

Article

Seismic Observations in Bucharest Area with a Raspberry Shake Citizen Science Network

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Abstract: Technological advancements and the appearance of low-cost Raspberry Shake seismographs have enabled the development of citizen science seismic networks in many areas worldwide. These networks can help reduce seismic risk and increase citizens' understanding of seismology and earthquakes. Such a network exists in Bucharest, one of the cities in Europe that are struck and affected by strong Vrancea earthquakes. The paper aims to show that data from such networks can be used in both outreach programs and research studies. There are presented, for the first time, seismic observations collected over two years beginning in the summer of 2020 in the Bucharest area based on the low-cost seismometers from the citizen science Raspberry Shake network. A significant number of earthquakes from the Vrancea region were recorded by the Bucharest Raspberry Shake Seismic Network (BRSSN). Some of them were felt by Bucharest inhabitants. The National Institute for Earth Physics in Magurele (Romania) organizes educational events that promote geosciences among the population and presents the tools at its disposal for a better understanding of earthquakes and their effects, contributing this way to the development of the concept of citizen science. Citizens are the first witnesses to seismic events and the citizen science seismic network provides them with the first direct information about the event via web apps available for any internet-connected device. Their involvement as non-professional participants helps in providing data for scientists via questionnaire forms to improve scientific research for earthquake assessment. Since citizen seismometers are installed in urban areas, an analysis of the ambient seismic noise (ASN) was performed in addition to the analysis of recorded seismic events. The analysis indicates that the level of seismic noise is mainly controlled by human activities. At the same time, for one citizen seismometer installed in a school in Bucharest, the results show patterns of noise variations due to students' activity.

Keywords: citizen seismology; citizen science; earthquakes; Raspberry Shake; seismicity



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1. Introduction

Technological developments in recent years and the appearance of low-cost instruments have made possible the development of worldwide citizen science networks in various science fields [1–3]. One of these networks is the Raspberry Shake Network [4], which is a global community of citizen scientists, geophysical institutes, and private enterprises sharing data from Earth monitoring devices, such as the low-cost Raspberry Shake (RS) seismographs. This citizen science network continues successful educational initiatives from the last decades from various educational networks integrated with the “Seismographs in school” project, promoted by the Incorporated Research Institutions for Seismology (IRIS) in the United States [5], the “Schools Seismology Network” in the United Kingdom, managed by the British Geological Survey [6], the Australian AuSIS network [7], the French “Sismo à l’école” [8], the “Seismology in Schools” project managed by the Dublin Institute for Advanced Studies (DIAS) in Ireland [9], or the ROEDUSEIS project led by the National Institute for Earth Physics (NIEP) in Romania [10].

The RS seismograph is based on the Raspberry Pi computer and combines the latest technologies in the field of electronics, becoming one of the smallest and most accessible electronic seismographs on the market, with semi-professional performance. Correcting all the shortcomings of previous generations of educational seismometers by becoming a plug-and-go earth monitor, RS has captivated hobbyists, citizen scientists, and teachers.

Although some RSs are installed for various scientific studies, information about what they record and where they are installed is available not only to researchers but also to all those interested in the study of earthquakes or those who want to find out new information about earthquakes [11]. This category usually includes students and teachers, but also general people interested in earthquake science with science hobbies.

Normally, seismological devices such as broadband instruments from the URS (URban Seismology) project [12] installed within cities have been used to provide data for local seismic hazards assessments, building monitoring and civil engineering analyses. By using a citizen seismic network, many urban activities can be seismically recorded [13] and more citizens can become interested in the interpretation of the recorded seismograms. In recent years, citizen seismology has achieved several important goals, combining the interest of citizen science in general and, especially, in informing and raising seismic risk awareness.

Romania is a seismic country, with more than 1000 earthquakes reported yearly. Bucharest is the capital city of Romania, and its seismic hazard is dominated by the Vrancea [14] intermediate-depth seismic source, which can produce, on average, 2–3 large magnitude seismic events in each century.

The National Institute for Earth Physics (NIEP) noticed a lack of seismic education in Romania and initiated the first seismic education program starting in 2012 through the ROEDUSEIS project [10], setting up an Education, Outreach, and Training team (EOT) at the same time (<https://eertis.eu/erlb-2200-000x-0091>, accessed on 18 January 2023). Thus, every year, NIEP through EOT hosts a series of educational events [15] (e.g., Otherwise School, Magurele Science and Technology Summer School, Researchers Night, Seismology Workshops for students, teachers, and others) that aim to popularize geosciences among citizens, but also increase the awareness and reduction of seismic risk. Only in the “School Otherwise” program does the average number of visitors to NIEP exceed 1000 people annually. The other events are usually held in public spaces and the number of participants is much higher. Although primary and secondary school students are the most captivated by the information they receive, the most active participants are high school students and their teachers. We still do not have clear statistics on the number of people who access data from the RS seismometers, but responses to feedback questionnaires following the events and posts on social media networks show that interest is growing.

An analysis of global seismic risk data shows that one in three people are exposed to earthquakes [16] and most injuries and deaths in the case of seismic events are caused by damage to or collapse of residential buildings. Citizen involvement in disaster risk reduction activities steadily increases through joint data collection, education/training, and citizen science activities. Schools [17–19] have a central role in engaging young students and increasing risk awareness and preparation. From now on, Bucharest city is seismically investigated with real data coming not just from the stations belonging to the National Seismic Network, but from the Bucharest Raspberry Shake Seismic Network (BRSSN) as well. Being part of the global Raspberry Shake Citizen Science Network, the access to this data is public and contributes to increasing citizens’ knowledge about earthquakes by using the apps developed by Raspberry Shake’s manufacturer and participating in actions coordinated by NIEP. The data also complement researchers’ information about the internal structure of the Earth beneath the city. NIEP, through its Education, Outreach, and Training team promotes science in general and earthquakes in particular at various events, contributing to increasing the number of citizens interested in earthquakes and seismic risk. This became visible through posts on social networks, with recordings from educational seismometers and through the completion of questionnaires such as *Did you feel it?* both on the website of NIEP (<https://infpapi.infp.ro/feedback/30387>, accessed on 12 Decem-

ber 2022) and also on the website of the European-Mediterranean Seismological Center (EMSC) (<https://www.emsc-csem.org/Earthquake/Contribute/testimonies.php?lang=ro&id=1185128>, accessed on 12 December 2022). Access to information and knowledge is not restricted only to citizens in Bucharest. The paper presents seismological information from seven RSs from the Bucharest area. At the national level, there are almost 30 such devices and data from any of them can be used by anyone. In this way, future generations of citizens will have a high level of knowledge of seismic risk thanks to the information provided by the citizen science network. Additionally, the investigation on how educational networks can contribute to citizen interest and knowledge focused, in this study, on the Bucharest area can be easily extended to any other city exposed to seismic action.

