

The AdriaArray Temporary Broadband Network in Romania: Enhancing Seismic Monitoring and Data Quality

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Abstract

The AdriaArray initiative is a broad international collaborative effort to investigate the dynamic deformation of the Adriatic Plate and its interactions with surrounding regions. The main component of this effort is the AdriaArray Seismic Network, which provides an unprecedented dataset for studying the complex geodynamic processes that drive seismic activity by gathering recordings from both permanent and temporary broadband seismic stations deployed across the Mediterranean area. The National Institute for Earth Physics (NIEP), Romania, contributes to AdriaArray through the deployment, operation, and maintenance of seismic stations, as well as data management, technical guidance, and research to better understand the geodynamics of this complex region. NIEP participated in the deployment of 44 temporary broadband stations, provided by several European institutions. The temporary stations complemented the permanent stations of the Romanian Seismic Network, enhancing station coverage and seismic monitoring resolution, particularly in notable tectonic areas such as Vrancea, one of Europe's most seismically active regions. Vrancea is well-known for its large-magnitude intermediate-depth earthquakes ($M > 7.0$), generated by the descent of a lithospheric slab beneath the southeastern Carpathians, making it a crucial area for many research topics. This study presents a comprehensive overview of AdriaArray activities in Romania, including details on sites and seismic equipment. We evaluate the quality of the recorded data to ensure the reliability of seismic observations. This includes near-real time data flow monitoring, data availability analysis, ambient noise characteristics, and sensor orientation assessment to confirm the accuracy

of the recordings. High-quality seismic data are essential for refining seismic monitoring techniques and enhancing automated processing methods. The results of this study support future research aimed at improving our understanding of seismic activity in Romania, lithospheric structure, tectonic evolution, and earthquake dynamics, while also contributing to the broader goal of the AdriaArray initiative in advancing geophysical research and seismic hazard assessment across the Adriatic region and beyond.

Keywords: Seismic Activity; Advanced Seismic Monitoring; Earthquake Source Characterization; High-Resolution Seismic Imaging; Crust and Upper Mantle Structure; Seismic Hazard

1. Introduction

The AdriaArray initiative (Kolínský et al., 2025a) is an international collaboration benefiting from the success of earlier large-scale seismic deployments, as the USArray in North America (Meltzer et al., 1999) or the AlpArray in Central and Western Europe (Hetényi et al., 2018). These projects demonstrated the potential of dense seismic arrays for improving our understanding of crustal and mantle processes.

The main goal of the AdriaArray is to gather high-quality seismological data to address long-standing questions about the tectonic evolution and ongoing geophysical processes in the region. Understanding the seismic activity, stress fields, and fault kinematics in this area is essential for advancing fundamental scientific knowledge, providing reliable seismic hazard assessment, and geohazard mitigation strategies. Due to the vulnerability of this region to tectonic and volcanic activity, this initiative has substantial consequences for the safety and resilience of the population.

The National Institute for Earth Physics (NIEP) is the leading institution in Romania responsible for seismic monitoring and controls the Romanian Seismic Network (RSN, National Institute for Earth Physics-NIEP Romania, 1994), which has significantly improved and expanded over the last decades (Mărmurenu et al., 2021). NIEP is actively involved in the AdriaArray initiative, covering a broad spectrum of activities essential for advancing multidisciplinary research. NIEP provides technical expertise and guidance for AdriaArray Working Groups and Collaborative Research Groups (CRG). Additionally, NIEP operates the NIEP EIDA (European Integrated Data Archive) node (Strollo et al., 2021), which archives and facilitates access to seismic data recorded by the Y8 network (Neagoe, 2022). Y8 is integrated into the virtual _ADARRAY network managed by EIDA and comprises temporary stations installed across Romania, Poland, and Bulgaria (Neagoe, 2022). NIEP strengthens the AdriaArray initiative's mission by cooperating with many organizations across Europe, i.e., with the Institute of Geophysics of the Czech Academy of Sciences, the Institute of Rock Structure and Mechanics of the Czech Academy of Sciences, the University of Helsinki and the Sodankylä Geophysical Observatory of the University of Oulu, both in Finland, as well as Aarhus University in Denmark and Uppsala University in Sweden. Among others, the cooperation includes the deployment and maintenance of temporary seismic stations throughout Romania (Fig. 1). The partner institutions provided, for the deployment, variously sized contingents of broadband stations with sensors of various corner periods (Fig. 2), which complemented the existing permanent stations and created a dense seismic array with an interstation distance of about 40 km (Fig. 1).

This paper describes the AdriaArray project in Romania, offering an overview of sites and seismic equipment, data requirements and management. We also assessed data quality, including near-real time data flow monitoring, availability analysis, ambient seismic noise characteristics, and evaluation of sensor orientation. The insights gained from this study support not only the general goals of the AdriaArray initiative but also provide valuable input for future research aimed at enhancing various seismic processing algorithms. These advancements will improve our understanding of seismic activity in Romania, as well as of lithospheric structure and tectonic evolution. At the same time, the results will contribute to a better understanding of the geodynamic context of the greater Adriatic region, complementing the project's objective to promote seismic research and hazard assessment on a continental scale.

2. Seismic network requirements and data management

The AdriaArray Seismic Network provides dense and uniform coverage of the Adriatic plate. As part of this regional initiative, Romania hosts 44 three-component broadband stations (Fig. 2), operated by five organizations (Table 1), which are continuously recording ground motion. NIEP, in cooperation with the organizations providing the temporary stations, ensures the optimal operation of the stations and the reliable transfer of data to the EIDA node in Măgurele. The site selection and installation of the temporary stations were carried out to ensure the safety of the seismic equipment and a stable power supply from the commercial line. We also kept the installation costs of the temporary stations as low as possible, since institutional resources were limited and no European funding was available. Therefore, the stations were deployed in free-field environments, inside former school buildings, unused basements, sheds or sometimes public utility buildings.

Considering that temporary stations in Romania were deployed both indoors and outdoors, the installation process for different stations varied and was, in some cases, challenging. This was particularly true for the stations placed in free-field environments, which required additional groundwork, such as the construction of concrete bases for the sensors and the installation of protective enclosures for seismic equipment. Thermal insulation of seismic sensors also required different strategies. Figures 3 and 4 depict the main components of a seismic station and typical configurations for indoor and outdoor installations, highlighting the communication systems and thermal insulation measures used to minimize long-period noise and environmental disturbances.

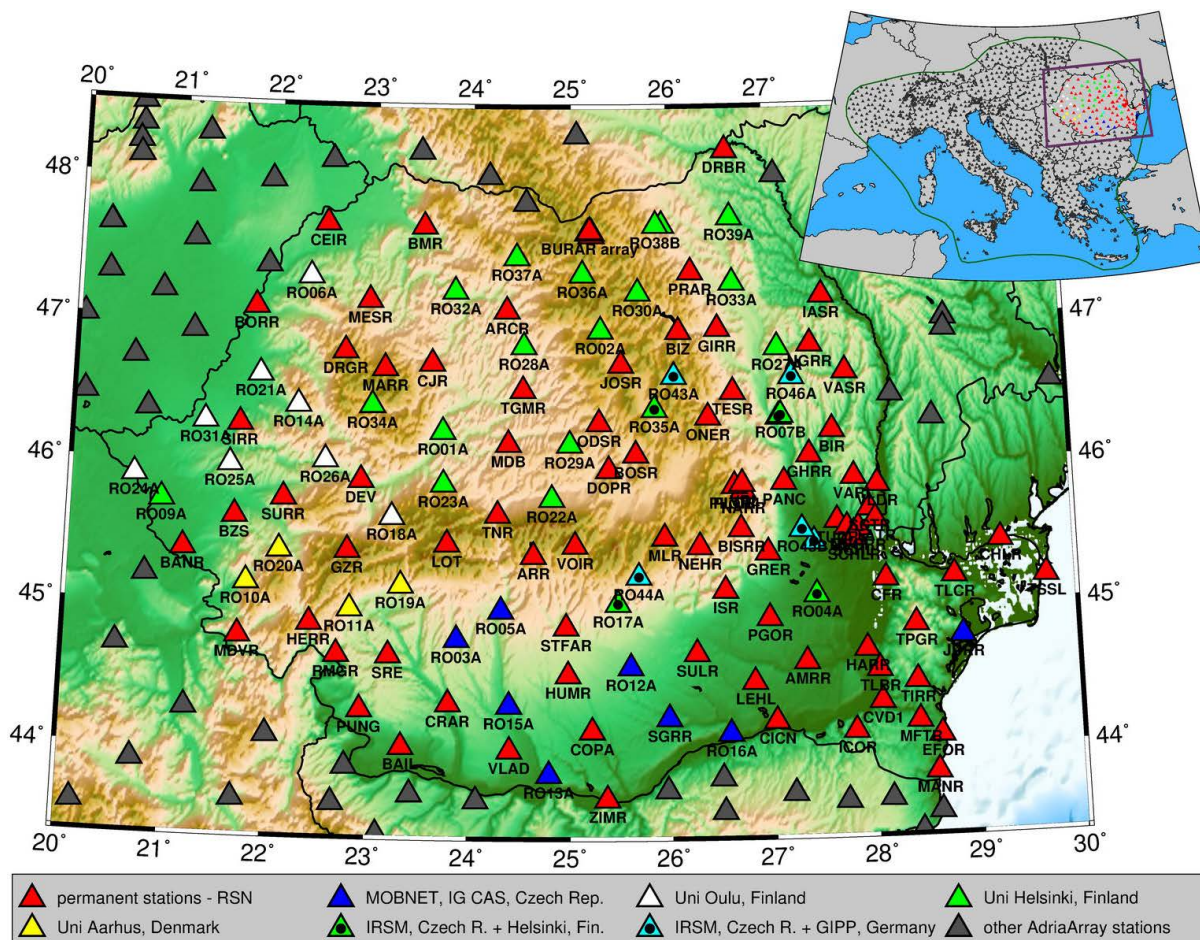


Figure 1. Permanent and temporary broadband stations of the AdriaArray Seismic Network installed throughout Romania. The permanent stations of the RSN are depicted by red triangles. Other colors indicate the temporary stations belonging to different institutions, as shown in the legend. Gray triangles represent the stations of the AdriaArray Seismic Network deployed in the surrounding countries. The inset shows the seismic station coverage in the Adriatic region and adjacent areas. The magenta polygon indicates Romania, and the AdriaArray region is delineated by the green curve.

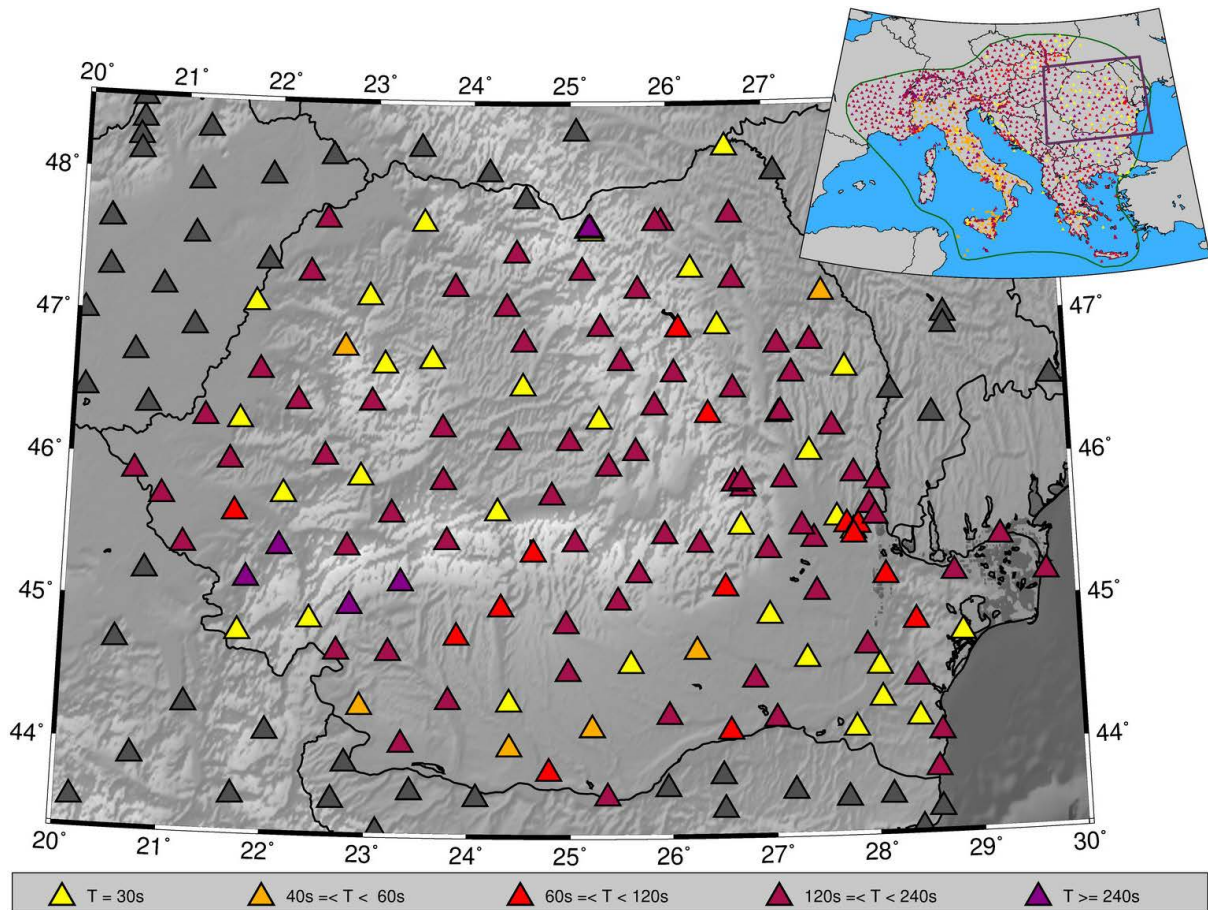


Figure 2. Distribution of permanent and temporary seismic stations across Romania, color-coded by sensor corner period: yellow (30 s), orange (40-60 s), red (60-120 s), carmine red (120-240 s), and violet (>240 s). Gray triangles represent AdriaArray stations deployed in the surrounding countries. The inset shows the seismic station coverage in the Adriatic region and adjacent areas, keeping the same color-coding. The magenta polygon indicates Romania, and the AdriaArray region is delineated by the green contour.

