PRELIMINARY STUDY OF
RIETI EARTHQUAKE
GROUND MOTION DATA V1.0

Consiglio Nazionale delle Ricerche

INGV

reluis

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1. Introduction

The Italian Accelerometric Network (RAN), managed by the Department of Civil Protection (DPC), and the Italian seismic network (RSN), managed by the Istituto Nazionale di Geofisica e Vulcanologia (INGV) have made available the records of the recent earthquake with epicenter located in the vicinity of Amatrice, central Italy (date 24/08/2016 1.36:32 AM – UTC; Mw 6.0, ref. Bollettino Sismico INGV).

About 200 accelerometric signals, manually processed using the procedure by Paolucci et al (2011), are used to evaluate the peak ground motion, acceleration and displacement spectral ordinates, integral parameters and measures of duration. **Corrected records and details of correction are available on the Engineering Strong-Motion database website (http://esm.mi.ingv.it). The unprocessed records are available at http://ran.protezionecivile.it/IT/index.php?evid=340867 for the RAN network and at the European Integrated Data Archive (http://www.orfeus-eu.org/data/eida/) for the RSN, that includes local networks (University of Genova, University of Trieste, AMRA, among others).**

 In order to analyze peak values and spectral acceleration (Sa or PSA), data have been processed and compared to the Ground Motion Prediction Equation (GMPE) by Bindi et al (2011) for rock and soil. The geometric mean of the horizontal components are used in the analysis. As a function of epicentral distance and for fixed spectral ordinate, the average attenuation law (and its standard deviation) have been compared with the points corresponding to the values recorded at the various stations.

Moreover *Peak Ground Acceleration* (PGA), *Peak Ground Velocity* (PGV) and *Peak Ground Displacement* (PGD) are calculated for the three components and they are reported in Tables 1. *Arias Intensity* (I_A) and Housner Intensity are the integral parameters computed for each record. Durations is computed for each record

as *Significant Duration* (Sd) estimated between 5% and 95% of the I_A. In Tables 2 are reported integral parameters and duration for the three directions of each record.

2. Geographic Information

An earthquake of Mw 6.0 struck central Italy on 2016-08-24 at 01:36:32 GMT (Bollettino sismico INGV), in the vicinity of Amatrice, causing diffuse building collapse and about 250 casualties. The causative fault is normal, the prevalent style of faulting in the area. The location of the epicentre and the distribution of strong-motion stations are reported in Figure 1. Figure 2 reports the shakamp of the event.

The Amatrice seismic sequence struck an area where several large earthquakes occurred in the past. According to the recent historical catalog CPTI15 (Rovida et al., 2016 **http://emidius.mi.ingv.it/CPTI15-DBMI15/**, updated to 2015) the strongest earthquake occurred on 1639 (Amatrice, Io 9-10 MCS, Mw 6.2) and destroyed the Amatrice village and its neighbourhood (Figure 2).
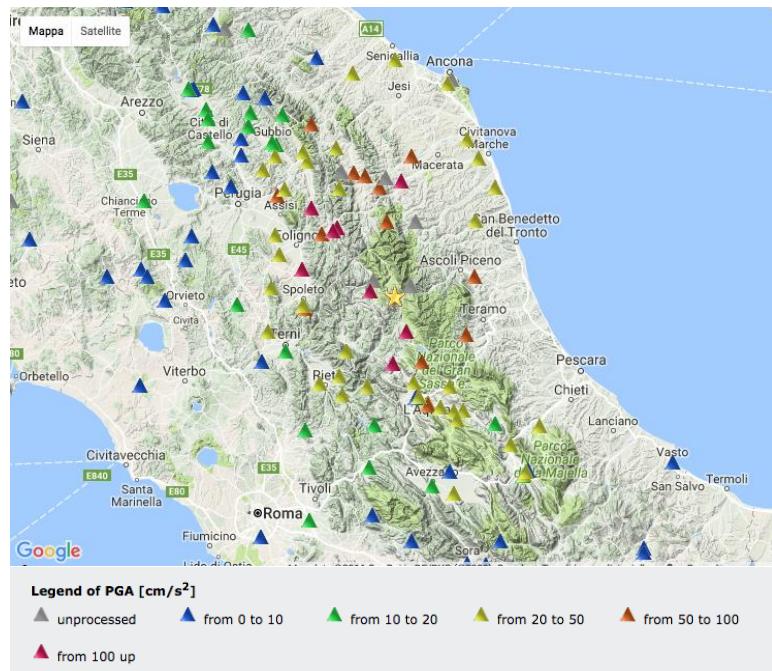

Figure 1: location of the epicentre (yellow star) and strong motion stations within 200 km from the epicentre. The square indicate strong-motion stations and the colours correspond to the PGA values (gal).
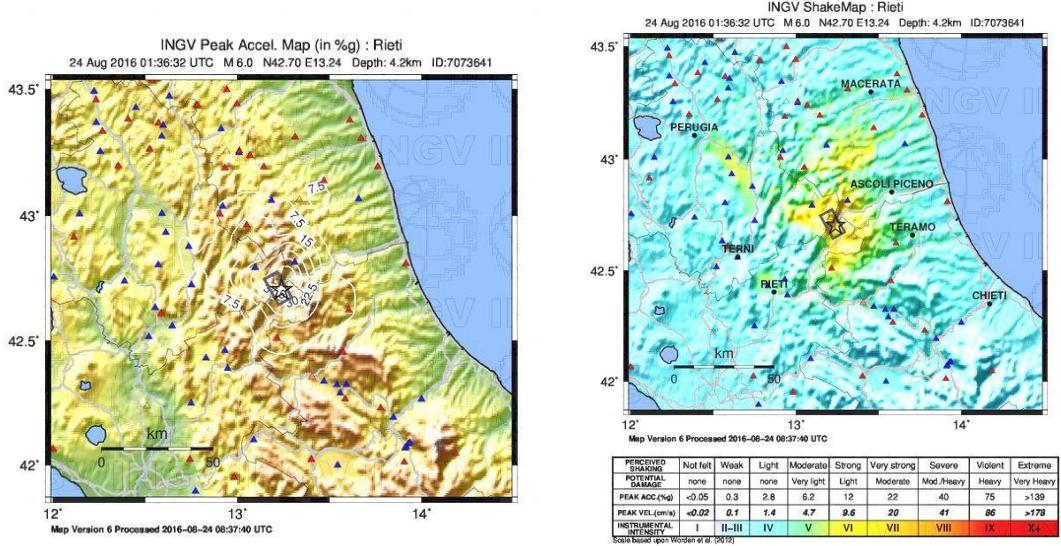
Figure 2: Shakemap of the mainshock (http://shakemap.rm.ingv.it/shake/)
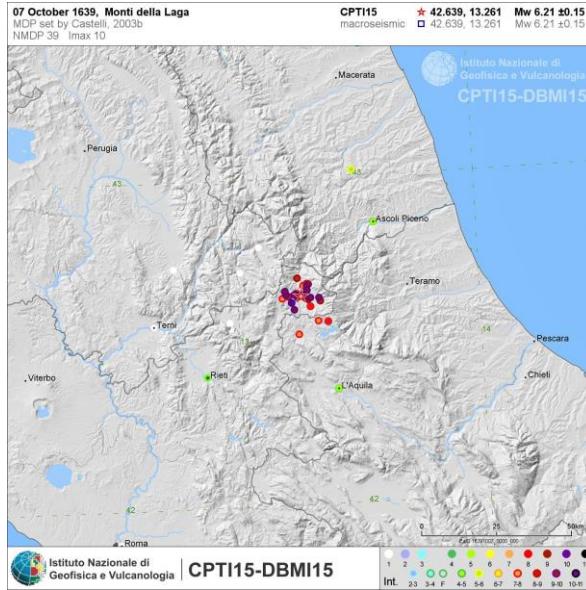
Figure 3: macroseismic field of the 1639 Mw 6.2 Amatrice earthquake (from http://emidius.mi.ingv.it/CPTI15-DBMI15/)

3. Strong Motion Data

The Italian Accelerometric Network (RAN), managed by the Department of Civil Protection (DPC), and the Italian seismic network, managed by the Istituto Nazionale di Geofisica e Vulcanologia (INGV) have made available the records of about 200 accelerometric stations. Appendix 1 lists networks id, station id, geographic coordinates of the station and soil type, where available. These data are also available at the Engineering Strong-motion database (esm.mi.ingv.it).

The largest Peak Ground Acceleration (PGA) have been recorded at short epicentral distances (< 15 km) at the stations Amatrice (AMT, 452.60 gal, uncorrected value, E-W component), Norcia (NRC, 376.96, N-S component) and Arquata del Tronto (RQT, 447.87 gal, E-W component, N-S component not available). The peak parameters of the available records are reported in the following table:

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Table 1.

Record Name	Stream	R_epi (km)	PGA (cm/s/s)	PGV (cm/s)	PGD (cm)
NRC	HGE	13.7	352.654	29.671	5.713
NRC	HGN	13.7	366.325	23.774	6.958
NRC	HGZ	13.7	211.482	11.675	3.261
RM33	HNE	22.3	100.360	9.299	2.390
RM33	HNN	22.3	99.030	6.245	2.010
RM33	HNZ	22.3	35.178	4.986	1.757
TERO	HNE	32.9	55.541	3.158	1.269
TERO	HNN	32.9	83.550	4.305	1.516
TERO	HNZ	32.9	35.029	2.838	0.977
SPM	HGE	38.4	65.951	2.388	0.730
SPM	HGN	38.4	63.548	3.042	1.464
SPM	HGZ	38.4	20.573	1.394	0.611
MNF	HGE	38.9	71.656	4.766	1.308
MNF	HGN	38.9	43.459	2.902	1.428
MNF	HGZ	38.9	59.656	4.649	1.971
TRE	HGE	43.7	62.958	6.105	1.101
TRE	HGN	43.7	108.501	7.807	2.086
TRE	HGZ	43.7	44.714	3.396	0.790
MDAR	HNE	54	38.939	3.441	0.903
MDAR	HNN	54	54.611	3.714	1.382
MDAR	HNZ	54	29.010	2.820	1.204
NCR	HGE	57	217.648	7.061	0.635
NCR	HGN	57	149.013	4.925	1.181
NCR	HGZ	57	39.401	2.397	1.140
SSM1	HNE	57.7	22.141	1.361	0.407
SSM1	HNN	57.7	58.151	3.633	0.995
SSM1	HNZ	57.7	39.187	4.005	1.927
GAG1	HNE	60	75.895	6.484	1.082
GAG1	HNN	60	89.474	7.267	1.821
GAG1	HNZ	60	57.109	3.998	1.640
MTL	HGE	62.4	69.952	3.718	1.050
MTL	HGN	62.4	66.714	6.468	1.316
MTL	HGZ	62.4	31.023	4.614	1.248
TRE1	HNE	67.2	62.079	6.082	2.230
TRE1	HNN	67.2	71.314	4.348	1.707
TRE1	HNZ	67.2	30.885	2.752	1.135
PP3	HNE	80.7	49.555	4.162	3.058
PP3	HNN	80.7	40.420	2.885	2.150
PP3	HNZ	80.7	14.311	2.854	1.663
MURB	HNE	83.6	45.599	3.103	0.553
MURB	HNN	83.6	40.572	3.255	0.997
MURB	HNZ	83.6	13.943	2.000	0.953

SSFR	HNE	88.2	57.113	2.437	0.370
SSFR	HNN	88.2	49.564	1.830	0.670
SSFR	HNZ	88.2	20.424	1.211	0.632

Table 2 reports some integral measures reported for the same records.

Table 2.

Record Name	Stream	Arias Intensity (cm/s)	Significant Duration 5-95	Significant Duration 5-75
NRC	HGE	104.552	6.025	1.740
NRC	HGN	82.667	6.325	1.595
NRC	HGZ	37.894	5.560	2.380
RM33	HNE	8.724	9.465	2.960
RM33	HNN	6.128	10.070	3.825
RM33	HNZ	1.804	14.335	8.160
TERO	HNE	4.778	12.785	5.915
TERO	HNN	7.647	11.325	4.610
TERO	HNZ	1.738	14.675	7.480
SPM	HGE	4.932	14.435	7.030
SPM	HGN	4.986	12.485	8.340
SPM	HGZ	0.897	16.210	9.150
MNF	HGE	3.030	6.865	1.670
MNF	HGN	1.479	10.915	5.180
MNF	HGZ	2.166	6.590	2.275
TRE	HGE	5.100	14.620	6.195
TRE	HGN	10.625	14.520	3.355
TRE	HGZ	2.128	15.165	8.145
MDAR	HNE	1.293	11.305	3.695
MDAR	HNN	1.965	10.005	2.620
MDAR	HNZ	0.674	14.885	7.780
NCR	HGE	31.664	4.845	1.240
NCR	HGN	19.012	7.200	2.985
NCR	HGZ	1.757	13.600	7.510
SSM1	HNE	1.082	143.560	86.400
SSM1	HNN	2.989	11.880	4.380
SSM1	HNZ	1.622	17.460	10.445
GAG1	HNE	9.845	12.125	5.800
GAG1	HNN	10.900	11.945	4.790
GAG1	HNZ	5.604	14.995	7.455
MTL	HGE	4.722	15.400	6.510
MTL	HGN	5.250	13.120	6.205
MTL	HGZ	1.886	19.340	9.180
TRE1	HNE	5.281	18.335	5.230
TRE1	HNN	4.687	15.600	6.055
TRE1	HNZ	1.466	19.160	10.945
PP3	HNE	3.019	35.055	13.745

PP3	HNN	2.194	43.135	15.295
PP3	HNZ	0.726	54.205	36.620
MURB	HNE	2.479	19.610	8.485
MURB	HNN	2.296	19.715	7.070
MURB	HNZ	0.383	25.870	13.170
SSFR	HNE	2.757	17.670	9.345
SSFR	HNN	2.518	21.780	13.465
SSFR	HNZ	0.431	18.175	9.055

3. Data comparison with GMPE

Some GM parameters (PGA, PGV and acceleration spectral ordinates at 0.3, 1 and 3 seconds, period used to calculate shakemaps) are compared to the predictions by Bindi et al (2011). These results can be considered as preliminary since:

