**B4-1**

**GMPEs used in seismic hazard assessment for Bulgaria-selection and testing in Bulgaria**

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Ground Motion Prediction Equations-GMPEs define the values of a ground motion parameter as a function of earthquake size and the distance in terms of both expected values and their dispersion. GMPEs are essential in probabilistic seismic hazard studies, which are a key step for the evaluation of seismic risk and loss estimation for a region. In the present study, six attenuation relationships were selected for shallow and three for intermediate depth earthquakes on the base of general criteria. The Nakamura method was applied to classify the soil conditions of Bulgarian stations. The LLH and LH approaches were used for quantifying the goodness of fit of these relations to a large dataset of ground motion data from Balkan region.

**B4-2**

**SYNCHRONIZATION OF MICRO-SEISMIC NOISE AND ITS STATISTICAL PARAMETERS BEFORE RIDGECREST EARTHQUAKE M7.1 ON 6-TH OF JULAY 2019**

Assist. Prof. Dr. Emil Oynakov1; Prof. DSc. Dimcho Solakov1; Assoc. Prof. Dr. Irena Aleksandrova1; Assist. Prof. Dr. Maria Chamati1

We analyze the micro-seismic noise recorded at five seismic stations – DEC, DJJ, FMP, MWC and RPV. They operate within CI: Southern California Seismic Network (SCSN), USA. The data set is collected from 01 July 2018 till 31 July 2019 and all seismic events with a magnitude Mw≤4 are excluded.
Our main goal is to find the effects of seismic noise synchronization between different seismic stations using data relevant to the vertical seismic components.
The width of the multifractal spectrum, the spectral exponent and Hurst exponent are determined, analyzed and discussed. About 150 days before Ridgecrest earthquake M7.1, the onset of low-frequency synchronization between all analyzed seismic stations is observed, rising to high frequencies as the earthquake approaches. Also a stable level of increasing coherence is observed which begins 70 days before the earthquake happened and remains at a relatively high level until the earthquake. There is an unusual and extremely increasing of Hurst and the spectral exponents 50 days before the earthquake.
Our study is an independent confirmation of scientific results obtained by other authors.

**B4-3**

**Seismic sources and Earth structure in the transition zone between Fore-Balkan unit and Moesian platform, NE Bulgaria**

Lilia Dimitrova, Gergana Georgieva, Petya Trifonova, Emil Oinakov, Valentina Protopopova & Metodi Metodiev

Investigations of hydraulically induced micro-seismicity are typically connected with magma injections, exploitation of geothermal fields and salt mines. Our study examines the seismicity and seismic sources in a peri-platform region with long salt production history. In addition, a very large site for extraction of aggregates and limestone is presented in the area. Increased seismicity in the region has been observed for several decades as during the study period of the last 12 years, more than 1000 events with magnitude

M < 4.3 have been registered. To study the complex seismic sources concentrated in such small area spatial distribution of seismicity and fault plane solutions are analyzed together with available geological and geophysical data, in order to connect registered earthquakes swarms with geological structures. Results show that several faults are outlined from geological information and confirmed by interpretation of geophysical data. Very different focal mechanisms calculated for the 13 earthquakes in the near region of the salt production site cannot propose a dominant fault mechanism and confirm the complexity of the seismic sources in the area. Our results suppose that activation of some of these structures is more likely due to water injected in the salt dome as part of the production process, which changes the stress equilibrium in the Earth crust.

**B4-4**

**CORRELATION BETWEEN GRAVITY AND MAGNETIC FIELDS ON THE TERRITORY OF BULGARIA**

**Assist. Prof. Dr. Emil Oynakov, Prof. DSc. Dimcho Solakov , Prof. Dr. Boyko Ranguelov, Prof. DSc. Stefan Dimovsky**

Correlation studies have been made between the gravitational field (Bouguer anomalies- G) and the magnetic field (common vector (T) and the vertical component dZ) for the territory of Bulgaria. The map data is in digital format, which makes it easier to calculate. The correlation itself is estimated from -1 to 0 and from 0 to +1, which means that a positive correlation is possible in the case of increased values of both parameters and vice versa - decreasing values are associated with reduced values. This forms a positive correlation. A negative correlation is observed when both parameters have minimum values. Zero correlation means - NO correlation (both parameters are min-max or max-min). The calculations from the maps give a clear picture of the positive and negative correlations and the ability to calculate areas with significant positive and /or negative correlations.

