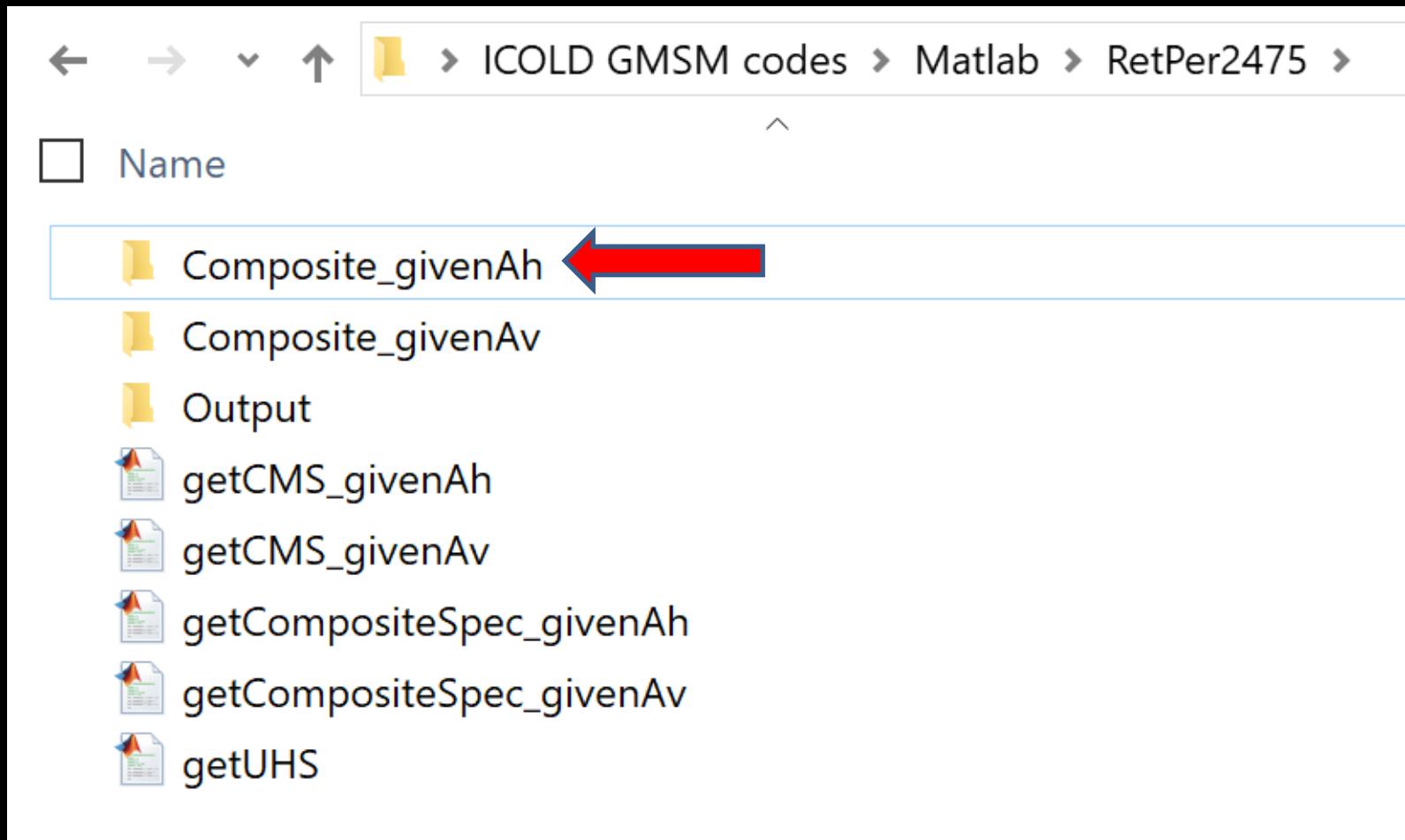
EDITOR PUBLISH VIEW

FILE NAVIGATE EDIT BREAKPOINTS RUN

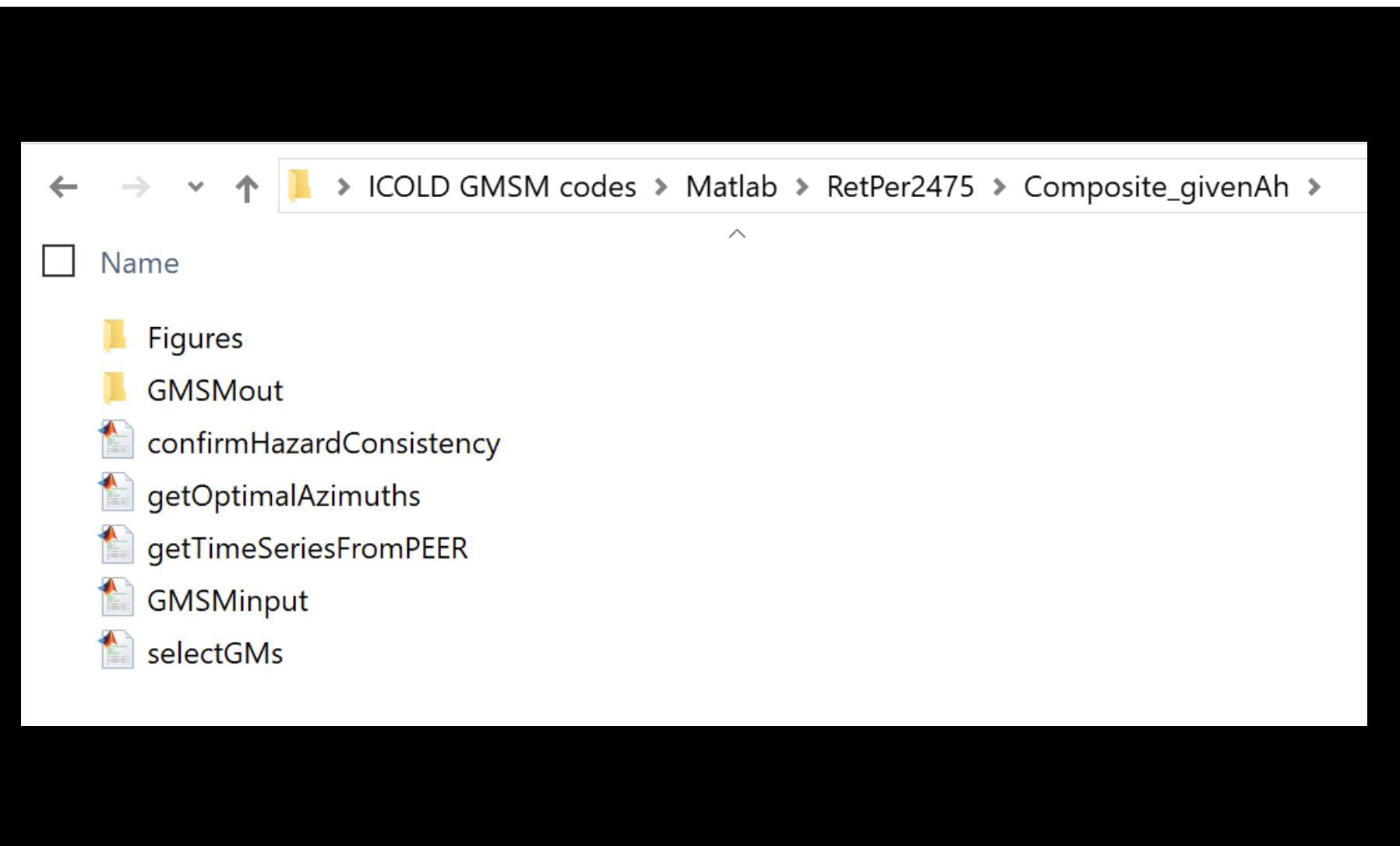
```
getCompositeSpec_givenAh.m x +
```

```
1 %% Get multicomponent Composite Spectrum given Ah at Tmin to Tmax
2 % Note: Ensure beforehand that CMSs have been determined for Tmin and Tmax
3 clear all; close all; clc;
4
5 %% Input
6 % Define component of GM for conditioning
7 compStr = 'Ah';
8
9 % Specify range of vibration periods
10 Tmin = 0.1; % Make sure CMS has been computed for this period
11 Tmax = 0.75; % Make sure CMS has been computed for this period
12
13 % Create label for chosen Tmin and Tmax
14 TminStr = num2str(Tmin);
15 TminStr = strrep(TminStr,'.', 'p'); % Replace period to avoid clash with Windows extensions
16 TmaxStr = num2str(Tmax);
17 TmaxStr = strrep(TmaxStr,'.', 'p'); % Replace period to avoid clash with Windows extensions
18
19 % Specify output directory and filename
20 outputDir = './Output\' ;
21 outputFilename = ['CompositeGiven' compStr '_' TminStr '_' TmaxStr '.mat'];
22
23 % Load ERF and GMPM data for disaggregation
24 PSHAdir = '../PSHA\Output\' ;
25 load(fullfile(PSHAdir, 'OpenSHAout.mat'));
26 load(fullfile(PSHAdir, 'GMPMout.mat'));
```

