PSHA Workshop

Future directions for probabilistic seismic hazard assessment
at a local, national and transnational scale
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Site characterization, site effects and site amplification: Implication to the ongoing revision of EC8 Part1

Kyriazis Pitilakis
Aristotle University
Greece

Website: http://users.auth.gr/~kpitilak/
http://sdgee.civil.auth.gr

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  and design response spectra

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Soil and site classification in EC8

Ground type	Description of stratigraphic profile	Parameters		
		$V_{s,30}$ (m/s)	N_{SPT}	*Su* (kPa)
A	Rock or other rock-like geological formation, including at most 5 m of weaker material at the surface.	>800	-	-
B	Deposits of very dense sand, gravel, or very stiff clay, at least several tens of meters in thickness, characterized by a gradual increase of mechanical properties with depth.	360-800	>50	>250
C	Deep deposits of dense or medium-dense sand, gravel or stiff clay with thickness from several tens to many hundreds of meters.	180-360	15-50	70-250
D	Deposits of loose-to-medium cohesionless soil (with or without some soft cohesive layers), or of predominantly soft-to-firm cohesive soil.	<180	<15	<70
E	A soil profile consisting of a surface alluvium layer with Vs values of type C or D and thickness varying between about 5 m and 20 m, underlain by stiffer material with Vs>800 m/s.			
S1	Deposits consisting, or containing a layer at least 10 m thick, of soft clays/silts with a high plasticity index (PI>40) and high water content.	<100 (indicative)	-	10-20
S2	Deposits of liquefiable soils, of sensitive clays, or any other soil profile not included in types A – E or S1.			

Soil and site classification in EC8

The main classification parameter is Vs,30, which is the time-based average shear wave velocity of the top 30m.
The use of Vs,30 as a unique parameters for SC is long debated and disputed. However the co-existence of other geotechnical parameters is act as a good counterbalance.

Based on Vs30, five main soil types A, B, C, D and E, and 2 special categories S1 and S2 are defined.

Unfortunately there are some recent ideas presented in Europe removing N-SPT and Su or other geotechnical parameters from the site classification, keeping only Vs (practically Vs,30) and an ambiguous evaluation of the depth to the seismic bedrock H800.

Is $V_{s,30}$ appropriate for site – soil classification?

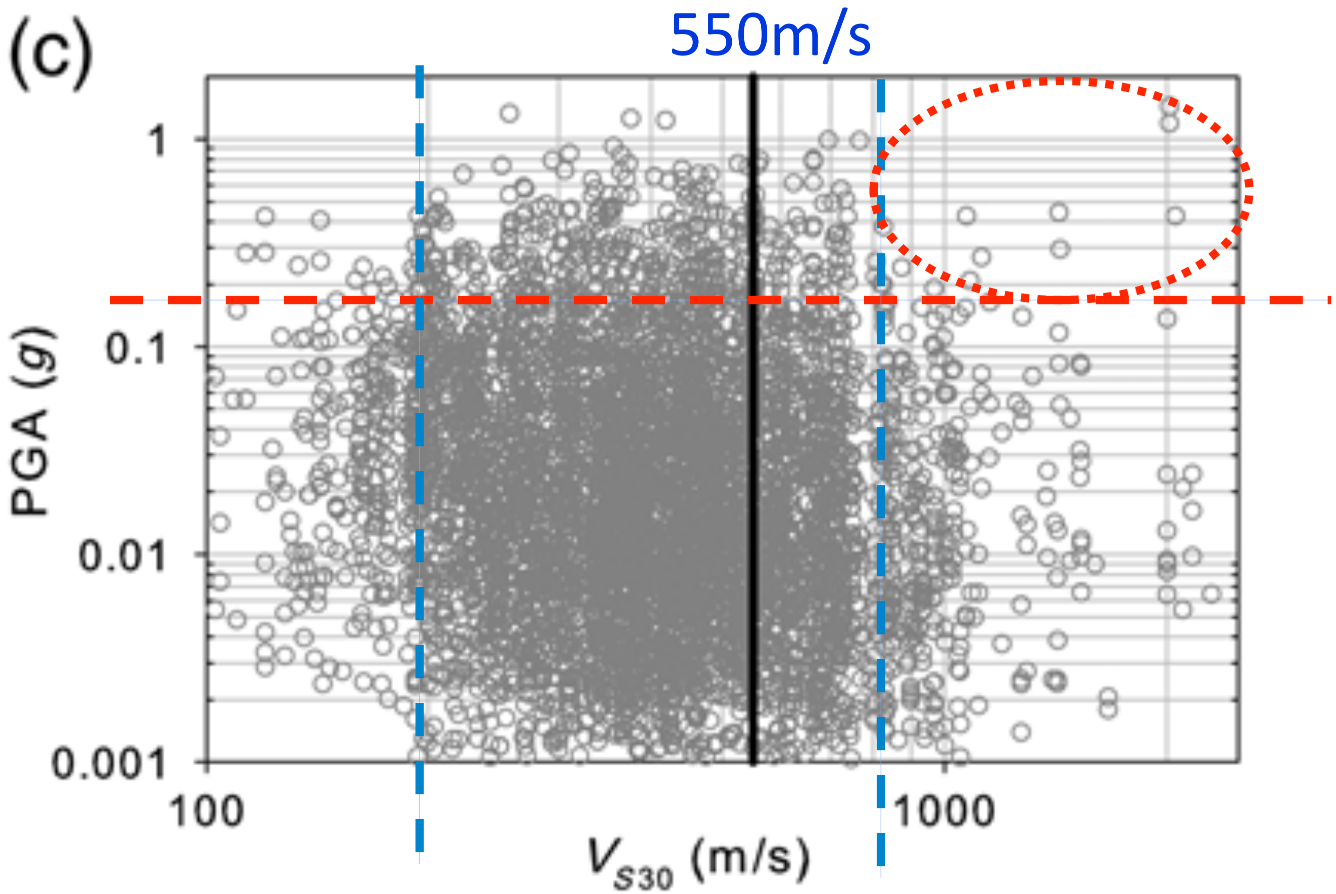
Yes, under certain conditions. For example very shallow and very deep, rather soft soil profiles or soil profiles having an inversed rigidity should be excluded of the use of $V_{s,30}$

Soil and site classification should be based on a appropriate geotechnical – geological description including the depth to the seismic bedrock (Vs>800m/s) and several geotechnical parameters like SPT, CPT, Su, PI, Dr(%). Removing geotechnical description for the EC8 main part of the site classification is a serious shortcoming.

In any case a very useful parameter to describe the site amplification particularly in low to medium seismic intensities (nearly linear elastic range of ground response) is the fundamental period To of the site

Vs Measurements: (Methods-data?)

Poor and loose data distribution for hard-rock conditions and PGA>0.20g
The bulk of the data are within 200 m/s $\leq V_{S30} \leq$ 700 m/s and PGA<0.20g



A Sandıkkaya,*S.Akkar, & P-Y Bard, 2013, "A Nonlinear Site-Amplification Model for the Next Pan-European Ground-Motion Prediction Equations"

Amplification factors and elastic response spectra in EC8

Type 1 Spectrum - $M_S>5.5$

Ground Type	S	$T_B (s)$	$T_C (s)$	$T_D (s)$
A	1.00	0.15	0.40	2.00
B	1.20	0.15	0.50	2.00
C	1.15	0.20	0.60	2.00
D	1.35	0.20	0.80	2.00
E	1.40	0.15	0.50	2.00
Type 2 Spectrum - $M_S\leq5.5$				
Ground Type	S	$T_B (s)$	$T_C (s)$	$T_D (s)$
A	1.00	0.05	0.25	1.20
B	1.35	0.05	0.25	1.20
C	1.50	0.10	0.25	1.20
D	1.80	0.10	0.30	1.20
E	1.60	0.05	0.25	1.20

Needs for revision

- Site classification and amplification factors are based on very few data (available almost 20-25 years ago!) and should be at least upgraded and adapted to the acquired numerous new data, rich scientific knowledge and the exponential increase of available strong motion records in Europe and worldwide.

- Instead of having two seismicity regions i.e. Mw<5.5 and M>5.5 is probably better to propose amplification factors for increasing ground motion intensity for example PGA steps of 0.1g as in NEHERP

- Instead of anchoring the design response spectra to PGA (T=0sec) should be better to anchor to two spectral parameters Ss at 0.1-0.2sec and S1 at 1.0sec

Past work in SHARE

Validation of the present amplification factors in EC8

&

New site-soil classification scheme, amplification factors and design response spectra

keeping the present seismicity categorization (Type 1 and 2)

Related publications

- **Pitilakis K., Riga E., Anastasiadis A., 2013**, "New code site classification, amplification factors and normalized response spectra based on a worldwide ground-motion database", Bulletin of Earthquake Engineering, 11, 4, 925-966, DOI: 10.1007/s10518-013-9440-9.
- **Pitilakis K., Riga E., Anastasiadis A., 2012**, "Design spectra and amplification factors for Eurocode 8", Bulletin of Earthquake Engineering, 10, 5, 1377-1400, DOI: 10.1007/s10518-012-9367-6.

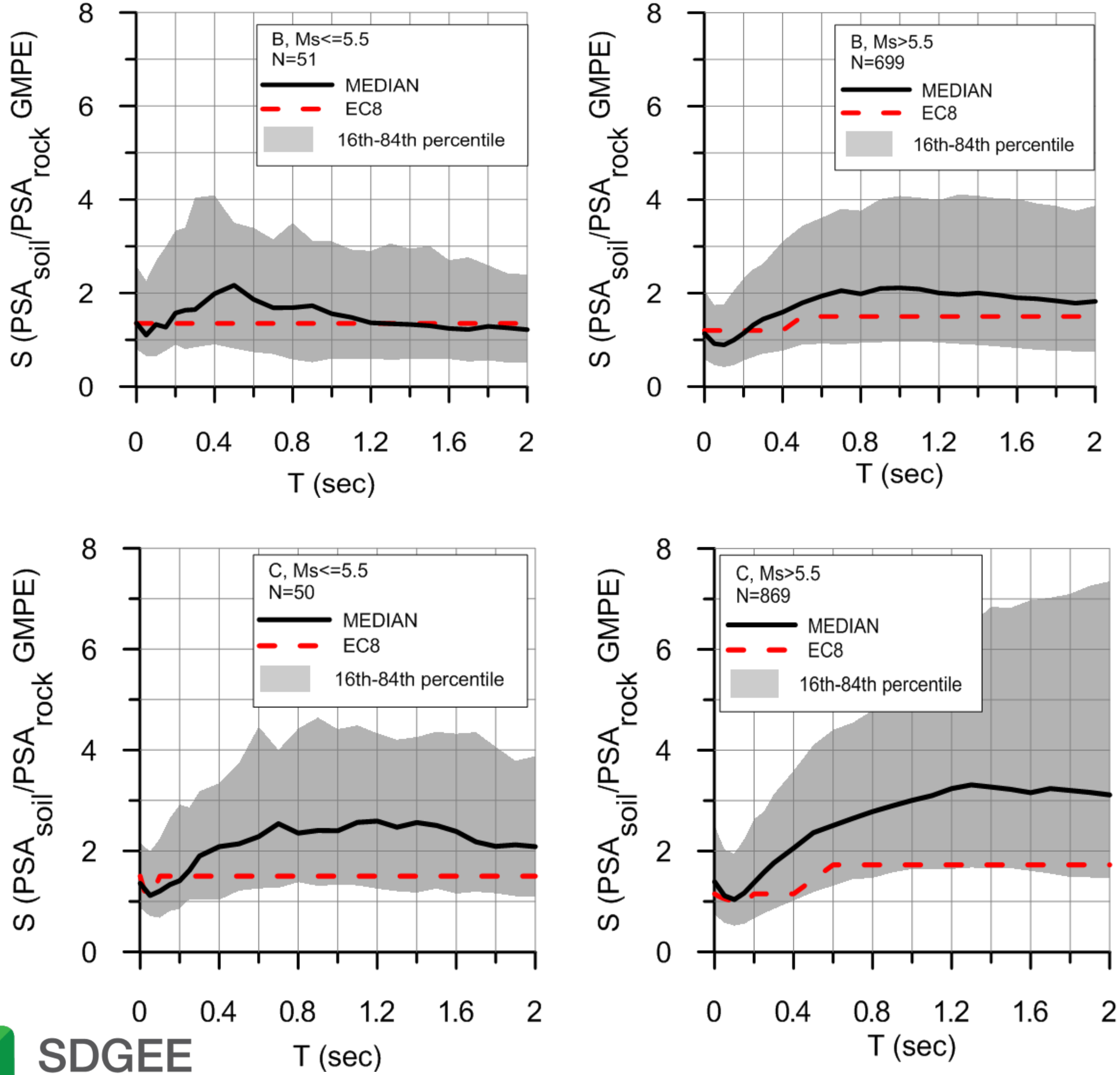
Data selection

- Proposal of a new soil-site classification scheme, amplification factors and design spectra:

  - SHARE-AUTH database (Pitilakis et al., 2013)
  - 3,666 records from 536 stations from Greece, Italy, Turkey, Japan and USA with a **well-documented soil profile** to the 'seismic' bedrock (V_s>800m/s)
  - For all sites: $H_{bedrock}$, $V_{s,average}$, $V_{s,30}$, T_0
  - Dataset: $M_s \geq 4$, $T_{usable} \geq 2.5$ sec and PGA ≥ 20 cm/s^2

Improved Soil Factors for EC8 soil classification

Approach 1 (Choi & Stewart, 2005)



$$S_{ij}(T) = GM_{ij}/(GM_r)_{ij}$$

$$(GM_r)_{ij}(T) = 0.35\cdot(GM_r)_{ij,AB} + 0.35\cdot(GM_r)_{ij,CF} + 0.10\cdot(GM_r)_{ij,Zh} + 0.20\cdot(GM_r)_{ij,CY}$$

Main problem:
Results depend on the reliability of **the GMPEs for rock**

Pitilakis et al. (2012)

New site – soil classification scheme

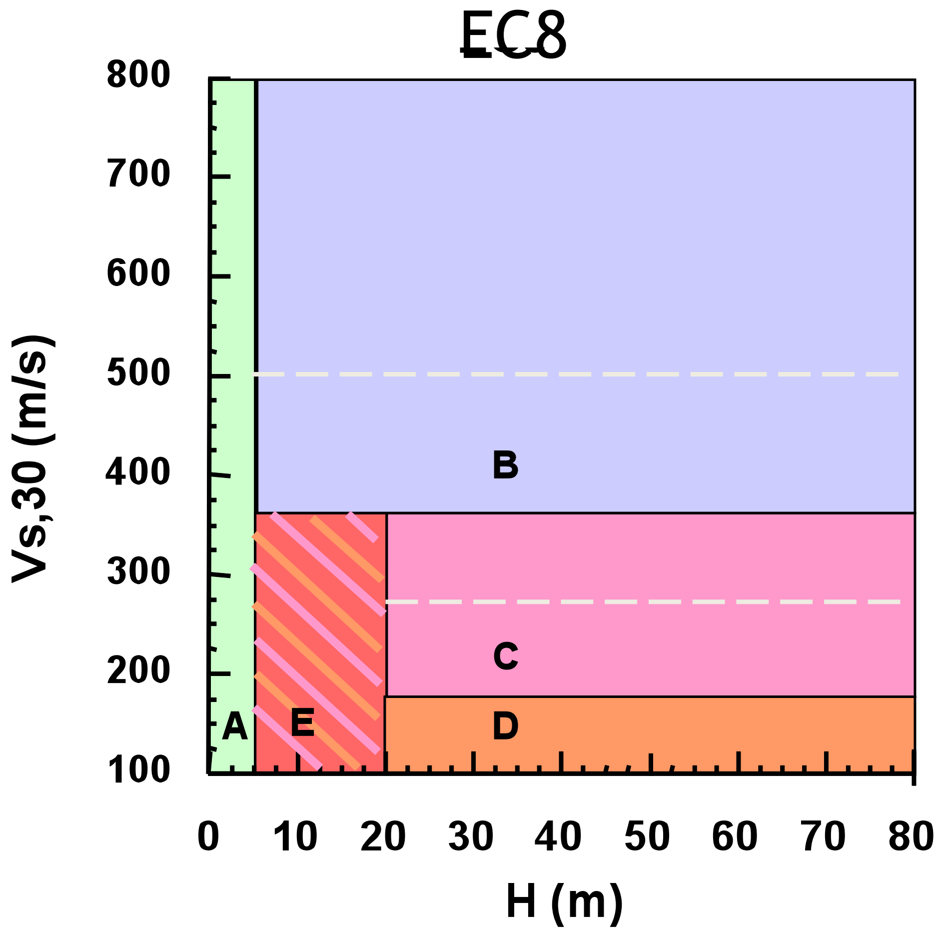
- Exclusively based on experimental data from the SHARE –AUTH database (Pitilakis et al., 2013)

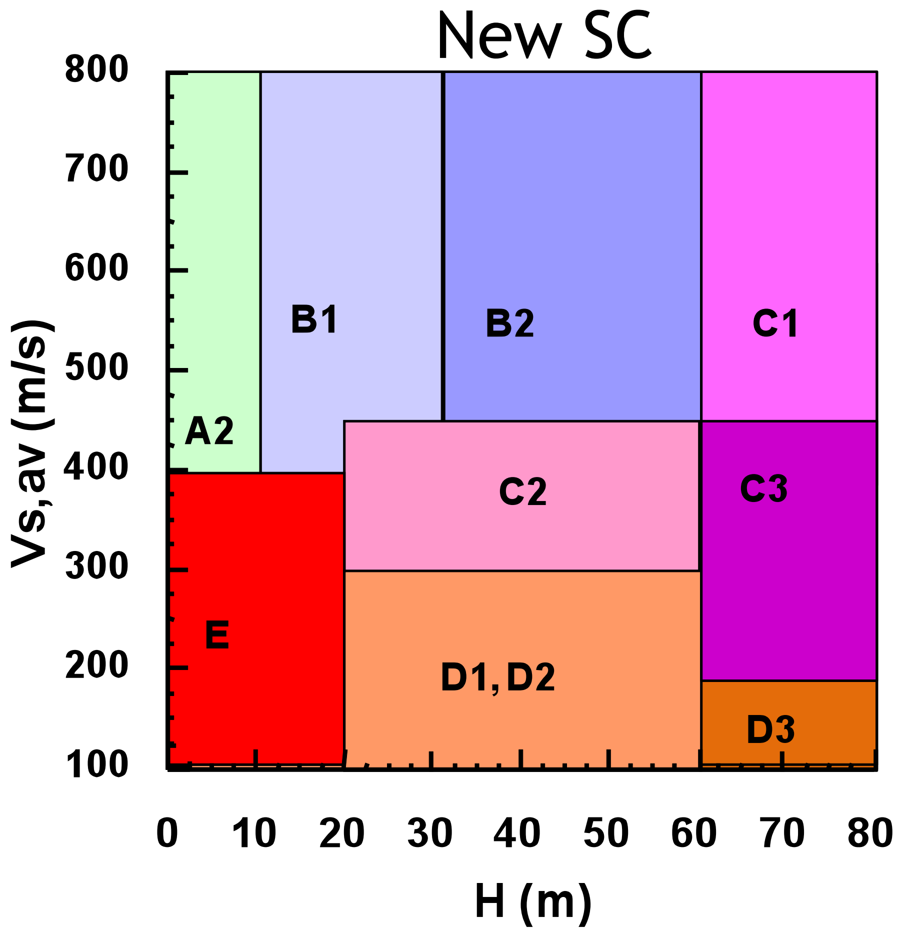
- Main parameters:
  - **Fundamental period of soil deposit T_0**
  - Average shear wave velocity of the entire soil deposit $V_{s,av}$
  - Thickness of soil deposit H to the “seismic” bedrock
  - N-SPT, PI, S_u
  - More detailed geotechnical soil description and categorization

Soil classification scheme by Pitilakis et al. (2013)

	Description	T_0	Remarks
C1	Soil formations of dense to very dense sand – sand gravel and/or stiff to very stiff clay, of great thickness (> 60.0m), whose mechanical properties and strength are constant and/or increase with depth	≤ 1.5s	$V_{s,av}$: 400-800 m/s N -SPT> 50 Su > 200 KPa
C2	Soil formations of medium dense sand – sand gravel and/or medium stiffness clay (PI > 15, fines percentage > 30%) of medium thickness (20.0 – 60.0m)	≤ 1.5s	$V_{s,av}$: 200-450 m/s N -SPT> 20 Su > 70 KPa
C3	Category C2 soil formations of great thickness (>60.0 m), homogenous or stratified that are not interrupted by any other soil formation with a thickness of more than 5.0m and of lower strength and Vs velocity	≤ 1.8s	$V_{s,av}$:200-450 m/s N-SPT > 20 Su > 70 Kpa

New site – soil classification scheme





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New site – soil classification scheme and amplification factors

- Same logic tree approach as for EC8
- Dataset DS4 from SHARE-AUTH database : $M_s \geq 4$, $T_{usable} \geq 2.5$ sec and PGA ≥20 cm/s^2

Soil Class	Type 2 ($M_s \leq 5.5$)					Type 1 ($M_s > 5.5$)				
	Ap. 1	Ap. 2	Weighted Average	NEW	EC8	Ap. 1	Ap. 2	Weighted Average	NEW	EC8
B1	1.28	0.99	1.13	**1.20**	**1.35 (B)**	1.03	1.03	1.03	**1.10**	**1.20 (B)**
B2	1.89	1.17	1.53	**1.50**		1.36	1.28	1.32	**1.30**	
C1	2.02	1.46	1.74	**1.80**	**1.50 (C)**	2.19	1.27	1.73	**1.70**	**1.15 (C)**
C2	2.08	1.39	1.74	**1.70**		1.35	1.15	1.25	**1.30**	
C3	2.59	1.61	2.10	**2.10**		1.57	1.07	1.32	**1.30**	
D	2.19	2.26	2.23	**2.00**[a]	**1.80**	2.03	1.79	1.91	**1.80** [a]	**1.35**
E	1.54	1.30	1.42	**1.60**[a]	**1.60**	1.10	0.94	1.02	**1.40** [a]	**1.40**

[a] Site specific ground response analysis required

Pitilakis et al. (2013)

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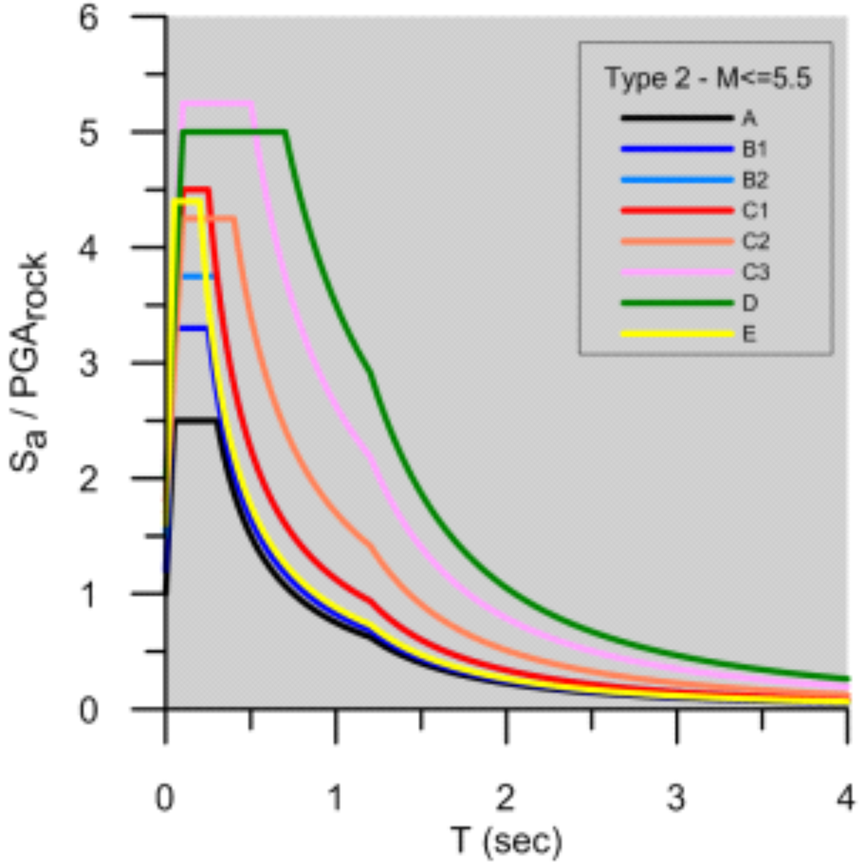
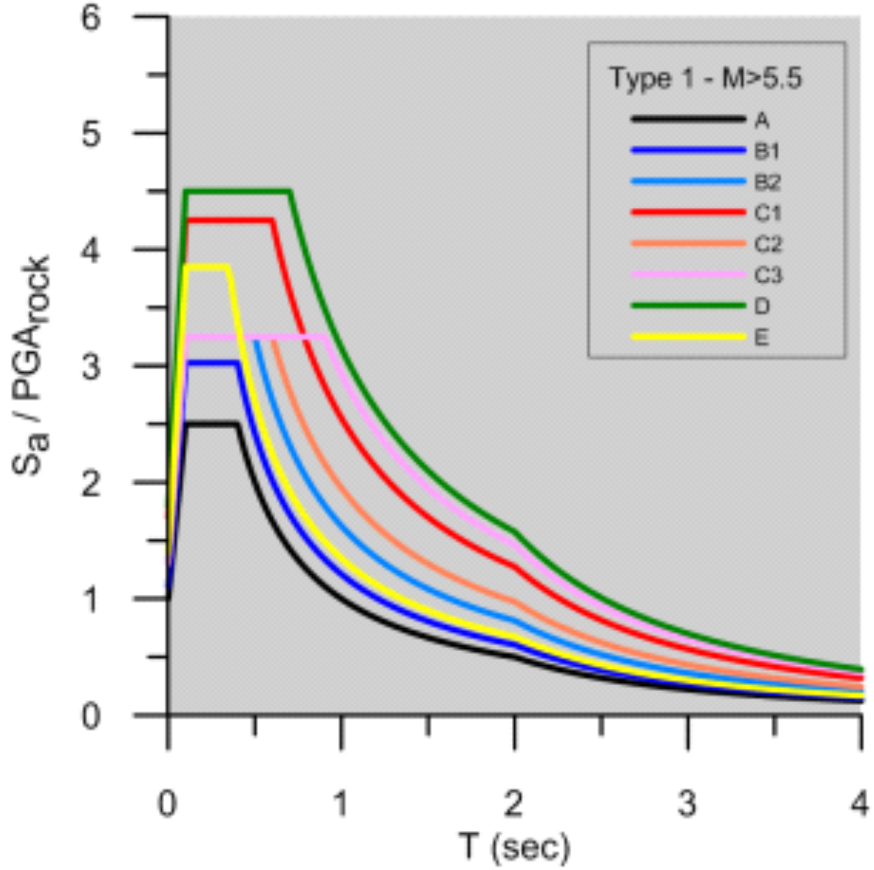
New site – soil classification scheme