- the distance is the epicentral distance, whilst Bindi et al. adopts the Joyner-Boore distance; the latter could not be estimated because the fault geometry is still not available.
- the comparison at 3s is outside the range of validity of this GMPE, that can be used until 2s.
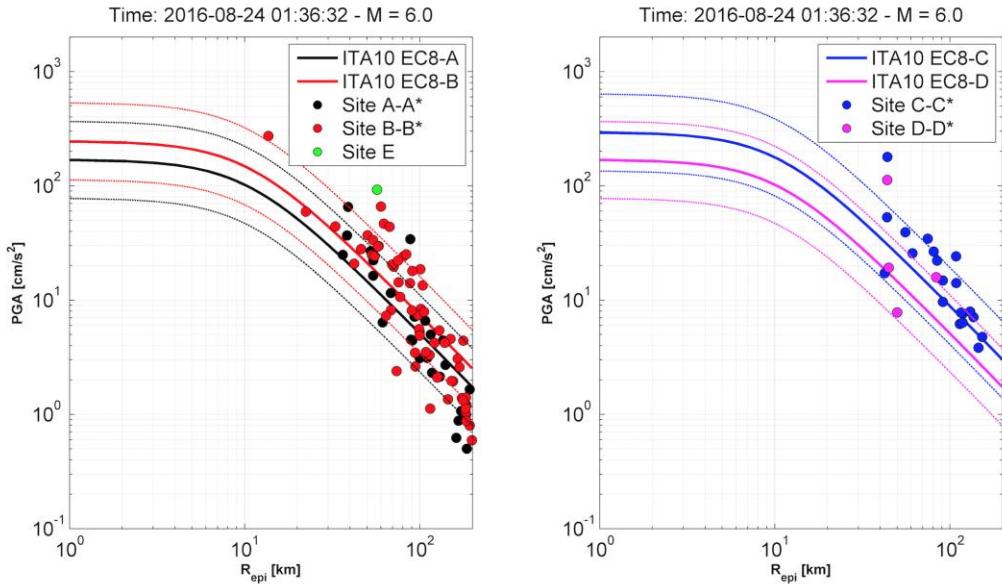
Figure 4: Observed horizontal PGA against Bindi et al (2011): left EC8 A and B sites; right EC8 C and D sites
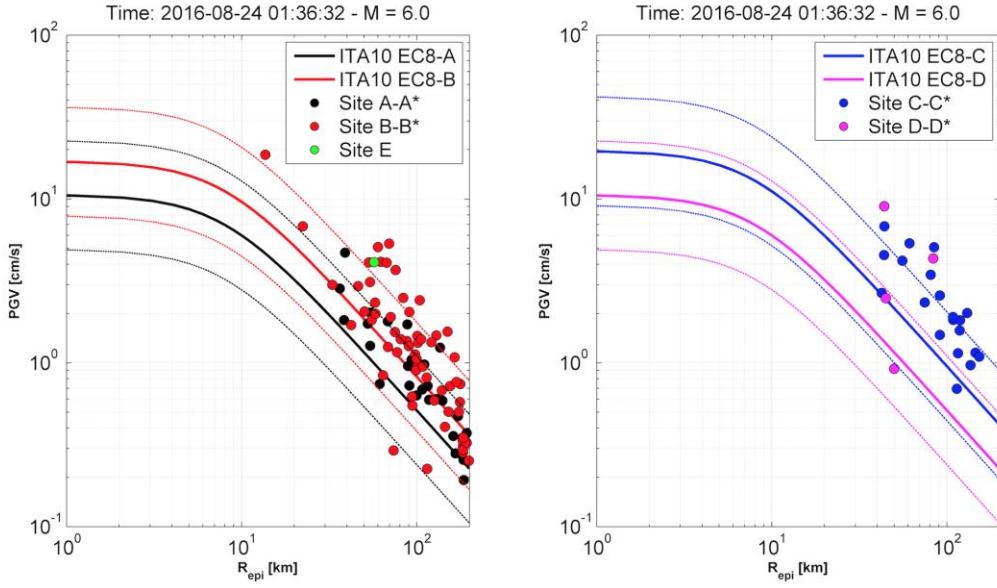
Figure 5: Observed horizontal PGV against Bindi et al (2011): left EC8 A and B sites; right EC8 C and D sites
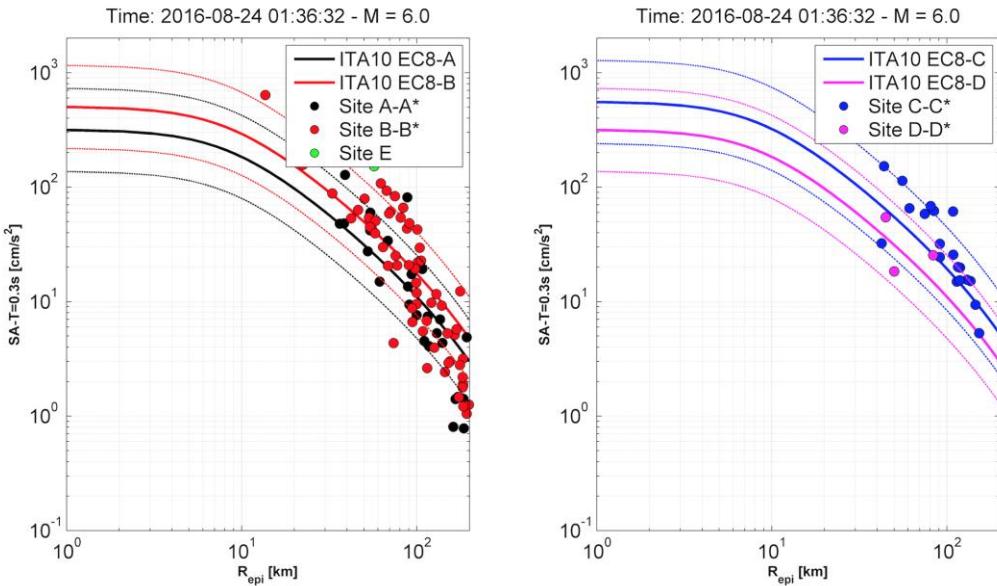
Figure 6: Observed horizontal SA (0.3s) against Bindi et al (2011): left EC8 A and B sites; right EC8 C and D sites
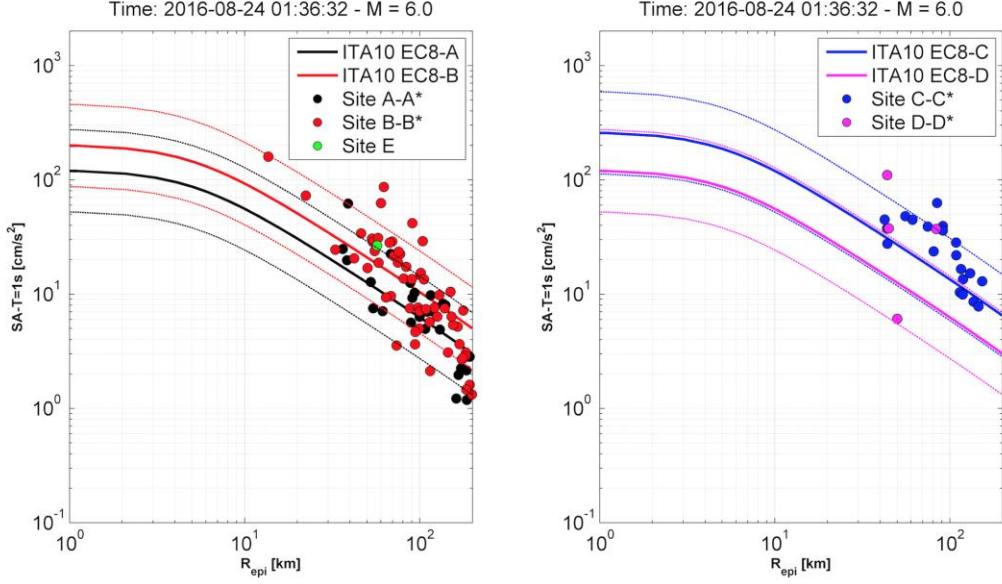
Figure 7: Observed horizontal SA (1s) against Bindi et al (2011): left EC8 A and B sites; right EC8 C and D sites
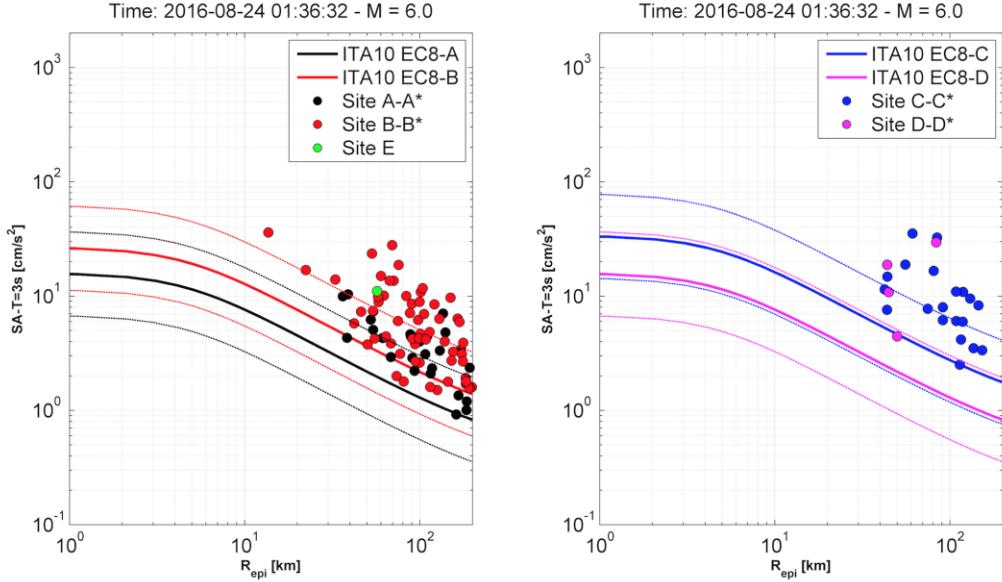
Figure 8: Observed horizontal SA (3s) against Bindi et al (2011): left EC8 A and B sites; right EC8 C and D sites

5. Response Spectra

In this section, the pseudo-spectral acceleration (PSA), pseudo-spectral velocity (PSV) and spectral displacement (SD) are reported for all the available records for three different values of damping ratio, (z), that is 2%, 5% and 10%.
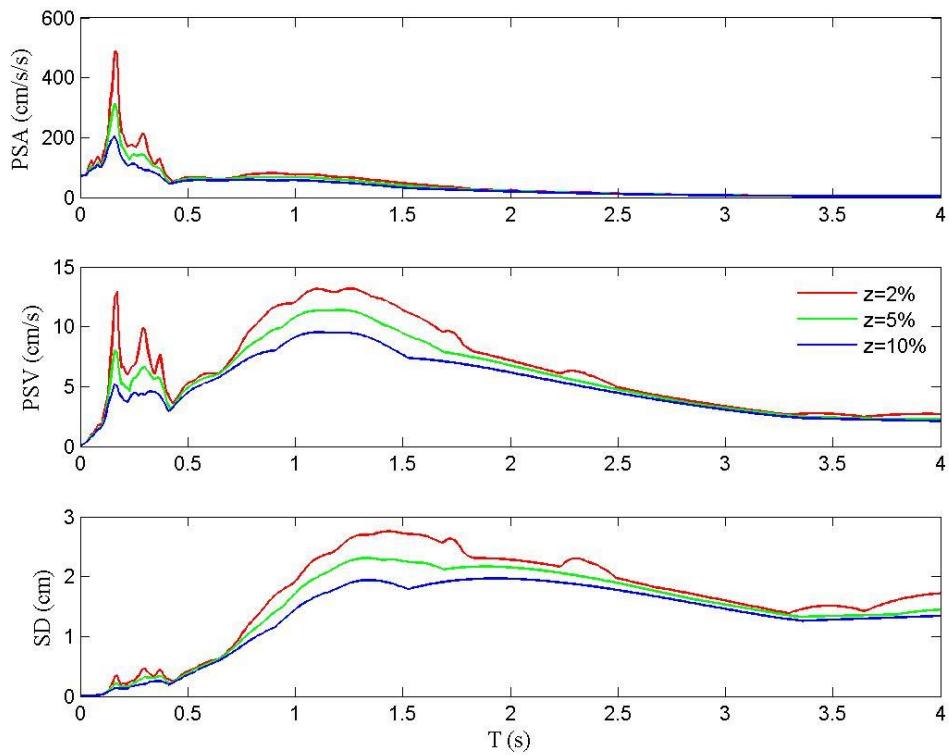
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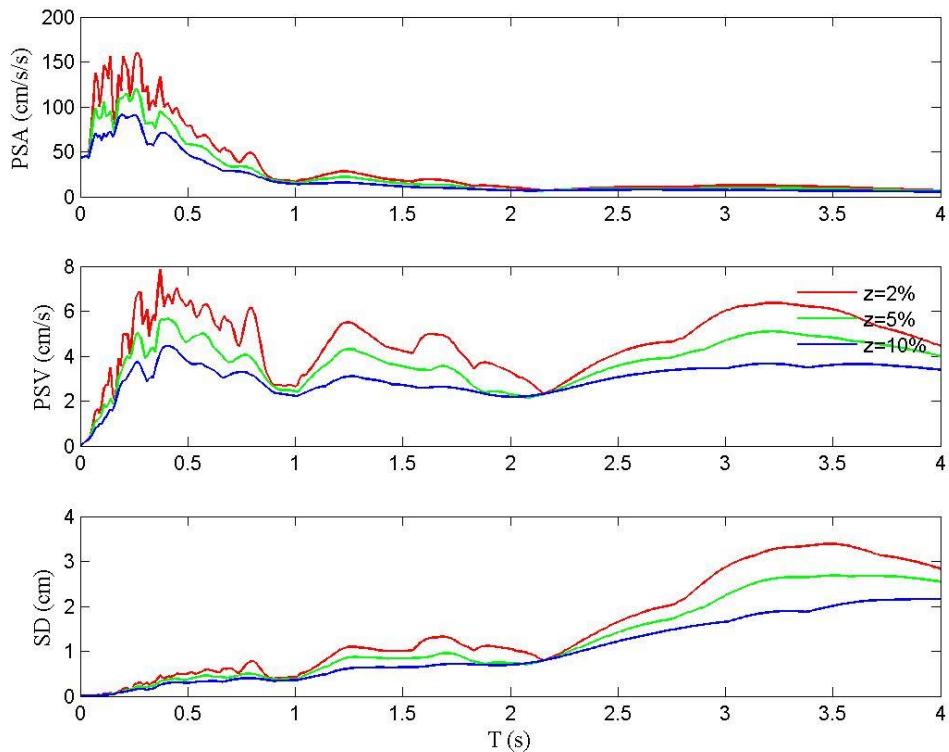
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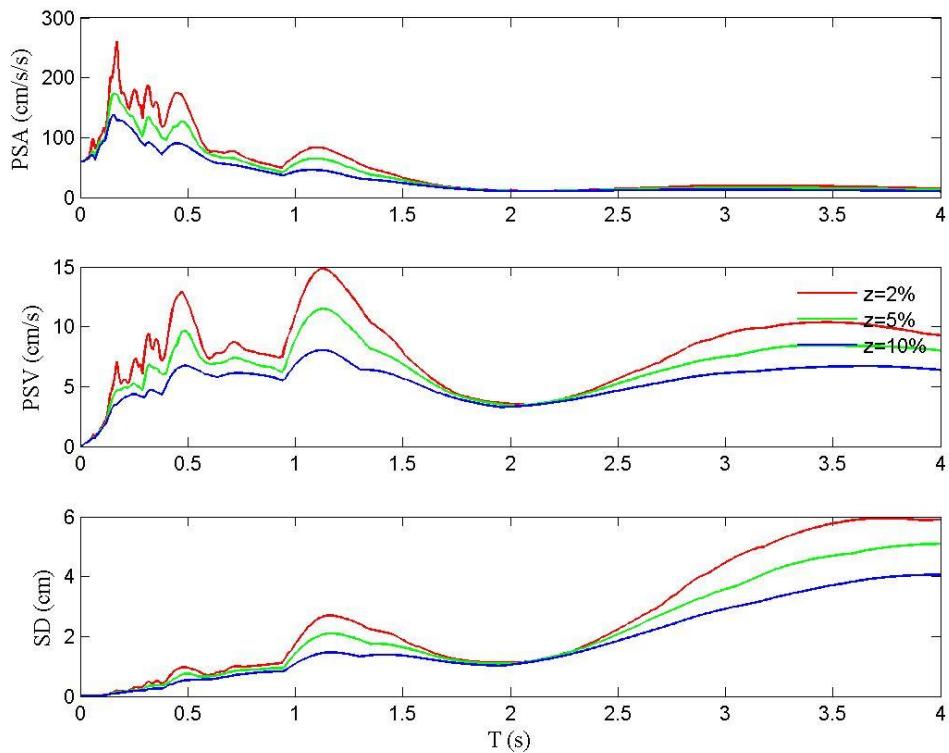
MNF_HGZ

