

Monitoring and Station Health of Türkiye – KOERI Stations and Their Contribution to AdriaArray Seismic Network

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Abstract

The Kandilli Observatory and Earthquake Research Institute (KOERI) has played a pivotal role in seismic monitoring in Türkiye since the late 19th century. This study highlights recent advances in the KOERI seismic network including the installation of new broadband and accelerometer stations, data management under the European Integrated Data Archive (EIDA) and contributions to the AdriaArray project. AdriaArray is a large-scale passive seismic experiment designed to improve the resolution of seismic imaging and geodynamic models across southeastern Europe by integrating data from a dense broadband seismic network. This initiative enables detailed investigations of crustal and mantle structure, anisotropy, and lithospheric deformation, offering new insights into the complex interactions between the Eurasian, Adriatic and Anatolian plates. As part of this effort, three key stations (DOGC, CRLU and TEKI) were installed in the Thrace Basin, providing valuable data for analyzing regional seismicity and tectonic activity. The performance of these stations was assessed alongside seismicity trends before and after their installation. This work emphasizes KOERI's role in advancing regional seismic monitoring capabilities and its notable contributions to global seismological research. Furthermore, the findings underscore the transformative impact of high-density seismic networks in improving the detection of microseismic events and refining our understanding of tectonic processes. These developments also highlight the critical role of cross-border collaboration and state-of-the-art instrumentation in mitigating earthquake risks and fostering global geoscientific progress.

Keywords: Seismology; KOERI; AdriaArray; Seismic Networks; Large Seismic Monitoring; Seismic Imaging

1. Introduction

Türkiye is one of the most tectonically active regions in the world, located at the complex convergence zone of the Eurasian, Arabian, and African tectonic plates. This interaction results in a diverse range of tectonic processes such as continental collision, oceanic subduction, back-arc extension and strike-slip faulting. These processes shape Türkiye's unique geodynamic landscape, dominated by major fault systems such as the North Anatolian Fault (NAF), the East Anatolian Fault (EAF) and the Hellenic subduction zone.

The NAF, extending over 1200 kilometers, is one of the most seismically active right-lateral strike-slip fault systems globally. It has generated several devastating earthquakes including the 1999 İzmit earthquake (Mw:7.4) and the 1999 Düzce Earthquake (Mw: 7.2). The EAF, a left-lateral strike-slip fault system, plays a crucial role in accommodating the tectonic escape of the Anatolian Plate toward the Aegean Sea. Southward, the Hellenic subduction zone is characterized by intense seismicity due to the convergence of the African Plate beneath the Eurasian Plate (Şengör et al., 2005). This tectonic setting makes Türkiye a natural laboratory for studying seismic processes and understanding regional geodynamics. Within this framework, the Thrace Basin is a key area influenced by the western extensions of the NAF. It is characterized by a network of secondary fault systems and notable seismicity despite being less studied compared to other regions in Türkiye (Seyitoğlu et al., 2000). The recent addition of modern seismic stations by the Kandilli Observatory and Earthquake Research Institute (KOERI) has significantly enhanced the understanding of its tectonic activity and potential earthquake hazards.

Established in 1868, KOERI has evolved into a globally recognized institution contributing to earthquake research and hazard mitigation. Moreover, KOERI has been instrumental in monitoring and analyzing seismicity across this complex tectonic setting since 1894 (Cambaz et al., 2021). Recent improvements in seismic station installations, data management systems and international collaborations have further enhanced this mission. KOERI's integration into European Integrated Data Archive (EIDA) and AdriaArray experiment demonstrate the commitment to regional and global seismological research and highlights Türkiye's active participation and collaboration with numerous seismology centers across Europe. As a multinational initiative to cover the Adriatic Plate and its active margins by a dense regional array of seismic stations, AdriaArray aims to image the crustal and upper mantle structures and assesses the impact of these structures on seismic activity and hazard (Kolínský et al., 2025). The project aims to establish a seismic network (with station spacing of 50-55 km) through the cooperation of 50 centers and 64 institutions from 30 countries. Real-time data recorded by 1068 permanent and 440 temporary broadband stations from 23 mobile pools are transmitted to 12 nodes of EIDA. KOERI, through its Regional Earthquake-Tsunami Monitoring Center (RETMTC), actively contributes to this initiative. Since July 2022, three new strong ground motion stations have been installed as part of the AdriaArray project. This study emphasizes these developments focusing on the historical evolution of the KOERI network, the recent installations within the AdriaArray framework and their transformative impact on advancing seismic monitoring capabilities. By integrating modern instrumentation, enhanced data-sharing platforms and international collaboration, we evaluate seismicity trends in the Thrace Basin, particularly underlining the improved detection of microseismic events and further understanding of complex tectonic processes. These achievements not only underscore KOERI's role in addressing regional seismic hazards but also the contributions to global geoscientific initiatives, providing critical insights on advancing earthquake monitoring and risk mitigation strategies.

2. Development of KOERI Network and Contribution to AdriaArray Experiment

2.1 Historical and Present-Day Perspective

Since its establishment in 1868, KOERI has undergone continuous evolution, transitioning from basic mechanical seismometers to a sophisticated network of broadband and accelerometer stations. Key milestones include the installation of seismographs following the 1894 Istanbul earthquake, which marked the introduction of modern seismological techniques to Türkiye (Cambaz et al., 2021). Significant expansions after the catastrophic 1939 Erzincan earthquake prompted the addition of more mechanical seismometers to monitor seismic activity in eastern Türkiye (Kalafat, 2016). The transition to digital seismic monitoring systems in the early 1990s led to the adoption of modern broadband instruments capable of recording a wide range of seismic frequencies. A major turning point occurred following the 1999 İzmit earthquake, as KOERI prioritized the establishment of strong-motion sensors

across urban and rural regions to better assess earthquake-induced ground shaking (Cambaz et al., 2021). Integration with EIDA in 2014 ensured global access to seismic data collected by KOERI stations and initiated numerous international research collaborations. Statistical evolution of the Türkiye earthquake catalog and the KOERI seismic network have been presented in earlier studies (Cambaz et al., 2019b, Necmioglu et al., 2021). This study presents recent developments of the KOERI seismic network focusing on the most recent deployments.