Elastic acceleration response spectra (5%)

Type 2 (M<5.5)



Type 1 (M>5.5)



Pitilakis et al. (2013)

New
site classification, amplification factors and design response spectra

Considering

Two anchoring spectral parameters

Ss and S1

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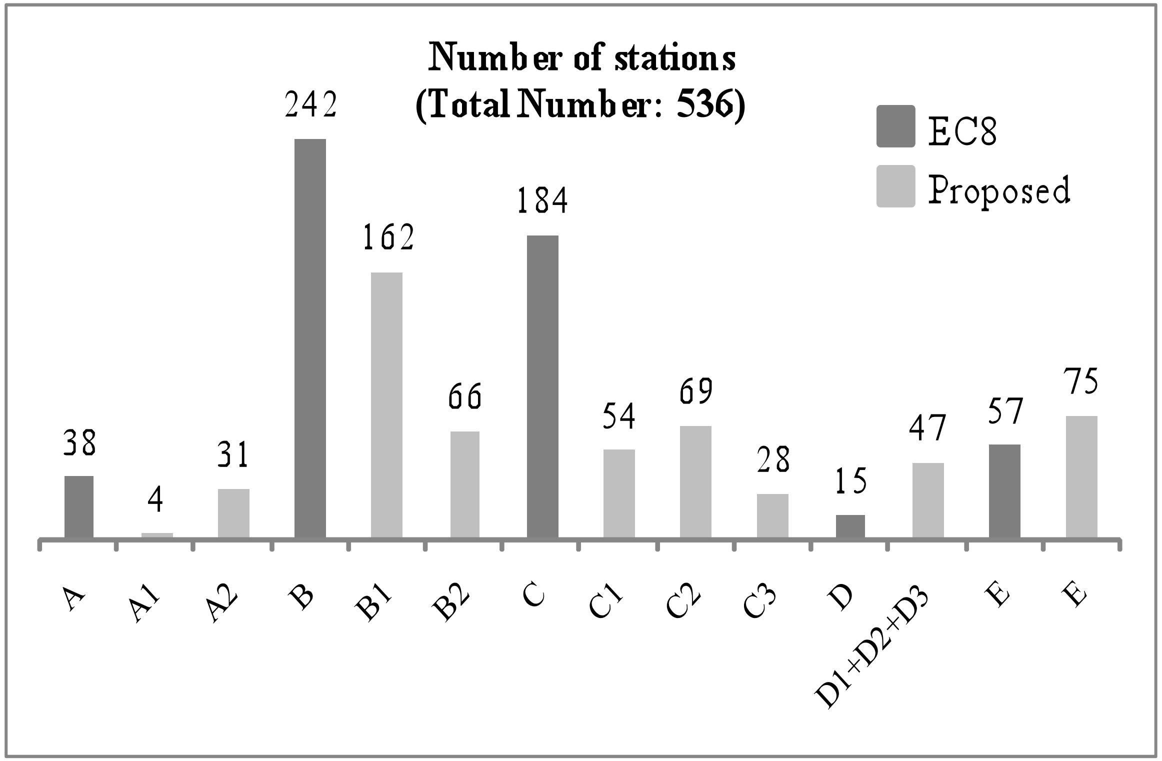
Scalar increase of seismic intensity

SHARE-AUTH database

- 3,666 records from 536 stations from Greece, Italy, Turkey, Japan and USA with a well-documented soil profile up to the seismic bedrock (Vs>800m/s)



Pitilakis et al. (2013)

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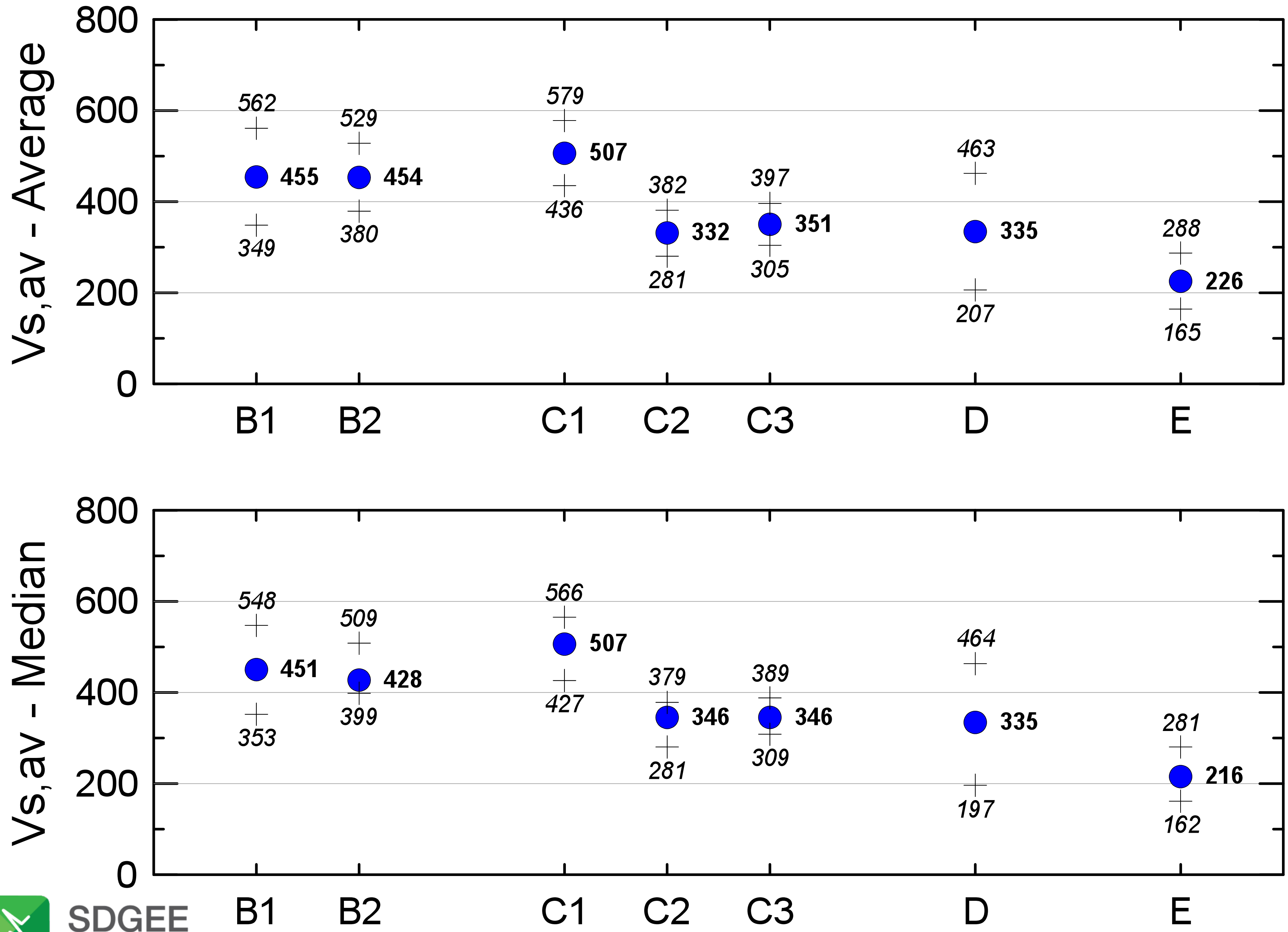

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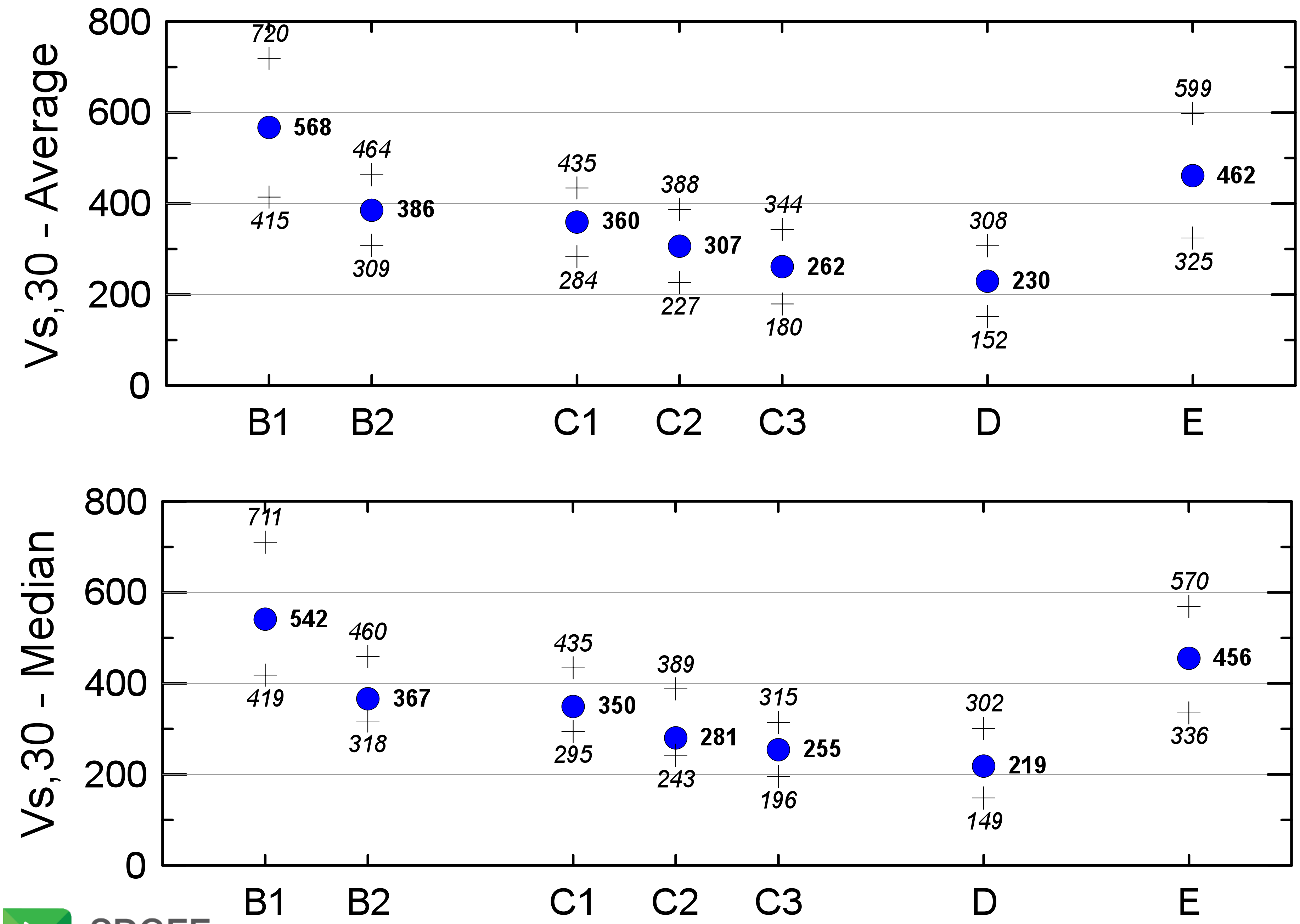
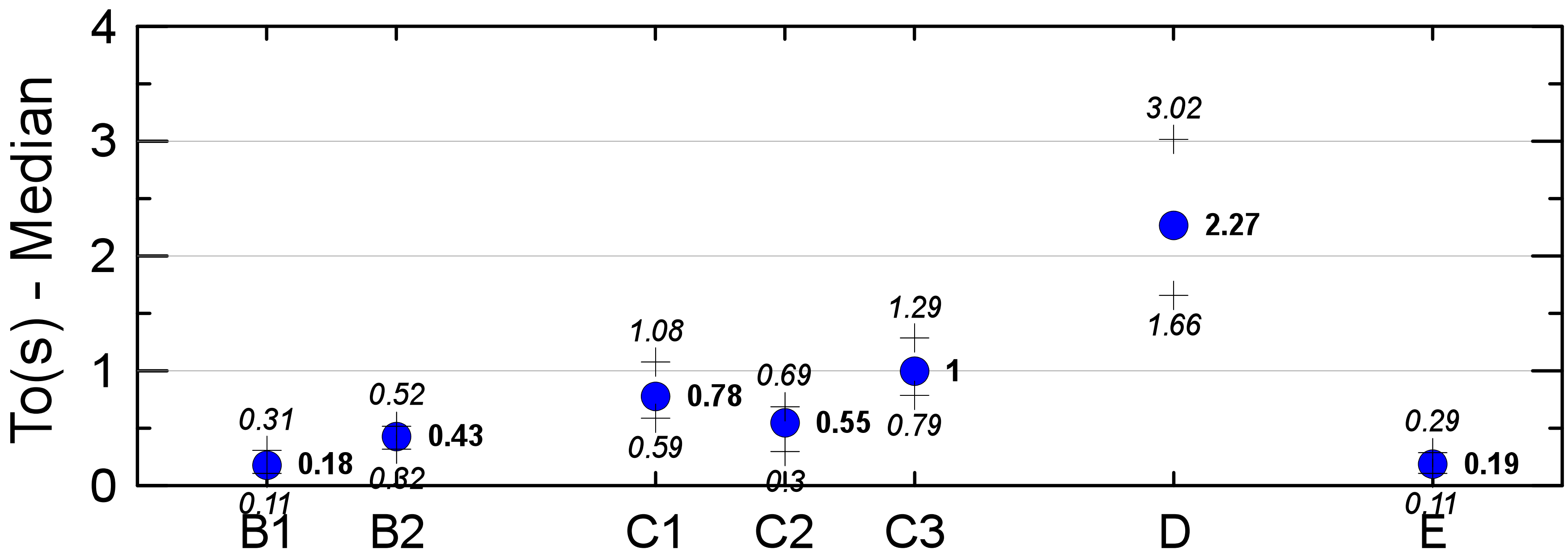

Vs,30 - Average
800
600
400
200
0
720
568
415
464
386
309
435
360
284
388
307
227
344
262
180
308
230
152
599
462
325
B1
B2
C1
C2
C3
D
E
Vs,30 - Median
711
542
419
460
367
318
435
350
295
389
281
243
315
255
196
302
219
149
570
456
336


To(s) - Median
0
1
2
3
4
B1
B2
C1
C2
C3
D
E
0.31
0.18
0.11
0.52
0.43
0.32
1.08
0.78
0.59
0.69
0.55
0.3
1.29
1
0.79
3.02
2.27
1.66
0.29
0.19
0.11

New proposal for site – soil classification scheme

	Description	T_0	Remarks	
C1	Soil formations of dense sand – sand gravel and/or stiff clay, of great thickness (> 60.0m), whose mechanical properties and strength are constant and/or increase with depth **H>60m**	0.6-1.0s ≤ 1.0s	$V_{s,av}$: 400-600 m/s V_{s30} :350-450 m/s N -SPT> 50 S_u > 150 KPa	**C1**
C2	Soil formations of medium dense sand – sand gravel and/or medium stiffness clay (PI > 15, fines percentage > 30%) **20m <H< 60m**	0.3-0.7s ≤ 0.8s	$V_{s,av}$: 250-450 m/s V_{s30} :250-400 m/s N -SPT> 20 150KPa> S_u > 70 KPa	**C2**
C3	Like C2 but with great thickness **H>60m**	0.7-1.4s ≤ 1.4s	$V_{s,av}$: 300-500 m/s V_{s30} :200-350 m/s N -SPT> 20 150KPa > S_u > 70 KPa	**C3**

Seismic action

The seismic hazard is described in terms of two parameters, namely:

- $\mathbf{S_{s,ref}}$ the reference maximum spectral acceleration, corresponding to the constant acceleration branch of the horizontal 5% damped elastic response spectrum
- $\mathbf{S_{1,ref}}$ the reference spectral acceleration at the vibration period T = 1s of the horizontal 5% damped elastic response spectrum

$\mathbf{S_{s,ref}}$ and $\mathbf{S_{1,ref}}$ are given for the reference return period for example 475y or 10% probability of exceedence in 50 years

Soil amplification factors

- The soil factors proposed by Pitilakis et al. (2013) were properly adjusted to include the nonlinear term developed by Seyhan and Stewart (2014) and adopted in the Boore et al. (2014) GMPE:

$$F_{S,B} = \ln(F_{lin}) + \ln(F_{nl})$$

$$\ln(F_{nl}) = f_1 + f_2 \ln\left(\frac{PGA_r + f_3}{f_3}\right)$$

$$f_2 = f_4\left[\exp\{f_5(\min(V_{S30}, 760) - 360)\} - \exp\{f_5(760 - 360)\}\right]$$

f_1=0, f_3=0.1, f_4, f_5=period-dependent constant values

- Site amplification factors $\mathbf{F_s}$ and $\mathbf{F_1}$ are proposed for the different site classes and for distinct values of $\mathbf{S_{sRP}}$ at rock site conditions representing very low-low, medium and high seismicity ($\mathbf{S_{sRP}=PGA_r \bullet F_0}$).
- Nonlinear terms are estimated for increasing S_{sRP} values using the properly estimated GMPE coefficients for short $(\mathbf{F_s})$ and intermediate period (T=1s) $(\mathbf{F_1})$

Horizontal elastic response spectrum

Recommended values for seismic hazard parameters defining the elastic response spectrum

T_A (s)	κ (*)	F_0(**)	T_D (s)
0,03	**5.0**	**2.5**	2 if $S_{1RP} \leq 0{,}1g$ $1+10 \cdot S_{1RP}$ if $S_{1RP} > 0{,}1g$

F_0 may take higher or lower values e.g. 2.75 for site categories E in particular of low seismicity regions or 2.30 for very soft soils with considerable thickness.

The spectral accelerations S_s and S_1 are defined as follows:

$$\mathbf{S_s = F_T \times F_B \times F_s \times S_{sRP}}$$

$$\mathbf{S_1 = F_T \times F_B \times F_1 \times S_{1RP}}$$

where

- F_s short period site amplification factor
- F_1 intermediate period (T1 = 1 s) site amplification factor
- F_T topography amplification factor
- F_B basin (or valley) period dependent amplification factor (see next)

New Soil Amplification Factors

Fs Factors

Site class	S_{sRP} maximum response spectral acceleration at short period on site class A in g[a]					
	S_{sRP} <0.25 ([c])	S_{sRP} =0.25	S_{sRP} =0.5	S_{sRP} =0.75	S_{sRP} =1.0	S_{sRP} ≥1.25
A	1.00	1.00	1.00	1.00	1.00	1.00
B1	1.30	1.30	1.20	1.20	1.20	1.20
B2	1.40	1.30	1.30	1.20	1.10	1.10
C1	1.70	1.60	1.40	1.30	1.30	1.20
C2	1.60	1.50	1.30	1.20	1.10	1.00
C3	1.80	1.60	1.40	1.20	1.10	1.00
D[b]	2.20	1.90	1.60	1.40	1.20	1.00
E[b]	1.70	1.60	1.60	1.50	1.50	1.50
X[b]	-	-	-	-	-	-

[a] Use straight line interpolation for intermediate values of S_{sRP}.

[b] Site-specific geotechnical investigation and dynamic site response analyses shall be performed under certain conditions

[c] Dynamic soil response practically in the elastic range

New Soil Amplification Factors

F_1 Factors

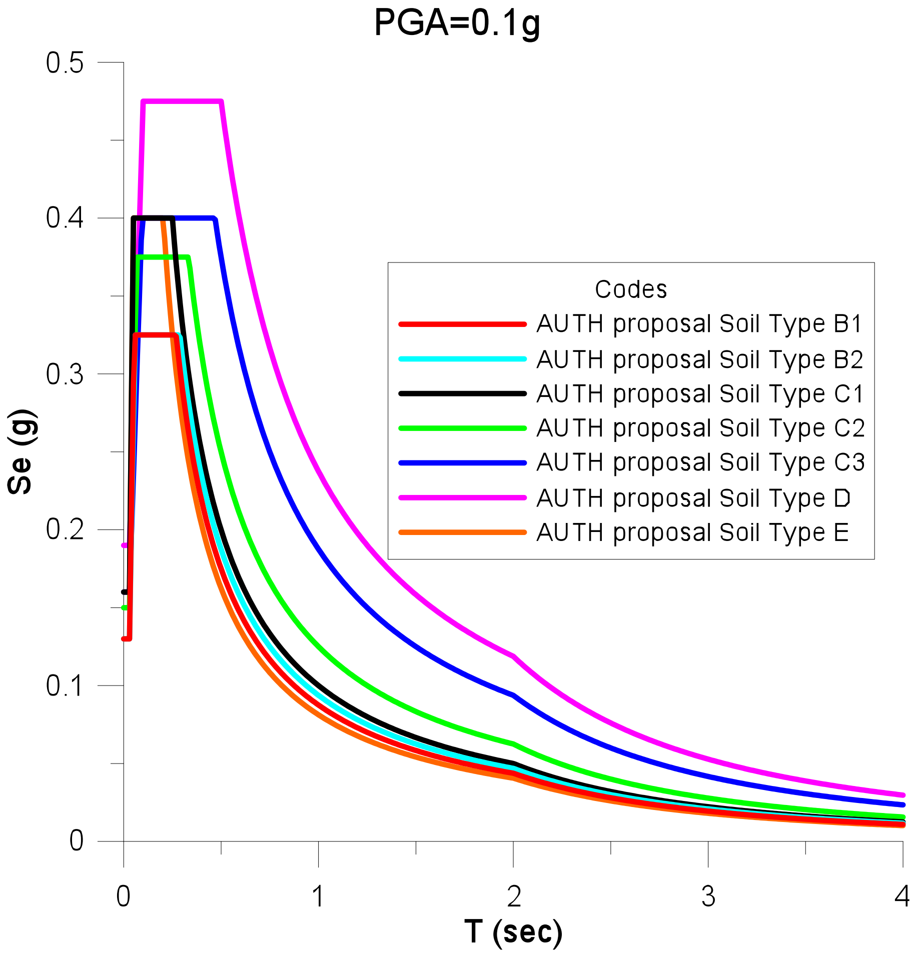
Site class	S_{sRP} maximum response spectral acceleration at short period on site class A in g[a]					
	S_{sRP} <0.25 [(c)]	S_{sRP} =0.25	S_{sRP} =0.5	S_{sRP} =0.75	S_{sRP} =1.0	S_{sRP} ≥1.25
A	1.00	1.00	1.00	1.00	1.00	1.00
B1	1.40	1.40	1.40	1.40	1.30	1.30
B2	1.60	1.50	1.50	1.50	1.40	1.30
C1	1.70	1.60	1.50	1.50	1.40	1.30
C2	2.10	2.00	1.90	1.80	1.80	1.70
C3	3.20	3.00	2.70	2.50	2.40	2.30
D[b]	4.10	3.80	3.30	3.00	2.80	2.70
E[b]	1.30	1.30	1.20	1.20	1.20	1.20
X[b]	-	-	-	-	-	-

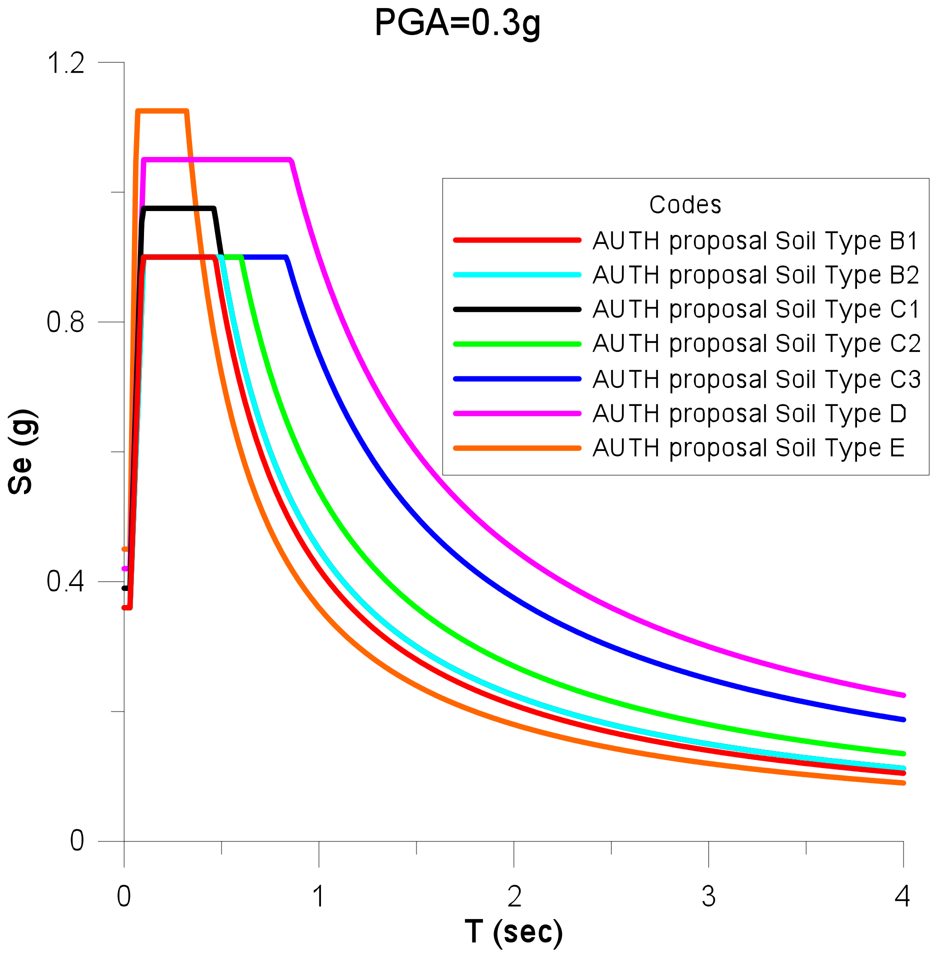
[a] Use straight line interpolation for intermediate values of S_{sRP}.