MTL_HGE

MTL_HGN

MTL_HGZ

11

NCR_HGE


NCR_HGN

12

NCR_HGZ


NRC_HGE

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NRC_HGN

NRC_HGZ

14

SPM_HGE

SPM_HGN

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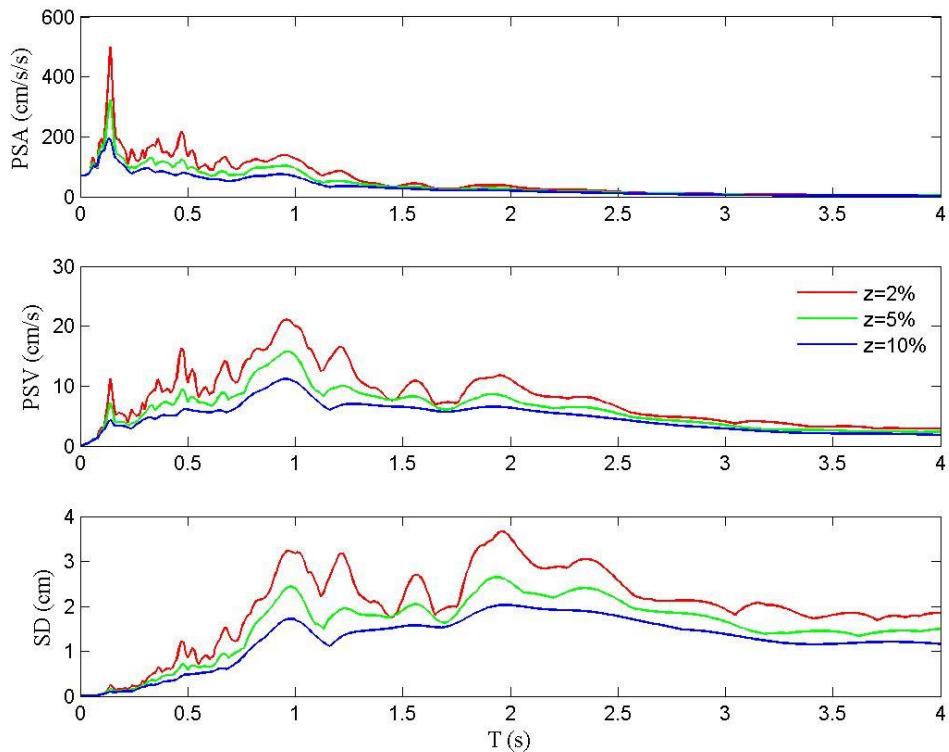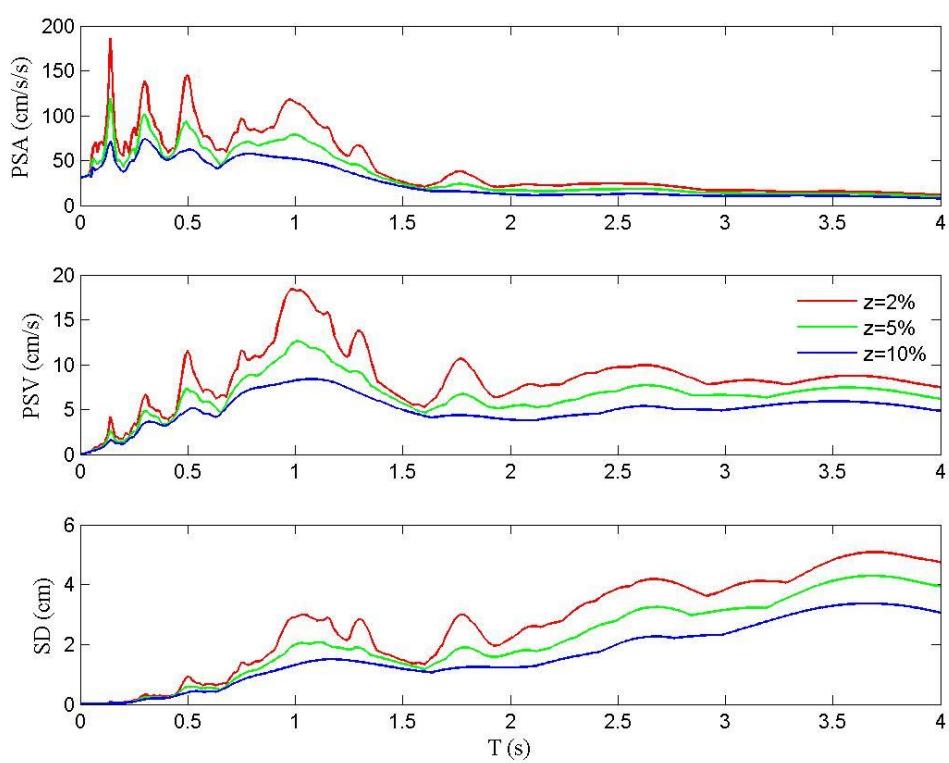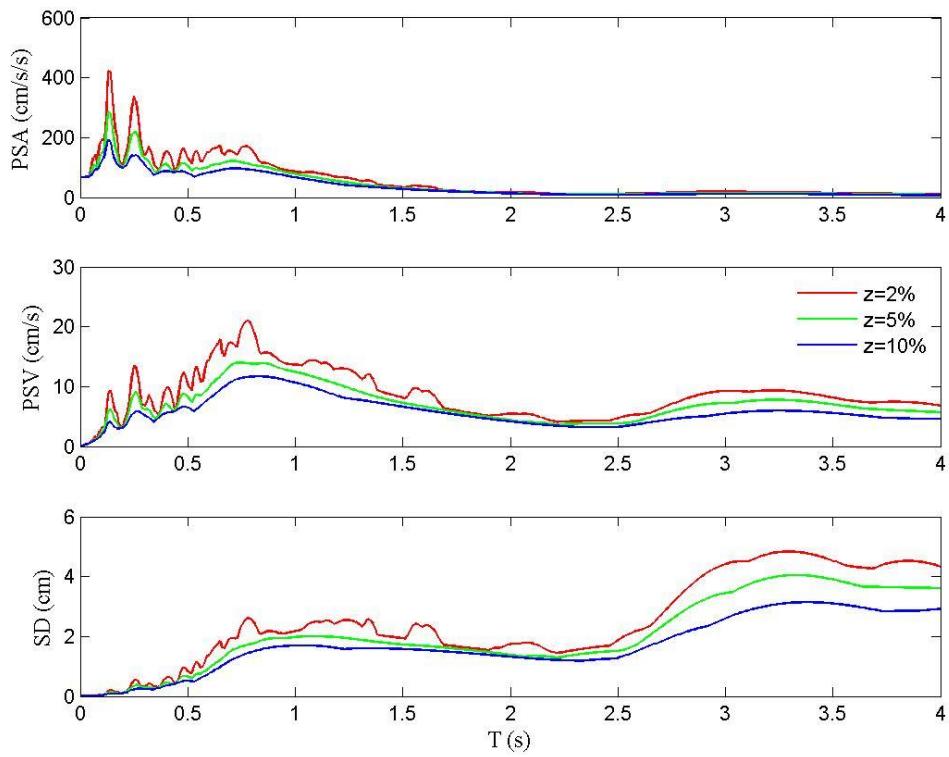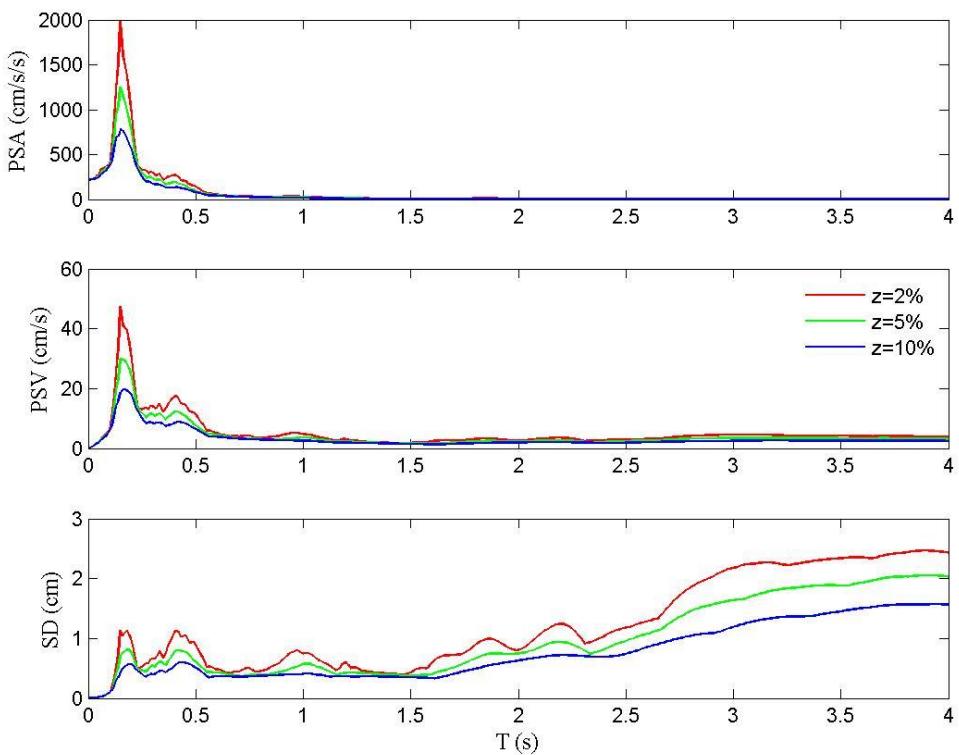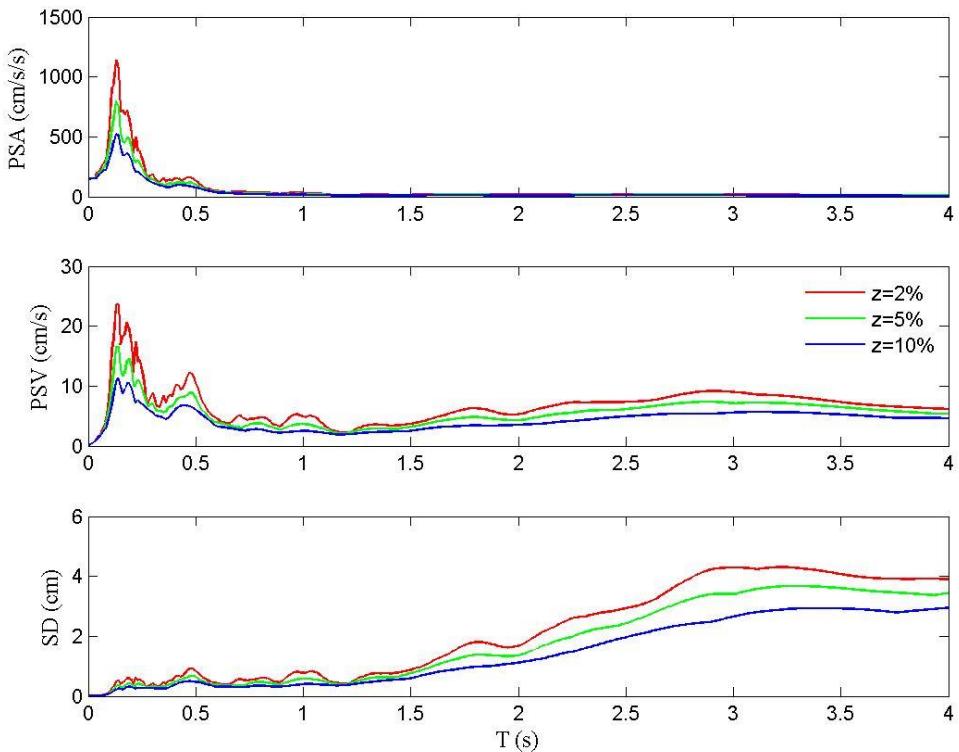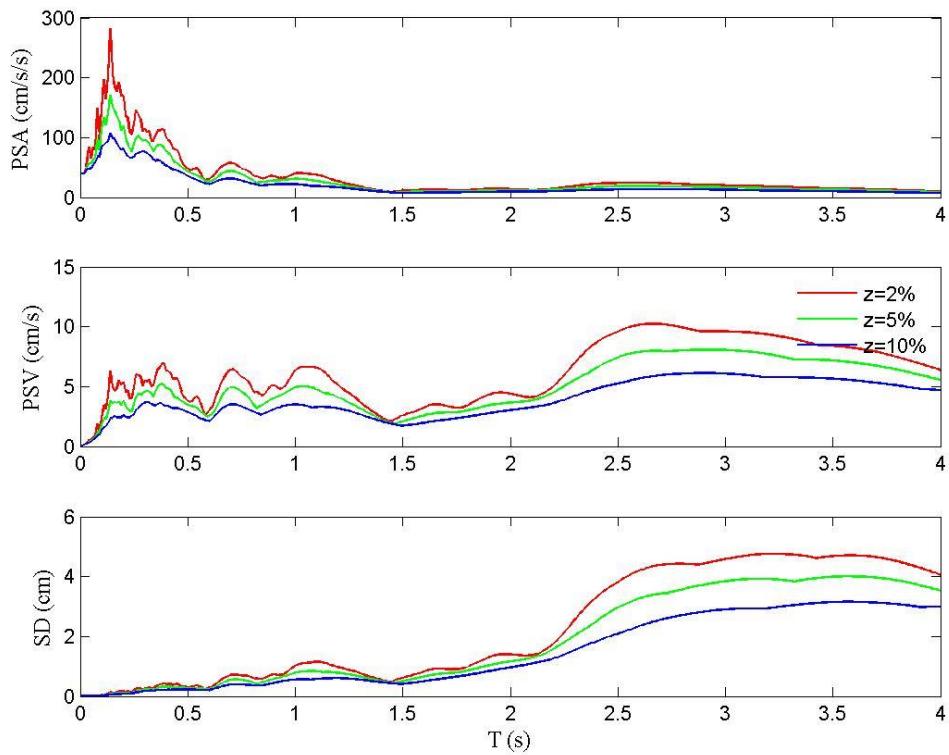