KOERI operates an advanced seismic network consisting of 297 stations strategically distributed across Türkiye (Fig. 1). This network integrates 147 broadband, 135 strong-motion, and 15 short-period sensors enabling comprehensive coverage of the region’s diverse tectonic activity (<http://www.koeri.boun.edu.tr/sismo/2/seismic-network/seismic-station-list/>). Furthermore, through collaborative data-sharing agreements with national and international seismic networks operating in the Mediterranean region, the total number of sensors contributing to the system exceeds 350. This extensive network facilitates a broad spectrum of scientific applications, ranging from the detection of microseismic events to the analysis of large-scale tectonic dynamics. RETMC operates under the auspices of the International Federation of Digital Seismograph Networks (FDSN) with the network code “KO” (<http://dx.doi.org/10.7914/SN/KO>). As the oldest seismological monitoring center in Türkiye and its surrounding regions, RETMC is equipped with a robust infrastructure for data management and distribution, advanced software systems and extensive operational capabilities. KOERI also serves as a principal node of the EIDA; (<http://www.orfeus-eu.org/data/eida/>), which operates under the framework of the European Observatories and Research Facilities for Seismology (ORFEUS). These collaborations further enhance KOERI’s contributions to earthquake and tsunami preparedness, awareness and risk mitigation, addressing both natural and technological disasters in Türkiye and neighboring regions.

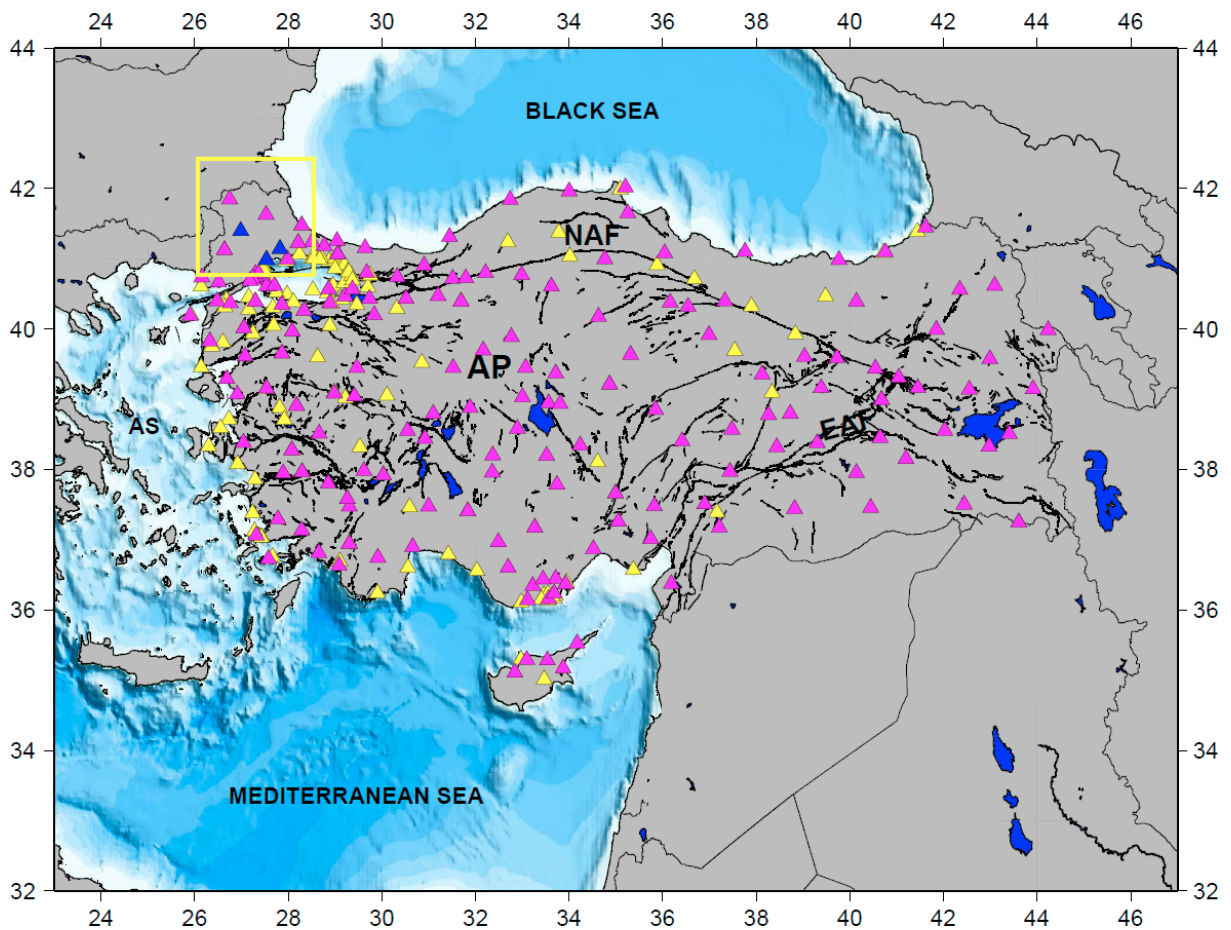


Figure 1. Distribution of seismic stations. Purple and yellow triangles represent the broadband and strongmotion stations contributing to the EIDA (<http://eida.koeri.boun.edu.tr>) network, respectively. Major faults are depicted as solid black lines (Emre et al., 2018). The location of the Thrace Basin is shown by the yellow square. Abbreviations: NAF: North Anatolian Fault; EAF: East Anatolian Fault; AP: Anatolian Plate; AS: Aegean Sea.

A detailed map of KOERI's seismic network provides a comprehensive overview of the geographic distribution and strategic positioning of the stations across Türkiye. This map highlights the network's spatial coverage and operational capabilities, demonstrating its effectiveness in monitoring seismicity within diverse tectonic environments.

2.2 Contribution to AdriaArray Seismic Network

Between 2021 and 2025, KOERI significantly enhanced its seismic monitoring capabilities by installing 54 new seismic stations. These installations were strategically positioned to improve spatial resolution and enhance the detection of microseismic activity in Türkiye. As part of the AdriaArray project, which aims to establish a uniform seismic network with station intervals of 50-55 km, KOERI has played a pivotal role in the Thrace Basin.

The AdriaArray initiative represents a large-scale collaborative effort across Europe, emphasizing uniformity in seismic data acquisition to better understand regional and global tectonic processes (Kolínský et al., 2022). In this context, KOERI has made substantial contributions by installing three key accelerometer stations in the Thrace Basin during 2022. The technical specifications and operational details of these stations are summarized in Table 1 and Fig. 2.

Table 1. Technical Specifications of Installed Stations.

