Boğaziçi University
Kandilli Observatory & Earthquake Research Institute (KOERI)
Department of Earthquake Engineering

23 April 2025 (12:49 p.m)
M6.1 Off Silivri-Istanbul Earthquake

Istanbul Earthquake Rapid Response System (IERRS)

Report on the Real-Time Assessment of Strong Ground Motion and Building Damage Estimations

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28.04.2025 (v2)
23.04.2025 (v1), Istanbul

Magnitude (M_w) : 6.0 (revised as 6.1)

Epicenter : 40.8508° N / 28.233° E

Depth : 13.1 km

The Istanbul Earthquake Rapid Response System (IERRS) was triggered by the occurrence of an earthquake of magnitude 6.0 at 12:49 p.m (local time) on April 23 (https://eqe.bogazici.edu.tr/en/istanbul-earthquake-rapid-response-and-early-warning-laboratory). Processing of the recorded strong motion data and building damage estimation analyses were automatically performed and completed within the 90 minutes of the event occurence. Following the calculation of peak ground acceleration (PGA), peak ground velocity (PGV), 5%-damped elastic spectral acceleration (Sa(0.2), Sa(1.0)) values for three components (two horizontal, one vertical) recorded at each station, the system produced bias-adjusted ground shaking maps. The acquisition of the geographical distributions of strong ground motion parameters throughout the city was then followed by spectral acceleration-displacement based damage estimation analysis for the grid-based Istanbul building inventory.

This report presents the system outputs as such the maps for the spatial distributions of PGA, PGV, Sa and instrumental intensity, and building damage estimations. Examples of the recorded strong motion data and comparisons with several GMPEs are also provided.

SPATIAL DISTRIBUTIONS OF THE STRONG GROUND MOTION

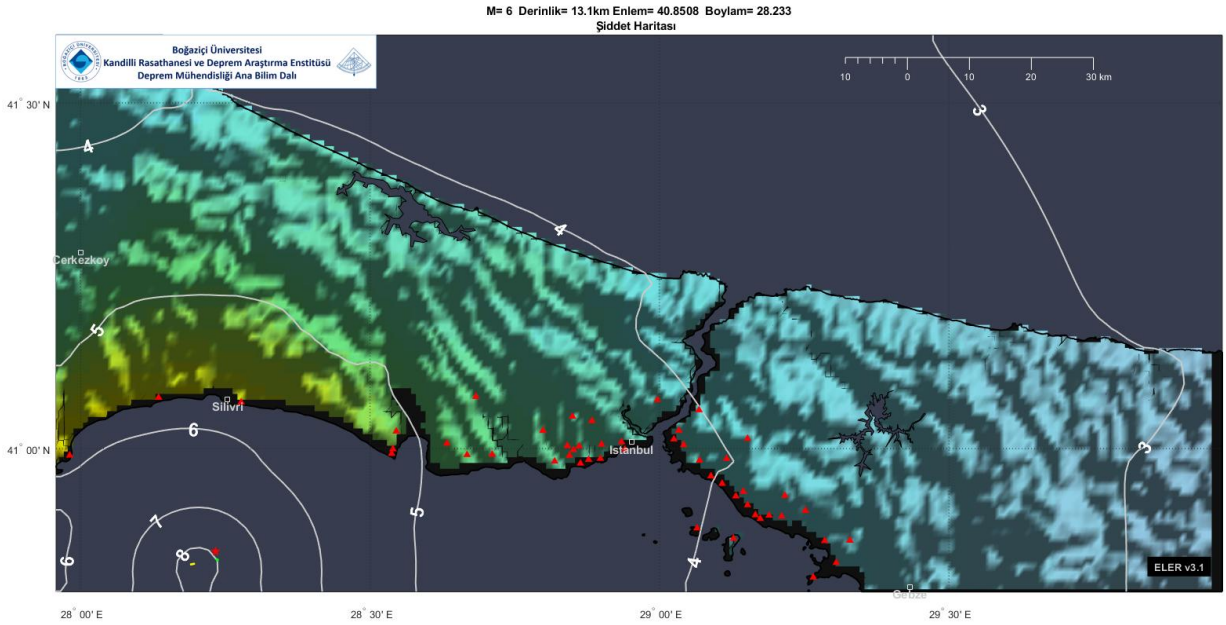


Figure 1. Instrumental intensity (MMI)

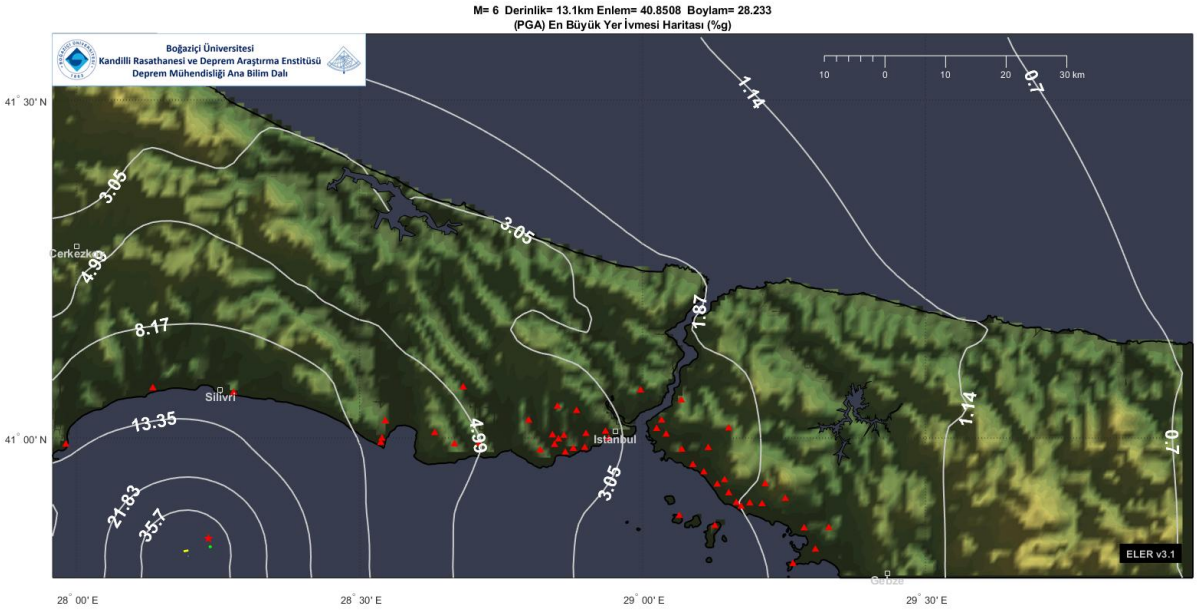


Figure 2. Peak ground acceleration (PGA, %g)

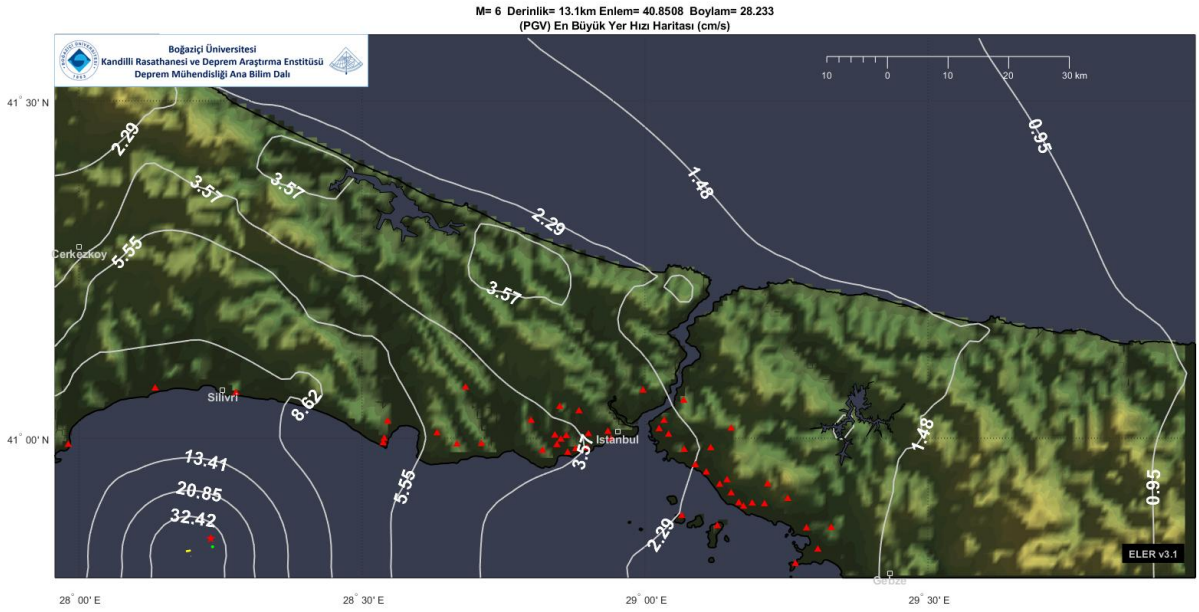


Figure 3. Peak ground velocity (PGV, cm/s)