To be included within the AdriaArray Seismic Network, each station must be equipped with three-component sensors and have a corner period of at least 30 seconds (Fig. 2). Data should be recorded at a minimum sampling rate of 100 sps and streamed to EIDA in miniSEED format, preferably in near-real time.

The temporary stations deployed in Romania at new locations have been assigned five-character codes. The first two characters represent the country code (RO), followed by a two-digit number (e.g., 07) and a version identifier (e.g., A/B). The letter “A” indicates the station’s initial location, while “B” denotes a station relocated more than 10 m away. For instance, the station RO07A was relocated a few kilometers away and renamed RO07B. If a sensor is moved a short distance (<10 m), only the channel location code is changed (e.g., from 00 to 01) while the station name remains unchanged. Temporary stations co-located with short-period stations operated by the RSN retained their original station names, with only the network code updated to Y8. This was the case for two stations, JURR and SGRR (more details are given in Section 4 and Kolínský et al., 2025a).

AdriaArray promotes data sharing, making all collected data accessible via EIDA. Permanent station data recorded by the RSN and its metadata are open access, while temporary station data in Romania are under a two-year rolling embargo, except for the participants from member institutions, who have immediate access.

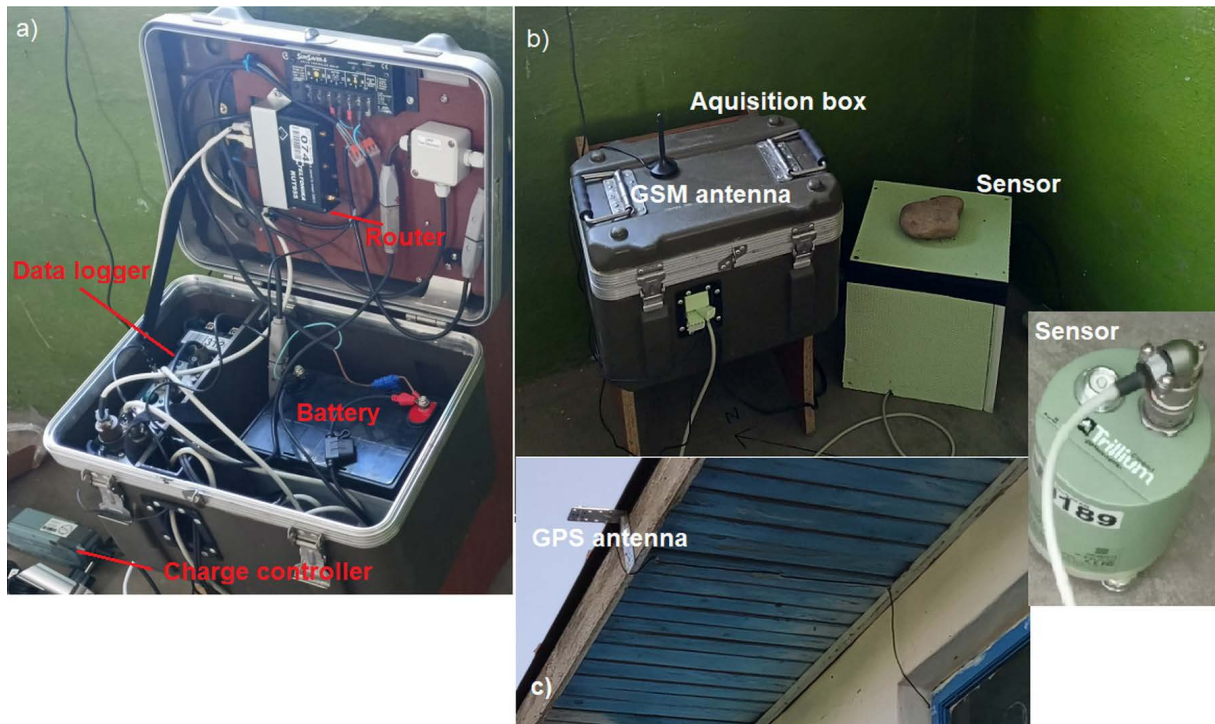


Figure 3. Typical indoor temporary station configuration (RO46A) in Romania: (a) acquisition box and main components (data logger, router, battery, and charge controller); (b) layout of the seismic equipment, thermal insulation, and sensor model; (c) location of the GPS antenna.



Figure 4. Location of the RO16A temporary station in the yard of the local museum in Chirnogi, with an overview of the surrounding area. The plastic enclosure (non-isolated/isolated), isolated broadband seismometer, data acquisition system GAIA, and communication system are shown.

3. Enhancing Seismic Monitoring in Romania

Romania is located at the western edge of the East European Platform, a region shaped by a complex geological history involving passive margin collision, volcanism, and significant deformation driven by the advance of the Adriatic Plate toward Eurasia. This movement closed several Tethys oceanic basins and resulted in the accretion of micro-continental blocks into the Carpathian embayment during the Miocene, forming the Carpathian Orogen, which is part of the larger Alpine-Himalayan orogenic chain (Maţenco et al., 2010; Schmid et al., 2020). These processes also contributed to the formation of the Pannonian Basin through extensional forces, while the Moesian Platform acted as a stable cratonic block (Georgieva, 2015; Vinnik et al., 2021), influencing deformation patterns along the Southern Carpathians (Fig. 5).

Romania's seismic activity is driven by a complex interplay of tectonic forces at the convergence of major lithospheric structures. The most significant source of seismicity is the Vrancea Seismic Zone (Fig. 5), an intraplate seismic region, producing large intermediate depth earthquakes ($M > 7.0$) in a confined volume ($70 \times 20 \times 220$ km) beneath the Eastern Carpathian Arc due to the descent of a dense lithospheric slab into the asthenosphere (Radulian et al., 2023; Petrescu and Enescu, 2025). These earthquakes pose the highest seismic hazard in Romania, with widespread effects that increase seismic risk, particularly in developing Eastern European countries (Fig. 6). Crustal seismicity within and adjacent to the Vrancea region is distinct from the subcrustal seismicity, showing a more scattered distribution and lower intensity (Bala et al., 2015; Petrescu et al., 2021; Radulian et al., 2023; Ghita et al., 2025). The presumptive link between crustal and intermediate-depth seismicity in the Vrancea region remains debated, as underlined by previous research (Müller et al., 2010; Mitrofan et al., 2014). Crustal seismicity extends beyond

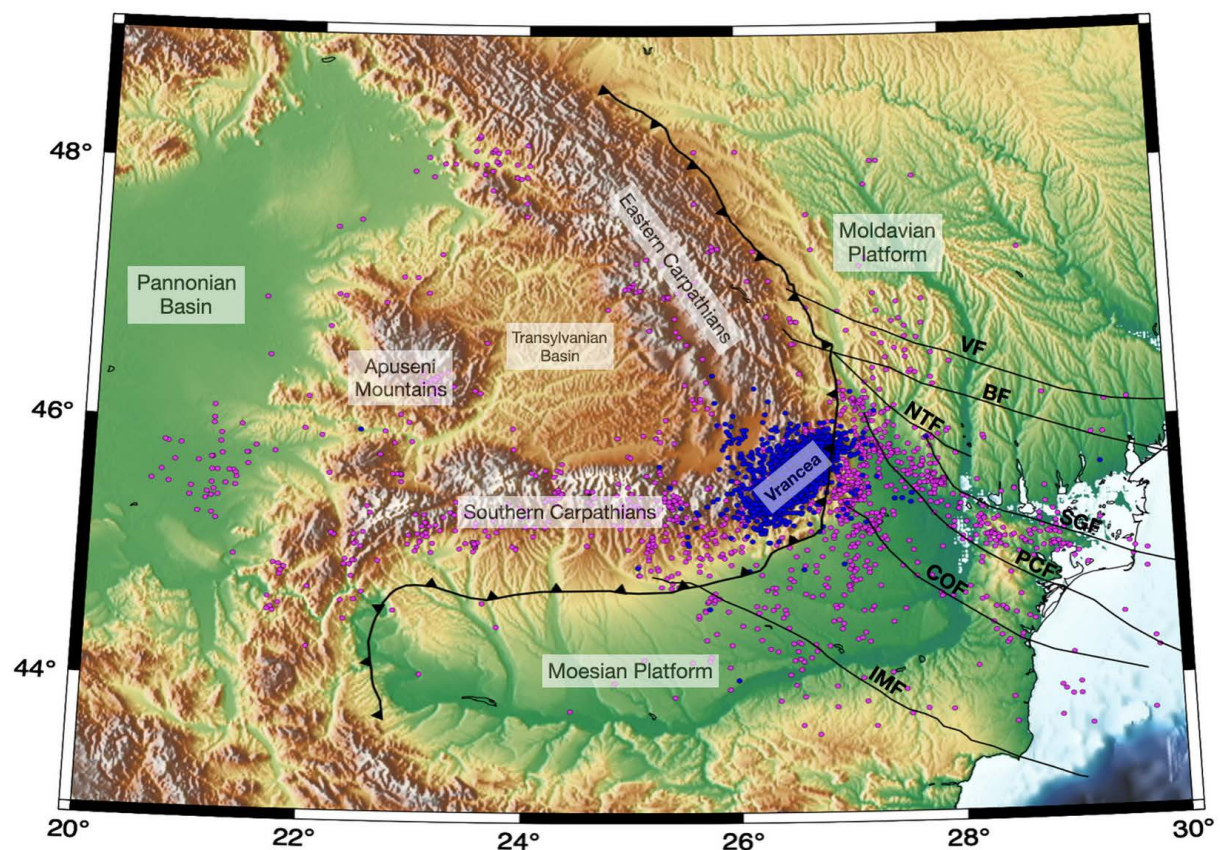


Figure 5. Seismotectonic map of Romania, a key region for studying the structure and geodynamics of the continued collision and deformation caused by the convergence of Adria towards Eurasia. Epicenters of earthquakes with magnitudes $M_w > 2.5$ are plotted with colored circles (blue for mantle earthquakes with depths below 50 km and magenta for crustal earthquakes with depths above 50 km). Major fault boundaries are abbreviated as follows: IMF – Intramoesian Fault, COF – Capidava-Ovidiu Fault, PCF – Peceneaga Camena Fault, SGF – Sfântul Gheorghe Fault, NTF – New Trotuş Fault, BF – Bârlad Fault, VF – Vaslui Fault.

