SEPTEMBER 26, 2019 Mw5.8 MARMARA SEA-SILIVRI (ISTANBUL) EARTHQUAKE: ANALYSIS OF GROUND MOTION RECORDS

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Introduction

Marmara region located on the western end of the North Anatolian Fault Zone is a tectonically active region in Turkey. There have been frequent severe earthquakes in the region in the historical and instrumental period. The last severe earthquake in the region was 1999 Mw7.6 Kocaeli Earthquake. The Marmara Sea offshore earthquake Mw5.8 close to Silivri Town of Istanbul Metropolitan City has occurred on September 26, 2019 daytime at 13:59 at the depth of 7.0km. It was felt in almost all Marmara region**. The ground motion records and selected parameters have been examined in this study. The ground motion parameters (MMI,PGA, Sa) distributions have been achieved and checked by the recent NGA-West2 ground motion prediction equations 2014 GMPEs (Abrahamson et al., 2014), (ASK14), (Boore et al., 2014) (BSSA14) and (Chiou and Youngs, 2014) (CY14) including Turkey regional factors (Bozorgnia et al., 2014).**

The compatibility of the 2014-NGAs for a moderate size Marmara Sea earthquake has been examined by considering the ground motion data from stations up to 100 km from the earthquake epicenter. In Table 1, information about ground motion recording stations and ground motion records in the region are given, and in Figure 1, station locations and PGA values recorded in each station are given on the map. Maximum ground acceleration was obtained as 0.81m/s² at Silivri station.

Table 1. Mw 5.8 Silivri offshore (Marmara Sea) earthquake records station information (https://deprem.afad.gov.tr/).

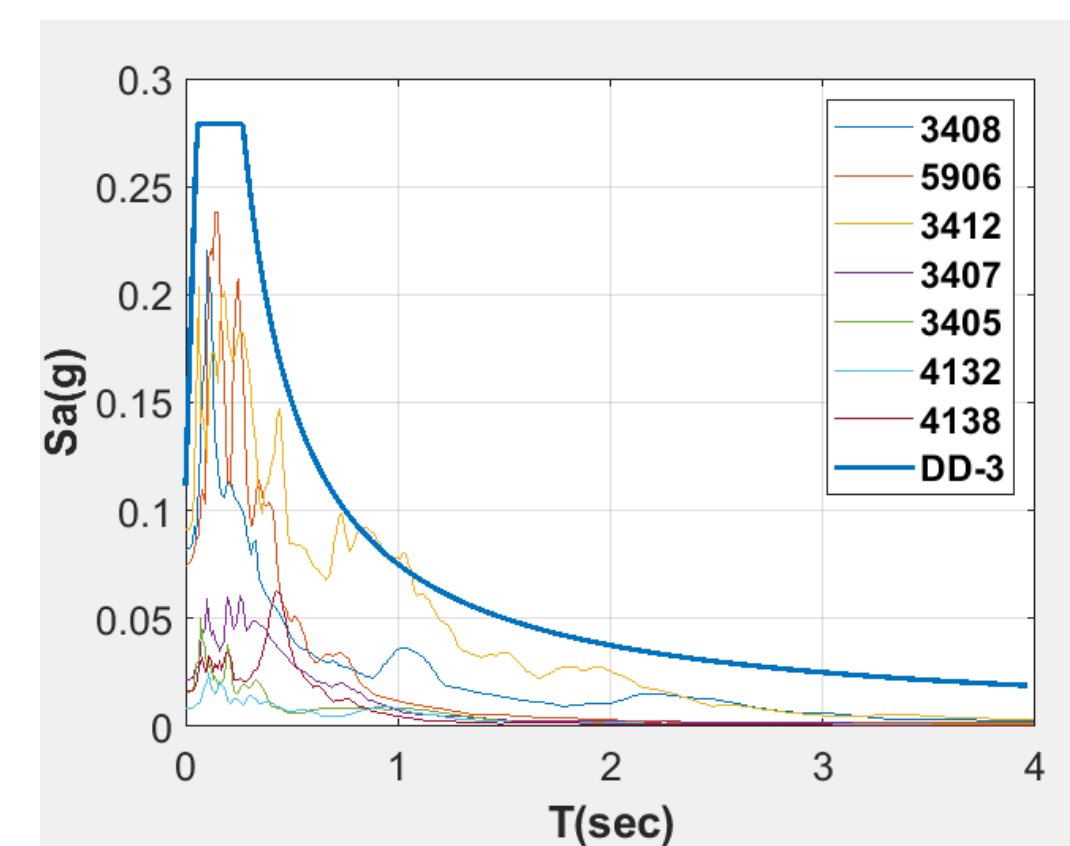| ID	Name	R_{epi} (km)	Site Class	PGA(gal)	PGA$_{calculated}$
3408	Silivri	23	C	81.62(NS)	89
5906*	MarmaraEreğlisi	25	D	73.04(NS)	73
3412*	Büyükçekmece	36	D	84.93(EW)	52
3407	Besiktas	72	C	21.84(EW)	22
3405*	Kartal	81	D	14.5(NS)	19
3406*	Umraniye	83	D	31.39(NS)	19
5912*	Hayrabolu	98	D	14.99(EW)	15
4132*	Çayırova_2	98	D	8.73(NS)	14
4138*	Darıca	100	D	16.63(EW)	13