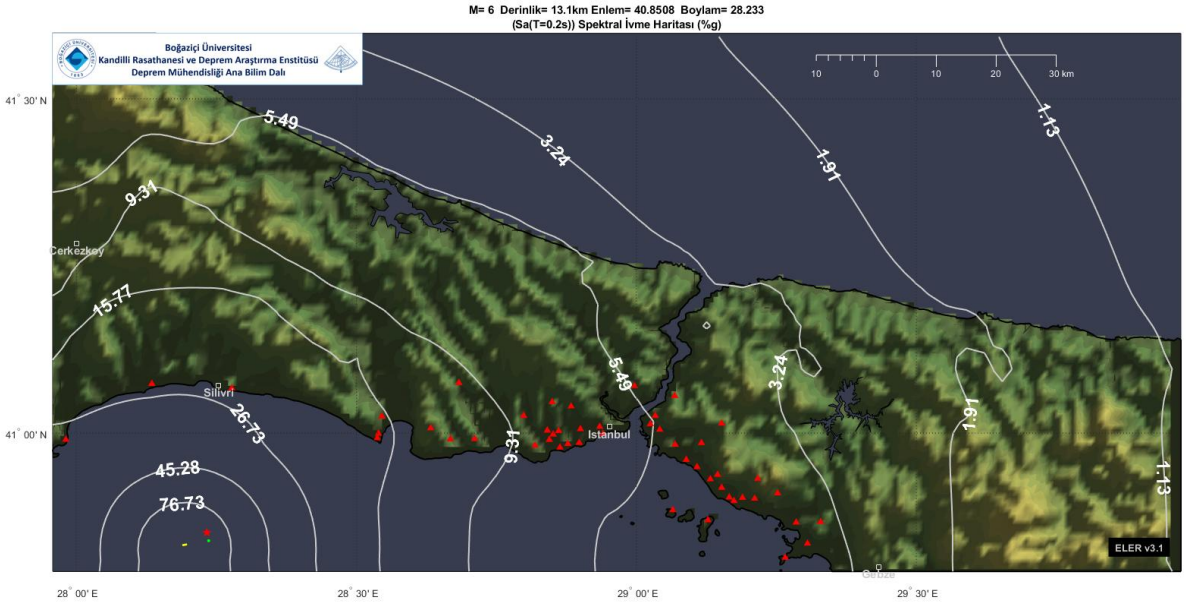
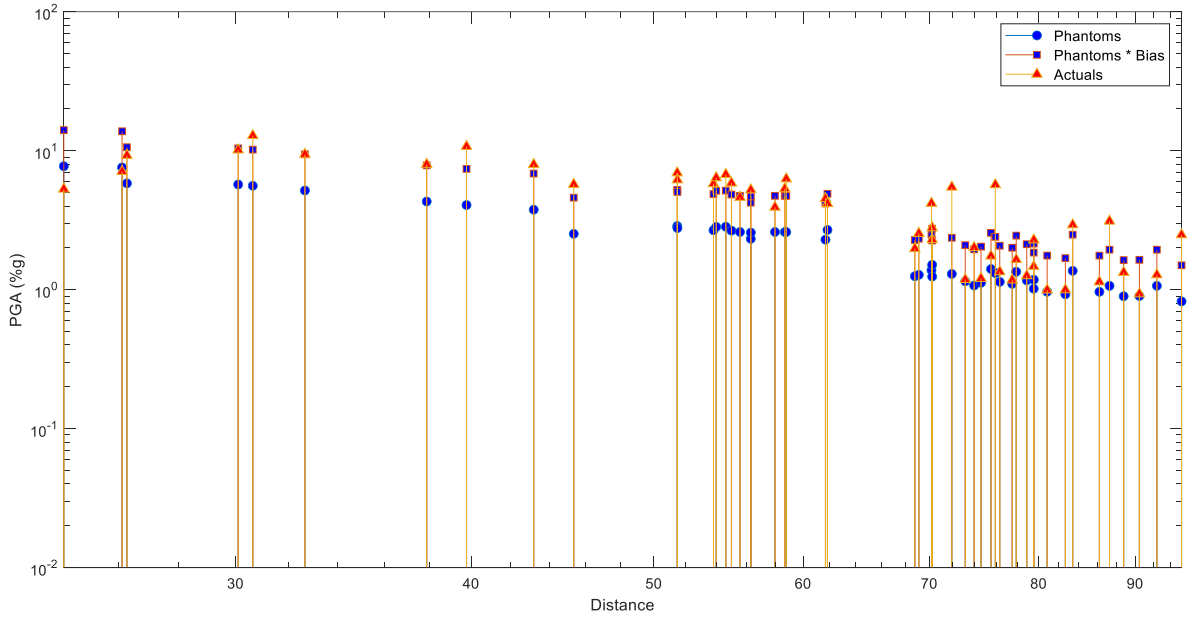
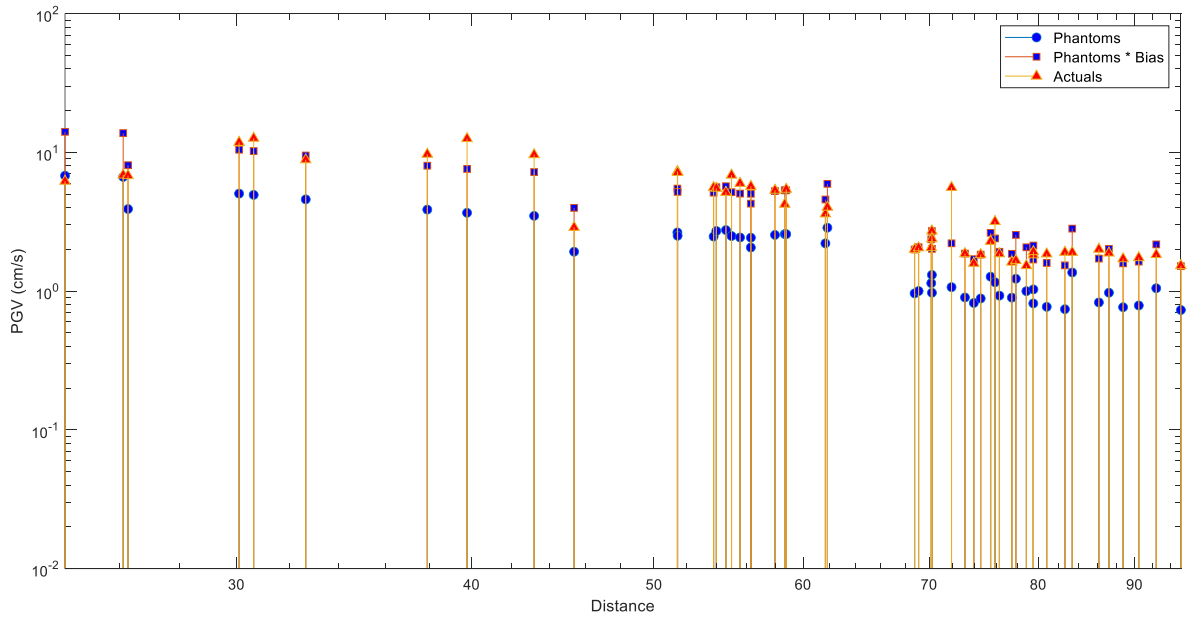


Figure 4. Spectral acceleration (Sa(0.2), %g)

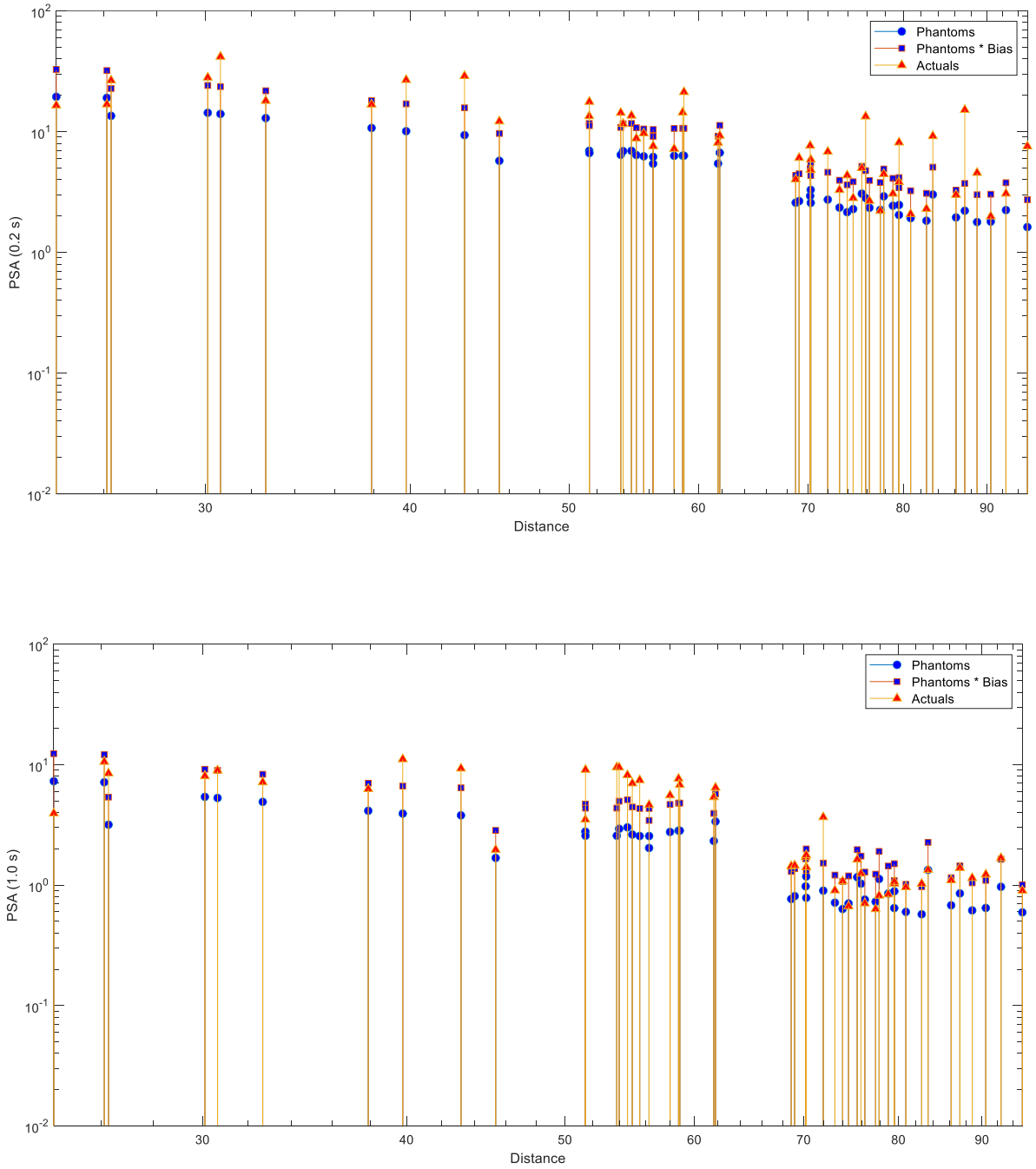
Figure 5. Spectral acceleration (Sa(1.0), %g)