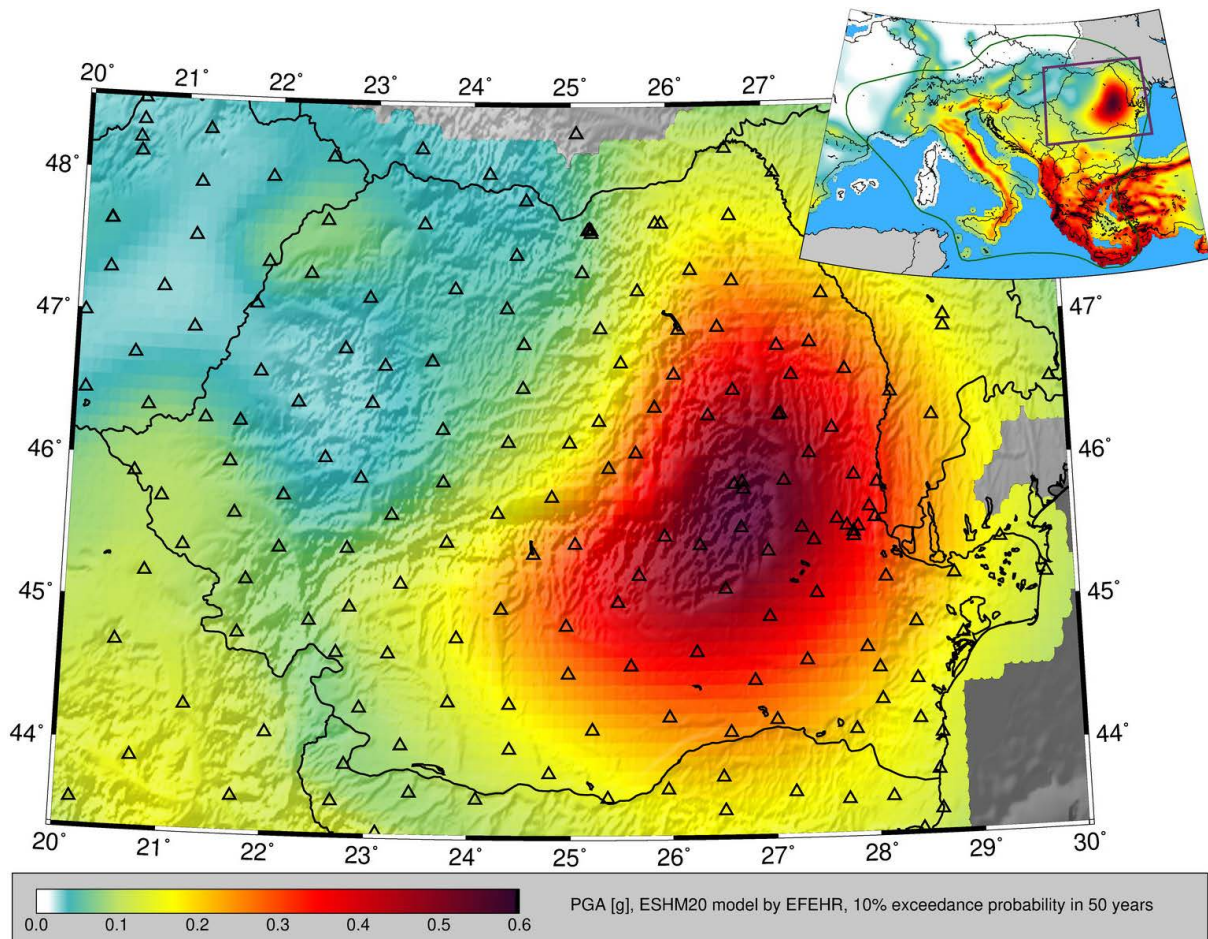


Figure 6. Map displaying the seismic hazard of Romania derived from the European Seismic Hazard Model (ESHM20), provided by the European Facilities for Earthquake Hazard and Risk (Danciu et al., 2021).

the Vrancea region to the Carpathian foredeep and western Romania, where notable seismic activity occurs (Bala et al., 2015; Oros et al., 2022; Ghita et al., 2025). One of the major challenges in understanding crustal seismicity (Fig. 5) is the presence of thick Neogene and Quaternary sedimentary layers that cover much of the country. These layers make it difficult to identify active faults and determine their kinematics.

The AdriaArray initiative has significantly strengthened seismic monitoring capabilities in Romania and across Eastern Europe, increasing station coverage and improving the accuracy of seismic event detection. This expansion has increased our ability to detect a wider range of seismic events (Figs. 7 and 8) as well as the accuracy with which source parameters are estimated for both shallow and intermediate-depth events. This represents a first step toward gaining a better knowledge of regional seismic activity. In addition, the high-quality data recorded by AdriaArray will enhance our understanding of geodynamic processes and lithosphere structure. Beyond local and regional monitoring, this unprecedented coverage with seismic stations improved detection capabilities at teleseismic distances, enhancing the location accuracy of seismic events and distinguishing between natural tectonic events and those with anthropogenic origins. These advancements are crucial for refining seismic hazard models, improving risk reduction strategies, and supporting long-term earthquake preparedness efforts in Romania and neighboring Eastern European countries.

To emphasize the quality of the recordings of both AdriaArray temporary stations and the permanent broadband stations operating in Romania, we present vertical component (HHZ) seismograms of the intermediate-depth earthquake that occurred in the Vrancea region on September 16, 2024, at 14:40 UTC (Fig. 7). The recordings show clear P- and S-wave arrivals at the stations distributed at local distances relative to the earthquake epicenter ($\Delta < 4^\circ$). Seismograms from a distant earthquake that occurred in Taiwan on April 2, 2025, at 23:58 UTC are displayed in Fig. 8. The vertical component recordings (HHZ) of AdriaArray temporary and permanent broadband stations clearly show the arrivals of P- and S-waves, followed by high-amplitude surface waves with distinct dispersion characteristics.

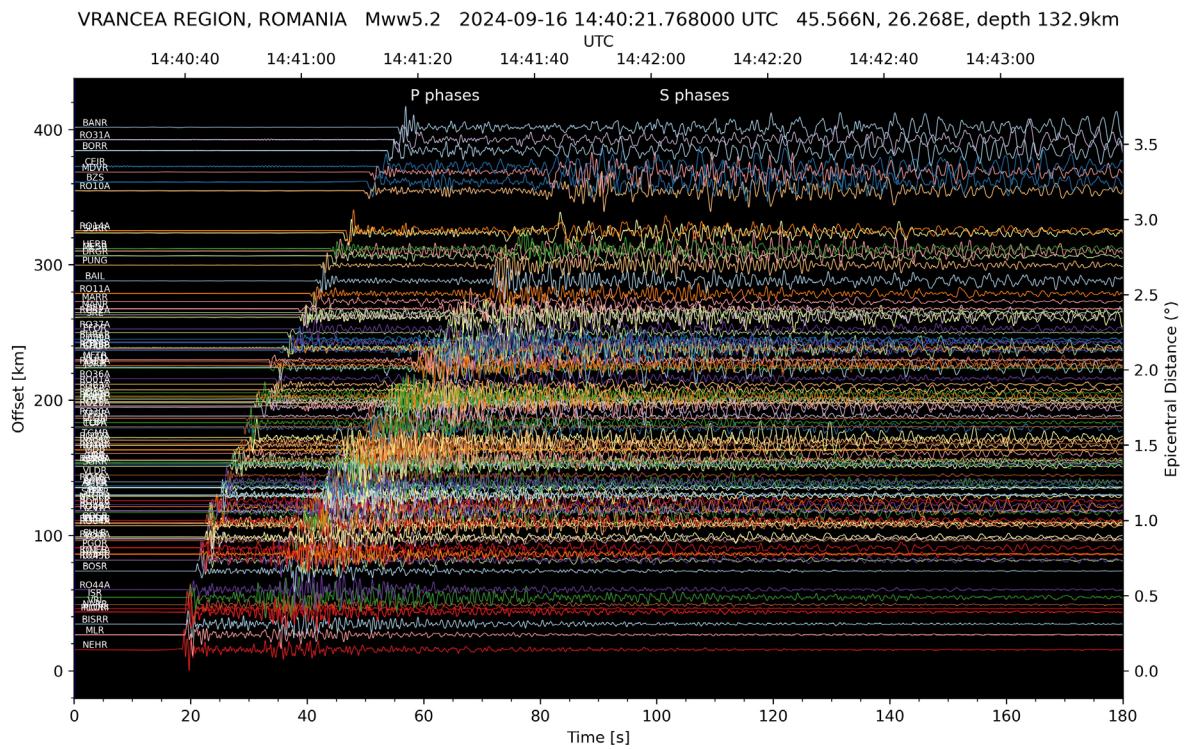


Figure 7. Example of seismograms bandpass filtered between 0.05 and 2 Hz (0.5-20 s) generated by a local subcrustal event from the Vrancea region (16.09.2024, 14:40 UTC; $H = 133$ km; $M_{ww} = 5.2$, after U.S. Geological Survey), recorded on the vertical components (HHZ) of permanent and AdriaArray temporary stations in Romania. Recordings are normalized on the traces maxima.

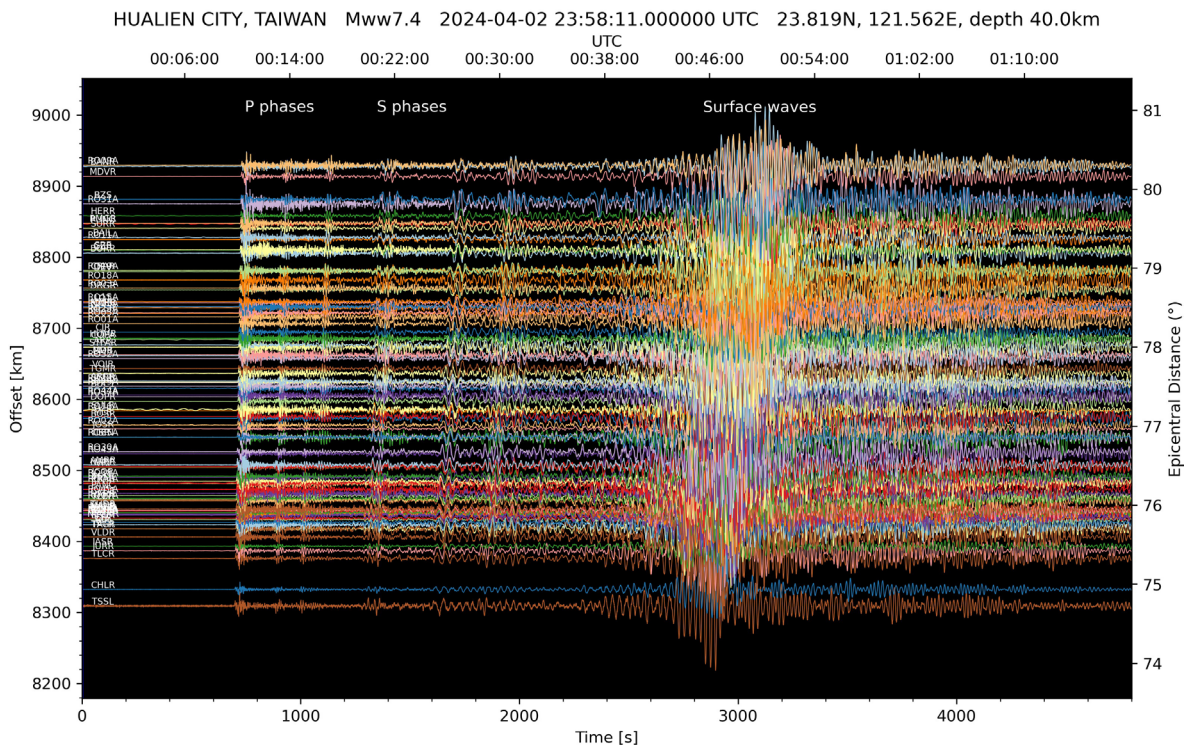


Figure 8. Example of seismograms bandpass filtered between 0.0125 and 1 Hz (1-80 s) generated by a distant earthquake in Taiwan (02.04.2024, 23:58 UTC; $H = 40$ km; $M_{ww} = 7.4$, after U.S. Geological Survey), recorded on the vertical components (HHZ) of permanent and AdriaArray temporary stations in Romania. Recordings are normalized on the traces maxima.

4. Temporary station characteristics

The site selection and installation process followed an economical procedure while ensuring the safety of the seismic equipment. All stations are powered by the commercial power line, and 43 of the 44 stations are sending data in near-real time. The contributions of each organization to station installation, maintenance, and data transmission are described below. Table 1, presented at the end of the paper, provides a concise overview of the sites and the seismic equipment.

The Institute of Geophysics of the Czech Academy of Sciences (IG CAS) actively participates in the AdriaArray project with 52 broadband stations from the MOBNET pool (Plomerová, 2025). These stations are deployed across several European countries, with 34 located in Czechia and Slovakia (Vecsey et al., 2025), eight in Romania, and 10 in Bulgaria (Kampfová Exnerová et al., 2025). Stations in Romania were deployed between 6th and 17th June 2022, during the first campaign for station deployment within the AdriaArray project. The stations are distributed in the southern part of Romania, from the Olt River valley toward the Black Sea coast (Fig. 1). Six sites are new, selected to meet the geometry of the AdriaArray network (Kolínský et al., 2025a). The remaining two stations, Singureni (SGRR) and Jurilovca (JURR), are co-located with the short-period stations of the RSN.