[b] Site-specific geotechnical investigation and dynamic site response analyses shall be performed under conditions defined in this document

[c] Dynamic soil response practically in the elastic range

Elastic response spectra



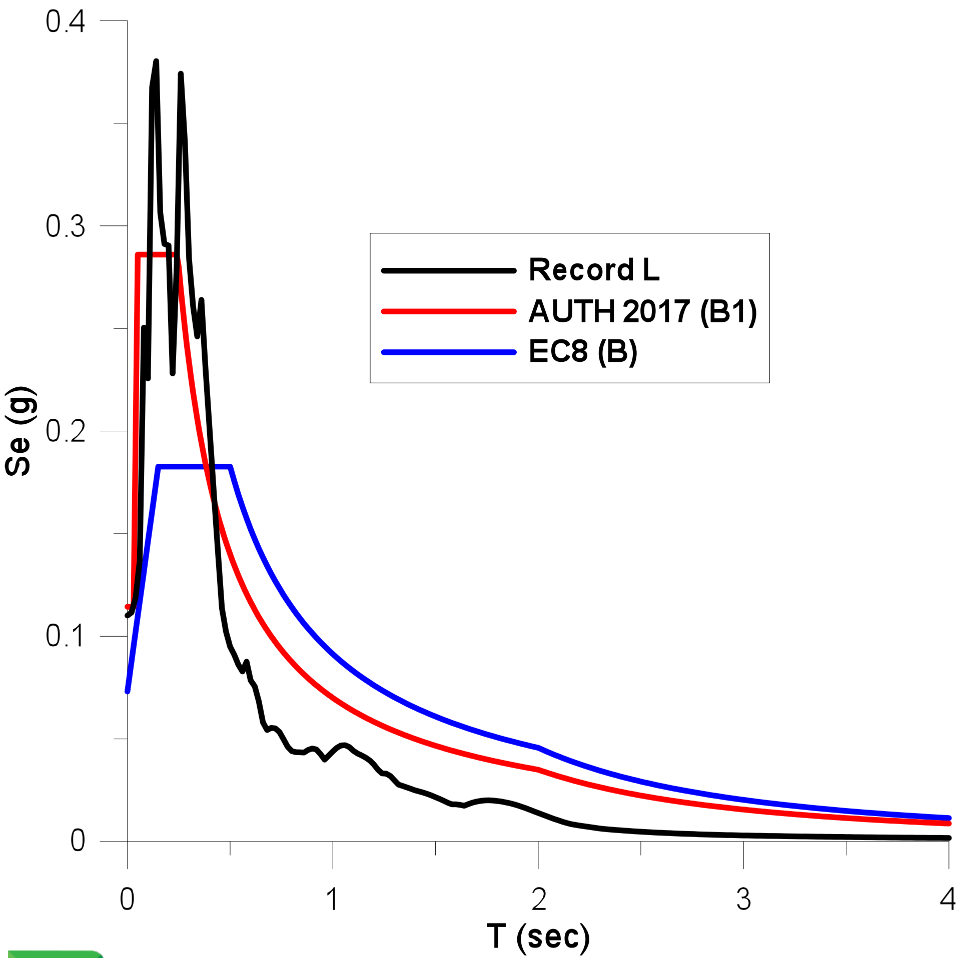


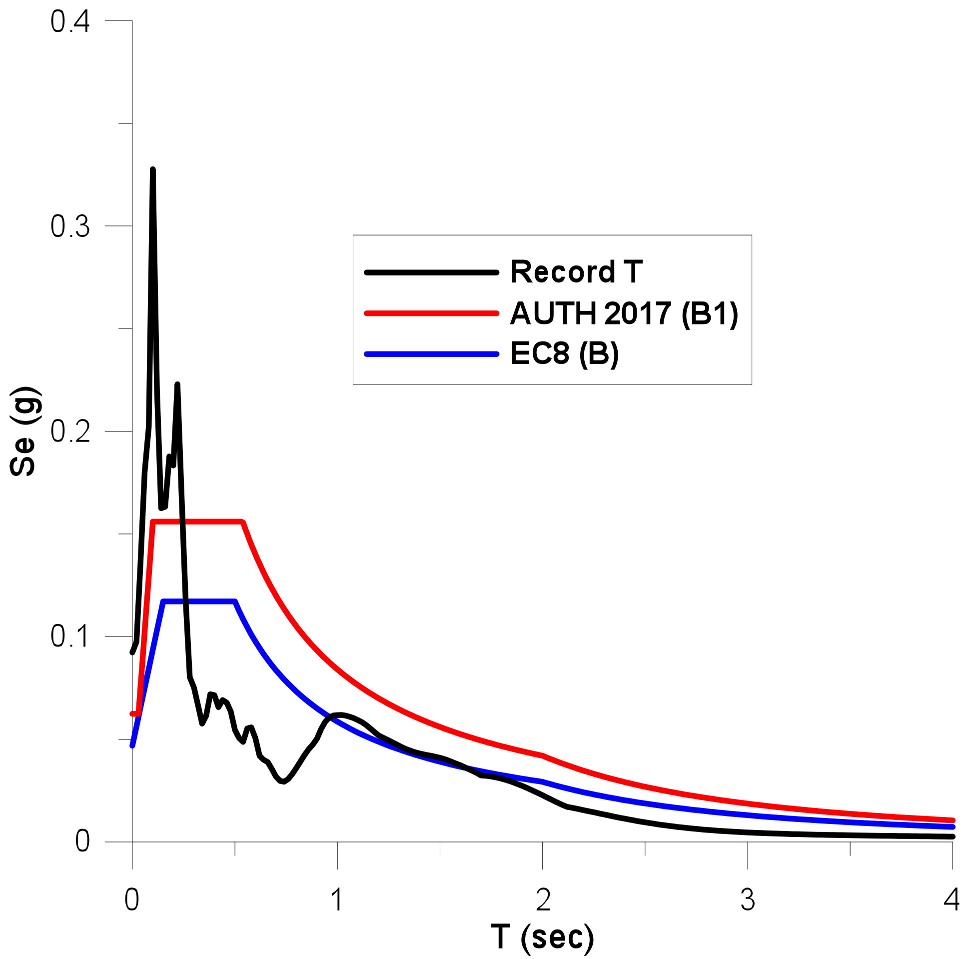
Examples from selected stations in Italy and Greece where the new AUTH_2017 proposal is applied

Selected stations with sufficiently good geotechnical information and available records at the ground surface (M>5).

Bedrock motions are estimated either from 1D deconvolution analysis of the available records or using appropriate GMPE for outcrop conditions

Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
Chalandri	L T	Athens Long Athens Trans	07-09-1999 11:56:50	5.9	18.00	0.110 0.092





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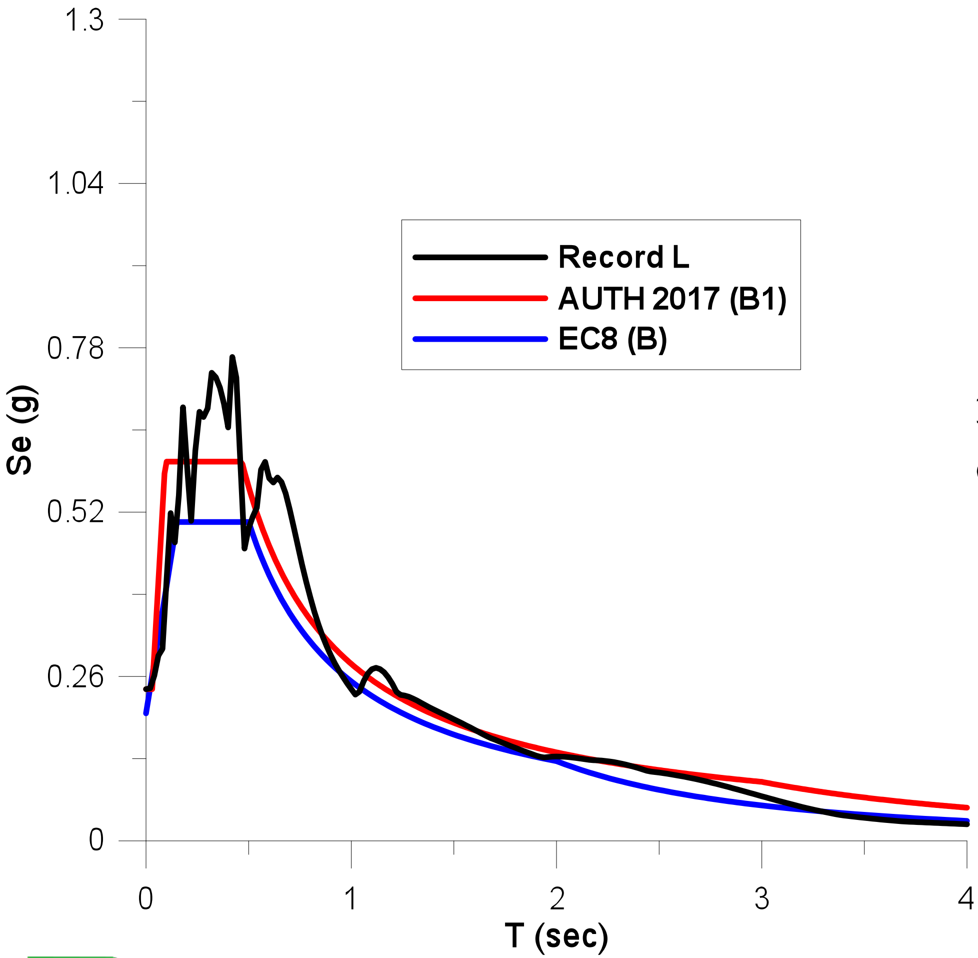
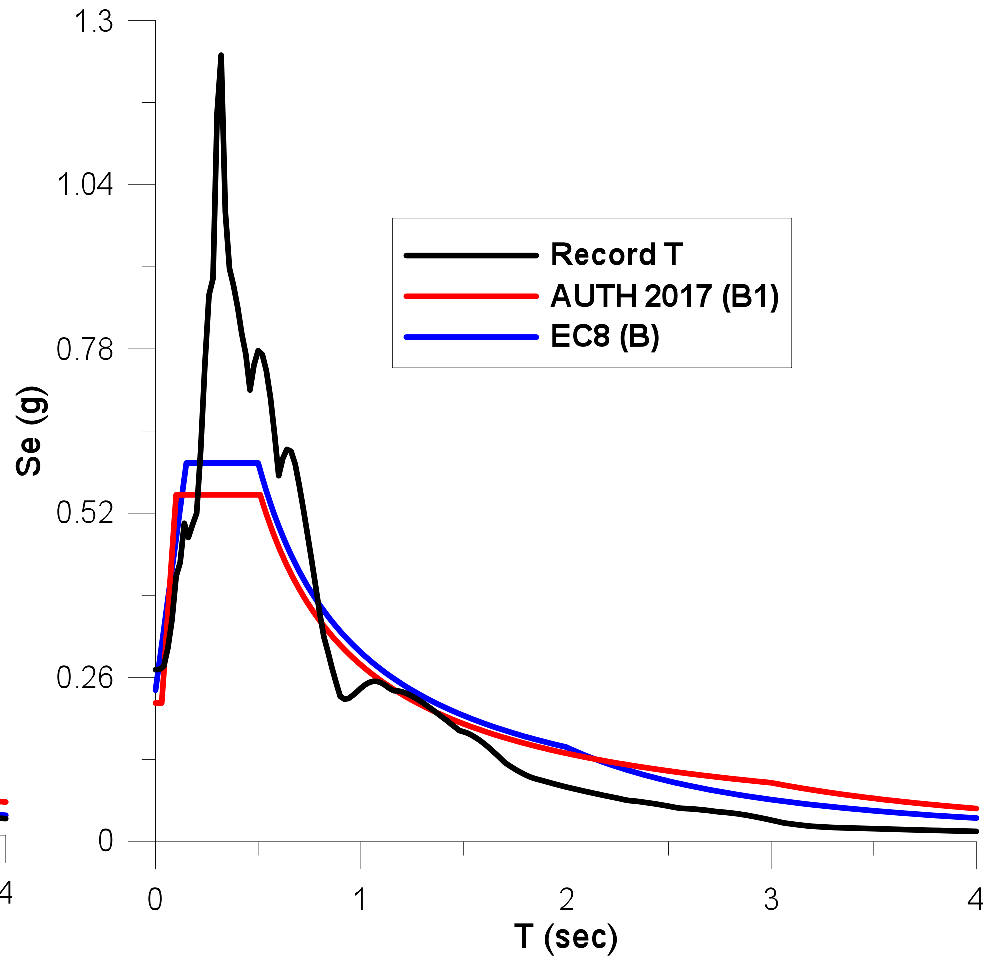
Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
Kalamata Prefecture	L T	Kalamata main event Long Kalamata main event Trans	13-09-1986 17:24:35	5.9	11.00	0.240 0.272





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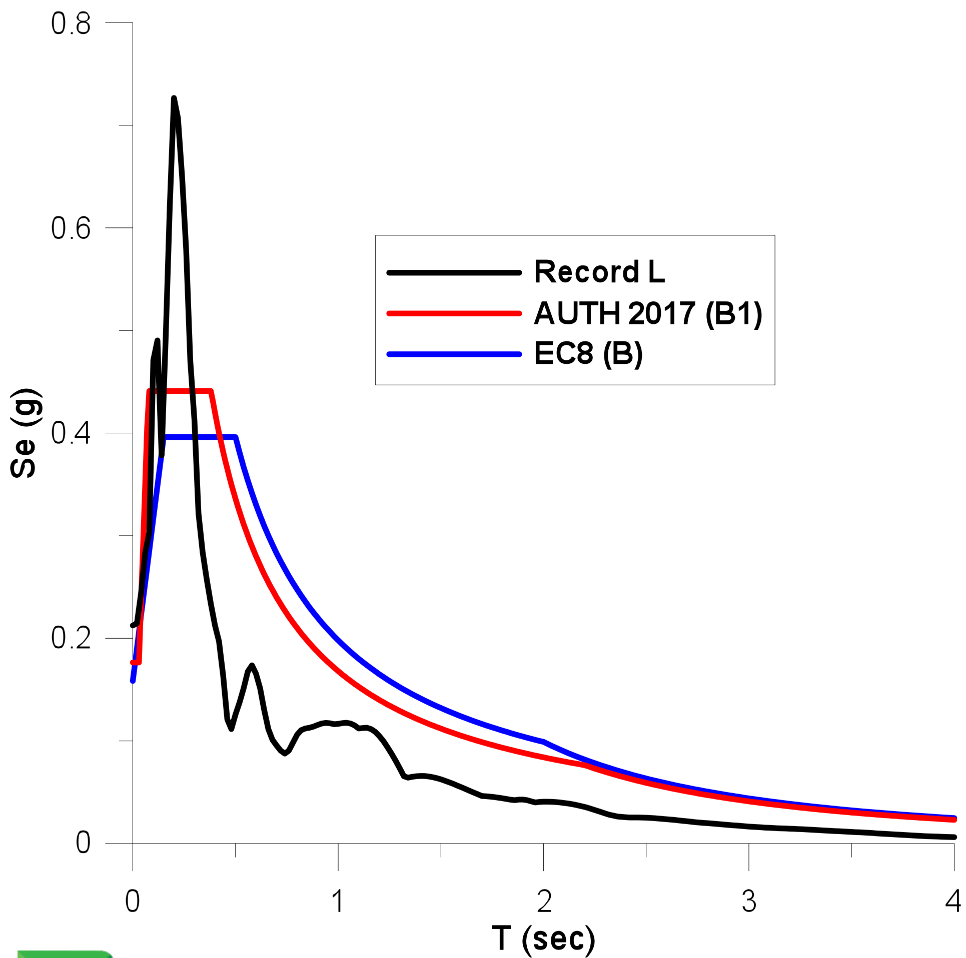
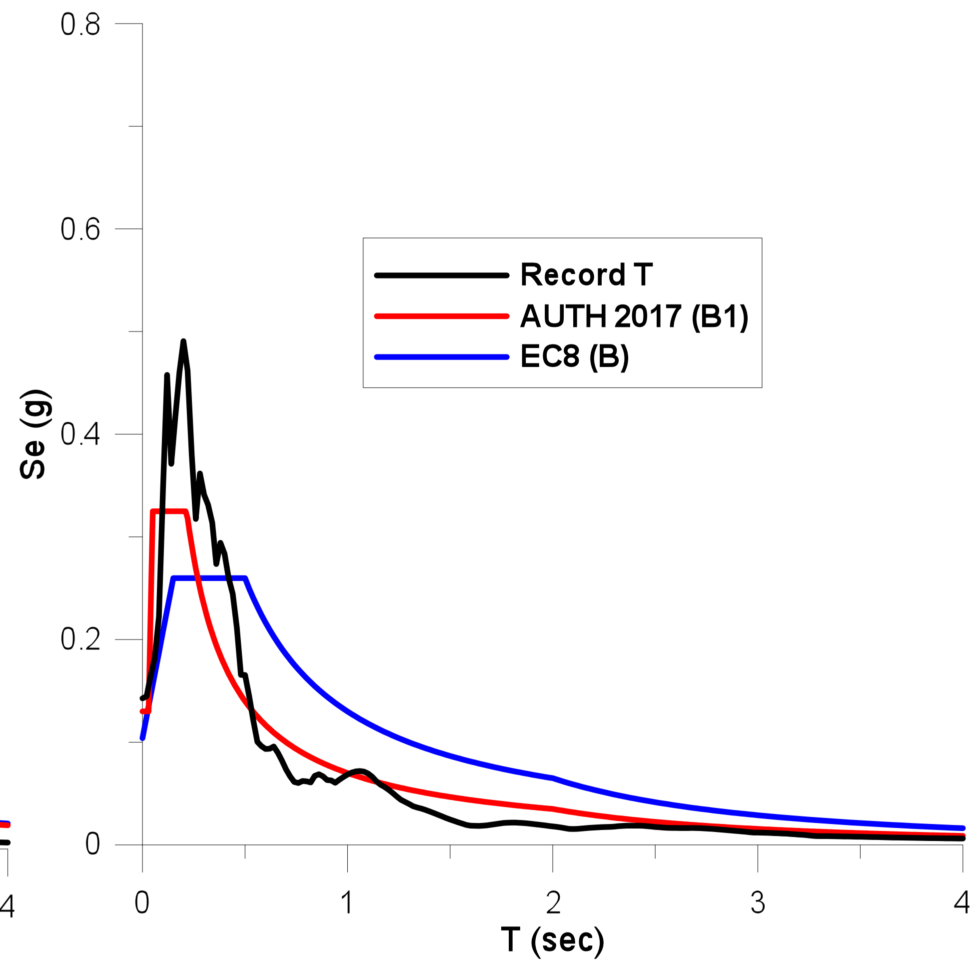
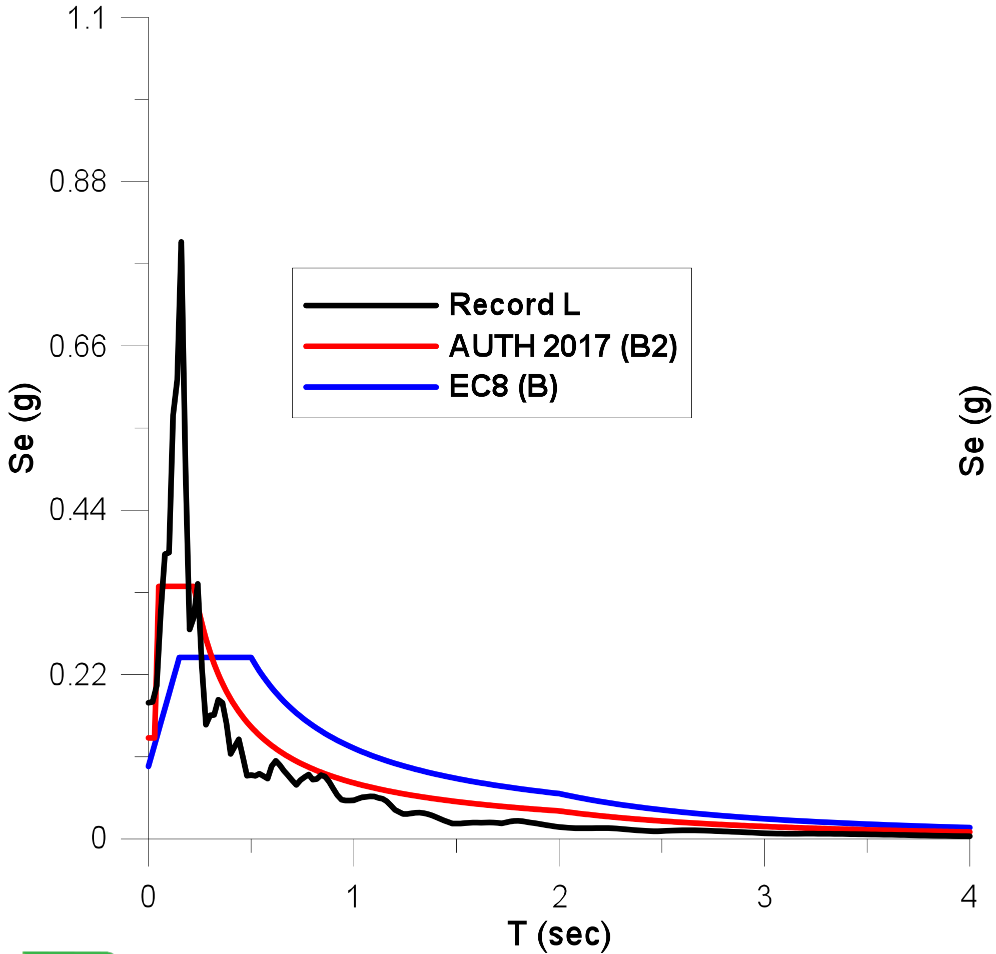
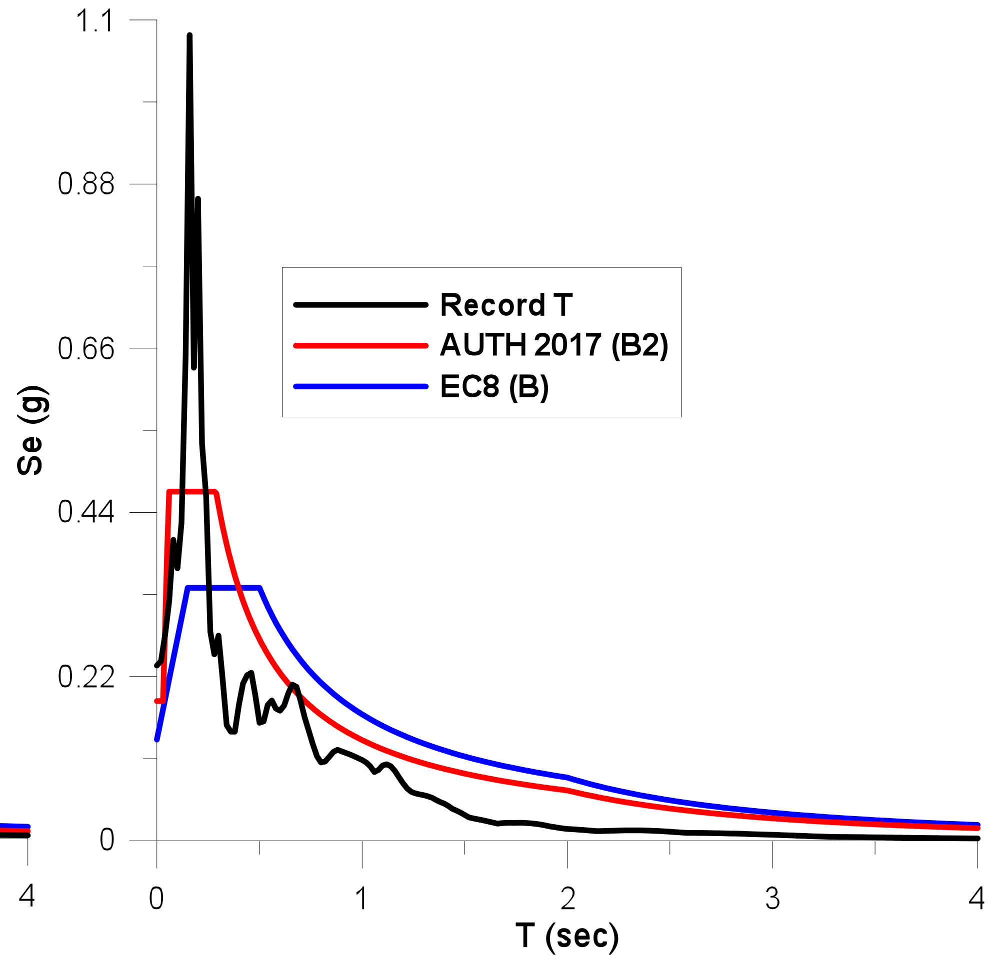
Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
Kozani Prefecture	L T	Kozani Long Kozani Trans	13-05-1995 08:47:15	6.5	17.00	0.212 0.142



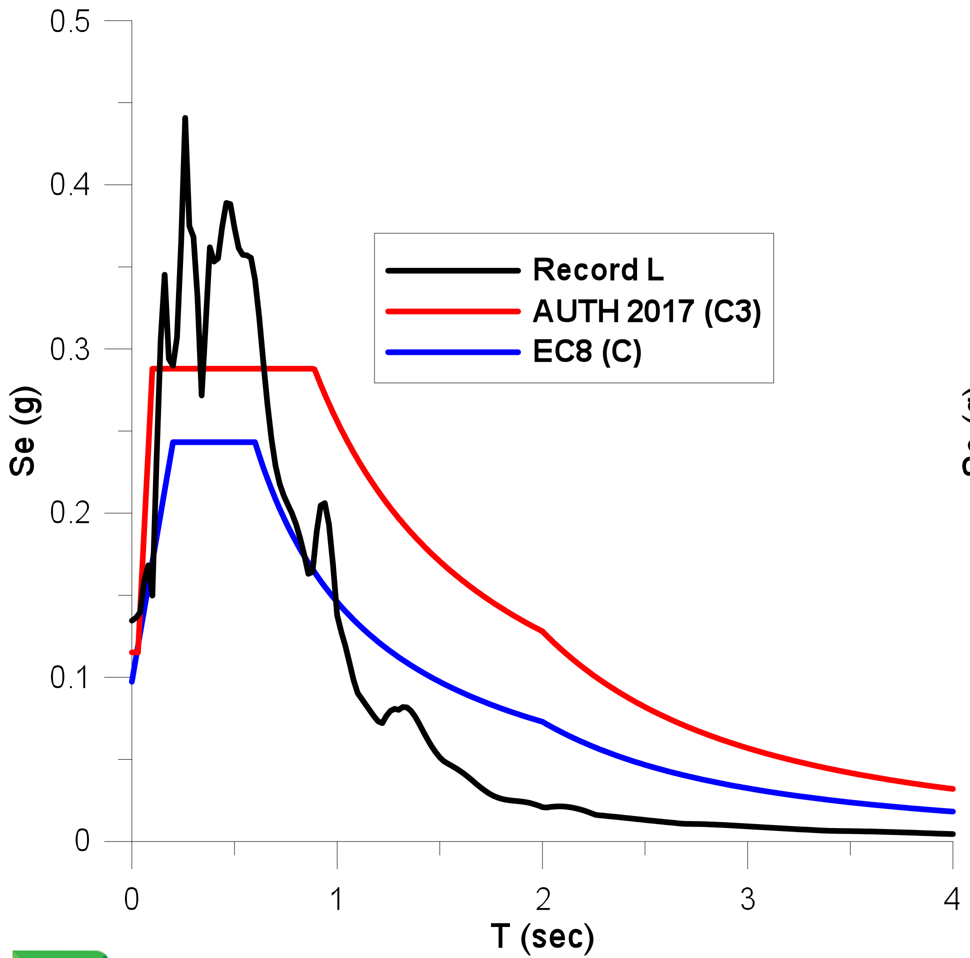


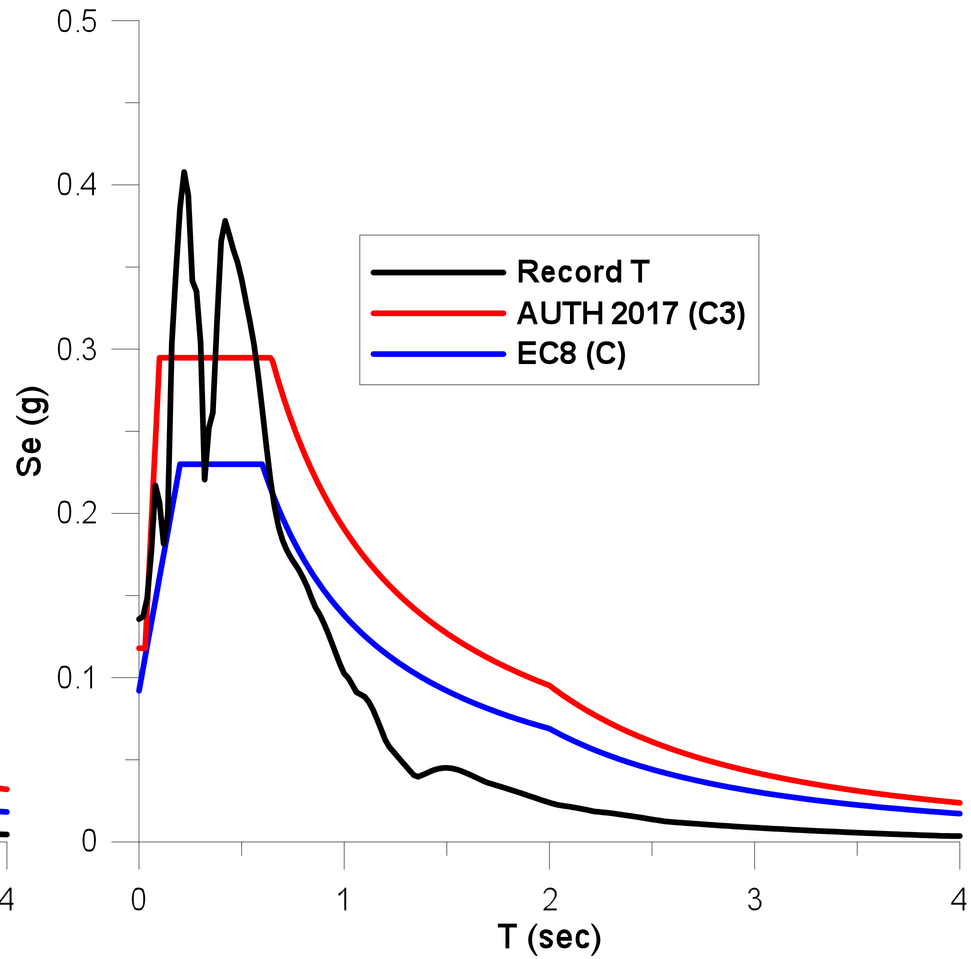
Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
Argostoli Telecomm. building	L T	Argostoli Long Argostoli Trans	23-03-1983 23:51:05	6.2	18.00	0.182 0.235