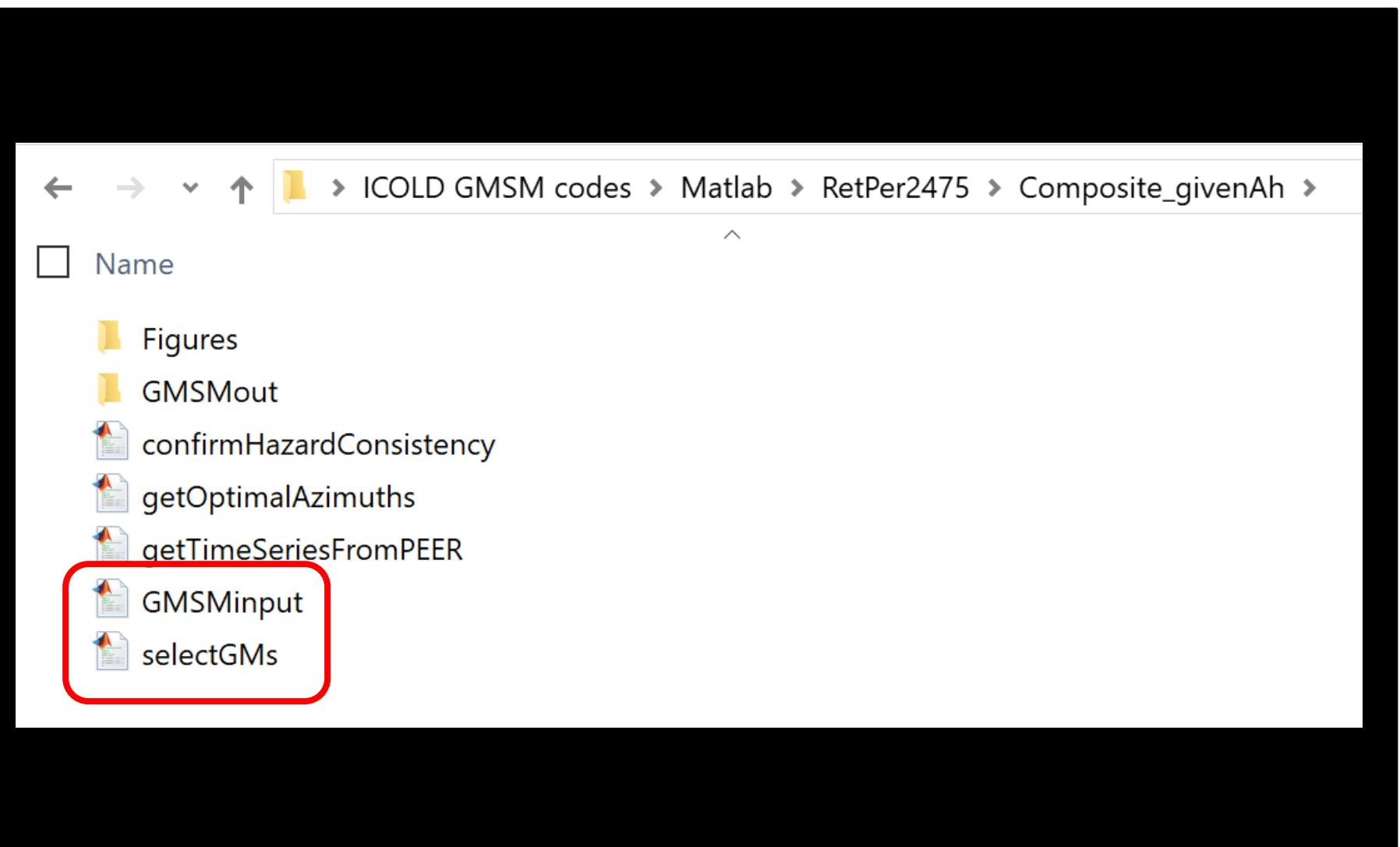
# Given target spectrum, select GMs



# Given target spectrum, select GMs



# Given target spectrum, select GMs

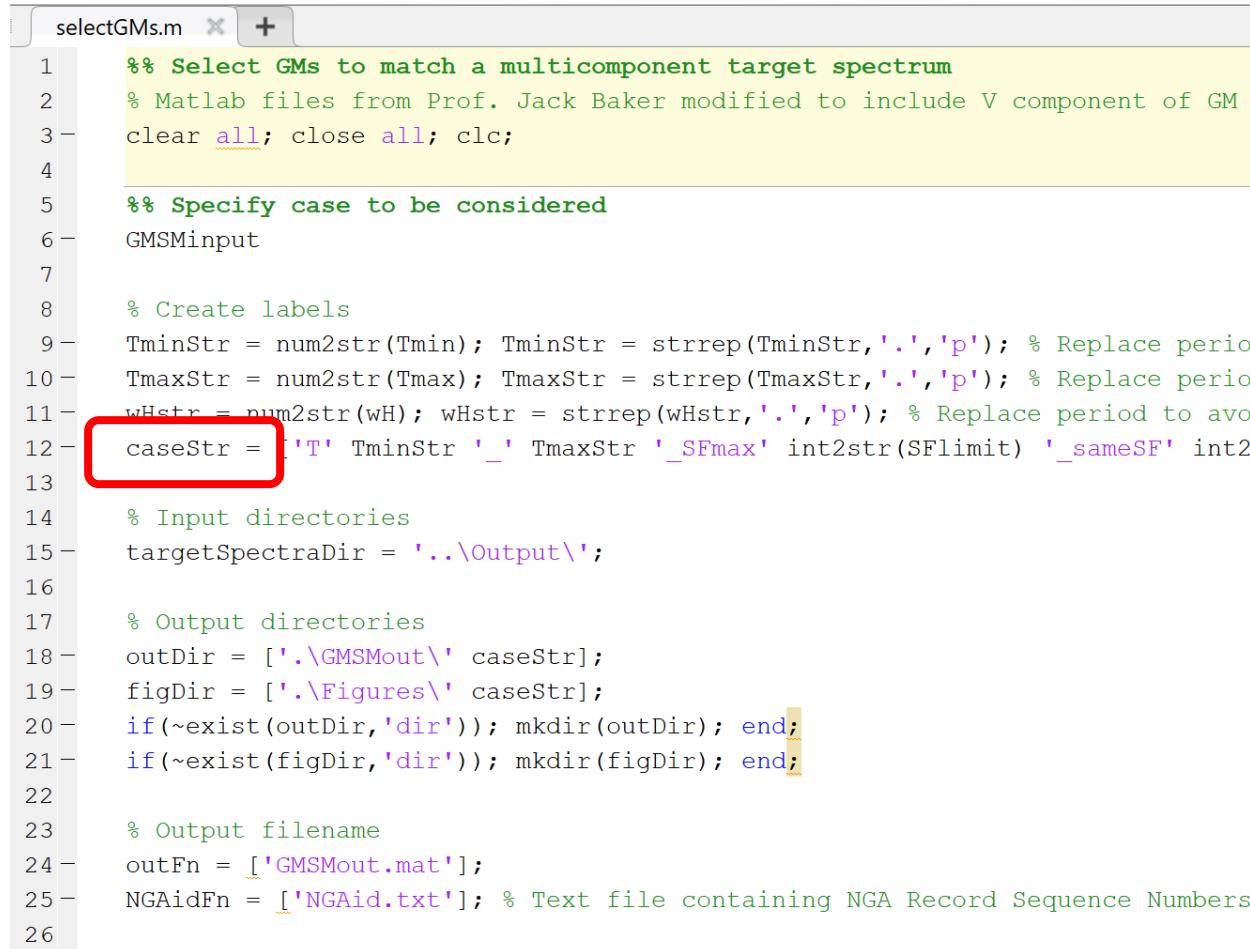


# Specify GMSM inputs

```
GMSMinput.m +
```

```
1 %% Specify inputs for using scripts under this "target spectrum" folder
2 % Target spectrum
3 tgtSpecStr = 'Composite';
4 compStr = 'Ah'; % Which component to condition upon
5 compForConditioning = 'H'; % Which component to condition upon
6
7 % Conditioning periods
8 Tmin = 0.1;
9 Tmax = 0.75;
10
11 % GMSM input
12 isScaledFlag = 1; % =1 scales GMs; otherwise, =0 and set SFlimit to unity
13 SFlimit = 4; % Limit scale factors (SFs) to within (1/SFlimit) to SFlimit
14 sameSFflag = 1; % =1 sets SF for V component to be same as SF for H compone
15 wH = 0.5; % Ranges from 0 (only V component) to 1 (only H component) when c
```

