AFROS Virtual Platform - Explanations

http://afros.infp.ro/AFROS.php

Seismicity

One can select the latitudes, longitudes, magnitudes, depths and time interval (format: YYYY-MM-DD) of interest.

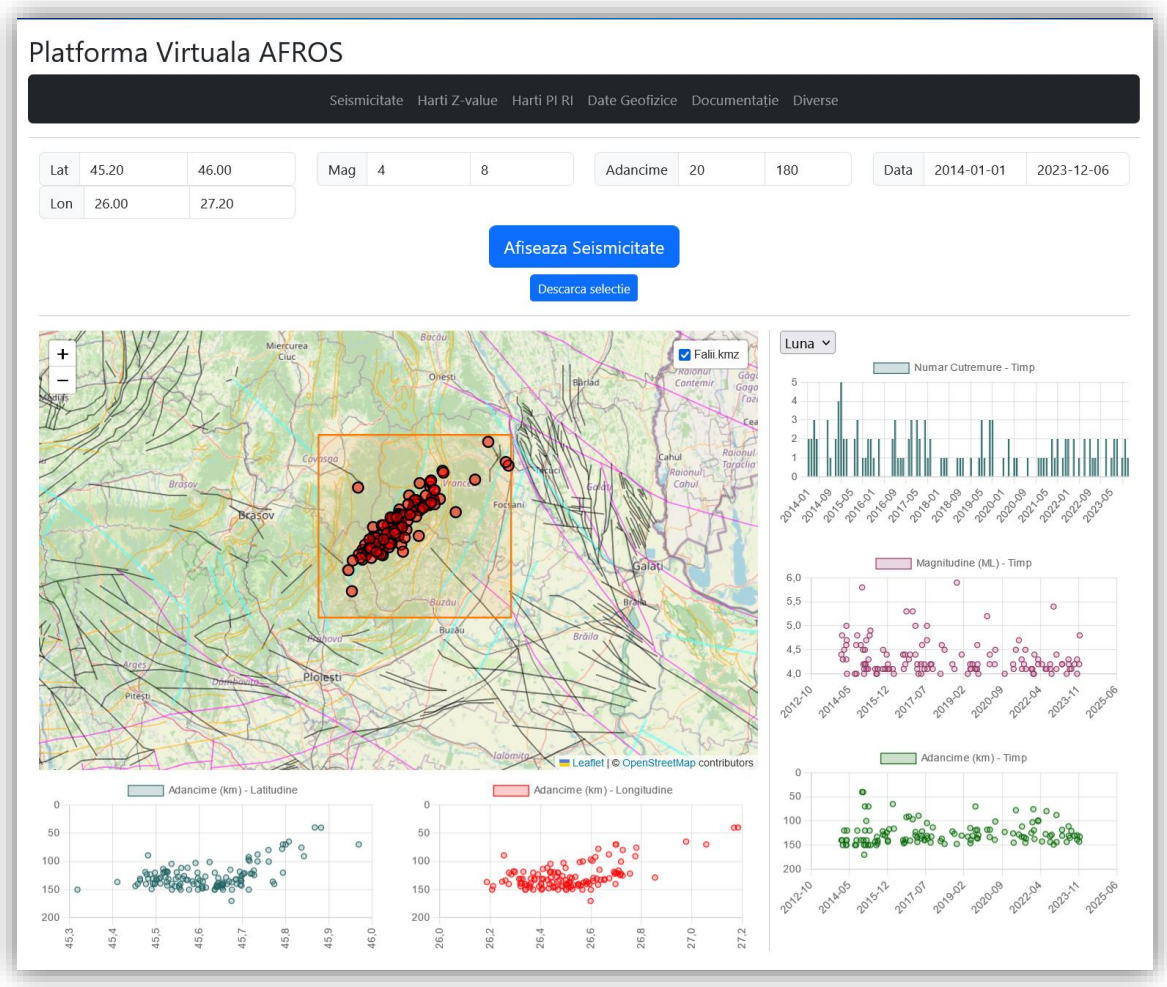

Figure 1. The first part of the Seismicity page in AFROS (the shown figure is from the Romanian version of the platform, but the setting is the same).
http://afros.infp.ro/AFROS.php?link=seismicitate

The minimum magnitude that can be selected is 2.0.

The available earthquake catalog is the one that contains real-time seismicity, in the „Dataportal" system. The first earthquake that is recorded in the catalog is from November 18, 2012.