Besides the broadband sensors (Table 1) and data acquisition devices, the seismic equipment contains three modems, antennas, a battery, and a charger. The modems serve different functions: one for near-real time data transmission, one for remote control, and one for sending SMS reports on station status. The first two also ensure remote access to the stations in case of emergencies. Additionally, each station includes an antenna for GPS time synchronization. At each station, the power system is backed up by a 12 V/24 Ah battery and an ADS13.8 charge controller to ensure continuous operation.

Online data are sent via SeedLink to the IG CAS, and after name adjustment, they are forwarded to the NIEP EIDA node in Măgurele, Ilfov, Romania. All data are stored locally on two 16 GB SD cards at each station to prevent loss and ensure backup availability.

During installation, the sensors were covered by Styrofoam boxes for thermal insulation. During the station maintenance in May 2023, the insulation was enhanced by adding an extra layer (Fig. 4). At all stations, a 25 mm thick mineral wool insulating sleeve with an outer layer of durable aluminum laminate was placed beneath the Styrofoam box. Stations RO03A and RO16A (Fig. 4) are installed in a free-field environment in a protective plastic enclosure, and therefore, the enclosure was thermally isolated with 6 mm thick synthetic rubber adhesive insulation with aluminum foil on the surface. Using the results from seismic noise analysis (see Section 6), the IG CAS team continued to implement various sensor isolation procedures to minimize the seismic noise. At RO03A, RO16A, and JURR stations, the Styrofoam box was replaced entirely with an additional layer of insulating sleeve in October 2023. At station RO12A, the box was removed, and a single layer of insulating sleeve was kept. At station RO05A, the outer aluminum layer of the sleeve was removed, and a Styrofoam box was kept.

The IG CAS team maintains and retrieves offline data twice a year. The first yearly maintenance, in May, includes all stations, and the second maintenance, usually in October, only those requiring an on-site technical intervention that cannot be handled remotely. In addition, the NIEP team helped to solve technical issues whenever they occurred. Routine maintenance includes centering the seismometer pendulums, verifying sensor leveling, calibrating both sensors and digitizers, and rechecking sensor orientation using a fiber-optic gyrocompass. In addition, all cables, antennas, and insulation of the seismometer are examined.

The offline data gathered during maintenance are validated at IG CAS for quality, potential time errors, and gain imperfections, which are subsequently corrected (Vecsey et al., 2017; Kolínský et al., 2025b). In case of data gaps on SD cards, the online data initially transmitted from the stations is checked for availability. Data from SD cards are then filled with online data. Finally, with about a one-year delay, the complete set of the corrected and cleaned data replaces the online data initially sent to the EIDA node. This procedure provides immediate access to the data and a complete, high-quality dataset.

The Institute of Rock Structure and Mechanics of the Czech Academy of Sciences (IRSM CAS) has deployed eight broadband stations in Romania as a contribution to the AdriaArray initiative. Four of them are provided by the University of Helsinki (UH) pool through the mobile Finnish Seismic Instrument Pool FINNSIP, and the other four are provided by the Geophysical Instrument Pool Potsdam (GIPP), which is part of the GFZ Helmholtz Centre for Geosciences. During installation, the sensors were thermally insulated with Styrofoam boxes and the sensor orientation was measured using an optical gyrocompass for stations: RO07B, RO35A, RO43A, RO44A, RO45A, RO45B and RO46A. All data are transmitted online through Teltonika GPRS units by SeedLink to the NIEP EIDA node.

Data recorded by UH stations are saved locally on 128 GB SD cards for backup, whereas data recorded by GIPP stations are saved on 32 GB SD cards. The power system is backed up at each station by a 12 V/24 Ah battery, a 7A CTEK MXS 5.0 charge controller (RO04A, RO17A, RO35A), a 4A Mascot 2140 charge controller (RO07A, RO07B) and a 5A Voltcraft Iceman 5R charge controller (RO43A, RO44A, RO45A, RO45B, RO46A) to ensure continuous operation.

The NIEP and IRSM CAS teams conduct station maintenance once a year, and the NIEP team makes special visits to the stations if there are any technical concerns. During routine maintenance visits, the seismometer pendulums are centered, local data are copied to external hard drives, the sensor and digitizer are verified, and the sensor orientation is checked. In addition, all wires, antennas, and seismometer insulation are examined.

The University of Helsinki pool comprises 16 broadband stations from the mobile Finnish Seismic Instrument Pool FINNSIP (Courbis et al., 2024). During installation, the sensors were thermally insulated using Styrofoam boxes. Except for station RO32A (which has a Huawei GPRS unit), all data are transmitted online using Teltonika GPRS devices. The data are sent to the NIEP EIDA node via SeedLink and backed up on a 128 GB SD card available at each station. The power system is backed up by a 12 V/24 Ah battery, a 4A Mascot 2140 charge controller (RO02A, RO09A, RO22A, RO23A, RO27A, RO28A, RO29A, RO30A, RO33A, RO36A, RO37A, RO38A, RO39A) and a 7A CTEK charge controller (RO01A, RO02A and RO34A) to ensure continuous operation.

The Sodankylä Geophysical Observatory at the University of Oulu (OU) pool comprises eight broadband stations, supported by a grant from the Väisälä Fund of the Finnish Academy of Science and Letters. During installation, sensors were thermally insulated with Styrofoam boxes. Except for RO21A, all stations transmit data online. Stations RO14A and RO26A send data via Digi GPRS units to the University of Vienna, from where it is routed to the NIEP EIDA node. The remaining stations transmit data online through Teltonika GPRS units via SeedLink to the same EIDA node. To prevent loss and ensure backup availability, data are saved locally at each station on SD cards of various sizes (between 512 MB and 64 GB). To ensure continuous operation, a 12 V/24 Ah battery and a 7A CTEK MXS 5.0 charge controller are installed at each station.

The Aarhus University (AU) pool deployed 19 broadband stations as part of AdriaArray: 15 in Bulgaria (Kampfová Exnerová et al., 2025) and four in Romania. All stations are equipped with the same sensor and digitizer, supported by the project “Tracking the ocean along the upper-lower-mantle boundary” by the Independent Research Fund Denmark. Sensors were thermally insulated with the original insulation hoods provided by Nanometrics. All data are transmitted online through Teltonika GPRS units using the SeedLink protocol to the NIEP EIDA node. At each station, data are also saved locally on 32 GB SD cards. The power system at each station is backed up by a 12 V/24 Ah battery, a 2 A Lan Power charge controller (RO10A, RO19A, RO20A), and a 7A CTEK MXS 5.0 charge controller (RO11A), to ensure continuous operation.

The NIEP team maintains the stations of the UH, OU, and AU pools once a year and makes special visits to the stations if any technical issues arise. During routine maintenance visits, the seismometer pendulums are centered, local data are saved on external hard drives, and the sensor and digitizer are verified. In addition, all wires, antennas, and seismometer insulation are inspected.

5. Near-Real Time Data Flow Monitoring and Availability Assessment

To ensure a quick reaction to any potential station failure, we continually monitor the data flow from all the temporary stations deployed across Romania. Based on a recent ObsPy module (Krischer et al., 2015), we automatically generate an HTML report page (Fig. 9), which is regularly updated, providing near-real time information about the state of health of each station. The HTML report page gives us key information like data latency, station availability, and the number of data gaps.

In Fig. 9, each station is represented by a line, with the color indicating the status of the station. The green line indicates that the station is operational and has passed all diagnostic checks without errors. If the data latency exceeds one hour, the line turns yellow; if the delay reaches a day, the line turns red. If a station has less than 99.5% data availability or more than 20 data gaps in the previous seven days, the line is highlighted in dark blue, indicating a serious problem with data quality. Finally, dark gray lines mark stations for which data has been missing for more than 30 days.

Figure 10 highlights data availability from June 2022 to November 2024, derived from the vertical component recordings of temporary stations deployed across Romania within AdriaArray. The figure includes only stations with

**SDS Report for mseed/
Latency data percentage, number of
gaps/overlaps (last 7 days) Thu Nov
28 11:30:14 2024 UTC**

All checks pass				
Last 7 days: < 99.5% data or > 20 gaps				
Latency > 1h				
Latency > 1d				
No data within 30 days				
Y8 JURR	00	HHZ	1m	
Y8 R001A	00	HHZ	2m	
Y8 R002A	00	HHZ	1m	94.2%
Y8 R003A	00	HHZ	7m	
Y8 R004A	00	HHZ	2m	
Y8 R005A	00	HHZ	2m	
Y8 R006A		HHZ	3m	81.6% 989#
Y8 R007B	00	HHZ	2m	
Y8 R009A	00	HHZ	2m	
Y8 R010A	00	HHZ	8d 2h 56m	0.0%
Y8 R011A	00	HHZ	1m	
Y8 R012A	00	HHZ	3m	
Y8 R013A	00	HHZ	3m	
Y8 R014A	00	HHZ	2m	74.3% 52#
Y8 R015A	00	HHZ	2m	
Y8 R016A	00	HHZ	2m	
Y8 R017A	00	HHZ	2m	
Y8 R018A	00	HHZ		
Y8 R019A	00	HHZ	4m	
Y8 R022A	00	HHZ		
Y8 R023A	00	HHZ	2m	
Y8 R024A		HHZ	4m	81.7% 989#
Y8 R025A		HHZ	1m	
Y8 R027A	00	HHZ		
Y8 R028A	00	HHZ	1m	
Y8 R029A	00	HHZ	2m	
Y8 R030A	00	HHZ	1m	
Y8 R031A	00	HHZ	3m	
Y8 R032A	00	HHZ	2m	
Y8 R034A	00	HHZ	1m	
Y8 R035A	00	HHZ	1m	14.9%
Y8 R036A	00	HHZ		
Y8 R037A	00	HHZ	1m	
Y8 R038B	00	HHZ	1m	
Y8 R039A	00	HHZ	3m	
Y8 R043A		HHZ	1m	
Y8 R044A		HHZ	2m	
Y8 R045B		HHZ	2m	
Y8 R046A		HHZ	1m	
Y8 SGRR	00	HHZ	1d 8h 51m	80.7%
Y8 R020A	00	HHZ	30+d	Y8 R026A 00 HHZ 30+d
Y8 R033A	00	HHZ	30+d	

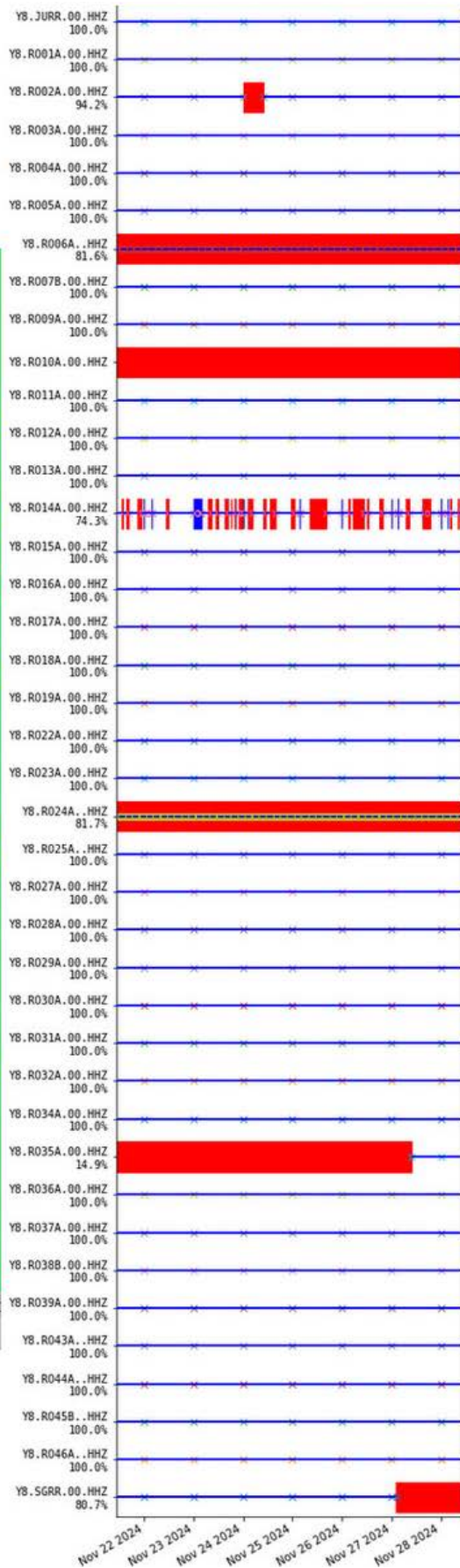


Figure 9. Screenshot of the near-real time data quality report (28 November 2024) for AdriaArray temporary stations deployed in Romania, generated using the ObsPy SDS HTML Report module (Krischer et al., 2015).

data availability of at least 90%. The plot was obtained using the ObsPy scan module (Krischer et al., 2015). Complete data were only available for the stations operated by IG CAS (RO03A, RO05A, RO12A, RO13A, RO15A, RO16A, JURR, and SGRR). The IG CAS team filled data gaps from near-real time transmission with locally recorded data from memory cards at the seismic stations. For the other stations, only the near-real time data archived in the EIDA node was available. As a next step, for the remaining stations, the locally recorded data from memory cards will be added to the EIDA server, ensuring a more accurate image of data availability.