2. Bucharest Raspberry Shake Seismic Network

The Raspberry Shake is a plug-and-go solution for seismological applications. It can record earthquakes from very small magnitudes that are not felt by humans to destructive earthquakes that occur in many places on Earth. This seismometer, with similar characteristics to professional ones, but with much lower production and maintenance costs, is produced in a wide variety of setups: 1D, 3D, 4D, Boom, and Shake&Boom. Due to the widespread installation of these RSs, the Raspberry Shake Citizen Science Network currently lists over 2000 online seismometers and their number is continuously increasing [11].

RS4D is a seismograph equipped with multiple sensors (Figure 1). RS4D includes a Raspberry Pi computer, a vertical geophone (4.5 Hz and sampling rates are adaptable up to 100 Hz), a triaxial accelerometer, a digitizer, and near-real-time miniSEED data transmission. The performance of RS4D in the context of seismic wave propagation monitoring was evaluated by laboratory tests and field observations by [20]. During the investigated period, no significant earthquakes occurred in the Vrancea region and therefore no data from accelerometers were used [21]. Unlike RS4D, RS1D (Figure 1) contains a Raspberry Pi computer, a vertical geophone, a digitizer, and near-real-time miniSEED data transmission. Moreover, also in [22], it was observed that RSs are more suitable for characterizing local events with magnitude $M > 2.5$, regional events with magnitude $M > 4.5$, or teleseismic events with magnitude $M > 6$. However, given their easy installation, relatively low cost, and real-time data transmission, RS sensors may be an ideal candidate for the densification of seismic networks for local and regional events whose data can be used in both public information programs and research studies.

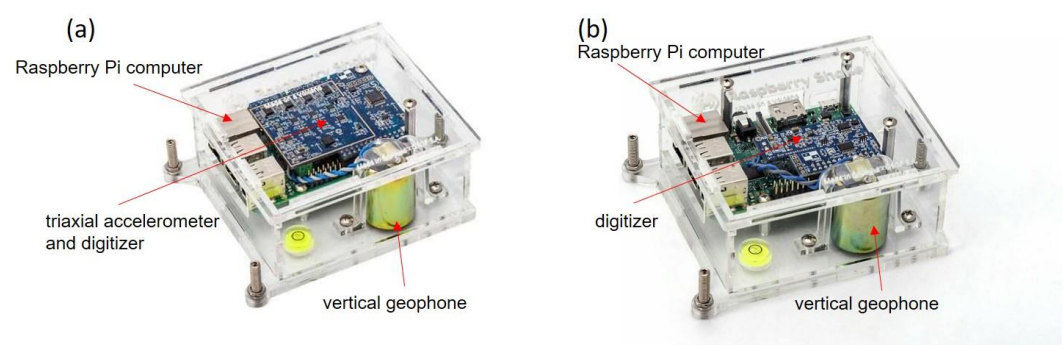


Figure 1. (a) Raspberry Shake 4D sensor (vertical geophone, triaxial accelerometer and digitizer) and (b) Raspberry Shake 1D sensor (vertical geophone and digitizer).

The power supply is 5 V (2.5 A) and the power consumption for an RS unit is estimated at 2.8 W at start-up and 1.5 W during operation. Data are stored on a local SD card (default 8 Gb, but larger cards can be installed). The estimated amount of data per channel is less than 10 Mb per day. The local storage can thus be adapted according to the SD card fitted, the number of sensors, and the selected sampling rate. Time synchronization is based on NTP (Network Time Protocol), but a GPS module can be connected via USB. The Raspberry Pi computer is pre-programmed and contains the SeisComp3 software [23]. SeisComp is a

seismological software for interactive data acquisition, processing, distribution, and analysis. It includes many features based on standard protocols (e.g., seedlink) and allows data acquisition, waveform distribution and archiving, and real-time data exchange archiving. Waveforms are saved in miniSEED format. Using the SeisComP software package, data from seismometers are accessed via FDSN (International Federation of Digital Seismograph Networks [24]) web services. A data-flow transmission scheme is presented in Figure 2.

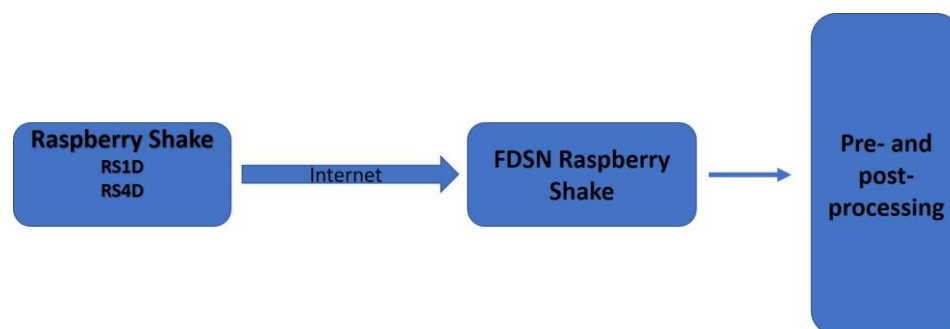


Figure 2. Data-flow transmission scheme used for RS sensors.