The results might be used for the interpretation of the studied potential fields in case of structural, regional and / or local changes in the gravity and magnetic fields, and their respective sources**.**

**B4-5**

**EFFECTS OF SYNCHRONIZATION BETWEEN ULTRA LOW FREQUENCY GEOMAGNETIC COMPONENTS VARIATIONS AND SEISMIC NOISE**

Assist. Prof. Dr. Maria Chamati, Assist. Prof. Dr. Emil Oynakov, Prof. DSc. Dimcho Solakov, Assoc. Prof. Dr. Irena Aleksandrova

We analyze a series of data in the ultra-low frequency (ULF) range of geomagnetic variations, which are collected from search coil instrument and acquisition system at Panagyuriste, Geomagnetic Observatory (PAG), Bulgaria, a part of South European Geomagnetic Array (SEGMA, http://sole-terra.aquila.infn.it/it/), and data for seismic noise collected at three Bulgarian seismic stations (VTS, RZN and KDZ part of National Operative Telemetric System for Seismological Information) and three Turkish seismic stations (GOM, KULA and ALAN, https://www.orfeus-eu.org). The analyzed time period begins at 01 December 2019 and lasts till 31 January 2020. DFA (detrended fluctuation analysis) scaling characteristics for two different time scales (10 – 180 sec. and 10 – 900 sec.), Hurst exponent and the coherence of the geomagnetic and seismic signals are determined and discussed. Wavelet analysis is applied to calculate and identify the dynamical behavior of the coherence of the width of singularity spectrum and of Hurst exponent for the vertical seismic components and the three geomagnetic components variations. We observe an unusual behavior

in all investigated parameters, which appears since the 22-nd of December 2019 till the end of January 2020 and two other periods (22-24 December 2019 and 10-12 January 2020) with unusual low levels for DFA exponent which appears for the vertical (Z) component of the geomagnetic field variations.
Based on the results obtained, we assume that such behavior of the studied parameters is not accidental and are most probably related to natural phenomena.

**B4-6**

**3D Modeling of Water-saturated Layers by Using the HVSR Method of Poisson**

**E. Oynakov, D. Solakov, I. Aleksandrova, M. Popova, D. Dragomirov**

Waters under Earth`s surface is difficult for direct observation, and so the monitoring, mapping and modeling are needed to determine the presence of subsurface waters. Usually, the geoelectrical method is used to determine the presence of underground waters. The present study shows that the HVSR method can be used in the research of underground waters.
The present study is aimed at researching the underground aquifer and the local geology of a landfill which spreads under three institutes of the Bulgarian Academy of Sciences (Institute of information and communication technologies, National institute of geophysics, geodesy and geography and Institute of Mechanics) with the use of HVSR method (Horizontal to Vertical Spectral Ratio).

**B4-7**

**SEISMICITY IN BULGARIA AND SURROUNDINGS IN THE FIRST 20 YEARS OF THE TWENTY-FIRST CENTURY**

**Dr. Mariya Popova, Dragomir Dragomirov, Assist. Prof. Dr Emil Oynakov, Valentin Buchakchiev, Yordan Milkov**

An earthquake catalogue covering the seismicity on the territory of Bulgaria and adjacent lands for the period 2000-2020 is presented in the current study. In this catalogue are included events with magnitude equal to or larger than Mw ≥ 2.5. As a country, Bulgaria belongs to the Alpo-Hymalian seismic belt, it is also not absent of strong earthquakes. Bulgaria is an earthquake prone country taking in account that on its territory are recorded some of the strongest earthquakes from the beginning of the last century until present day. The seismology in Bulgaria dates back to the beginning of the 20th century with the installation of the first seismograph on the territory of the country, going through the modernisation and establishment in 2006 of NOTSSI (National Operative Telemetric System for Seismological Information) and until today when there are 26 stations (this number includes two local seismic networks in Kozloduy and Provadia) from which NOTSSI receives real-time data. In the present catalogue, Mw magnitude is calculated for the entire period applying regression equations converting magnitude scales used in Bulgarian seismological routine practice (Md and Mp) to the most reliable and widely used scale of magnitude, i.e. the seismic moment magnitude, Mw. The current study presents spatial and temporal distribution of the earthquakes for the period 2000-2020. Before analysis of the data the catalogue was declustered –aftershocks and foreshocks were removed as well as artificial events such as explosions.
The fullness of the catalogue is examined through Gutenberg-Richter graphic. A depth-magnitude frequency histogram is done to establish earthquakes with what depth and magnitude are most often observed.

**B4-8**

**SPATIAL VARIATION OF PRECURSORY SEISMIC QUIESCENCE OBSERVED BEFORE EARTHQUAKE FROM 01.04.2010 IN THE REGION OF CRETE**

**Emil Oynakov, Dimcho Solakov, Irena Aleksandrova, Jordan Milkov**

Statistical analysis was performed, which reveals statistical parameters of the seismic setting before the earthquake in the region of Crete (01.04.2011 with coordinates 26.56oE, 35.64oN; Ml = 6.2, h = 63 km and T0 =13: 29: 10.5). For this purpose, the spatial and temporal changes in the b-value and the value of the Z-seismic lull were estimated. The temporary change in the b-value shows that the average value of b decreased from 1.75 ± 0.02 between 1985 and 2002 to 1.4 ± 0.02 between 2003 and 2011. A significant decrease in the b-value and clear anomalies of calm in the Z-value in early 2011 were also observed in several neighboring areas. The epicenter of the earthquake falls in an area with a relatively low value of the a-parameter estimated for the entire previous period. In the study area, the abnormal decreasing trend of the b-value may be an indicator of increased stress, and the increasing trend of the Z-value may indicate areas of calm before the studied earthquake.