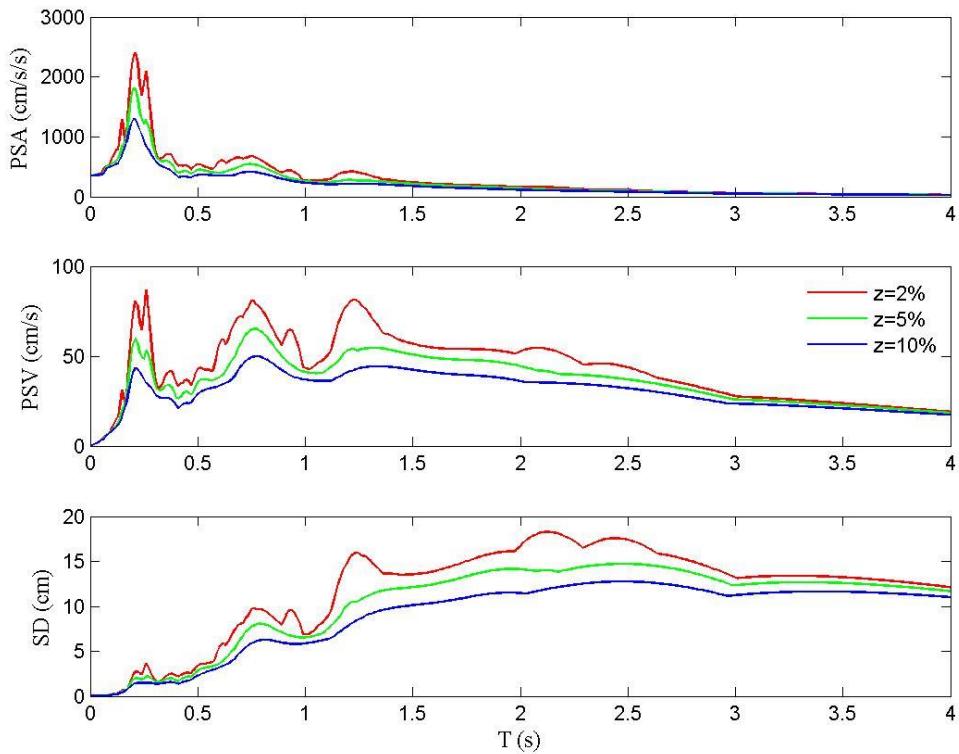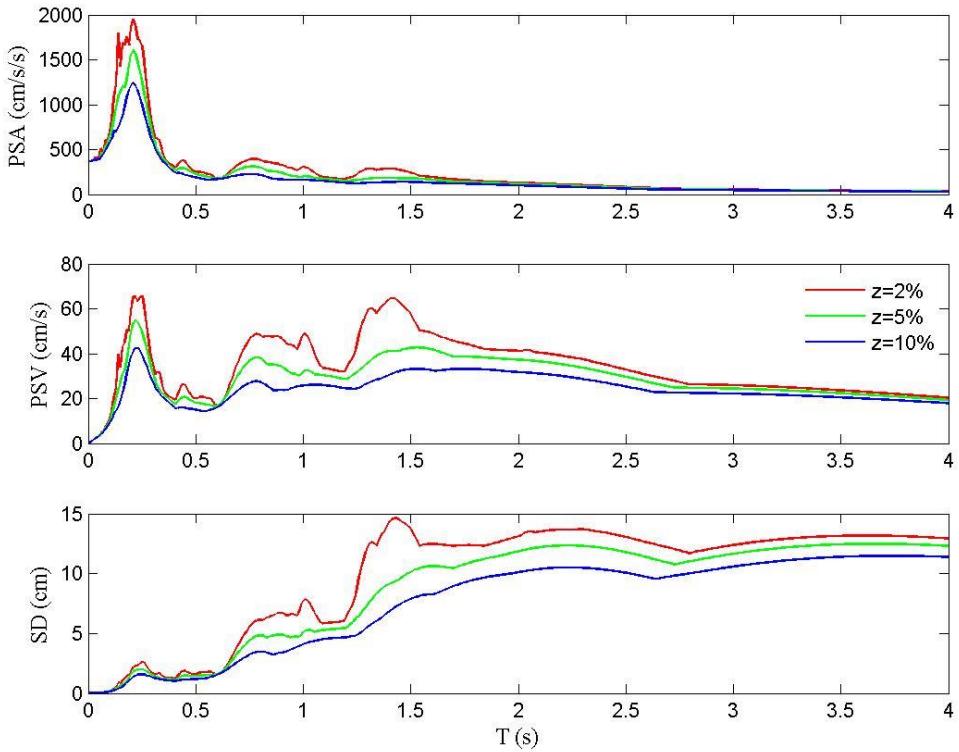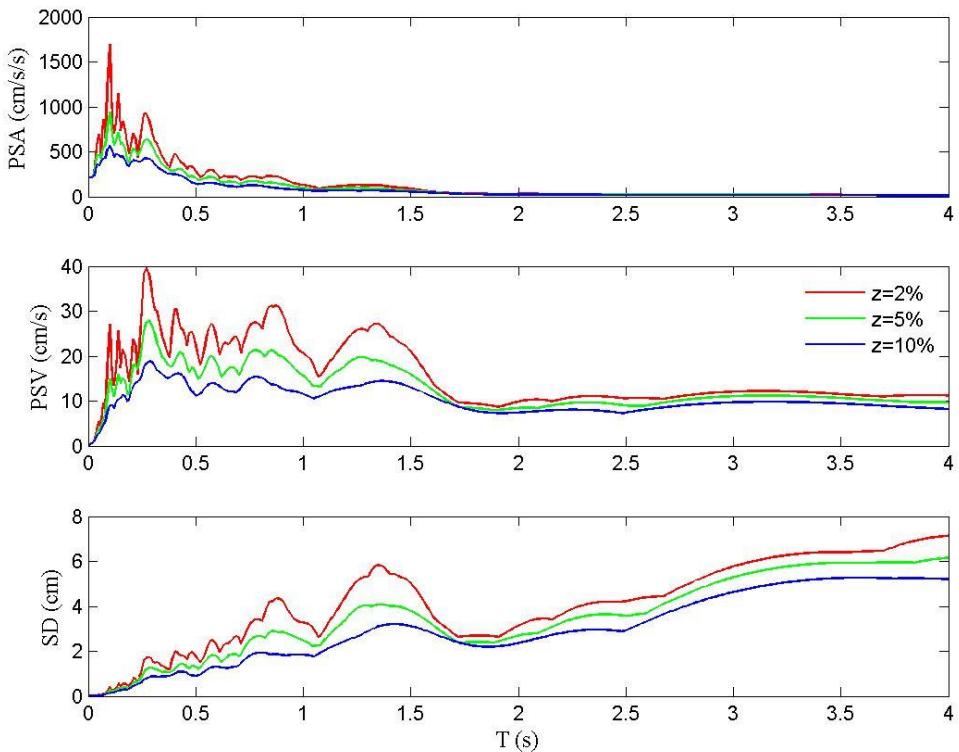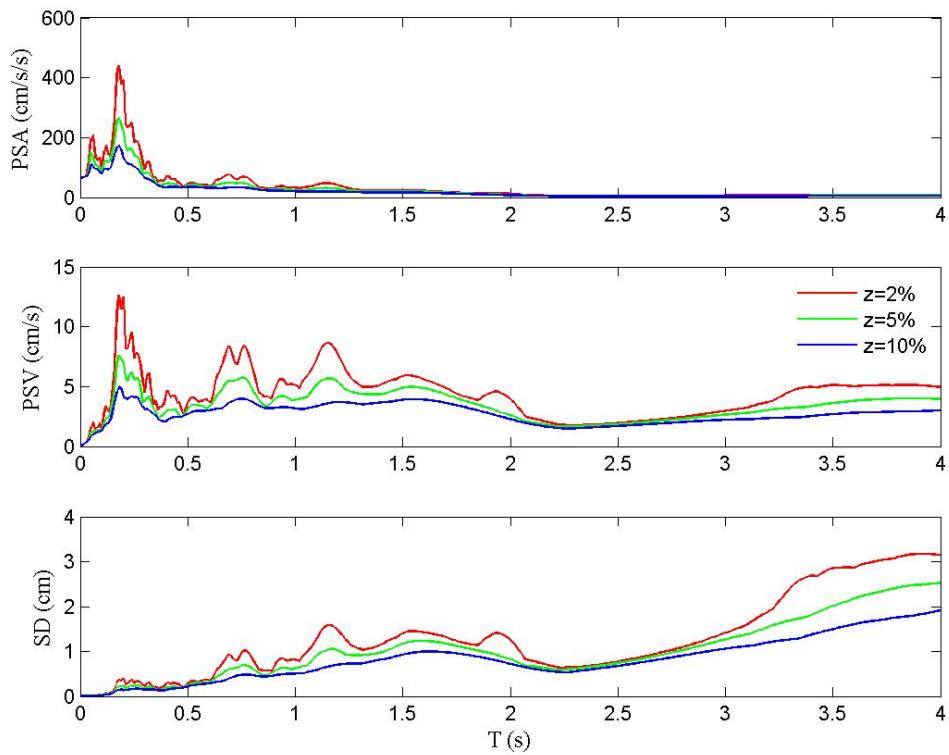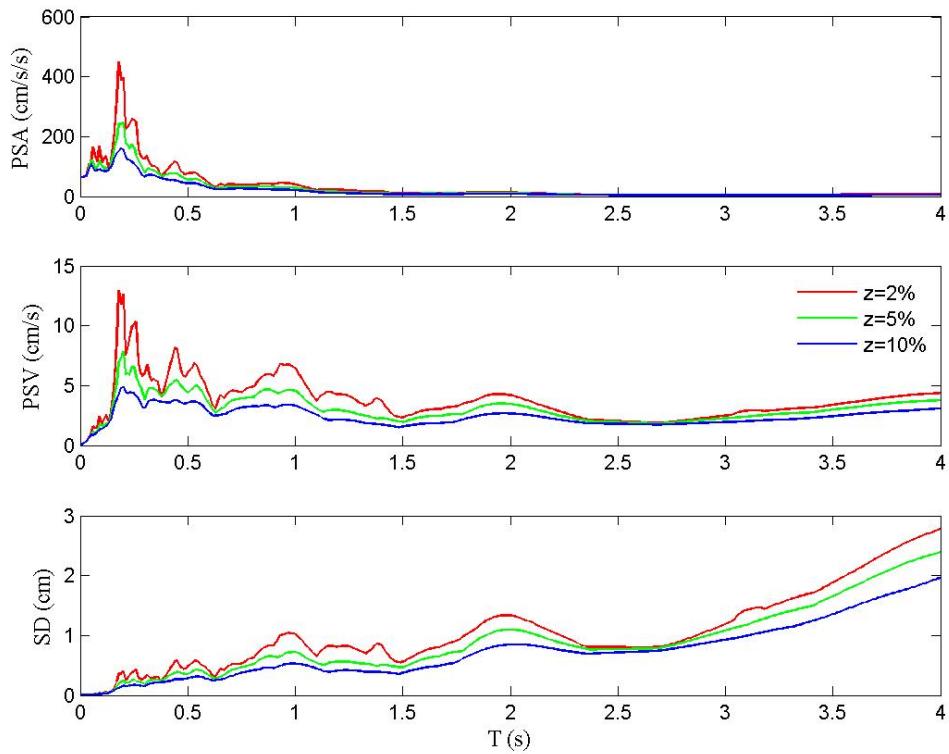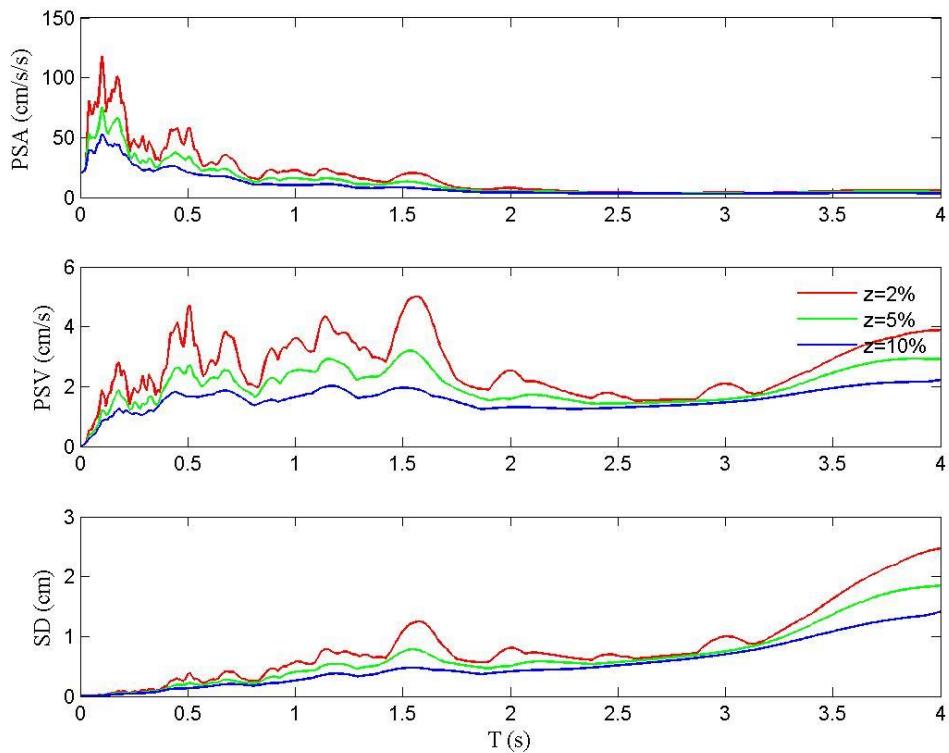
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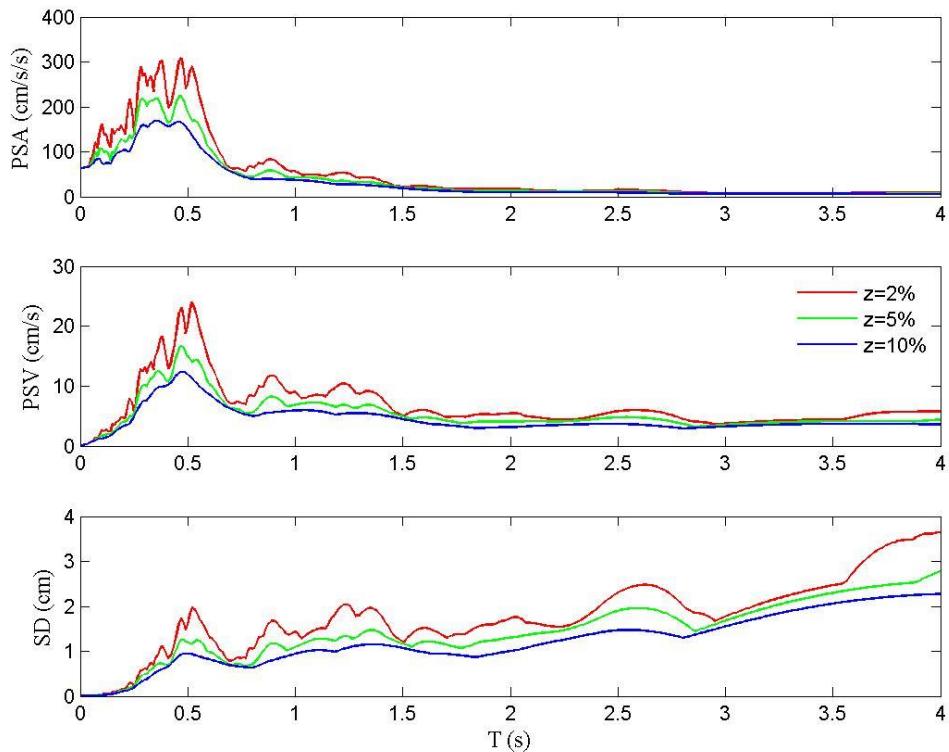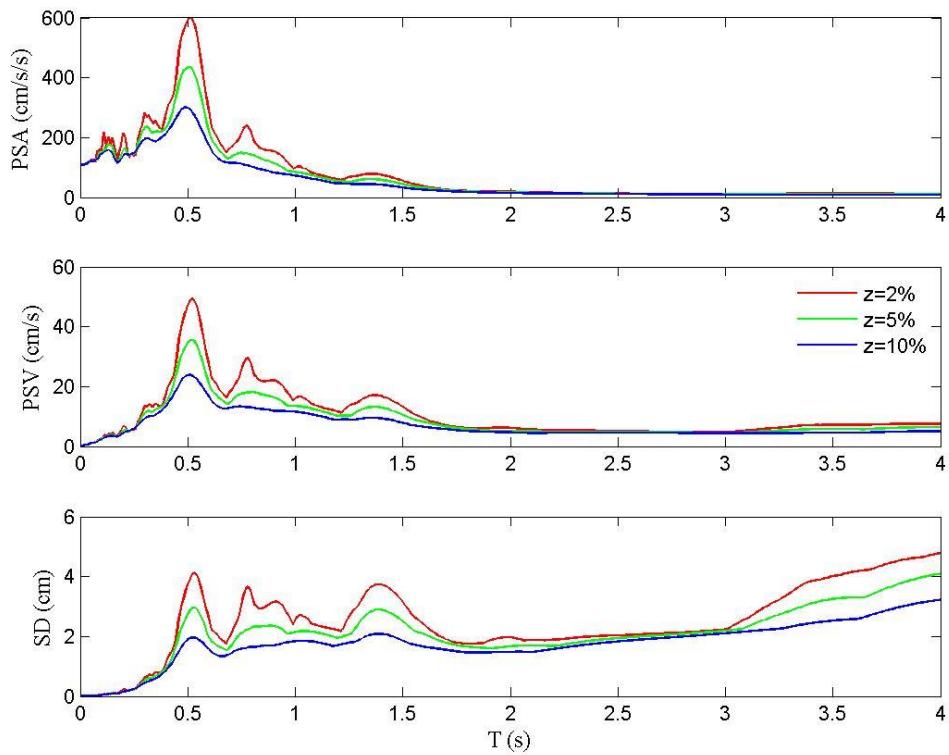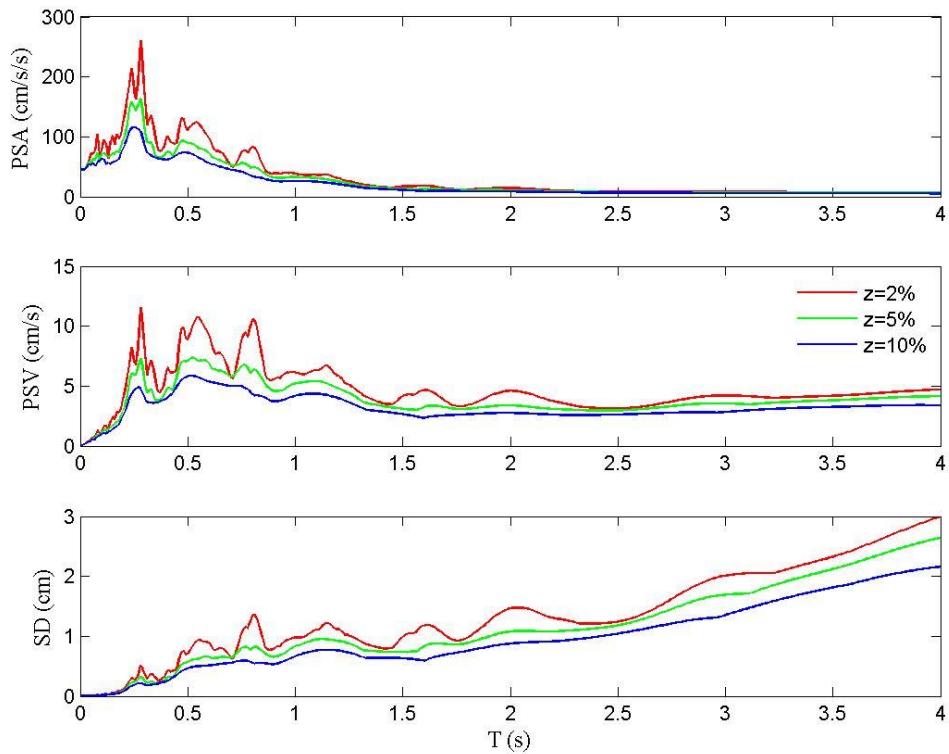
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TRE_HGN