From the Raspberry Shake FDSN web services, the data is downloaded with Python notebooks from JupyterHub. The notebooks are based on the ObsPy Python module, which is a collection of open-source programs developed to provide a Python framework for the acquisition/processing and analysis of seismological data [25–27]. For amateurs, there is the possibility to view the data in the manufacturer’s apps on both internet-connected devices [28] and smartphones [29]. Earthquake citizen science networks can significantly contribute to mitigating seismic risk and improving citizens’ knowledge of seismology and earthquakes [30–32] in areas with intense seismic activity or that are affected by the seismic activity in the surrounding areas. As Bucharest is one of the most affected cities by earthquakes in Europe and has suffered much damage due to strong Vrancea intermediate-depth earthquakes, such a network, the Bucharest Raspberry Shake Seismic Network (BRSSN), was developed starting in June 2020 when 15 4D RSs were installed in five buildings [33] in Bucharest city to study their structural behavior during earthquakes. In the present study, we use the data from the seismometers listed in Table 1, which are installed in the building’s basement and/or ground floor. In the case of one building with two RSs (R7A63 and R8BAF, see Figure 3) installed in the basement and on the ground level, both seismometers were utilized. The BRSSN was upgraded in November 2020 with a 1D RS installed in the NIEP Seismolaboratory and a 4D RS installed in September 2022 at the Bucharest French School. These two seismometers are part of the Romanian Educational Seismic Network (ROEDUSEIS [22]), which comprises 24 Raspberry Shake seismometers integrated into the global citizen science Raspberry Shake network. Even though all these seismometers (Figure 3) are under the care of the National Institute for Earth Physics in Romania, they are integrated into the global citizen science Raspberry Shake network [4].

Table 1. Information about the Raspberry Shake seismometers installed in Bucharest and used in this study.

RS Code	Latitude	Longitude	Type
R3BC5	44.3423423	26.0276728	1D
R1784	44.5135135	26.0672459	4D
R13FF	44.4234234	26.0237325	4D
R7A63	44.4324324	26.1066105	4D
R8BAF	44.4324324	26.1066105	4D
RD1CA	44.4234234	26.1250955	4D
RB536	44.4324324	26.156008	4D

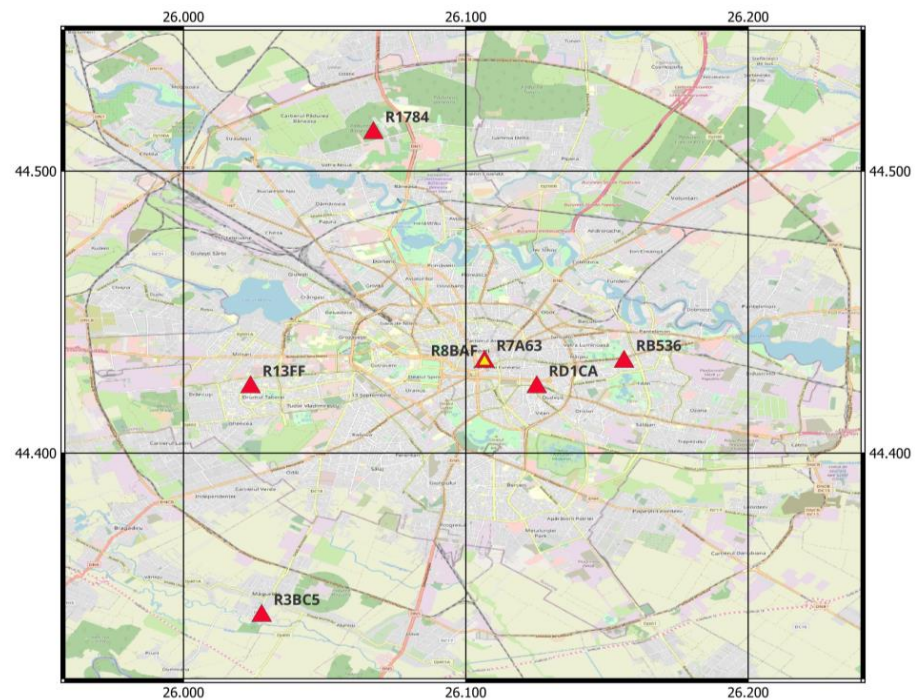


Figure 3. Bucharest Raspberry Shake Citizen Science network.

3. Data and Earthquake Observations

An advantage of RS seismometers is that budding geophysicists and citizen scientists can access the data through ShakeNet Web and Desktop apps [28] and ShakeNet Mobile apps [29] for Android and iOS developed by the manufacturer, or one can dive in and play around with the data directly.

Since installing the first Raspberry Shake seismometers in Bucharest in June 2020 and until the end of November 2022, over 3600 earthquakes have occurred in Romania, according to Romplus Catalog [34] (Figure 4). Of these, 41 earthquakes had a magnitude $M_L \geq 4$, most of which occurred in the Vrancea seismic region.

Earthquakes of a magnitude around 4 are small to moderate earthquakes and do not cause damage to the built environment. Still, they can shake the population by alerting them and taking them out of their comfort zone. Earthquakes of this size, however, are poorly recorded by RS seismometers. Things are different for larger earthquakes, such as the 5.3 magnitude earthquake of 3 November 2022, the largest earthquake during the period analyzed. Six seismometers connected to the Raspberry Shake Citizen Science network in Bucharest were online and recorded the earthquake at that time. Figure 5 shows a distribution of waveforms as a function of epicentral distance.

These records are generated with Python code notebooks from the JupyterHub created specifically for ROEDUSEIS Network data users [22]. All seismograms show P- and S-waves, even though the recordings are from the seismometers' vertical channel (EHZ). For inexperienced users who wish to learn about earthquakes recorded by citizen science networks, data from Raspberry Shake seismometers can be viewed online using ShakeNet Web and Desktop Apps [28], available for any devices connected to the internet. To use these applications, creating a user account is unnecessary, and the working steps are very intuitive, generally involving searching for the seismometer code and the date of the month for which you want to view the data. Figure 6 below shows the outputs (helicorder, waveforms, power and frequency spectra) for the 3 November earthquake recorded by the R1784 seismometer deployed in the northern part of Bucharest using the Raspberry Shake online applications: ShakeNet Web and Desktop Apps (left) [28] and ShakeNet Mobile Apps for Android and iOS (right) [29].