**B4-9**

**ASSESSMENT OF THE HISTORICAL AND RECENT SEISMICITY OF THE BLACK SEA REGION**

**Assoc. Prof. Dr. Liliya Dimitrova, Assis. Prof. Dr. Emil Oynakov, Assoc. Prof. Dr. Eng. Lyubka Pashova Mag. Dragomir Dragomirov**

The study of seismicity in the Black Sea region is of particular interest for assessing the vulnerability of the surrounding coastal zones to strong earthquakes and their consequences. The seismicity pattern in the area is determined by the geodynamic processes along the boundaries of the Eurasian, Anatolian and Arabian tectonic plates. The paper presents an approach to assessing the seismic activity of the Black Sea and the surrounding region covering historical and recent seismicity. The historical events since after Christ are included in the catalogue compiled in our previous study, which contains 6468 de-clustered events from 1905 to 2021 with a magnitude M≥3. All catalogue data are processed by ZMAP, which is routinely applied in the seismological practice to evaluate catalogue quality and in routine network operations. Based on the Frequency-Magnitude Distribution of the overall catalogue, we compiled the magnitude of completeness Mc, b-value and probability maps with their error evaluations for the two periods: recent seismicity (1977-2021) and including historical events, respectively.

The catalogue data show a significant increase in small to moderate (3.0≤M<5.0) earthquakes after 1980. The considerable increase in the number of seismic stations installed in the countries bordering the Black Sea increases the sensitivity to earthquake detection capability. The seismic events are clustered to the strongest (M≥6) earthquakes and outlined the main seismic zones: Shabla-Kaliakra, the Crimean peninsula, three clusters located on the eastern shores of the Black Sea, and one on the southern coast near Bartin, Turkey. These seismic zones outline tectonic units, with specific seismicity patterns in the locations of the clusters.

**B4-10**

**Experimental Evaluation of the Dynamical Parameters f0 and $A_0$ Using the Method HVSR**

**M. Popova1, E. Oynakov1, D. Solakov1, I. Aleksandrova1, D. Dragomirov1, R. Ivanov1**

Microzonation is one of the main tasks in the analysis of the seismic hazard, seismic risk and the following political planning to lower damage from earthquakes. For the purposes of microzonation first the dynamical capabilities of the soil have to be determined. This information can be attained by invasive and time-consuming methods. Extra problems arise in a city area where the measurements are affected by industrial noise and traffic. It is necessary the development of quick, effective and non-invasive methods aimed at the evaluation of the seismic characteristic of the upper layers of Earth`s crust. Passive seismic methods depend on the registration and analysis of microseismic noise from a natural, as well as from anthropogenic origin, the latter being very common in cities.
In this research for the purpose of evaluating the resonance effects by seismic waves is used the method of Horizontal to Vertical Spectral Ratio (HVSR) of microseismic noise, which can evaluate the relation between soil/construction. For areas with potentially high seismic risk, like the one that is observed in the area of Sofia, this method is suitable. This method is suitable for a city area because it does not need sources of artificial origin.

**Г7-1**

**COMPARISON OF NOTSSI NETWORK STATIONS' CORRECTIONS, AFTER ANALYSIS OF THE SEISMIC NOISE AND EARTHQUAKES, USING THE METHOD FOR CALCULATING THE RATIO OF THE AMPLITUDE SPECTRUES OF H-V SIGNAL COMPONENTS**

**Assoc. Prof. Dr. Irena Aleksandrova, Prof. DSc. Dimcho Solakov, Assist. Prof. Dr. Emil Oynakov**

Eleven stations of the Bulgarian seismological network - National Operating Telemetry System for Seismological Information have been used for an assessment of the stations' corrections (site effect), to account for the impact on the seismic waves of the low-density layer immediately below the seismic stations, amplifying the signal. Nakamura's method for calculating the ratio of the spectrum of the horizontal component to the spectrum of the vertical component (H-to-V) is applied. Data from 20 local and regional earthquakes and more than 1,300 sixty-second seismic noise recordings were analyzed.
The initial data are 2-hour records of seismic noise and 60-second records of earthquakes S-waves. The standard deviations are calculated - microseismic noise /earthquake. The stations' corrections for seismic noise in the range from 0.5 to 20 Hz and S - waves of earthquakes - in the range from 0.5 to 20 Hz are estimated. For some of the stations - VTS1, PSN, KKB, KDZ, SZH, TRAN and PRD the spectral ratio curves are identical. For five of the stations - KKB, MMB, PLD, PRD and VTS1 H / V the spectral ratio fluctuates in the range 0.6 - 3, while for stations KDZ, PGB, PSN, SZH and TRAN it changes in the range 0.4 - 6. The values of A0 (f0) – amplification factor (site-effect) and f0 - resonant frequency, were obtained. A comparison of the curves of the spectral H / V ratios obtained in both ways is presented. The correlation coefficients for the curves of the spectral H / V ratios, using different methods, are obtained.

