



Disaster and Emergency Management Authority

ASSESSMENT REPORT

March 20th, 2019 (Mw 5.5)

Acipayam(Denizli) Earthquake

1. GENERAL INFORMATIONS

An earthquake with magnitude $M_w=5.5$ occurred at local time 09:34 on March, 20, 2019. Epicentral coordinates of the earthquake was determined as 37.4313 N - 29.4313 E. and 10.76 km depth. After this earthquake, 1500 aftershocks were recorded with magnitude range 1.0- 5.0 in the eight days. Acıpayam Basin is bounded by NE-SW and NW-SE oriented normal faults. Focal mechanism solution represents NW-SE oriented normal faulting. (Fig.1, Table 1.1)

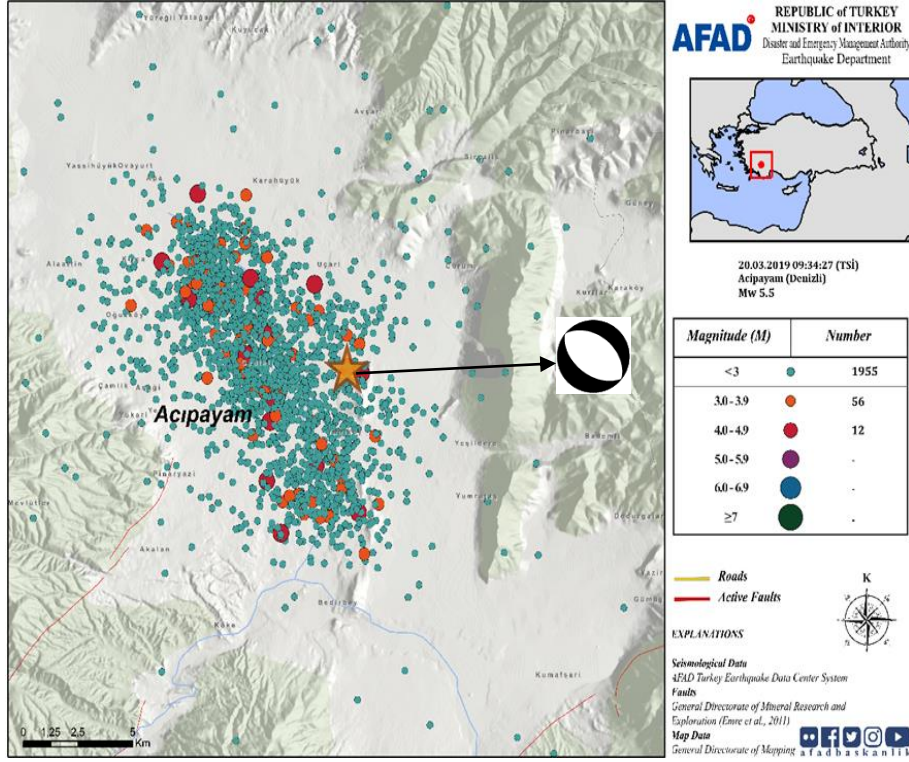


Figure 1. March, 20, 2019. Acıpayam (Denizli) Earthquake and Aftershock Distribution (Mw 5.5)

This earthquake was strongly felt in Denizli City and Districts. The nearest settlement is Yeniköy village, which is 1.89 km away from the epicenter area.(Table1.2)

Table 1.1 Earthquake Parameters

Magnitude	Mw 5.5
Location	Acipayam(Denizli)
Date	20.03.2019
Time	09:34:27 (Local Time)
Latitude	37.4313 N
Longitude	29.4385 E
Depth	10.76 km

Table 1.2 The Nearest Settlements to Epicenter Area

City	Discript	Village	Distance(Km)
Denizli	Acipayam	Yeniköy	1.89
Denizli	Acipayam	Yeşildere	4.83
Denizli	Acipayam	Uçarı	5.03
Denizli	Acipayam	Çorum	6.07
Denizli	Acipayam	Yumrutaş	6.15

Table 1.3 The Nearest City Center to Epicenter Area

City	Discript	Distance(Km)
Denizli	Center	49.73
Burdur	Center	80.60
Muğla	Center	99.38
Isparta	Center	104.53
Antalya	Center	125.99

2. HISTORICAL EARTHQUAKE ACTIVITY OF THE REGION

The Acıpayam-Denizli is an area that have moderate-large earthquakes since the historical times. Since 1900, **605** earthquakes with magnitudes bigger than 4.0 have occurred in the region.

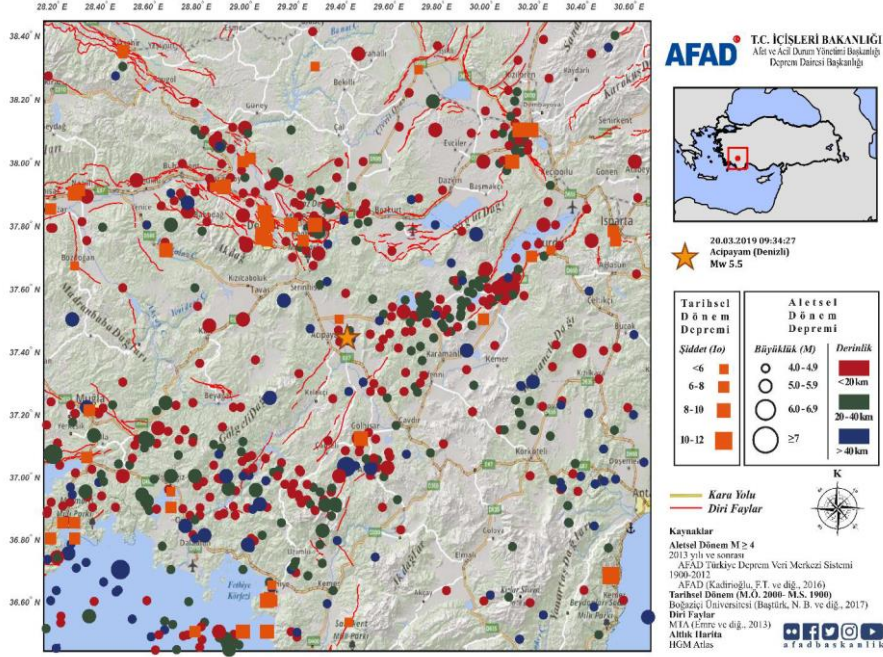


Figure 2. Historical Earthquake Activity of the Region

3. ACCELERATION VALUES

According to the records of 152 strong motion stations, highest acceleration have been measured as 361.24 gal. Epicentral distances (Repi) range from 7 to 3 9 9 km. PGA values are uncorrected data and given in the table 3.1. The largest peak ground acceleration (PGA) has been recorded at Acıpayam (2017) Station. The nearest five strong motion stations to the epicenter area are shown in figure 3. and the distribution of accelerometer stations recording the earthquake is shown in figure 4.