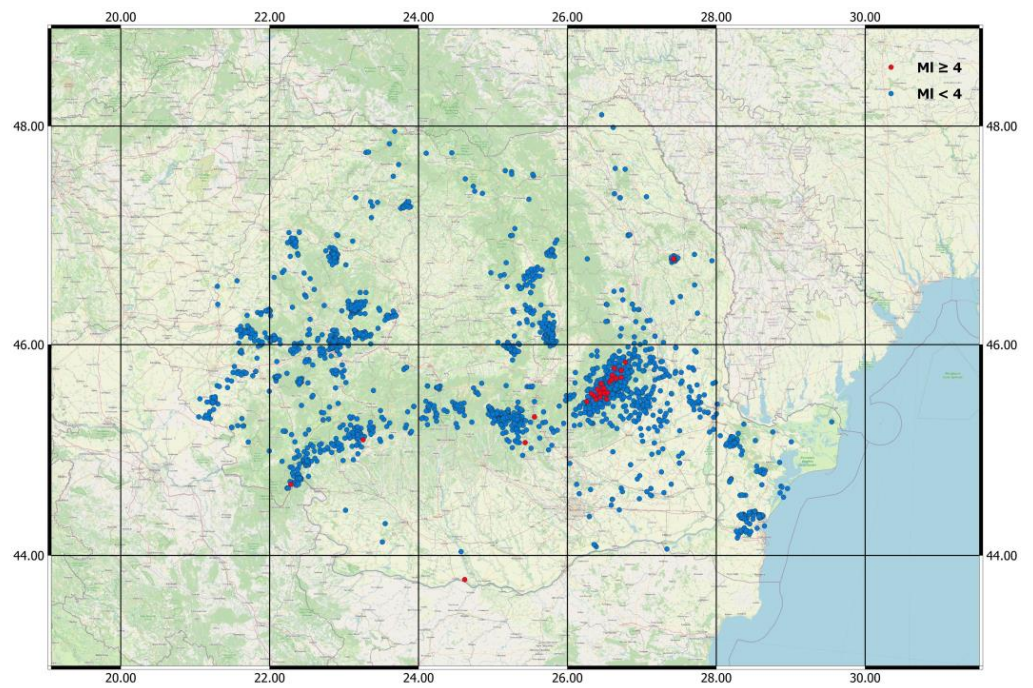


Figure 4. Earthquakes that occurred in Romania during the investigation period.

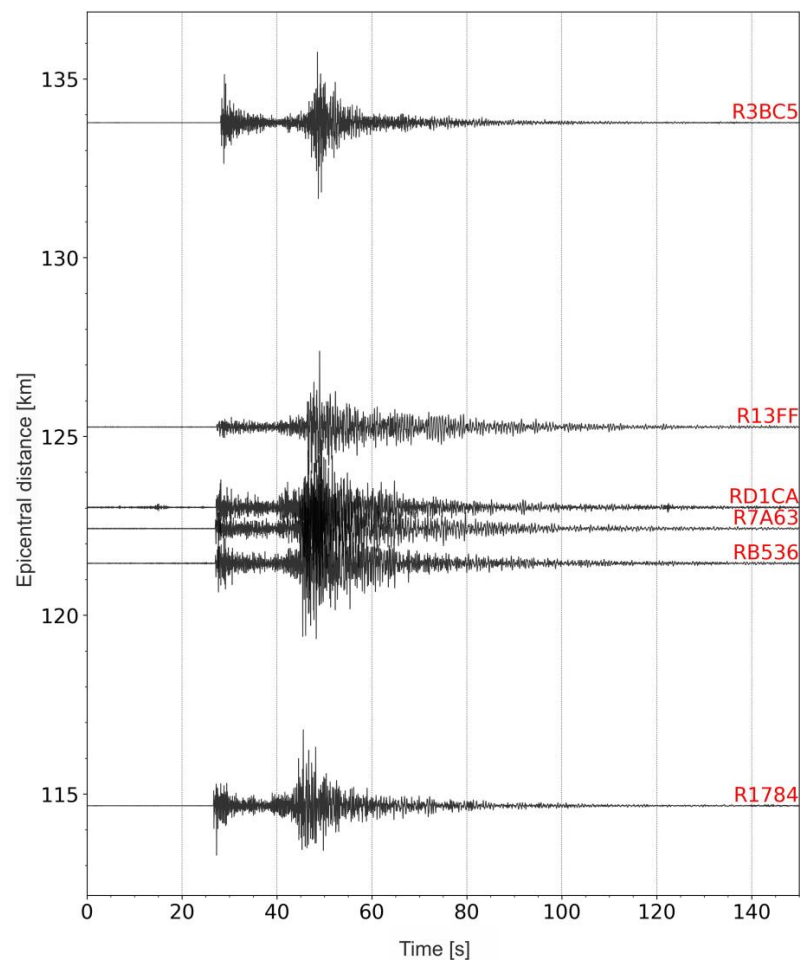


Figure 5. The MI 5.3 earthquake waveforms recorded by the Raspberry Shake Citizen Science Network in Bucharest city.