**Г7-2**

**Spatial and time variations of seismicity before strong earthquakes in the southern part of the Balkans**

**Emil Oynakov, Emil Botev**

A retrospective analysis of the spatial and time variations of three main statistical parameters of the seismicity before recent 4 stronger earthquakes (2015 – 2020) in the southern Balkans is presented. The modern extended software package ZMAP with various advanced seismological functions for earthquake catalog analysis is used for estimating the spatial-time variations in a-value (seismic activity), b-value (slope

of the recurrence graph) and z-value (parameter of the relative seismic quiescence). The catalog data from constantly updated catalog of the University of Athens for the period 1964-2020 and spatial window 32° - 44° N and 10° – 30° E are used for the various statistical interpretations. The main result of the whole analysis is that the abnormally low b-values and high z-values, defining the zones of relatively seismic quiescence, may be an indicator of imminent release of more significant stress in areas adjacent to the zones of relatively high a-values. Thus, the result of the proposed joint interpretation of the spatial-time variations of these three statistical parameters of seismicity could be considered as a kind of predictor of the stronger recent seismic events in the southern part of Balkans.

**Г7-3**

**Fractal Properties of Seismicity and Active Faults in Balkans**

**E. Oynakov and E. Botev**

The fractal properties of seismicity and active faults in Balkans have been studied on the basis of data for distribution of earthquakes and active fault structures in the region. It was found that the fractal dimension of the area distribution of earthquake epicenters for the Balkans $d_E$ is 1.74, the fractal dimension of the time distribution of the b-value from the recurrence graph of earthquakes is equal to 0.97 and the fractal dimension of the spatial distribution of fault structures $d_f$ is 1.66. The obtained results are the basis of the interpretation of self-similarity and self-organization of the two main geodynamic elements – the regional seismicity and the fault network of the Balkans.

**Г7-4**

**ASSESSMENT OF STATION CORECTIONS (SITE-EFFECT) FOR SEISMIC STATIONS FROM THE BULGARIAN SEISMIC NETWORK CALCULATED ON THE BASIS OF LOCAL AND REGIONAL EARTHQUAKES**

**Assist. Prof. Dr. Emil Oynakov, Prof. DSc. Dimcho Solakov, Assoc. Prof. Dr. Irena Aleksandrova**

The present study focuses on the assessment of station corrections for eleven seismic stations from the national network of National Operative Telemetric System for Seismological Information (NOTSSI). Station corrections are obtained by calculating the ratio of the spectrum of the horizontal components of the signal to the spectrum of the vertical component (H / V). Records of S-waves from 20 local and regional earthquakes are analyzed. The values of $A_0$ - site-effect and $f_0$ - resonant frequency were obtained. According to the type of obtained H / V- ratio curves, the studied seismic stations from the NOTSSI network can be divided into two groups. The first group includes stations with stable amplitude-frequency characteristics of the seismic signal - PRD, PLN, PLD, KDZ, MMB, KKB and VTS1. The resulting H / V ratio curves are close to straight lines with an amplitude of a unit. The second group of seismic stations are stations with medium level of amplification (2-3 times) - SZH, TRAN and PSN. The highest amplification for these stations is at frequencies from 4 to 4.5 Hz, which is probably an evidence of low impedance contrast between the foundation and the deposits. Polarization analysis for seismic stations is presented in order to study the influence of the location of the source (i.e. the azimuth from the source) on the level of motion amplification in the surface layer of the location. The obtained results give grounds for the conclusion that most stations in the network are "good" - i.e. no increase in the amplitudes of the recorded signals is observed due to resonant phenomena.

**Г7-5**

**CO-SEISMIC SURFACE DISPLACEMENTS AFTER THE EARTHQUAKES IN LARISSA, 3 MARCH 2021, DERIVED BY DINSAR**

**Assoc. Prof. Dr. Mila Atanasova, Assoc. Prof. Dr. Hristo Nikolov, Assist. Prof. Dr. Emil Oynakov**

The focus of this study is detection of the deformations of the Earth's surface caused by March 3 2021 earthquake using Differential Interferometric Radar Synthetic Aperture technique. This method takes advantage of the remotely sensed SAR data provided at no cost by ESAs' Sentinel-1 mission which are often used for creation of topographic maps as well as for detection of ground motions. The final results of this processing deliver reliable information about the displacements caused by the mentioned events with centimeter accuracy. The DInSAR approach is based on precise measurements of the phase of the backscattered from the surface radar signal at different dates of acquisition.

Based on the differences registered in both signals conclusions on the relative motions are drawn from the created interferometric image (IFI). In the course of the IFI formation a measure of its quality, named coherence, is created too. It needs to be emphasized that the registered ground displacements are in the line-of-sight of the radar and after additional calculations can be transformed into subsidence values.