TRE_HGZ
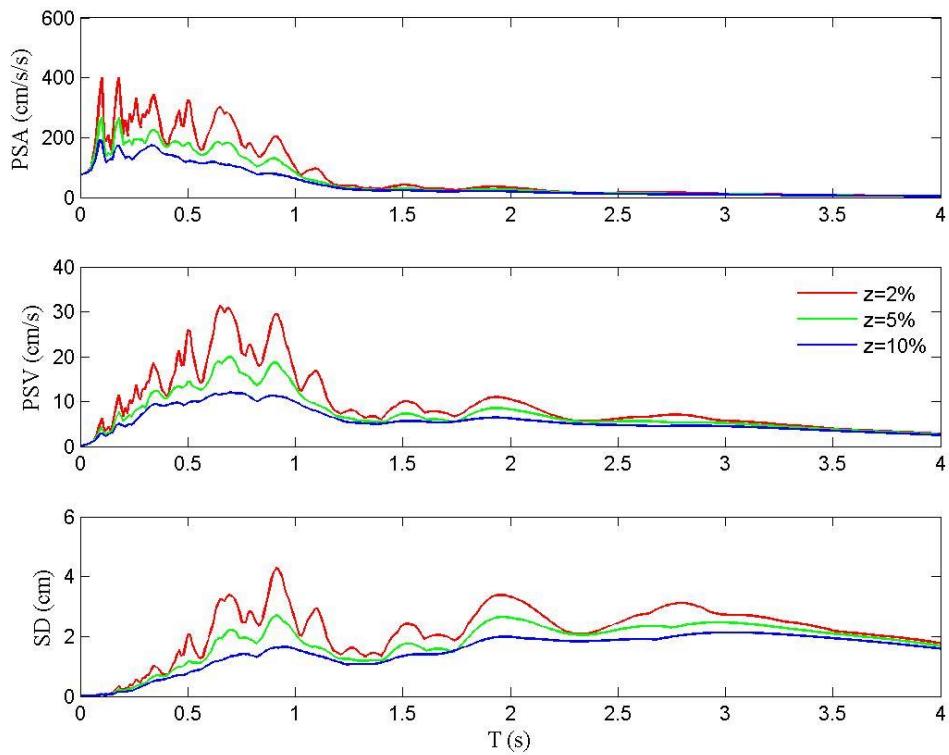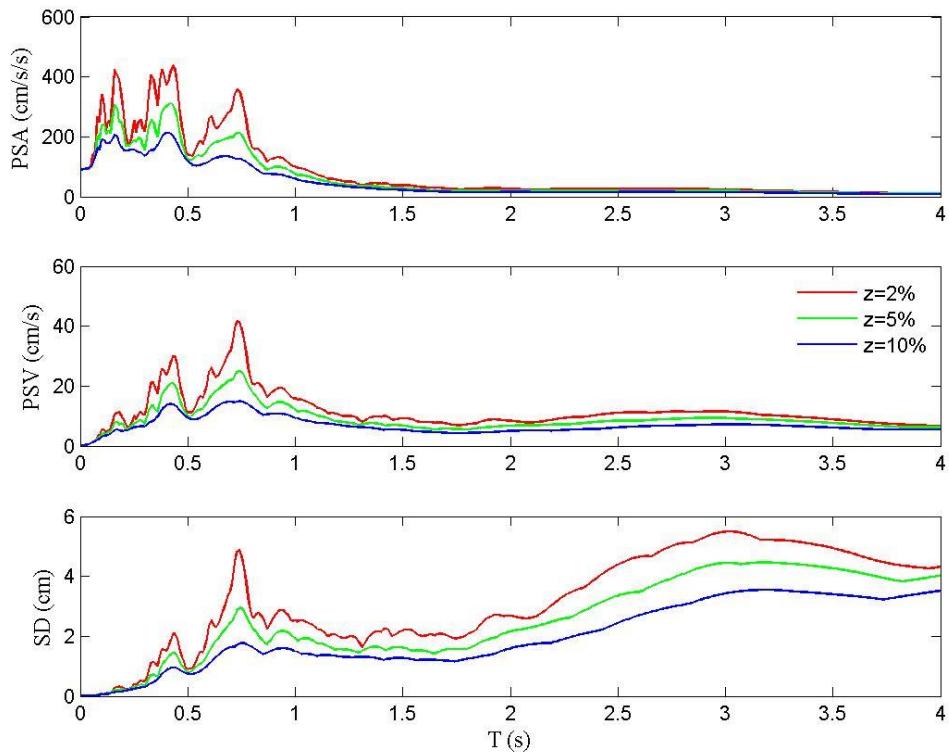
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GAG1_HNN
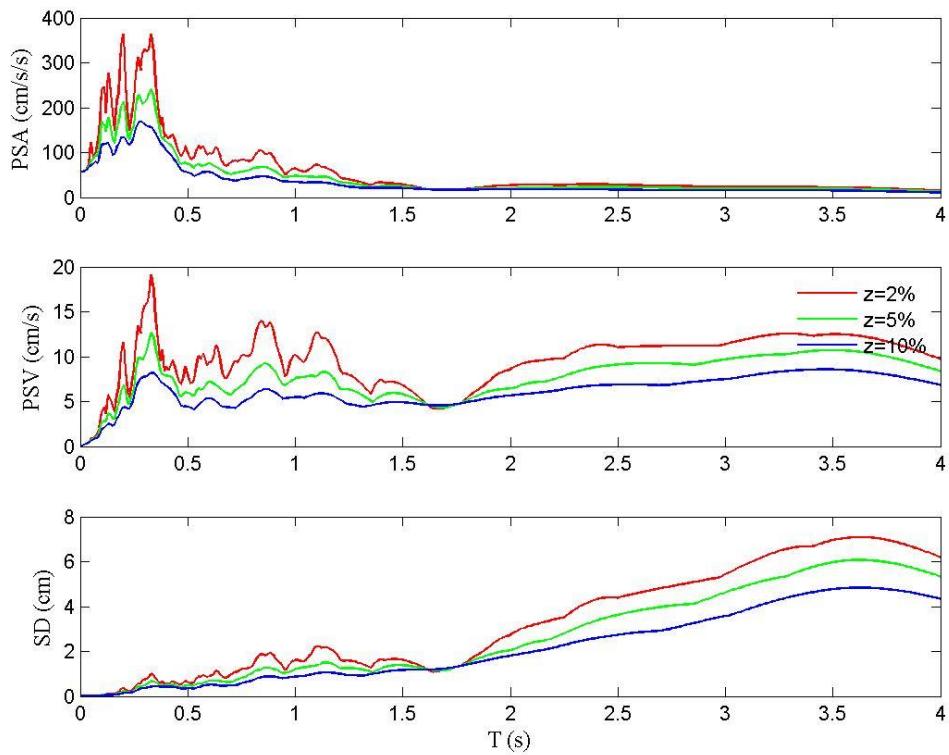
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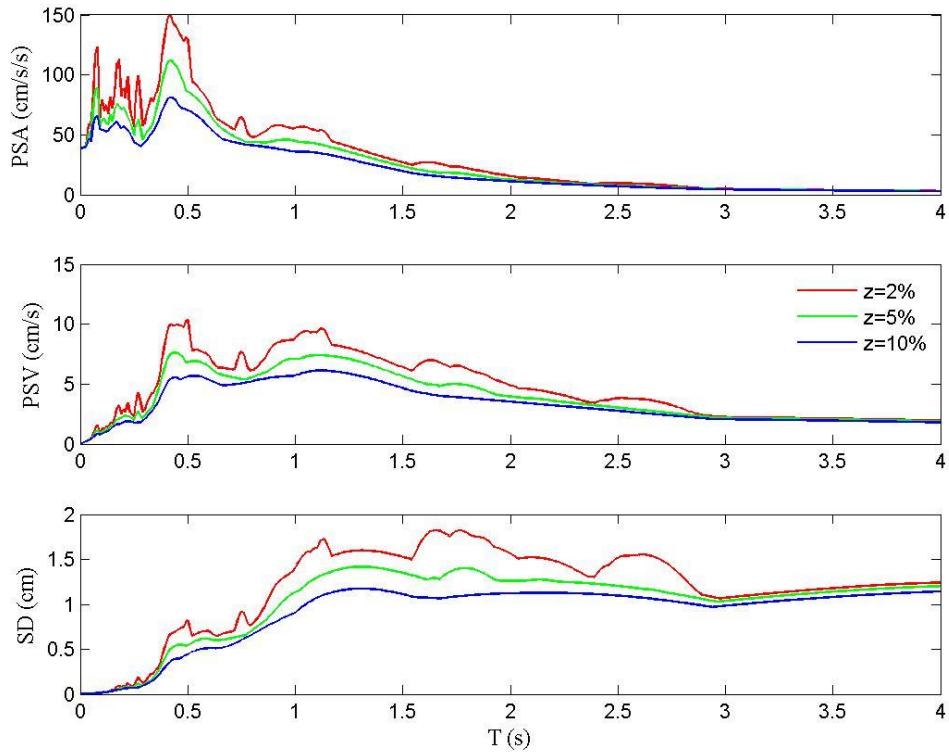
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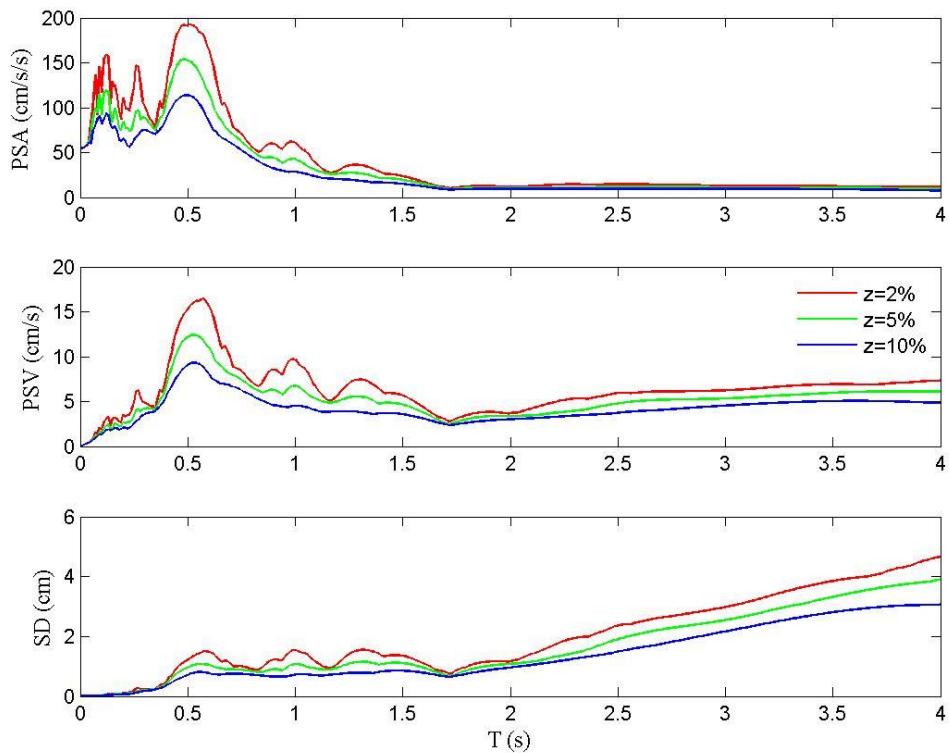
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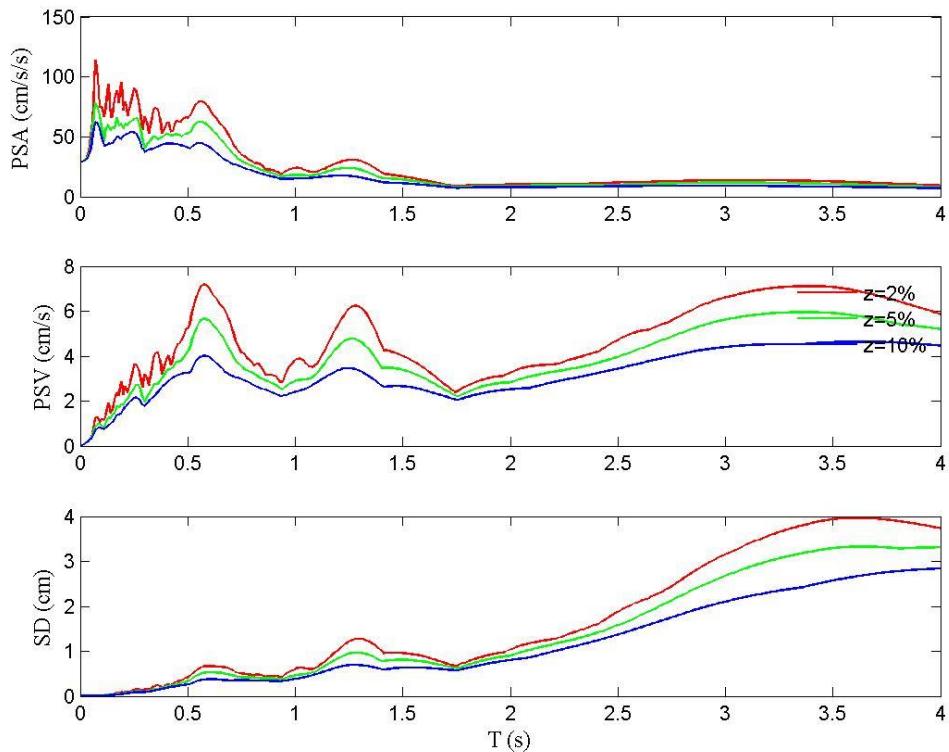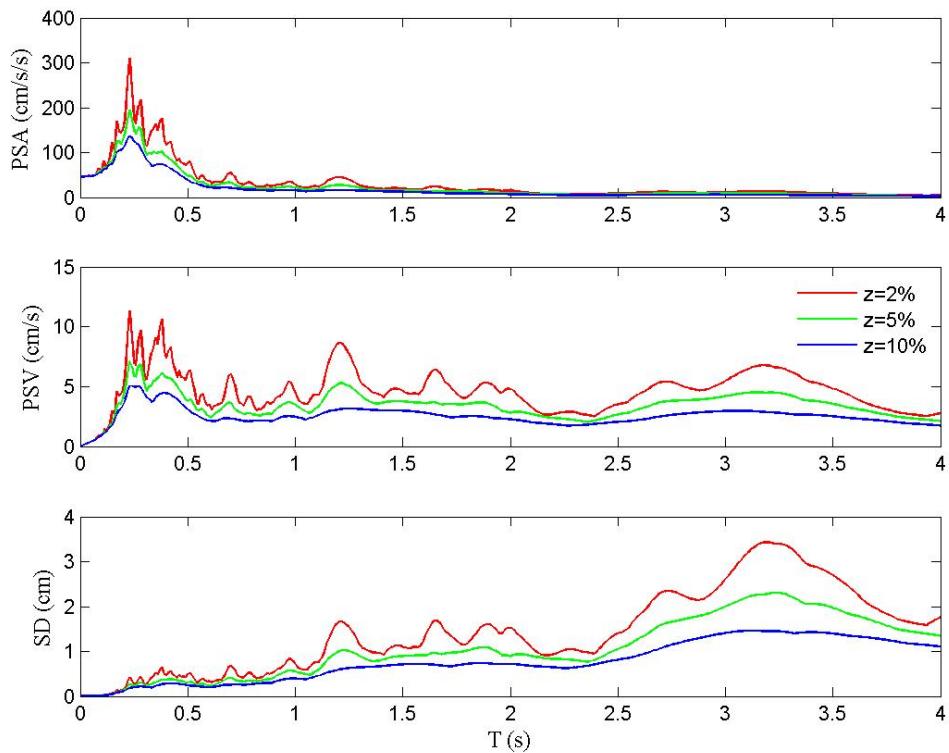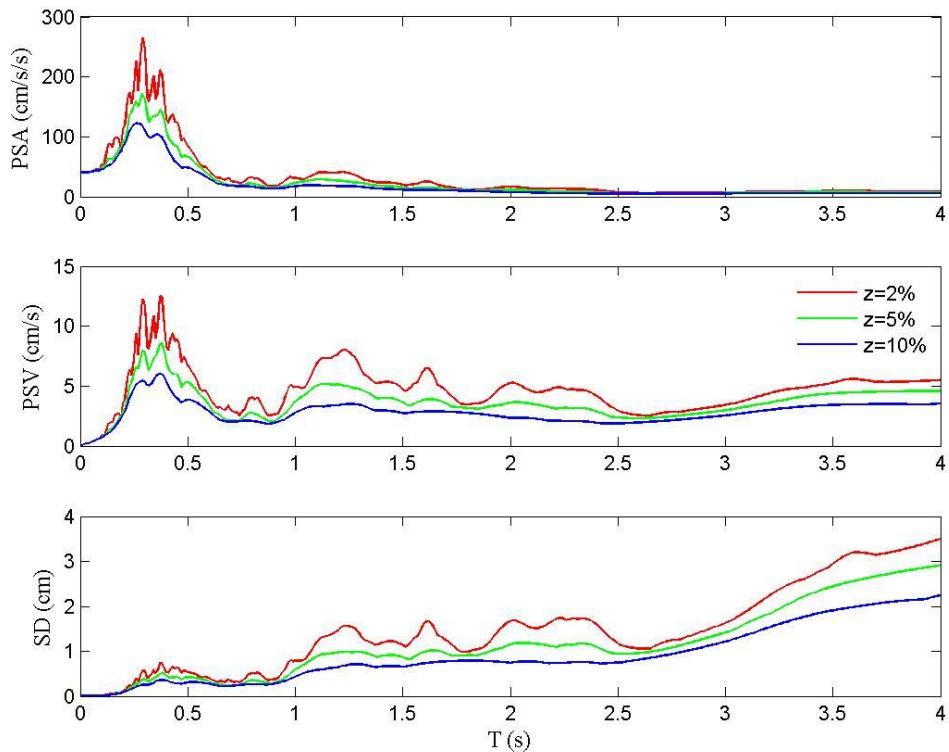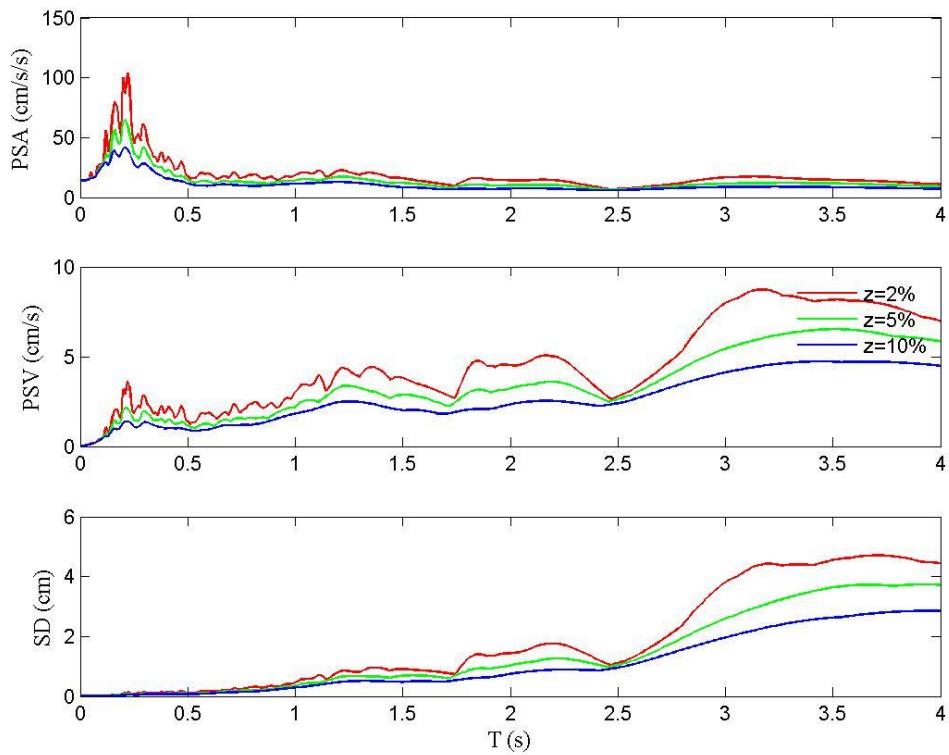
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MURB_HNN