*NEHRP site classes has been accepted according to surface geology.

Figure 1. PGA Values of Silivri Earthquake AFAD Station Records.
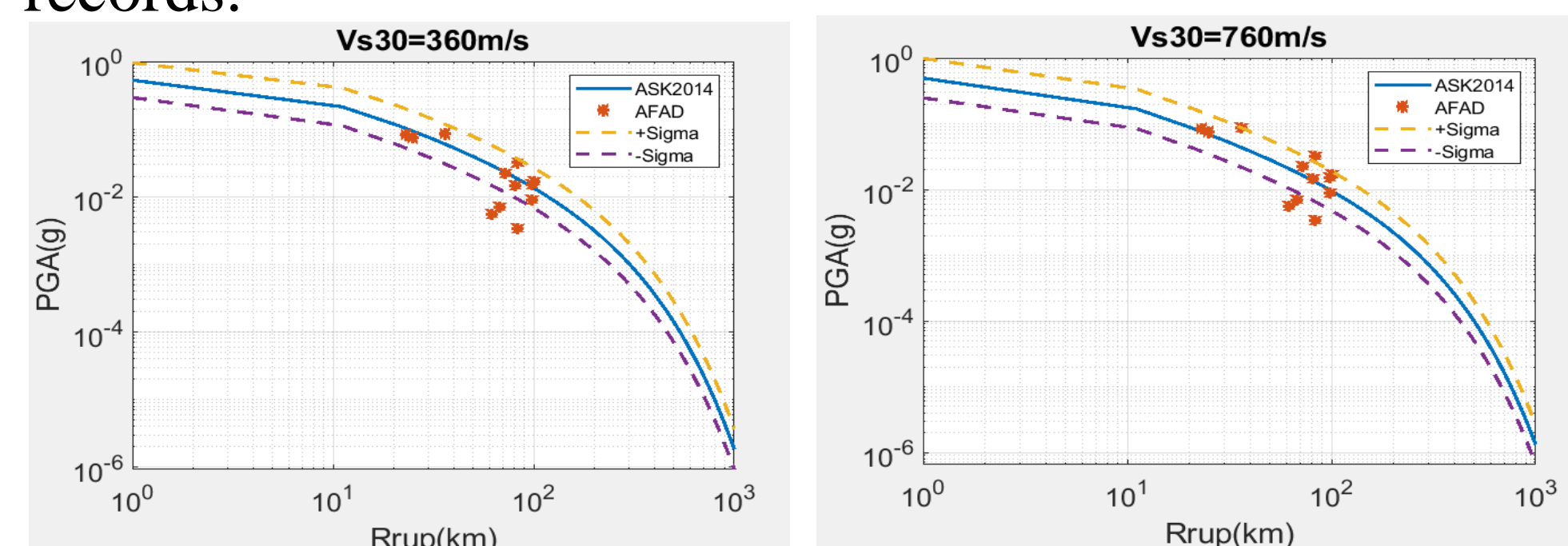
Methods