Station Name	Location	Network	Latitude	Longitude	Elevation	Sensor	Period	Digitizer	Serial Number	Established	Status	Type	Data Availability (%)
DOGC	Doğanca Pehlivan köyü KIRKLARELİ	KO	41.3949	26.9852	81	5T Güralp	100Hz	CMG CD24	T5V03 C1489	20220701	Open	Accelerometer	99%
CRLU	Çorlu TEKİRDAĞ	KO	41.1428	27.8215	126	SA10 SARA	100Hz	SL06	5410	20221215	Open	Accelerometer	99%
TEKI	Süleymanpaşa TEKİRDAĞ	KO	40.9862	27.5374	126	SA10 SARA	100HZ	SL06	5411	20221216	Open	Accelerometer	98%

Both the CRLU and TEKI stations, equipped with SA10 sensors paired with SL06 digitizers, and the DOGC station, utilizing a Güralp 5T accelerometer with a CMG-CD24 digitizer, significantly enhance seismic monitoring capabilities in the Thrace Basin (Fig. 1). The Güralp 5T accelerometer combines low-noise components with high feedback loop gain, providing a highly precise transducer with an extensive dynamic range. Its ability to capture a wide range of frequencies and amplitudes makes it particularly well-suited for the Thrace Basin's complex geological setting, characterized by a thick sedimentary cover spanning several hundred meters. This sedimentary layer significantly influences the attenuation, amplification, and propagation of seismic waves, presenting both challenges and opportunities for seismic monitoring.

Similarly, the SA10 sensors at CRLU and TEKI stations, optimized for accelerometric applications, provide exceptional sensitivity to ground motion. These systems enable the detection of a broad spectrum of seismic events, from microseismic activities to moderate size earthquakes. The integration of these systems ensures precise recording of transient ground motions and significantly improves overall data quality.

The exterior view of the DOGC station highlights its solar panel system and secure enclosure. The interior showcases the seismic instrumentation, including accelerometers and advanced data acquisition systems (Fig. 2a). The CRLU station's exterior reflects its robust design, while the surrounding environment underscores its strategic placement within an urban setting (Fig. 2b). The TEKI station's exterior is a weather-resistant design and the interior reveals its accelerometer setup and associated seismic monitoring equipment (Fig. 2c).

All three stations are equipped with advanced telemetry systems that facilitate real-time data transmission to KOERI's central servers. The high sampling rate of 100Hz ensures detailed waveform recordings, which are crucial for accurately analyzing seismic source mechanisms and characterizing fault dynamics. In terms of energy efficiency and sustainability, each station is powered by solar panel systems with battery backups, ensuring uninterrupted operation even in remote areas. The design prioritizes energy efficiency while maintaining consistent data availability



Figure2. Installation and Overview of the AdriaArray Stations; (a) DOGC, (b) CRLU and (c) TEKI.

exceeding 98%. The inclusion of these stations significantly improved the monitoring of microseismic activity and regional tectonics. Data availability analysis (Fig. 3) highlights the stations' consistent performance, with minor interruptions attributed to communication issues.

2.3 Station Health and Data Availability

The performance and operational health of DOGC, CRLU, and TEKI have been thoroughly evaluated to ensure their reliability and effectiveness. As shown in Fig. 3, the data availability for all three stations consistently exceeds 98%, demonstrating their robust performance. Specifically, CRLU and DOGC exhibit 99% data availability, while TEKI achieves 98%. Despite these adequate metrics, minor data gaps have been identified, primarily due to temporary communication issues.

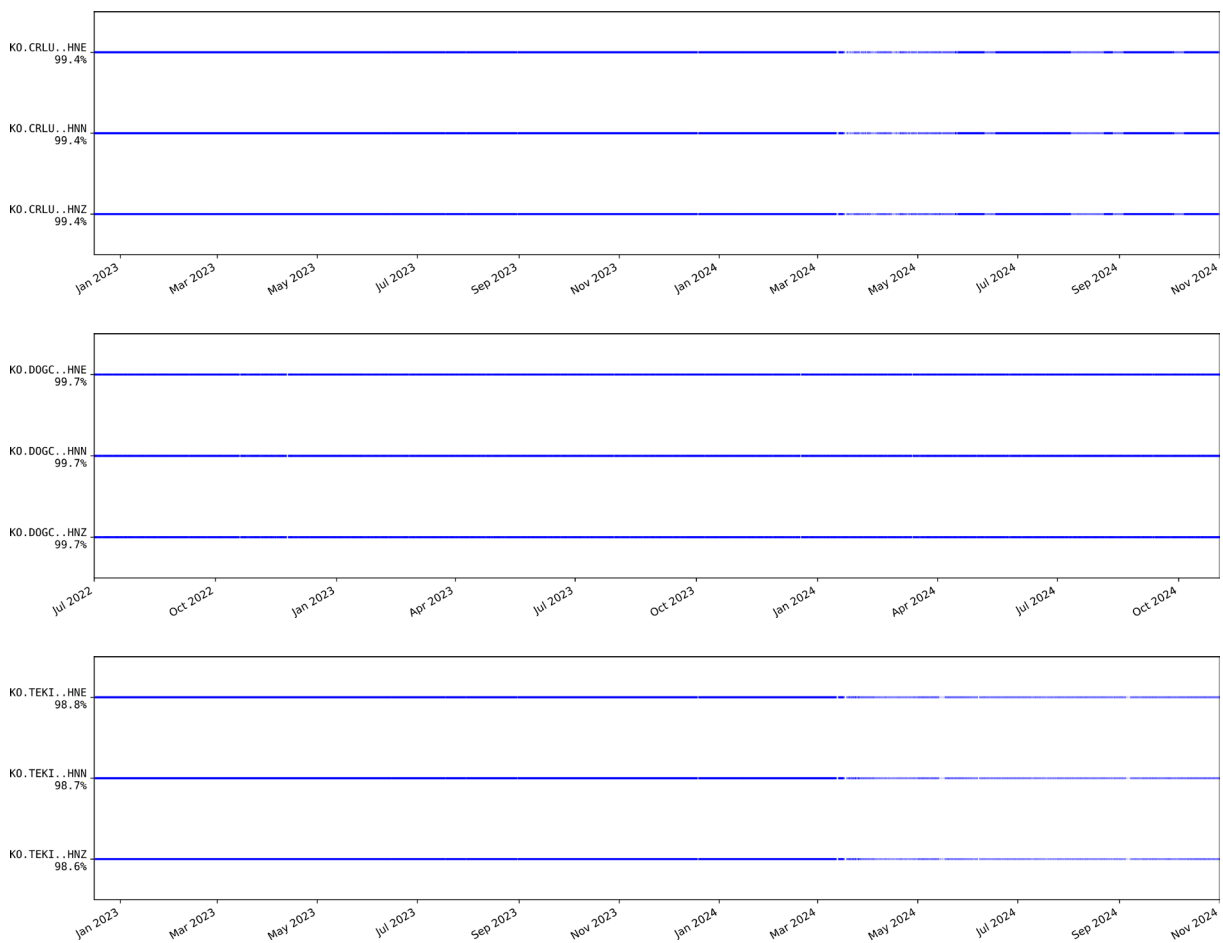


Figure 3. Data Availability Metrics for AdriaArray KOERI stations (CRLU, DOGC, TEKI) were visualized using the ObsPy-scan tool (v1.4.0), a module of the open-source ObsPy framework (Beyreuther et al., 2010).