MURB_HNZ
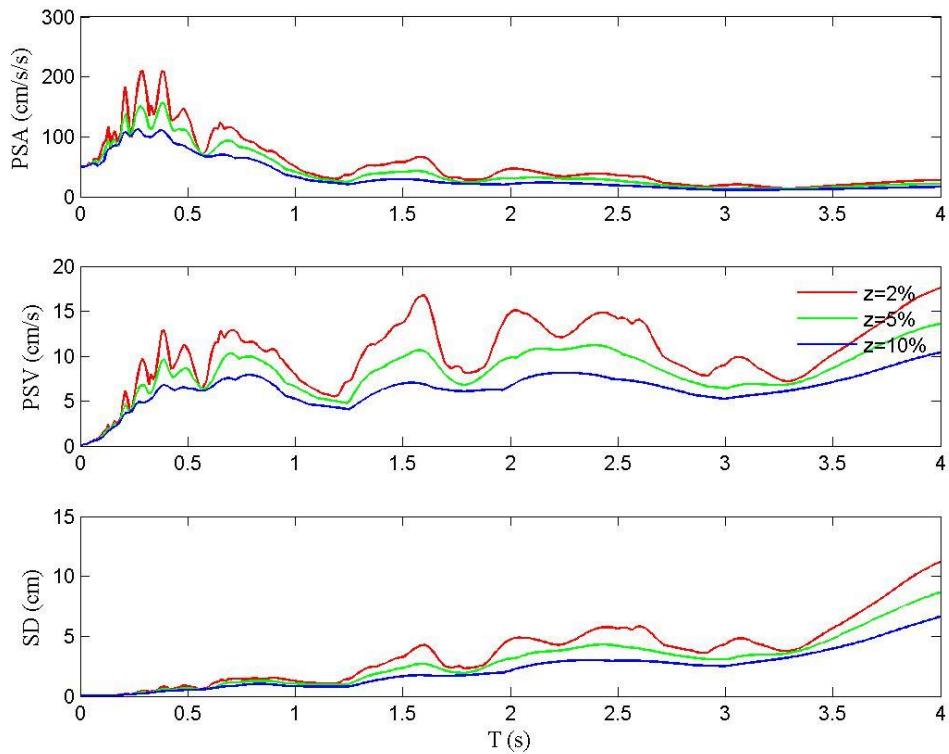
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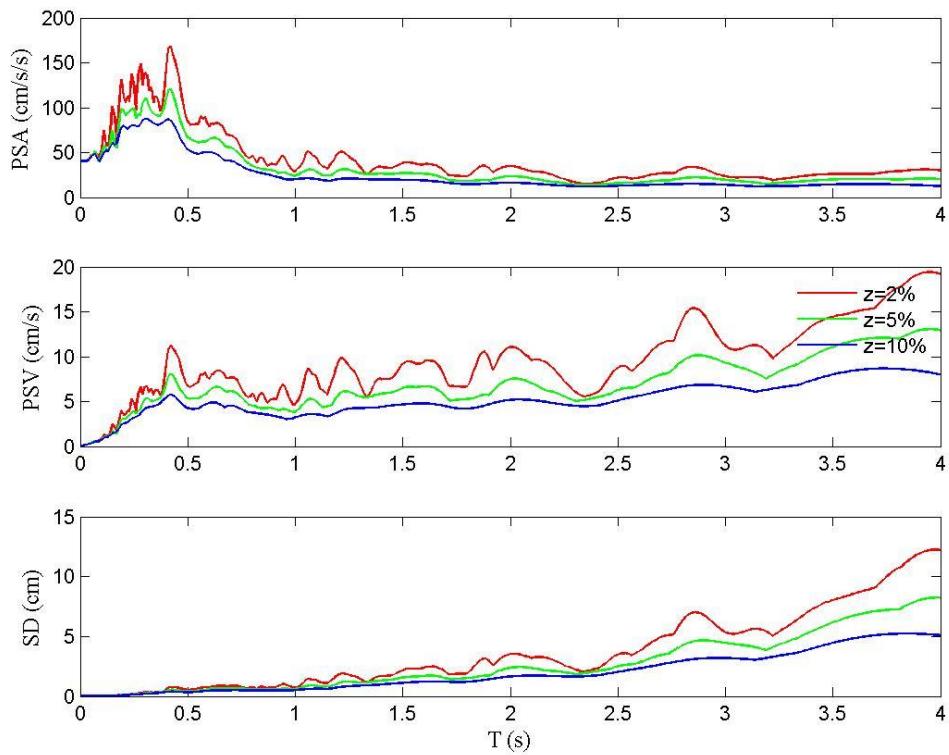
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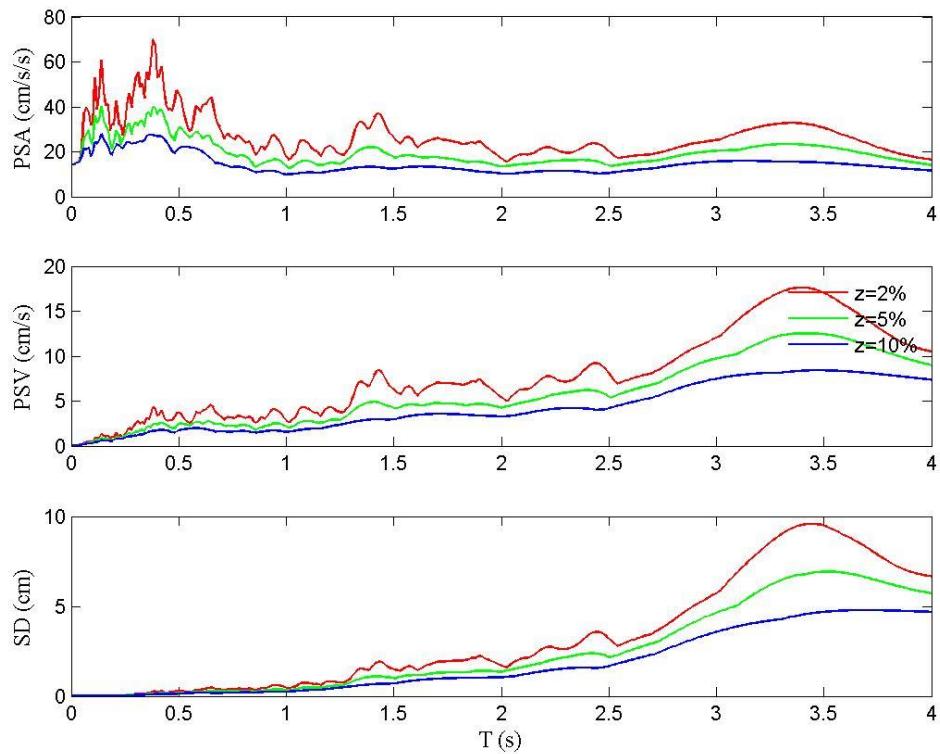
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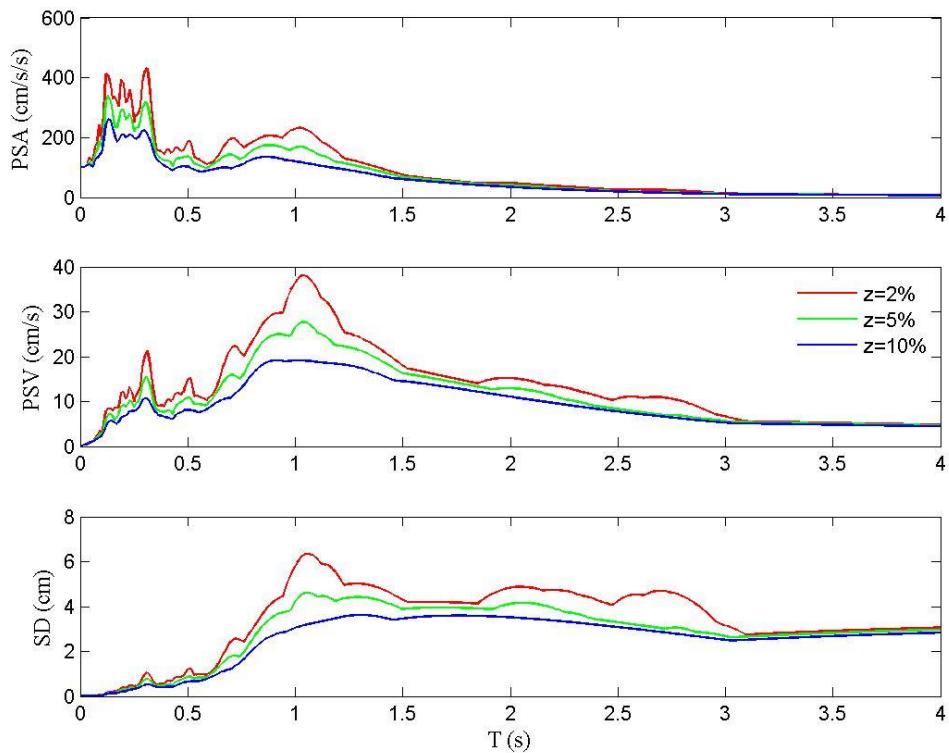
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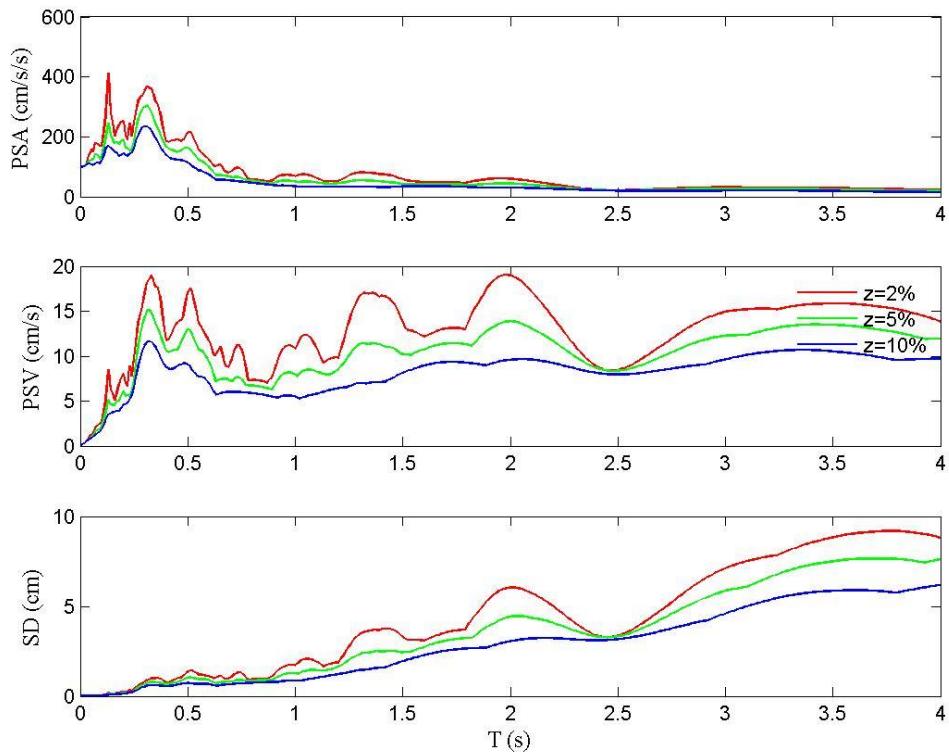
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RM33_HNZ