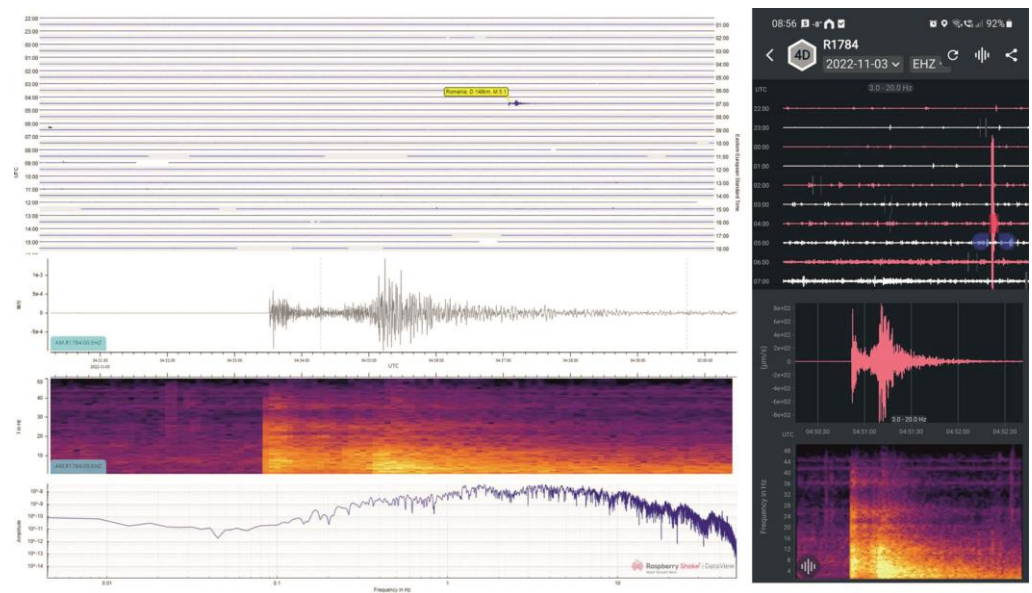


Figure 6. 3 November earthquake outputs from the ShakeNet Web and Desktop Apps (left) [28] and ShakeNet Mobile Apps for Android and iOS (right) [29].

When an earthquake of this magnitude is triggered in the Vrancea seismic zone, the population of cities that are further away from the epicenter, such as Bucharest, will feel its effects. This is clearly evidenced when examining the map depicting the locations of completed “Did you feel it?” questionnaires. Although the earthquake did not cause any damage, it alerted the population. This is demonstrated by the significant number of “Did you feel it?” surveys completed on both the National Institute for Earth Physics and the European-Mediterranean Seismological Centre websites. According to the NIEP questionnaire, approximately 1500 people from the Bucharest region filled out the form indicating that they felt the earthquake, which assisted the researchers in evaluating the earthquake intensity (<http://www.infp.ro/comments.php?id=c2IUQ0hWTWNNdCtaStOSnFtYitqZz09&intensity=5&lang=ro>, accessed on 12 December 2022). If we look at the questionnaires on a larger scale, at EMSC, there were about 2000 citizen observations of the earthquake (<https://www.emsc-csem.org/Earthquake/earthquake.php?id=1185128#map>, accessed on 12 December 2022) (Figure 7). The fact that the seismic movement was not felt in the inner side of the Carpathians Arc is in agreement with the asymmetric distribution of the ground motion characterizing the Vrancea earthquakes [35].

A large percentage of respondents to both surveys claim to have felt the earthquake, demonstrating that the general public is aware of the seismic danger. Citizens are unwittingly the first witnesses of the seismic event, and their reporting helps researchers assess the earthquake intensity distribution.

Local earthquakes less powerful than the one that occurred on 3 November can be captured using Raspberry Shake seismometers. The capacity of the educational seismometers in the ROEDUSEIS network, which includes Raspberry Shake seismometers, to detect earthquakes was examined in prior research [22]. It was found that the smallest local earthquake recorded by a Raspberry Shake seismometer in Romania had a magnitude $M_L = 2.5$ and an epicentral distance of 25 km. In comparison, for an epicentral distance of about 120 km, as is the case of Bucharest compared to the Vrancea earthquakes, the smallest magnitude was $M_L = 3.9$.

On 6 February 2023, at around 4:15 a.m. and 1:30 p.m. local time, two powerful earthquakes with magnitudes of 7.8 and 7.5 struck southeast Turkey, significantly impacting many people. These earthquakes caused widespread, intense shaking that shook populated cities and villages. Figure 8 displays earthquake data recorded by one of the Bucharest Raspberry Shake seismometers (R1784).

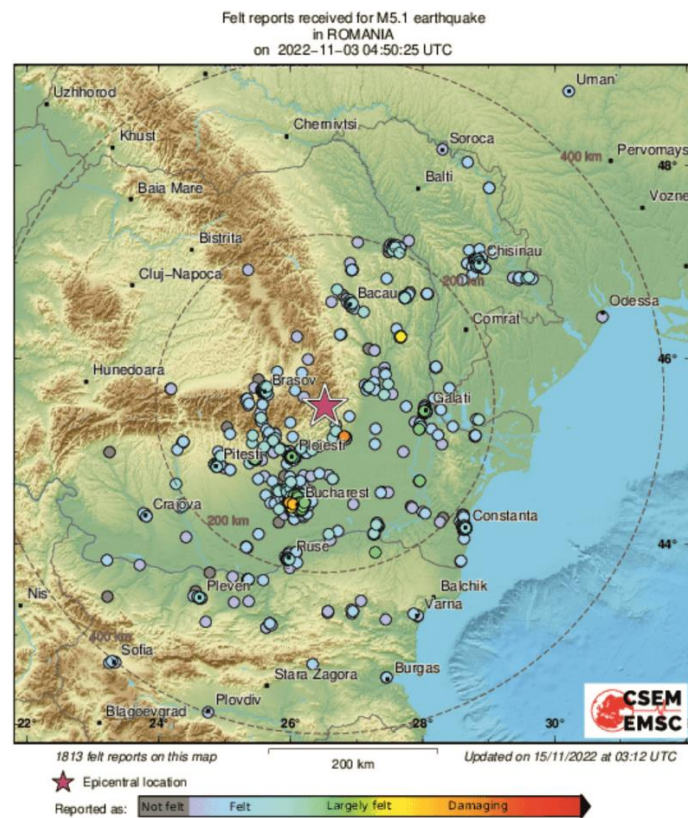


Figure 7. On European-Mediterranean Seismological Centre questionnaire report map for $M_L = 5.1$ Vrancea earthquake [36].