To ensure long-term operational efficiency, KOERI implements rigorous maintenance protocols like routine diagnostic checks, calibration of equipment, and real time monitoring. These measures collectively maintain the network's high standards of reliability and data quality. By minimizing data interruptions, KOERI ensures the availability of valuable seismic information, which is critical for advancing research on seismic hazards and tectonic processes.

3. Seismicity of Türkiye

The complex geodynamics of Türkiye, as described in introduction, gives rise to intense seismic activity. The vast majority of seismic activity is concentrated along the various segments of two major fault zones: the North Anatolian Fault (NAF) and the East Anatolian Fault (EAF). Most recently, the Mw 7.7 and Mw 7.6 earthquakes that occurred on February 6, 2023 initiated a major sequence along the EAF that led to the recording of over 60,000 aftershocks up to date, emphasizing the region's vulnerability to large-magnitude events (Fig. 4).

Seismicity along the Hellenic subduction zone exhibits typical subduction zone characteristics, with deeper seismic events occurring toward the back-arc region where the seismogenic zone terminates at approximately 180 km depth (Papazachos et al., 2000). Intermediate-depth events (60-150 km) are primarily located within the inner part of the arc and in the Antalya Basin. Shallow events are widespread along the Hellenic Arc, mainland Greece, and Türkiye, as well as the Aegean Sea (Fig. 4). In comparison, the Cyprian Arc is seismically less active than the Hellenic Arc (Engdhal, 1998; Wdowinski et al., 2006). Most earthquakes in this region occur beneath the Anaximander Mountains and the Florence Rise. Notably, there are no indications of a Benioff zone in the eastern Cyprus Arc which forms the plate boundary between the Anatolian Plate to the north and the Sinai Plate to the south (Segev et al., 2006; Wdowinski et al., 2006).

The seismicity map illustrates Türkiye's complex seismic landscape, emphasizing areas of elevated seismic hazard shaped by active fault zones and plate boundary dynamics. The NAF and EAF are the primary zones of strain release with significant implications for seismic hazard assessment. Subduction zones along the Hellenic and Cyprus arcs contribute to regional seismicity and tsunamigenic risks, particularly in the eastern Mediterranean.

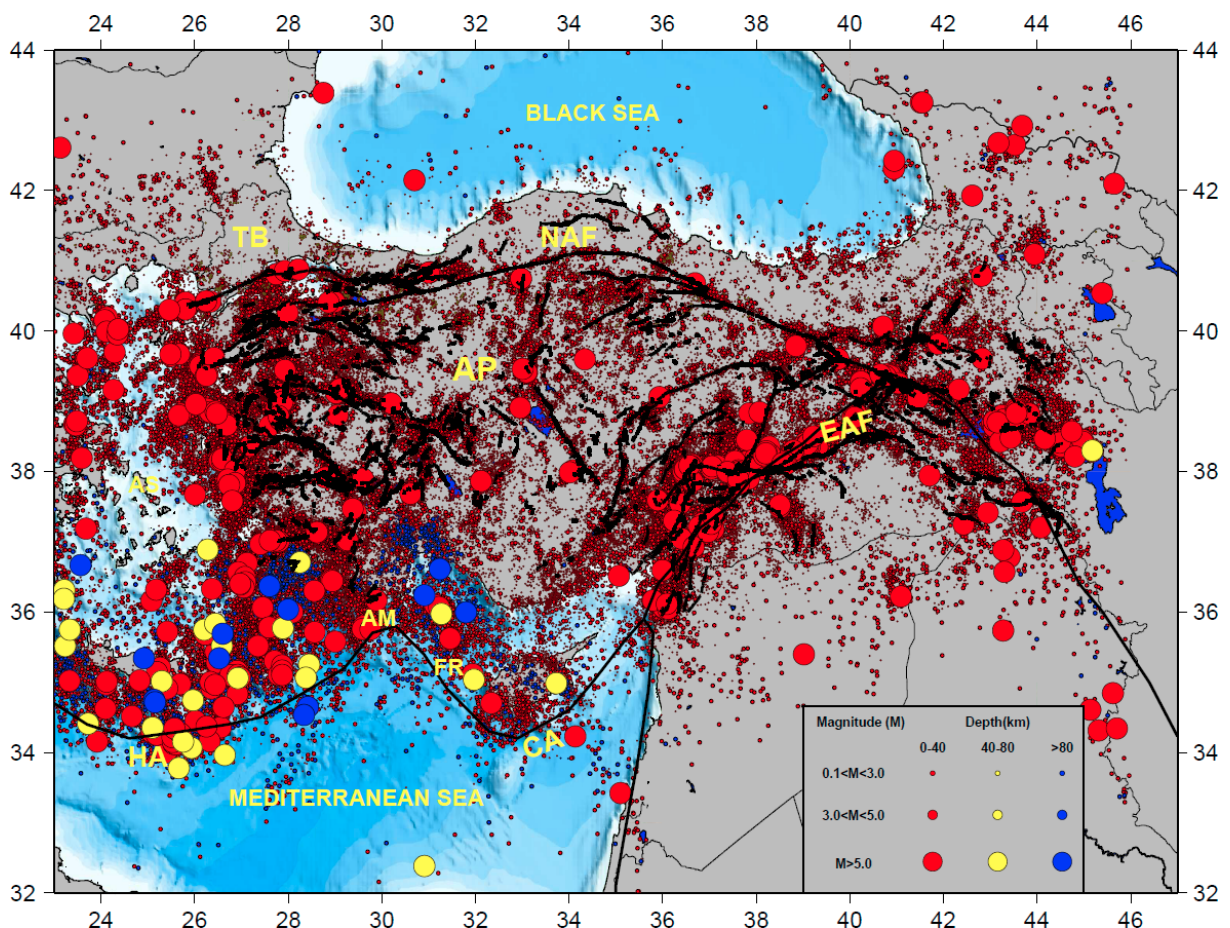


Figure 4. Seismicity of Türkiye and its surroundings (from 1905 to present, taken from the Kandilli catalog). Major faults and plate boundaries are marked by solid black lines and earthquakes are shown in circles (a detailed description is given in the inset). Abbreviations: NAF: North Anatolian Fault, EAF: East Anatolian Fault, AP: Anatolian Plate, AS: Aegean Sea, CA: Cyprus Arc, HA: Hellenic Arc, FR: Florence Rise, AM: Anaximander Mountain, TB: Thrace Basin.