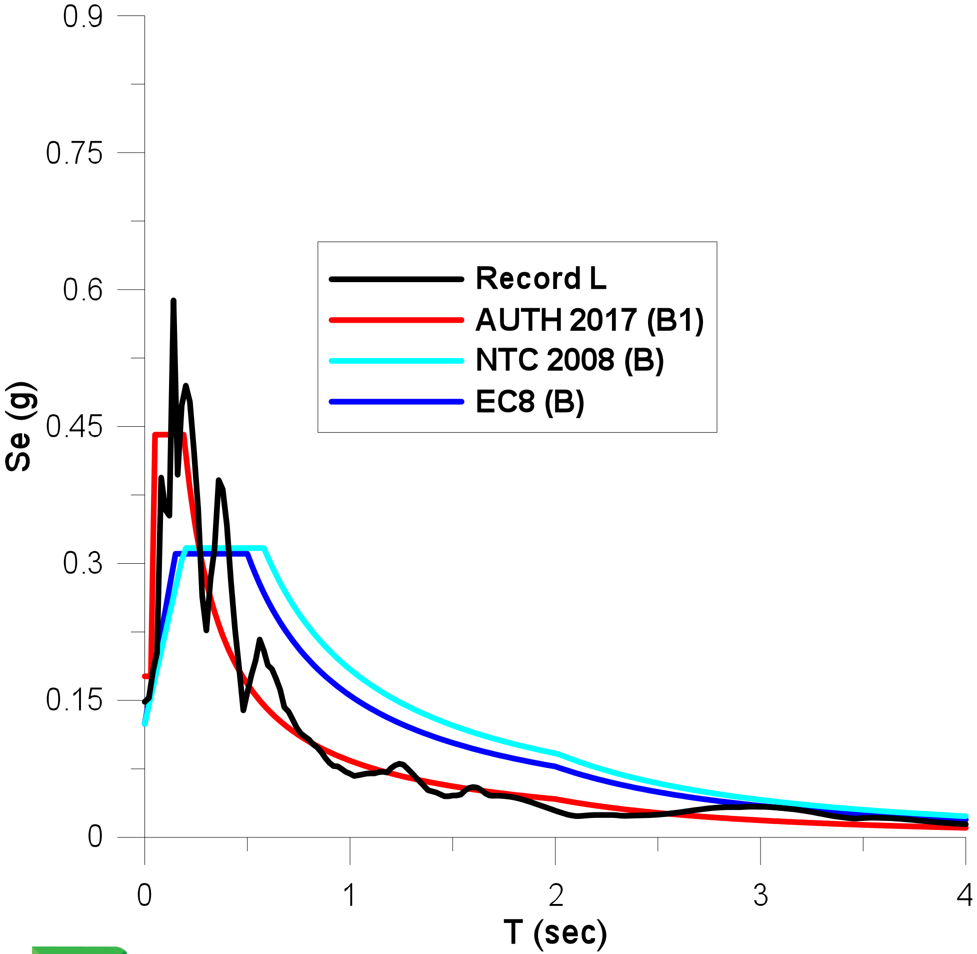


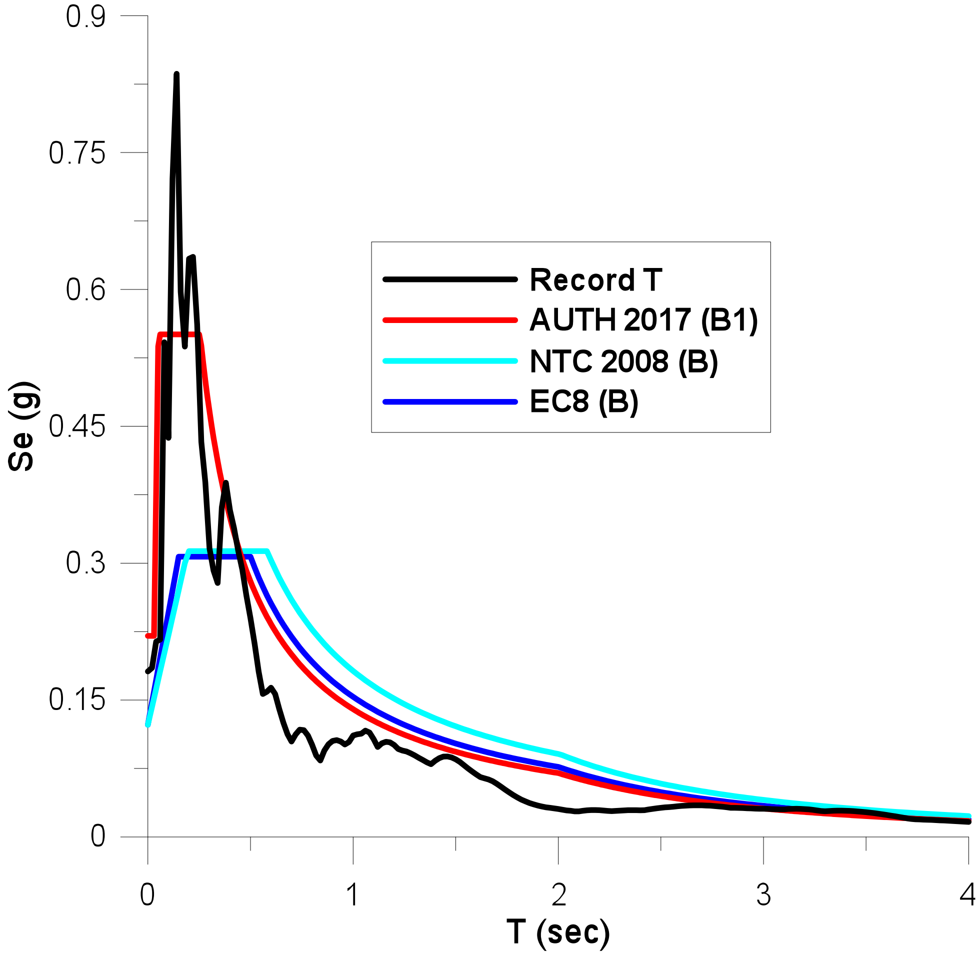
Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
Lefkada Hospital	L	Lefkada Long	25-02-1994	5.4	15.00	0.135
	T	Lefkada Trans	02:30:49			0.136



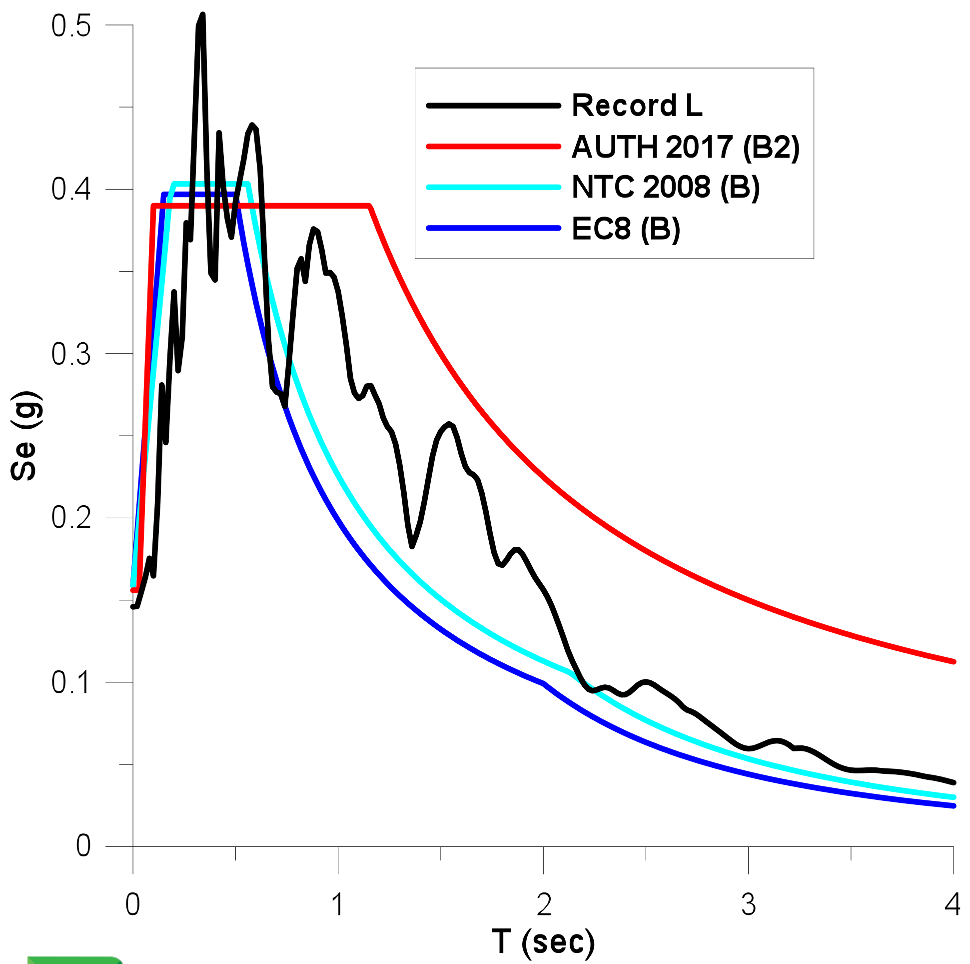


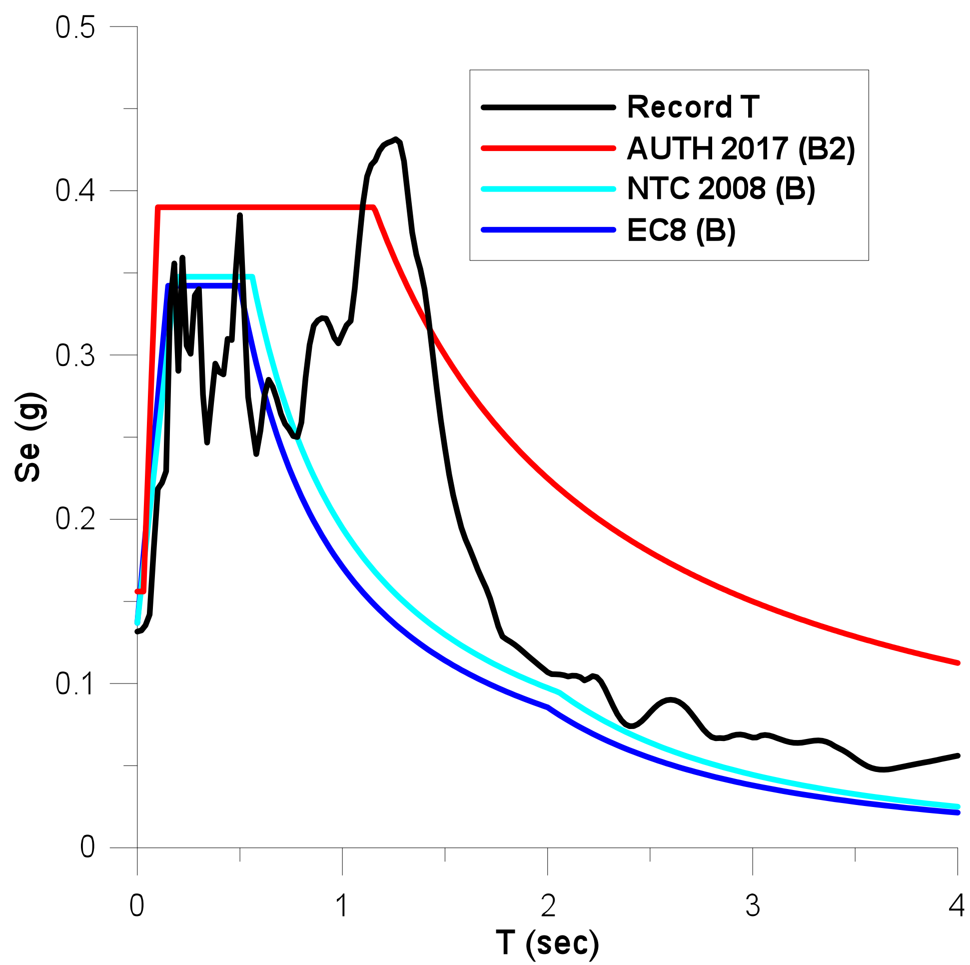
Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
Brienza (BRN)	L	IRPINIA Long	23-11-1980	6.9	42.60	0.148
	T	IRPINIA Trans	18:34:53			0.181





Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
Calitri (CLT)	L T	IRPINIA Long IRPINIA Trans	23-11-1980 18:34:53	6.9	18.90	0.146 0.132





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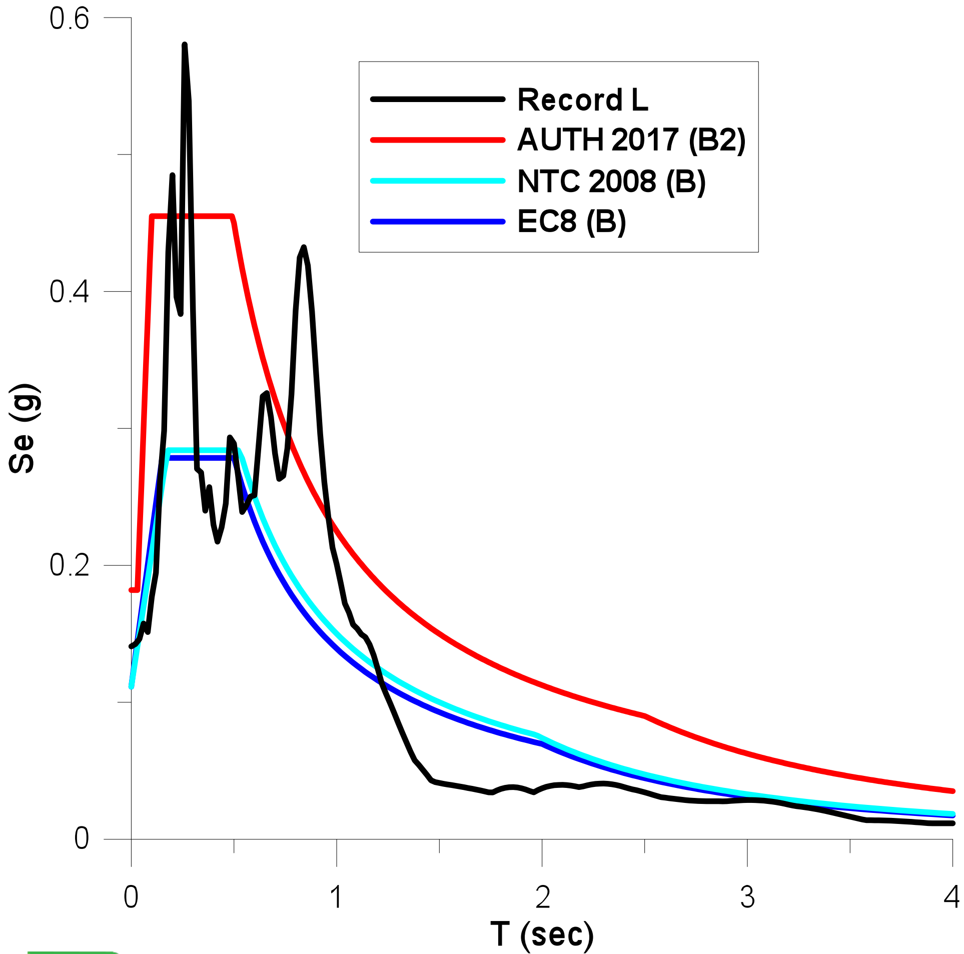
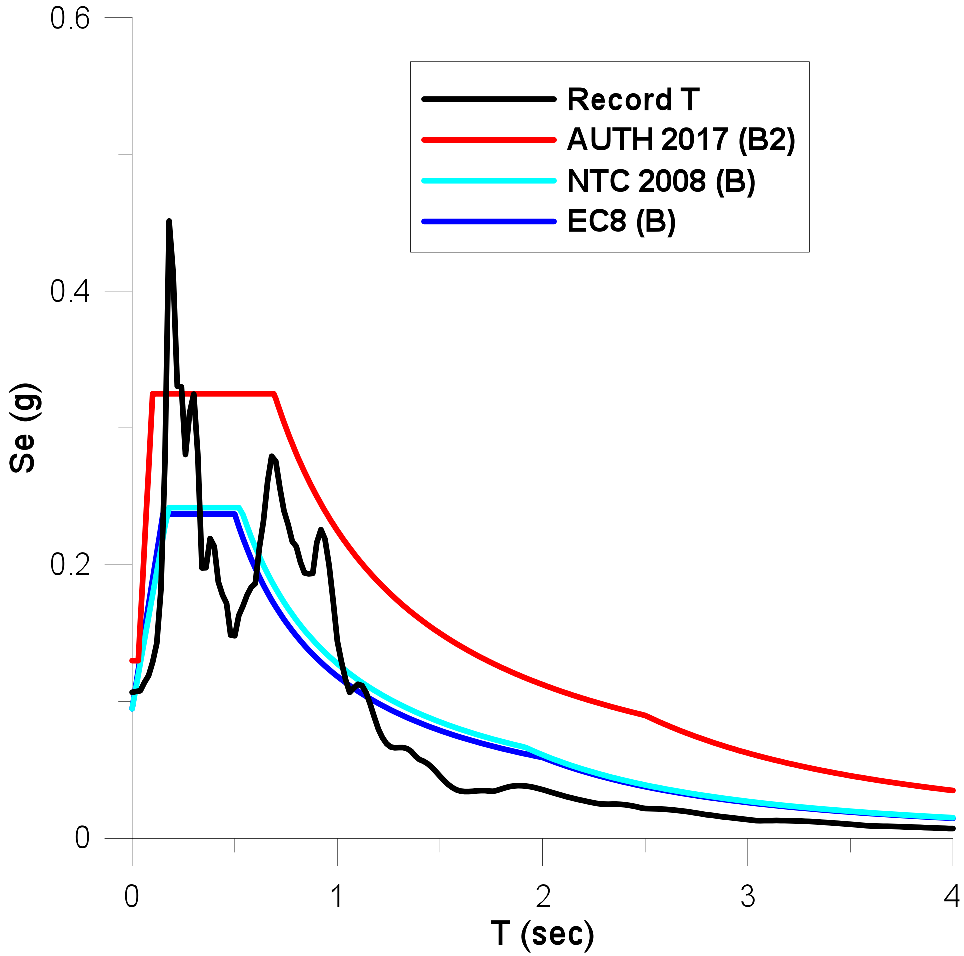
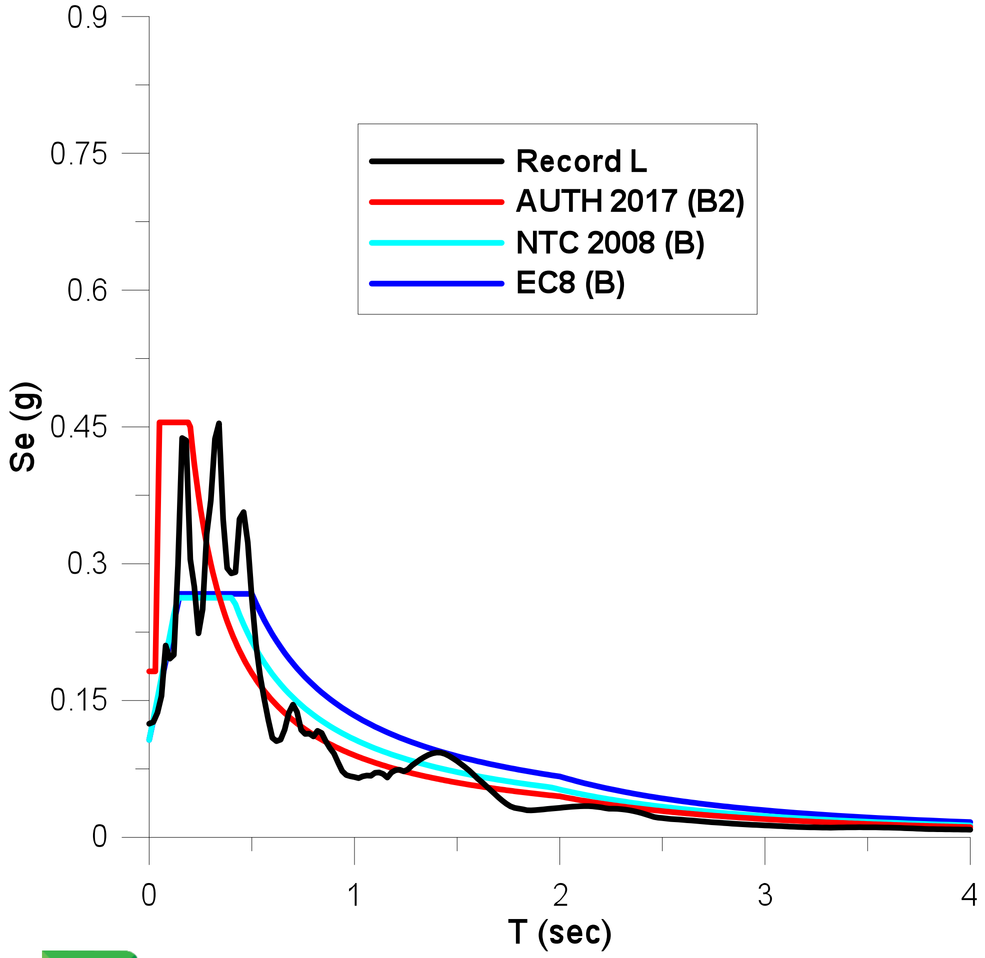
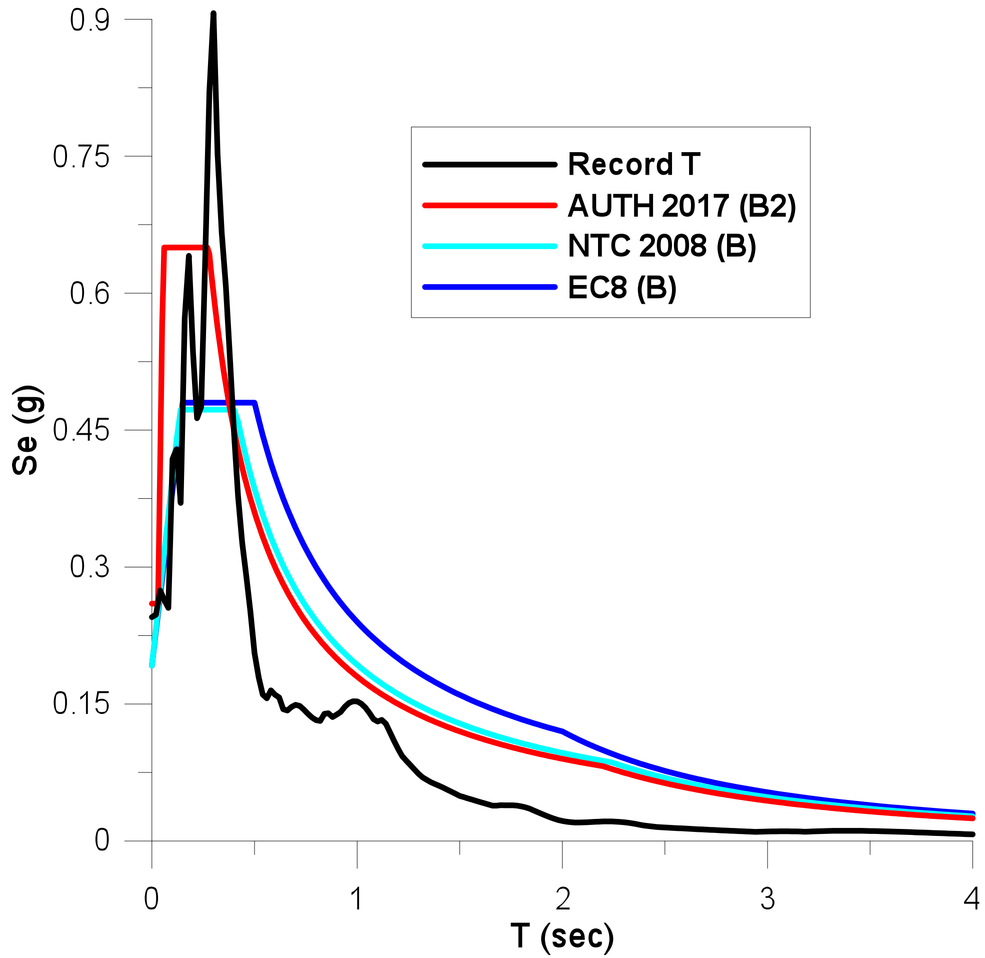
Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
Mercato S. Severino (MRT)	L T	IRPINIA Long IRPINIA Trans	23-11-1980 18:34:53	6.9	47.10	0.141 0.107