# Unique GMSM output folder



```
1 %% Select GMs to match a multicomponent target spectrum
2 % Matlab files from Prof. Jack Baker modified to include V component of GM
3 clear all; close all; clc;
4
5 %% Specify case to be considered
6 GMSMinput
7
8 % Create labels
9 TminStr = num2str(Tmin); TminStr = strrep(TminStr,'.', 'p'); % Replace period
10 TmaxStr = num2str(Tmax); TmaxStr = strrep(TmaxStr,'.', 'p'); % Replace period
11 wHstr = num2str(wH); wHstr = strrep(wHstr,'.', 'p'); % Replace period to avoid
12 caseStr = ['T' TminStr '_' TmaxStr '_SFmax' int2str(SFlimit) '_sameSF' int2
13
14 % Input directories
15 targetSpectraDir = '..\Output\';
16
17 % Output directories
18 outDir = ['.\GMSMout\' caseStr];
19 figDir = ['.\Figures\' caseStr];
20 if(~exist(outDir,'dir')); mkdir(outDir); end;
21 if(~exist(figDir,'dir')); mkdir(figDir); end;
22
23 % Output filename
24 outFn = ['GMSMout.mat'];
25 NGAidFn = ['NGAid.txt']; % Text file containing NGA Record Sequence Numbers
26
```

# Specify GMSELECT inputs

```
selectGMs.m +  
43  
44 %% Specify GMSELECT inputs  
45 % Ground motion database and type of selection  
46 - selectionParams.databaseDir = '..\..\Databases';  
47 - selectionParams.databaseFile = 'NGA_W2_meta_data';  
48 - selectionParams.DtD = 50; % Define H component of GM  
49 - selectionParams.nGM = 11; % number of ground motions to be sele  
50  
51 % Spectral periods of interest  
52 - selectionParams.cond = 1; % =1 to include T* into periods for selecti  
53 - selectionParams.Tcond = logspace(log10(Tmin),log10(Tmax),20); % Period  
54 - selectionParams.TgtPer = logspace(log10(0.01),log10(10),20); % Periods  
55  
56 % Parameters for scaling GMs  
57 - selectionParams.condComp = compForConditioning; % ='H' to scale GMs to ma  
58 - selectionParams.isScaled = isScaledFlag; % =1 scales GMs; otherwise, =0 a  
59 - selectionParams.maxScale = SFlimit; % Limit scale factors (SFs) to within  
60 - selectionParams.sameSF = sameSFflag; % =1 sets SF for V component to be  
61  
62 % Relative importance of H component of GM  
63 - selectionParams.wH = wH; % Ranges from 0 (only V component) to 1 (o  
64  
65 + %{ ... %}  
66 % Limits on metadata for filtering GM database  
67 - allowedRecs.Mag = [ 5 Inf]; % upper and lower bound of allowable ma  
68 - allowedRecs.Vs30 = [180 Inf]; % upper and lower bound of allowable Vs  
69 - allowedRecs.LUF = [ 0 0.1]; % upper and lower bound of allowable Lo  
70 - allowedRecs.D = [ 15 Inf]; % upper and lower bound of allowable di  
71 - allowedRecs.NGAinvalid = [4577:4839 6993:8055 9194]; % Exclude NGA Record S  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81
```

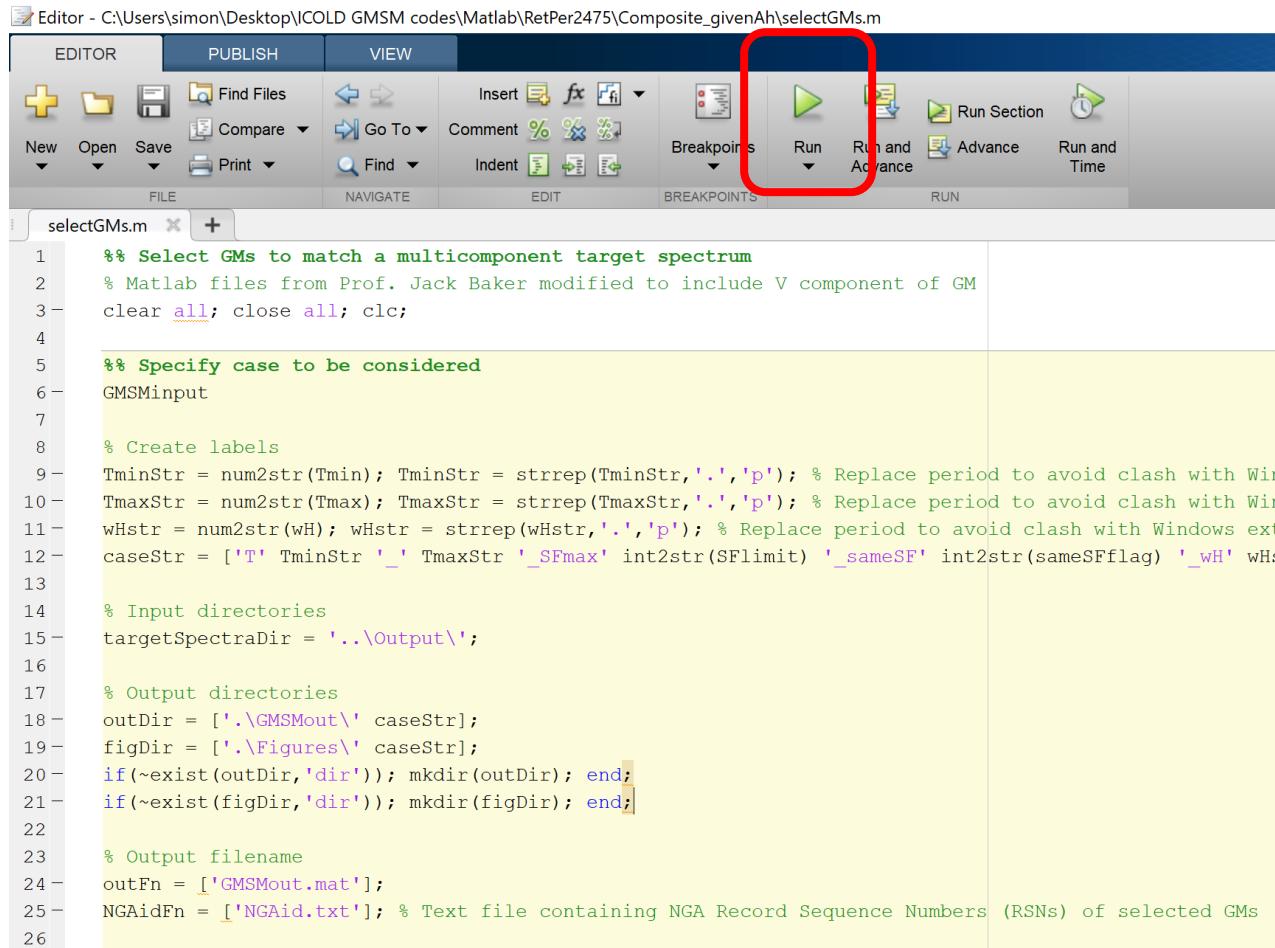
# Specify GMSELECT inputs

```
selectGMs.m +  
43  
44 %% Specify GMSELECT inputs  
45 % Ground motion database and type of selection  
46 - selectionParams.databaseDir = '..\..\Databases';  
47 - selectionParams.databaseFile = 'NGA_W2_meta_data';  
48 - selectionParams.RotD = 50; % Define H component of GM  
49 - selectionParams.nGM = 11; % number of ground motions to be sele  
50  
51 % Spectral periods of interest  
52 - selectionParams.cond = 1; % =1 to include T* into periods for selecti  
53 - selectionParams.Tgnd = logspace(log10(Tmin), log10(Tmax), 20); % Period  
54 - selectionParams.TgtPer = logspace(log10(0.01), log10(10), 20); % Periods  
55  
56 % Parameters for scaling GMs  
57 - selectionParams.condComp = compForConditioning; % ='H' to scale GMs to ma  
58 - selectionParams.isScaled = isScaledFlag; % =1 scales GMs; otherwise, =0 a  
59 - selectionParams.maxScale = SFlimit; % Limit scale factors (SFs) to within  
60 - selectionParams.sameSF = sameSFflag; % =1 sets SF for V component to be  
61  
62 % Relative importance of H component of GM  
63 - selectionParams.wH = wH; % Ranges from 0 (only V component) to 1 (o  
64  
65 + %{ ... %}  
66 % Limits on metadata for filtering GM database  
67 - allowedRecs.Mag = [ 5 Inf]; % upper and lower bound of allowable ma  
68 - allowedRecs.Vs30 = [180 Inf]; % upper and lower bound of allowable Vs  
69 - allowedRecs.LUF = [ 0 0.1]; % upper and lower bound of allowable Lo  
70 - allowedRecs.D = [ 15 Inf]; % upper and lower bound of allowable di  
71 - allowedRecs.NGAinvalid = [4577:4839 6993:8055 9194]; % Exclude NGA Record S  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81
```