3.1 Regional Focus: Thrace Basin

The Thrace Basin, located in northwestern Türkiye (Fig. 1), is a tectonically active region that serves as a critical transition zone between the strike-slip deformation of the NAFZ and the extensional regime of the Aegean system. This unique geological setting makes the basin an ideal natural laboratory for studying plate interactions, sedimentary basin evolution and seismic hazard assessment. The basin's thick sedimentary cover, hydrocarbon potential and moderate seismicity are key features that will be explored in this section.

3.1.1 Thick Sedimentary Cover and Hydrocarbon Potential

The Thrace Basin is characterized by a thick sedimentary sequence, with deposits ranging from Eocene to Miocene in age. These sediments, which can reach thicknesses of up to 8-9 kilometers in some areas, reflect the basin's complex evolution as a forearc and backarc system during the subduction of the African Plate beneath the Eurasian Plate (Okay et al., 2004; Turgut et al., 1991). The sedimentary layers include organic-rich shales, sandstones and coal seams which have contributed to the basin's status as Türkiye's most prolific natural gas-producing region (Görür and Tüysüz, 2001).

The hydrocarbon potential of the Thrace Basin has been extensively studied, with numerous gas fields discovered and developed since the 1970s. The basin's natural gas reserves are primarily located in the Hamitabat and Değirmenköy formations, which are known for their high organic content and favorable reservoir properties (Seyitoğlu et al., 2000). Ongoing exploration activities, including seismic surveys and drilling continue to reveal new reserves, underscoring the basin's economic importance (Türkmen et al., 2012).

However, the thick sedimentary cover also poses challenges for seismic hazard assessment. The soft sediments amplify ground motion during earthquakes leading to increased seismic risk in populated areas such as Tekirdağ and Edirne (Erdik et al., 2004). This phenomenon was particularly evident during the 1912 Mürefte earthquake, where significant damage was reported in areas underlain by thick sediments (Ambraseys and Finkel, 1987).

3.1.2 Tectonic Structures in the Thrace Basin

The Thrace Basin acts as a transitional zone between the strike-slip dynamics of the NAF and the extensional regime of the Aegean system. This tectonic interplay governs much of the region's deformation patterns and seismic activity. The interaction between these systems is illustrated in Fig. 5, which shows the major fault systems and their relationships within the basin. The basin's tectonic complexity is further evidenced by the presence of secondary faults and folds, which have been mapped through seismic reflection studies and field observations (Okay et al., 2004; Yalçınrak et al., 2000).

The tectonic framework of the Thrace Basin is dominated by several major fault systems including the Ganos Fault (GF) and Saros Fault (SF), which are extensions of the NAF. These faults play a crucial role in the basin's deformation and seismic activity. The Ganos Fault (GF), in particular, has generated significant historical earthquakes that caused widespread damage and highlighted the seismic potential of the region (Ambraseys and Finkel, 1987; Armijo et al., 2005).

3.1.3 Low to Moderate Seismicity

Although the Thrace Basin exhibits relatively low seismicity compared to the highly active segments of the NAFZ, its tectonic significance cannot be understated. The basin serves as a critical link between the Marmara Sea and the broader Aegean extensional system, influencing the distribution of seismic activity in the region. Historical earthquakes, such as the 1912 Mw 7.2 Mürefte earthquake and the 1964 Mw 7.3 Tekirdağ earthquake demonstrate the seismic hazard posed by the eastern continuation of the GF and its surrounding areas (Ambraseys and Finkel, 1987; Erdik et al., 2004).

In recent years, moderate-magnitude earthquakes have been recorded near the Turkish-Bulgarian border, including an Mw 4.2 event on August 21, 2010, and a Mw 4.0 event on July 9, 2023. Focal mechanism solutions for

these events, obtained using the ISOLA software, indicate strike-slip faulting along localized structural features (Sokos and Zahradník, 2008). These moderate events provide valuable insights into the microseismicity and tectonic dynamics of the Thrace Basin, shedding light on its interaction with adjacent fault systems and its role within the regional tectonic framework (Fig. 5).

Given its complex geological structure including thick sedimentary cover, segmented fault systems, and moderate yet meaningful seismicity the Thrace Basin remains a key area for understanding the interaction between regional stress fields and crustal deformation. Future research should focus on integrating geophysical, geological, and geodetic data to better constrain the basin's tectonic evolution and seismic potential.