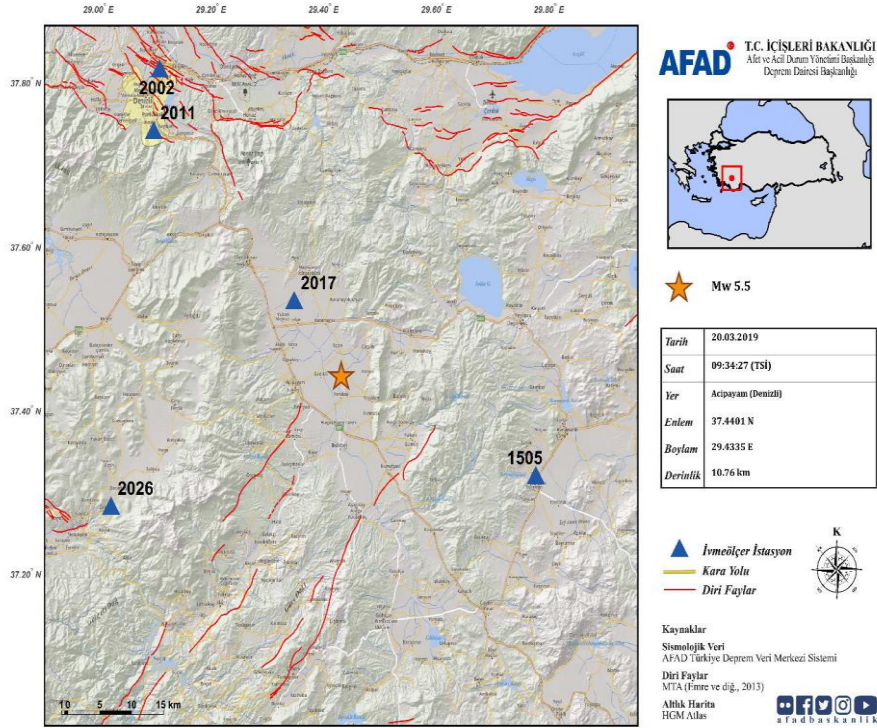


Figure 3. Map showing five strong motion stations measured five biggest acceleration values

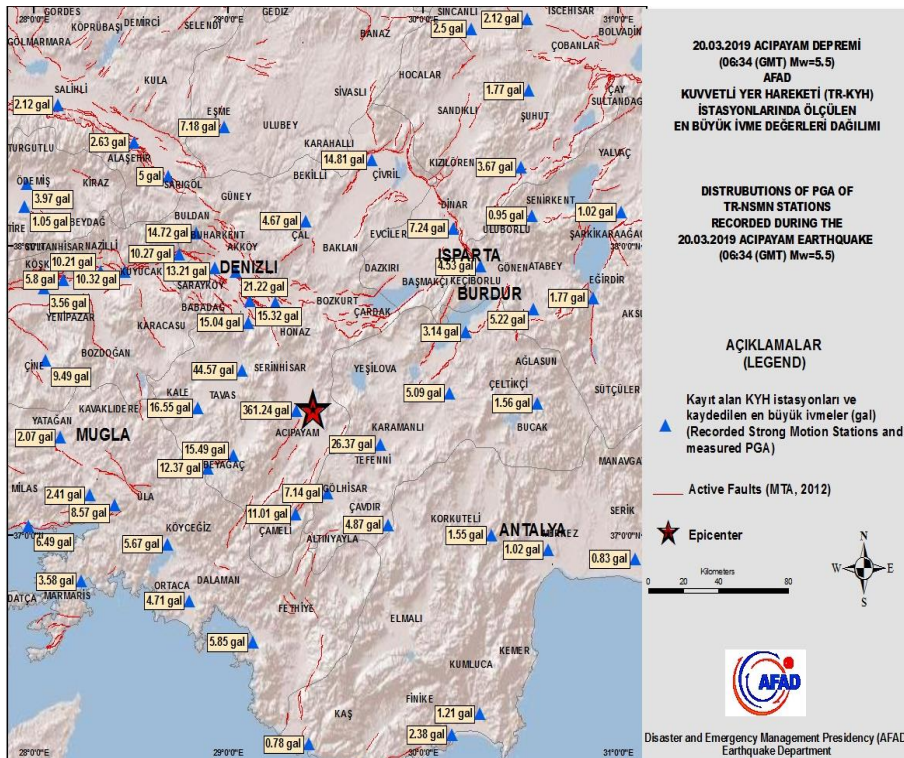


Figure 4. Distribution of accelerometer stations and PGA values measured during the Acıpayam EQ (Mw= 5.5).

Table 3.1 Measured Acceleration Values

Station					PGA(cm/sn ²)			Distance (R _{epi}) (Km)
Code	City	Discript	Latitude	Longitude	NS	EW	UD	
2017	Denizli	Acipayam	37.5300	29.3500	361.2400	184.4200	142.9400	7.00
1505	Burdur	Tefenni	37.3161	29.7790	26.3700	14.3300	14.9700	34.00
2026	Denizli	Tavas	37.2787	29.0248	14.0200	15.4900	14.8400	40.00
2011	Denizli	Kınıklı	37.7372	29.1006	15.0400	12.2300	8.0100	44.00
2002	Denizli	Merkez	37.8125	29.1111	11.9200	15.3200	11.3900	50.00

The largest peak ground acceleration (PGA) has been recorded at Acipayam (2017) Station. Acceleration, Velocity Waveforms and Fourier and Response spectrum graphs of Acipayam (2017) station are given in the figure 5. According to record, SM durations have been calculated as follows; Effective and Significant Duration 7.7 sec (estimated between 5% and 95% of the IA) as seen in the figure 6.