# Specify GMSELECT inputs

```
selectGMs.m + 43  
44 %% Specify GMSELECT inputs  
45 % Ground motion database and type of selection  
46 - selectionParams.databaseDir      = '..\..\Databases';  
47 - selectionParams.databaseFile    = 'NGA_W2_meta_data';  
48 - selectionParams.RotD           = 50; % Define H component of GM  
49 - selectionParams.nGM            = 11; % number of ground motions to be sele  
50  
51 % Spectral periods of interest  
52 - selectionParams.cond          = 1; % =1 to include T* into periods for selecti  
53 - selectionParams.Tcond         = logspace(log10(Tmin),log10(Tmax),20); % Period  
54 - selectionParams.TgtPer        = logspace(log10(0.01),log10(10),20); % Periods  
55  
56 % Parameters for scaling GMs  
57 - selectionParams.condComp     = compForConditioning; % ='H' to scale GMs to ma  
58 - selectionParams.isScaled      = isScaledFlag; % =1 scales GMs; otherwise, =0 a  
59 - selectionParams.maxScale     = SFlimit; % Limit scale factors (SFs) to within  
60 - selectionParams.sameSF       = sameSFflag; % =1 sets SF for V component to be  
61  
62 % Relative importance of H component of GM  
63 - selectionParams.wH           = wH; % Ranges from 0 (only V component) to 1 (o  
64  
65 + %{ ... %}  
66 % Limits on metadata for filtering GM database  
67 allowedRecs.Mag   = [ 5 Inf];      % upper and lower bound of allowable ma  
68 allowedRecs.Vs30  = [180 Inf];     % upper and lower bound of allowable Vs  
69 allowedRecs.LUF   = [ 0 0.1];      % upper and lower bound of allowable Lo  
70 allowedRecs.D     = [ 15 Inf];      % upper and lower bound of allowable di  
71 allowedRecs.NGAinvalid = [4577:4839 6993:8055 9194]; %Exclude NGA Record S  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81
```

# Select GMs



The screenshot shows the MATLAB Editor interface with the following details:

- Toolbar:** The top menu bar includes "EDITOR", "PUBLISH", and "VIEW". Below it is a toolbar with various icons for file operations (New, Open, Save, Find Files, Compare, Go To, Print, Find, Insert, Comment, Indent), code navigation (Breakpoints, Run, Run and Advance, Run Section, Advance, Run and Time), and file management (FILE, NAVIGATE, EDIT, BREAKPOINTS, RUN).
- Code Area:** The main window displays a MATLAB script named "selectGMs.m". The code is as follows:

```
%> Select GMs to match a multicomponent target spectrum
% Matlab files from Prof. Jack Baker modified to include V component of GM
clear all; close all; clc;

%% Specify case to be considered
GMSMinput

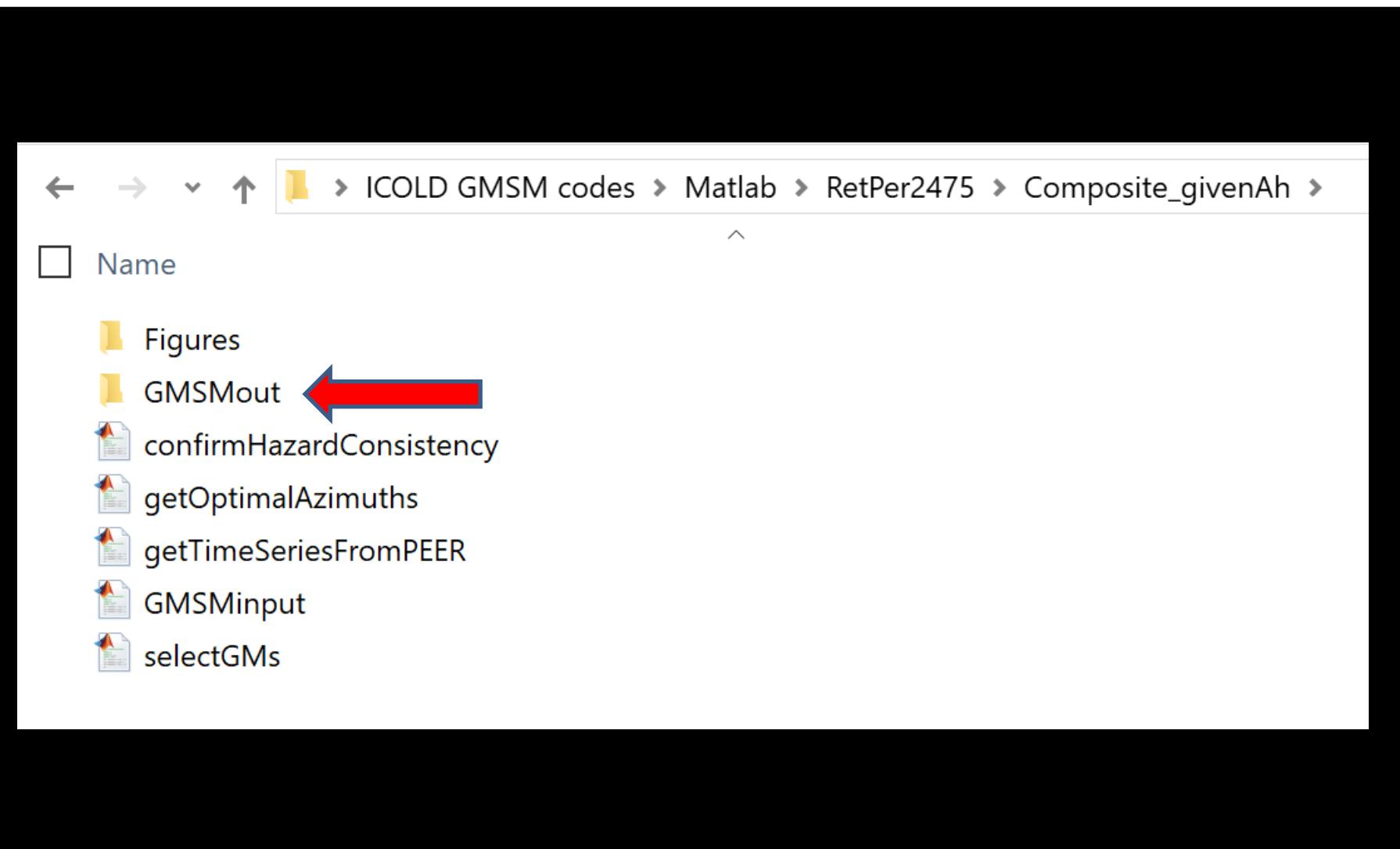
% Create labels
TminStr = num2str(Tmin); TminStr = strrep(TminStr,'.', 'p'); % Replace period to avoid clash with Windows
TmaxStr = num2str(Tmax); TmaxStr = strrep(TmaxStr,'.', 'p'); % Replace period to avoid clash with Windows
wHstr = num2str(wH); wHstr = strrep(wHstr,'.', 'p'); % Replace period to avoid clash with Windows exten
caseStr = ['T' TminStr '_' TmaxStr '_SFmax' int2str(SFLimit) '_sameSF' int2str(sameSFflag) '_wH' wHstr];

% Input directories
targetSpectraDir = '..\Output\';

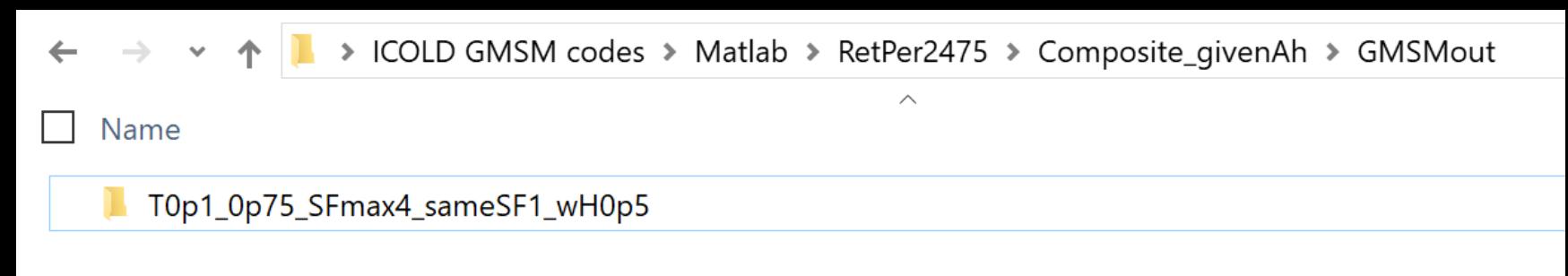
% Output directories
outDir = ['.\GMSMout\' caseStr];
figDir = ['.\Figures\' caseStr];
if(~exist(outDir,'dir')); mkdir(outDir); end;
if(~exist(figDir,'dir')); mkdir(figDir); end;

% Output filename
outFn = ['GMSMout.mat'];
NGAidFn = ['NGAid.txt']; % Text file containing NGA Record Sequence Numbers (RSNs) of selected GMs
```

