December 17th, 2023 Offshore- Çınarçık Earthquake (M4.0)

Earthquake Information Report

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Description of the event

An earthquake of magnitude M4.0 occurred on December 17th, 2023, at 23:53 (local time; GMT 20:53) in the offshore Çınarcık, Yalova region of Türkiye. The earthquake parameters reported by EMSC-CSEM are given in Table 1. The earthquake was felt in the Marmara region with a macro-seismic intensity of MMI IV (reported by USGS and shown in Figure 1). Most felt reports are from the larger Istanbul metropolitan area, about 30-40 km North of the epicenter. Table 2 shows the densely populated urban settlements near the earthquake epicenter. The location of the event is shown in Figure 1 and Figure 2.

Table 1. Important indicators of the offshore Çınarcık earthquake (source: EMSC-CSEM)

Magnitude*	4.0
Country	Türkiye
Date time	17.12.2023 23:53:52 UTC
Epicenter	40.722N – 29.099E
Depth**	11 km

* KOERI reported the magnitude as moment magnitude M_w 4.0; AFAD reports the magnitude as M_w 4.1, USGS reports the magnitude as mb 4.2
** KOERI and AFAD report the depth as 11 km, and USGS reports the depth as 12.5 km

Table 2. The nearest urban settlements and their populations to the epicenter of the December 17th M4 event (source: USGS)

Nearby Settlements and Their Populations
Çınarcık, Yalova, 11 km, Population: 7,629
Yalova, 20 km, Population: 71,289
Maltepe, Istanbul, 24k m, Population: 427,040
Ataşehir, İstanbul, 28 km, Population: 361,615
Sultanbeyli, Istanbul, 39 km, Population: 286,622

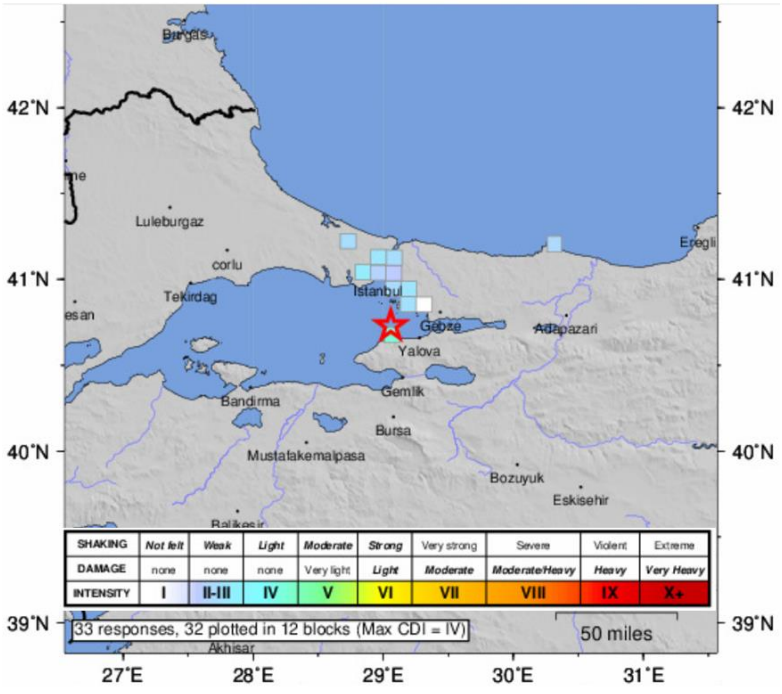

Figure 1. The red star shows the location of the December 17 23:53 offshore-Çınarcık earthquake. The square symbols denote the MMI intensities based on the felt reports (source: USGS)

The earthquake source. The earthquake is in a region of dense seismic stations; therefore, the source parameters are well-constrained. Using the waveform data recorded at nearby seismic stations a focal mechanism showed predominantly normal faulting with the small right-lateral strike-slip component (Figure 2, upper panel). The fault plane steeply dipped toward the northeast a likely fault plane. The main trace of the NAFZ crossing the Çınarcık Basin is a strike-slip fault accommodating the motion between Anatolia and Eurasia (Figure 2, bottom right panel). On the other hand, most of the secondary fault traces show a normal faulting mechanism (Figure 2, bottom left panel). Thus, the normal faulting mechanism of the December 17, 2023, Offshore Çınarcık earthquake is evidence showing that it took place on a secondary fault trace. Controversially, this earthquake could also have occurred on the normal fault passing through the southern boundary of the Çınarcık basin (Figure 3) that dips towards the north with an approximate dipping angle of 45 degrees.