Comparison of acceleration spectra of records with TBDY 2018 (2018-Turkey Earthquake Building Seismic Code) design spectrum of DD-3 level is shown in Figure 2. DD-3 level represents a mid-size earthquake with a probability of exceedance 50% in 50 years which equals to 72 years return period.
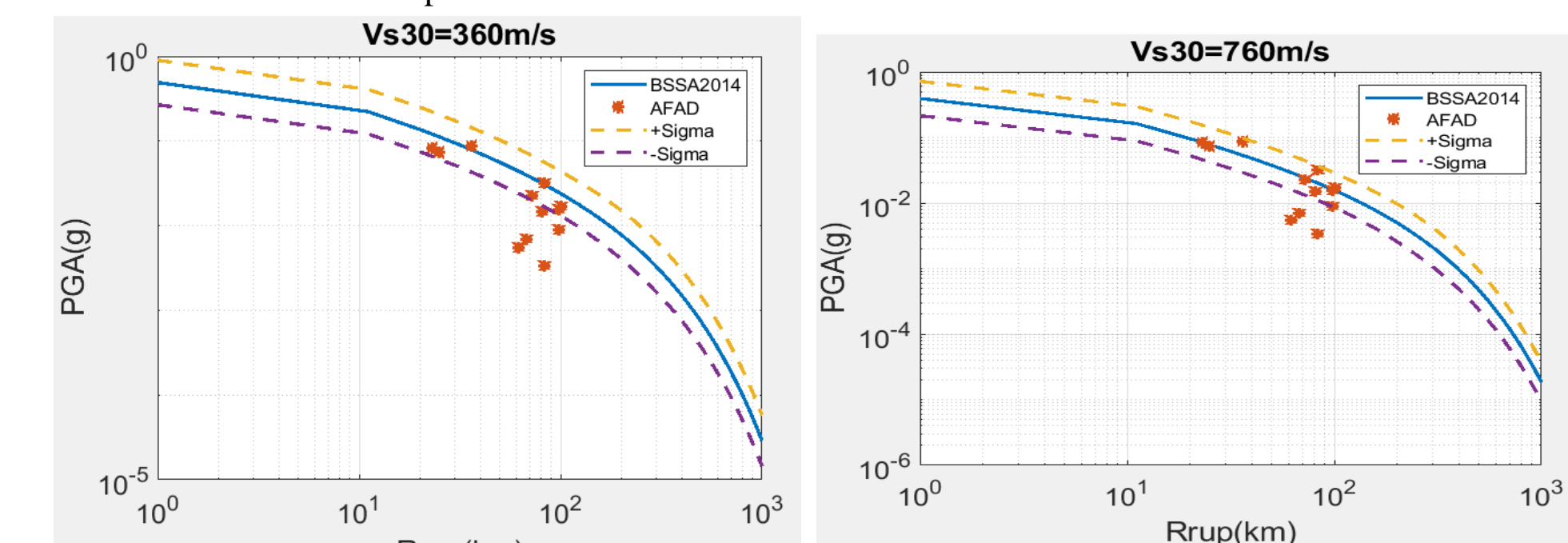

It was observed that spectrum curves obtained from the earthquake records remained below the design spectrum curve in all periods (TBDY, 2018) for DD-3 earthquake level.