Figures 9 and 10 highlight the overall reliable performance of the seismic stations over different time periods. It is worth noting that more than half of the temporary stations maintained data archiving rates above 90%.

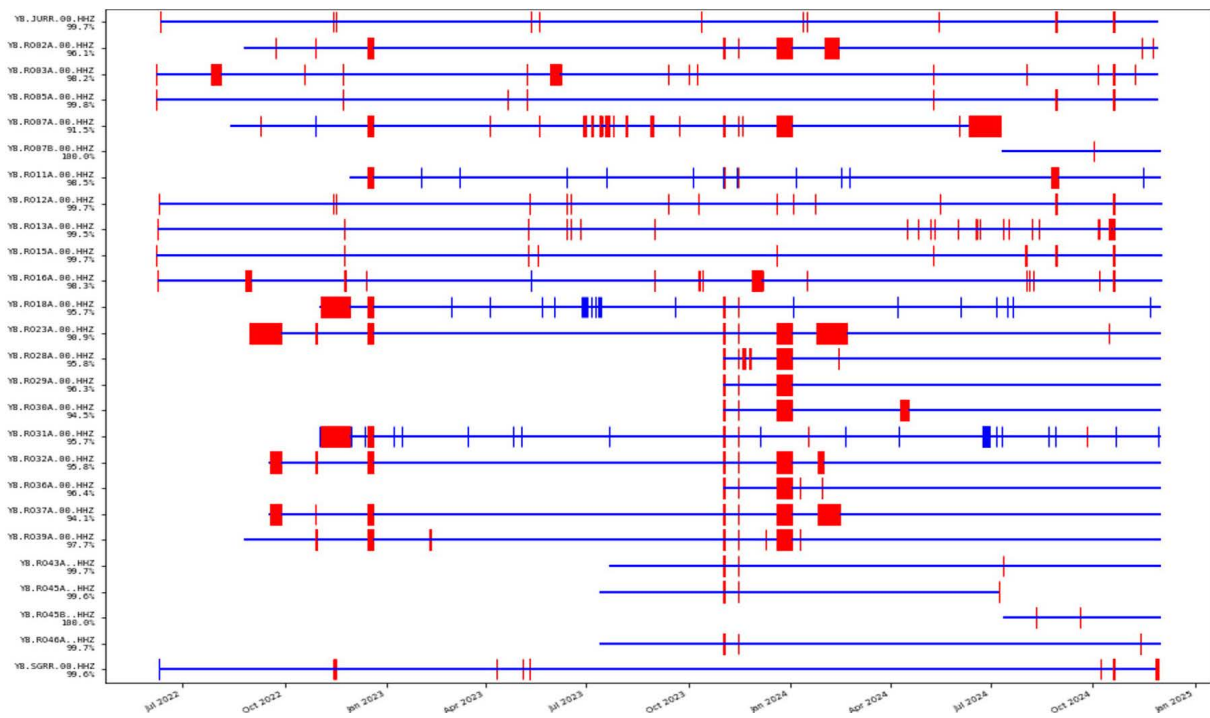


Figure 10. Data availability between June 2022 and November 2024 for vertical components (HHZ) of the temporary stations installed in Romania within the AdriaArray. Only stations with a data availability of at least 90% are included. Blue horizontal bars represent available data, while the red lines/bars indicate data gaps. In white are shown intervals before the start time or after station closing (see the stations RO07B and RO45B with the start time in 2024 or closed stations RO07A and RO45A).

The data show gaps of varied lengths, spanning from a few seconds to several weeks, caused by a combination of operational and technical factors. The stations deployed by IG CAS, where locally recorded data were used to fill data transmitted in near-real time have the highest data availability (above 99%), with only short gaps spanning from seconds to minutes. These short interruptions are primarily caused by routine maintenance activities or transient power outages. In contrast, for stations where locally recorded data has not yet been completed, data gaps can span several weeks. These longer gaps may result from a variety of factors, including power outages, failures in real-time data transmission (e.g., due to communication network issues), or malfunctions of seismic equipment.

6. Seismic Noise Analysis

The ambient seismic noise recorded by temporary broadband seismic stations installed throughout Romania within the AdriaArray initiative was investigated using power spectral density (PSD) estimates and probability density functions (PDFs). The methodology follows the research proposed by McNamara and Buland (2004) as a tool for monitoring seismic station performance and helping network operators as well. To investigate ambient seismic noise, we began with the daily raw waveform recordings, which were first corrected for instrument response

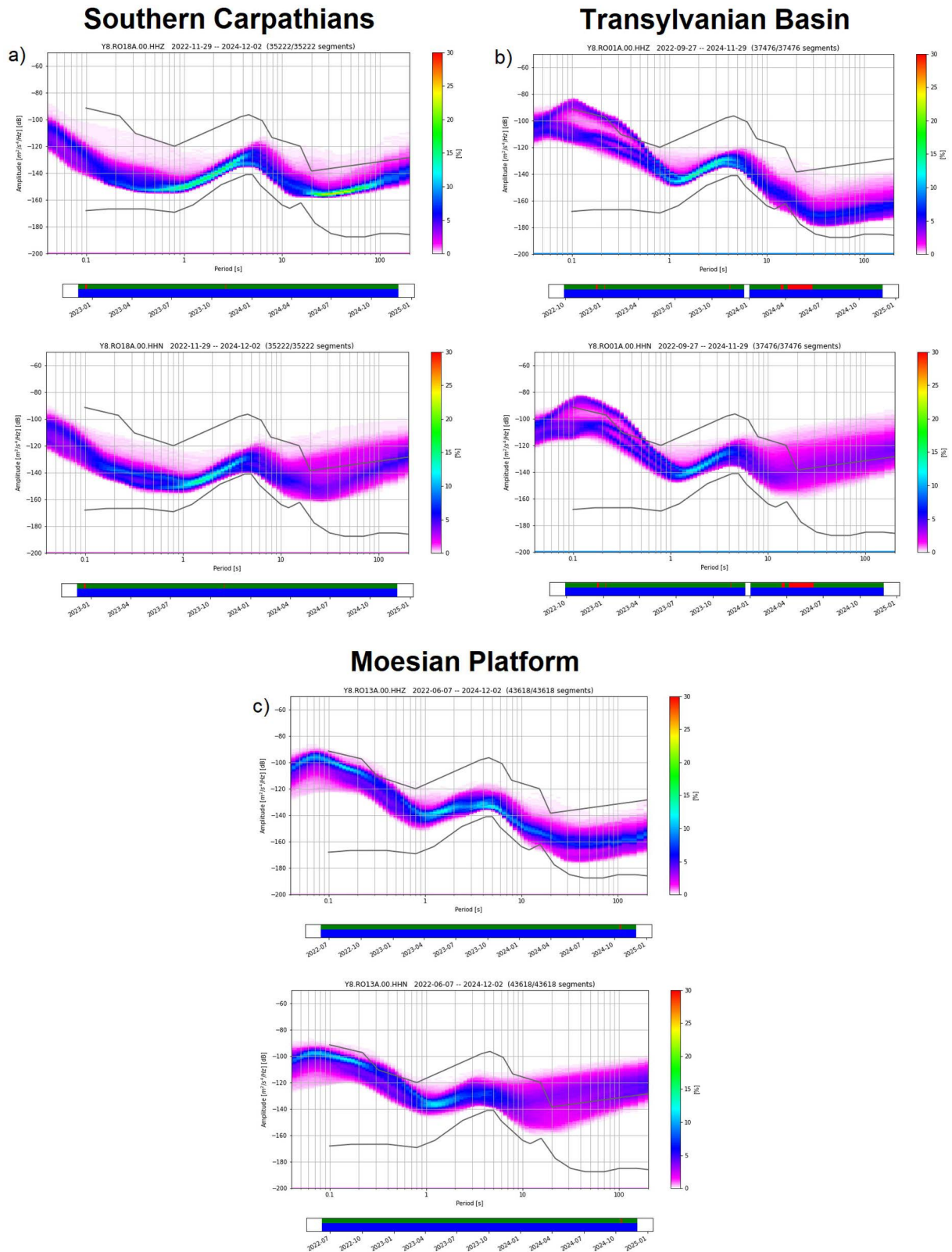


Figure 11. Examples of PDFs derived from recordings of vertical (top) and N-S components (bottom) of stations located in distinct geological environments: (a) station RO18A (Trillium Compact, 120 s) installed in the Carpathian Orogen; (b) station RO01A (CMG-3ESP, 120 s) installed in the Transylvanian Basin and (c) station RO13A (CMG-3ESPC, 60 s) installed in the Moesian Platform. Solid lines mark the N-HM and N-LM noise models (Peterson, 1993). The time interval selected for the analysis is given above each panel.

to remove the influence of different sensor characteristics. The corrected signals were then divided into 60-minute time windows with 50% overlap to reduce variance in the PSD computation (Cooley and Tukey, 1965). Fast Fourier Transform (FFT) was applied to each window to estimate the PSD, expressed in decibels (dB) relative to acceleration $(\text{m/s}^2)^2/\text{Hz}$. To derive the PDF, a frequency distribution from the individual PSDs was first produced by binning periods into 0.125-octave intervals and power values into 1 dB bins. Finally, the raw frequency bins were normalized using the total number of PSDs. The spectral estimates are displayed together with Peterson’s (1993) New Low Noise Model (NLNM) and New High Noise Model (NHNM), which serve as global reference standards.

This type of analysis has become a standard procedure for analyzing station performance, finding operational artifacts, detecting transient cultural noise, and evaluating the overall quality of seismic data. To ensure an exhaustive investigation of seismic noise characteristics, we relied on the Probabilistic Power Spectral Densities (PPSD) module from ObsPy (Krischer et al., 2015) to analyze the recordings from each temporary seismic station installed across

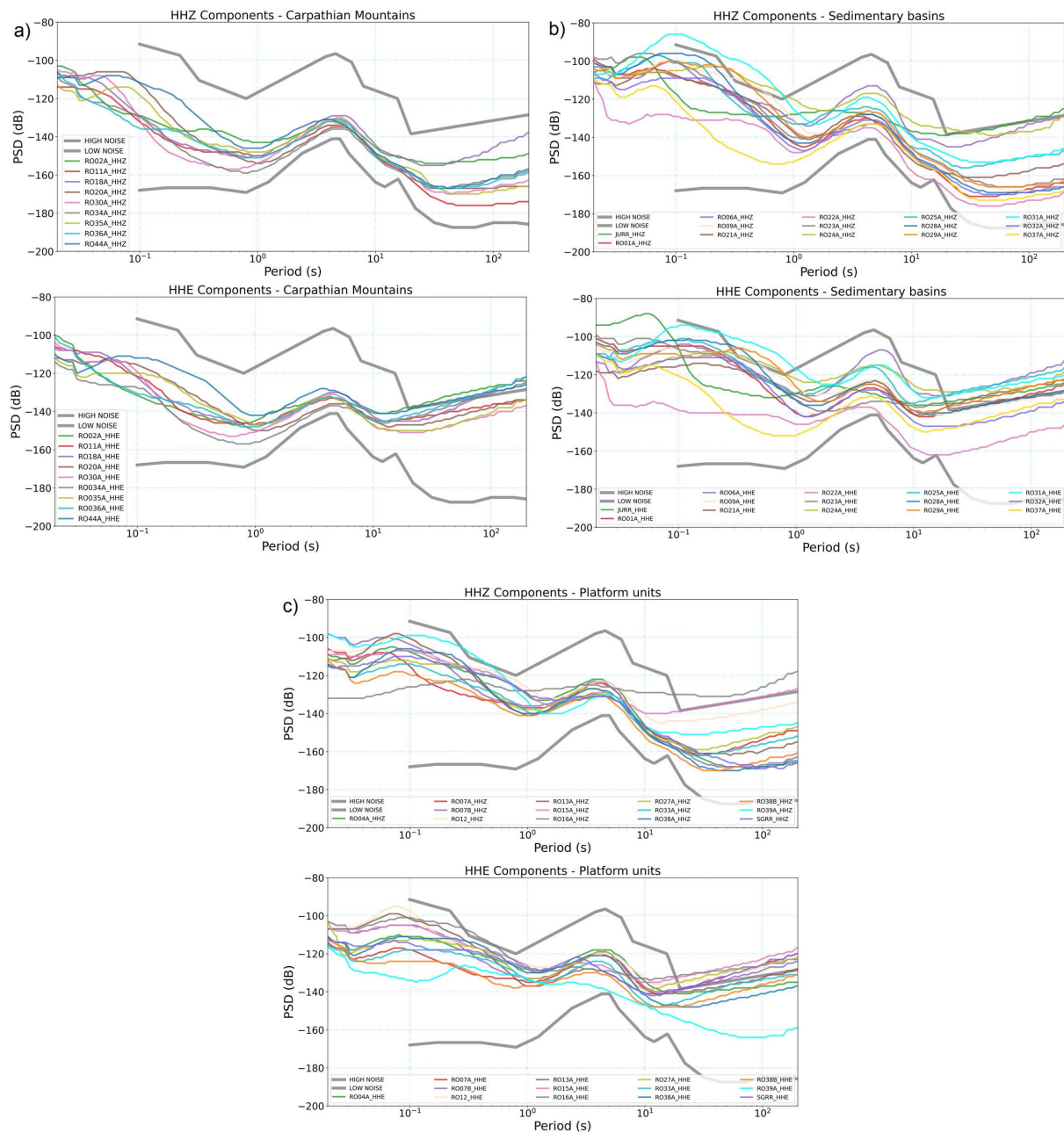


Figure 12. Median Power Spectral Density curves derived from recordings of vertical components (top) and East-West (E-W) components (bottom) of temporary AdriaArray stations located throughout Romania, across different geological environments: (a) Carpathian Mountains; (b) sedimentary basins; and (c) Moesian and Moldavian platforms. Each curve represents data from an individual station. The gray lines indicate the NHNM and NLNM models.