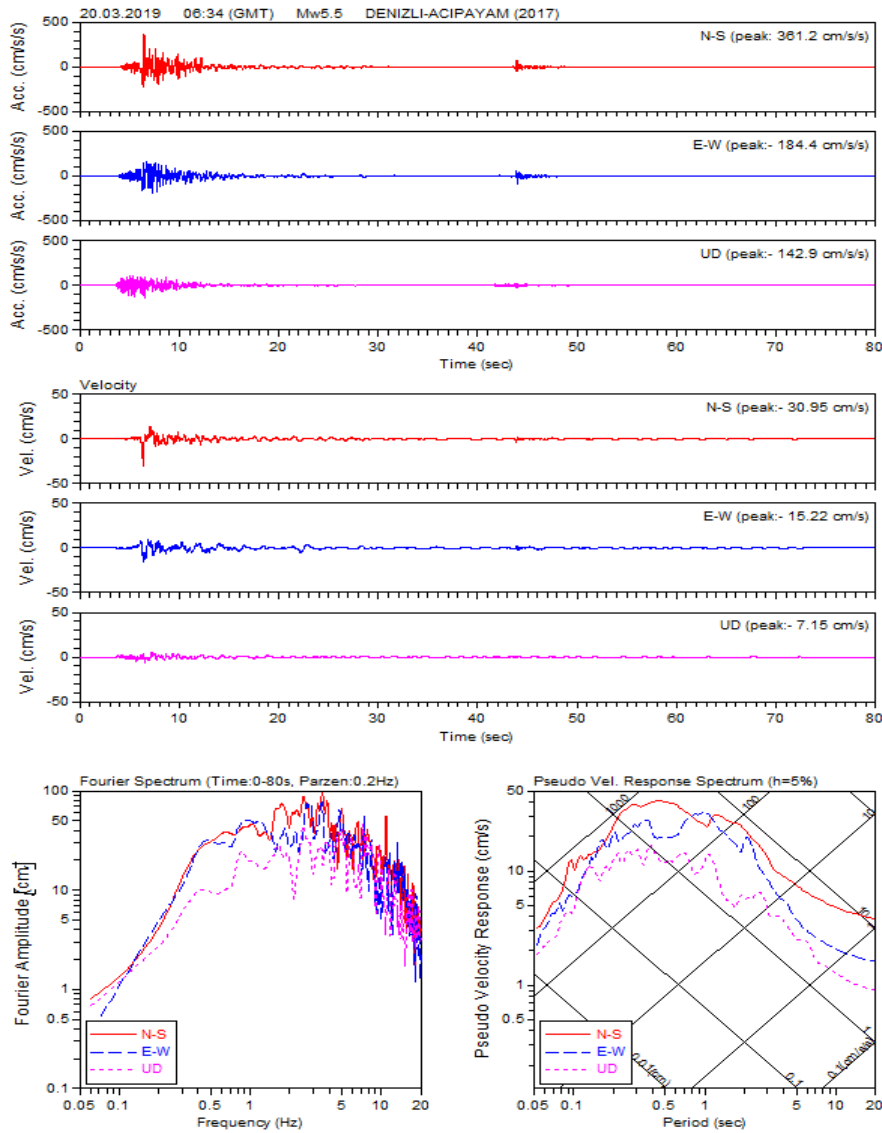


Figure 5. Acc, Velocity, Fourier and Response spectrum graphs of the Acipayam EQ (M_w= 5.5).

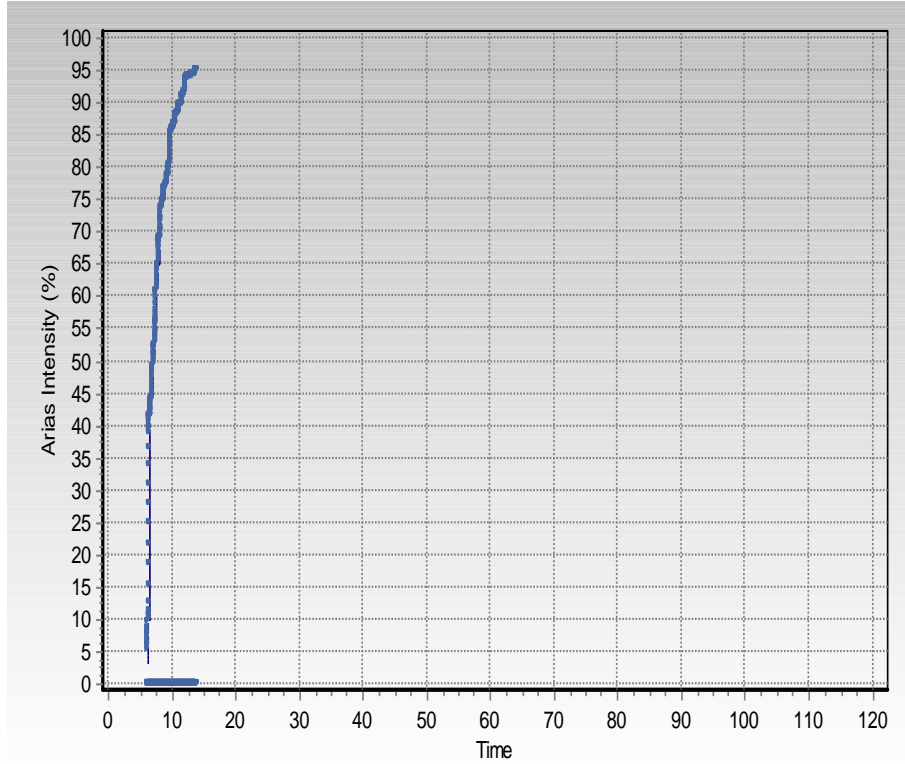


Figure 6. Arias Intensity (IA) Graph of Acıpayam EQ ($M_w= 5.5$) calculated from 2017 (Acıpayam) station.