Date/Local tine	Latitudine	Longitudine	Depth	Geographic area	Magnitude
11/18/2012 22:35	45.3221	27.0107	23.1	SEISMIC VRANCEA ZONE, BUZĂU COUNTY	1.2

The first two years of the catalog are transition years, so for data selection we recommend the period after November/December 2014. The predefined selection contains seismicity from the Vrancea area.

Pressing the "Show Seismicity" button will display the selection of earthquakes in the map/graphs from the Seismicity page, and pressing "Download selection" allows the selected data to be saved in "json" format (for processing with other programs, etc. .).

On the right side of the map, the page displays (from top to bottom): "Number of earthquakes vs. time", "Magnitude (ML) - Time" and "Depth (km) - Time". The histogram "Number of earthquakes as a function of time" can be made monthly or annually.

At the bottom of the map, two graphs are displayed: "Depth (km) - Latitude" and "Depth (km) - Longitude".

Below these graphs presented in Figure 1, the "Frequency - Magnitude (ML)" graph of earthquakes is displayed (Figure 2).

Frequency is given in log (N) form, where N is the cumulative number of earthquakes of magnitude greater than or equal to M. The graph also displays the slope of the distribution, b, from the equation:

$$\log N = a - bM \quad (1)$$

Global-scale seismicity is characterized by a value of b around 1.0. Values greater than 1.0 show the relative predominance of smaller earthquakes, while a value less than 1.0 shows the relative predominance of larger earthquakes. Numerous authors have observed a decrease in the parameter b before stronger earthquakes

The graph at the bottom of the page represents accumulated energy as a function of time. The energy is calculated based on the magnitude of the earthquakes, using the formula:

$$\text{Energy} = 10^{(1.5*\text{Magnitude} + 4.8)} \quad (2)$$

Cumulative energy is calculated by summing the energy values for each earthquake and then converting to equivalent magnitude units (which are plotted on the vertical axis).

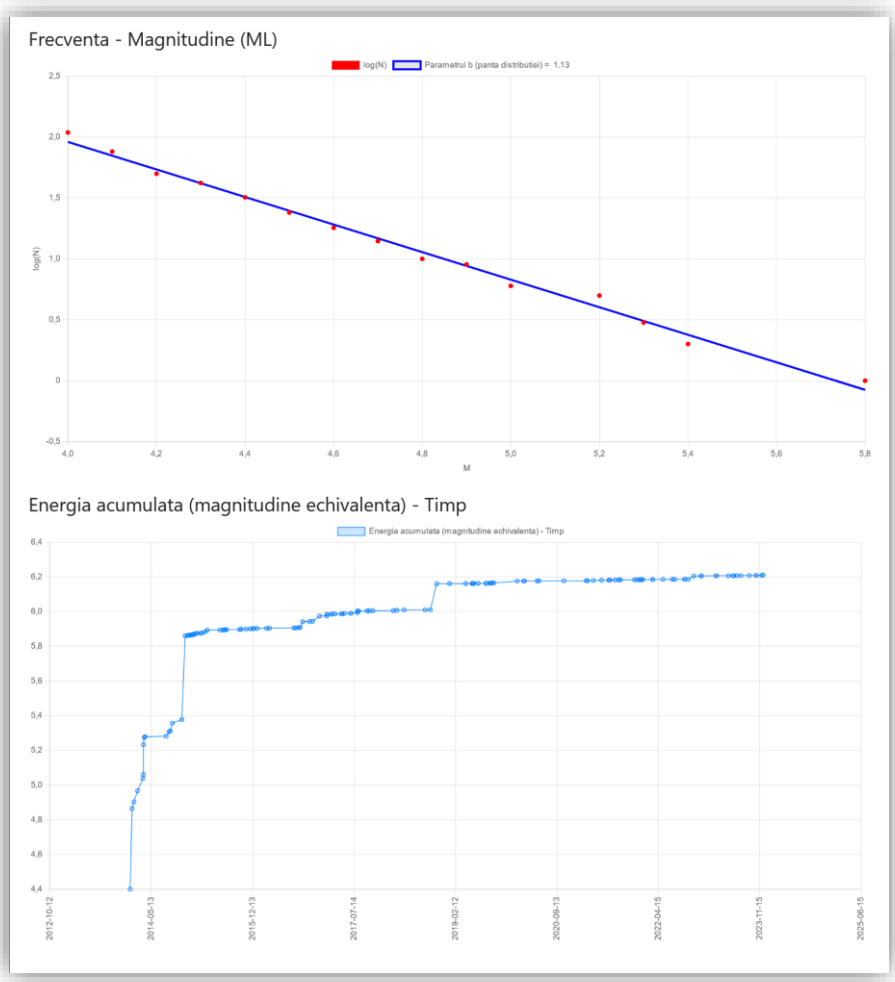

Figure 2. The second part of the Seismicity page, from the AFROS platform http://afros.infp.ro/AFROS.php?link=seismicitate

Z-value maps

The Z parameter is a statistical parameter that can be used to indicate a relative increase or decrease in seismicity rate between two time periods; is mathematically defined as: where,

$$z = \frac{m_1 - m_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \qquad (3)$$

- m_1 și m_2 reprezent the average rates of earthquakes for the 2 perioads (W_1 și W_2) that we would like to compaere;
- n_1, n_2 și s_1, s_2 are, respectively, the numbers of earthquakes and the standard deviations for the 2 time perioads.