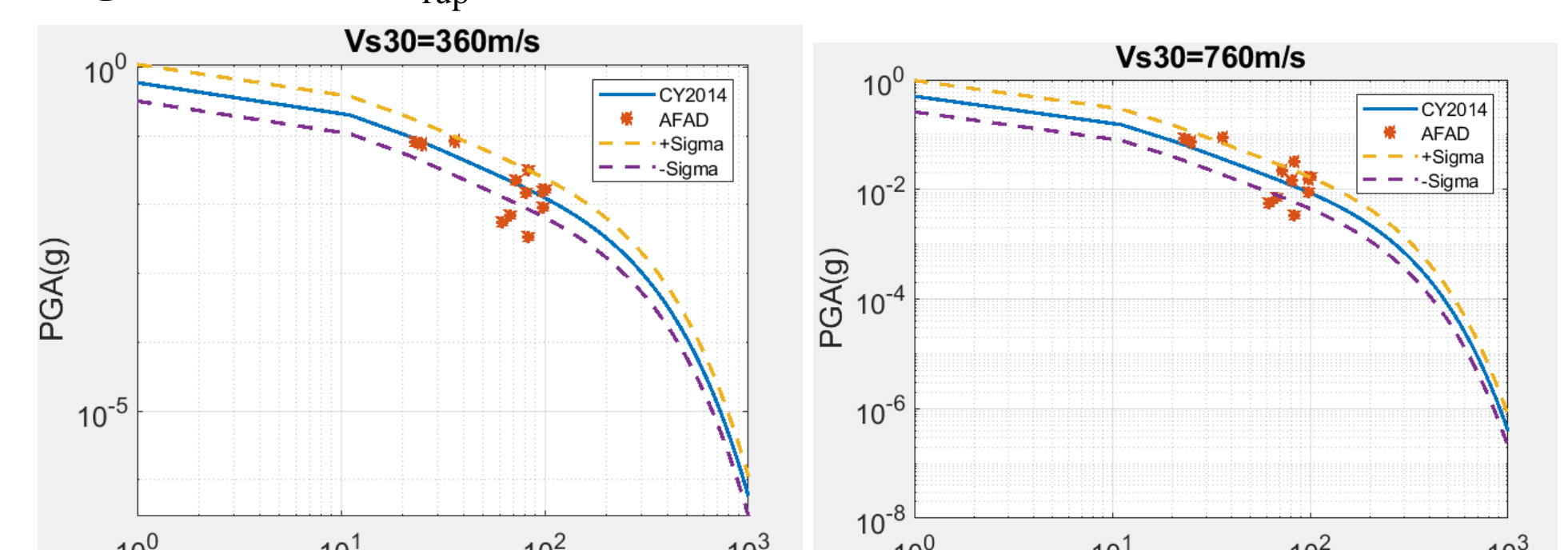**Figure 2.** DD-3 Earthquake Level Spectrum and Spectrum of the Records

Using the PGA values and above mentioned GMPEs, PGA-R$_{rup}$ (fault rupture distance) variations were plotted for V$_{s30}$=360m/s and V$_{s30}$=760m/s as shown in the Figure 3, Figure 4 and Figure 5. PGA-R$_{rup}$ relations were shown with standard deviation values. The calculated PGA values were compared with the recorded PGA values as shown in the Table 1 and in the Figures 3 to 5. The results show that estimations match well with the observed records.

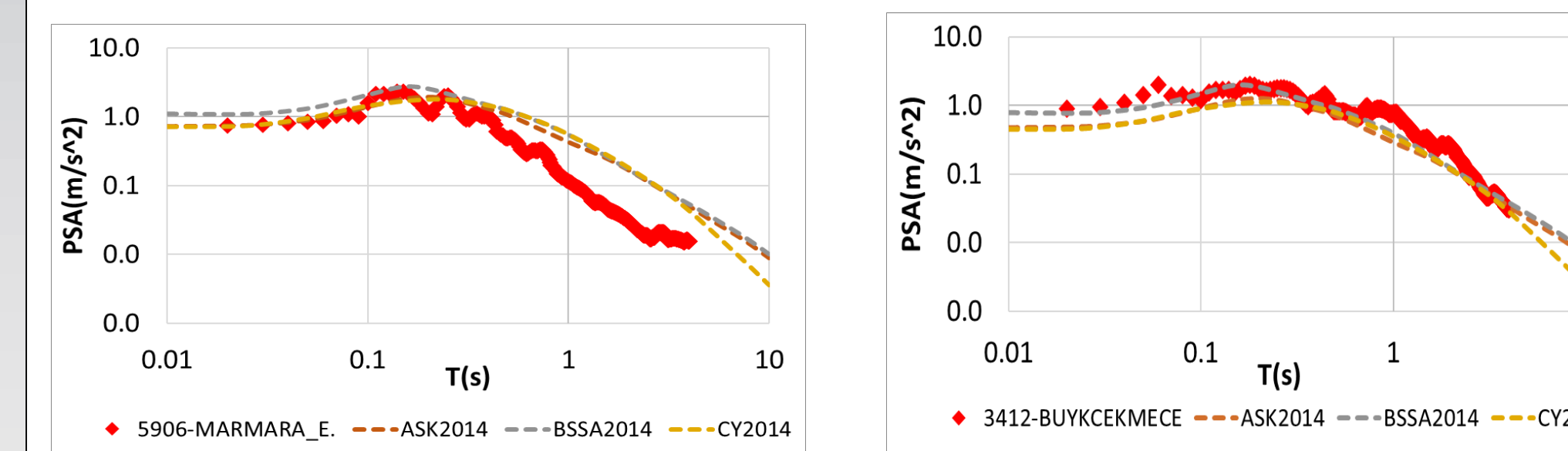**Figure 3.** PGA-R$_{rup}$ Analizi (ASK14) for Vs30=360m/s and Vs30=760m/s