4. SEISMIC HAZARD OF REGION

According to New Seismic Hazard Map of Turkey, the regional seismic hazard is shown at Figure 7. PGA 475 value in the epicenter area in the map is indicated as 0.3949 g.

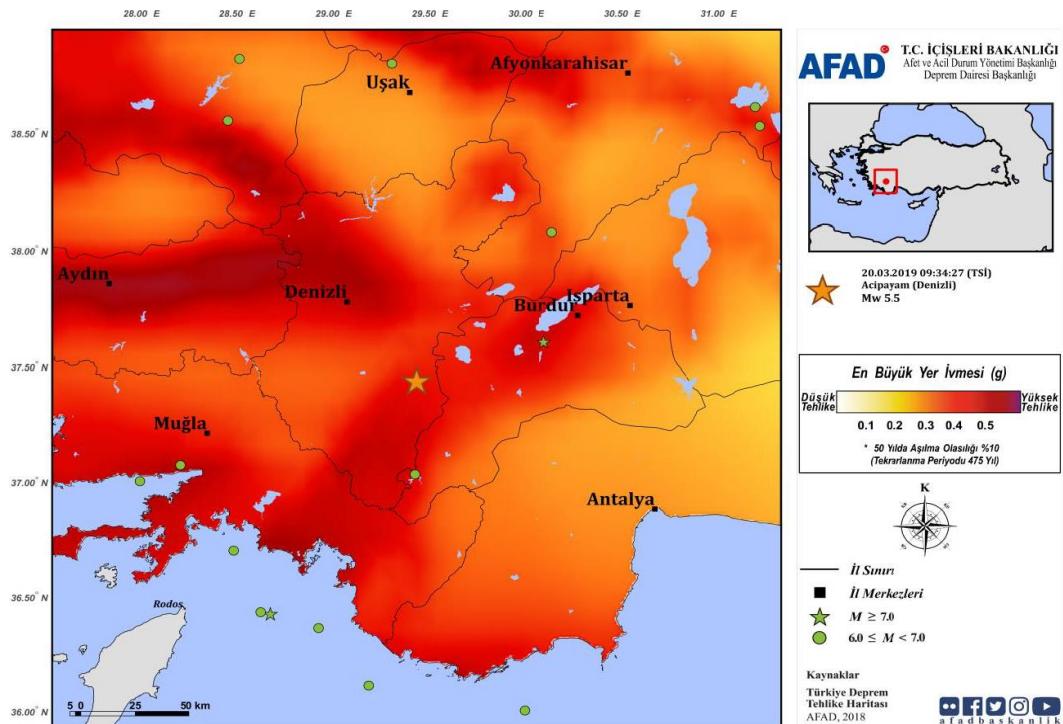


Figure 7. The Seismic Hazard Map of the Region
Earthquake Department
March 2019

5. EARTHQUAKE INTENSITY

Maximum Estimated Intensity have been calculated as MMI VII by National Preliminary Damage Assessment Software (AFAD-RED). AFAD-RED (Rapid Damage and Loss Estimation System), intensity Map is given in the Figure 8.

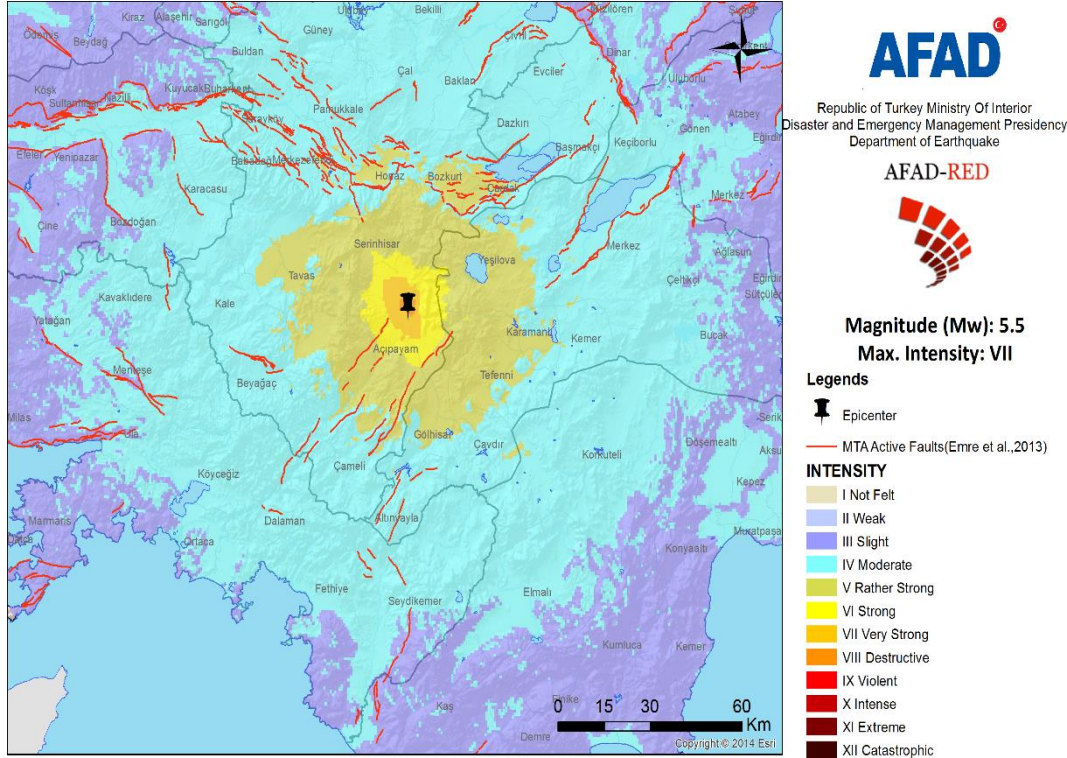


Figure 8. AFAD-RED Preliminary Estimated Intensity Map

6. InSAR RESULT

After the Mw=5.5 main shock, in order to observe potential co-seismic deformation, it is benefited from C-band (~6 cm wavelength) Sentinel 1 A/B data. Including pre and post-earthquake, 2 images were evaluated on ascending Track 58 (17/03/2019-23/03/2019) by the help of the GmtSAR Software (Figure 9). According to obtained interferogram, approximately 3-4 cm subsidence has been observed on the east part of the Acipayam (each color fringe indicates 28 mm displacement) (Figure 10). The fault causing the earthquake is thought to be a NW-SE trending normal fault with NE dipping which is perpendicular to the Acipayam Fault. Focal mechanism results support this thesis.