Romania. Previous studies (Molinari et al., 2016; Fuchs et al., 2016; Grecu et al., 2018; Bociarska et al., 2021) have shown that the shape of the PDF is significantly influenced by several factors, including sensor sensitivity, instrument response, and sensor noise level. Additionally, the installation environment plays a crucial role, as local topography and subsurface conditions directly impact the characteristics of the ambient seismic noise recorded at a station.

Our results are consistent with previous studies, confirming that the installation environment influences the characteristics of ambient seismic noise. Figure 11 shows PDF plots for stations located in sedimentary basins, mountainous regions, and platform areas to highlight these differences. In these plots, low-probability PSD values correspond to transient signals as earthquakes or calibration pulses, while the high-probability range reflects the background seismic noise level. Similar plots can be computed in near-real time and for custom time periods for both temporary and permanent RSN stations using the SeedPSD algorithm developed by the EPOS-France seismological data center (Résif-DC). This algorithm is implemented and continuously updated at NIEP and is accessible at <https://seedpsd.infp.ro>.

To better assess the variations in noise levels and station performance across the temporary seismic network deployed within AdriaArray, we computed the median PSD from the PDFs for each component. The resulting Median Power Spectral Density curves are displayed in separate panels corresponding to the main geological features (Fig. 12), allowing for a clear comparison of noise conditions across different environments. Our analysis reveals that for about half of these stations, the Median Power Spectral Density curves computed for each component are distributed below the NHNM limit across all period ranges. This result indicates that these sites are well-suited for seismic monitoring purposes, providing high-quality data, although they were placed in different geological environments, and most of these stations were installed near populated areas, with only three of them (see Section 4 and Table 1) located in isolated areas. At the same time, our results reveal that the recordings of these stations can be successfully used in various research, ranging from the detection of microseismicity to in-depth studies of ambient noise.

7. Analyses of Sensor Orientation

The proper orientation of a seismometer is one of the most important steps in ensuring the accuracy and usefulness of seismic data. Sensors need to be oriented properly using high-precision tools such as optical gyroscopes. Even if the initial orientation was performed with such a device, it is important to ensure that the alignment remains unchanged during each maintenance visit. This certifies that the sensor was not misoriented during the recording period, eliminating any artifacts and ensuring high data quality. For several temporary stations (RO02A, RO03A, RO04A, RO05A, RO07B, RO12A, RO13A, RO15A, RO16A, RO17A, RO27A, RO35A, RO38B, RO43A, RO44A, RO45A, RO45B, RO46A, JURR, SGRR), particularly those deployed by the Czech Institutes (IG CAS and IRSM CAS), the sensor orientation was carried out with a high-accuracy fiber-optic gyrocompass and these were taken as a reference in the current analysis. For the remaining stations, sensor orientation was estimated using a magnetic compass without considering the magnetic declination. To obtain an image of the sensor orientation's accuracy, we proceeded by determining the sensor deviation from the north using a recent open-source package, OrientPy (Audet, 2020) that uses two different methods. The first algorithm, known as the BNG method, was proposed by Braunmiller, Nabelek, and Ghods (2020). Based on previous studies (Stachnik et al., 2012; Wang et al., 2016), it determines the direction of P-wave polarization from earthquakes at teleseismic distances by minimizing energy on the transverse component within a time window around the P-wave. The rotation that minimizes P-wave energy on the transverse component corresponds to the station-event backazimuth, which is determined empirically. The difference between the theoretical and empirical backazimuths provides the sensor orientation, with positive values indicating a clockwise misorientation. However, the accuracy of the results is influenced by the distribution of selected events depending on different factors such as backazimuth, epicentral distance, or magnitude. For this analysis, we selected earthquakes that occurred between 2022 and 2024, in a distance range between 30 and 175° and large magnitudes ($M > 6.0$). We filtered all waveforms using a bandpass filter between 0.04 and 0.1 Hz (10-25 s) to remove noise and retain the phase information. The values of the parameters considered to assess the average misorientation angle were estimated using several trial-and-error tests on the i) cross-correlation between vertical and radial components ($CC = 0.5$); ii) signal-to-noise ratio on vertical component ($SNR = 5\text{db}$); iii) inverse of transverse to radial ratio $(1 - T/R) > 0.49$; iv) radial to vertical ratio $(1 - R/Z) > -1$.

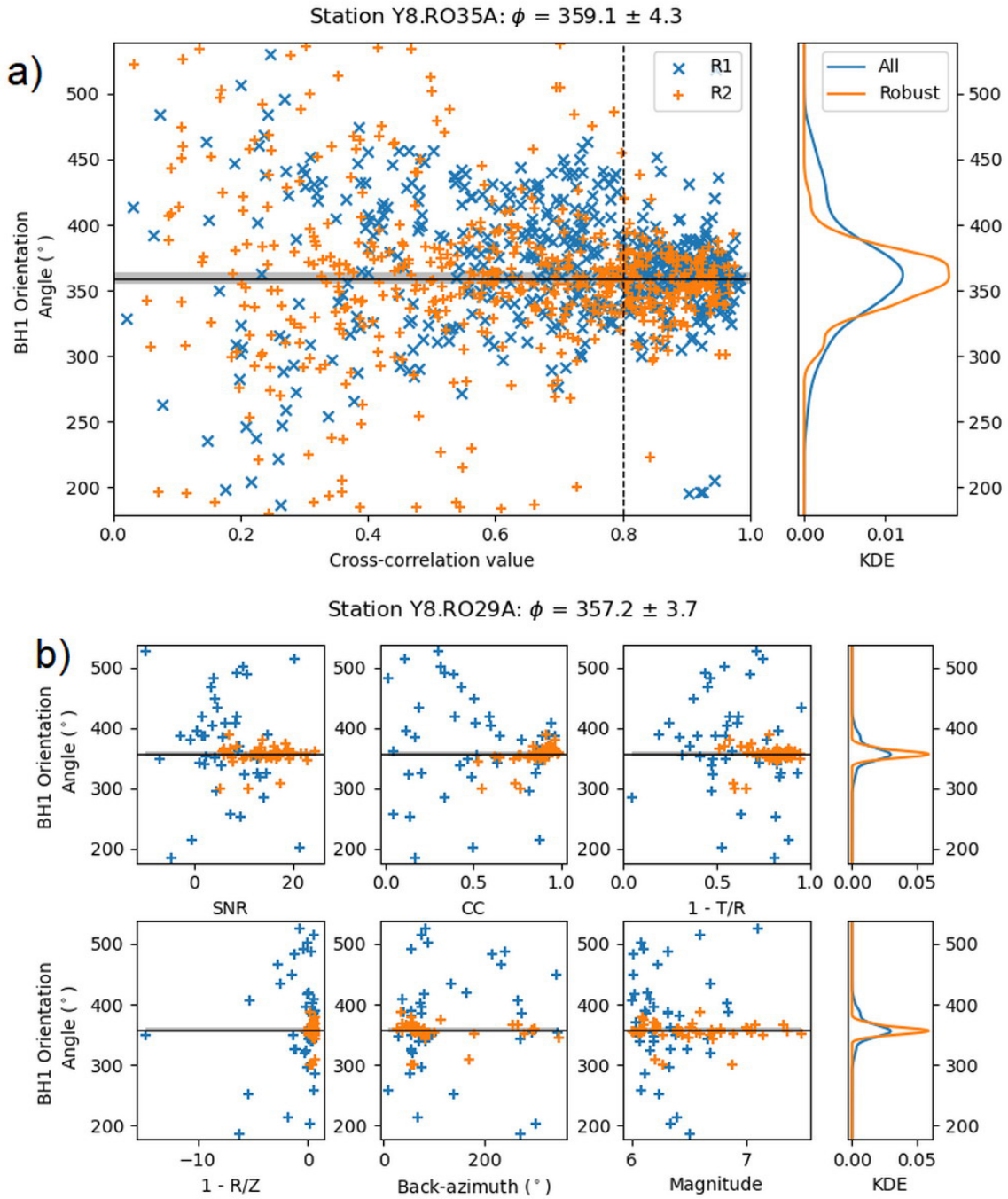


Figure 13. Results of the misorientation angles for (a) DL algorithm and RO35A recordings (2023-2024). The analysis includes estimates derived from all direct and complementary Rayleigh-wave arrivals (blue) and robust estimates (orange). A cross-correlation threshold of 0.8 (dashed vertical line) was used to identify reliable measurements. BH1 Orientation Angle indicates the angle (in degrees) of the horizontal component (BH1), relative to true North. The sensor’s final orientation is estimated at $359.1^\circ \pm 4.3^\circ$, indicated by the solid horizontal line and shaded confidence band. Smooth curves of orientation distributions are displayed using kernel density estimation (KDE) with a confidence interval of 95%; (b) BNG method and RO29A recordings (2023-2024). Each panel shows the variation of the orientation angle as a function of: signal-to-noise ratio (SNR), CC, the inverse of the transverse-to-radial amplitude ratio ($1 - T/R$), inverse of the radial-to-vertical amplitude ratio ($1 - R/Z$), backazimuth, and magnitude. Orange symbols display estimates that remained after applying selection criteria (robust estimates), while blue symbols represent all measurements. The solid horizontal line and shaded area indicate the final orientation angle estimate of $357.2^\circ \pm 3.7^\circ$ and its confidence interval. The KDE plots show the smoothed distribution of orientation angles for all and robust estimates with a confidence interval of 95%.

The second approach, proposed by Doran and Laske (2017), known as DL or DLOPy (Doran-Laske-Orientat-ion-Python), is based on measuring Rayleigh-wave polarization at a number of periods and for the direct and complementary globe-encircling path. They assume that an isolated Rayleigh wave in a three-component seismogram, when rotated into a ray-based coordinate system, only appears on the radial component and not on the transverse. The radial component is further correlated with the Hilbert-transformed vertical component. Using a grid search, they rotate the horizontal components by an angle α (ranging from 0° to 360° in 0.25° intervals) and look for the α that maximizes the cross-correlation between the Hilbert-transformed vertical component and the radial component. After adjusting for the source-receiver backazimuth, this angle is considered the measured arrival angle. For this method, we selected data from earthquakes that occurred between 2022 and 2024, with distances ranging from 6° to 174° , depths up to 150 km, and large magnitudes ($M > 6.0$). The cross-correlation threshold for computing the average misorientation angle was chosen at 0.8 based on multiple trial-and-error tests. For both selected algorithms (DL and BNG), the earthquake parameters were taken from the GEOFON earthquake service (Quinteros et al., 2021). However, the selected dataset varies from station to station, depending on the installation date and data availability.

Misorientation angles for two temporary stations installed in locations with different geological settings and noise conditions are presented in Fig. 13. Station RO35A, located in the Eastern Carpathians, in the basement of the Șoimeni village Cultural Center, has a misorientation angle of 359.1° and an estimation error of $\pm 4.3^\circ$ based on the DL algorithm (Fig. 13a). This confirms the correct sensor orientation and the accuracy of the determination when the DL method is applied. This result is confirmed by the fiber-optic gyroscope measurement, which showed a near-zero deviation of 0.02° , demonstrating the precision of the DL approach. Similarly, at station RO29A, placed in the Transylvanian Basin on the ground floor of the Cloașterf village Cultural Center, the BNG method estimates a misorientation angle of $357.2^\circ \pm 3.7^\circ$ (Fig. 13b). The value recently determined (July 11, 2025) with the optical gyroscope was 355.7° , demonstrating the robustness of this method. These examples demonstrate the performance of the selected algorithms for identifying sensor misalignments, especially when high-quality and long-duration recordings are available. However, stations with fewer recordings or those experiencing performance issues, as frequent gaps, spikes, or other anomalous signals, tend to exhibit higher estimation errors. These limitations currently prevent precise determinations for all stations. With an increased volume of high-quality recordings, we anticipate that it will be possible to conduct a more detailed analysis to provide accurate misorientation angles for all the stations deployed in Romania.