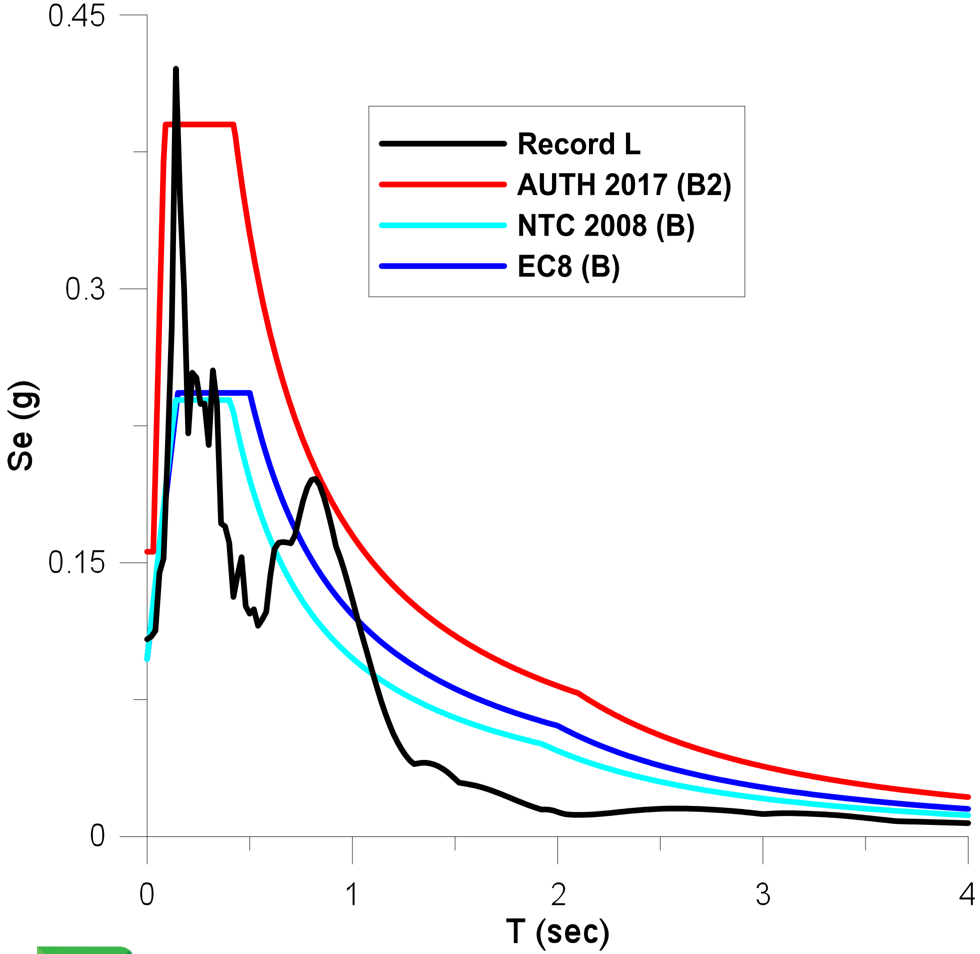


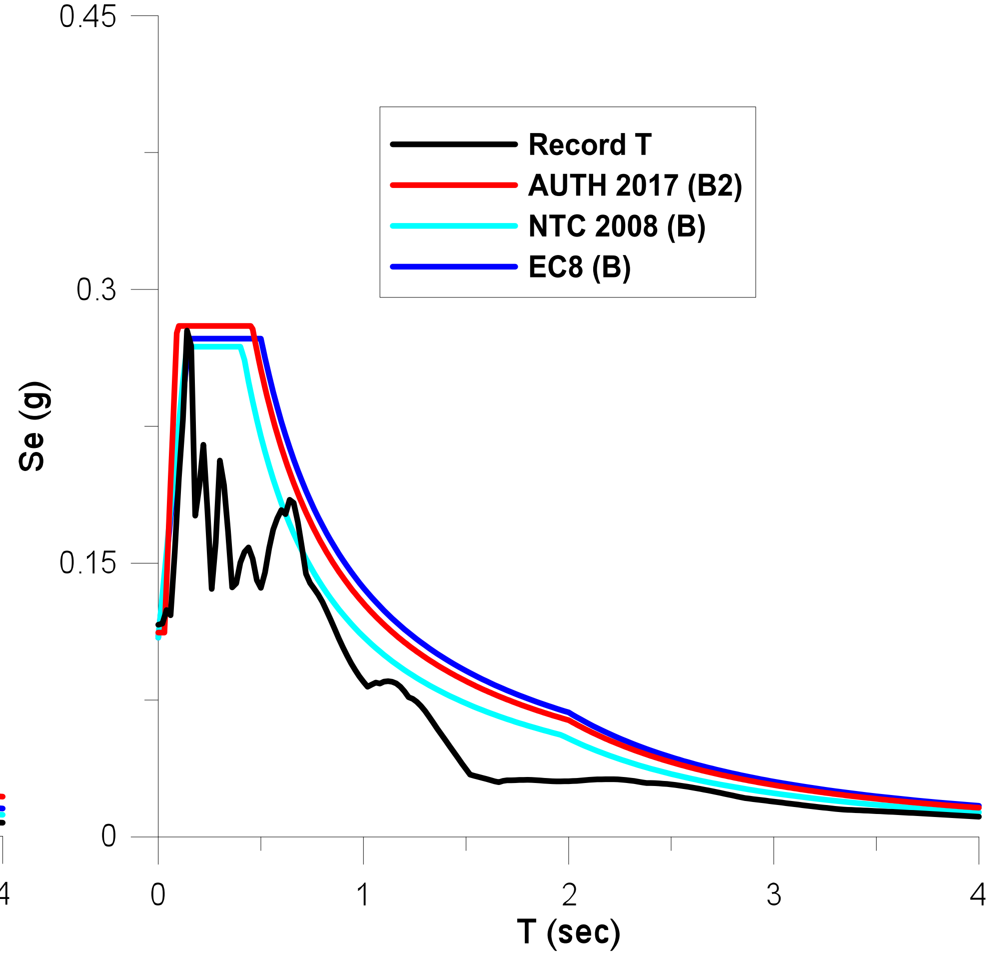
Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
MATELICA (MTL)	L	CENTRAL ITALY Long	26-10-2016 19:18:06	5.9	39.104	0.125
	T	CENTRAL ITALY Trans				0.245





Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
MATELICA (MTL)	L T	UMBRIA MARCHE 2ND SHOCK Long UMBRIA MARCHE 2ND SHOCK Trans	26-09-1997 09:40:24	6.0	27.00	0.108 0.116





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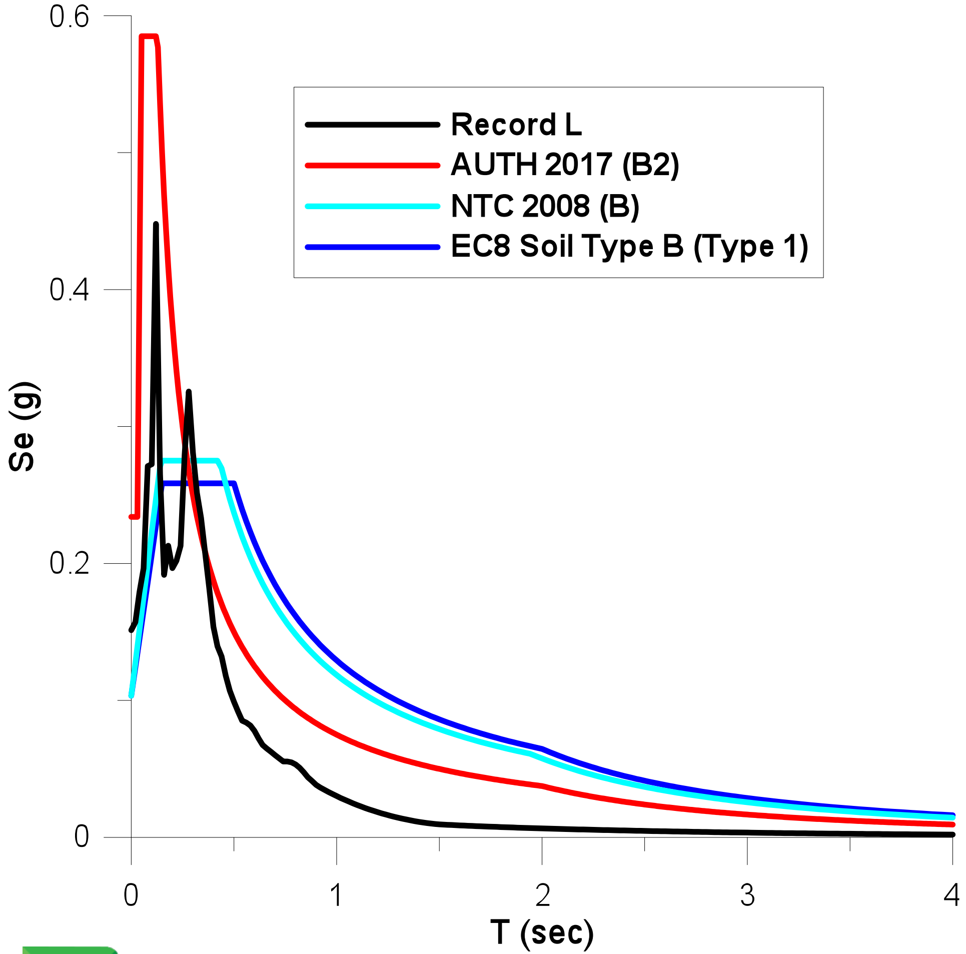
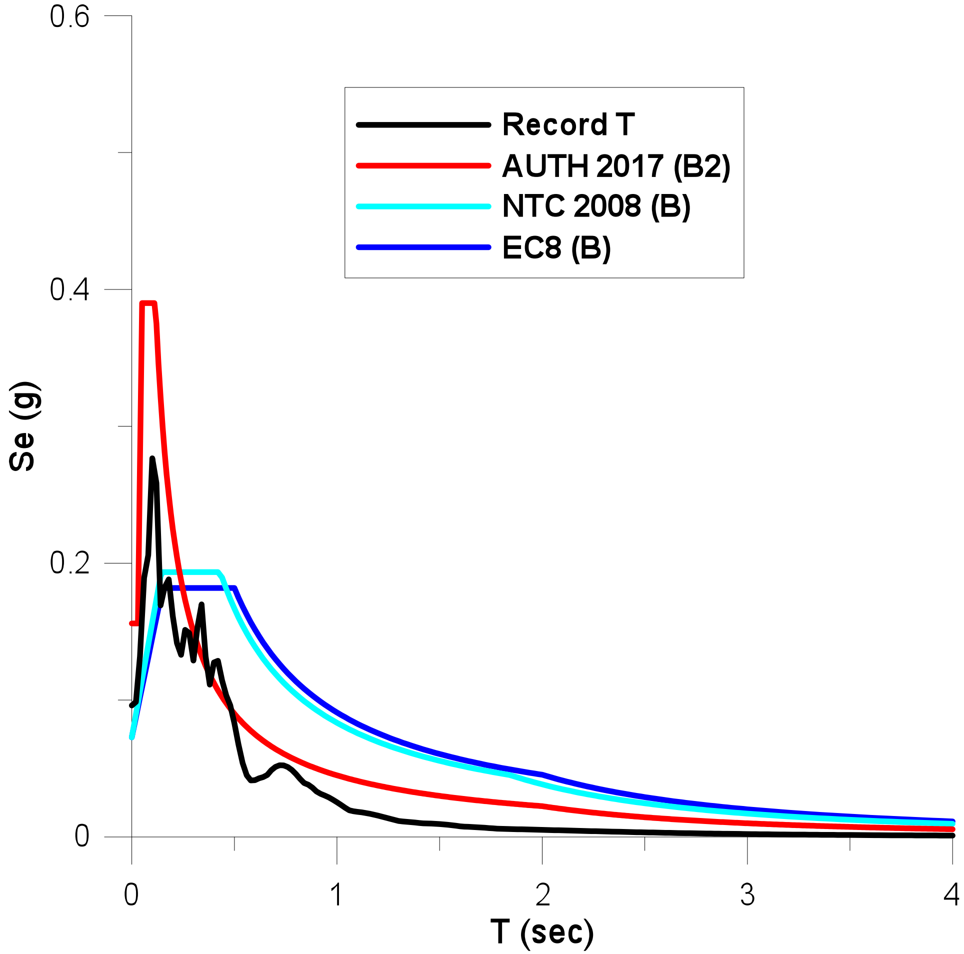
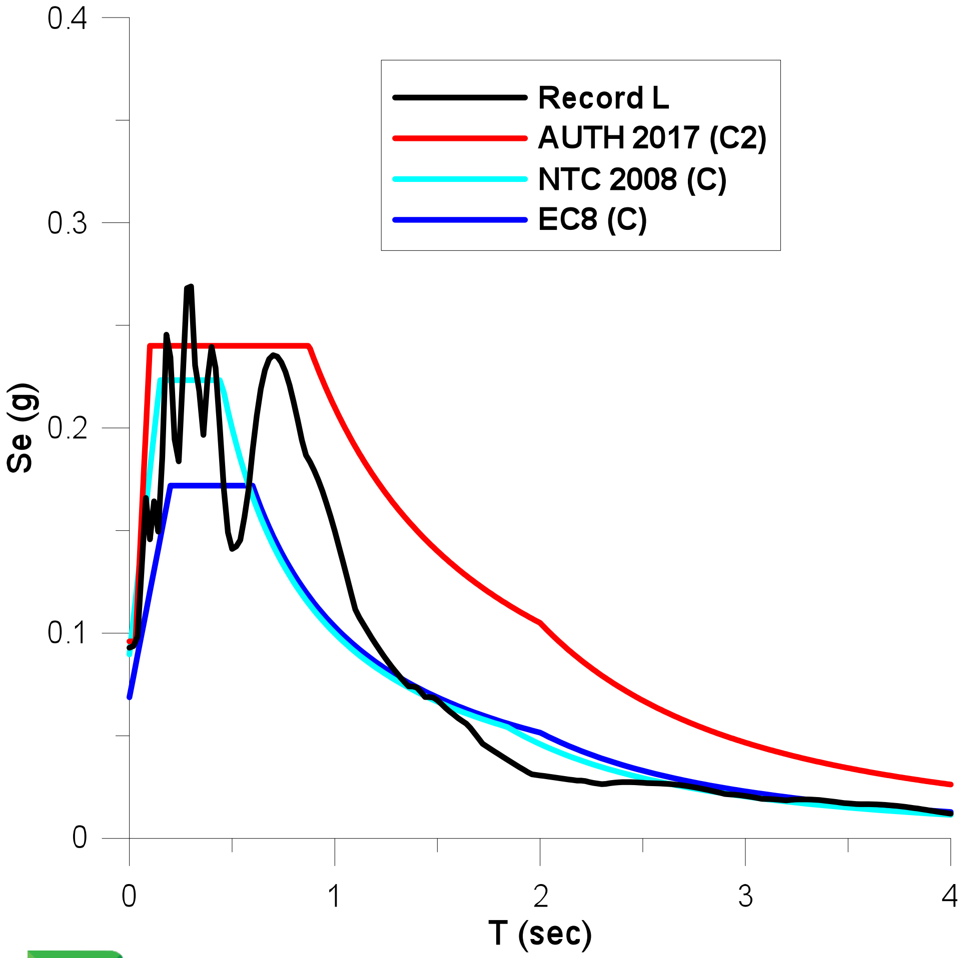
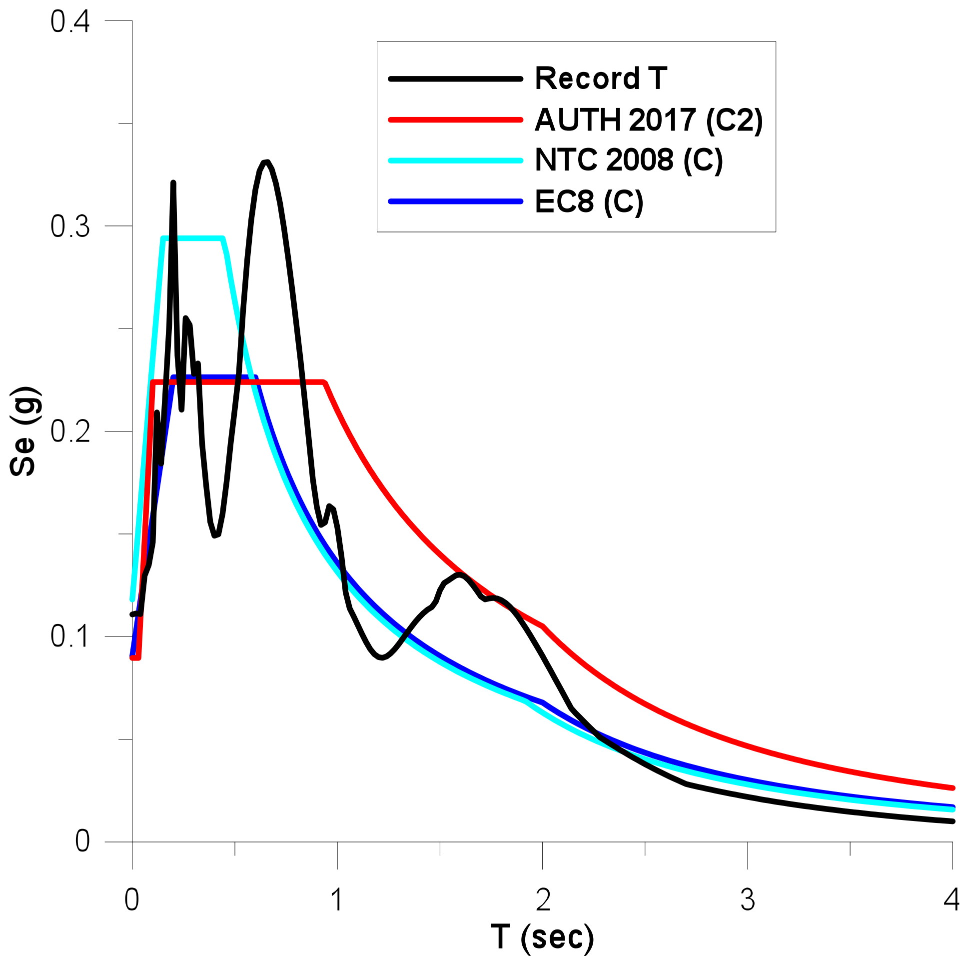
Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
L'AQUILA - V. ATERNO - CENTRO VALLE (AQV)	L T	CENTRAL ITALY Long CENTRAL ITALY Trans	07-04-2009 17:47:37	5.5	14.30	0.151 0.096





Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
BUIA (BUI)	L T	FRIULI 2ND SHOCK Long FRIULI 2ND SHOCK Trans	15-09-1976 03:15:18	5.9	11.20	0.093 0.111





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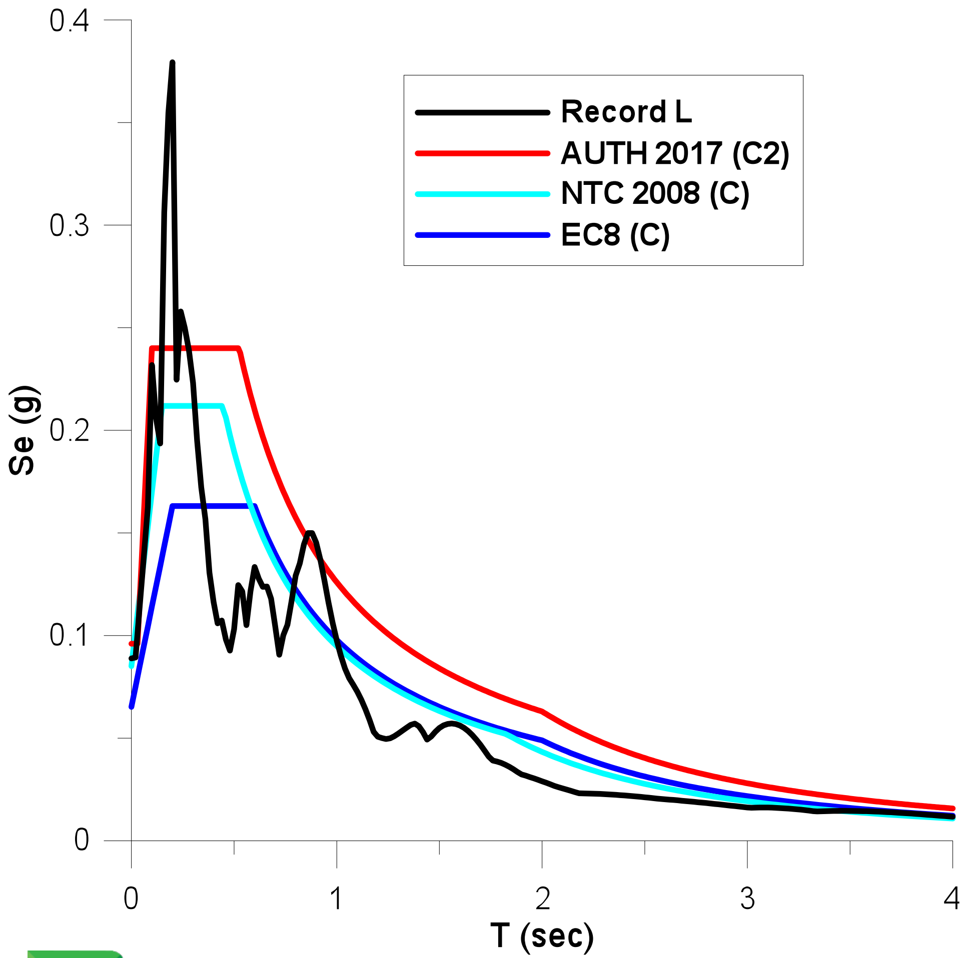
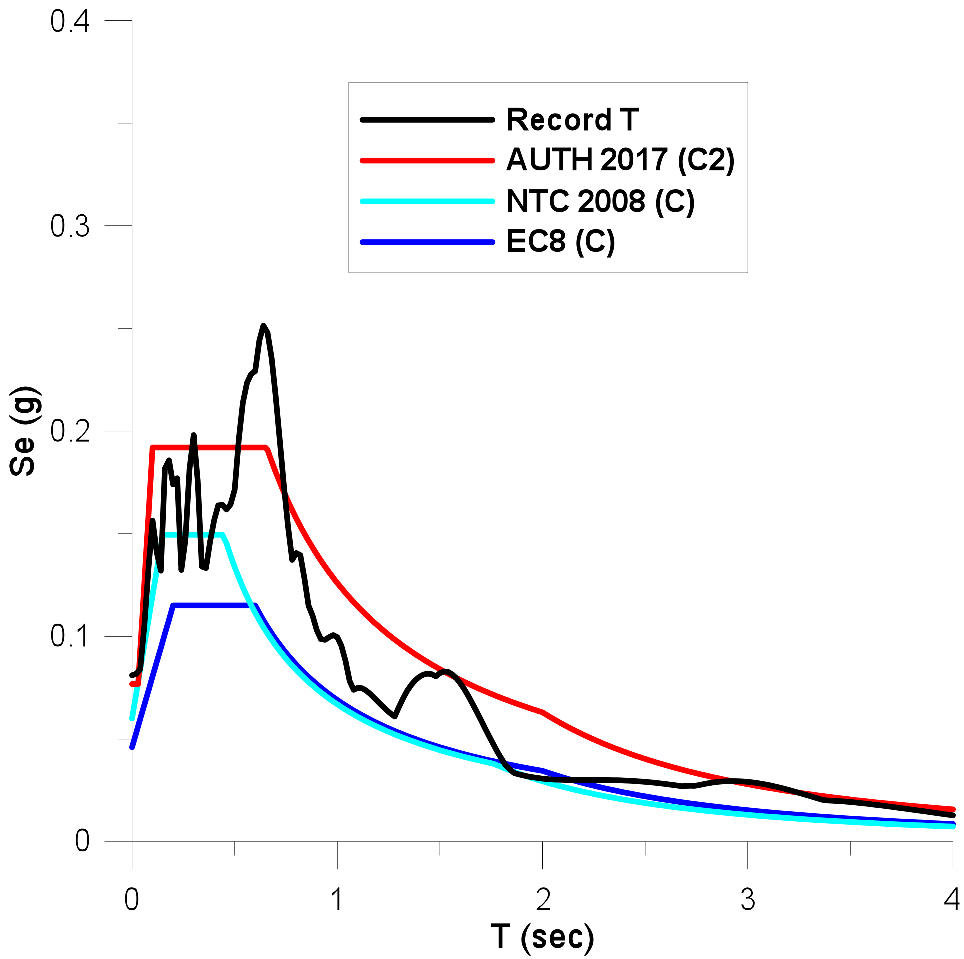
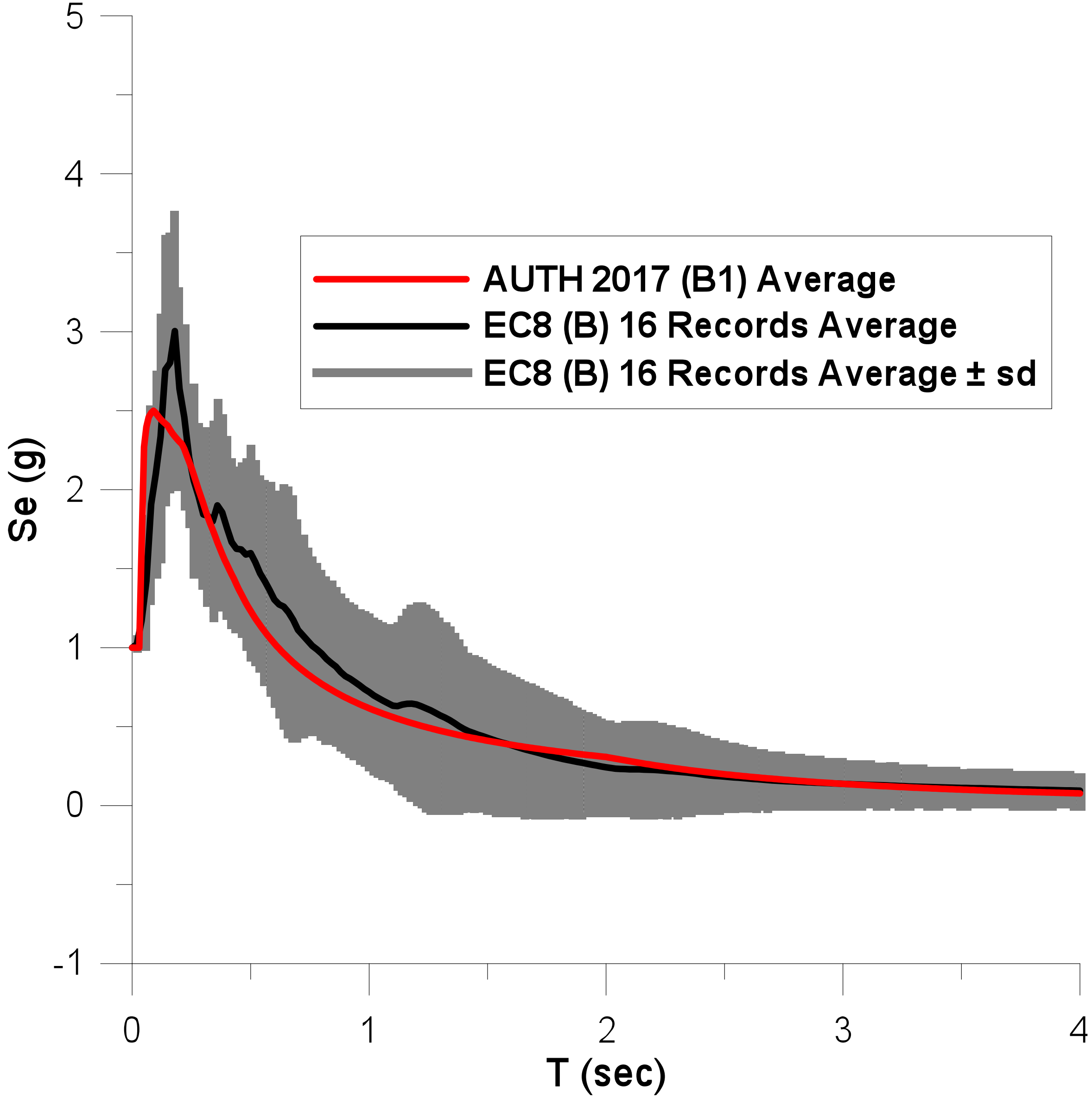
Station Name	Record	Earthquake name	Date	M_W	R epi. [km]	PGA [g]
BUIA (BUI)	L	FRIULI 3RD SHOCK Long	15-09-1976	6.0	10.80	0.089
	T	FRIULI 3RD SHOCK Trans	09:21:18			0.081