SSFR_HNE

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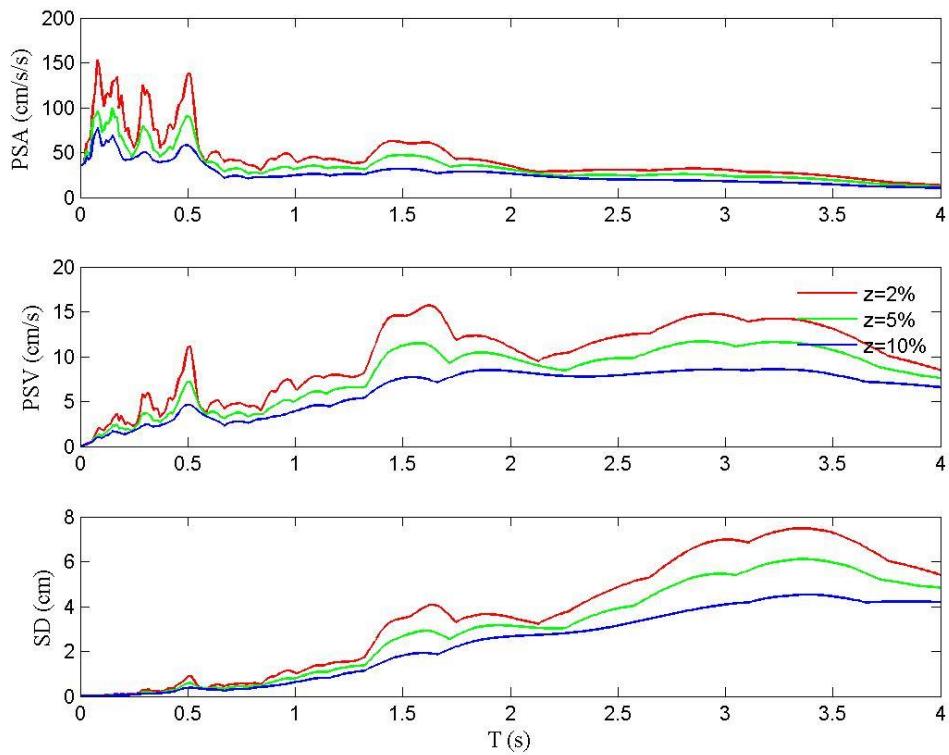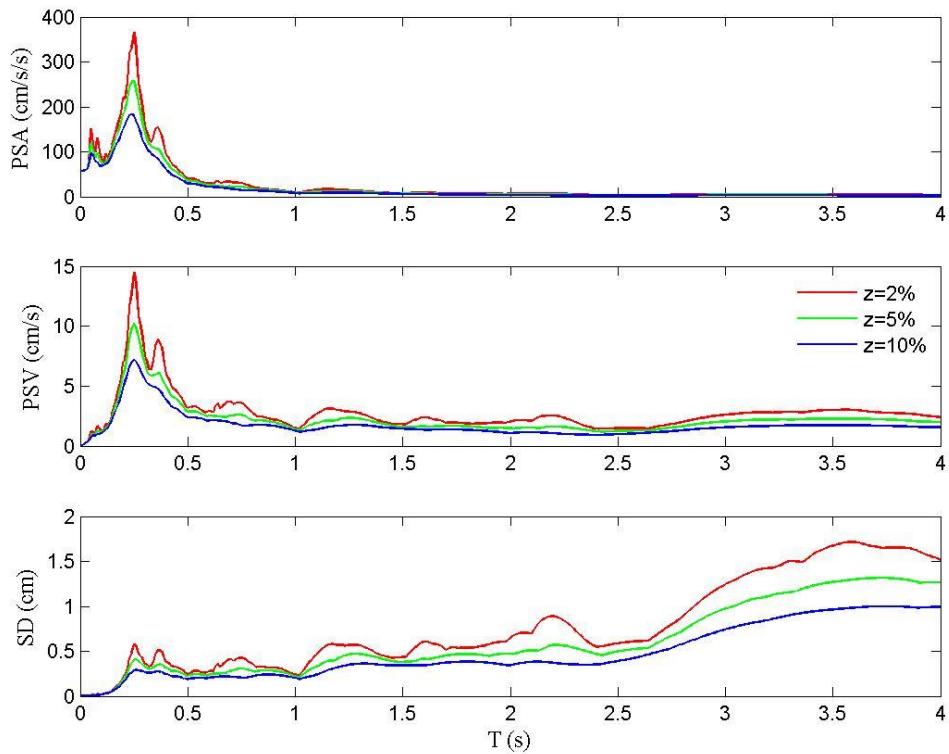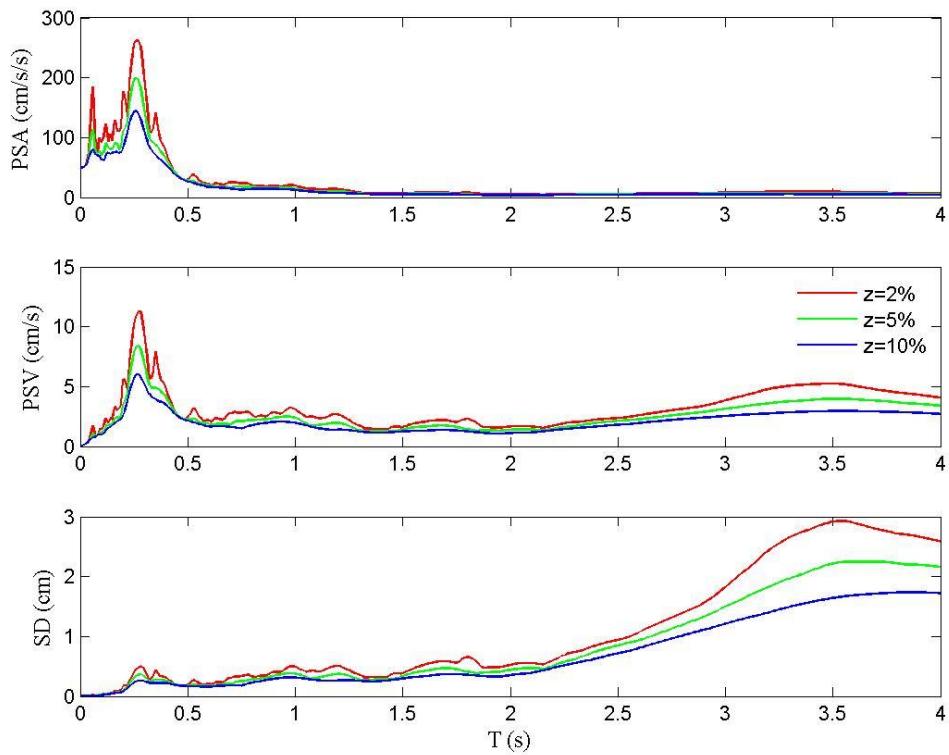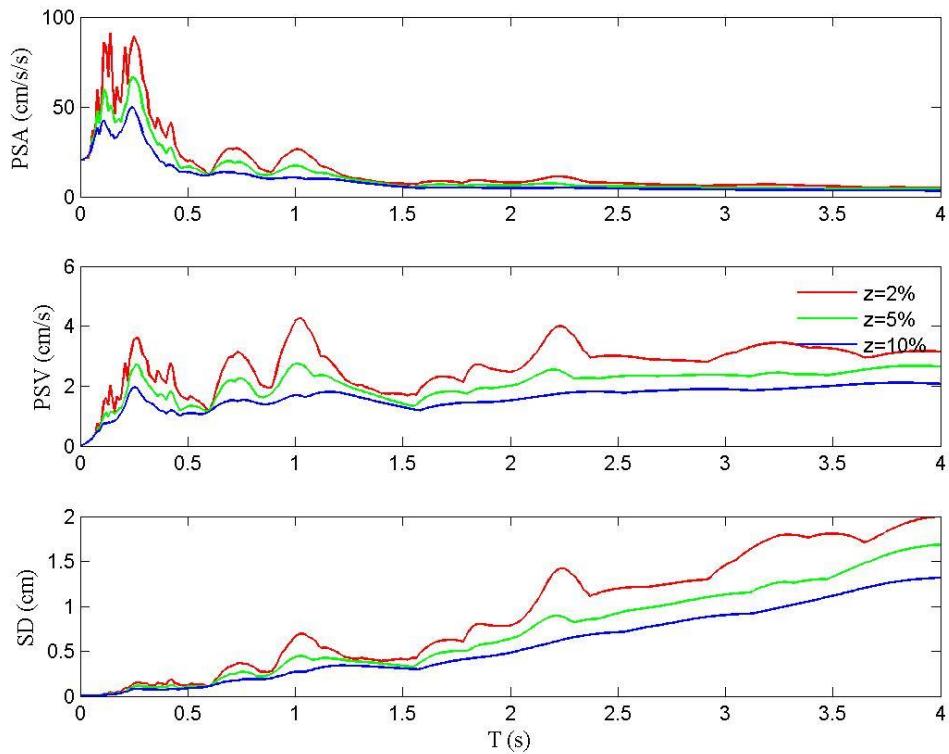
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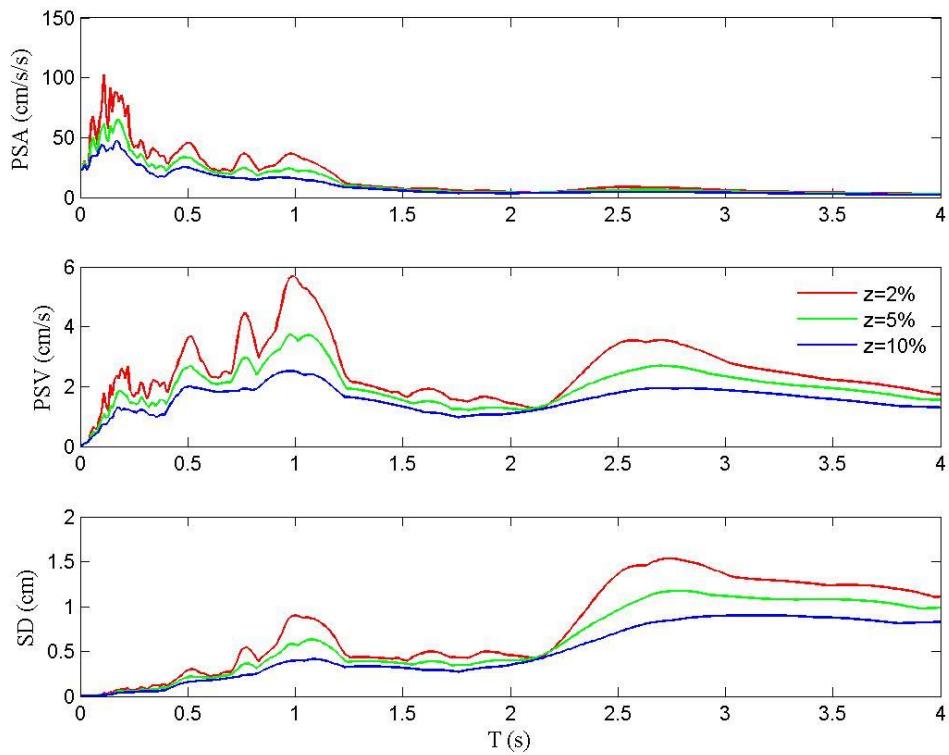
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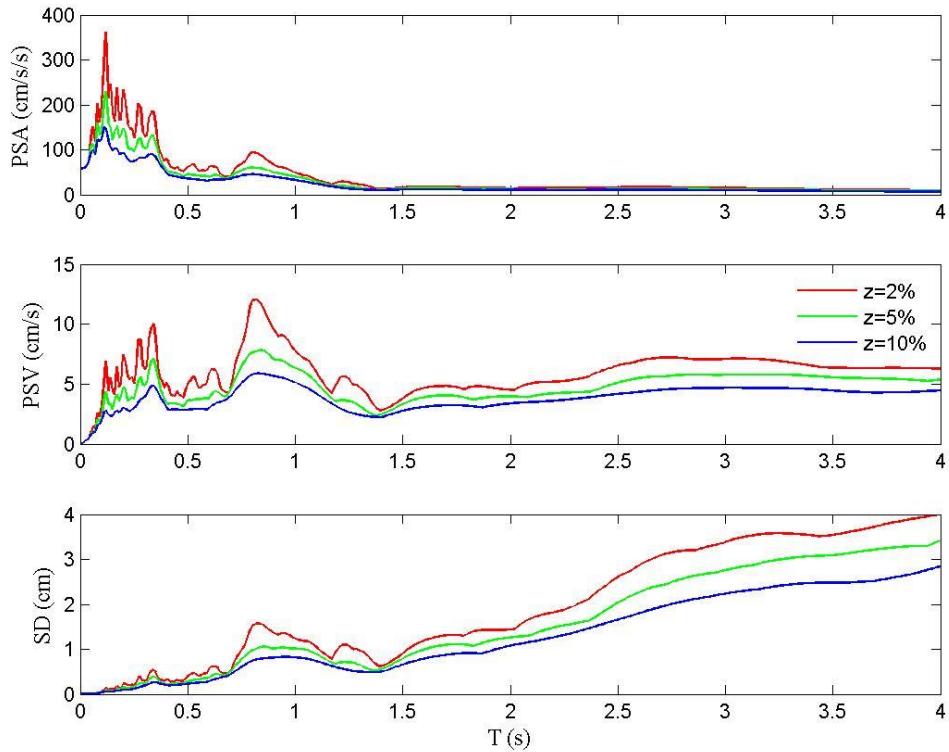
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SSM1_HNZ
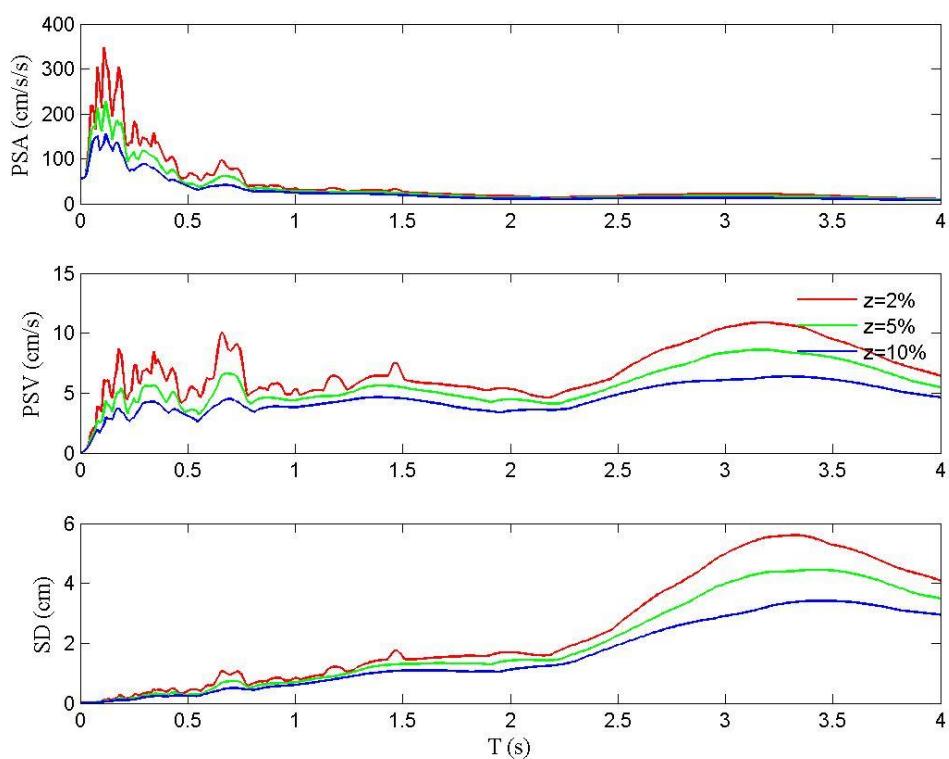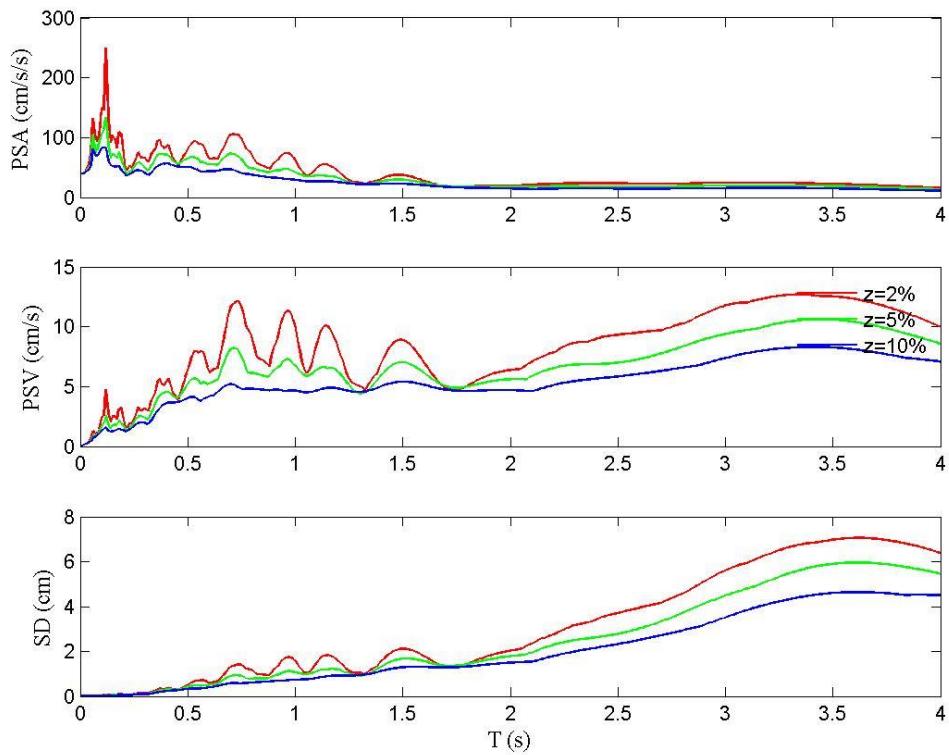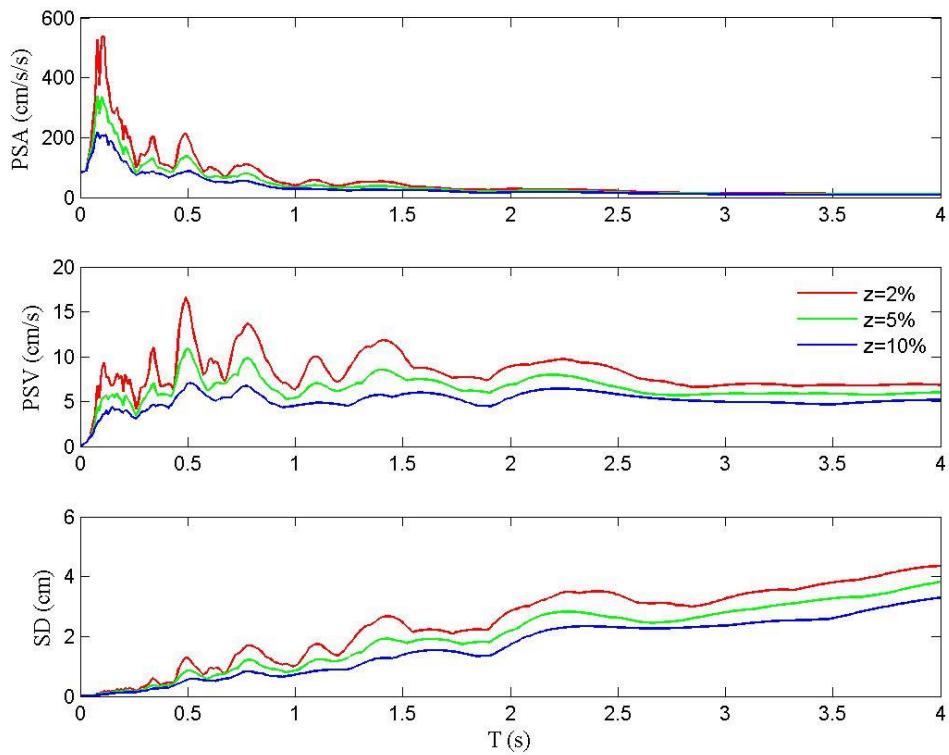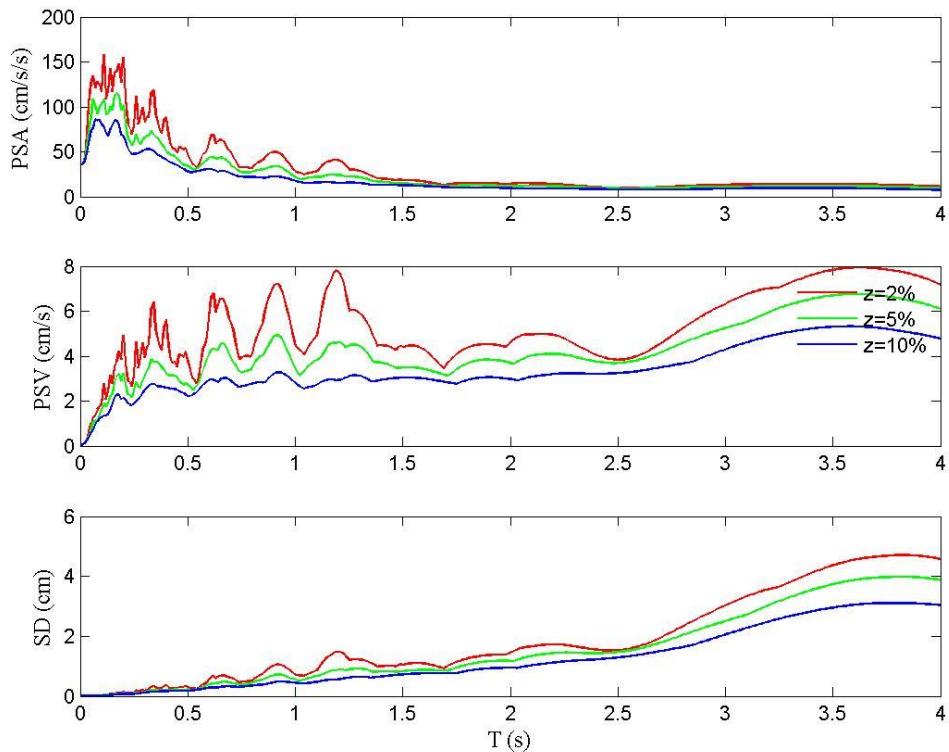
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TERO_HNN