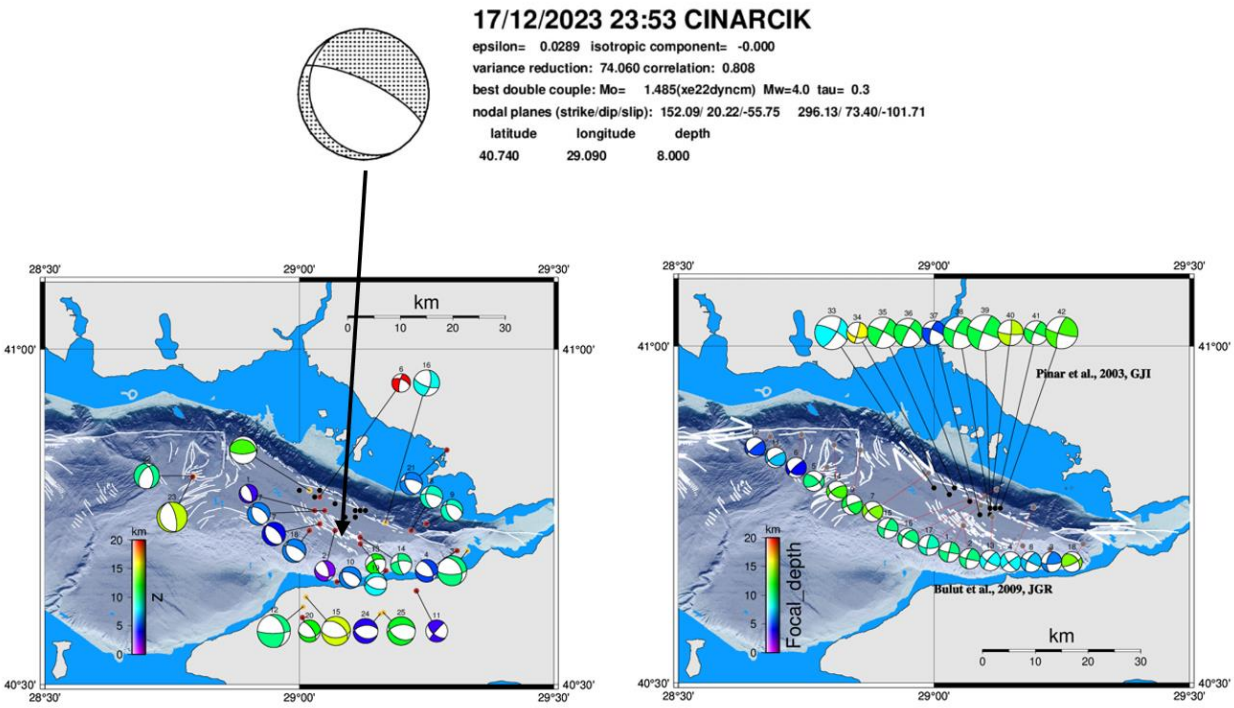

Figure 2. The focal mechanisms that are associated with earthquakes are on secondary faults (normal faulting) and along the main trace of the NAFZ (strike-slip faulting). The epicentral location and the focal mechanism of the December 17th, 2023 offshore Çınarcık earthquakes are also shown on the left panel (modified from Pınar et al., 2016).

Figure 3 also shows the last 14-year seismicity of earthquakes between 2.5 ≤ M ≤ 6 that occurred mostly in the central and northern branches of NAF. The map encompasses a square region of 200 km by 150 km and the December 17th, 2023 event is approximately in the center of this region. Note that almost no seismic activity is observed to the east of this region as the fault segments along the Izmit Bay were ruptured by the 1999 Izmit earthquake (M7.5) and its aftershocks. The seismicity contrast advocates that the faults beneath the Gulf are at a stage of new strain accumulation. The elevated seismicity to the west of Izmit Gulf reflects stress loading where secondary and major faults are accumulating and releasing stress. The September 26th, 2019 offshore Silivri Earthquake (M5.7) is an example of a rupture on a such secondary fault that was followed by an intense aftershock activity (Figure 3).