8. Conclusions

In this paper, we have described the evolution of the AdriaArray initiative in Romania, highlighting the deployment of temporary broadband stations, seismic equipment, data requirements and management. We also evaluated the quality of the recorded data by analyzing near-real time data flow, availability, ambient seismic noise levels, and sensor orientation. These efforts ensure that the seismic recordings are reliable for ongoing and future research within AdriaArray and beyond.

The temporary AdriaArray stations, combined with the permanent stations of the Romanian Seismic Network, provide the most comprehensive seismic station coverage ever achieved in Romania. This dataset, along with complementary recordings from surrounding countries, will be further analyzed within the AdriaArray Collaborative Research Groups to improve our understanding of earthquake generation processes and to refine models of lithospheric evolution in this complex tectonic environment.

The National Institute for Earth Physics supported the Romanian component of the project by providing technical guidance within the AdriaArray Working Group 2 (Technical advice) and leading the Surface Wave Tomography Collaborative Research Group. NIEP also collaborated with the Institute of Geophysics, the Institute of Rock Structure and Mechanics, the University of Oulu, the University of Helsinki, Aarhus University, and Uppsala University in the deployment and maintenance of 44 broadband seismic stations. Data from these stations contribute to the Y8 network and are archived at the NIEP EIDA node.

More than half of the temporary stations deployed in Romania have continuously recorded ground vibrations, with over 90% data availability. For about half of the operational stations, the Median Power Spectral Density curves for all three components remain below the NHNM limit across all period ranges, indicating the high quality of recordings.

For stations with high-quality data and long recording durations, orientation analysis gave results that are close to those obtained with the optical gyrocompass, confirming the reliability of the applied algorithms. This represents a preliminary step toward estimating misorientation angles for all broadband stations operated in Romania.

The data and resources established through the AdriaArray initiative will improve our understanding of seismic processes and help mitigate the impact of earthquakes. This initiative will play a key role in enhancing seismic risk assessment, particularly in regions where strong earthquakes pose a threat to densely populated areas. By improving monitoring capabilities and supporting the development of more accurate prediction models, AdriaArray will contribute to more effective strategies for protecting both people and infrastructure.

Table 1. Overview of sites and station characteristics deployed across Romania as part of the AdriaArray initiative.

Station Code	Locality/ County	Sensor model	Corner period (s)	Digitizer type	Stations and Sites overview	Geology	Housing Class	Subpool/ Institution
RO01A	Beldiu/AB	CMG-3ESPC	120	Minimus	The seismic equipment is hosted in the Ethnographic Museum, with the sensor installed on the concrete floor and the GPS antenna mounted on the roof. The station is located in the Transylvanian Basin, underlain by Holocene alluvial unconsolidated sediments and Pleistocene-Pliocene deposits.	Transylvanian Basin/ Unconsolidated rocks	UFF	FINNSIP UH
RO02A	Toplița/HR	CMG-3ESPC	120	Minimus	It operates in a free field setting, within a protective plastic enclosure in a remote area near the city. The sensor sits on a concrete base, and the GPS antenna is placed inside. The station is located in the Eastern Carpathians, in a Neogene post-collisional volcanic region, underlain by volcanogenic-sedimentary deposits and close to multiple quarries.	Eastern Carpathians/ Consolidated rocks	FF	FINNSIP UH
RO03A	Zătreni/GJ	CMG-3ESP	60	GAIA 5+	It is deployed in a protective plastic enclosure in a free field environment near the village. The sensor sits on a concrete base with the GPS antenna placed outside the enclosure. The station is situated in the South Carpathian foreland basin on top of 100-250 m of unconsolidated sediments, underlain by Neogene deposits.	Getic Depression/ Unconsolidated rocks	FF	MOBNET IG CAS
RO04A	Berlești/BR	CMG-3ESPC	120	Minimus	It is installed in a former school within the village, with the sensor on the concrete floor and the GPS antenna mounted on the roof. The station is located in the Moesian Platform, overlying Lower Holocene loessoid deposits and Neogene formations of clays, marls, and sands with thicknesses ranging from 400 to 3200 m.	Moesian Platform/ Unconsolidated rocks	UFF	FINNSIP IRSM CAS
RO05A	Cremenari/ VL	CMG-3ESP	60	GAIA 5+	It is deployed in a former school, within the village with the sensor fixed on the tiled floor and the GPS antenna mounted outside, on the window. It is located in the South Carpathian foreland basin with a sedimentary profile similar to RO03A.	Getic Depression/ Unconsolidated rocks	UFF	MOBNET IG CAS

Abbreviations for the housing classes are as follows: FF – free field, UFF – urban free field. These were classified using the ORFEUS Station Book classes (https://alparray.ethz.ch/en/seismic_network/backbone/standards-for-seismic-stations-and-data-management/).

County abbreviations are as follows: AB – Alba Iulia, AR – Arad, BC – Bacău, BH – Bihor, BN – Bistrița-Năsăud, BR – Brăila, BT – Botoșani, BV – Brașov, CJ – Cluj, CL – Călărași, CS – Caraș-Severin, DB – Dâmbovița, GJ – Gorj, GR – Giurgiu, HD – Hunedoara, HR – Harghita, IS – Iași, MH – Mehedinți, MS – Mureș, OT – Olt, PH – Prahova, SV – Suceava, TL – Tulcea, TM – Timiș, TR – Teleorman, VL – Vâlcea, VN – Vrancea.

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Station Code	Locality/ County	Sensor model	Corner period (s)	Digitizer type	Stations and Sites overview	Geology	Housing Class	Subpool/ Institution
RO06A	Chiribiș/BH	Trillium Compact	120	EDR-210	It is placed in the yard of the Cultural Center within the village. The equipment is housed in a protective plastic enclosure, placed outside, near the building. The sensor sits on a concrete base and the GPS antenna is fixed inside. The station is placed in the Pannonian Basin, overlying Quaternary gravels, sands, and clays with a thickness of 85-100 m, underlain by Neogene layers of sands, conglomerates, sandstones, marls, and limestones, ranging from 800 to 900 m in thickness.	Pannonian Basin/ Unconsolidated rocks	UFF	OU
RO07A	Fulgeriș/BC	CMG-3ESPC	120	Minimus	It was deployed in a former school within the village, with the sensor installed on the concrete floor and the GPS antenna fixed on the roof. The station was located in the Moldavian Platform, near the New Trotuș Fault (Figs. 1 and 5), overlying 200-500 m thick Miocene-Pliocene sedimentary sequences of clays and cineritic sands. The station was decommissioned on June 11, 2024, due to building restoration work.	Moldavian Platform/ Unconsolidated rocks	UFF	FINNSIP IRSM CAS
RO07B	Chilia Benei/ BC	CMG-3ESPC	120	Minimus	It comprises the same equipment as RO07A and is currently deployed in a former school within the village, with the sensor sitting on a concrete floor and the GPS antenna placed on the roof. The station is located 2 km northeast of RO07A.	Moldavian Platform/ Unconsolidated rocks	UFF	FINNSIP IRSM CAS
RO09A	Cenei/TM	CMG-3ESPC	120	Minimus	The seismic equipment is hosted in the Cultural Center within the village with the sensor placed on a concrete floor and the GPS antenna fixed on the exterior wall. The station is located at the western edge of the Pannonian Basin, underlain by Holocene, Pleistocene and Pannonian-age sedimentary sequences overlying a crystalline basement approximately 4 km deep.	Pannonian Basin/ Unconsolidated rocks	Building	FINNSIP UH
RO10A	Ciudanovița/ CS	Trillium	240	Centaur-3-0600	It is installed in the technical room of a primary school in the village of Ciudanovița, with the sensor on a concrete floor and the GPS antenna placed on the exterior wall, near the roof. The station is located in the Southern Carpathians, at the boundary between Lower Permian sandstone and clay conglomerates, and Upper Jurassic limestone and marl deposits within the Getic domain.	Southern Carpathians/ Consolidated rocks	UFF	DANSEIS AU
RO11A	Dealul Mare/ MH	Trillium	240	Centaur-3-0600	It is deployed in the Cultural Center within the village, with the sensor placed on the concrete base and the GPS antenna fixed on the exterior wall. The station is situated in the Southern Carpathians, within the Severin Parautochthon, on 1500 m thick Jurassic-Cretaceous sedimentary formations, including conglomerates, sandstones, clays, and limestone.	Southern Carpathians – Getic Depression boundary/ Consolidated rocks	UFF	DANSEIS AU

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Station Code	Locality/ County	Sensor model	Corner period (s)	Digitizer type	Stations and Sites overview	Geology	Housing Class	Subpool/ Institution
RO12A	Vlăsconi/DB	CMG-40T	30	GAIA 5+	It is installed in the plastic enclosure in the wooden warehouse of a school in use on the Moesian Platform, with the sensor placed on the concrete base and the GPS antenna fixed on the roof. The site is underlain by a 210 m sequence of alluvial, loess-like, and soft sedimentary deposits.	Moesian Platform/ Unconsolidated rocks	UFF	MOBNET IG CAS
RO13A	Segarcea/TR	CMG-3ESPC	60	GAIA 5+	The station is deployed in a local museum within the village, with the sensor on a concrete floor and the GPS antenna placed above the entrance door. The station is located on the Moesian Platform, underlain by a sequence of clay sands, loess-like deposits, dune sands, and gravels, with a total thickness of 5 to 70 m.	Moesian Platform/ Unconsolidated rocks	Building	MOBNET IG CAS
RO14A	Dezna/AR	Trillium Compact	120	Reftek 130	The seismic equipment is hosted in an unused room of a mortuary chapel, within the village, with the sensor on the tiled floor and the GPS antenna fixed on the exterior wall. The station is located in the Pannonian Basin, at the junction between Neogene andesites and Pleistocene floodplain deposits of boulders, gravels, and sands.	Pannonian Basin/ Unconsolidated rocks	UFF	OU
RO15A	Ipoțești/OT	CMG-3ESPC	30	GAIA 5+	It is deployed in a warehouse of a school in use within the Moesian Platform, with the sensor on the concrete floor and the GPS antenna fixed on the roof. The station sits on interlayered young alluvial sediments above soft, unconsolidated Pliocene and Pleistocene deposits.	Moesian Platform/ Unconsolidated rocks	UFF	MOBNET IG CAS
RO16A	Chirnogi/CL	CMG-3ESP	60	GAIA 5+	The station is installed in a protective plastic enclosure in a free field setting in the yard of the local museum in the village of Chirnogi (Fig. 4). The sensor sits on a concrete base and the GPS antenna is fixed outside the enclosure. The station is placed on top of Upper Holocene alluvial and aeolian sediments (5-20 m) overlying Pleistocene formations, including gravels, sands, a marly complex, and the Frățești strata.	Moesian Platform/ Unconsolidated rocks	FF	MOBNET IG CAS
RO17A	Schela/DB	CMG-3ESPC	120	Minimus	It operates in a former school within the village. The sensor is mounted on the concrete floor, with the GPS antenna fixed on the roof. The station is placed in the Eastern Carpathian Foredeep, overlying Pliocene deposits dominated by sands, with Pontian and Meotian marls, clays, and sandstones, and Helvetian gypsum-bearing formations.	Carpathian Foredeep/ Unconsolidated rocks	UFF	FINNSIP IRSM CAS
RO18A	Grădișteea de Munte/HD	Trillium Compact	120	Centaur CTR4-6S	It is installed in the basement of a house within the village. The sensor sits on a concrete floor, with the GPS antenna mounted on the exterior wall. The station is situated in the Southern Carpathians, on a metamorphic crystalline basement which includes pegmatites, paragneisses, micaschists.	Southern Carpathians/ Consolidated rocks	UFF	OU

Abbreviations for the housing classes are as follows: FF – free field, UFF – urban free field. These were classified using the ORFEUS Station Book classes (https://alparray.ethz.ch/en/seismic_network/backbone/standards-for-seismic-stations-and-data-management/).