Figure 4. PGA-R$_{rup}$ Analizi (BSSA14) for Vs30=360m/s and Vs30=760m/s

Figure 5. PGA-R$_{rup}$ Analizi (CY14) for Vs30=360m/s and Vs30=760m/s
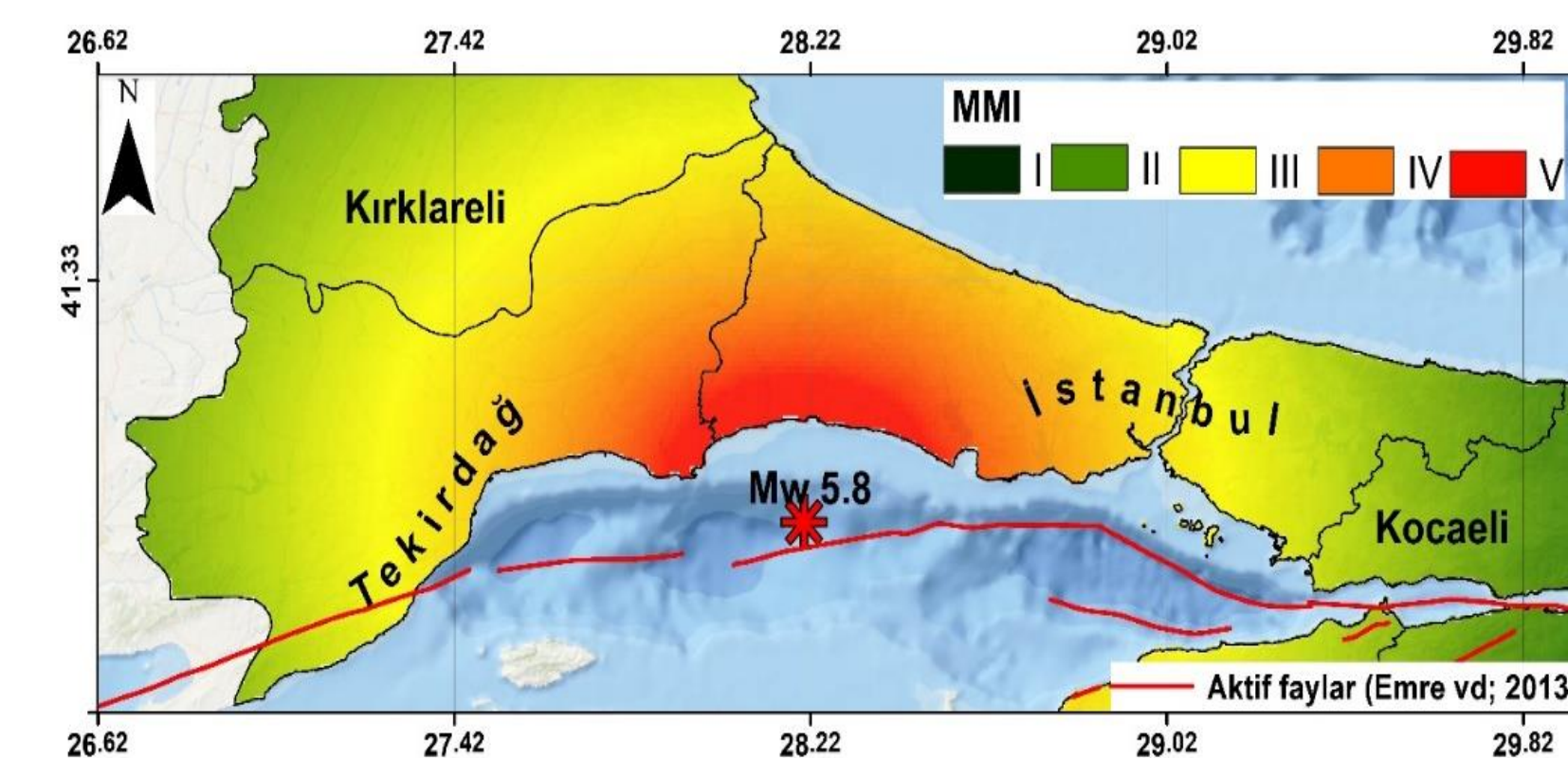
Analysis