# GMSM output



# GMSM output



# GMSM output

Name	Type
timeSeriesData	MATLAB Data
PEERNGARecords_Unscaled	Compressed (zipped)..
NGAid	TXT File
GMSMout_rotated	MATLAB Data
GMSMout	MATLAB Data
PEERNGARecords_Unscaled	File folder

# Get NGA RSNs for time series

	NGAid.txt
1	2623 ,
2	2981 ,
3	3000 ,
4	3002 ,
5	3188 ,
6	4153 ,
7	4212 ,
8	5292 ,
9	5652 ,
10	5672 ,
11	5811 ,
12	

# Get time series

The screenshot shows a web browser window with the URL [ngawest2.berkeley.edu](https://ngawest2.berkeley.edu). A red box highlights the address bar. The page content includes a note about download restrictions, information about the NGA-West2 database, and details about the NGA-East database. To the right, there are two cartoon illustrations of databases: one blue cylinder labeled "NGA West2 Center" and one grey cylinder labeled "NGA East Center", both with cloud-like shapes around them.

PEER Ground Motion Database - [X](#) +

[ngawest2.berkeley.edu](#)

Please note that, due to copyright issues, a strict limit has been imposed on the number of records that can be downloaded within a unique time window. The current limit is set at approximately 200 records every two weeks, 400 every month. Abusive downloads will result in further restrictions.

The database and web site are periodically updated and expanded. Comments on the features of this web site are gratefully welcome; please send emails to: [peer\\_center@berkeley.edu](mailto:peer_center@berkeley.edu)

**NGA-West2 -- Shallow Crustal Earthquakes in Active Tectonic Regimes**

The NGA-West2 ground motion database includes a very large set of ground motions recorded in worldwide shallow crustal earthquakes in active tectonic regimes. The database has one of the most comprehensive sets of meta-data, including different distance measure, various site characterizations, earthquake source data, etc. The current version of the database is similar to the NGA-West2 database, which was used to develop the 2014 NGA-West2 ground motion models (GMMs). [peer.berkeley.edu/ngawest2](http://peer.berkeley.edu/ngawest2)

**NGA-East -- Central & Eastern North-America**

The objective of NGA-East is to develop a new ground motion characterization (GMC) model for the Central and Eastern North-American (CENA) region. The GMC model consists in a set of new ground motion models (GMMs) for median and standard deviation of ground motions (GMs) and their associated weights in the logic-trees for use in probabilistic seismic hazard analyses (PSHA). [peer.berkeley.edu/ngaeast](http://peer.berkeley.edu/ngaeast)

# Get time series

The screenshot shows a web browser window for the PEER Ground Motion Database NGA-West2. The URL in the address bar is `ngawest2.berkeley.edu/spectras/new?sourceDb_flag=1`. The page title is "PEER Ground Motion Database NGA-West2 Pacific Earthquake Engineering Research Center". The navigation menu includes links for HOME, DOCUMENTATION, HELP, SUBSCRIBE, and PEER. A user's email address, NEALSIMONKWONG@BERKELEY.EDU, is displayed next to a SIGN\_OUT link. A red box highlights a success message: "Signed in successfully." Below this, the "Target Spectrum" section has a blue header "Select Spectrum Model". A dropdown menu is open, showing the option "No Scaling" with a red border around it. To the right of the dropdown are three links: "Show/Hide GMM Notation", "Show/Hide GMM Regions", and "Show/Hide GMM Figures". At the bottom left is a "Submit" button.

# Provide NGA RSNs

PEER Ground Motion Database - X +

ngawest2.berkeley.edu/spectras/230301/searches/new

Load Sample Input Values | Clear Input Values

**Search**

These characteristics are defined in the NGA-West2 Flatfile. You need to re-run Search when any of these parameters are updated.

**Record Characteristics:**

RSN(s) : 2623 , 2981 , 3000 (RSN1..RSNn)

Event Name :

Station Name :

**Suite**

Spectral Ordinate : SRSS ▾

Damping Ratio : 5% ▾

Suite Average : Arithmetic ▾

**Search Parameters:**

Fault Type : All Types ▾

Magnitude :  min,max

R\_JB(km) :  min,max

R\_rup(km) :  min,max

Vs30(m/s) :  min,max

D5-95(sec) :  min,max

Pulse : Any Record ▾

**Additional Characteristics:**

Max No. Records :  (<=100)

**Controls**

**Search Records**

325 Davis Hall, University of California, Berkeley, CA 94720-1792 - Phone: (510) 642-3437 | Fax: (510) 642-1655 | Email: peer\_center@berkeley.edu

The screenshot shows the 'ngawest2.berkeley.edu/spectras/230301/searches/new' search interface. The 'Record Characteristics' section has 'RSN(s)' set to '2623 , 2981 , 3000 (RSN1..RSNn)', which is highlighted with a red box. The 'Suite' section shows 'Spectral Ordinate' as 'SRSS', 'Damping Ratio' as '5%', and 'Suite Average' as 'Arithmetic'. The 'Search Parameters' section includes dropdowns for Fault Type ('All Types'), Magnitude, R\_JB(km), R\_rup(km), Vs30(m/s), D5-95(sec), and Pulse ('Any Record'). The 'Additional Characteristics' section has 'Max No. Records' set to '<=100'. At the bottom, there are 'Controls' and a large red 'Search Records' button. The footer provides contact information for the PEER Center at UC Berkeley.

# Get time series

PEER Ground Motion Database - X +

ngawest2.berkeley.edu/spectras/230301/searches/new

Load Sample Input Values | Clear Input Values

**Search**

These characteristics are defined in the NGA-West2 Flatfile. You need to re-run Search when any of these parameters are updated.

**Record Characteristics:**

RSN(s) : 2623 , 2981 , 3000 RSN1..RSNn

Event Name :

Station Name :