For this research produced were IFIs from two ascending (south-north) and two descending (north-south) orbits of the satellite which provided more details on the occurred ground motions after all earthquake events. The time period covered by the IFIs is from February 25th 2021 to March 20th 2021. The results obtained exhibited high values in the coherence images which guarantee reliability of the final information. All geocoded IFIs were co-registered to the first one which is produced. After that several profile lines reflecting the surface displacements resulting from the events were produced.

**Г7-6**

**Study of the Seasonal Changes of the Amplitude-frequency Characteristics of the Microseismic Noise**

**E. Oynakov, D. Solakov, I. Aleksandrova**

The aim of the present study is to assess and analyze the amplitude-frequency composition of microseismic oscillations and their possible seasonal variations in the territory of the seismic network NOTSSI (National Operating Telemetry System for Seismological Information) with the method of spectral relations (H / V).

Researchers of the consequences of strong and catastrophic earthquakes prove that the surface sedimentary layer can significantly increase the amplitudes of surface seismic waves, which can cause further destruction Borcherdt (1970, 1992). Determining the influence of the geological environment on seismic waves, in this sense, is an important component of the micro-zoning of areas with moderate and high seismic activity. The most commonly used method of a wide range of developed methods Andrews (1996), Field (1993), Lermo (1994), and Drouet (2008) for estimating the amplitude-frequency characteristics of the surface layer is the method of H / V spectral relations (Nakamura method).

The aim of the present study is to assess and analyze the amplitude-frequency composition of microseismic oscillations and their possible seasonal variations in the territory of the seismic network NOTSSI (National Operating Telemetry System for Seismological Information) with the method of spectral relations (H / V).

**Г8-1**

**Sensitivity of the Method of Microseismic Sounding for the Depth's Research in Different Seismic Zones - Vrancea and Calabria.**

**E.Oynakov, B.Rangelov**

The application of a method for constructing a deep model according the relative variation of the amplitudes and relative contrast of seismic velocities using the records of microseismic noise of fixed broadband seismic stations is presented. This research examines the effect on the sensitivity of the method and resolution in depth, using different time series of the microseismic noise. The methodology is based on an assessment of the statistical parameters of the distributions (dispersion, mean square deviation, the contrast of the relative sounding velocities to the different modes of noise) thus obtaining the deep velocity structures of reconstructed geological model.

**Г8-2**

**DEEP SEISMIC SOUNDING BY MICROSEISMIC TREMOR (SSMT) BROADBAND SIGNALS FOR CALABRIA SEISMIC ZONE**

**Oynakov E.**

The microseismic noise and its components of the Raleigh waves are applied for the velocity inhomogeneities exploration of the Calabria Arc deep seismogenic structure. The method of the microseismic depth's sounding consists of two main components – use of a broadband seismic network for the noise registration and use the natural microseismic noise for depth differentiation with good resolution for the structural reveal of the subducted layers. Advantages of the method are: satisfaction of the modern environmental requirements for non-blast study of deep velocity structure and use of natural seismic noise like probe sounding of significant depths. The results of data processing of the 58 broadband seismic stations on the territory of southern Italy covering the Calabrian arc are presented.

**Г8-3**

**PROJECT A C U S A N (ACOUSTIC INVESTIGATIONS IN ANTARCTICA)**

**Boyko Ranguelov, Tatiana Asenova, Emil Oinakov**

Проектът АКУСАН (Акустически изследвания в Антарктида) е представен и одобрен през 2016 година от Българския Антарктически Институт (БАИ). Основната му цел е чрез измервания и документиране на различни акустични сигнали и шумове, да се охарактеризира акустичната среда в района на Българската Антарктическа База (БАБ). Проектът има както чисто физически, така и някои психологически и психосоматични задачи, за да определи как и по какъв начин влияят на българските изследователи пребиваващи на БАБ по време на антарктическото лято, звуците и шумовете от естествен и/или антропогенен произход. Като се има предвид абсолютната девственост на околната шумова среда в околностите на БАБ, да се определят основните честотни и динамични характеристики на звуците, регистрирани в естествена среда с различна апаратура.
Попътно, друга основна задача решавана от изследователския екип е регистрацията на естествени и изкуствено създавани звуци и шумове по време на пътуването - до и от БАБ на остров Ливингстън. Като се има предвид богатото разнообразие на различните звукови източници по пътя на изследователите от естествени и изкуствени източници, да се проследят адаптационните

възможности на хората. Проектът включваше два етапа. Първи – събиране, регистрация и архивиране на различните звукови и шумови сигнали. Втори – обработка на данните и сигналите с цел, пълно охарактеризиране на спектралния и динамичен диапазон на акустичната среда – на БАБ и по дългия път към нея.