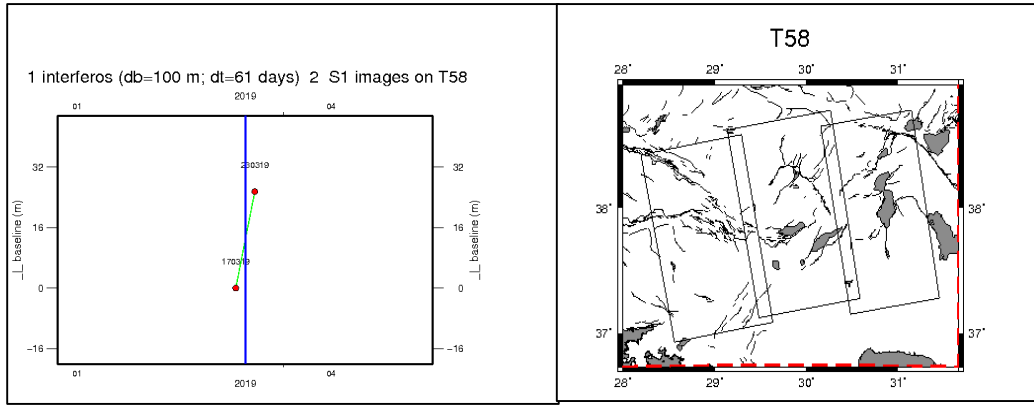


Figure 9: Matching 2 image pairs with the GmtSAR Software (17/03/2019-23/03/2019)

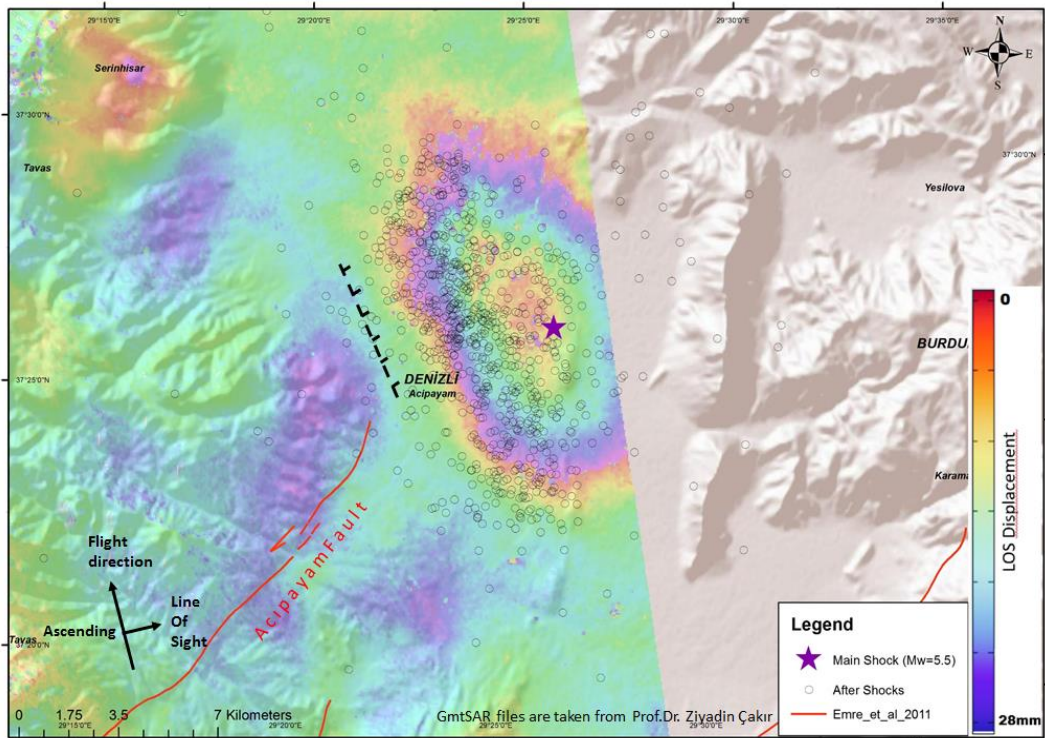


Figure 10. The interferogram obtained from Track 58 Ascending 17/03/2019-23/03/2019 image pairs. (black dashed line indicates the fault thought to cause earthquakes)

7.HypoDD

An efficient method to determine high-resolution hypocenter locations over large distances. The location method incorporates ordinary absolute travel-time measurements and/or cross-correlation P-and-S-wave differential travel-time measurements. Residuals between observed and theoretical travel-time differences (or double-differences) are minimized for pairs of earthquakes at each station while linking together all observed event-station pairs. Statistical resampling methods are used to estimate data accuracy and location errors.