(Actuals: Recorded values, Phantoms: Estimated values)

Figure 6. Bias correction of the PGA and PGV values estimated with the GMPE (CY14) based on the recorded values



(Actuals: Recorded values, Phantoms: Estimated values)

Figure 7. Bias correction of the Sa(0.2) and Sa(1.0) values estimated with the GMPE (CY14) based on the recorded values

BUILDING DAMAGE ESTIMATIONS

The IERRS conducts spectral acceleration-displacement based damage assessment with the Urban Earthquake Risk Analysis Module of ELER software (Earthquake Loss Estimation Routine, https://eqe.bogazici.edu.tr/en/eler-methodology-and-software) for the grid-based Istanbul building inventory. Spectral accelerations are used for the construction of demand spectrum for each grid. The performance points are computed for each building class using the demand and capacity spectra. Fragility functions in terms of spectral displacement are utilized for the computation of damage exceedance probabilities. Maps illustrating the distributions of the number of damaged buildings at each of *Slight, Moderate, Extensive and Complete Damage States* as well as *Undamaged Buildings*.

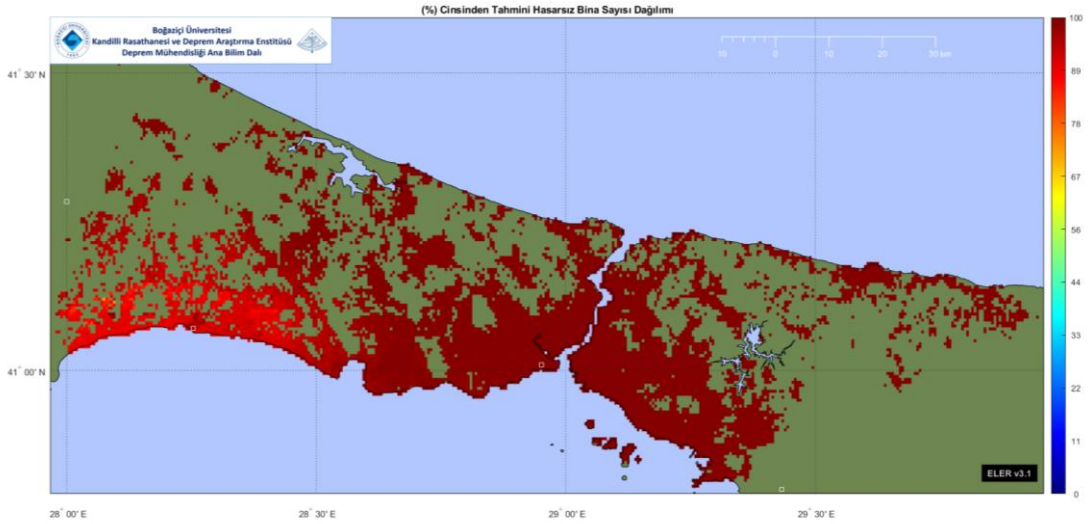


Figure 8. Estimated grid-based distribution of '*Undamaged*' buildings as a percentage of the total number of the buildings

The inventory analyzed contains information about approximately 1.2 million buildings at a grid resolution of 0.005°. Damage estimation analysis yielded that approximately 99% of the total number of buildings in the city would remain undamaged. Slight damages might be observed in several locations, which represented as lighter colored areas in Figure 8, mostly in Silivri, Büyükçekmece, Beylikdüzü, Avcılar ve Küçükçekmece districts. The number of slighlty damaged buildings was estimated as 8‰ of the total number of buildings in the inventory.

It is noted noted that in the damage estimation procedure detailed above the Vs30 values taken into account in the computation of site-dependent ground motions for each analysis grid are based on the IMM-2009 study and the building inventory dataset is the one compiled in 2018 within the scope of the IMM-2019 study. Analyses to be performed with up-to-date data and information will yield different results than those presented in this report.

RECORDED STRONG GROUND MOTIONS

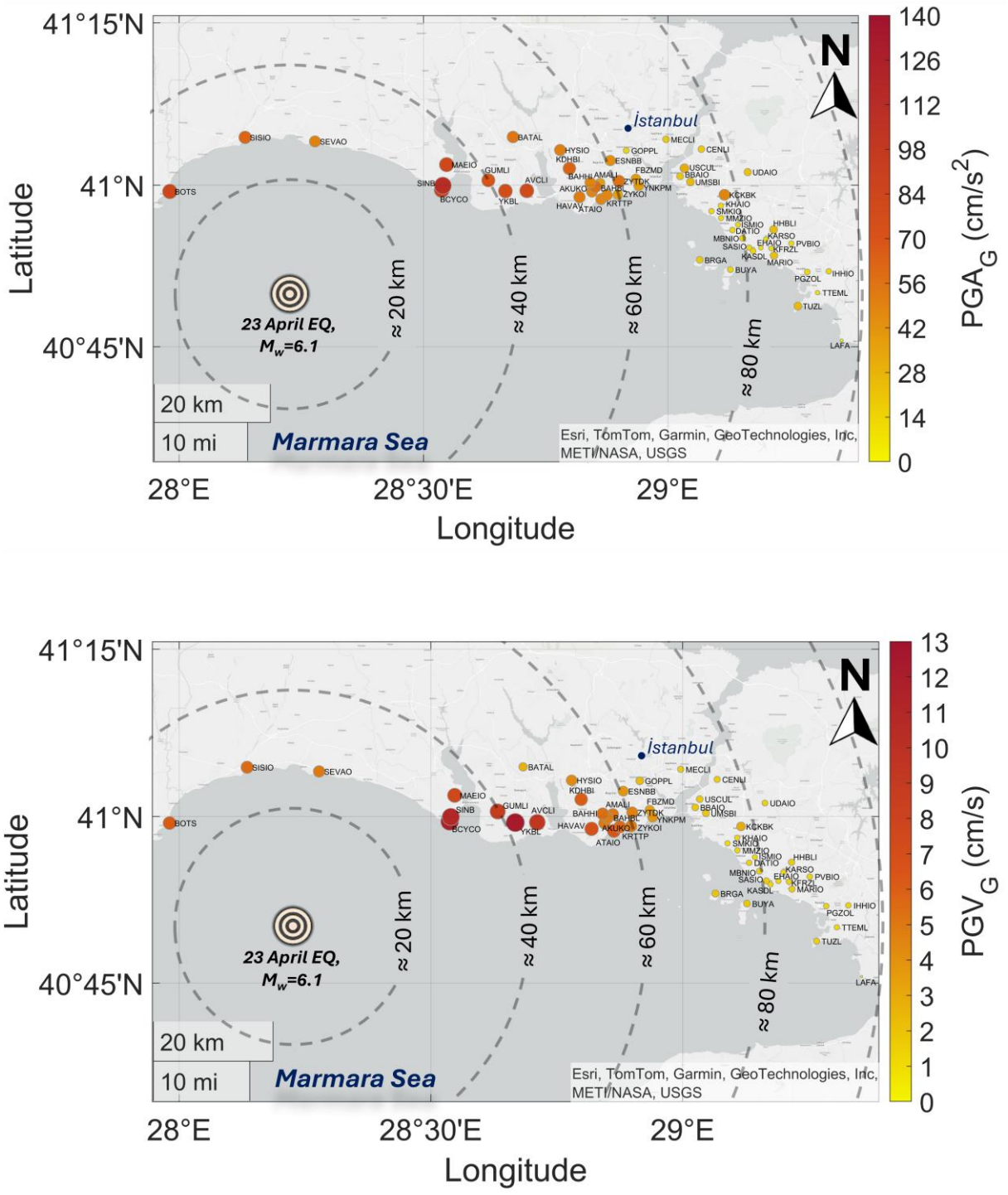


Figure 9. PGA and PGV values recorded at each station

Stations Recorded the Highest Accelerations

SINB (B.Çekmece), YKBL (Beylikdüzü), BCYCO (B.Çekmece), MAEIO (B.Çekmece), BOTS (M.Ereğlisi), AVCLI (Avcılar), SISIO (Silivri), KDHBI (K.Çekmece).