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Station Code	Locality/ County	Sensor model	Corner period (s)	Digitizer type	Stations and Sites overview	Geology	Housing Class	Subpool/ Institution
RO19A	Arsuri/GJ	Trillium	240	Centaur-3-0600	The seismic equipment is hosted in a former school within the village. The sensor sits on the concrete base and the GPS antenna is mounted on the exterior wall. The station is located in the folded South Carpathian foreland, overlying sedimentary deposits from the Sarmatian-Meotian period, including clays, marly clays, and marl. The site is surrounded by several quarries whose operational status is uncertain.	Getic Depression/ Unconsolidated rocks	UFF	DanSeis AU
RO20A	Ohabăța/CS	Trillium	240	Centaur-3-0600	It is deployed in a former store within the village. The sensor is set on the tiled floor, with the GPS antenna mounted on the exterior wall. The station is located at the bend of the Southern Carpathians, sitting on metamorphic crystalline rocks, including sericite-chlorite shale, mica schists, and paragneiss.	Southern Carpathians/ Consolidated rocks	UFF	DanSeis AU
RO21A	Moșiori/AR	Trillium Compact	120	Reftek 130	The station is installed in a former kindergarten within the village. The sensor is placed on the concrete floor, with the GPS antenna fixed on the roof. The station is located in the Pannonian Basin, overlying upper Pleistocene loessoid deposits and Pannonian marly and sandy clays interbedded with sandstones.	Pannonian Basin/ Unconsolidated rocks	UFF	OU
RO22A	Sâmbăta de Sus/BV	CMG-3ESPC	120	Minimus	It operates in a football field locker room at the edge of the village. The sensor sits on a tiled floor and the GPS antenna is located inside the room, at the window. The station is placed in the Transylvanian Basin, near the South Carpathians and overlies 1500 m thick Sarmatian sedimentary sequences.	Transylvanian Basin/ Unconsolidated rocks	UFF	FINNSIP UH
RO23A	Gârbova/AB	CMG-3ESPC	120	Minimus	It is deployed in the basement of a house within the village. The sensor is placed on the concrete floor and the GPS antenna is mounted on the exterior wall. The station is located in the Transylvanian Basin on 600 m thick Sarmatian sedimentary sequences.	Transylvanian Basin/ Unconsolidated rocks	Building	FINNSIP UH
RO24A	Comloșu Mare/TM	Trillium Compact	120	EDR-210	The seismic equipment is hosted in the technical room of a chapel at the edge of the village. The sensor sits on a tiled floor, with the GPS antenna fixed on the roof. The station is placed in the western Pannonian Basin on lower Holocene to upper Pleistocene deposits, including loessoid layers, clays, and Pannonian sands and gravels, underlain by Helvetian gray marls and green clays.	Pannonian Basin/ Unconsolidated rocks	UFF	OU
RO25A	Bogda/TM	Trillium Compact	120	EDR-210	It is deployed in a local museum within the village. The sensor is placed on a tiled floor, with the GPS antenna mounted on the exterior wall. The station is located on Pannonian sedimentary deposits of gravels, sands, clays, and marls, underlain by Barremian gray limestone, sandstones, and clay shales.	Pannonian Basin/ Unconsolidated rocks	UFF	OU

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Station Code	Locality/ County	Sensor model	Corner period (s)	Digitizer type	Stations and Sites overview	Geology	Housing Class	Subpool/ Institution
RO26A	Godinești/ HD	Trillium Compact	120	Reftek 130	It operates in a former school within the village, with the sensor mounted on a concrete floor and the GPS antenna fixed near the roof. The station is placed in the Apuseni Mountains (Fig. 5), at the boundary between Cretaceous and Jurassic deposits, including conglomerates, limestones, clay schists and marl.	South Apuseni Mountains/ Consolidated rocks	UFF	OU
RO27A	Giurgeni//NT	CMG-3ESPC	120	Minimus	The station is deployed in a storage room of an operational school within the village. The sensor is fixed on the tiled floor, with the GPS antenna placed inside the room at the window. The station is situated in the Moldavian Platform north of the Vaslui Fault (Fig. 5) and overlies 600-1200 m thick Sarmatian sediments including limestone, marls, clays and sands.	Moldovian Platform/ Unconsolidated rocks	UFF	FINNSIP UH
RO28A	Băița/MS	CMG-3ESPC	120	Minimus	It is installed in a former clinic within the village, with the sensor fixed on the tiled floor and the GPS antenna mounted near the roof. The station is placed in the Transylvanian Basin, overlying Sarmatian unconsolidated and volcanoclastic sediments.	Transylvanian Basin/ Unconsolidated rocks	UFF	FINNSIP UH
RO29A	Cloașterf/MS	CMG-3ESPC	120	Minimus	It operates in the Cultural Center within the village. The sensor is placed on the tiled floor with the GPS antenna fixed on the exterior wall. The station is located in the eastern Transylvanian Basin, overlying volcanoclastic tuff sequences and Upper Miocene sediments.	Transylvanian Basin/ Unconsolidated rocks	Building	FINNSIP UH
RO30A	Neagra/SV	CMG-3ESPC	120	Minimus	It is installed in a shelter, within the village. The sensor sits on the tiled floor with the GPS antenna fixed on the roof. The station is placed in the Eastern Carpathians on a crystalline basement, composed of schists of Upper Paleozoic-Proterozoic age derived from sedimentary and volcanic parent rocks.	Eastern Carpathians/ Consolidated rocks	UFF	FINNSIP UH
RO31A	Șofronea/AR	Trillium Compact	120	Centaur CTR4-6S	It is deployed in the basement of the City Hall building. The sensor is set on a tiled floor, with the GPS antenna mounted near the roof. The station is located in the Pannonian Basin, overlying 1000 m thick Upper Pleistocene to Lower Holocene gravel, sand, and loessoid layers, underlain by Pannonian-age marly and sandy clays.	Pannonian Basin/ Unconsolidated rocks	Building	OU
RO32A	Sălișca/CJ	CMG-3ESPC	120	Minimus	The seismic equipment is hosted in the Cultural Center within the village. The sensor is placed on the tiled floor and the GPS antenna is mounted on the building's exterior wall. The station is located in the Transylvanian Basin, overlying 800-1000 m thick Miocene sedimentary sequences.	Transylvanian Basin/ Unconsolidated rocks	Building	FINNSIP UH

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Station Code	Locality/ County	Sensor model	Corner period (s)	Digitizer type	Stations and Sites overview	Geology	Housing Class	Subpool/ Institution
RO33A	Valea Seacă/ IS	CMG-3ESPC	120	Minimus	It operates in a vacant house at the edge of the village. The sensor sits on the tiled floor with the GPS antenna mounted indoors, at the window. The station is placed in the Moldavian Platform, overlying 400-800 m thick, soft and unconsolidated sedimentary sequences.	Moldavian Platform/ Unconsolidated rocks	UFF	FINNSIP UH
RO34A	Borlești/AB	CMG-3ESPC	120	Minimus	It is installed in a former school within the village. The sensor is placed on the concrete floor and the GPS antenna is fixed on the roof. The station is located in the Apuseni Mountains (Figs. 1 and 5), at the boundary between Permian metasomatic granitoid deposits and Upper Proterozoic-Paleozoic formations of the Arada Series, which include tuffogenic green rocks.	Apuseni Mountains/ Consolidated rocks	UFF	FINNSIP UH
RO35A	Șoimeni/HR	CMG-3ESPC	120	Minimus	The station is deployed in the basement of the Cultural Center within the village. The sensor sits on a tiled floor, with the GPS antenna mounted on the exterior wall. The station is located in the Eastern Carpathians on Neocomian-age sedimentary sequences of sandstones, limestone marl, and calcirudite.	Eastern Carpathians/ Consolidated rocks	UFF	FINNSIP IRSM CAS
RO36A	Teșna/SV	CMG-3ESPC	120	Minimus	It operates in a granary room within the village. The sensor is mounted on a concrete base with the GPS antenna fixed on the roof. The station is situated in the Eastern Carpathians, overlying 500 m thick Oligocene deposits composed of blackish bituminous schistous clays.	Eastern Carpathians/ Consolidated rocks	UFF	FINNSIP UH
RO37A	Telcișor/BN	CMG-3ESPC	120	Minimus	It is installed in the basement of an operational school within the village. The sensor sits on a concrete floor with the GPS antenna mounted on the exterior wall. The station is located in the Transylvanian Basin, overlying Lower Oligocene sedimentary sequences composed of flysch with interlayered marl, sandstone, and bituminous shale.	Transylvanian Basin/ Unconsolidated rocks	Building	FINNSIP UH
RO38A	Botoșana/SV	CMG-3ESPC	120	Minimus	It was deployed in a storage house within the village. The sensor was installed on the concrete floor, with the GPS antenna placed outside, on the wall. The station was located on the Moldavian Platform, overlying approximately 1000 m thick Miocene sedimentary deposits composed of gray marls, sands, and micaceous sandstones. Due to high noise levels, the station was relocated on July 15, 2024.	Moldavian Platform/ Unconsolidated rocks	Building	FINNSIP UH
RO38B	Poieni-Solca/SV	CMG-3ESPC	120	Minimus	It is currently installed in a seldom used football stadium, approximately 4.5 km west of its previous location (RO38A). The sensor is installed on a cement block buried in the ground, under the referee's cabin and the GPS antenna is placed outside, on the roof.	Moldavian Platform/ Unconsolidated rocks	UFF	FINNSIP UH

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Station Code	Locality/ County	Sensor model	Corner period (s)	Digitizer type	Stations and Sites overview	Geology	Housing Class	Subpool/ Institution
RO39A	Botoșani/BT	CMG-3ESPC	120	Minimus	It operates in a free field setting within a meteorological station within the city. The seismic equipment is kept in a protective plastic enclosure with the sensor placed on a concrete base and the GPS antenna fixed inside. The station is situated in the Moldavian Platform, overlying 100-250 m thick Sarmatian sedimentary sequences composed of clayey marls with sand intercalations, Burdujeni sandstones, and additional marls.	Moldavian Platform/ Unconsolidated rocks	FF	FINNSIP UH
RO43A	Bolovăniș/BC	Trillium Compact	120	EDR-210	The seismic equipment is hosted in a shelter designed for water treatment within the village. The sensor sits on a tiled floor, with the GPS antenna mounted on the exterior wall. The station is situated in the Eastern Carpathians on Albian-Vraconian-age flysch, comprising micaceous and calcareous sandstones, marls, and conglomerates.	Eastern Carpathians/ Consolidated rocks	UFF	GIPP IRSM CAS
RO44A	Plaiul Cornului/PH	Trillium Compact	120	EDR-210	It is deployed in a former school within the village. The sensor is installed on a concrete floor, with the GPS antenna placed near the roof. The station is located in the arc bend of the Eastern Subcarpathians, overlying Paleocene-Neogene sandstone-schist formations, sandstones, and marls.	Carpathian Foredeep/ Consolidated rocks	UFF	GIPP IRSM CAS
RO45A	Stupina/VN	Trillium Compact	120	EDR-210	The station was installed in a former school at the edge of the village. The sensor was placed on a concrete floor, with the GPS antenna fixed on the roof. The station was located in the eastern Moesian Platform on lower Holocene deposits of gravels, loess-like sands, and dune sands. Due to high noise levels, the station was relocated on July 08, 2024.	Moesian Platform/ Unconsolidated rocks	UFF	GIPP IRSM CAS
RO45B	Bordeasca-Veche/VN	Trillium Compact	120	EDR-210	It is currently deployed in the Cultural Center within the village. The sensor sits on a concrete floor, with a GPS antenna placed indoors at the window. The station is located 14.5 km northeast of RO45A.	Moesian Platform/ Unconsolidated rocks	UFF	GIPP IRSM CAS
RO46A	Valea Mare/BC	Trillium Compact	120	EDR-210	It operates in an old church close to the village. The sensor sits on a concrete floor, with the GPS antenna mounted near the roof. The station is located in the Moldavian Platform on Meotian deposits composed of clays and cineritic sands, with thicknesses of 200-500 m.	Moldavian Platform/ Unconsolidated rocks	UFF	GIPP IRSM CAS
JURR	Jurilovca/TL	CMG-40T	30	GAIA 5+	It is co-located with a permanent short-period station belonging to the RSN. It is deployed in a storage room of a meteorological station within the village. The sensor sits on a concrete floor and the GPS antenna is mounted outside beneath the roof. The station is placed in a Cretaceous Basin within the North Dobrogea Orogen, on top of shallow marine sedimentary sequences.	Babadag Basin/ Unconsolidated rocks	UFF	MOBNET IG CAS

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SGRR	Singureni/ GR	STS-2	120	GAIA 5+	It is co-located with a permanent short-period station operated by the RSN. It is installed in the basement of a telecommunication service building, near the village. The sensor is placed on the concrete floor and the GPS antenna is fixed on the window. The station is located in the southern Moesian Platform, on top of 100-200 m thick unconsolidated Holocene and Pleistocene deposits.	Moesian Platform/ Unconsolidated rocks	Building	MOBNET IG CAS

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