Normalized Response Spectra

ITACA Records
N=16



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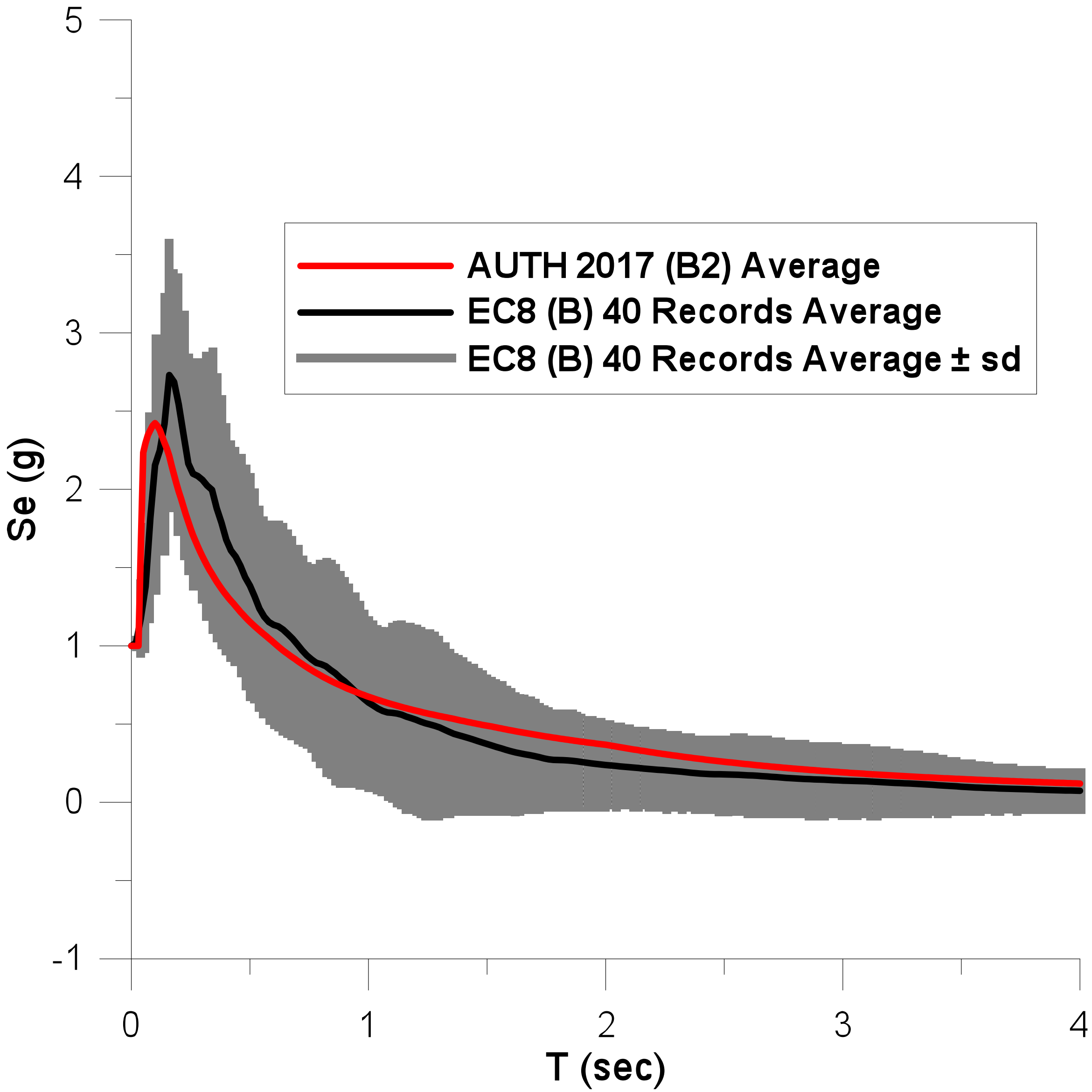
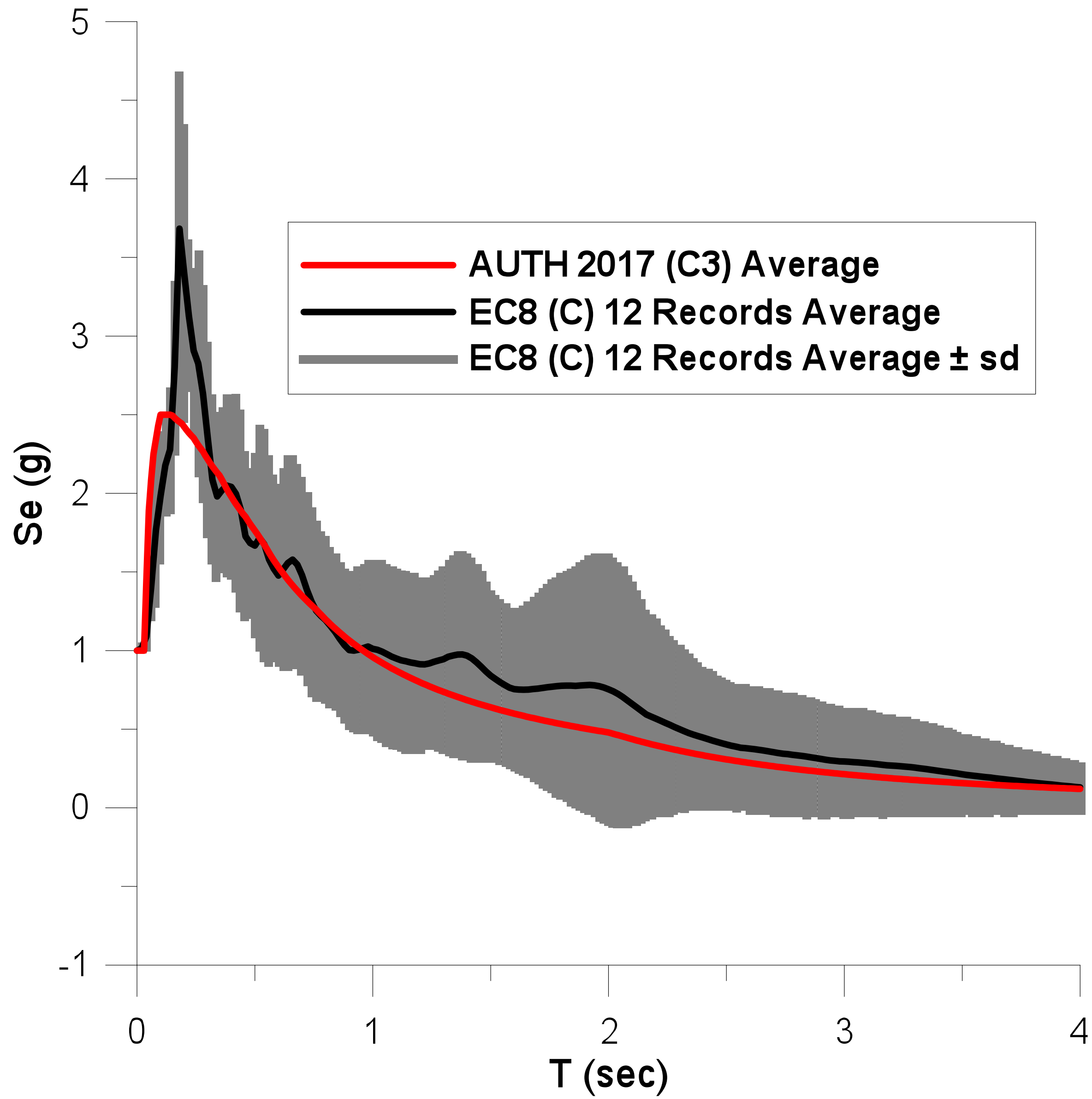
Normalized Response Spectra

ITACA Records
N=30



Normalized Response Spectra

ITACA Records
N=12



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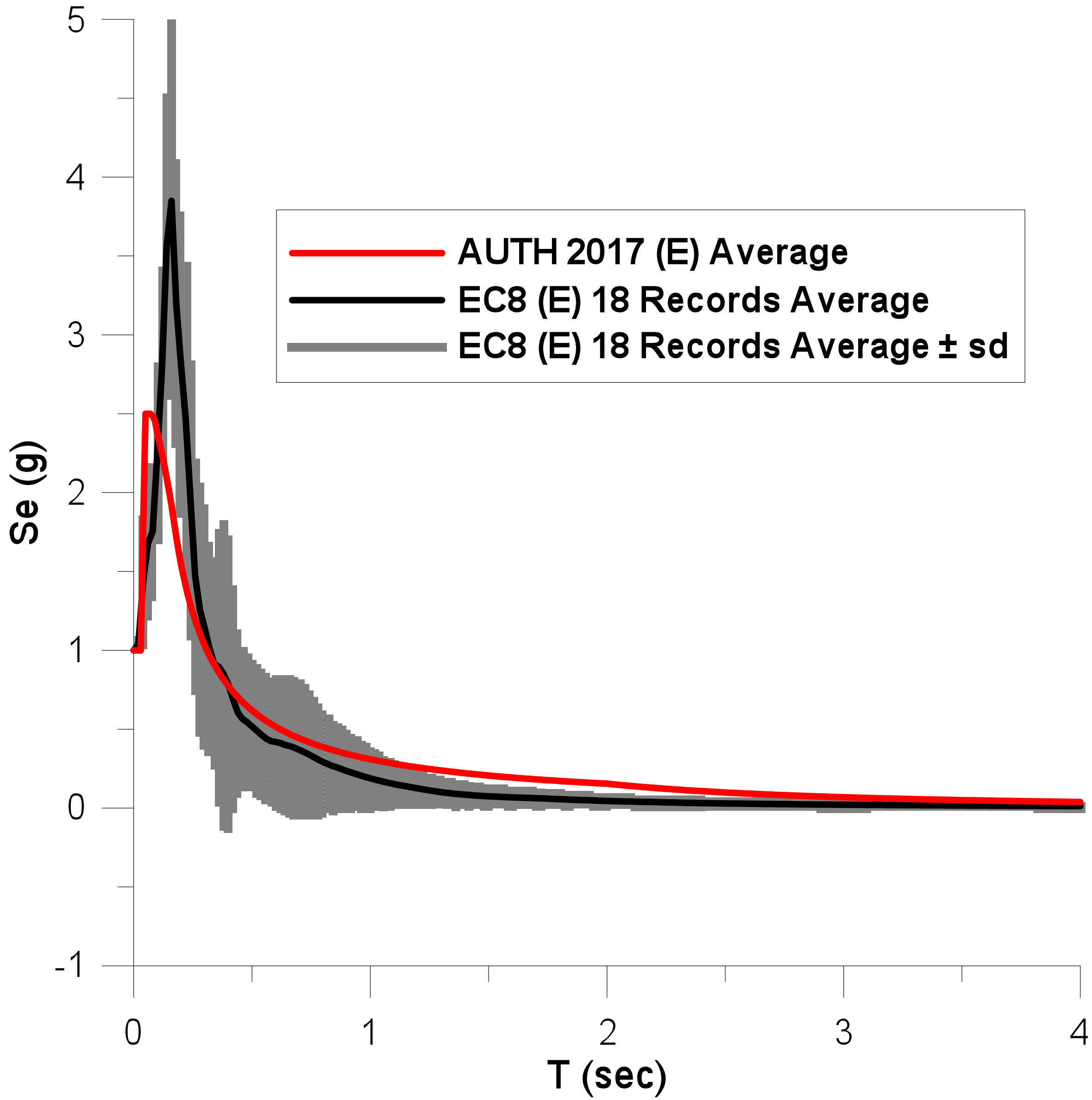
Normalized Response Spectra

ITACA Records



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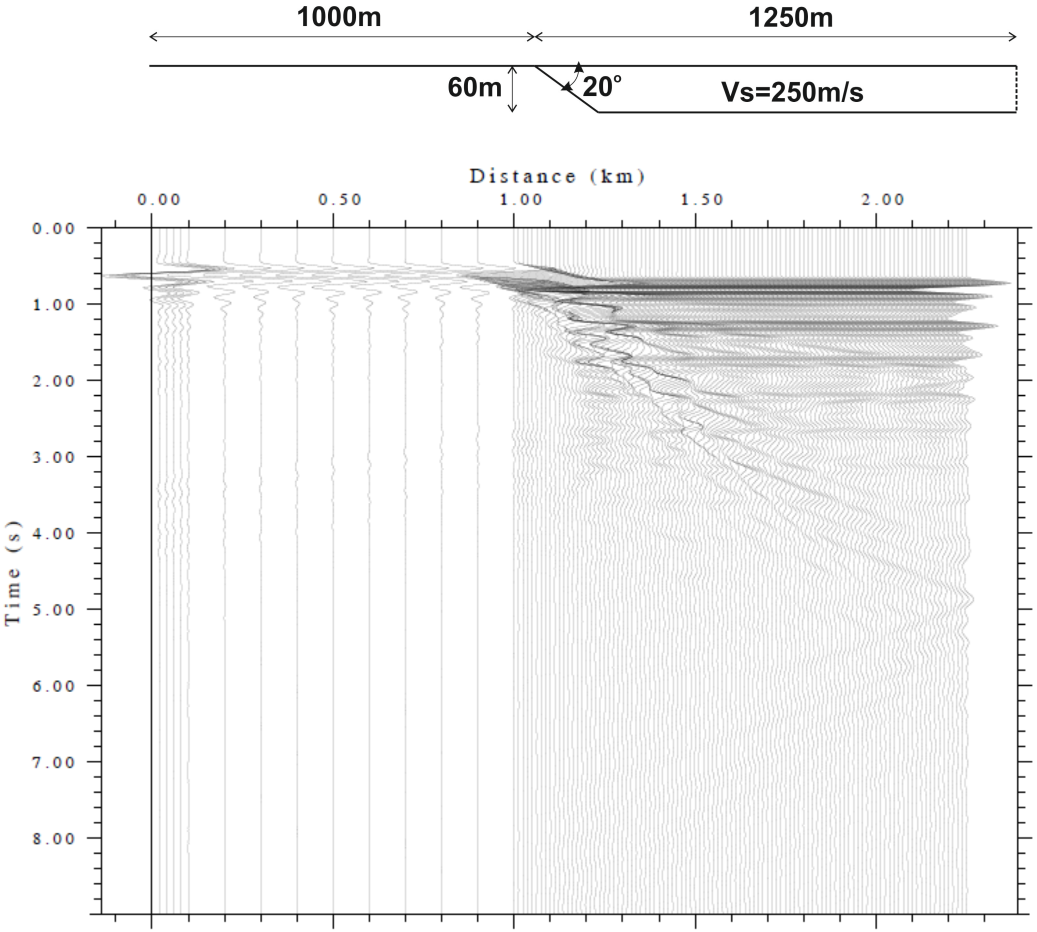
Aggravation factors to account for basin and valley effects

Related publication

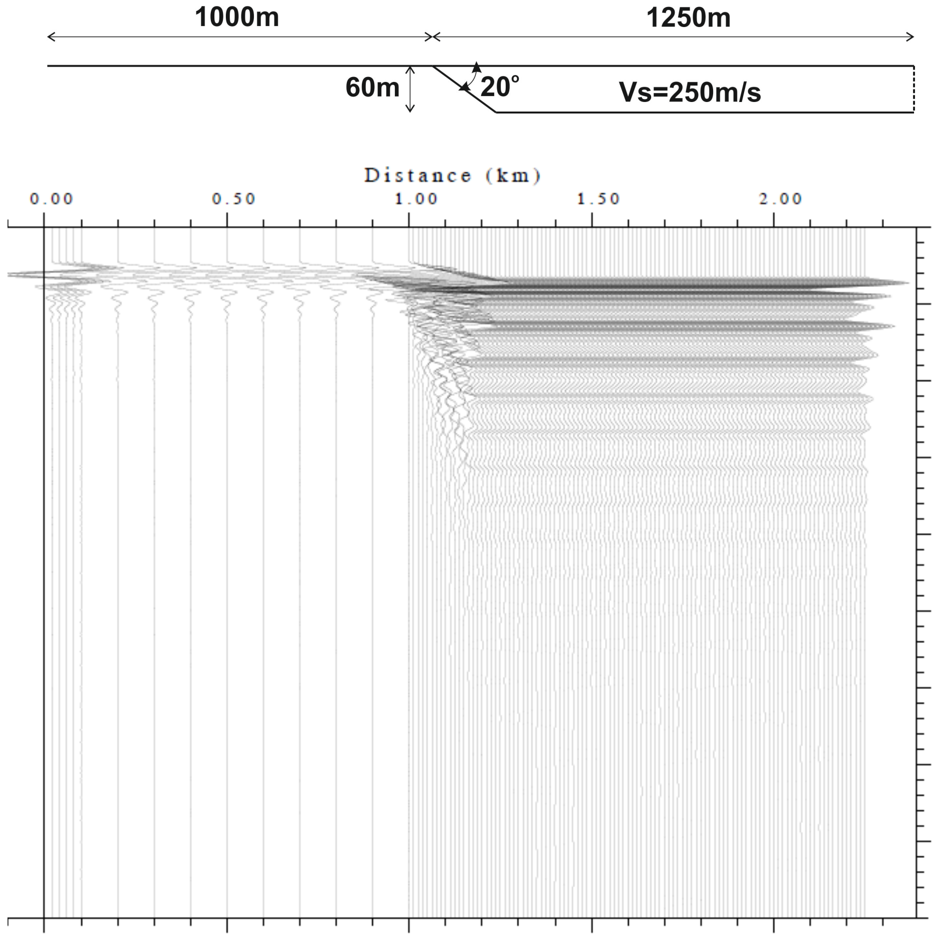
- **Riga E., Makra K., Pitilakis K., 2016**, "Aggravation factors for seismic response of sedimentary basins: A code-oriented parametric study", Soil Dynamics and Earthquake Engineering, Special Issue of Earthquake Engineering and Soil Dynamics (SOILDYN); Invited Paper at the 6th International Conference on Earthquake Geotechnical Engineering (6ICEGE), Christchurch, New Zealand, 2-4 November 2015, vol. 91, pp. 116-132, DOI: 10.1016/j.soildyn.2016.09.048.
- **Riga E., Makra K., Pitilakis K., 2017**, "Investigation of the effects of sediments inhomogeneity and nonlinearity on aggravation factors for sedimentary basins. Submitted to Soil Dynamics and Earthquake Engineering (SOILDYN); **Special Issue: Site effects and seismic codes.**

Parametric analyses

2D analysis



1D analysis



Aggravation factors

- The additional effect of the 2D response at different locations at the surface of the basin with respect to the corresponding 1D response of the isolated soil columns in each location is quantified through a period-dependent seismic aggravation factors (AGF):

$$AGF(T) = \frac{\text{Spectral acceleration from 2D analysis}}{\text{Spectral acceleration from 1D analysis}}$$

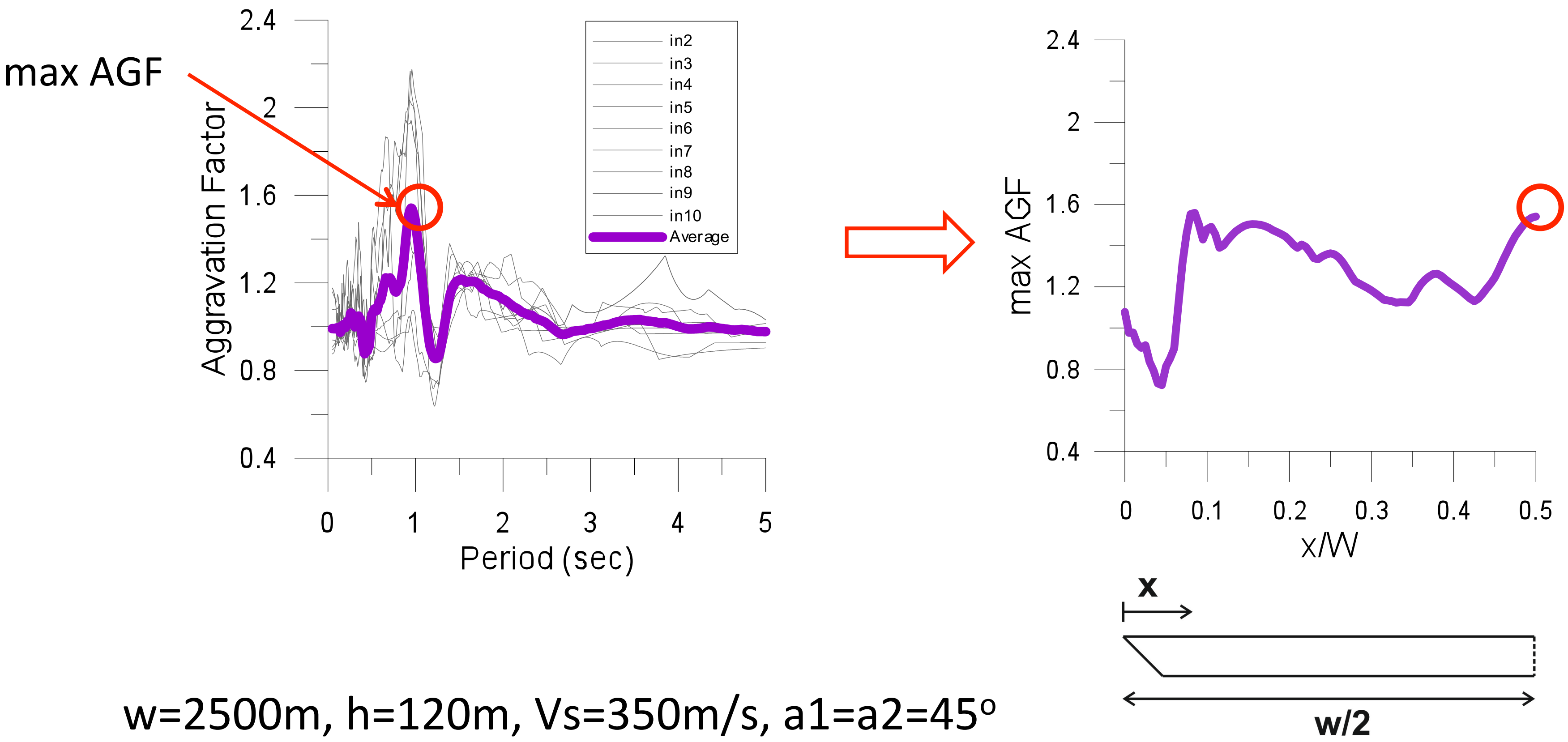
Chávez-García and Faccioli (2004)

- A period-dependent aggravation factor is computed at each receiver for each model and each input.

- For each model, the average period-dependent aggravation factor is calculated from the 9 accelerograms at each receiver.

- The maximum value of the average period-dependent aggravation factor at each receiver is identified.