**Г8-4**

**СЕИЗМИЧЕН АНАЛИЗ НА ЗЕМЕТРЕСЕНИЕТО ОТ 26 НОЕМВРИ 2017 Г. В РАЙОНА НА ГРАД КЛИСУРА**

**Ирена Александрова, Пламена Райкова, Емил Ойнаков**

Представен е сеизмичният анализ на земетресението от 26 ноември 2017 г. с магнитуд Mp4.1, реализирано в района на гр. Клисура. Разгледани са спектралните характеристики на земетресението чрез използване модела на Брун. С прилагането на този модел са определени характеристики, свързани с източника на земетресението, като снето напрежение (Δσ), радиус на източника и магнитуд по сеизмичен момент (Mw). За земетресението е представено подробно изследване на макросеизмичното поле на въздействията. Приложен е и Методът на микросеизмичното сондиране за наблюдаваното събитие.

**Г8-5**

**PRELIMINARY DATA ABOUT THE ASTHENOSPHERE STRUCTURE IN BULGARIA**

**Dimcho Josifov, Boyko Ranguelov, Emil Oynakov**

A deep asthenosphere structure is investigated by the methods of passive seismic method. As a probe signal, the microseismic noise is used. The microseismic background is composed from different surface waves of Raleigh, generated by different sources. The noise has a wide spectrum, thus providing the different depth's penetration. The broadband seismic records of the sparsely distributed seismic stations on the Balkans provide the reliable information for the Method of Microseisms Sounding (MMS). The application of the method reviles the velocity inhomogeneities responsible for the low and high velocity layers under crust, interpreted as asthenosphere (low velocity bodies) and possible non transparent diffuse areas (high velocity bodies), isolating the crust from the asthenosphere more mobile strata. The maps of the asthenospehre depths and thicknesses are presented.

**Г8-6**

**RESEARCH ON THE FRACTAL STATISTICAL CHARACTERISTICS AS POSSIBLE PROGNOSTIC PARAMETERS FOR EARTHQUAKES, GENERATED IN THE SEISMIC ZONE OF VRANCEA, IN THE PERIOD BETWEEN 01.08.2016 AND 30.12.2016**

**E. Oynakov, D. Solakov, I. Aleksandrova**

Using fractal analysis is an excellent alternative method for decode the seismic noise structure. Fractal analysis of microseismic noise could also be an appropriate method to detect earthquake indicators. The scientific goal is to detect standard signals, based on different earthquakes' focal mechanisms, separating the "individual" behavior of the elements of the monitoring systems.

The method for describing low-frequency microseismic noise from the network of seismic stations in a seismically active region of the Vrancea used. Seismic records of twenty-three broadband stations were analyzed, situated at distances of 20 to 500 km from the Vrancea earthquakes whit magnitudes $M_w$=5.7

and $M_w$=5.6 on September 23 and December 27, 2016, respectively. The daily assessment values of three multifractal parameters (characteristics of the multifractal singularity spectra of the waveform) from each station used for the description.
The present paper is a continuation of previous work [Oynakov et al., 2019], where the effects of synchronization in the low-frequency microseismic field were found before the Vrancea earthquake with magnitude $M_p$=5.6 on October 28, 2019.
The study shows that the noise coherence measure increased for stations, closer to the epicenter. However, the question of the source of this coherence remains open.

**Г8-7**

**VARIATIONS OF THE PARAMETERS OF BACKGROUND SEISMIC NOISE IN THE STAGE OF PREPARATION OF STRONG EARTHQUAKES IN THE VRANCEA REGION**

**E. Oynakov, I. Aleksandrova, D. Solakov**

The Balkans, including Bulgaria, is one of the most seismogenic zones in Europe. The relatively small depth of the hypocentres of earthquakes - up to 60-70 km, could greatly increase the effects on the ground surface. In conditions of relatively high population density and high urban constructions, even a moderate magnitude earthquake could lead to increased unfavorable consequences - destruction and human loses. The global impacts of atmospheric and oceanic processes, tidal deformations of the earth ‘s crust, as well as the less well-studied processes in the Earth ‘s crust, are associated with accumulation and slow dissipation of tectonic energy in the lithosphere.
These processes are the „ participants “ in the formation of the random process, where the traditional apparatus of spectral analysis is less effective. The usage of fractal analysis for decipher the structure of seismic noise is a good enough alternative. Since the early 1990s, the method is used in both: turbulence analysis and in financial and medical time series studies.
The development of new methods for earthquake forecasting based on data from geophysical and, in particular, seismic monitoring, is one of the priority goals of Earth science. Seismic records of twenty-three Balkan Peninsula stations were analyzed, at distances of 1 to 500 km far from the earthquake on 23.09.2016, 27.12.2016 and 28.10.2018 with magnitude more 5.5 in seismic zone Vranchea. For the analysis, the Lubusin method was used for fractal analysis of scalar time series.
A scientific goal is to detect common signals ignoring the „individual“ behavior of the elements of the monitoring systems.