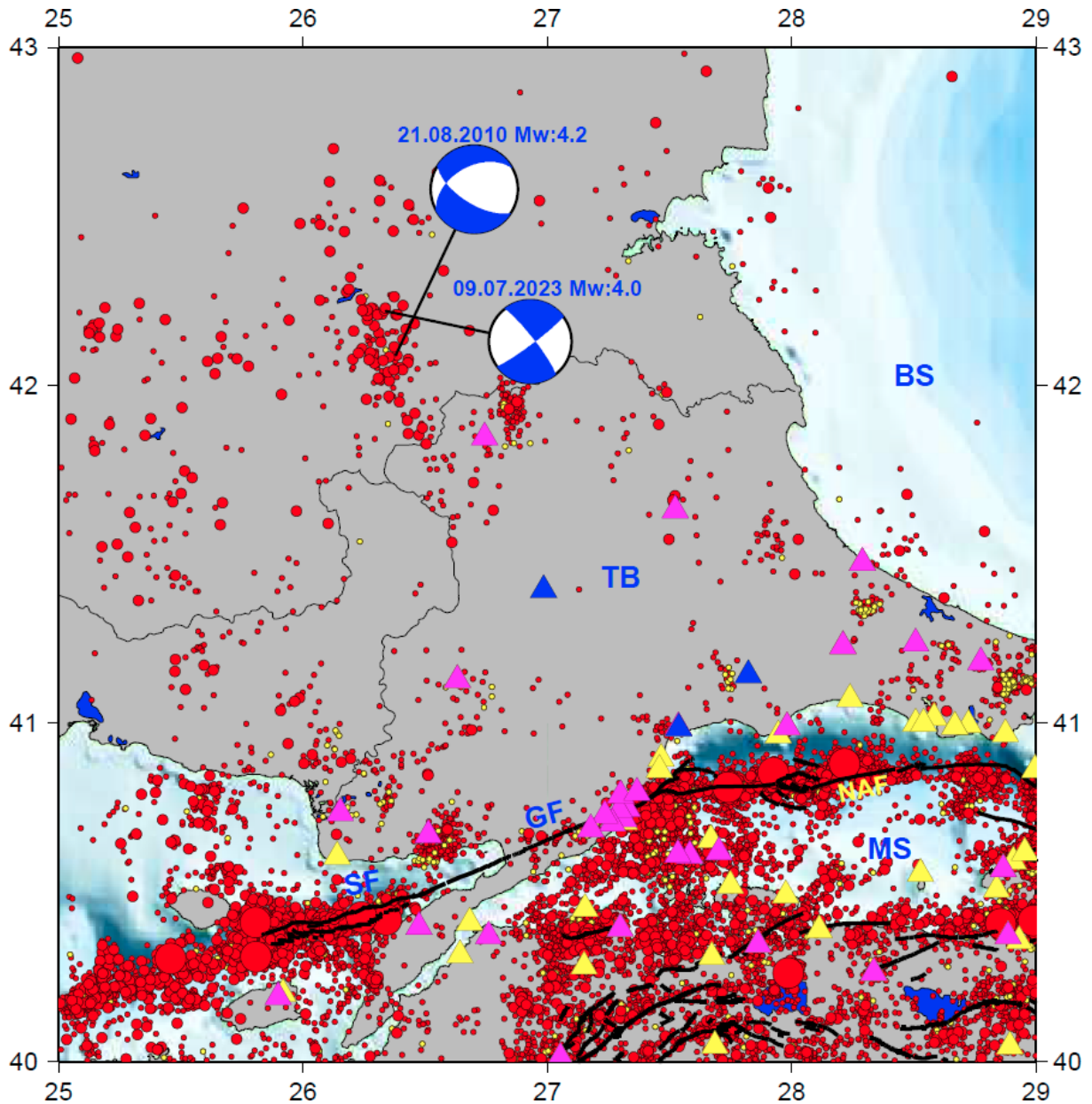


Figure 5. Seismicity of the Thrace Basin and its vicinity. Circles scaled by magnitude indicate the earthquakes (detailed explanation is given in the inset of Fig. 4). The focal mechanisms of the two moderate size earthquakes are represented by the corresponding beach balls. Broadband and strong motion sensors are shown by purple and yellow triangles, respectively. AdriaArray stations are also indicated by blue triangles. Faults are marked by solid black lines. Abbreviations: GF: Ganos Fault, NAF: North Anatolian Fault, MS: Marmara Sea. BS: Black Sea, SF: Saros Fault, TB: Thrace Basin.

4. Thrace Basin Case Study

4.1 Impact of DOGC, CRLU, and TEKI Stations on Magnitude Thresholds

The installation of the DOGC, CRLU, and TEKI stations has measurably improved the network's detection capability and event resolution in the Thrace Basin. To assess their impact, we compare the minimum detectable earthquake magnitude before and after the deployment of these stations. This comparison provides insight into how network expansion influences regional seismological monitoring, particularly in previously under-monitored areas (Fig. 6).

Prior to the deployment of the three stations, parts of the Thrace Basin were sparsely covered, which translated into higher magnitude detection thresholds. Figure 6a shows the baseline distribution before installing DOGC, CRLU, and TEKI: detectable minimum magnitudes range from ~ 1.5 to ~ 2.8 , with the highest values (>2.5) in the central and western parts of the basin. The limited number of stations in those areas reduced detection sensitivity, particularly for microseismicity ($M < 2.0$).

The improvement is summarized in the difference map (Fig. 6c), where $\Delta M = (a - b)$ is plotted on a positive-only scale (0-0.3) representing improvement relative to the baseline. Because no stations were removed, negative differences are not expected. The strongest gains cluster around the DOGC, CRLU, TEKI triangle i.e., the Lüleburgaz–Çorlu–Tekirdağ corridor (~ 26.8 - 28.3°E ; 41.0 - 41.6°N) whereas persistently sparse corners, especially parts of the southwestern and northeastern basin, retain relatively higher thresholds (≈ 2.5).

Magnitude-threshold calculations were performed with the Seismic Network Capability Assessment Software Tool (SNCAS) (Möllhoff et al., 2019), providing an objective appraisal of network performance. These results emphasize the value of expanding the broadband network to improve microseismic detection and, by extension, regional seismic hazard assessments.