The spectrum curves obtained from the records of 3408,5906 and 3412 stations, which are the closest stations to the epicenter of the earthquake, were compared with the spectrum curves obtained using the ASK14 ,BSSA14 and CY14 GMPEs, respectively.
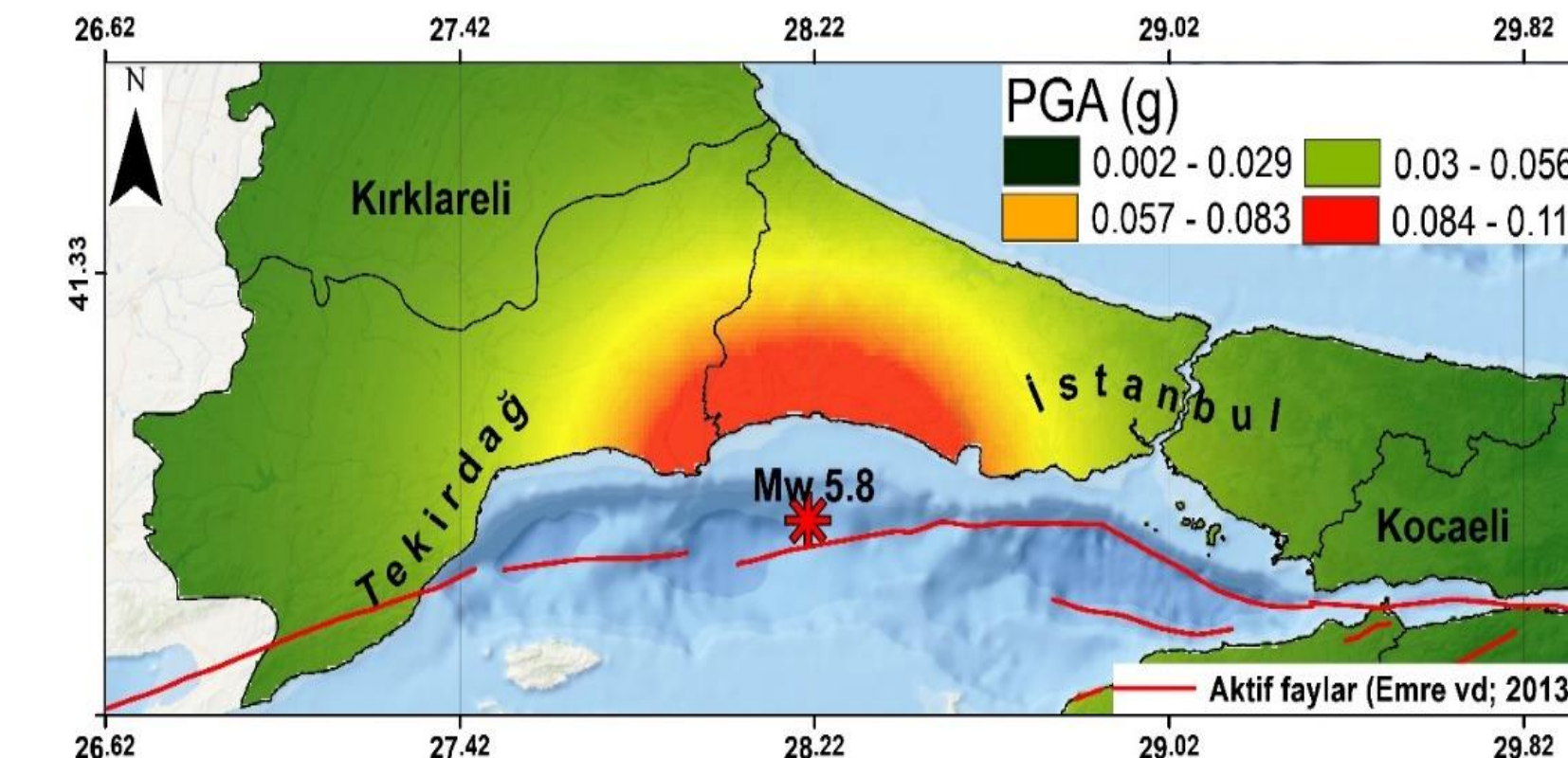

Figure 6. Comparison of calculated Spectral Acceleration with the predictions through the 2014NGA relations