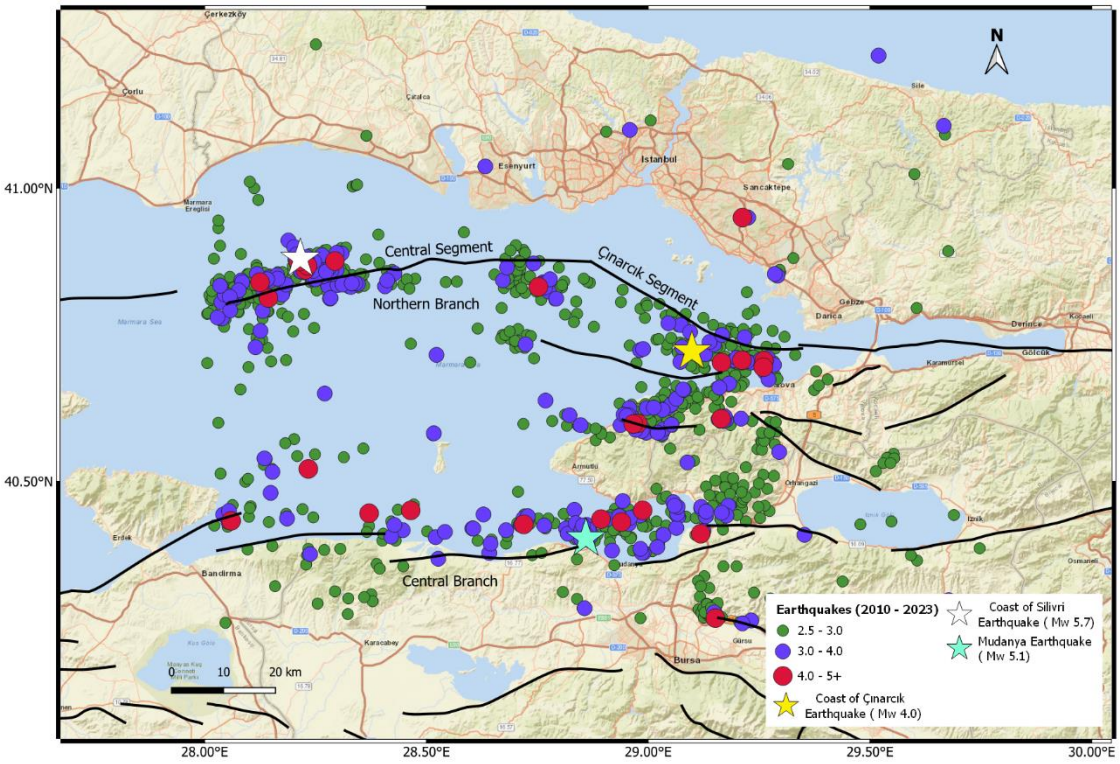

Figure 3. The last 14 years of seismic activity in the Central and Eastern Marmara Sea Region. (The map encompasses a 200 km by 150 km square region and the December 17th, 2023 event is approximately in the center of the square region). The map shows the epicenter of earthquakes with magnitudes 2.5 ≤ M ≤ 6. There are only two earthquakes M > 5; M5.1 December 4th, 2023 Mudanya Earthquake and Sept. 26th, 2019 M5.7 Silivri Earthquake [Source: Kandilli Observatory And Earthquake Research Institute (KOERI)]

While Figure 3 shows the last 14 years' spatial distribution of seismicity confined to the 200 km by 150 km square region Figure 4 illustrates their temporal distribution. The spatiotemporal distribution of the earthquakes suggests that the 4 ≤ M < 5 earthquakes are likely to take place anywhere in the Central and Eastern Marmara Sea region with an average biannual frequency of 2-3 earthquakes since 2010. (This relatively short-term statistic is later revisited in Figure 6). The increase in seismic activity in 2019 is attributed to aftershocks of the 2019 offshore M5.7 Silivri earthquake. Note that only two earthquakes of magnitude M > 5 occurred in the confined region since 2010 which are the 2019 Silivri Earthquake (M5.7) and the December 4th, 2023 Mudanya Earthquake (M5.1). (See IN2023-004 T-Rupt Technology Inc. report for a limited insight into the December 4th, 2023 Mudanya Earthquake).