**Search Parameters:**

Fault Type : All Types

Magnitude :  min,max

R\_JB(km) :  min,max

R\_rup(km) :  min,max

Vs30(m/s) :  min,max

D5-95(sec) :  min,max

Pulse : Any Record

**Suite**

Spectral Ordinate : SRSS

Damping Ratio : 5%

Suite Average : Arithmetic

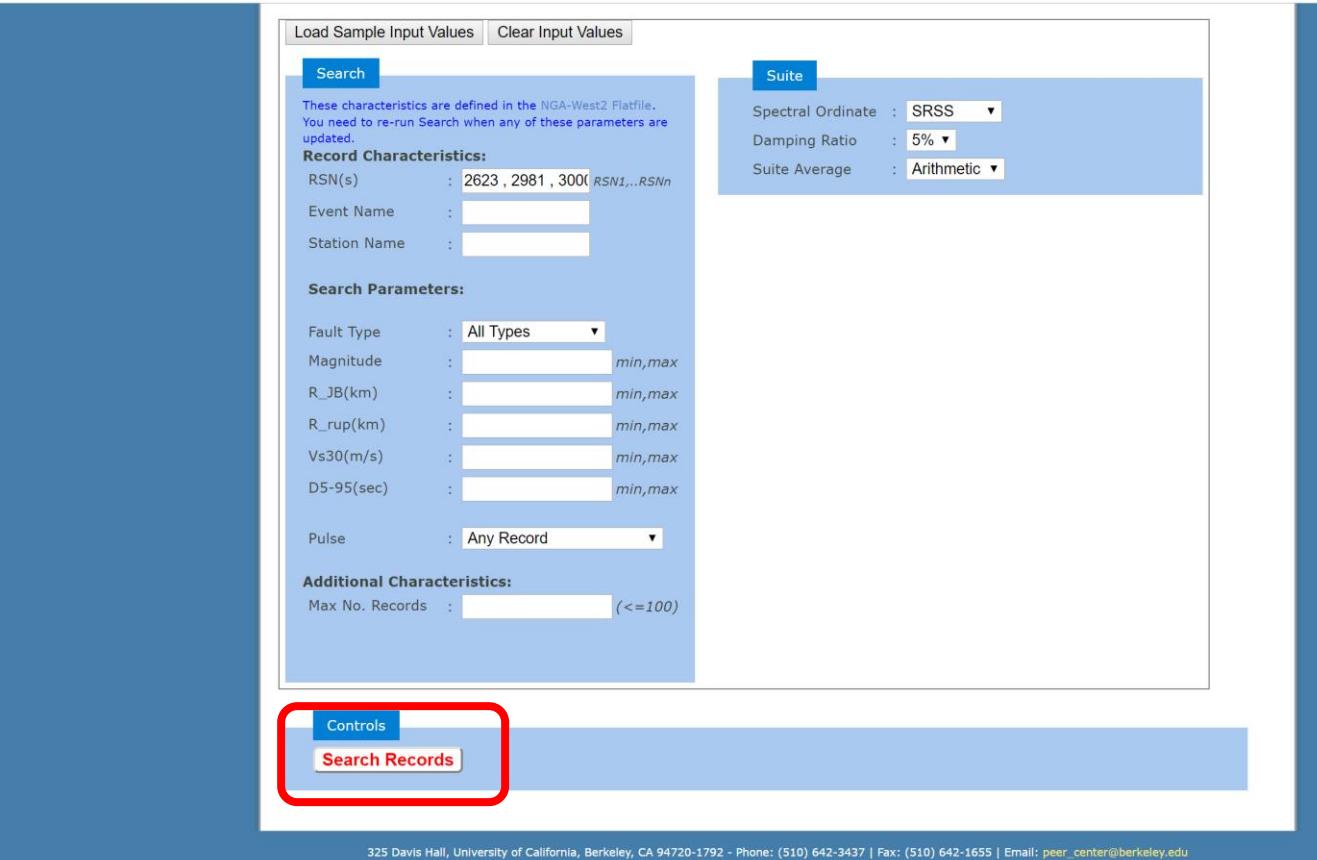
**Additional Characteristics:**

Max No. Records :  (<=100)

**Controls**

**Search Records**

325 Davis Hall, University of California, Berkeley, CA 94720-1792 - Phone: (510) 642-3437 | Fax: (510) 642-1655 | Email: peer\_center@berkeley.edu



# Get time series

PEER Ground Motion Database - x +

ngawest2.berkeley.edu/spectras/230301/searches/212186/edit

<input type="button" value="view"/>	9	SRSS	5652	-	1.0	-	9.4	33.1	1.2	Iwate, Japan	2008	IWTH20	6.9	Reverse
<input type="checkbox"/>	10	SRSS	5672	-	1.0	-	6.5	14.7	0.7	Iwate, Japan	2008	MYG013	6.9	Reverse
<input type="checkbox"/>	11	SRSS	5811	-	1.0	-	6.8	14.0	0.3	Iwate, Japan	2008	Shinchicho Yacigoya	6.9	Reverse

Download Options

Show/Hide Map

Google

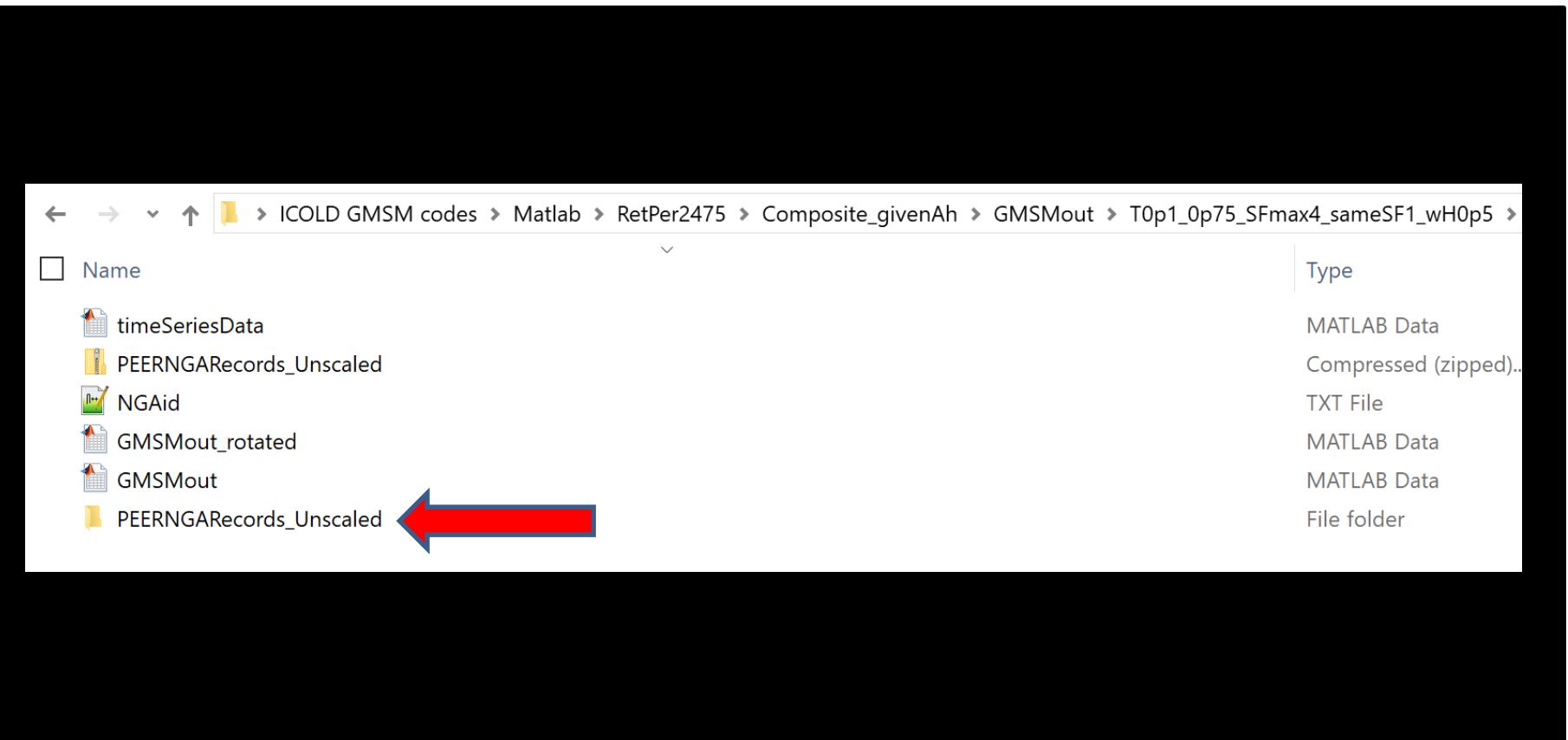
This page can't load Google Maps correctly.

Do you own this website?