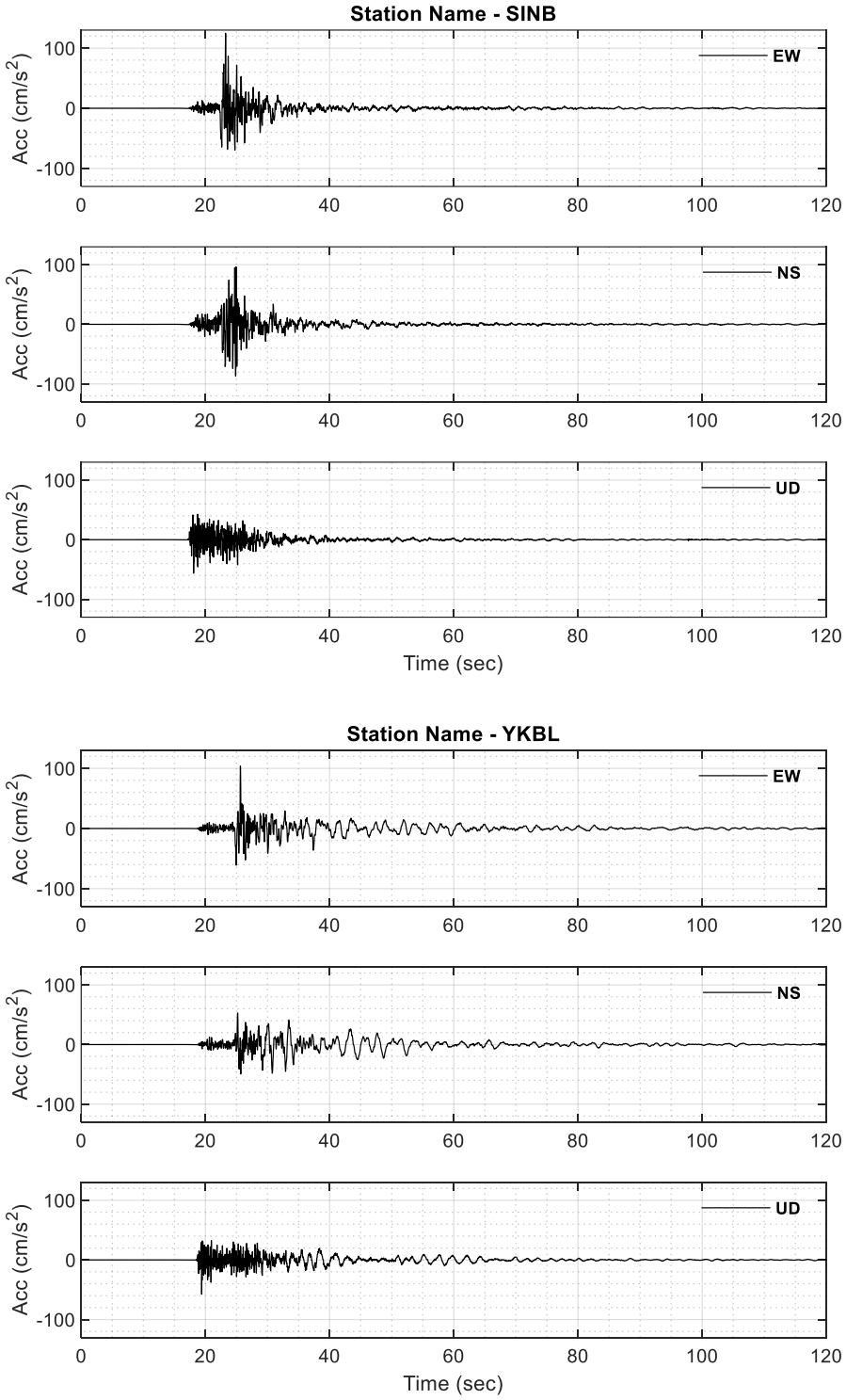


Figure 10. Acceleration time histories recorded at SINB and YKBL stations

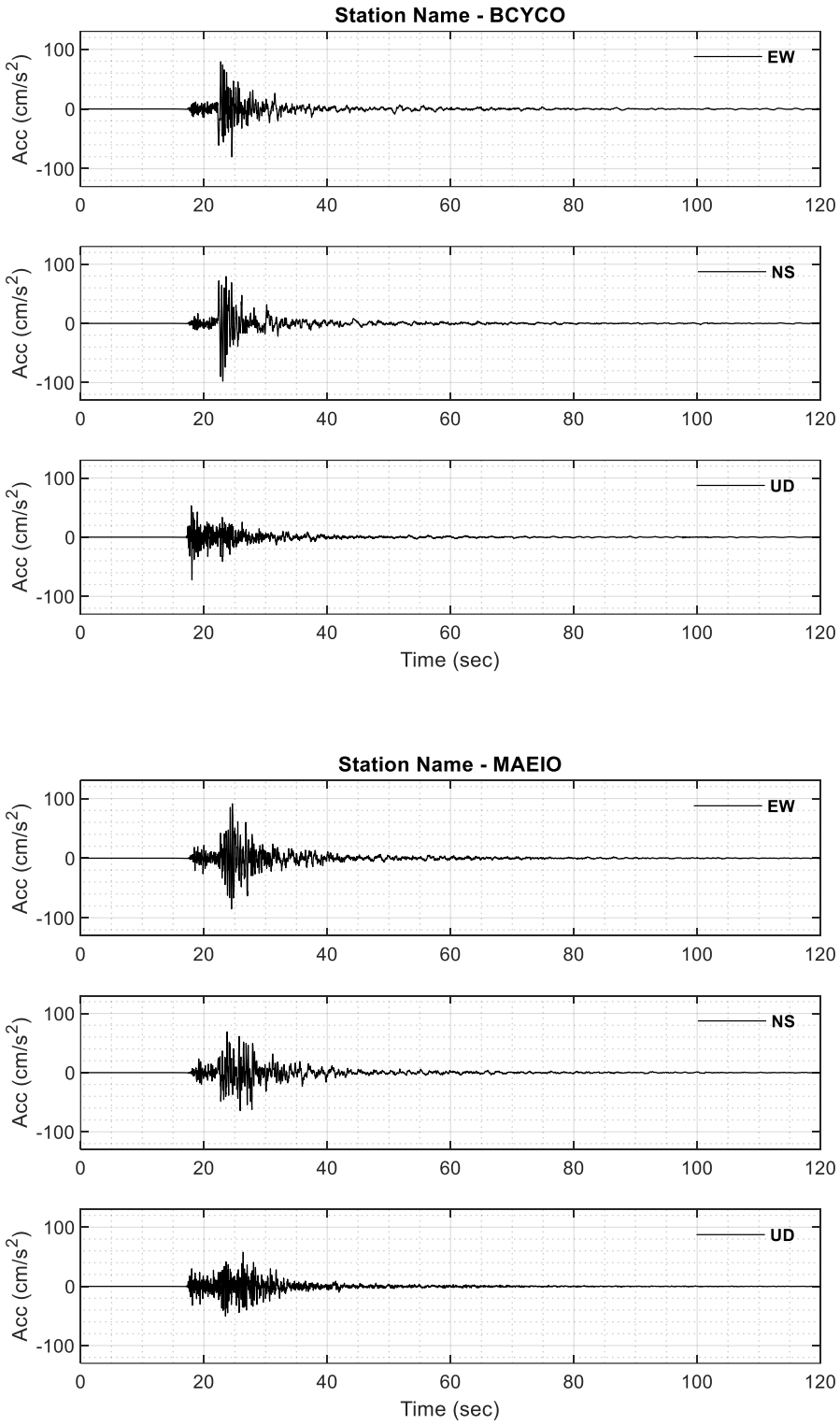


Figure 11. Acceleration time histories recorded at BCYCO ve MAEIO stations

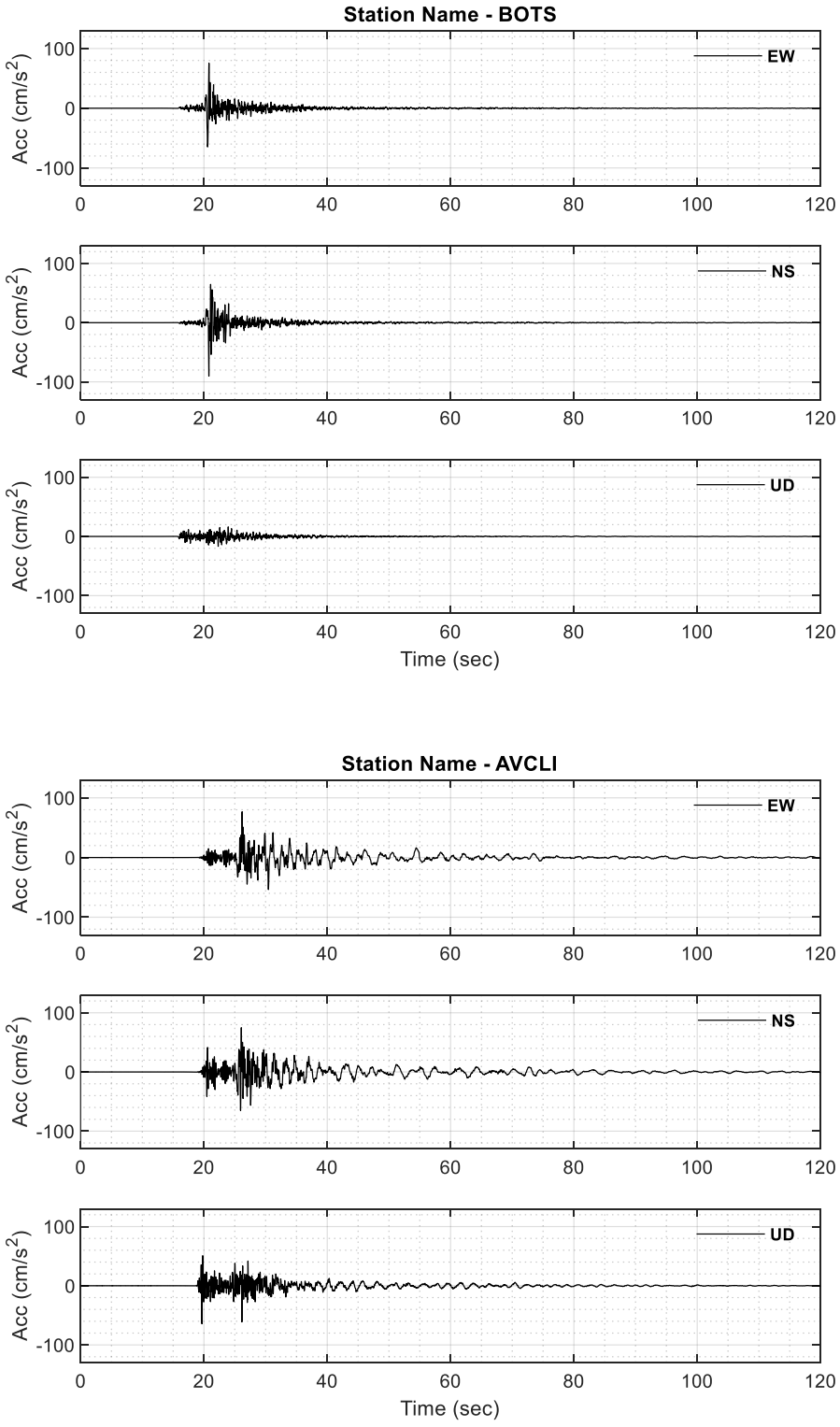


Figure 12. Acceleration time histories recorded at BOTS ve AVCLI stations