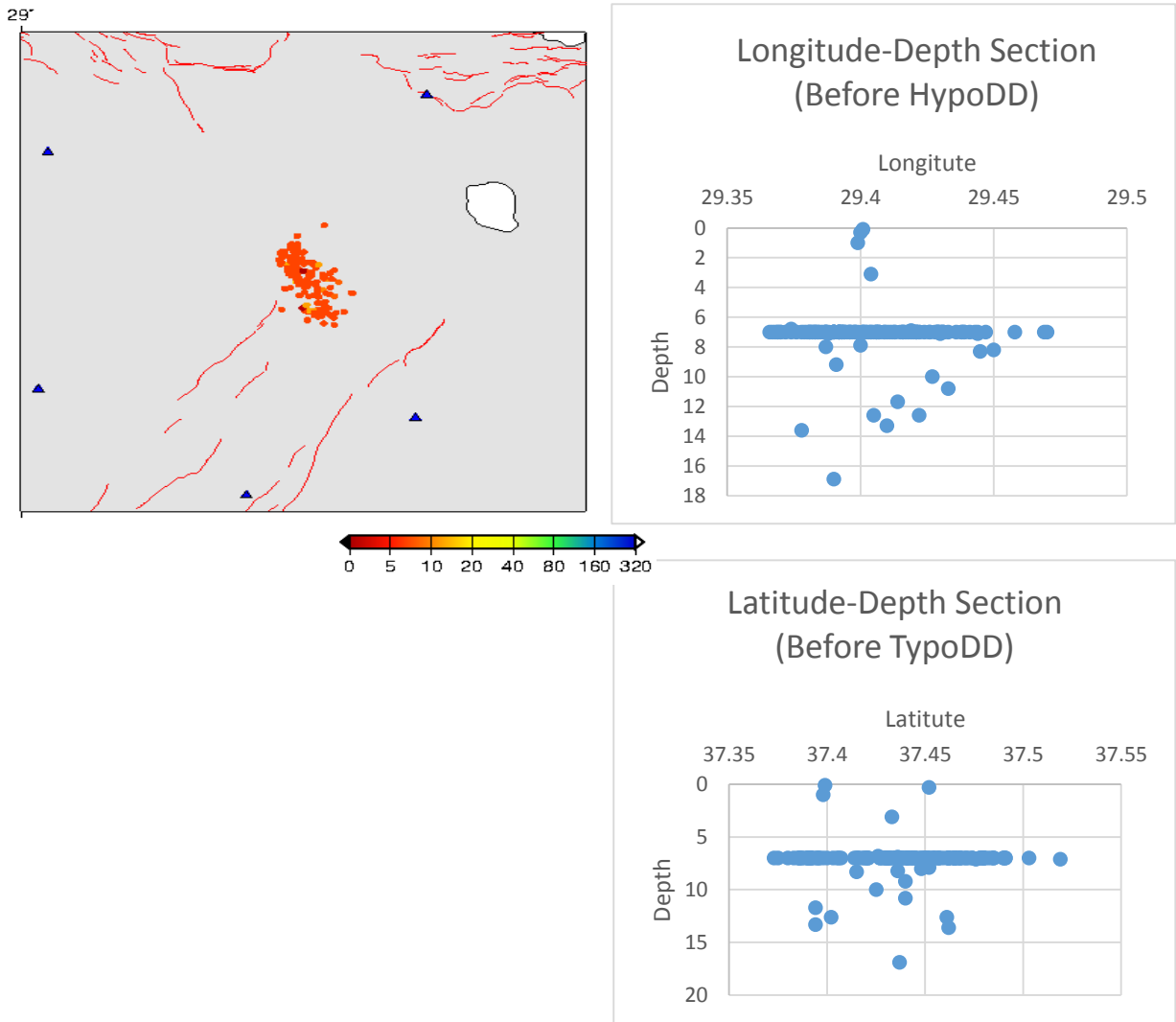


Figure 11. Improvment earthquake locations via HypoDD Method (Before HypoDD)