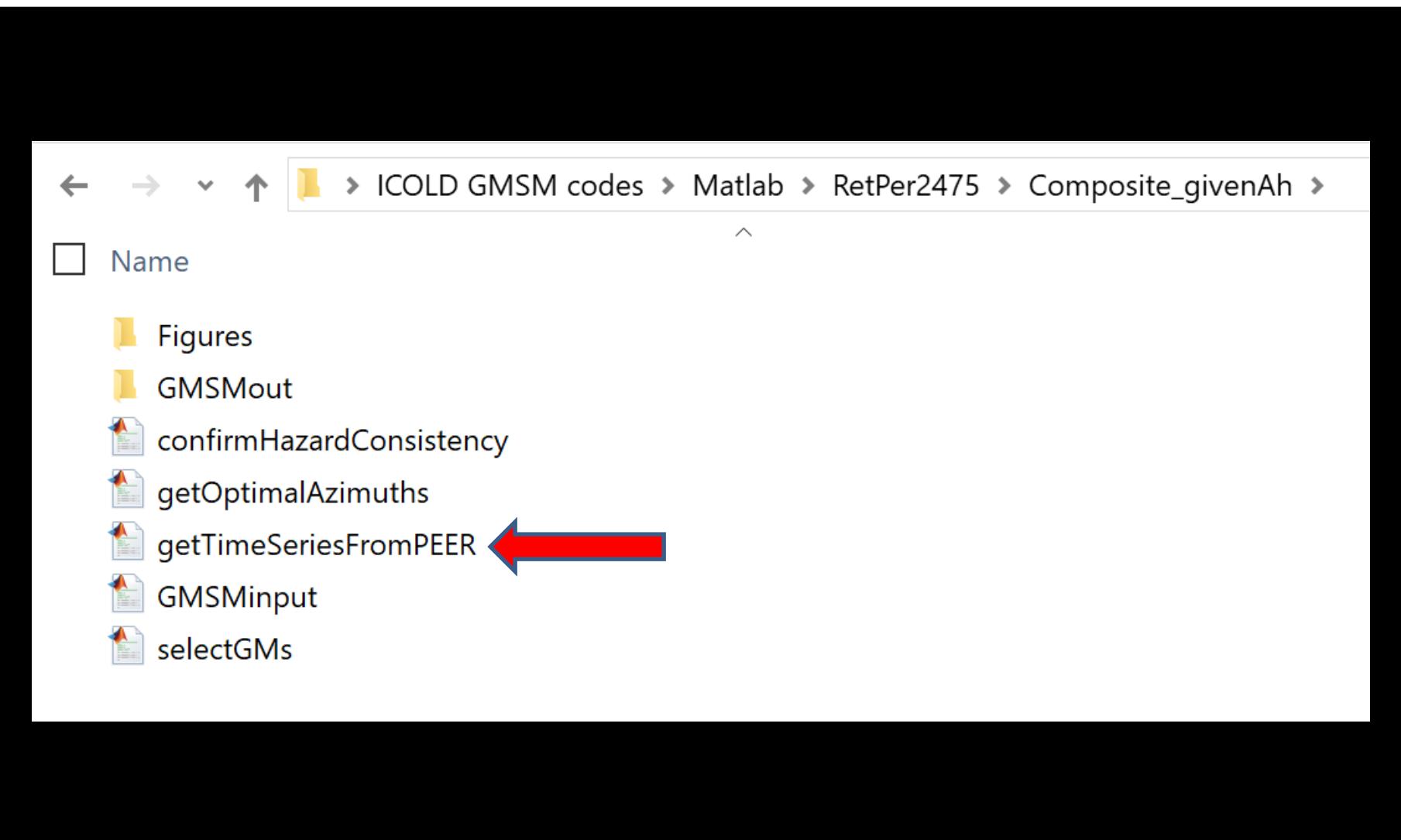
# Get time series



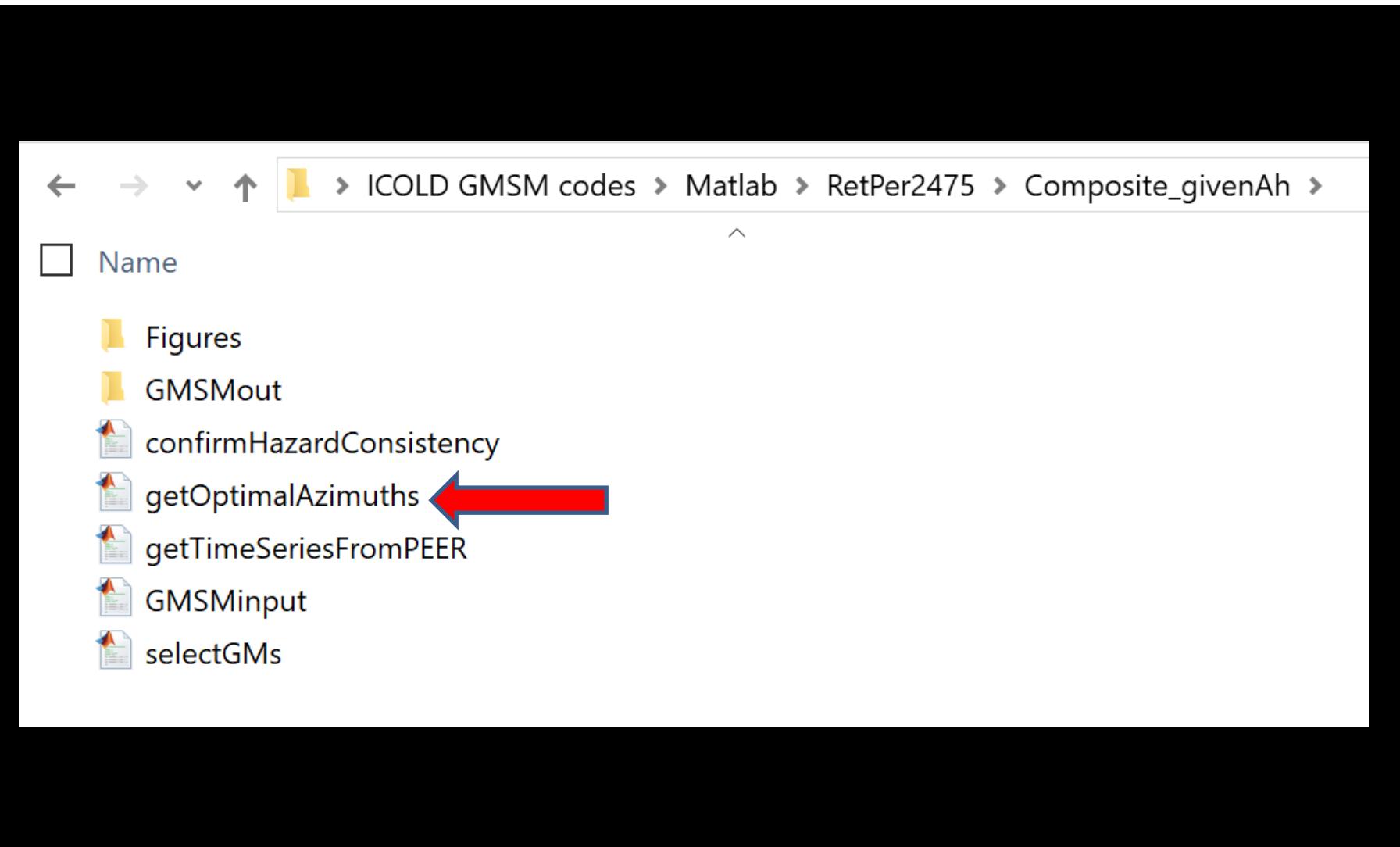
# Unzip folder for time series



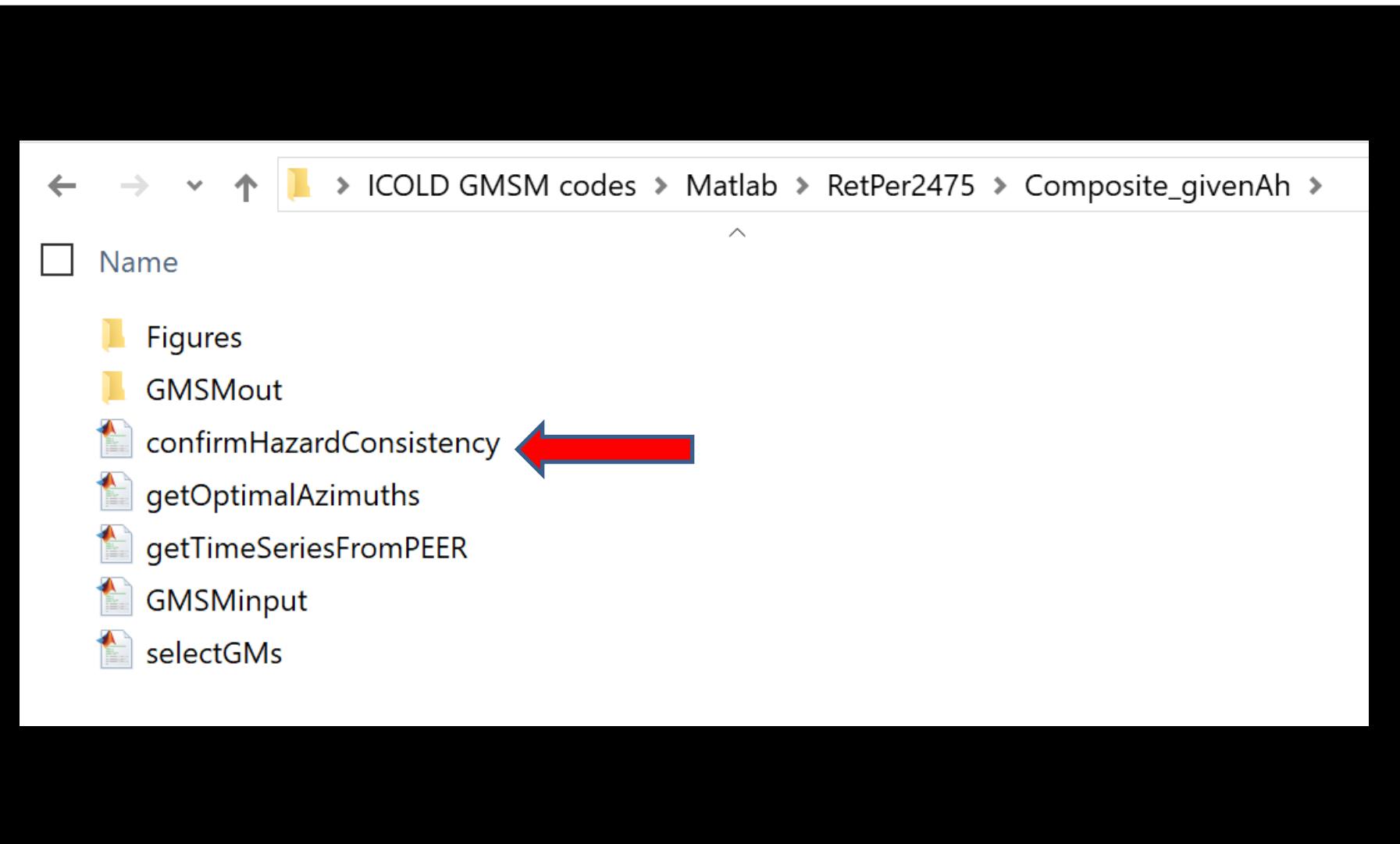
# Extract time series data



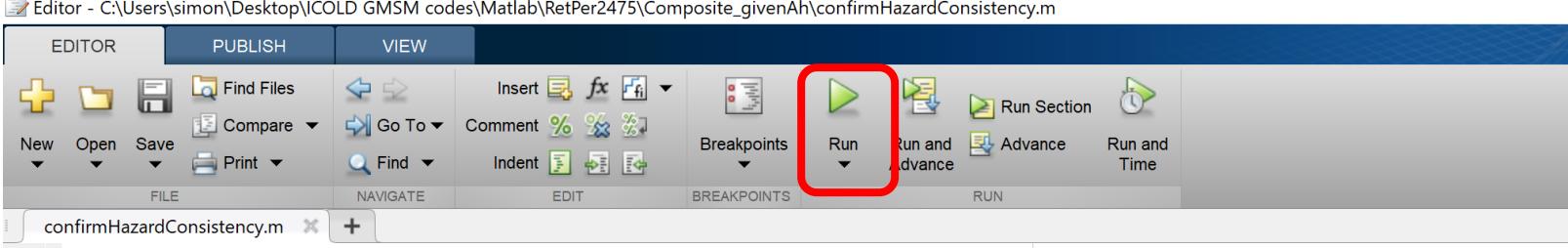
# Get optimal azimuths



# Confirm hazard consistency



# Confirm hazard consistency

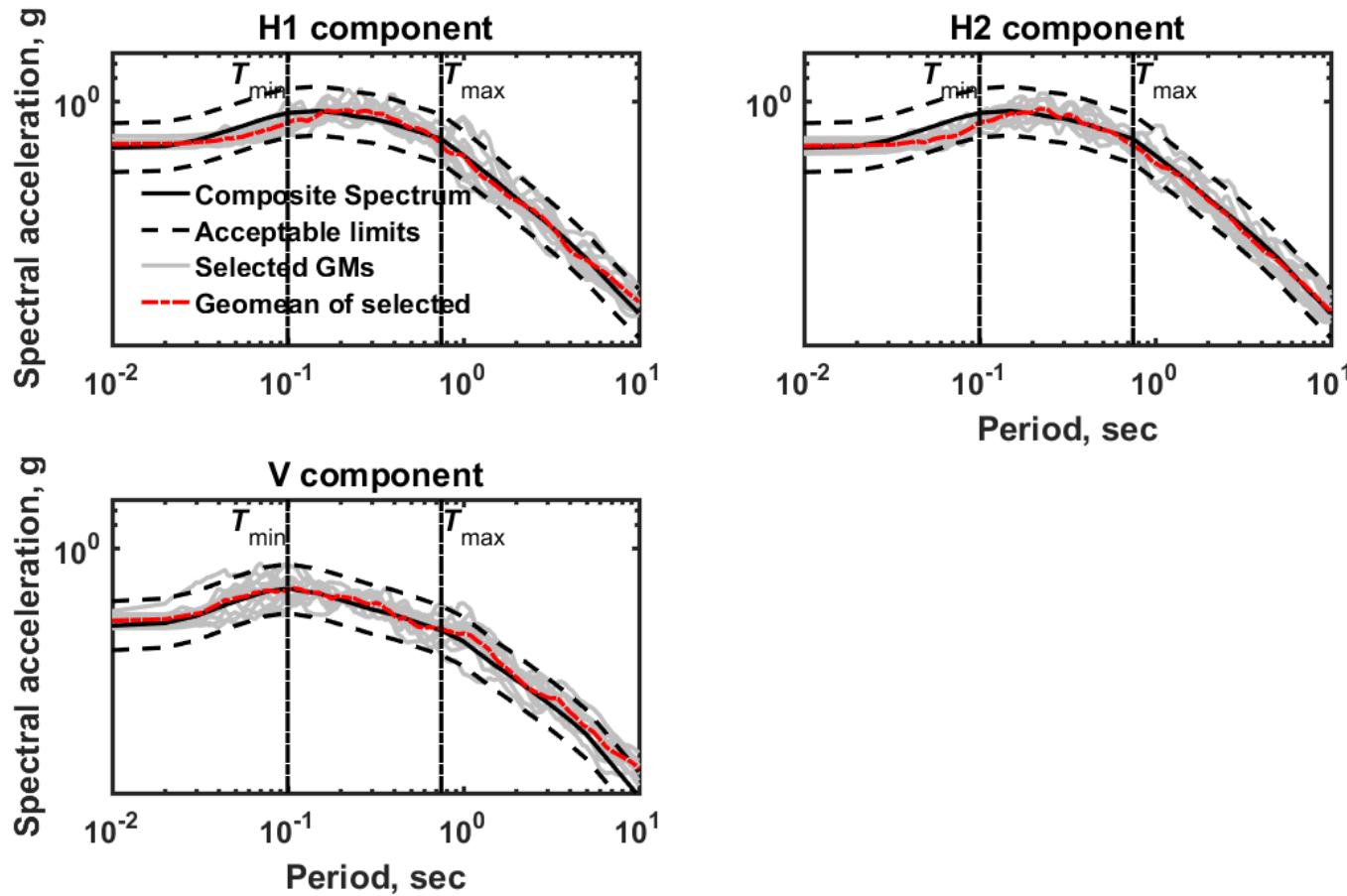


The screenshot shows the MATLAB Editor interface with the following details:

- Toolbar:** The toolbar includes buttons for New, Open, Save, Find Files, Compare, Print, Insert, Comment, Breakpoints, Run (highlighted with a red box), Run and Advance, Advance, and Run and Time.
- Editor Area:** The code editor displays a script named "confirmHazardConsistency.m".
- Code Content:**

```
1 % Confirm hazard consistency of selected GMs for all three components of GM
2 clear all; close all; clc;
3
4 %% Define case to be considered
5 GMSMinput
6
7 % Create labels
8 TminStr = num2str(Tmin); TminStr = strrep(TminStr,'.',','p'); % Replace period to avoid clash with Windows extensions
9 TmaxStr = num2str(Tmax); TmaxStr = strrep(TmaxStr,'.',','p'); % Replace period to avoid clash with Windows extensions
10 wHStr = num2str(wH); wHStr = strrep(wHStr,'.',','p'); % Replace period to avoid clash with Windows extensions