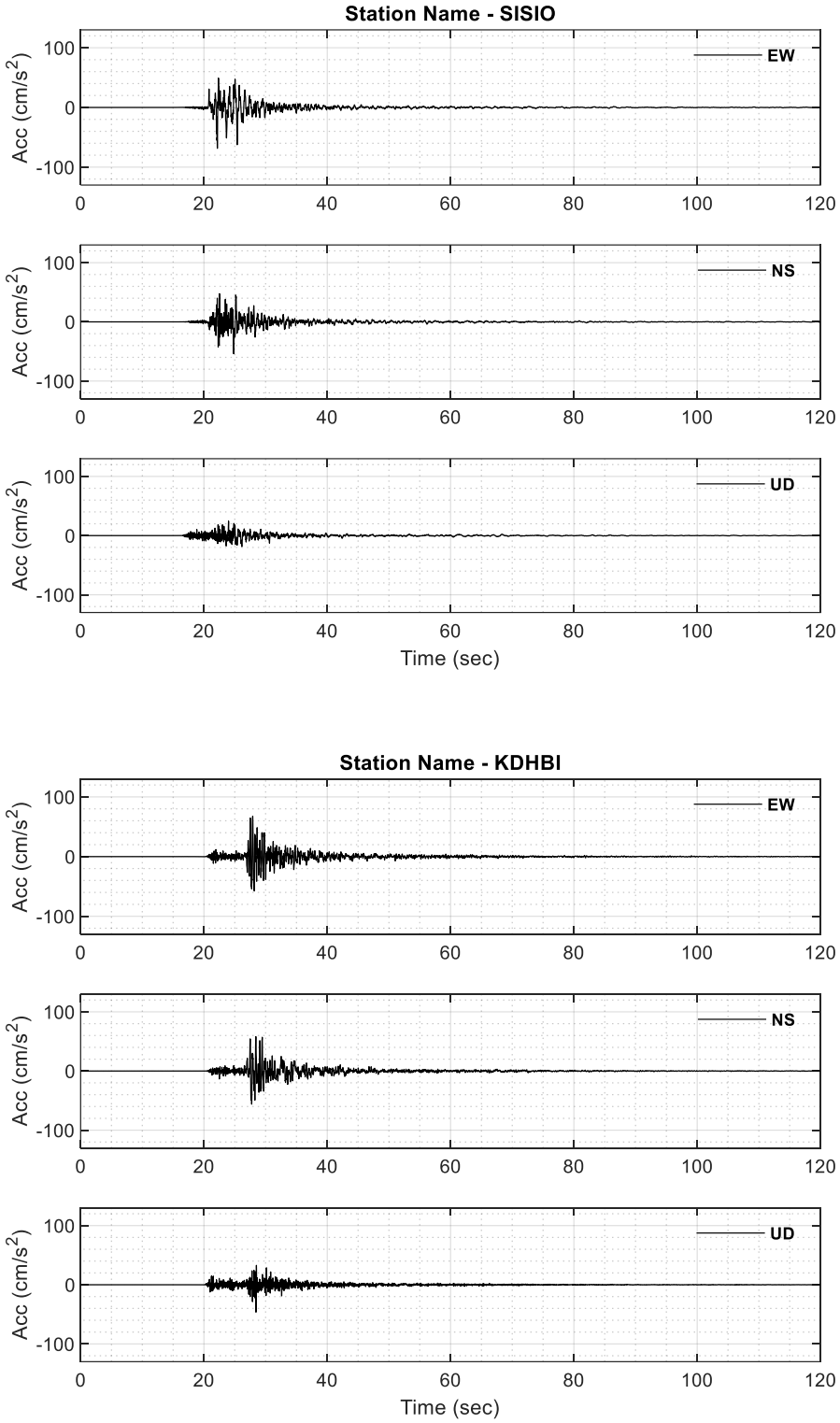


Figure 13. Acceleration time histories recorded at SISIOve KDHBI stations

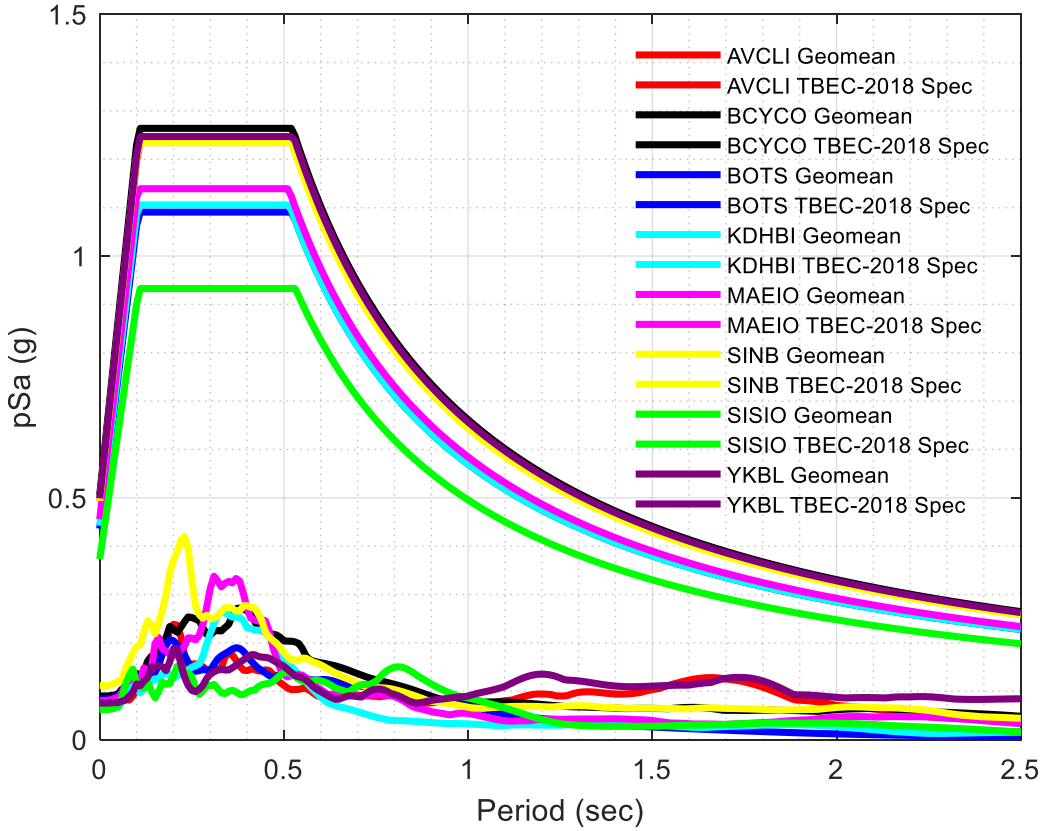


Figure 14. 5%-damped elastic response spectra for each station compared to the code spectra for design basis ground motion level (i.e. 10% in 50 yrs, TBEC-2018) at station locations