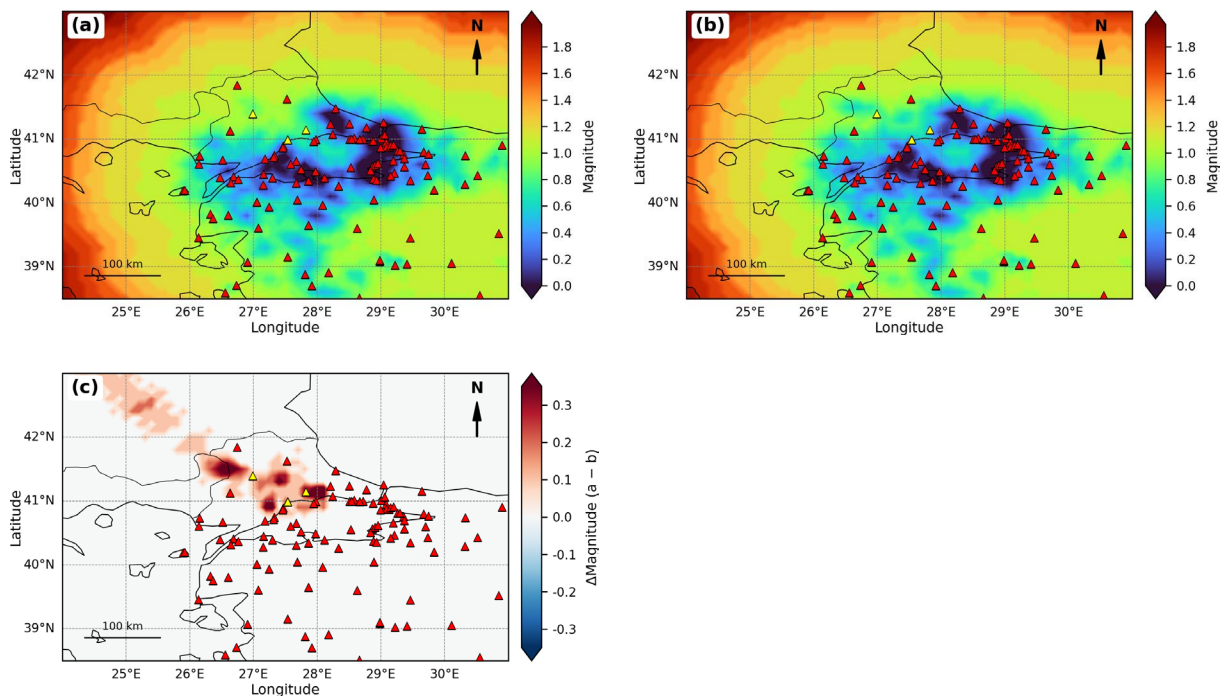


Figure 6. Magnitude threshold maps for the Marmara and North Aegean Region of Türkiye. (a) Baseline map (before adding the three stations). (b) After adding the three stations. Panels (a)-(b) share an identical color scale fixed to 0-2 M to allow direct comparison; lighter colors indicate lower thresholds (better sensitivity). (c) Difference map, $\Delta M = (a - b)$, shown with a zero-centered diverging scale limited to ± 0.3 M; positive values (warm colors) denote improvement (threshold decrease), negative values the opposite. Red triangles mark existing stations; yellow triangles mark the three added stations. Maps span 24-31°E and 38.5-43°N. Calculations were performed using SNCAS (Möllhoff et al., 2019).

4.2 Evaluation of Station Response to Regional Earthquakes

The performance of the DOGC, CRLU, and TEKI stations was evaluated during two significant seismic events: the February 6, 2023, Kahramanmaraş earthquake (Mw 7.8) and the December 4, 2023, Mudanya earthquake (Mw 5.1). These events provided valuable data for assessing the stations' sensitivity, recording capabilities, and contribution to seismic hazard assessment.

4.2.1 Kahramanmaraş Earthquake (Mw 7.8, 2023)

The Kahramanmaraş earthquake, one of the most devastating seismic events in Türkiye's recent history, was recorded by the DOGC, CRLU, and TEKI stations at an epicentral distance of approximately 600 km. The acceleration records captured by these stations exhibited strong low-frequency components (≤ 0.1 Hz), reflecting the regional propagation of seismic waves, while higher-frequency components (≥ 1 Hz) were attenuated due to the distance (Fig. 7). The stations' ability to record such a large-magnitude event with minimal filtering requirements underscores their long-range sensitivity and reliability.

4.2.2 Mudanya Earthquake (Mw 5.1, 2023)

The Mudanya earthquake, which occurred at an epicentral distance of 120-200 km from the stations, provided an opportunity to evaluate their performance during a moderate-magnitude event. Clear Pg and Sg phase arrivals were identified in the recorded waveforms, with higher-frequency content (≥ 1 Hz) due to the closer proximity of the event (Fig. 7). The stations demonstrated exceptional clarity in recording both local and regional seismic waves, with spectral analysis revealing consistent signal-to-noise ratios across the recorded events.

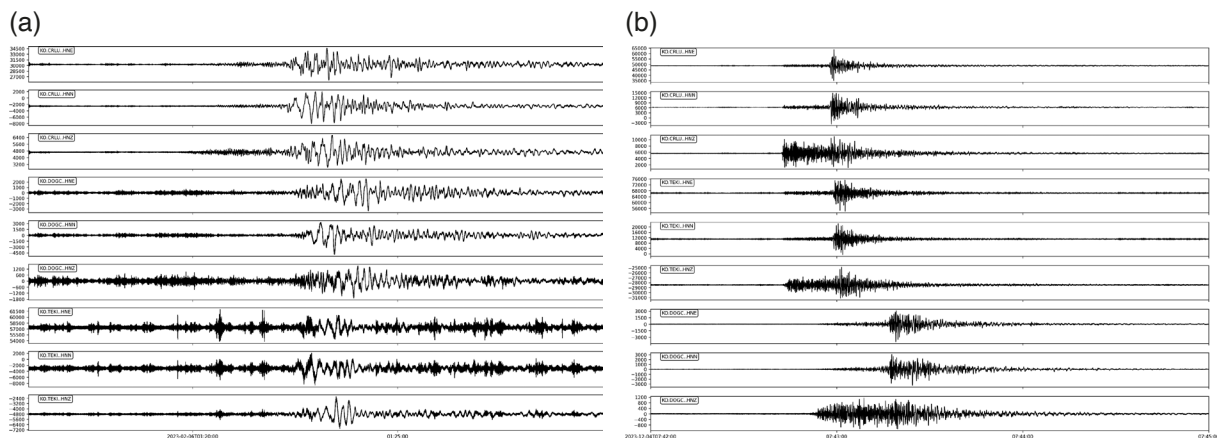


Figure 7. (a) Acceleration records from the Mw 7.8 Kahramanmaraş earthquake, recorded by TEKI, CRLU, and DOGC stations; (b) acceleration records from the Mw 5.1 Mudanya earthquake, recorded by the same stations.

4.3 Analysis of Strong-Motion Data

This section presents and analyzes the strong-motion data recorded at the TEKI station during the Mw 5.1 Mudanya earthquake. Figure 8 includes the seismic waveform display (scream view), acceleration, velocity, and displacement time histories, Fourier Amplitude Spectra (FAS), and response spectra (5% damping, PSA).

Figure 8a shows the scream view of the recorded waveform, providing a visual representation of the seismic signal as captured by the TEKI station. Figure 8b presents the acceleration, velocity, and displacement time series for the vertical (Z), north-south (N), and east-west (E) components recorded at the TEKI station. The horizontal components (N and E) exhibit higher amplitudes compared to the vertical motion, with a Peak Ground Acceleration