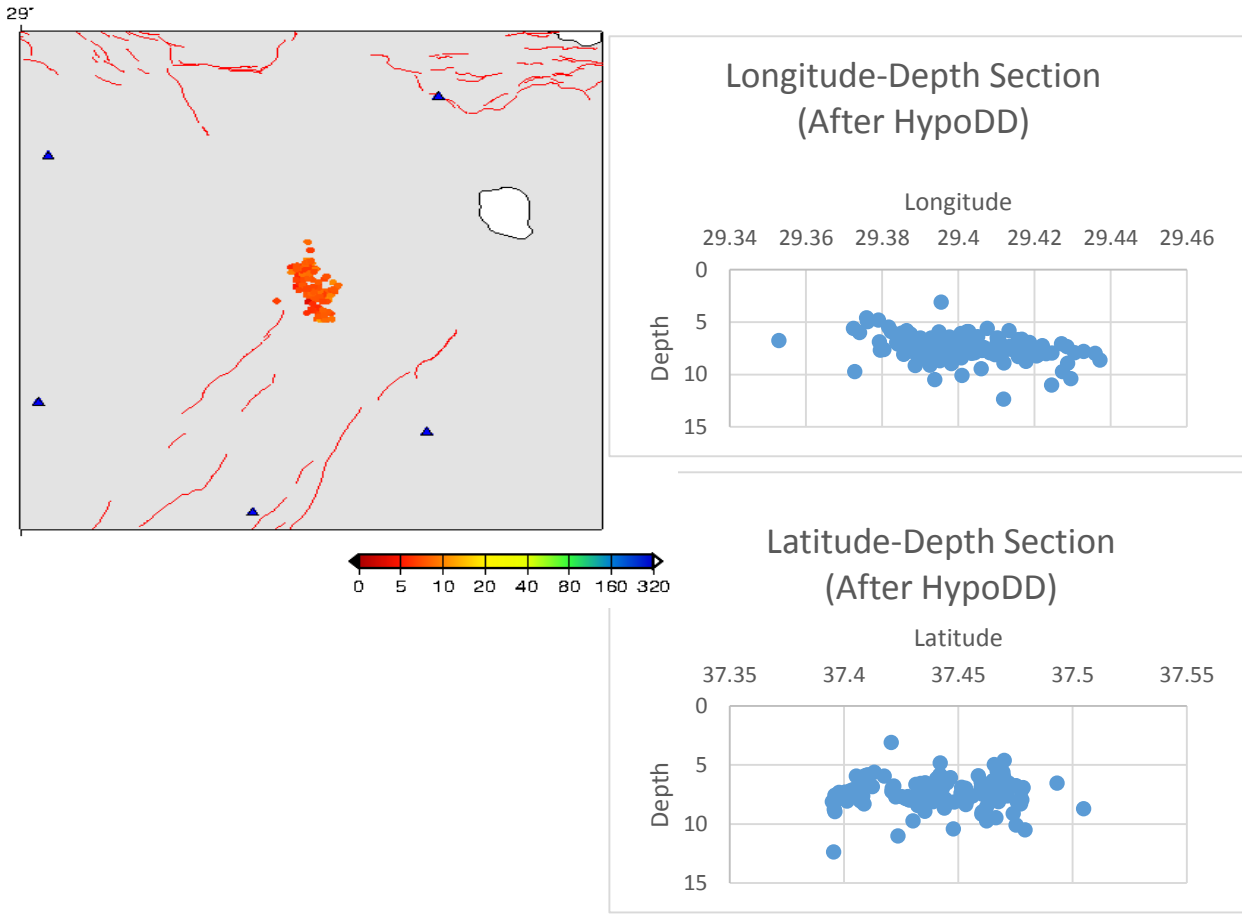


Figure 12. Improvement earthquake locations via HypoDD Method (After HypoDD).

8. SEISMOTECTONICS OF THE ACIPAYAM BASIN AND SURFACE CRACKS

The earthquake was located in the region close to the intersection of NE-SW and NW-SE trending faults in the Acipayam-Serinhisar graben of the left lateral strike-slip Fethiye-Burdur Fault System. The Acipayam basin is a graben with approximately 5-15 km wide and 30 km long bounded by NW-SE trending normal faults in both margins. An N-S trending elongated ridge composed of Pliocene clayey limestones and bounded by approximately 15 km long fault on the western side is located in the middle part extending from Bedirköy, Yeniköy to Ucarı of the Acipayam basin. The epicenter is located at the intersection between NW-SE trending normal fault bounding the SW margin of the basin and subsegment lying between Ucarı and Yeniköy of the N-S trending fault. The focal plane solution of the main shock was determined N50W trending and dipping 42° to NE dip-slip normal fault with rake angle of -89 degrees. 100-150 m long and discontinuities, N10E striking en-echelon surface cracks ranging from 1.0 m to 10 m with right steps developed in 7 km east of Acipayam, about 700 m south of Yeniköy. The right stepping cracks with 2-5 cm wide opening were linked with N30-40W trending cracks, which GGD blocks slipped down 1-2 cm.

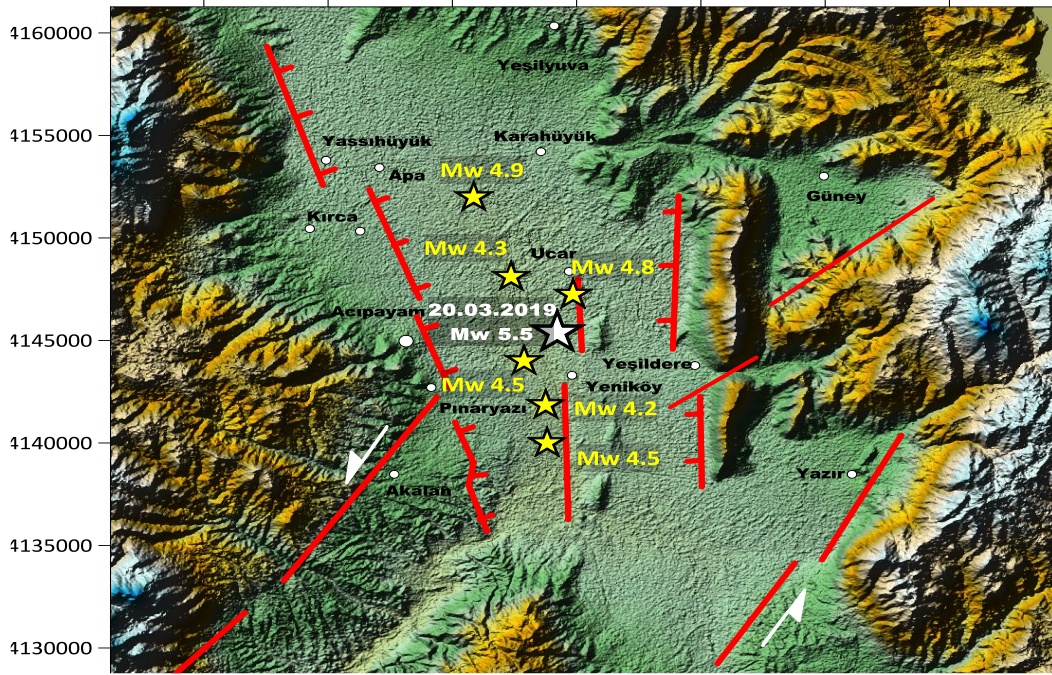


Figure 13. Morphotectonic map of the Acıpayam basin and 20 March 2019 Ucarı-Yeniköy (Acıpayam) earthquake main shock and aftershocks ($4.0 < M_w < 4.6$)