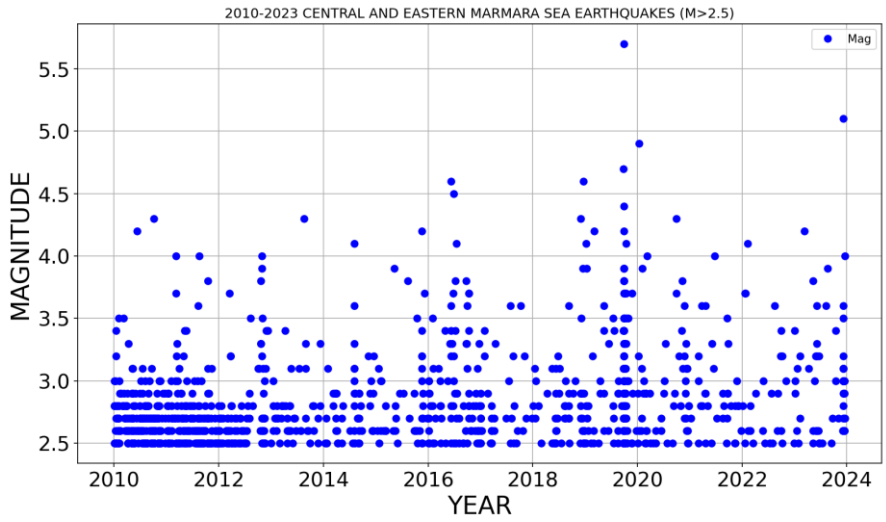

Figure 4. Temporal distribution of earthquake sizes in Central and Eastern Marmara Sea region.

The statistical information on the 14 years 2.5 ≤ M ≤ 6 earthquakes in the designated region is further provided in Figures 5 and 6. The presented statistics constitute raw data information (i.e., no declustering and completeness analyses are performed) where the data are compiled from the earthquake database of the Kandilli Observatory and Earthquake Research Institute (KOERI).

The earthquake frequency exponentially decays, as expected, from small to large magnitude events (Figure 5). The biannual normalized earthquake activity for different magnitude classes advocates a tendency towards a decrease in small magnitude activity, and an increase in large magnitude activity from 2010 to 2023 period at least for the region of interest in this informative note and for magnitudes between 2.5 ≤ M ≤ 6 (Figure 6, bottom panel). Note that this observation should not be taken as large magnitude events will be observed more frequently in the next coming years for the region of concern as such an assertion requires in-depth scientific studies, which is not the scope of this informative note. Similarly, it cannot be definitively asserted at this point whether this earthquake is a precursor to a seismic event of greater magnitude or not.

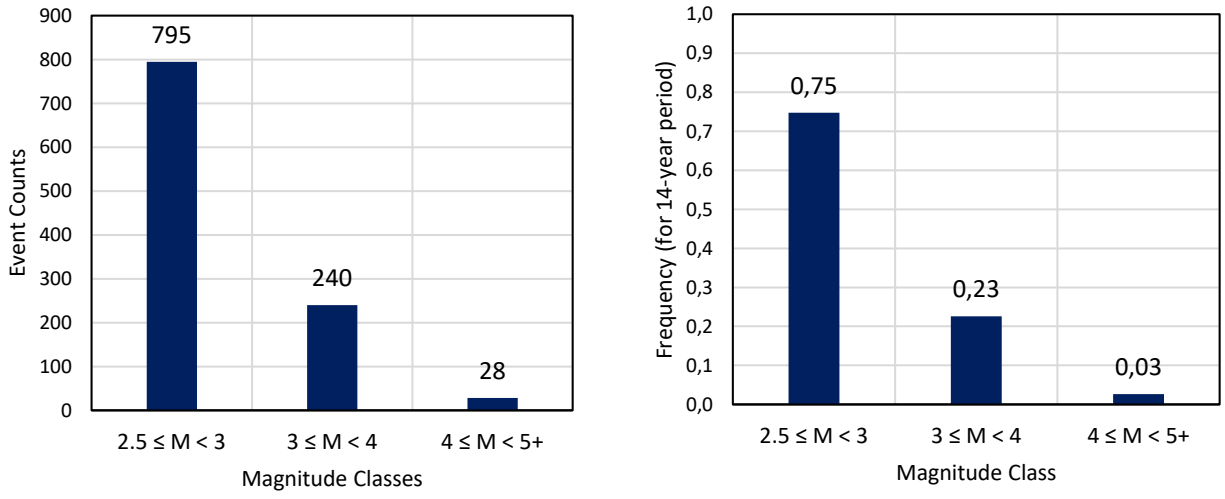

Figure 5. Magnitude distribution of in the region of interest for the time slot between 2010 and 2023. The left panel in event counts, right panel in frequency for 14-year time intervals.