11 caseStr = ['T' TminStr '_' TmaxStr '_SFmax' int2str(SFlimit) '_sameSF' int2str(sameSFflag) '_wH' wHStr];
12
13 %% Input
14 % Input directories and filenames
15 targetSpectraDir = '..\Output\' ;
16 targetSpectraMatFn = ['CompositeGiven' compStr '_' TminStr '_' TmaxStr '.mat'];
17 GMSMoutDir = ['.\GMSMout\' caseStr];
18 GMSMoutMatFn = 'GMSMout.mat';
19 timeSeriesOutMatFn = 'timeSeriesData.mat';
20 rotatedTimeSeriesMatFn = 'GMSMout_rotated.mat';
21
22 % Output directory
23 figDir = ['.\Figures\' caseStr];
```

# Example hazard consistency



# Final GMSM output

```
177
178 %% Summarize GMSM
179 GMSMtable = [NGAselected sfSelected sfSelected_vert thetaOpt_all];
180 open GMSMtable
```

# Final GMSM output

Variables - GMSMtable

PLOTS VARIABLE VIEW

New from Selection + Open Print Rows 1 Columns 1 Insert Delete Sort Transpose

VARIABLE SELECTION EDIT

GMSMtable

11x4 double

	1	2	3	4	5	6
1	2623	2.0465	2.0465	18		
2	2981	3.5424	3.5424	16		
3	3000	3.4822	3.4822	60		
4	3002	3.6831	3.6831	77		
5	3188	2.5850	2.5850	23		
6	4153	2.1781	2.1781	15		
7	4212	0.9267	0.9267	7		
8	5292	3.6836	3.6836	28		
9	5652	1.0741	1.0741	2		
10	5672	1.2480	1.2480	49		
11	5811	1.9691	1.9691	90		
12						
13						