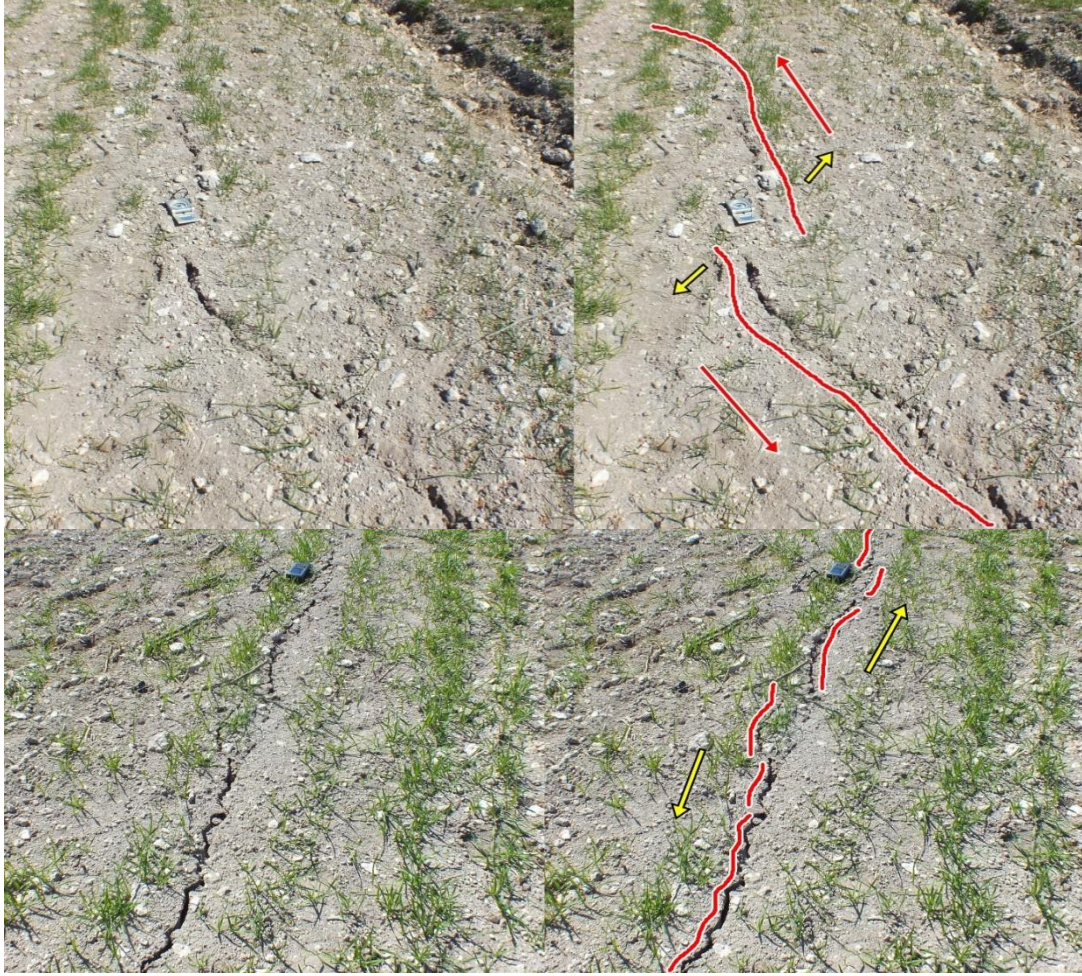


Figure 14. Surface cracks of the 20 March 2019 Ucarı-Yeniköy (Acıpayam) earthquake.

9.COULOMB STRESS CHANGE

The rapture took place along the normal fault which it limits Acıpayam basin from SW in the direction of SSE-NNW. There was almost 0.3 bar stress loaded to NW-SE ends of the fault.

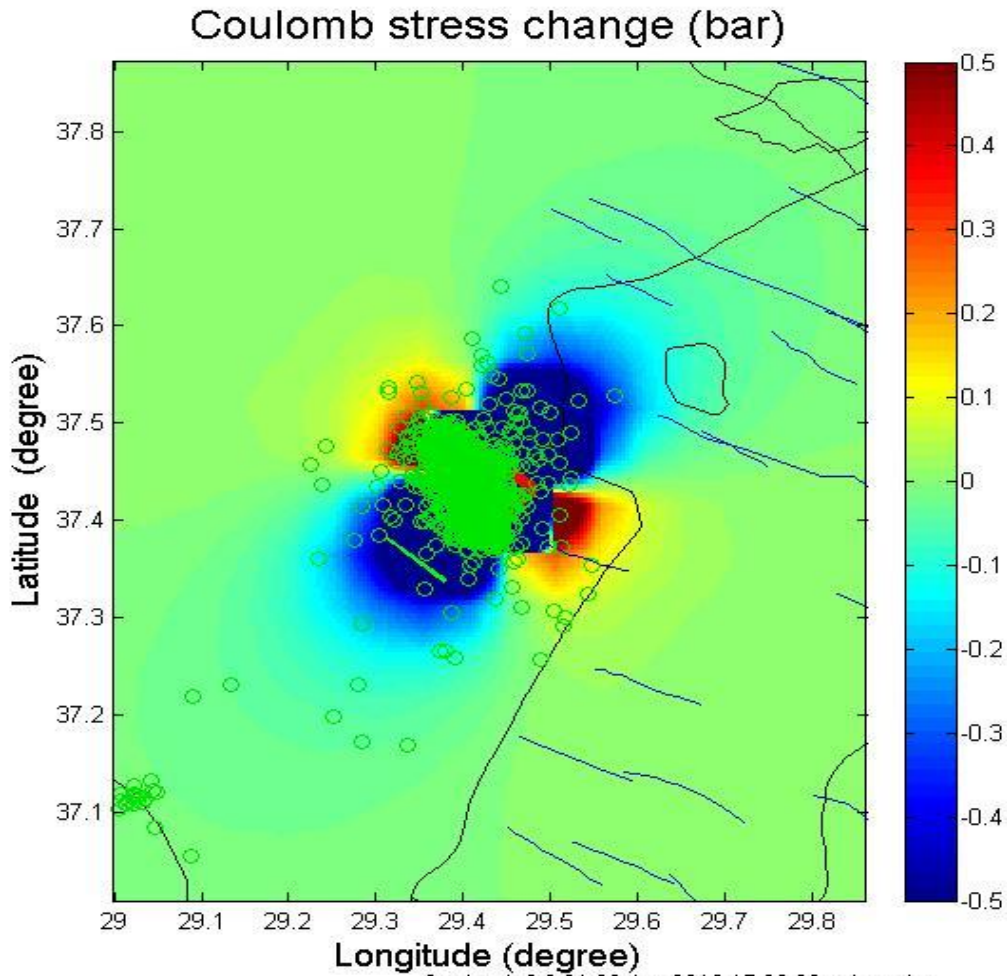


Figure 15. Coulomb stress change

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