Maximum aggravation factors

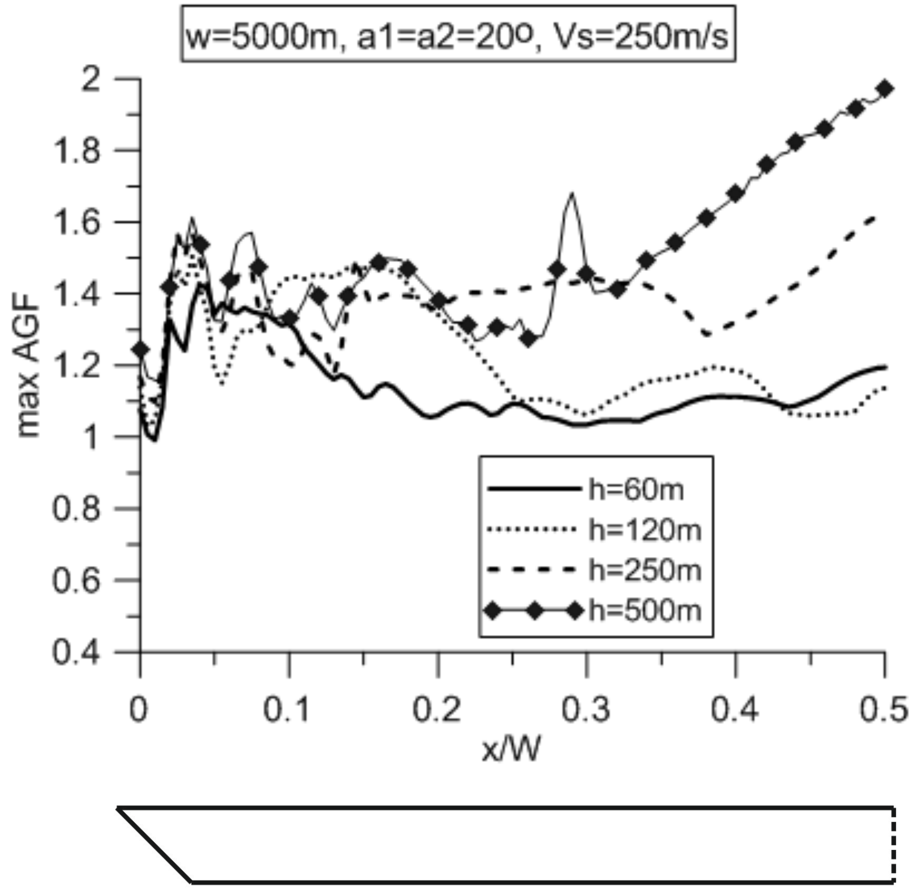


w=2500m, h=120m, Vs=350m/s, a1=a2=45°

center of basin (x/w=0.5)

Maximum aggravation factors

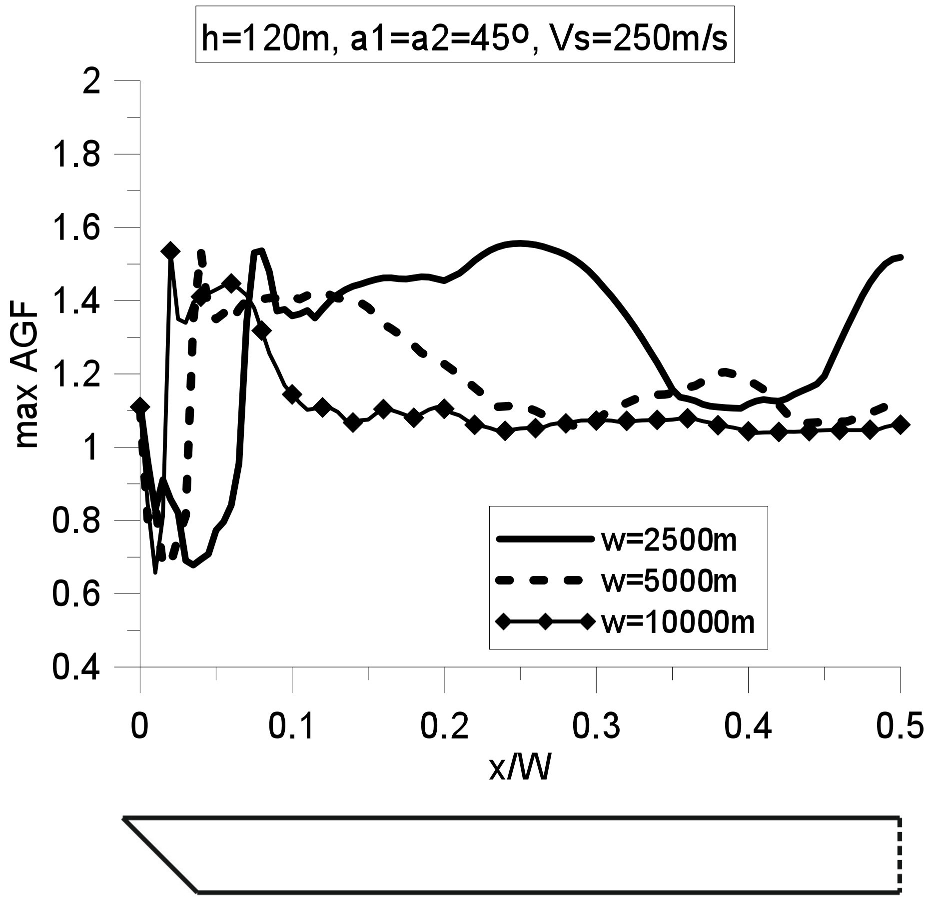
Influence of basin thickness (h)



- Increase of thickness → higher AGF, especially for sediments with low Vs

Maximum aggravation factors

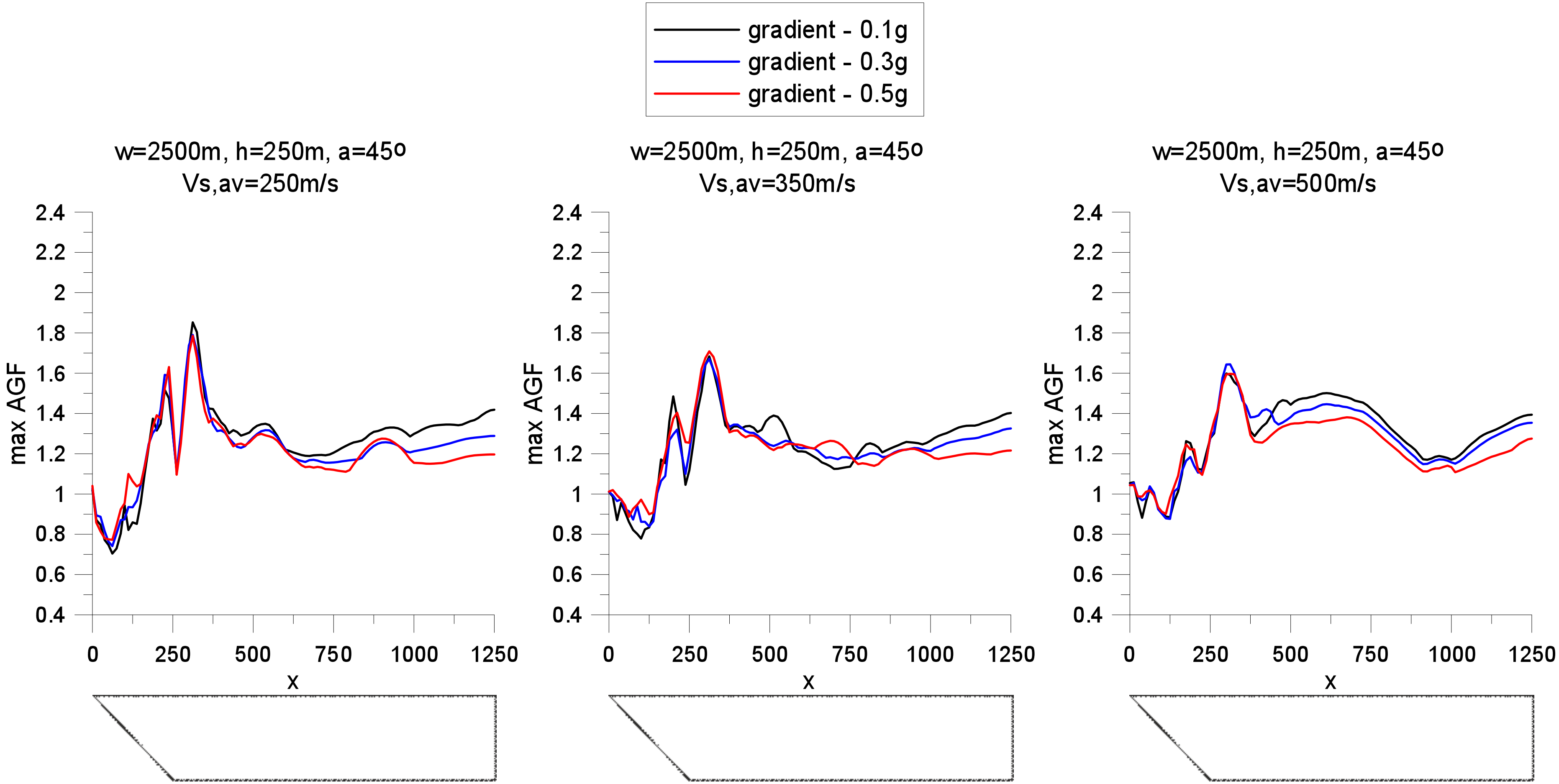
Influence of basin width (w)



➢ Increase of width →smaller AGF at the center of the basin

Maximum aggravation factors

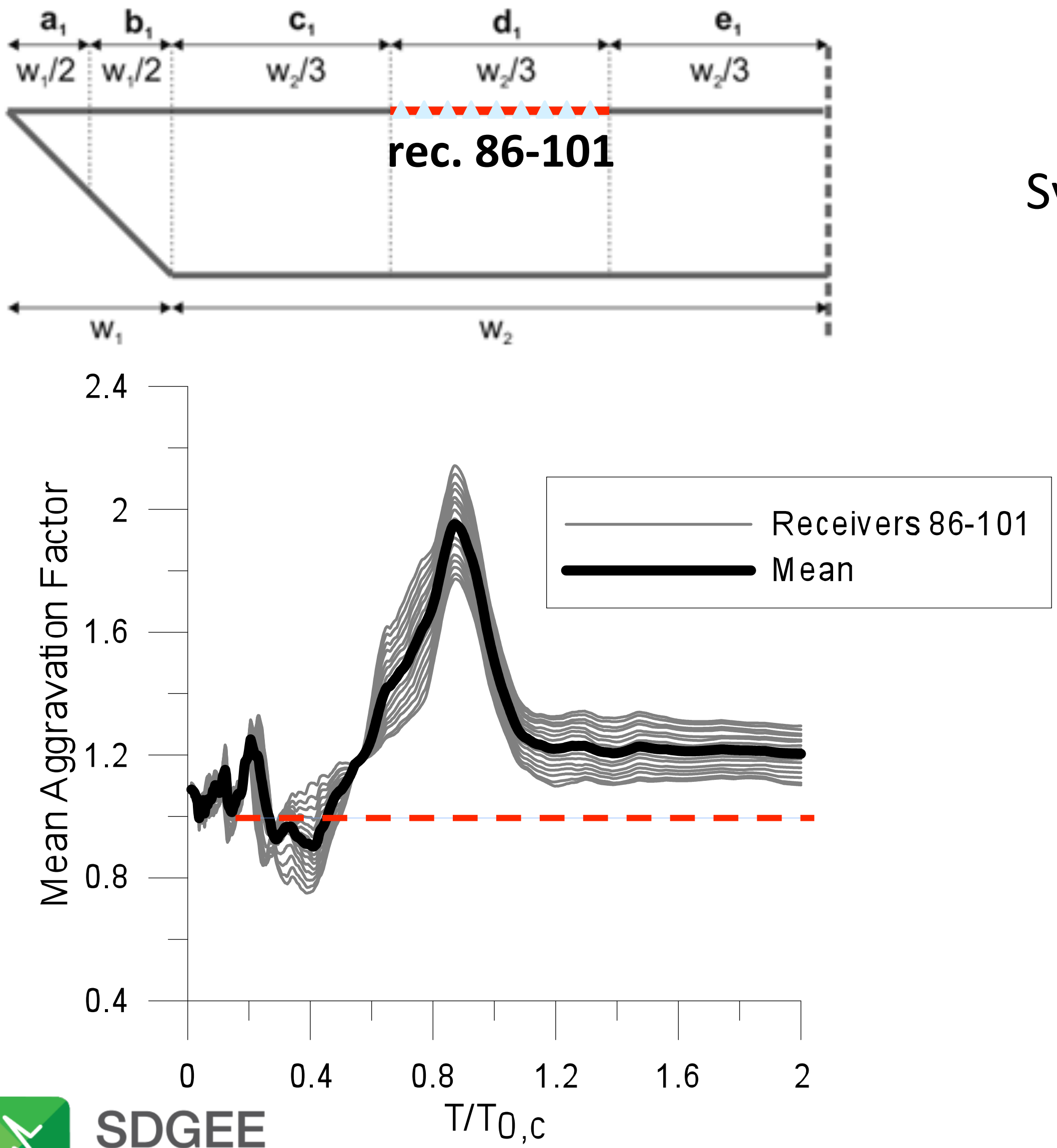
Effect of soil nonlinearity



Riga (2015)

- ➢ Consideration of soil nonlinearity for the sediments material does not affect the estimated aggravation factor significantly (small decrease of AGF far from the basin edge and minor increase close to the basin edge)

Towards practical recommendations: Spatial distribution of AGF



Symmetrical models:

Region d1 of model w1h3a1Vs1
w=2500m
h=250m,
a1=a2=20º
Vs=250m/s

$T_{0,c}$=4h/Vs
1D fundamental period
at the flat part of the basin

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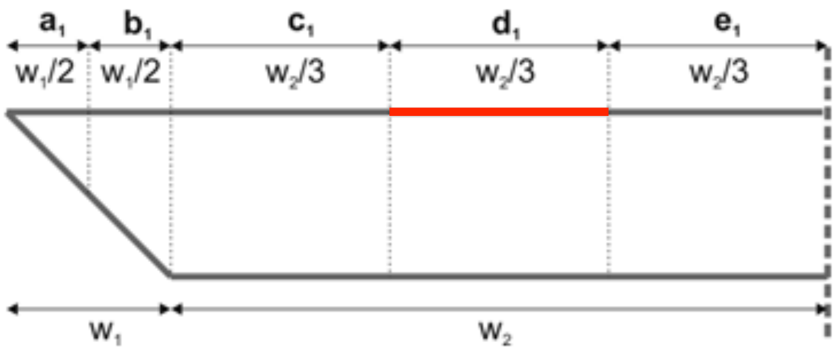
Preliminary recommendations for EC8

max AGF (Riga et al. (2016))

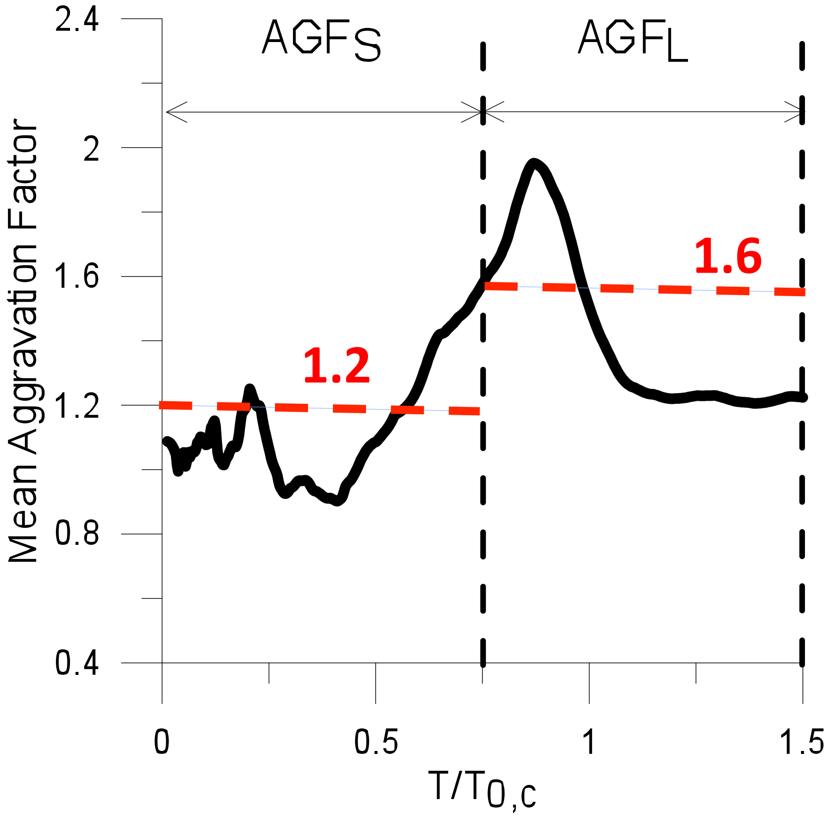
$T_{0,c}$		Region a1	Region b1	Region c1	Region d1	Region e1
Sallow basins $T_{0,c}$<3.0s	median	1.00	0.80	1.20	1.10	1.10
	84th	1.00	1.20	1.30	1.30	1.20
Deep basins $T_{0,c}$≥3.0s	median	1.10	1.20	1.50	1.50	1.90
	84th	2.00	1.40	1.70	1.90	2.30

For strong seismic excitations, only a small decrease of AGF of about 10% is expected at the flat part of the basin (regions c1, d1 and e1) (Riga et al., 2017).



Towards practical recommendations for EC8

Region d1 of model **w1h3a1Vs1**
(w=2500m, h=250m, a1=a2=20º , Vs=250m/s)



- **Short-period average for periods less than $0.75T_{0,c}$:**

  AGF_S=1.2

- **Long-period average for periods between $0.75T_{0,c}$-$1.50T_{0,c}$:**

  AGF_L=1.6

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Preliminary recommendations for EC8

Short-period AGF_S

$T_{0,c}$		Region a1	Region b1	Region c1	Region d1	Region e1
Sallow basins	median	0.80	0.70	1.10	1.05	1.00
$T_{0,c}$<3.0s	84th	0.90	1.00	1.15	1.10	1.10
Deep basins	median	0.80	0.70	1.10	1.10	1.15
$T_{0,c}$≥3.0s	84th	0.90	1.05	1.20	1.15	1.25

Long-period AGF_L

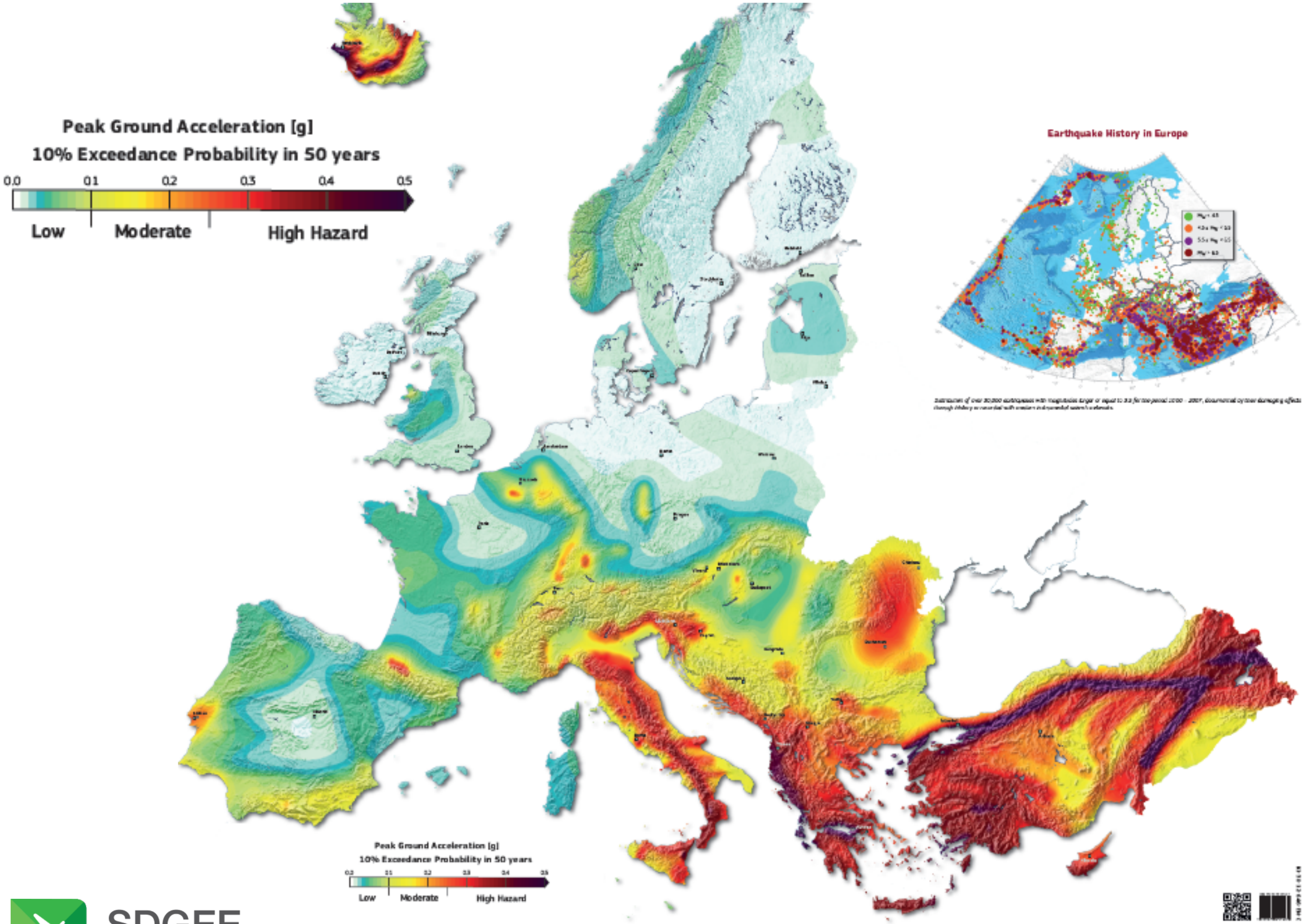
$T_{0,c}$		Region a1	Region b1	Region c1	Region d1	Region e1
Shallow basins	median	1.00	0.70	1.00	1.05	1.05
$T_{0,c}$<3.0s	84th	1.05	0.90	1.05	1.15	1.15
Deep basins	median	0.90	0.85	1.10	1.30	1.40
$T_{0,c}$≥3.0s	84th	1.60	1.10	1.30	1.50	1.80

UHS

(to use them or not?)

Seismic Hazard Map (PGA) : Bedrock Vs>800m/s

Return Period = 475 years



UHS (SHARE)

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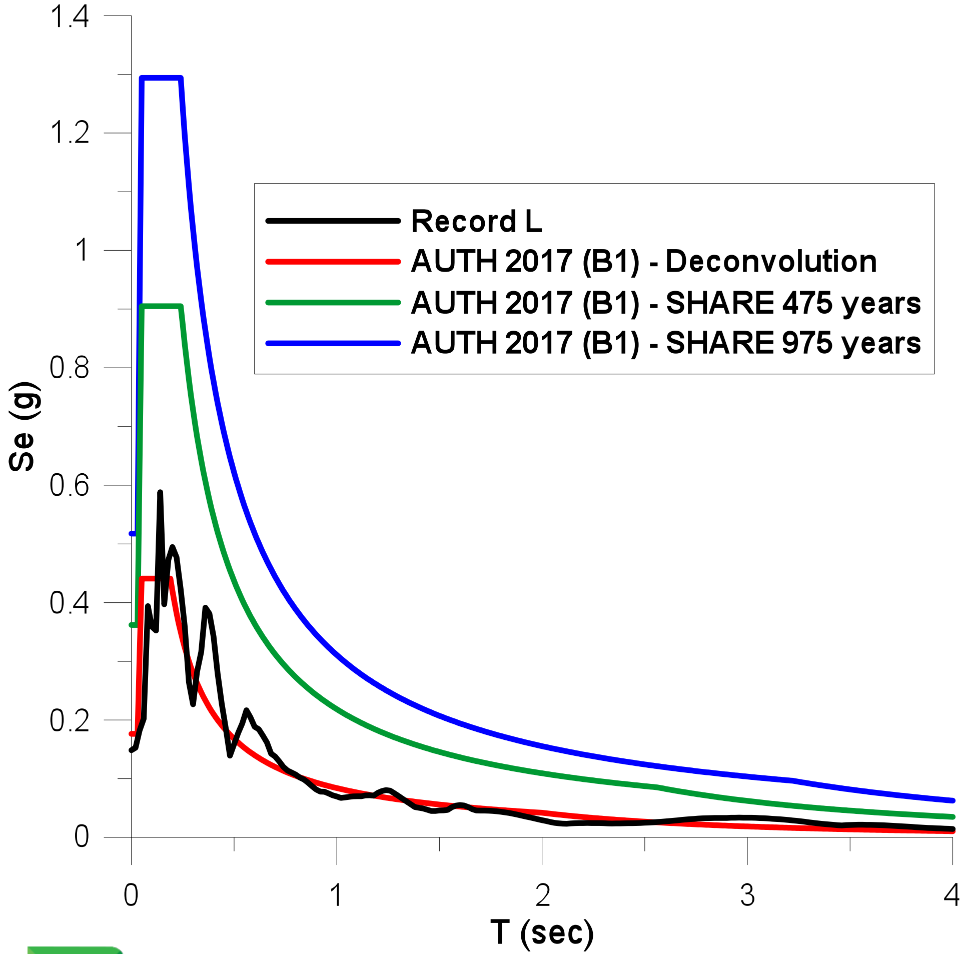

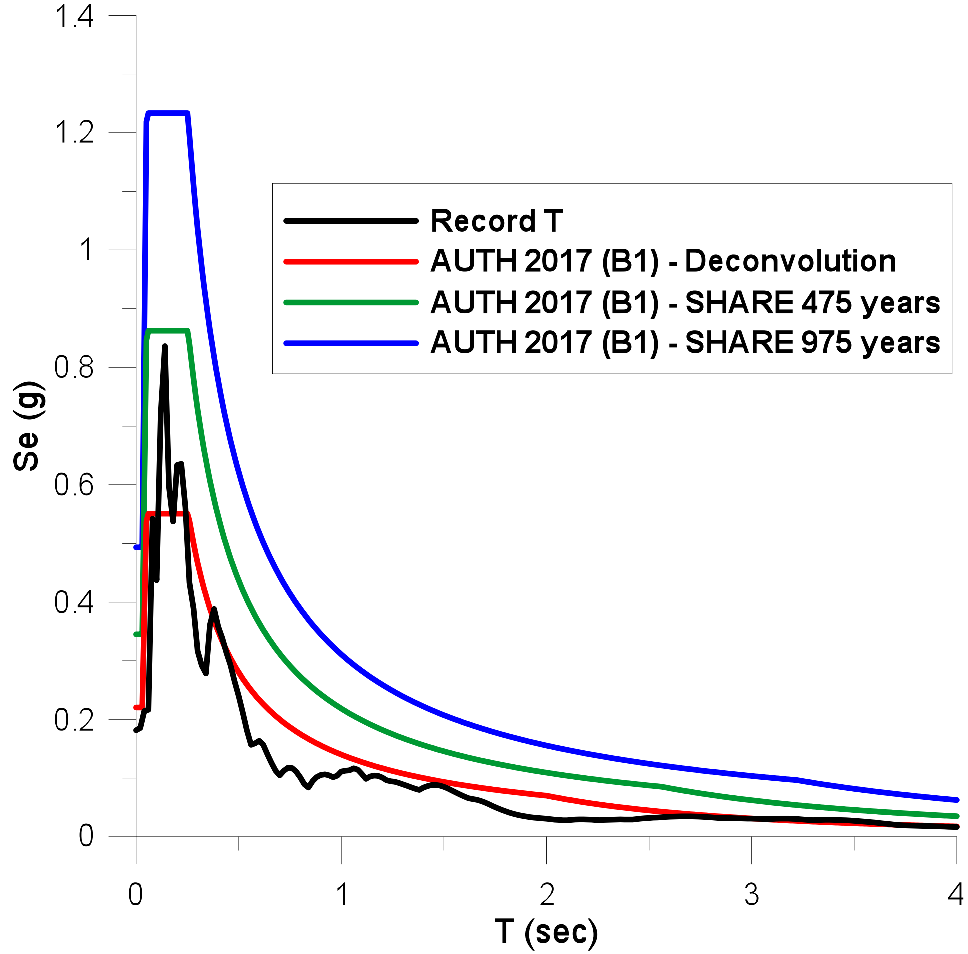

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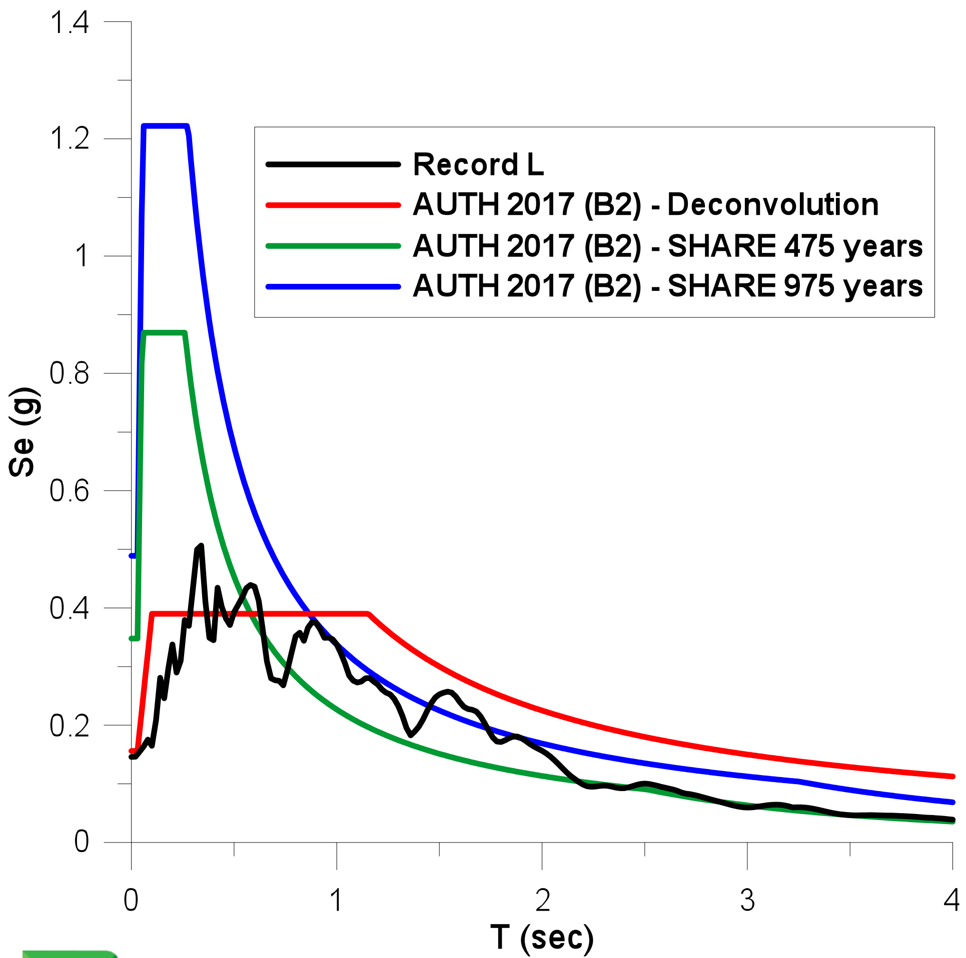