Comparison of Stations Recorded Values to the GMPEs

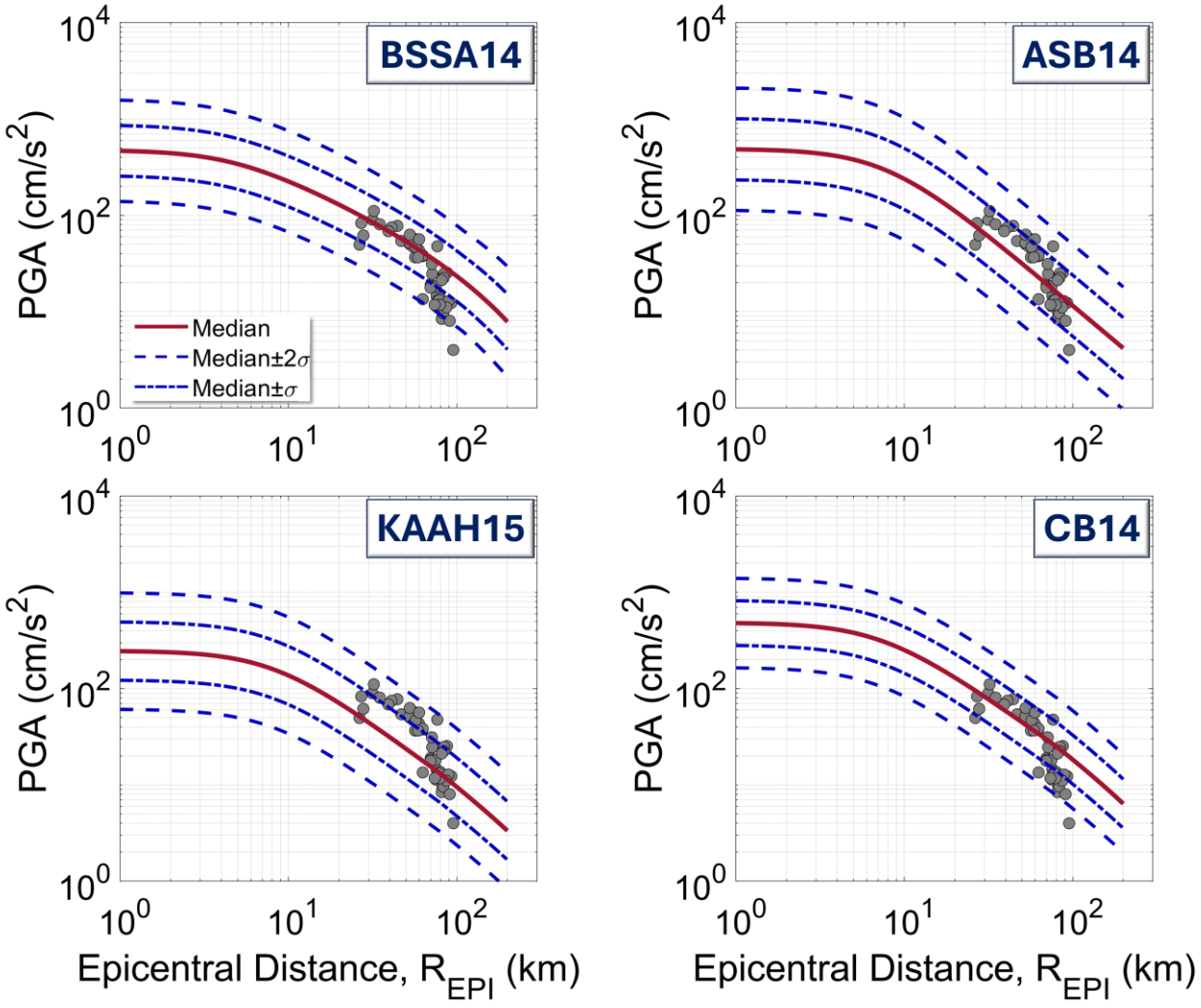


Figure 15. Comparison of the recorded values (PGA, geo. mean of two horizontal components) with GMPEs

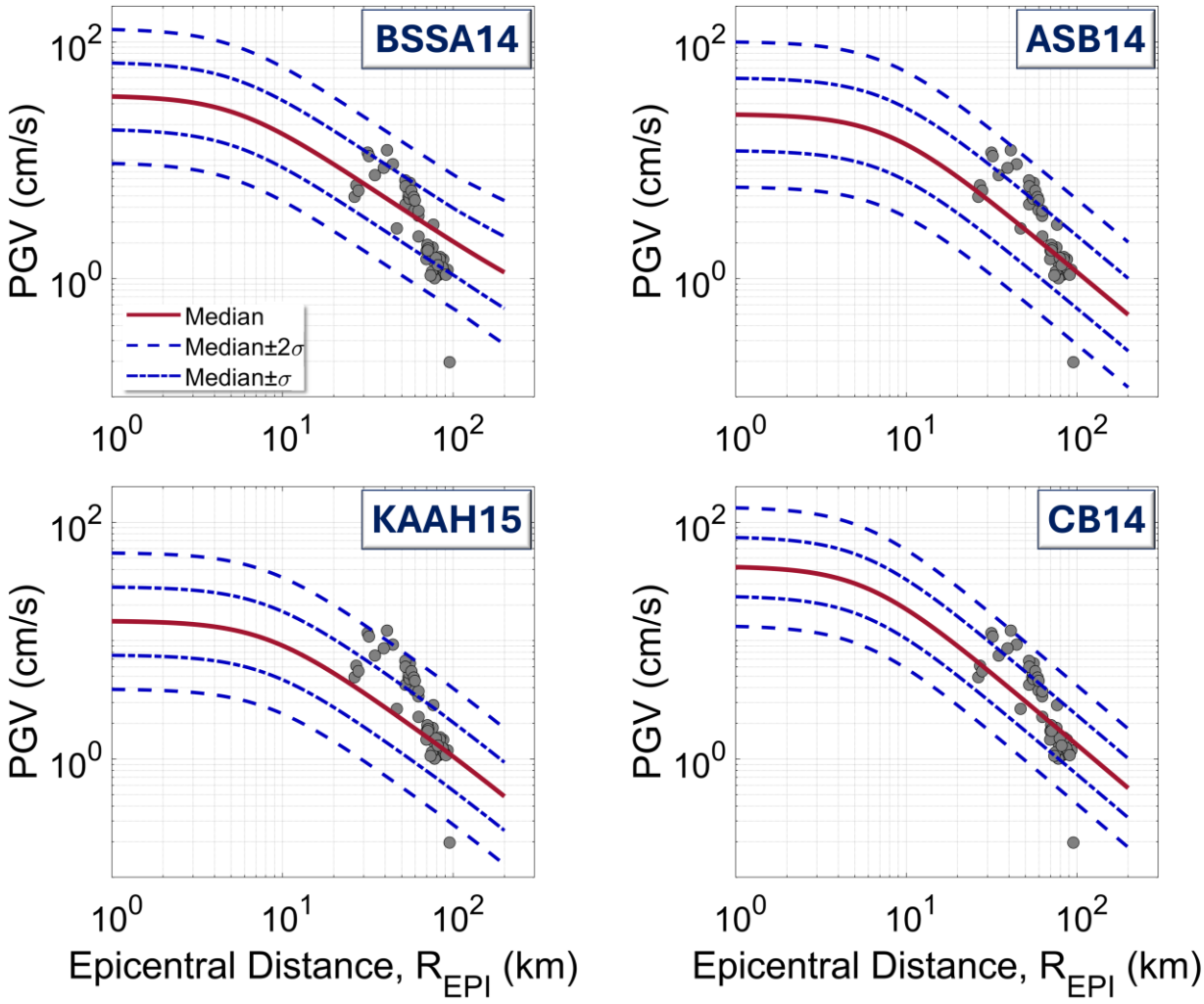


Figure 16. Comparison of the recorded values (PGV, geo. mean of two horizontal components) with GMPEs

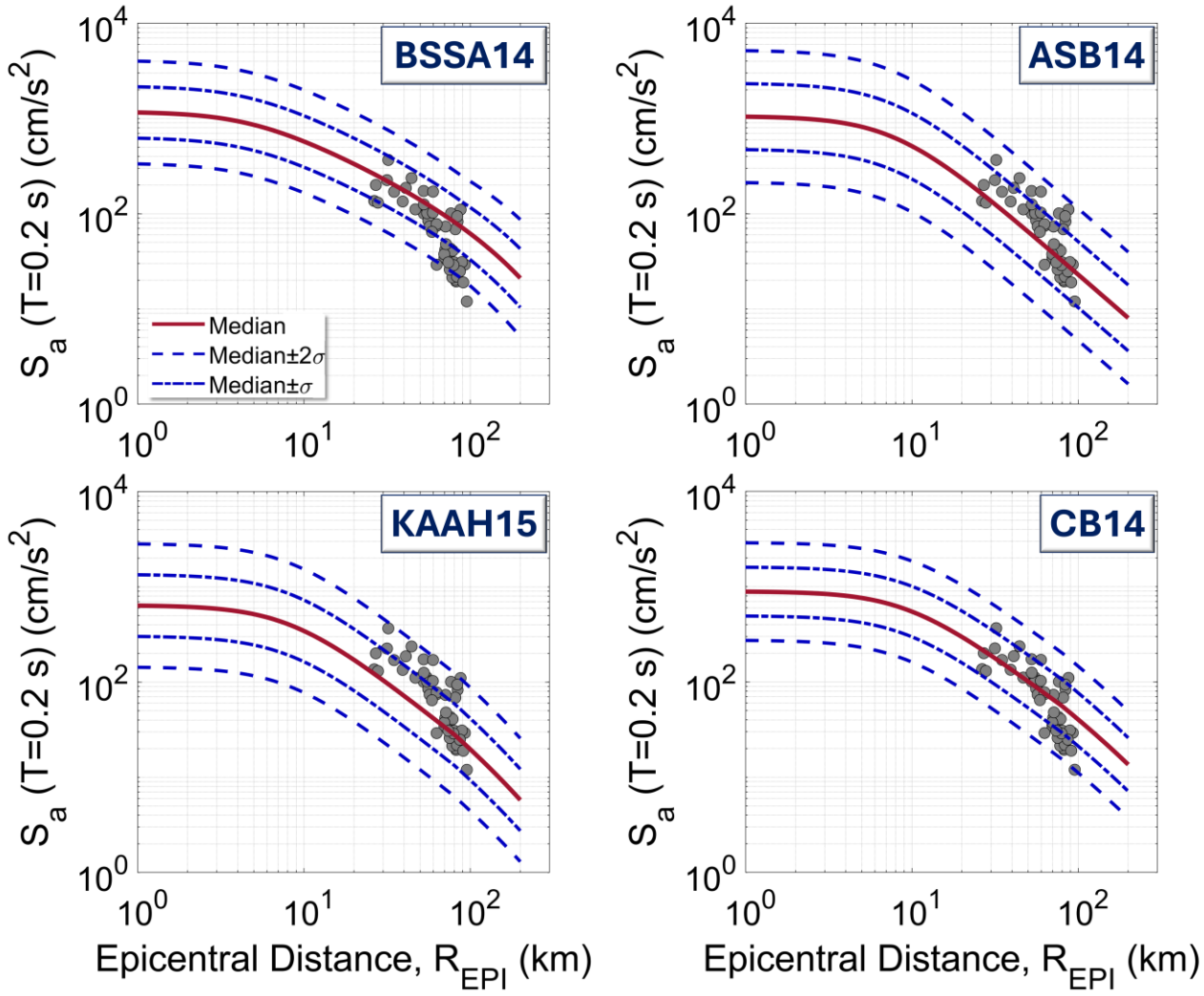


Figure 17. Comparison of the recorded values (Sa(0.2), geo. mean of two horizontal components) with GMPEs