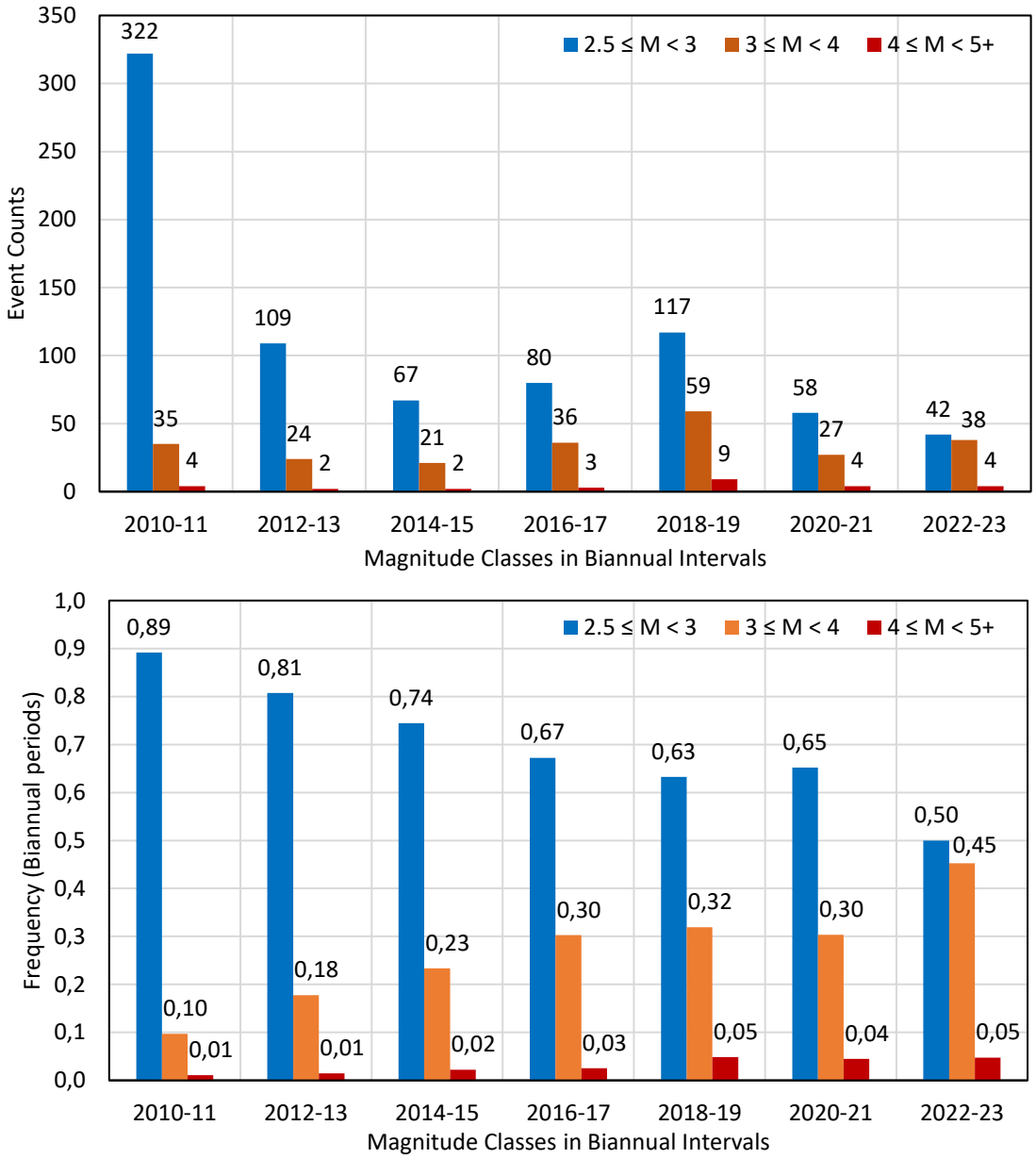

Figure 6. Top panel: Biannual event counts for different magnitude classes for the region of interest between 2010 and 2023; Bottom panel: Biannual frequencies for the region of interest between 2010 and 2023

References

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