The Figure 6 shows that Acceleration Response Spectrum at 3408 and 3412 stations in almost all period ranges and at 5906 station in the period range less than 0.5s are compatible with the estimated ones using the ASK14, BSSA14 and CY14 NGA relations.
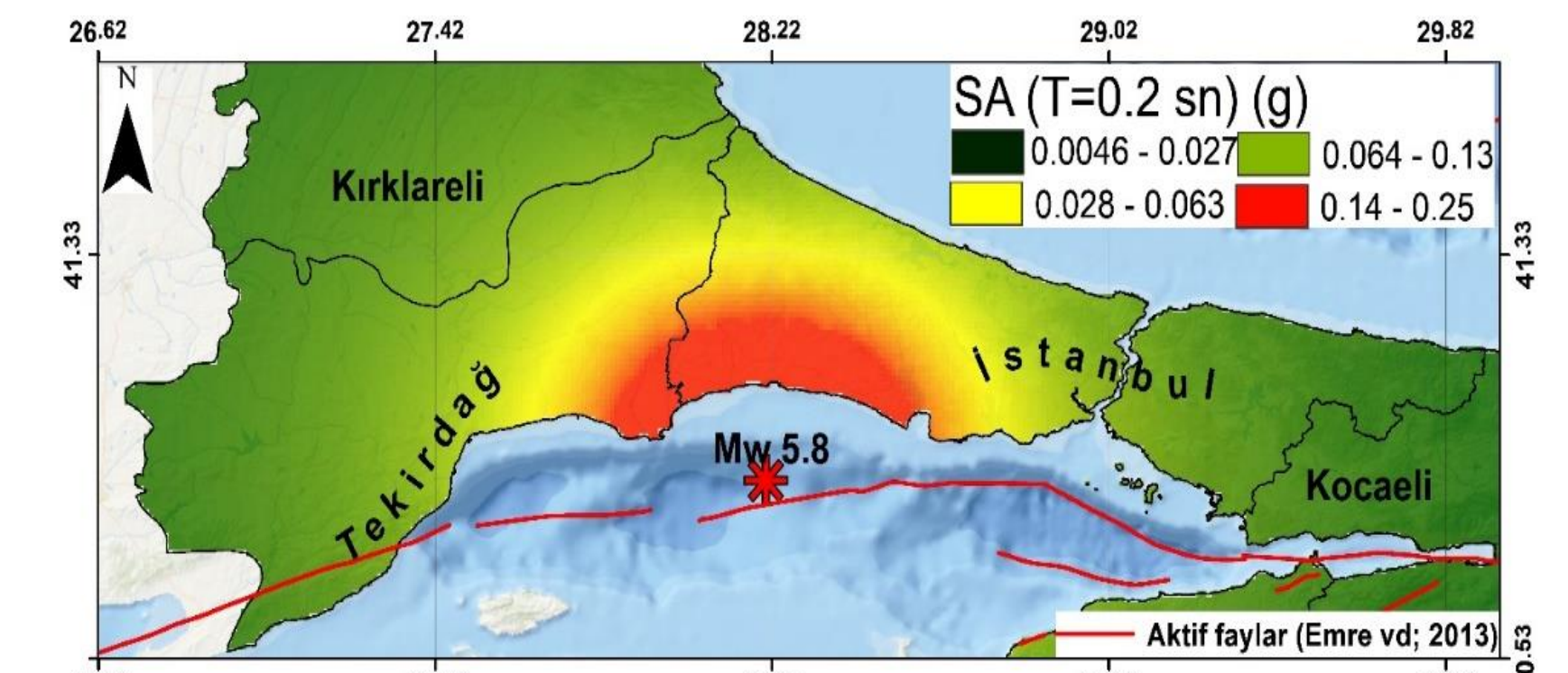
The CY14 NGA has been used in earthquake ground motion parameters (PGA, Sa,0.2sec and Sa,1.0sec) distribution analysis. The MMI conversion has been achieved through the regression relationships developed by Wald et al. The resulting maps are given between Figure 7-8-9-10. The MMI and PGA distribution maps matched well with the felt records and the station records, respectively. The highest values of ground motion parameters were seen in Silivri district which is the closest to the epicenter.
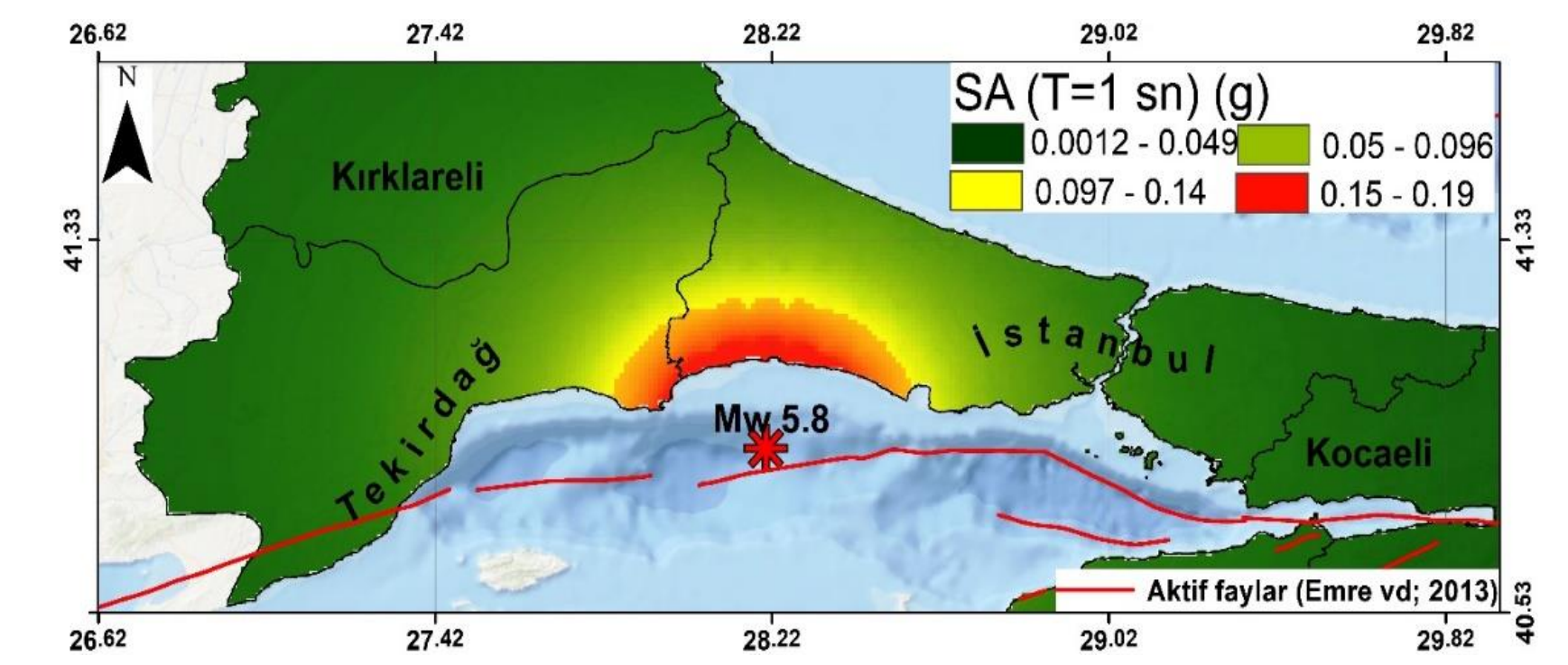

Figure 7. MMI Distribution Map for İstanbul Earthqauke

Figure 8. PGA Distribution Map for İstanbul Earthqauke

Figure 9. Sa(T=0.2sec) Distribution Map for İstanbul Earthqauke

Figure 10. Sa(T=1sec) Distribution Map for İstanbul Earthqauke

Conclusions

Within the scope of the study, the NGA2014 relations with Turkey regional factor have been examined for the mid-size Marmara Sea earthquake.

As a result of the PGA-Rrup analysis, the CY14 results were best fitted with Mw 5.8 Silivri earthquake records parameters. The estimated Acceleration Response Spectrum with ASK14, BSSA14, CY14 NGAs matched well with the calculated ones as shown in the Figure 6.

After the earthquake, slight damages have been observed in some buildings located different parts of Istanbul. According to the TBDY2018, although the design earthquake level is DD2 (475 years RP), the Acceleration Spectrum of the recorded motions have been compared with DD3 earthquake level (72 years RP) design spectrum. The calculated Spectral Acceleration values are within the DD3 level design limits in all periods.

References

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