TERO_HNZ
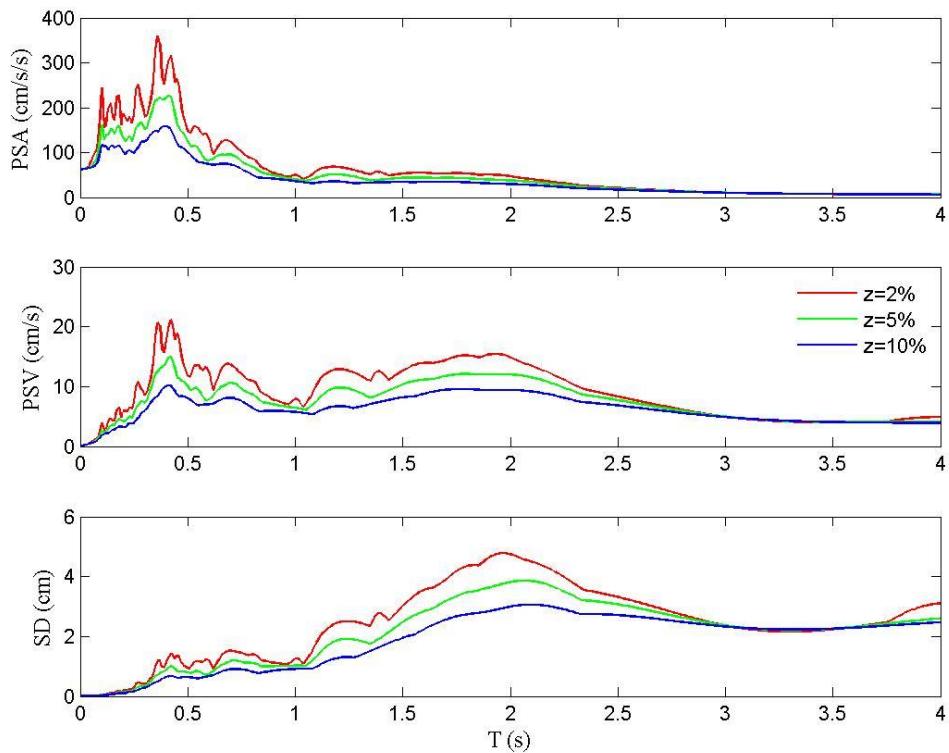
TRE1_HNE
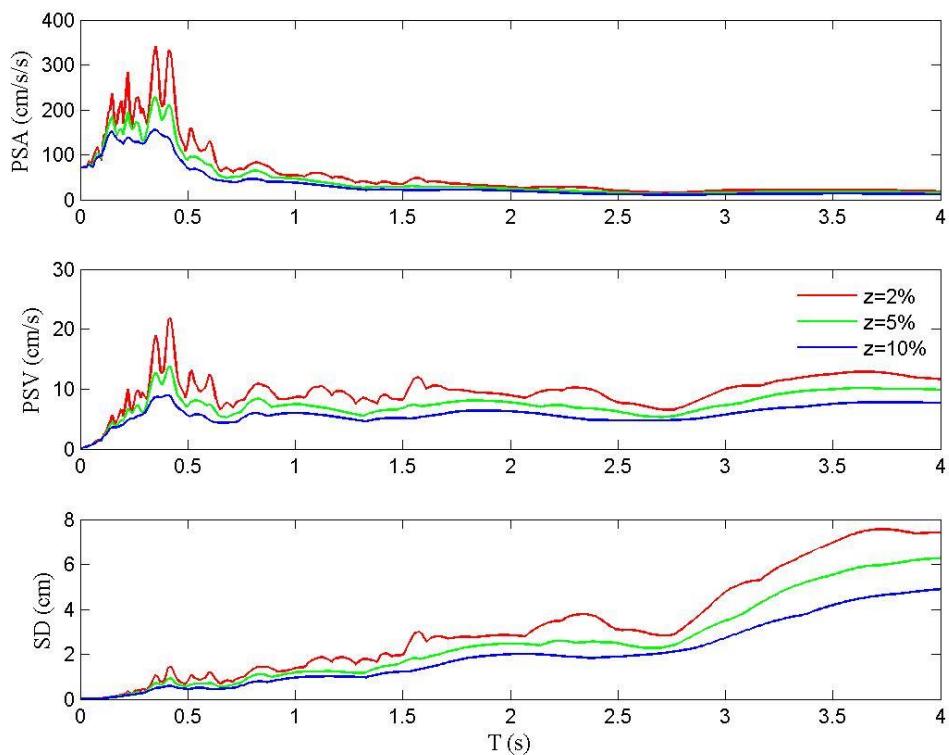
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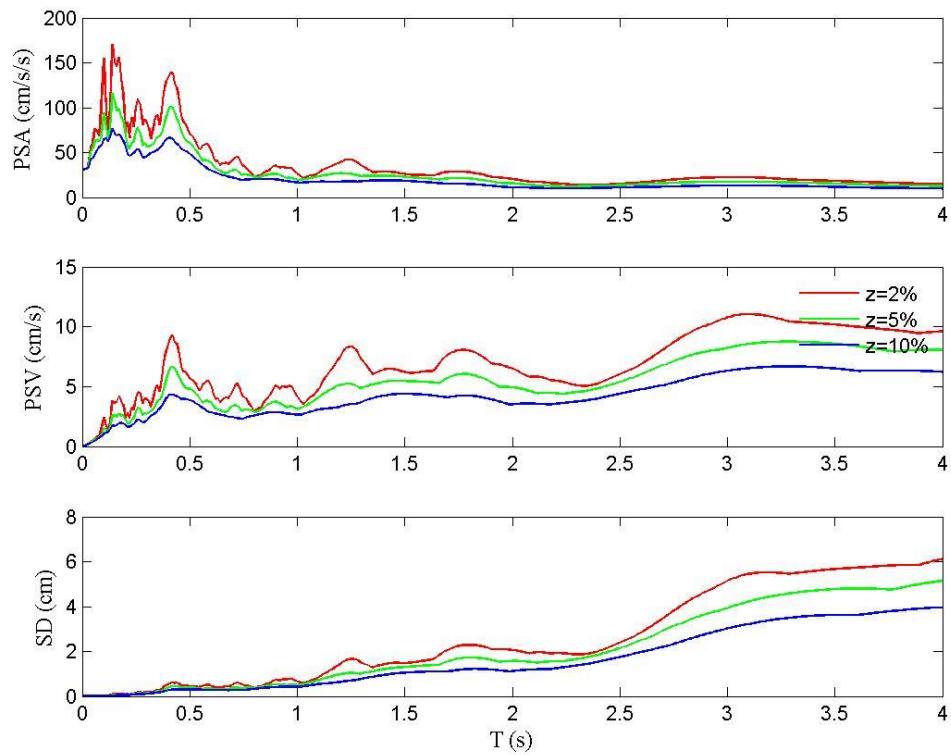
TRE_HNZ

Appendix 1

net_code	station_code	ec8_code	st_latitude	st_longitude
IT	0CAN		43.472301	12.6308
IV	ACER	B*	40.7867	15.9427
OX	ACOM		46.548	13.5137
OX	AGOR		46.2329	12.0472
IT	ANB	B*	43.59229	13.507411
IV	APEC	B*	43.55846	12.41991
IV	APRC		41.75738	15.54308
MN	AQU	C*	42.35388	13.40193
IV	ASOL	A*	45.8003	11.9023
IV	ATCC	B*	43.18514	12.63994
IV	ATFO	B*	43.3666	12.5715
IV	ATLO	B*	43.3152	12.4073
IT	ATN	A*	41.620319	13.801154
IV	ATPC	B*	43.4807	12.457
IV	ATTE	A*	43.1979	12.3536
IV	ATVO	B*	43.38211	12.40663
IT	AVL	C*	40.922832	14.787044
IT	BCN	C*	40.634346	15.382376
IV	BDI	B*	44.0624	10.597
IT	BGR	B*	43.889511	11.991291
IV	BIOG	B*	41.199899	15.132629
MN	BLY		44.7488	17.1839
IT	BNE	C*	41.127556	14.784882
IV	BOB	B*	44.7679	9.4478
IV	BRIS	B*	44.2245	11.7666
IT	BRS	A*	42.324272	13.59007
IT	BSS	B*	42.191732	13.845266
IV	BSSO	A*	41.5461	14.5938
IT	BTT2	D	41.998333	13.543056
IT	BVG	C	42.932367	12.611065
IT	BZZ	B	42.337025	13.468575
IV	CADA	B*	43.1942	13.7614
IV	CAFE	A*	41.028	15.2366
IT	CCT	C*	43.3683	12.2346
IV	CDCA	C*	43.4584	12.2336
IT	CER	B*	41.2595	15.9102
IV	CERA	A*	41.5978	14.0183
OX	CGRP		45.8806	11.8047
IV	CIMA	B*	43.305297	13.670091
OX	CIMO		46.3116	12.4448
IT	CLF	D	43.036714	12.920428

IT	CLN	B*	42.085224	13.520722
OX	CLUD		46.4569	12.8814
IT	CMB	B*	41.5628	14.6523
IT	CME	A*	43.9543	10.3012
IV	CMPO	C*	44.5808	11.8056
IV	COR1	B*	43.6318	13.0003
IV	CPGN	B*	43.8011	12.3205
IV	CRMI	B*	43.7956	10.9795
IV	CRND	C*	45.8361	12.0131
IT	CRP	C*	44.7823	10.8703
IT	CSA	C*	43.008015	12.590602
IT	CSD	B	42.754048	12.003539
IT	CSN	B	44.137005	12.241408
IT	CSO1	B*	42.100933	13.088044
IT	CSS	B	41.48579	13.82309
IT	CTD	B*	42.388366	12.947702
IV	CTL8	C*	45.2755	9.7621
IT	CTS	C*	43.491987	12.223396
MN	CUC	A*	39.9938	15.8155
IT	CVM	A*	42.994091	11.282305
ST	DOSS		45.8808	11.1884
IT	DUR	B*	41.6611	14.4565
IV	FAEN	C*	44.2895	11.877
IT	FAZ	C	44.298016	11.890746
IT	FBR	C*	43.343601	12.9119
IV	FERS	C	44.9035	11.5406
IT	FIE	B*	43.807251	11.294385
IV	FIU1	B*	43.188561	12.931604
IT	FOC	C*	43.0263	12.896506
IV	FOSV	B*	43.29483	12.76117
IV	FRE8	A*	46.015	12.3552
IT	FSS	C*	43.690477	12.810074
IV	GAG1	B*	43.2381	13.0674
IV	GATE	B*	41.513145	14.910201
IT	GBB	B*	43.356972	12.597252
IT	GBP	C	43.31381	12.58949
IT	GNU	A*	42.803818	12.570145
IT	GRN	A*	41.81346	13.316985
IV	GUMA	B*	43.0627	13.3352
IV	IMOL	C*	44.35955	11.74248
IV	LEOD	C*	45.4582	10.1234
IV	MCEL	A*	40.3249	15.8019
IT	MCR	C*	43.799889	12.447514
IT	MCS	B*	43.994366	12.107441
IV	MDAR	B*	43.1927	13.1427
IV	MELA	A*	41.7059	15.127

IV	MGAB	A*	42.91263	12.11214
IV	MGR	B*	40.1376	15.5535
IT	MLF	B	40.9944	15.6527
IT	MMP1	B*	42.249229	12.748319
IT	MNF	A*	43.059684	13.184466
IT	MNG	A*	41.70354	15.95803
IT	MNT	A*	43.139698	11.182792
IV	MNTV	C*	45.1495	10.7897
IV	MOCO	B*	41.37	15.158
IV	MODE	C*	44.6297	10.9492
OX	MPRI		46.2408	12.9877
IV	MRB1	B*	41.1227	14.96815
IV	MRLC	B*	40.7564	15.48892
IV	MSAG	A*	41.712	15.9096
IT	MTL	B	43.249435	13.008338
IV	MTRZ	B*	44.3128	11.4248
IV	MURB	B*	43.263	12.5246
IT	NAP	C*	40.799255	14.179607
IT	NCR	E	43.111583	12.784666
IV	NDIM	C*	44.8873	10.8987
IV	NEVI	B*	44.5834	10.3163
IT	NRC	B	42.792543	13.096475
IV	NRCA	B*	42.833549	13.11427
IT	NRN	A*	42.51556	12.51944
IV	OPPE	C*	45.3082	11.1724
IT	ORP	B	41.279228	15.265064
IV	ORZI	C*	45.4056	9.9307
IV	OSSC	B*	43.5236	11.2458
IT	PAN	B*	43.00581	12.14362
IV	PAOL	A*	41.031206	14.567486
IV	PCRO	B*	43.6077	13.5323
IT	PGG	B*	42.322872	13.539446
IV	PIEI	A*	43.53567	12.535
IV	PIGN	A*	41.200001	14.17989
IT	PNC	B*	42.847446	11.693599
IT	PNN	C	43.818159	12.262846
IV	POFI	A*	41.71743	13.71202
IV	PP3	C*	43.3778	13.6095
IT	PSC	A	41.812042	13.789196
IT	PTI	B*	43.066567	13.657076
IT	PTL	B*	43.427334	12.448597
IV	PTRJ	A*	41.3641	14.529
IT	PVF	B*	44.333096	10.825229
BA	PZUN	B*	40.6458	15.807
IT	RDG	A*	41.9264	15.8792
IV	RM33	B*	42.509	13.2145

IV	RNI2	A*	41.70328	14.1524
IV	ROM9	B*	41.828419	12.51553
IV	ROVR	A*	45.6468	11.0721
IT	RQT	B*	42.813091	13.311026
IT	RTI	D	42.430278	12.829097
OX	SABO	B*	45.9875	13.6336
IV	SACS	B*	42.84906	11.90967
IT	SAG	A*	40.93156	15.18763
IV	SALO	A*	45.6183	10.5243
IV	SANR	C*	45.64	11.6099
IV	SBPO	C*	45.0511	10.9199
IT	SCF	B*	42.265117	13.998489
IT	SDM	A*	42.289706	13.557652
IV	SERM	C*	45.01	11.2958
IV	SGG	A*	41.38667	14.37917
IT	SGMA	B*	41.684502	14.9644
IT	SGPA	B	41.687599	14.9629
IT	SGPA	B	41.687599	14.9629
IT	SGSC	B*	41.689201	14.9581
IT	SGSC	B*	41.689201	14.9581
IV	SGTA	B*	41.135	15.365
IV	SIRI	B*	40.1821	15.8675
FR	SMPL	A*	42.094	9.285
IV	SNAL	A*	40.9254	15.2091
IT	SNG	C	43.68558	13.226162
IT	SNI	B*	42.632	12.5536
IT	SNM	B*	43.934326	12.44929
IT	SNS1	C*	43.573502	12.1312
IV	SNTG	A*	43.255	12.9406
IT	SPM	A*	42.72324	12.751268
IV	SSFR	A*	43.4363	12.7822
IT	SSG	B*	43.569859	12.146323
IV	SSM1	B*	43.228783	13.176956
IT	SSO		43.571499	12.154
IV	STAL	B*	46.2601	12.7104
IT	STF	B*	43.908112	11.794457
IT	SUL	A*	42.089	13.934
IT	SULA	C*	42.0734	13.9166
IT	SULC	C*	42.068	13.909
IT	SULP	B*	42.085	13.9274
IV	TERO	B*	42.62279	13.60393
IT	TOD	A*	42.738174	12.387275
IT	TRE	C*	42.876499	12.7358
IV	TRE1	B*	43.311198	13.312848
IV	TREG	C*	45.523	11.1606
IV	TRIV	B*	41.7666	14.5502

IT	TRL	A*	42.461314	12.932308
IT	TRN1	D*	42.558201	12.6461
IT	TSC	A*	42.422613	11.8696
IT	TVL	B*	41.893015	12.773221
IT	UMB	B*	43.254437	12.2556
IV	VAGA	A*	41.4154	14.2342
ST	VARA	A*	45.826	10.8965
OX	VARN		45.9922	12.1051
IV	VENL	D*	45.4167	12.3765
IV	VITU	A*	41.18326	14.630154
MN	VLC	A*	44.1594	10.3864
IT	VLL	B*	41.67047	12.77267
IT	VLN	C*	43.142733	11.894722
IT	VNF1	C*	41.480499	14.0501
IV	VOBA	C*	45.6429	10.504
IT	VSE	B*	42.12218	14.707188
IV	VULT	B*	40.9549	15.6163
IV	ZCCA	B*	44.35085	10.9765
IV	ZEN8	A*	45.6378	10.7319
OX	ZOU2		46.5584	12.9729
IV	ZOVE	B*	45.4536	11.4876