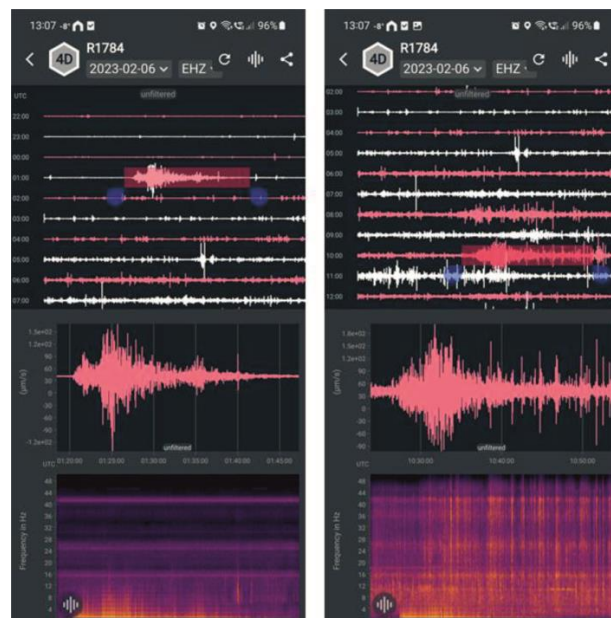


Figure 8. M7.8 (left) and M7.5 (right) earthquakes occurred in Turkey on 6 February 2023, recorded by the R1784 RS seismograph and displayed with ShakeNet Mobile Apps [29].

More than 6500 citizens completed the **Did you feel it?** questionnaire available from the European-Mediterranean Seismological Centre and helped researchers to map (Figure 9) the areas where the earthquake was felt and damage occurred.



Figure 9. European-Mediterranean Seismological Centre questionnaire report map of the M7.8 earthquake from Turkey [37].

As shown in Figure 9, for epicentral distances up to 500 km, the existence of a Raspberry Shake citizen science network could have helped citizens to be sure they have experienced the earthquake by accessing the Raspberry Shake web apps. The development of such a network in Turkey has only just begun through an educational program in partnership with neighboring countries (<https://seismolab.gein.noa.gr/>, accessed on 9 February 2023). Furthermore, the seismometer RS R1784 from BRSSN, which recorded the earthquakes from southeast Turkey (Figure 8), is also part of this project.

4. Ambient Noise Observations

Citizen seismometers are most frequently employed to capture natural phenomena such as earthquakes. However, as most of them are deployed in urban areas, they also record ambient seismic noise (ASN) generated mainly by human activities. Lecocq et al. (2020b) [38] used citizen seismometers in addition to professional seismometers to describe the decreases in ASN seen at schools and colleges during the COVID-19 lockdown. The use of both citizen [39–41] and professional seismometers [42–44] in ambient noise analysis during COVID-19 provided valuable insights into the impact of human activities on seismic signals and highlights the potential for citizen scientists to contribute to scientific research.

We performed an ASN analysis to investigate noise behavior at the BRSSN citizen seismometers in the high-frequency domain (5–40 Hz). To estimate background noise levels at the stations, we computed the Probability Density Functions (PDFs) following the methodology described by McNamara and Buland (2004) [45]. The process involves calculating the Power Spectral Density (PSD) for each time segment and channel. Subsequently, the individual PSDs are collected to create frequency distributions, which are constructed by binning periods in 1/8 octave intervals and power in 1 dB intervals. Each frequency

distribution bin is then normalized using the total number of PSDs, creating a PDF for that bin. The PDFs are useful for tracking and assessing seismic station performance [45–48]. Figure 10 shows the PDFs computed for two Raspberry Shake seismometers for almost six months of continuous data recordings at R13FF and R1784. To facilitate the understanding of the results, the PDFs are displayed combined with two globally acknowledged standard models, Peterson’s (1993) [49] low and high new noise models (NLNM and NHNM). It is observed that the background seismic noise level depicted by the high probability region lies closely above NHNM for the entire high-frequency band (1–40 Hz). This implies a high noise level at the stations, in agreement with the various anthropogenic noise sources that affect the seismic records.

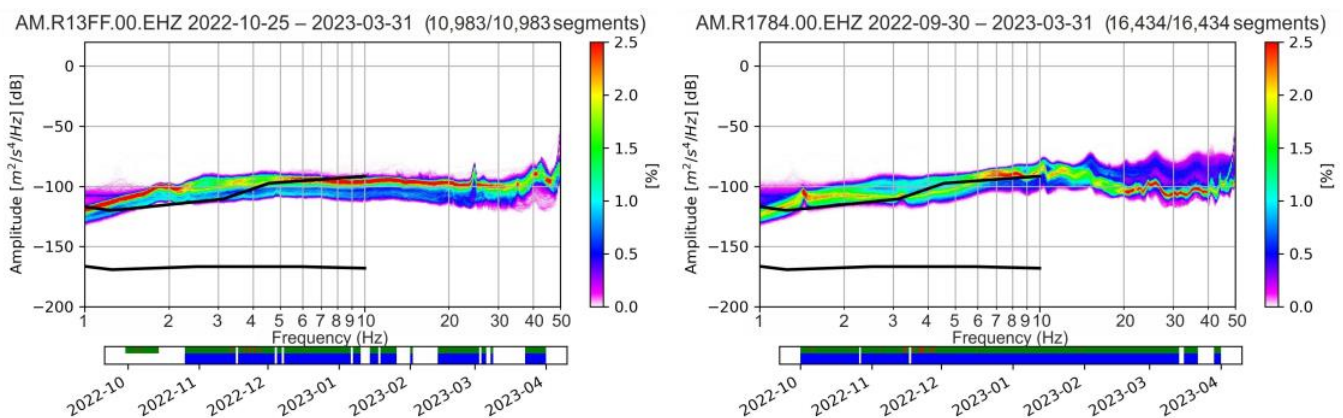


Figure 10. Probability Density Functions computed for R13FF and R1784 seismometers. The black lines are the two noise models, NHNM and NLNM. We chose the time period (6 months) with the most available data due to the differing starting dates of the seismic stations. The available data are represented by the green color in the top row, while the red color represents data that have gaps and were utilized in the PSD calculations. In the blue bottom row, data used in the PDF plot are displayed, and empty segments indicate data gaps, with a segment length of 30 min.