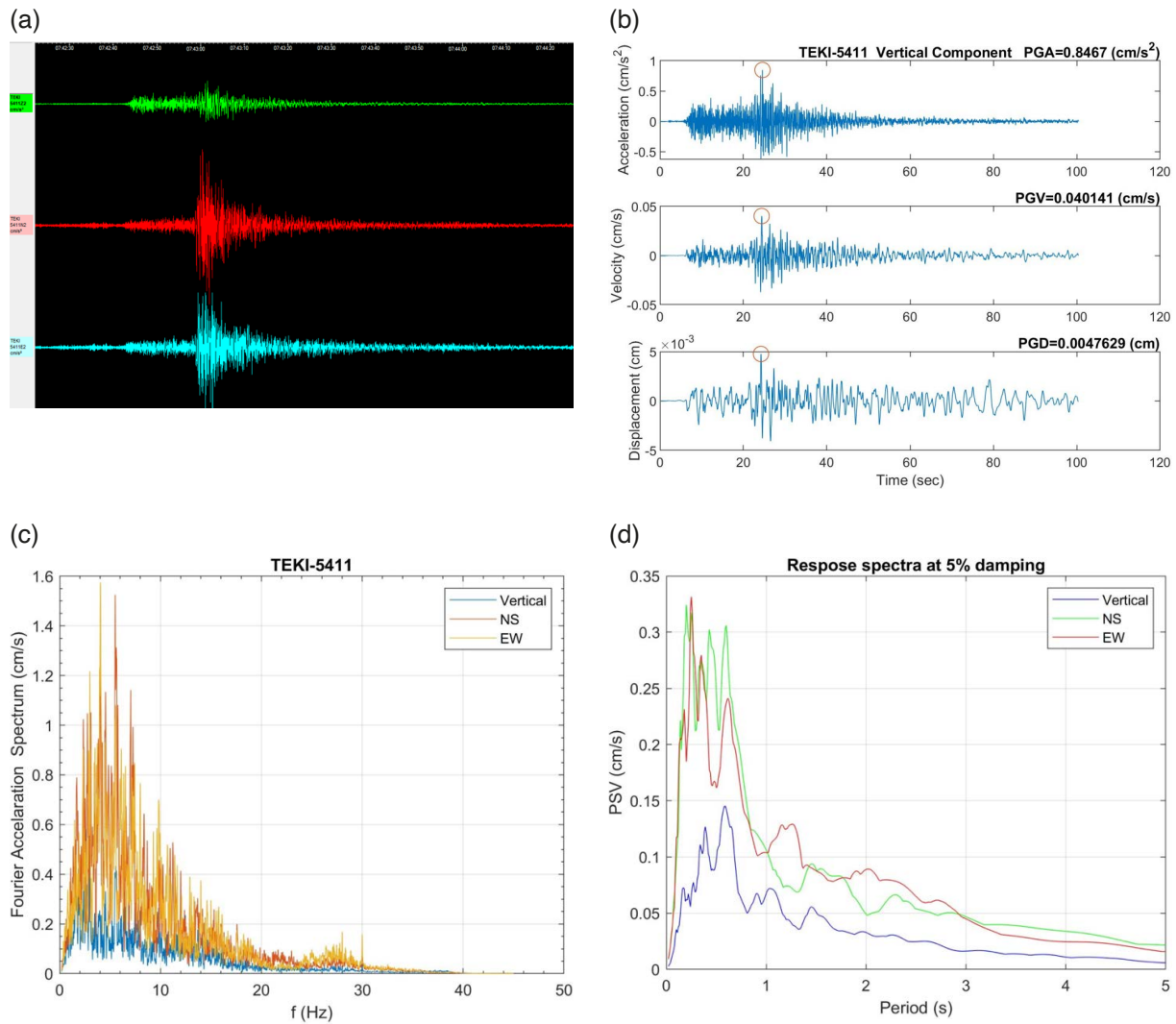


Figure 8. Strong-motion analysis of the Mw 5.1 Mudanya earthquake recorded at the TEKI station. (a) Screenshot of the recorded waveform. (b) Acceleration, velocity, and displacement time histories for the Z, N, and E components. (c) Fourier Amplitude Spectra (FAS). (d) 5%-damped response spectra.

(PGA) of 0.85 cm/s², a Peak Ground Velocity (PGV) of 0.04 cm/s, and a Peak Ground Displacement (PGD) of 0.005 cm. These time-history plots provide insight into the initial arrivals of seismic waves and possible local site effects, which may influence the amplitude and duration of the motion.

Figure 8c presents the Fourier Amplitude Spectra (FAS) for the three components (Z, N, E) in the 0-50 Hz frequency range. Most of the energy is concentrated in the 2-15 Hz band, with higher amplitudes in the horizontal components. This pattern highlights the significance of directionality in seismic excitation, as structures with natural periods within these dominant frequency ranges may be more vulnerable to earthquake-induced shaking.

Figure 8d displays the 5%-damped response spectra, illustrating the frequency-dependent amplification characteristics of the recorded ground motion. The horizontal components (N and E) exhibit higher spectral amplitudes, particularly in the short-period range (up to ~1 s), indicating stronger shaking in this range. The vertical component shows lower spectral amplitudes, which is consistent with the typical behavior observed in seismic recordings.

Overall, these analyses confirm that the Mw 5.1 Mudanya earthquake produced moderate ground motion levels. However, the differences between vertical and horizontal motions emphasize the importance of multi-component seismic analysis.

5. Conclusions

The Thrace Basin is a key transitional zone within the broader Eurasian tectonic framework, shaped by the interaction of the North Anatolian Fault (NAF), the Aegean extensional regime and the Adria microplate. This complex setting produces a dynamic interplay of strike-slip motion, extensional deformation, and secondary faulting, resulting in spatial variations in strain accumulation and release. Despite its significant seismic potential, the region has historically been underrepresented in seismological studies, limiting the resolution of earthquake catalogs and geodynamic models. Expanding seismic station coverage in this area is therefore essential for improving earthquake detection, refining source parameters, and advancing our understanding of crustal deformation.

As part of the AdriaArray initiative, the installation of three new seismic stations (DOGC, CRLU and TEKI) in the Thrace Basin has produced measurable improvements in network performance. Even with this limited number, the enhanced geometry has lowered magnitude detection thresholds, enabled the identification of microseismic events previously below detection limits, and improved hypocenter accuracy. Recordings from major regional earthquakes, including the Mw 7.8 Kahramanmaraş and Mw 5.1 Mudanya events, have enriched the dataset with high-quality waveforms that provide valuable constraints on wave propagation, frequency content, and site response, thereby strengthening the basis for seismic hazard assessment.

The integration of these stations into KOERI's broader network, and their connection to both EIDA and AdriaArray, ensures standardized data formats, real-time availability, and compatibility with international studies. This linkage enhances regional earthquake monitoring while contributing to global research on lithospheric deformation and plate boundary dynamics. The progress achieved through these targeted additions demonstrates the impact of strategic station deployment and underlines the importance of sustained international collaboration in advancing earthquake science and hazard mitigation.

Looking ahead, maintaining and expanding high-density seismic networks, supported by multidisciplinary approaches integrating seismological, geodetic, and geological observations, will be essential for improving hazard models and real-time monitoring. Initiatives like AdriaArray driven by collaboration and innovation are vital for addressing seismic risk, advancing early warning capabilities, and deepening understanding of complex tectonic regions. The experience from the Thrace Basin illustrates how targeted enhancements can yield significant scientific and practical benefits, both regionally and globally.

Data availability statement. Data can be downloaded at: <https://eida.koeri.boun.edu.tr>

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