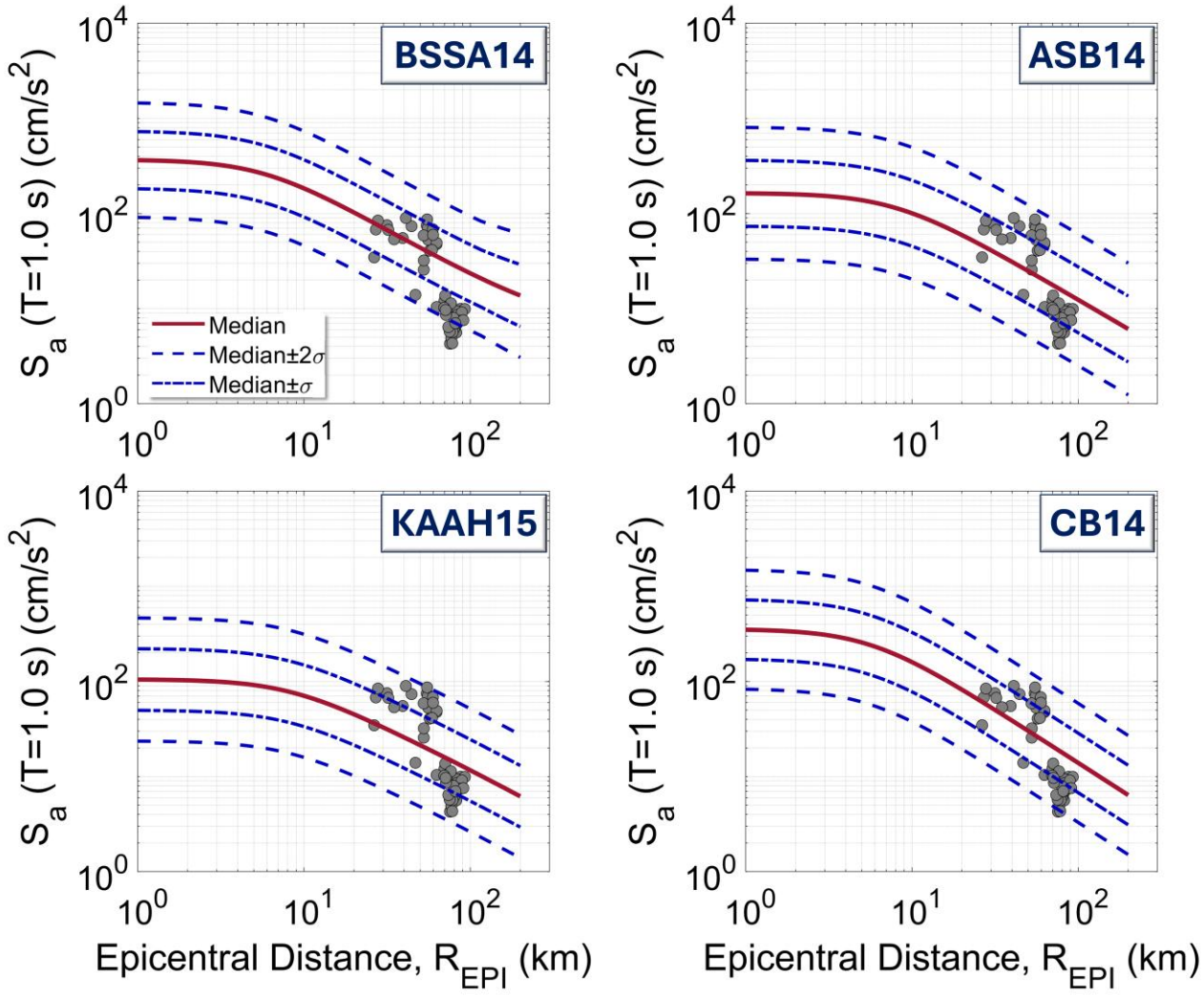


Figure 18. Comparison of the recorded values (Sa(1.0), geo. mean of two horizontal components) with GMPEs

Istanbul Earthquake Rapid Response System-Stations Data

Station		Lat	Lon	$V_{s,30}$ (m/s)	R_{epi} (km)	Comp.	PGA (cm/s^2)	PGV (cm/s)	Sa(0.2) (cm/s^2)	Sa(1.0) (cm/s^2)
Name	Code									
AKUKO	5BG8	40.9899°	28.8445°	341	53.78	EW	41.11	4.28	88.99	60.03
						NS	56.79	5.59	140.46	93.43
						UD	19.54	1.77	44.58	21.28
AMALI	5BN8	41.0033°	28.8611°	332	55.55	EW	29.08	4.07	91.14	54.65
						NS	45.31	5.99	94.90	73.02
						UD	19.88	1.63	49.49	18.55
ATAIO	5BG7	40.9785°	28.8635°	327	54.97	EW	40.02	6.86	82.55	40.65
						NS	57.44	5.97	86.29	68.68
						UD	18.28	2.14	37.97	29.85
AVCLI	5BK2	40.9913°	28.711°	296	43.18	EW	78.09	9.63	196.31	91.25
						NS	76.43	8.82	283.32	59.48
						UD	64.68	4.94	178.94	31.77
BAHBL	5BM9	40.9981°	28.8514°	289	54.60	EW	48.25	4.33	78.53	62.33
						NS	66.20	5.16	133.21	80.48
						UD	28.31	1.88	60.78	20.94
BAHHI	5BT9	41.0041°	28.8409°	300	53.96	EW	35.46	5.13	88.75	93.09
						NS	62.70	5.52	113.91	80.46
						UD	21.96	1.75	72.77	25.59
BATAL	5BQ4	41.0752°	28.683°	600	45.34	EW	49.48	2.43	119.35	19.30
						NS	56.19	2.88	103.49	10.12
						UD	31.03	1.79	49.80	8.63
BBAIO	5BK6	41.0135°	29.025°	775	69.11	EW	24.92	1.43	59.47	10.25
						NS	14.29	2.05	20.33	14.30
						UD	11.10	0.60	14.95	5.96
BCYCO	5BN2	40.9927°	28.5374°	313	30.09	EW	80.14	11.32	275.10	71.97
						NS	99.32	11.83	179.82	78.81
						UD	73.14	4.04	152.54	31.79
C2474	TUZL	40.8132°	29.2659°	769	87.23	EW	20.74	1.12	79.84	7.25
						NS	30.54	1.88	148.66	13.63
						UD	6.72	0.74	11.33	3.36
C2490	BOTS	40.9902°	27.981°	313	26.27	EW	75.03	6.81	154.89	55.50
						NS	90.85	5.52	260.58	83.16
						UD	16.70	1.09	60.47	18.66
C2493	SINB	40.9994°	28.5395°	313	30.64	EW	126.05	12.67	324.50	87.94
						NS	99.18	9.21	409.61	51.31
						UD	56.48	3.52	123.03	16.16
C2497	YKBL	40.9909°	28.6676°	313	39.77	EW	105.33	12.59	262.85	73.74
						NS	52.95	11.65	130.74	109.03
						UD	58.26	6.33	113.09	52.06
C2515	BUYA	40.8696°	29.1278°	513	75.47	EW	12.11	2.28	36.82	15.99
						NS	17.12	1.45	48.94	7.88
						UD	11.31	0.94	26.63	3.65
C2524	BRGA	40.8846°	29.065°	543	70.24	EW	14.61	1.36	36.40	10.81
						NS	22.50	2.71	47.49	17.43
						UD	9.65	0.74	19.92	7.76