The spectrograms and the noise amplitude–time plots for two seismometers, one installed on the ground floor of a residential building in the Bucharest western area (R13FF) and the other in French School Anna de Noailles located in the Bucharest northern area (R1784), are presented in Figure 11. The spectrograms and the amplitude–time plots are computed for a time window of seven days (31 October–6 November 2022), which includes the $M_L = 5.3$ Vrancea earthquake that occurred on 3 November. They both show an increase in seismic noise power during the day in the 0.02–0.5 s period range (2–50 Hz) and a decrease during the night. The amplitude–time plot and spectrogram for the R1784 seismometer also show a clear variation in noise levels between weekdays and weekends. The students who attend courses are responsible for the increased noise levels observed from Monday through Friday. The noise power of the 3 November 2022 earthquake can be seen in the 0.1–1 s period region, which is emphasized with a yellow line. This pattern is apparent in all seismometers used in this study and is plainly seen in the amplitude–time plots as well.

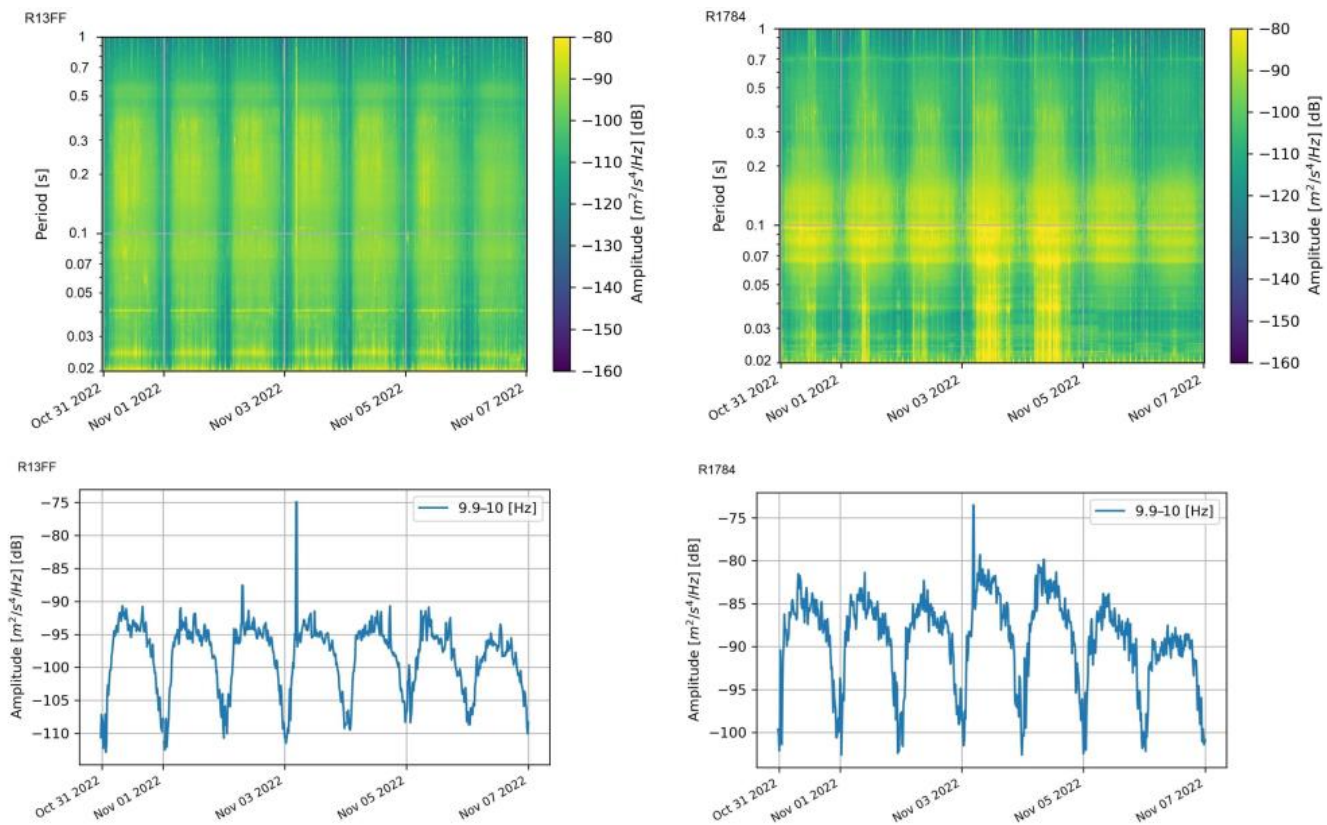


Figure 11. Spectrograms (top) and amplitude–time plots (bottom) showing noise level from Monday to Sunday (31 October–6 November 2022). The highlighted yellow line and the larger amplitude plot represent the 3 November 2022 earthquake from the Vrancea zone.

Following the methodology described by Lecocq et al. (2020a) [50], we computed the long-term evolution of the seismic noise for the citizen seismometer installed at the French School Anna de Noailles. To achieve this, we used the SeismoRMS software package (Lecocq et al., 2020b) [38], which is accessible to the general public. We employed 1800 s time frames that had a 50% overlap in order to determine the probabilistic power spectral density (PPSD) acceleration amplitudes for each day. After that, the PPSDs were converted into displacement spectral powers, and then, using Parseval’s identity, they were converted once again to the displacement root mean square in the frequency domain of interest. The analyzed period includes several national holidays for students, such as the autumn, Great Union, and winter holidays. We found that there is around a fifty percent reduction in the noise level on all holidays. Grecu et al. (2021) [43] demonstrated a similar behavior of ASN for several professional stations belonging to the Romanian Seismic Network that were installed in schools and kindergartens in Bucharest. Based on their findings, they concluded that the decrease in the noise level is predominantly related to the reduced human mobility inside the buildings in which the stations are housed. A zoom in on the week of 31 October–6 November 2022 provides a clearer perspective of the 3 November $M_L = 5.3$ Vrancea earthquake (Figure 12).