**Г8-8**

**SEISMICITY ON THE TERRITORY OF BULGARIA AND THE ADJACENT LANDS RECORDED BY NOTSSI IN 2017**

**V. Buchakchiev, E. Oynakov, D. Dragomirov, Y. Milkov**

A map of epicenters of 114 earthquakes with magnitude Mw >= 2.5 that occurred during 2017 in Bulgaria and surroundings (sector outlined by latitude j = 41$^o$- 44.5$^o$ N and longitude l = 22$^o$- 29$^o$ E) registered by NOTSSI is presented. Expert generalized analysis is proposed. Catalog of earthquakes is applied.

**Г8-9**

**ФРАКТАЛНИ ХАРАКТЕРИСТИКИ НА СЛУЧАЙНИТЕ ФЛУКТУАЦИИ НА СЕИЗМИЧНИТЕ ЗАПИСИ (МАМТЕМАТИЧЕСКИ АПАРАТ И СХЕМА НА ПОЕТАПНАТА ОБРАБОТКА)**

**Емил Ойнаков, Димчо Солаков, Ирена Александрова**

Едно от направленията за прогнозиране на земетресения е свързано с търсенето и установяването на сигнали-предиктори на земетресенията в сеизмичните записи. Използваните в настоящия момент сеизмични датчици са слабо чувствителни към сигнали-предиктори на земетресения, които са „скрити“ в микросеизмичния шум. Микросеизмичният шум не съдържа монохроматични компоненти и затова традиционно използваният в геофизичната практика спектрален анализ за неговото изследване се оказва неефективен. По тази причина се разработват различни математически методи за откриване в микросеизмичния шум на сигнали, предвестници на земетресения. В настоящата статия е представен подход, използващ апарата на мултифракталния анализ, позволяващ най-детайлно да бъде описана структурата на шума в дните от системите за сеизмологичен мониторинг.

**Г8-10**

**СЕИЗМИЧНИ ХАРАКТЕРИСТИКИ НА ЗЕМЕТРЕСЕНИЕТО ОТ 28.10.2018 Г., ГЕНЕРИРАНО В СЕИЗМОГЕННА ОБЛАСТ ВРАНЧА, РУМЪНИЯ**

**Емил Ойнаков, Ирена Александрова**

On October 28th 2018, in the Focsani depression - the seismogenic zone of Vrancea, Romania, another earthquake occurred, with a large area of influence on the territory of Bulgaria. Based on an analysis if received reports, describing the feeling and other effects, an intensive map of the seismic impact on people and the environment on the territory of the country was built. The maximum intensity (Imax) with which the earthquake was felt in our country is from the 5th grade on the Medvedev–Sponheuer–Karnik scale (MSK-64). The seismic forecast properties of the microseismic noise in the minute range (i.e., half a minute report), recorded in seismic stations, located on the territory of the Balkan Peninsula were examined. It has been applied a methodology, developed by Lyubushin, A.A. (1998, 2007, 2009), corresponding to the specificity of the studied region. All calculations are done in MATLAB. Characteristic changes of the statistical parameters of the background seismic noise were determined a few days before the earthquake, expressed by the relative reduction of the parameter's singular spectrum width ($\Delta\alpha$, $\alpha^*$) and increase of the Hearst index (H). The effect of synchronization of ground seismic noise in the earthquake preparation stage was sought. On the basis of the study, characteristic changes of the statistical parameters of the background seismic noise were established several days before the Vrancea earthquake (28.10.2018) with Mw = 5.5, which represents a relative decrease of the parameters $\Delta\alpha$, $\alpha^*$ and an increase of the parameter H. A method is presented in the study of the dynamics of the seismic noise before the event with the use of continuous time series of the statistical parameters $\Delta\alpha$, $\alpha^*$ and H. The effect of synchronization of the seismic noise in the earthquake preparation stage was discovered near the epicenter and within a distance of 250 km from it.

**Г8-11**

**СЕИЗМОПРОГНОСТИЧНИ СВОЙСТВА НА МИКРОСЕИЗМИЧЕН ШУМ В МИНУТНИЯ ДИАПАЗОН**

**Емил Ойнаков, Димчо Солаков, Бойко Рангелов**

За разшифроването на структурата на сеизмичния шум, използването на фракталния анализ се оказва добра алтернатива (Любушин, 2007). Този метод се използва от началото на 90-те години за

анализ на различни процеси (турбулентност, променлива геометрия във времето на различни обекти и други времеви редове).
Изследвани са сеизмопрогностичните свойства на микросеизмичен шум в минутния диапазон (т.е. 1 отчет на половин минута), регистриран на сеизмичните станции разположени на територията на Балканския полуостров. Метода се основава на методиката разработена от А. А. Любушин (Любушин,2009-2014) и отчитане на спецификата на всеки изследван регион. С този подход са определени относително малки по продължителност ефекти на синхронизация в поведението на сеизмичния шум от 3 до 5 дни преди земетресението на 28.10.2018 (Вранча, 00:38:15; 45.7/26.4; M = 5.5).