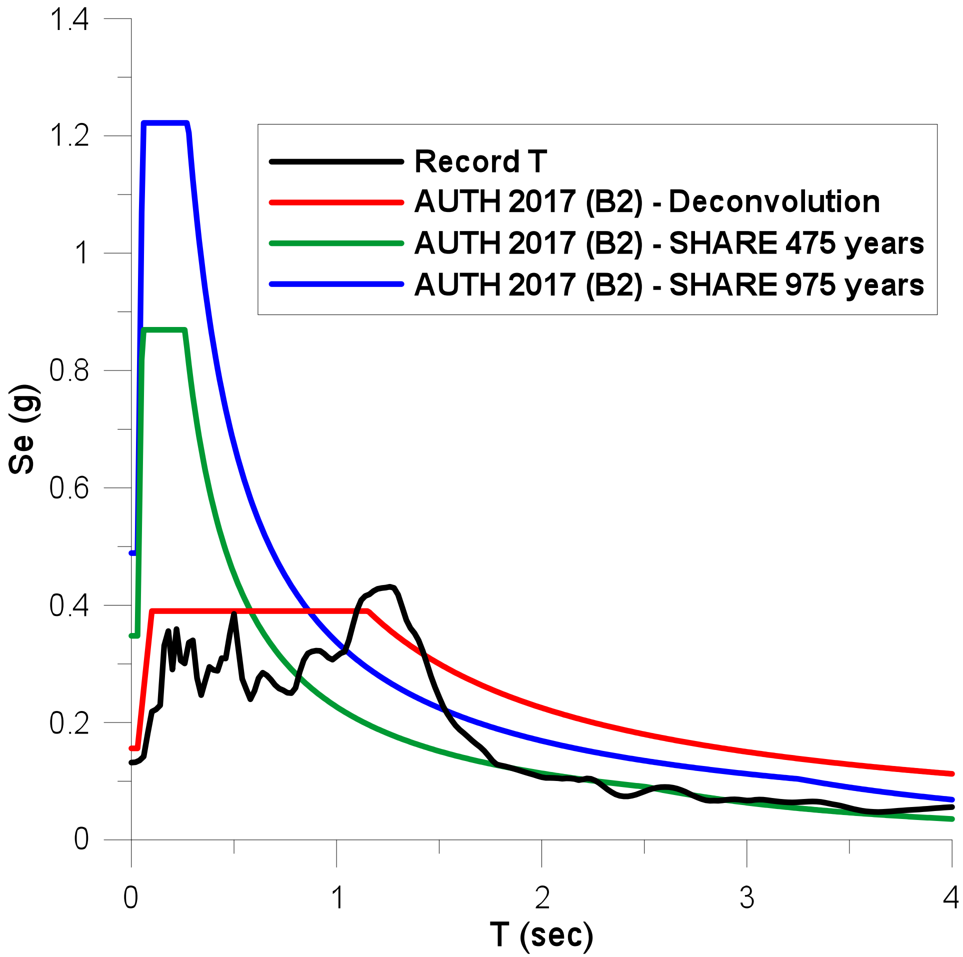

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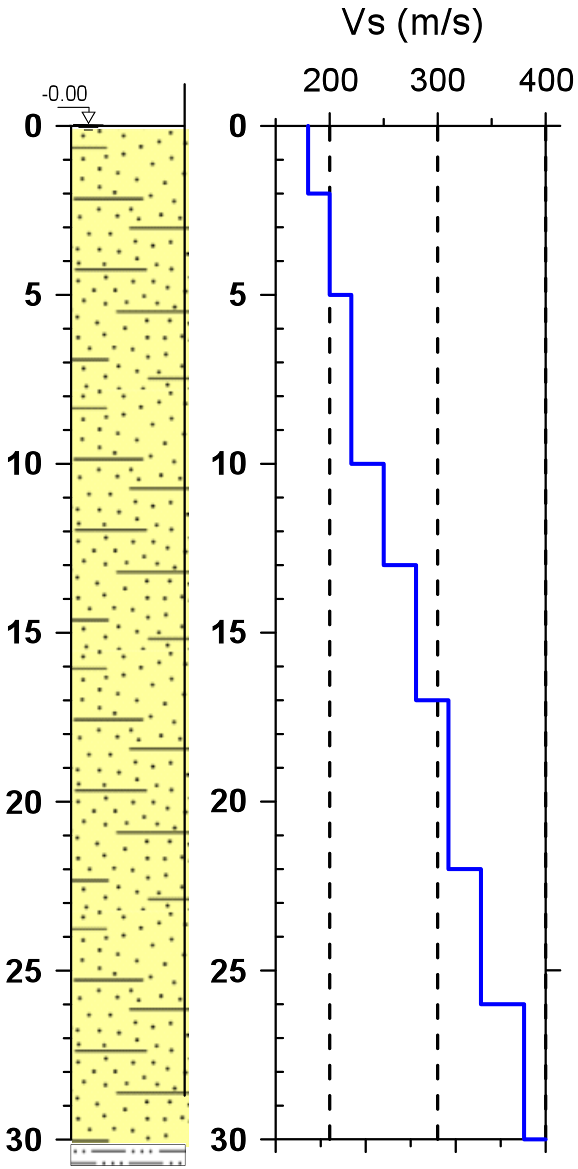
Geotechnical descriptive parameters

(to use them or not?)

1D Theoretical NL Amplification : Site C

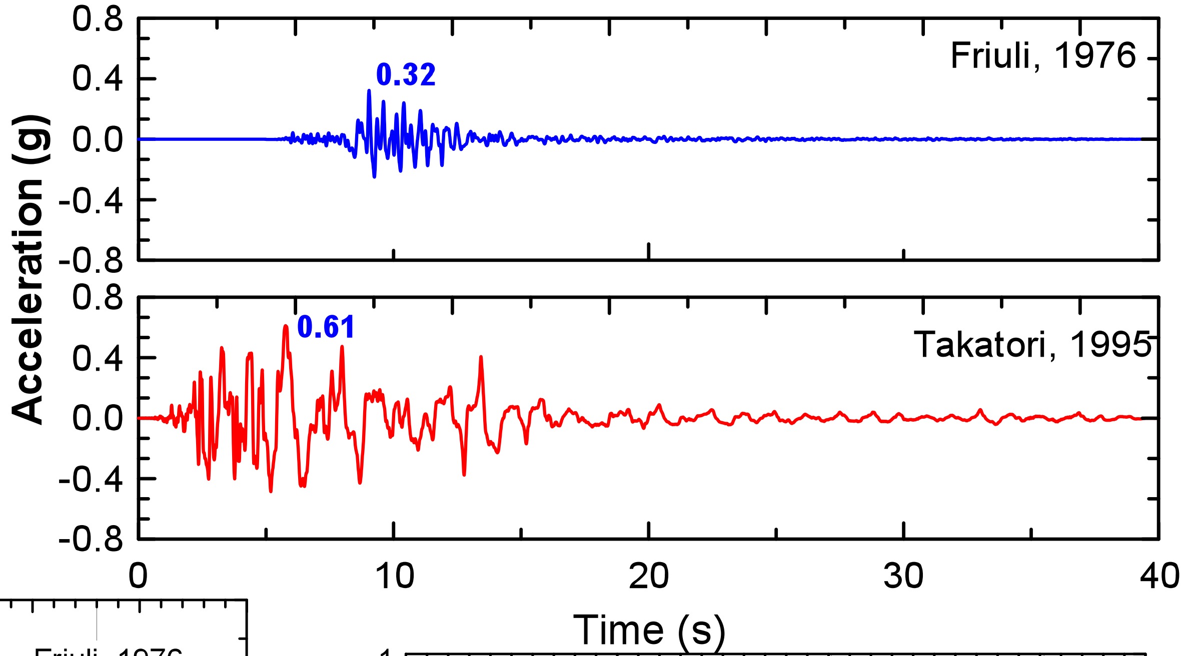


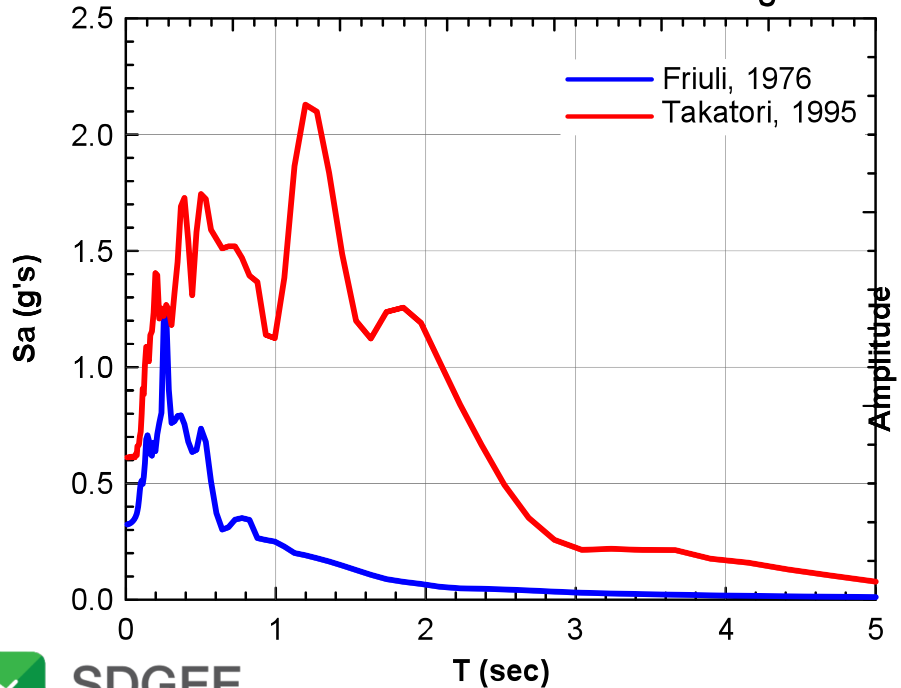
- Two representative soil models :
  EC8 – Class C
  Medium Density Sand and Clay (PI=30)

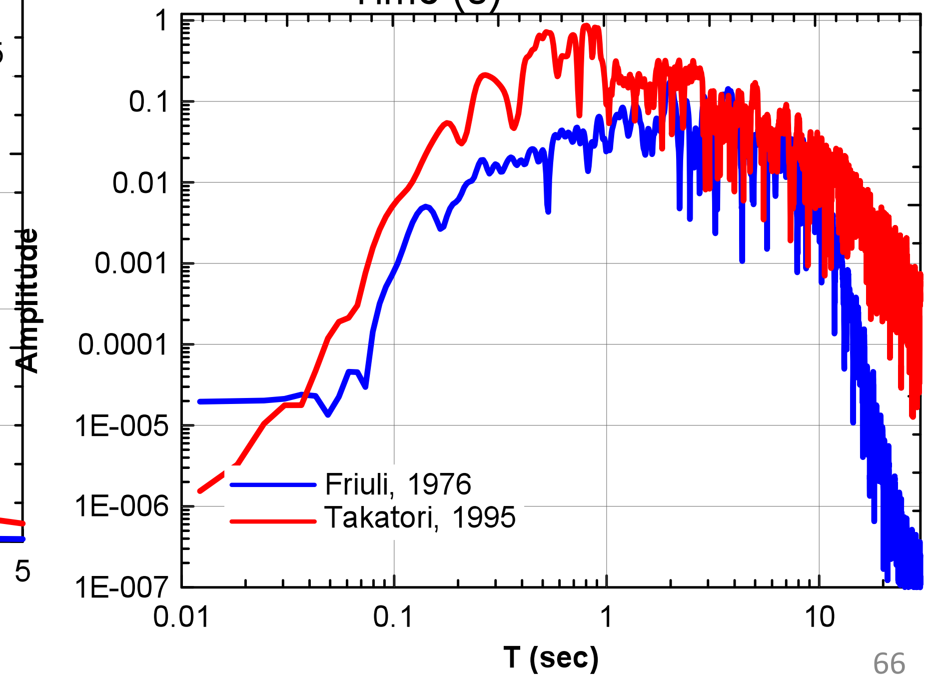
- Vs,30: 260m/s
- To=0.45 s
- fo=2.2 Hz

1D Theoretical NL Amplification : Site C

- 2 time histories







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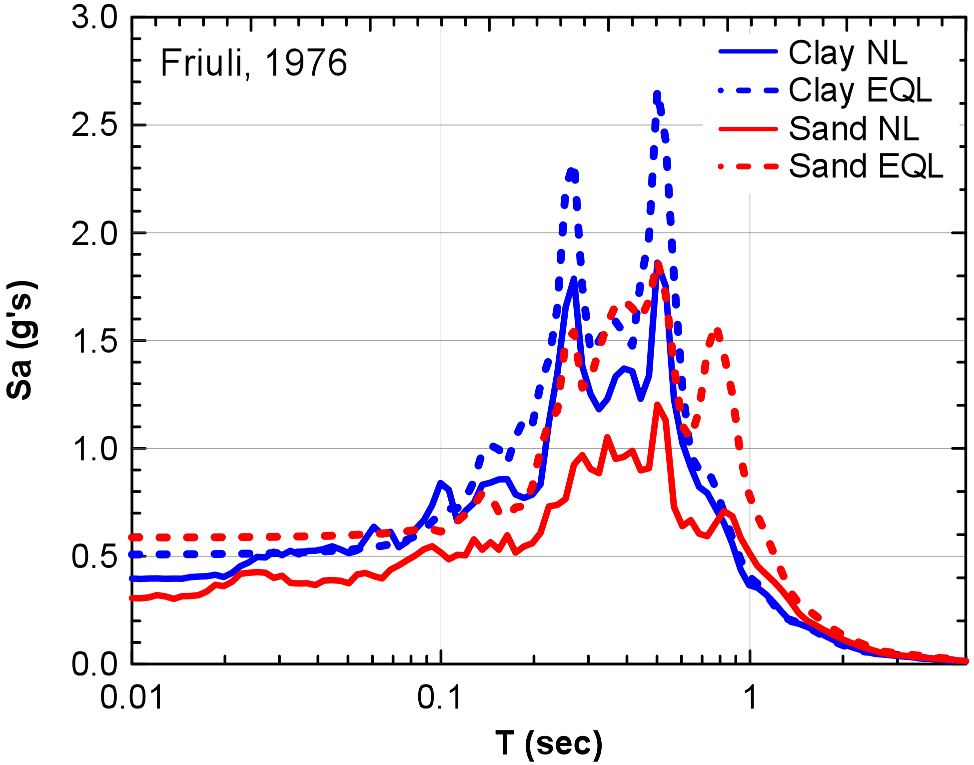
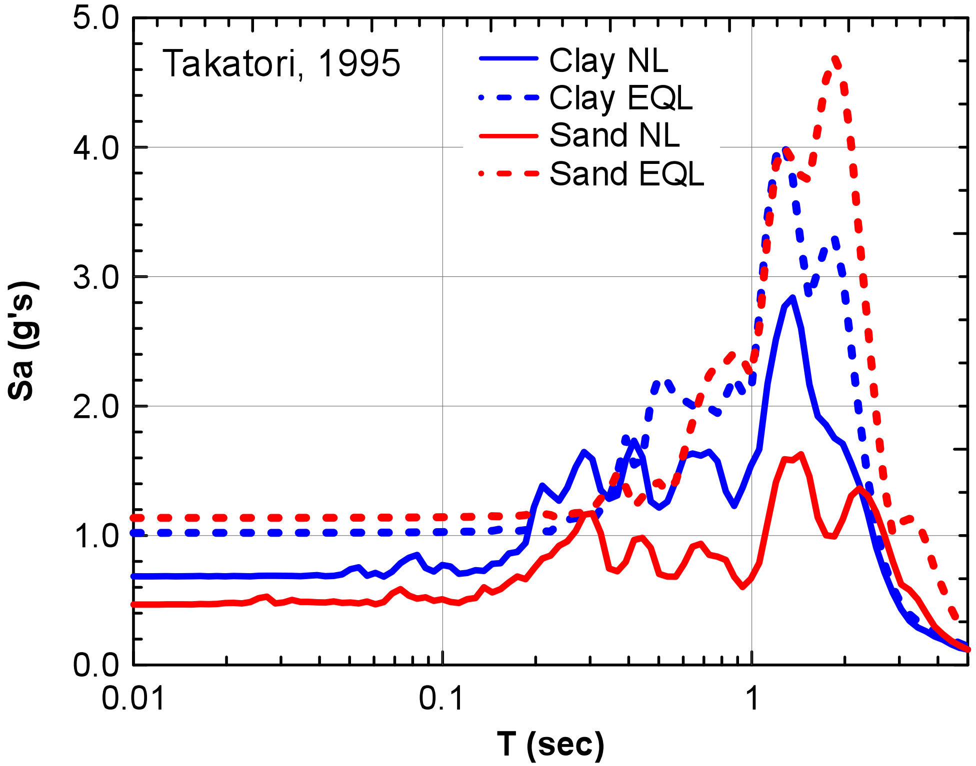
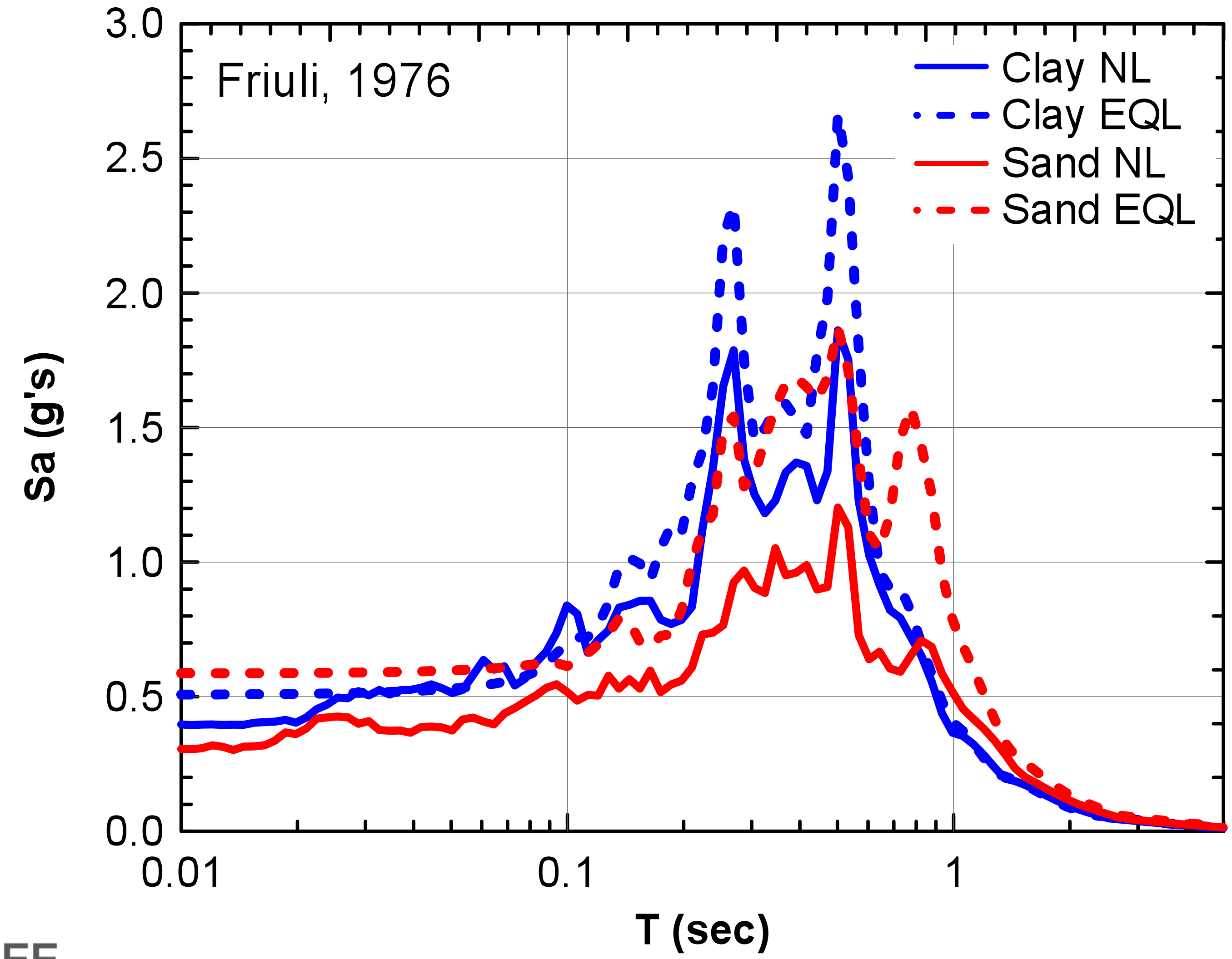
1D Theoretical NL Amplification : Site C

- Response Spectra at Surface





NL soil amplification is strongly depended on the soil type and properties which cannot be described only through Vs,30



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16TH EUROPEAN CONFERENCE ON

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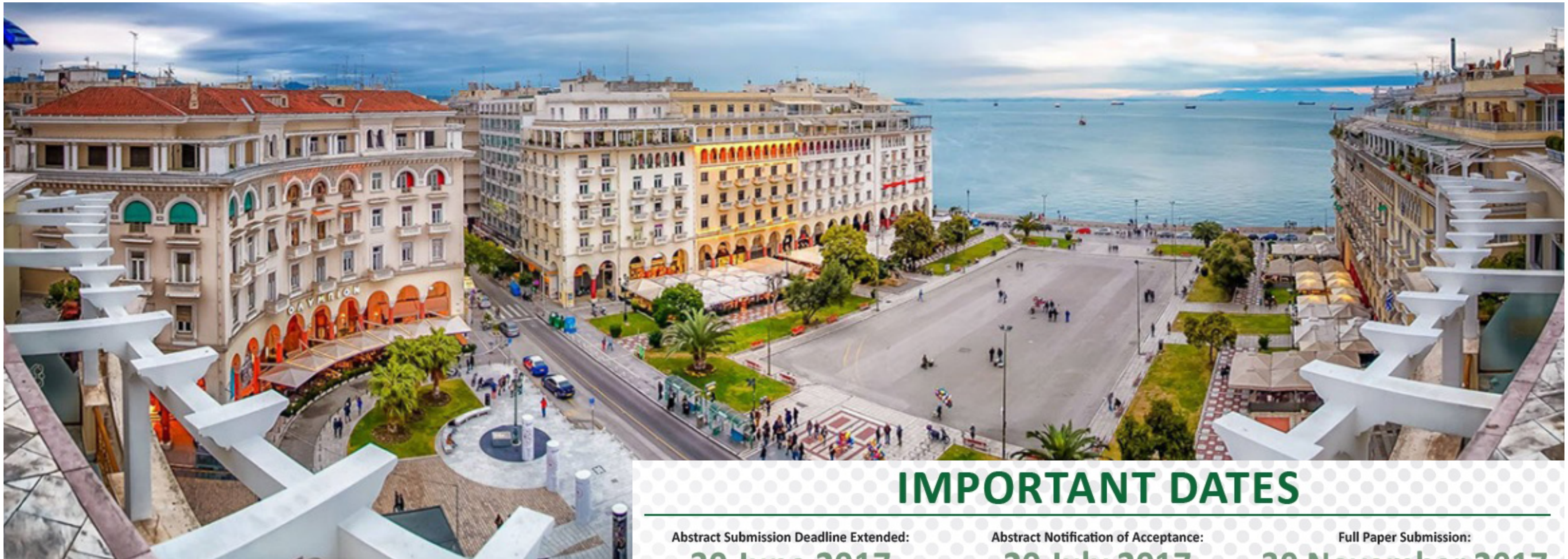

IMPORTANT DATES

Abstract Submission Deadline Extended:
30 June 2017

Abstract Notification of Acceptance:
20 July 2017

Full Paper Submission:
30 November 2017

Paper Notification of Acceptance:
31 January 2018

Final Paper Submission
28 February 2018

Early Bird Registration:
10 April 2018

4+ full days:
Prof. N. Ambraseys Distinguished Lecture
30 Keynote & Theme Lectures
more than 2000 submitted abstracts, Special & Technical Sessions,
Technical committee meetings, Exhibition, Pre & Post Conference Tours

Looking forward to welcoming you to Thessaloniki in June 2018