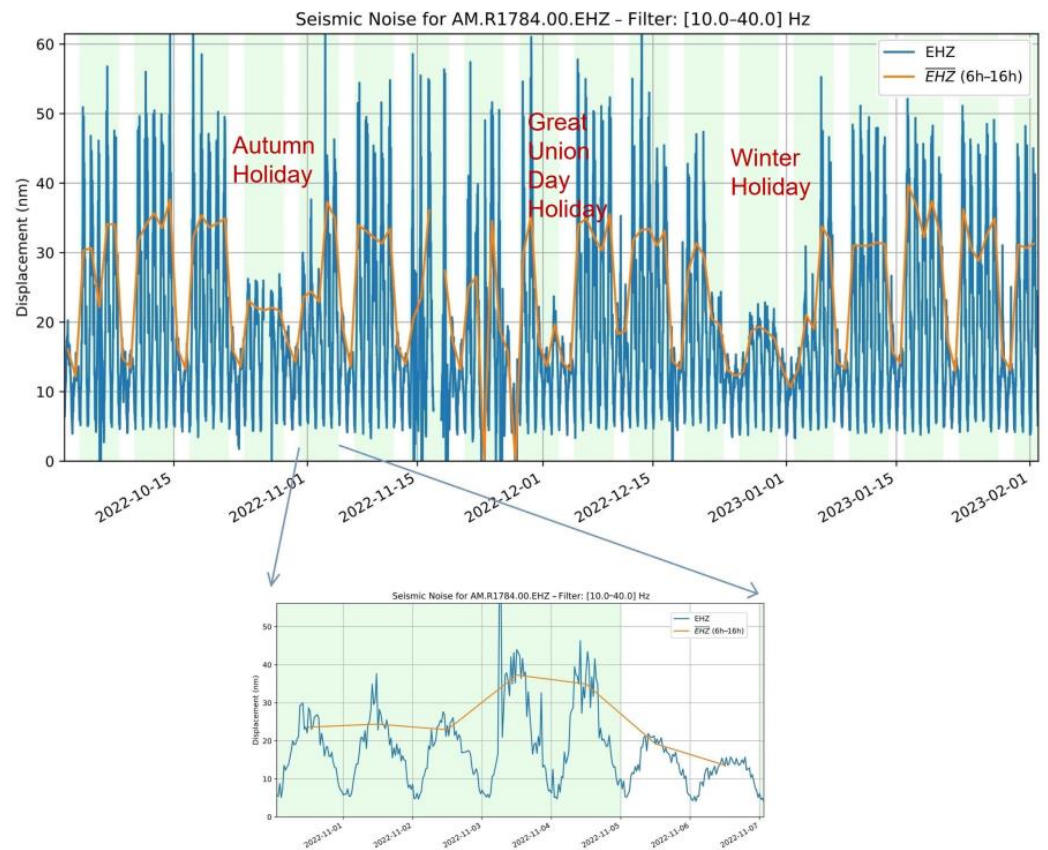


Figure 12. Long-term changes in seismic noise at the R1784 seismometer. The zoomed area highlights the 31 October–6 November 2022 week. The peak on 3 November corresponds to the $M_L = 5.3$ Vrancea earthquake.

5. Concluding Remarks

For more than 10 years, the National Institute for Earth Physics (NIEP) has been hosting, through EOT, a series of educational events (e.g., Otherwise School, Science and Technology Summer School in Măgurele, Researchers' Night, Seismology Workshops for students, teachers, and others) aimed to popularize geosciences among citizens and to raise awareness and reduce seismic risk. The citizen science activities promoted by NIEP at educational events have the dual objective of collecting data and increasing citizen engagement and participation. Thus, citizen participation in risk-related science activities has proven effective in increasing risk awareness and preparedness for disaster risk reduction. Risk awareness and preparedness are, in fact, the key to a better response before, during, and after seismic events and can greatly reduce the number of casualties.

These citizen science or educational networks with seismometers installed in civil buildings or schools are useful both for seismologists, as they complete the scientific data with real data, and for citizens who can obtain information about earthquakes directly. Citizen seismology has a high potential for raising community awareness of natural hazards. Citizens have an important role to play in gathering scientific data. Whether they like it or not, citizens are the first witnesses of seismic events and in such situations, they often have significant scientific knowledge that is too easily ignored. By involving citizens and using them as a primary source of information, scientists can study the population's reaction to seismic events (sociology of risk and risk management) and obtain important testimonies about the seismic events themselves. Thus, the aim of citizen seismology is to engage citizens to better understand seismic events and to protect societies more effectively.

In the present paper, we show the capability of a network of low-cost instruments (Raspberry Shake Citizen Science network) installed in an area with strong earthquake impacts (Bucharest) to provide useful data and information for the general public and for

research studies as well. To this aim, we analyze the data recorded by seven Raspberry Shake instruments between June 2020 and November 2022. During this time interval, 41 earthquakes with local magnitude above 4 (the largest magnitude being 5.3) were recorded, some of them being felt by the people in Bucharest. The rapid online access to seismograms and to online apps (ShakeNet Web and Desktop or Mobile) provides an excellent tool for citizen information and education. As our case study shows, the Raspberry Shake network can be useful in the rapid characterization of ground motion in correlation with macroseismic observations and in ambient noise analyses in urban areas.

The spectrograms and amplitude–time plots from the ASN analysis show characteristics often found at stations located near anthropogenic noise sources. Both outline an increase in seismic noise power during the day in the 0.02–0.5 s (2–50 Hz) period range and a decrease during the night. The amplitude–time plot and spectrogram for seismometer R1784 installed at the French School Anna de Noailles also indicate a clear variation in noise level between weekdays and weekends. Students attending classes are responsible for the increased noise levels observed from Monday to Friday. A similar behavior of the ASN was also observed for several professional stations belonging to the Romanian Seismic Network that were installed in schools and kindergartens in Bucharest [19], concluding that the decrease in noise levels is predominantly related to reduced human mobility inside the buildings where the stations are housed.

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