**Г8-12**

**SEISMICITY ON THE TERRITORY OF BULGARIA AND THE ADJACENT LANDS RECORDED BY NOTSSI IN 2018**

**D. Dragomirov, E. Oynakov, V. Buchakchiev, Y. Milkov**

A map of epicenters of 168 earthquakes with magnitude M >= 2.5 that occurred during 2018 in Bulgaria and surroundings (sector outlined by latitude = 41°-44.5° N and longitude = 22°- 29° E) registered by NOTSSI is presented. Expert generalized analysis is proposed. Catalog of earthquakes is applied.

**Г8-13**

**SEISMICITY PATTERNS ASSOCIATED WITH EARTHQUAKES ON THE BALKAN PENINSULA**

**Emil Oynakov, Dimcho Solakov, Irena Aleksandrova, Jordan Milkov**

Statistical analysis was performed, which revealed statistical parameters of the seismic setting before the earthquake in the region of Crete (01.04.2011 with coordinates 26.56°E, 35.64°N; $M_l$ = 6.2, h = 63 km and T0 = 13: 29: 10.5). For this purpose, the spatial and temporal changes in the b-value and the value of the Z-seismic lull were estimated. The temporary change in the b-value shows that the average value of b decreased from 1.75 ± 0.02 between 1985 and 2002 to 1.4 ± 0.02 between 2003 and 2011. A significant decrease in the b-value and clear anomalies of calm in the Z-value in early 2011 were also observed in several neighboring areas. The epicenter of the earthquake falls in an area with a relatively low value of the a-parameter estimated for the entire previous period. In the study area, the abnormal decreasing trend of the b-value may be an indicator of increased stress, and the increasing trend of the Z-value may indicate areas of calm before the studied earthquake.

**Г8-14**

**SEISMIC STATIONS SITE-EFFECT FOR THE NATIONAL OPERATIVE TELEMETRIC SYSTEM FOR SEISMOLOGICAL INFORMATION (NOTSSI) NETWORK CALCULATED ON THE BASIS OF MICROSEISMIC NOISE**

**Emil Oynakov, Dimcho Solakov, Irena Aleksandrova**

The present study investigates the characteristics of seismic sites of some of the NOTSSI monitoring network stations, based on microseismic noise. Nakamura's method of the spectral ratio of the horizontal to the vertical components of the seismic noise (H / V), directly related to the S-wave velocity of distribution (Vs) at the observed site was used for calculating the station repairs. The spectral H / V ratio of the seismic noise for 11 seismic stations is calculated, combined with geological data bellow each

station. The values of $A_0$ - site-effect, $f_0$ – resonance frequency and h - depth of reference at the most contrasting resonance boundary were obtained. Attention is paid to seismic instruments and sensors.

**Г8-15**

**HIDDEN PERIODICITY IN THE "STREAM" OF EARTHQUAKES IN THE SOUTHERN PART OF THE BALKAN PENINSULA**

**Emil Oynakov, Emil Botev**

The results of a research of the periodic components of seismicity in the southern part of the Balkan Peninsula are presented. Time-stable periods have been found and a model has been constructed on this basis. Most of the obtained periods coincide or are close to the periods obtained for the global seismic process on Earth. In the spectrum of fluctuations in the intensity of the "stream" of seismic events there is a clear peak with a period of 11-12 years, which coincides with the period of change in solar activity. The obtained results shed light on the nature of modern deformation processes and cycles of crustal destruction during earthquakes in the southern part of the Balkan Peninsula.

**Г8-16**

**SEISMICITY ON THE TERRITORY OF BULGARIA AND THE ADJACENT LANDS RECORDED BY NOTSSI IN 2019**

**D. Dragomirov, E. Oynakov, V. Buchakchiev, Y. Milkov**

A map of epicenters of 129 earthquakes with magnitude M >= 2.5 that occurred during 2019 in Bulgaria and surroundings (sector outlined by latitude = 41°- 44.5° N and longitude = 22°- 29° E) registered by NOTSSI is presented. Expert generalized analysis is proposed. Catalog of earthquakes is applied.

**Г8-17**

**SEISMICITY ON THE TERRITORY OF BULGARIA AND SURROUNDINGS RECORDED BY NOTSSI FOR THE PERIOD 2017-2019**

**Dragomir Dragomirov, Emil Oynakov, Valentin Buchakchiev, Yordan Milkov**

A map of epicenters of 411 earthquakes with magnitude Mw >= 2.5 that occurred from 2017 to 2019 in Bulgaria and surroundings (sector outlined by latitude = 41°- 44.5° N and longitude = 22°- 29° E) registered by NOTSSI is presented. Analysis is done on the distribution of the events through time and space, magnitude and depth. The events frequency progression is analyzed for the whole studied period and then compared with each year separately. Generalized analysis is proposed as to what can contribute to variations in the data for the studied period. Catalog of earthquakes with magnitude Mw >= 3.5 is applied.