Station		Lat	Lon	$V_{s,30}$ (m/s)	R_{epi} (km)	Comp.	PGA (cm/s^2)	PGV (cm/s)	Sa(0.2) (cm/s^2)	Sa(1.0) (cm/s^2)
Name	Code									
C2571	LAFA	40.7598°	29.3554°	999	95.25	EW	0.65	0.02	1.89	0.06
						NS	24.36	1.52	74.15	8.83
						UD	9.42	0.60	23.22	6.14
CENLI	5BU3	41.0558°	29.0685°	909	73.94	EW	16.94	1.58	42.62	10.56
						NS	19.71	1.38	38.03	8.33
						UD	11.13	0.81	26.83	7.39
DATIO	5BS7	40.931°	29.132°	751	76.29	EW	13.20	0.72	24.03	3.47
						NS	12.74	1.86	26.19	6.92
						UD	7.16	0.60	14.13	3.95
EHAIO	5BU2	40.9031°	29.1895°	881	80.83	EW	6.56	0.61	20.39	4.38
						NS	9.75	1.85	19.13	9.43
						UD	6.53	0.67	15.15	3.08
ESNBB	5BR0	41.0402°	28.8835°	295	58.67	EW	35.76	3.36	73.97	75.12
						NS	52.21	4.23	141.43	62.07
						UD	22.02	1.24	91.78	7.00
FBZMD	5BU7	41.0096°	28.9345°	327	61.66	EW	44.35	3.60	69.01	52.76
						NS	32.23	3.16	79.48	42.84
						UD	16.86	1.55	36.42	8.43
GUMLI	5AE1	41.0074°	28.6327°	292	37.89	EW	59.06	7.57	164.77	49.47
						NS	78.27	9.71	109.52	61.58
						UD	36.90	4.34	92.57	36.45
HAVAV	5BG3	40.9816°	28.819°	357	51.46	EW	44.28	6.32	166.92	38.90
						NS	60.52	7.17	173.35	89.08
						UD	25.97	4.18	72.81	74.76
HHBLI	5BQ6	40.9317°	29.2168°	409	83.39	EW	21.19	1.22	73.62	6.69
						NS	28.73	1.90	90.08	13.11
						UD	28.08	1.36	90.11	3.71
IHHIO	5BH1	40.8667°	29.329°	499	92.42	EW	12.19	0.75	30.10	5.99
						NS	12.54	1.83	28.34	16.45
						UD	9.09	0.93	12.31	7.21
ISMIO	5BN1	40.9377°	29.145°	768	77.46	EW	10.94	1.62	21.68	6.19
						NS	11.50	0.62	21.53	3.01
						UD	9.02	0.53	16.48	4.81
KASDL	5BU0	40.8983°	29.1742°	838	79.52	EW	14.45	0.79	37.57	3.70
						NS	12.23	1.82	24.97	10.09
						UD	7.51	0.70	10.44	2.78
KCKBK	5BG4	40.9853°	29.1161°	570	75.88	EW	40.61	2.55	76.30	10.54
						NS	55.80	3.17	131.14	12.22
						UD	18.76	1.04	35.77	5.75
KDHBI	5BP8	41.0259°	28.7987°	331	51.45	EW	68.00	4.95	117.17	30.05
						NS	57.91	7.29	131.99	34.37
						UD	46.24	1.38	98.40	9.21
KRFZL	5485	40.9019°	29.2112°	904	82.65	EW	9.71	0.76	21.31	4.95
						NS	9.78	1.90	22.52	10.07
						UD	0.34	0.04	0.87	0.16
KRTTP	5BQ1	40.984°	28.8777°	330	56.29	EW	51.25	5.29	72.23	36.49
						NS	42.67	5.69	74.45	45.48
						UD	41.90	2.07	87.45	18.51

Station		Lat	Lon	$V_{s,30}$ (m/s)	R_{epi} (km)	Comp.	PGA (cm/s^2)	PGV (cm/s)	Sa(0.2) (cm/s^2)	Sa(1.0) (cm/s^2)
Name	Code									
MAEIO	5BV6	41.025°	28.5454°	313	32.65	EW	92.33	6.33	176.54	40.86
						NS	69.76	8.86	161.95	70.11
						UD	58.07	3.20	231.33	36.14
MBNIO	5BV4	40.9182°	29.1523°	519	77.84	EW	10.48	1.07	43.67	3.99
						NS	16.15	1.66	38.15	8.02
						UD	9.19	0.68	21.66	3.96
MECLI	5BS1	41.0707°	28.9967°	817	68.77	EW	19.36	1.05	36.13	7.40
						NS	16.01	1.99	39.43	14.09
						UD	7.69	0.90	17.41	6.58
MMZIO	5BV5	40.9492°	29.1083°	821	74.56	EW	10.96	0.70	23.64	5.00
						NS	11.80	1.83	27.65	6.54
						UD	6.44	0.50	13.27	4.74
PGZOL	5BP3	40.8661°	29.2854°	785	88.75	EW	13.07	0.72	44.72	7.38
						NS	12.41	1.71	20.93	11.23
						UD	8.98	0.71	21.72	6.47
PVBIO	5BN5	40.91°	29.2522°	813	86.16	EW	10.81	2.00	21.15	10.76
						NS	11.15	0.75	29.41	5.14
						UD	10.24	0.69	15.29	3.05
SASIO	5526	40.9037°	29.1658°	669	78.84	EW	12.36	1.52	30.06	7.71
						NS	11.04	1.44	26.60	8.22
						UD	7.03	0.71	11.37	3.44
SEVAO	5DN3	41.0672°	28.2773°	313	24.32	EW	51.94	6.20	161.92	38.64
						NS	45.40	3.85	114.68	30.92
						UD	25.49	1.54	50.07	16.92
SISIO	5DM7	41.0739°	28.1346°	313	26.11	EW	69.56	6.87	99.71	103.70
						NS	53.75	4.44	165.09	68.52
						UD	24.66	1.89	48.42	28.63
SMKIO	5BG9	40.9601°	29.089°	824	73.14	EW	11.60	0.60	32.25	4.62
						NS	11.59	1.86	28.58	8.87
						UD	8.42	0.54	13.99	5.30
TTEML	5BS2	40.8344°	29.3055°	739	90.47	EW	6.92	0.66	18.19	4.75
						NS	9.15	1.74	19.50	12.02
						UD	4.96	0.67	9.94	3.07
UDAIO	5BU4	41.0144°	29.1523°	622	79.53	EW	20.04	0.86	56.77	4.72
						NS	22.37	1.92	79.82	10.46
						UD	11.81	0.66	22.71	5.67
UMSBI	5BN0	41.0053°	29.0417°	761	70.24	EW	27.36	1.35	57.64	5.33
						NS	21.91	2.38	38.81	13.84
						UD	9.20	0.61	15.53	5.45
USCUL	5BN3	41.026°	29.0337°	643	70.18	EW	41.08	1.44	75.05	5.59
						NS	23.31	2.06	71.67	16.76
						UD	13.89	0.82	20.74	5.00
YNKPM	5431	40.999°	28.9403°	230	61.81	EW	40.87	4.03	90.95	38.38
						NS	35.90	3.47	64.44	63.26
						UD	34.22	1.81	81.81	11.08
ZYKOI	5BK4	40.9855°	28.8979°	296	57.97	EW	38.49	5.34	70.71	54.62
						NS	34.73	4.44	57.62	31.15
						UD	19.05	1.83	43.14	24.20

Station		Lat	Lon	$V_{s,30}$ (m/s)	R_{epi} (km)	Comp.	PGA (cm/s^2)	PGV (cm/s)	Sa(0.2) (cm/s^2)	Sa(1.0) (cm/s^2)
Name	Code									
ZYTDK	5BU5	41.0061°	28.9001°	285	58.78	EW	61.51	3.84	208.75	53.32
						NS	51.84	5.43	137.61	66.72
						UD	19.88	1.43	39.29	16.00

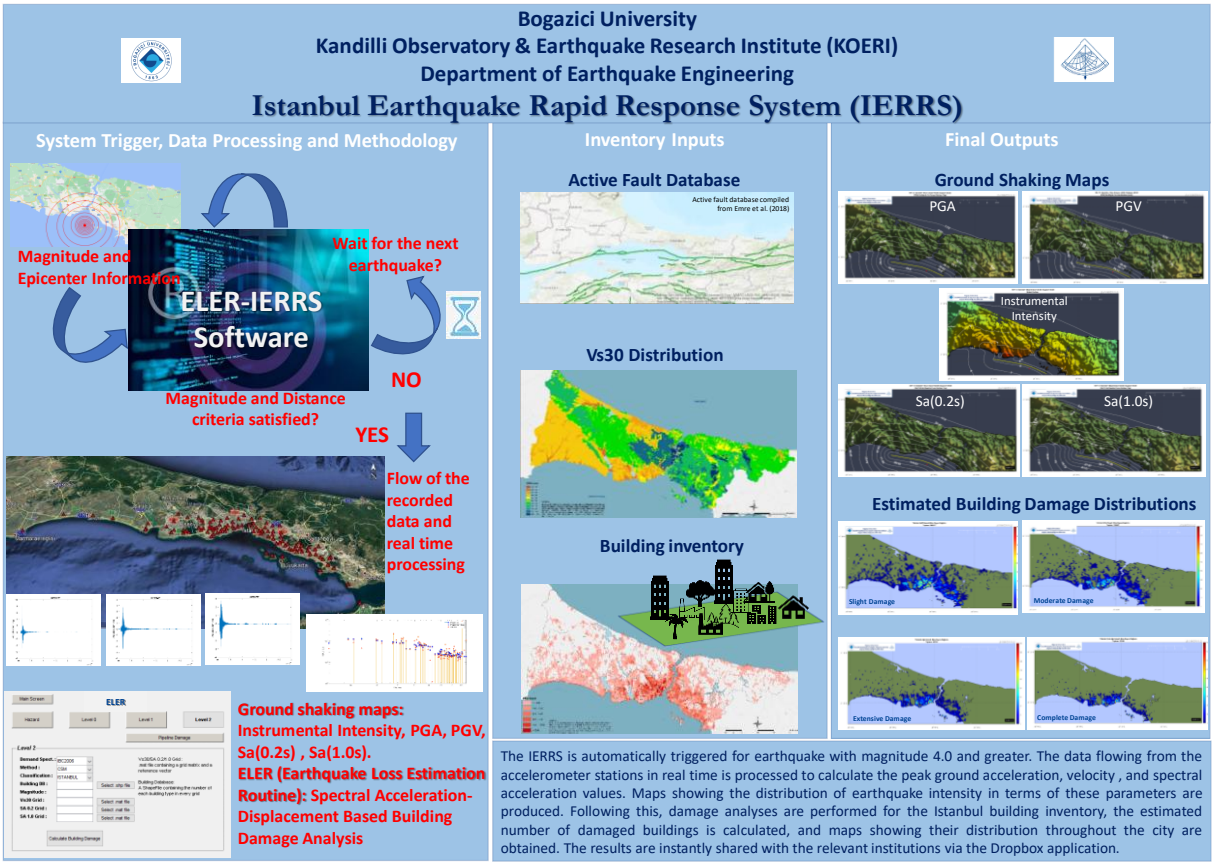


Figure 19. Istanbul Earthquake Rapid Response System: Algorithm flowchart, inputs and outputs

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