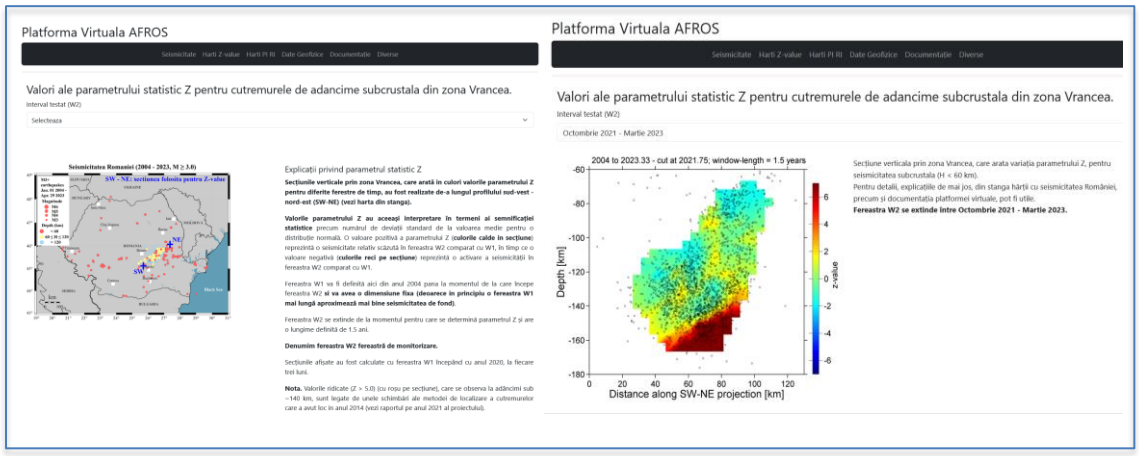

Figure 3. Pages 1 si 2 of “Z-value maps”, from the AFROS platform

On this page we present the variation of the Z parameter on a depth section oriented SW – NE, through the Vrancea area. We present results only for the range of intermediate (sub-crustal) earthquake depths.
The calculation algorithm to produce the depth sections of the "Z-value" is:
1. All earthquakes of intermediate depth in the Vrancea area (h >= 60 km), with M >= 3.0, are projected on a SW-NE section.
2. On the plan defined in (1), a network is formed that has the distance between nodes of 5 km x 5 km, covering most of the earthquakes in the section (see Figure 12 of the 2021 project report, in Romanian).
(Report 2021: http://afros.infp.ro/documente/raport_AFROS_2021_RO.pdf).
3. For each network node, the nearest 100 earthquakes are selected for the calculation of the Z parameter.
4. The Z parameter is calculated, for each node, using the formula above.
5. The values of the Z parameter are interpolated to create the figure showing the distribution of the parameter along the section, by depth (Figure 13 of the 2021 report).

A positive value of the Z parameter (warm colors on the map) represents relatively low seismicity in the W2 window compared to W1, while a negative value (cool colors on the map) represents an activation of seismicity in the W2 window compared to W1. The W1 window is variable and will be defined here from the year 2004 until the time when the W2 window begins. Ideally, a longer W1 window provides a better approximation of background seismicity, but other options (e.g., fixed length W1 window) can also be considered. The W2 window extends from the moment for which the Z parameter is determined and has a defined length of 1.5 years. *We call window W1 the background seismicity window, and window W2 the monitoring window.* Values of the Z parameter have the same interpretation in terms of statistical significance as the number of standard deviations from the mean for a normal distribution. The sections shown have been calculated starting from the year 2020, every three months.

Note. *The high values (Z > 5.0, in red on the map), which are observed at depths below ~140 km, are related to some changes in the method of locating earthquakes that occurred in 2014 (see the 2021 report of the project, in Romanian) .*

PI, RI Maps

Maps of PI, RI, for the territory of Romania are presented. These parameters are similar to the Z parameter in that they can be used to quantify changes in seismicity rate.

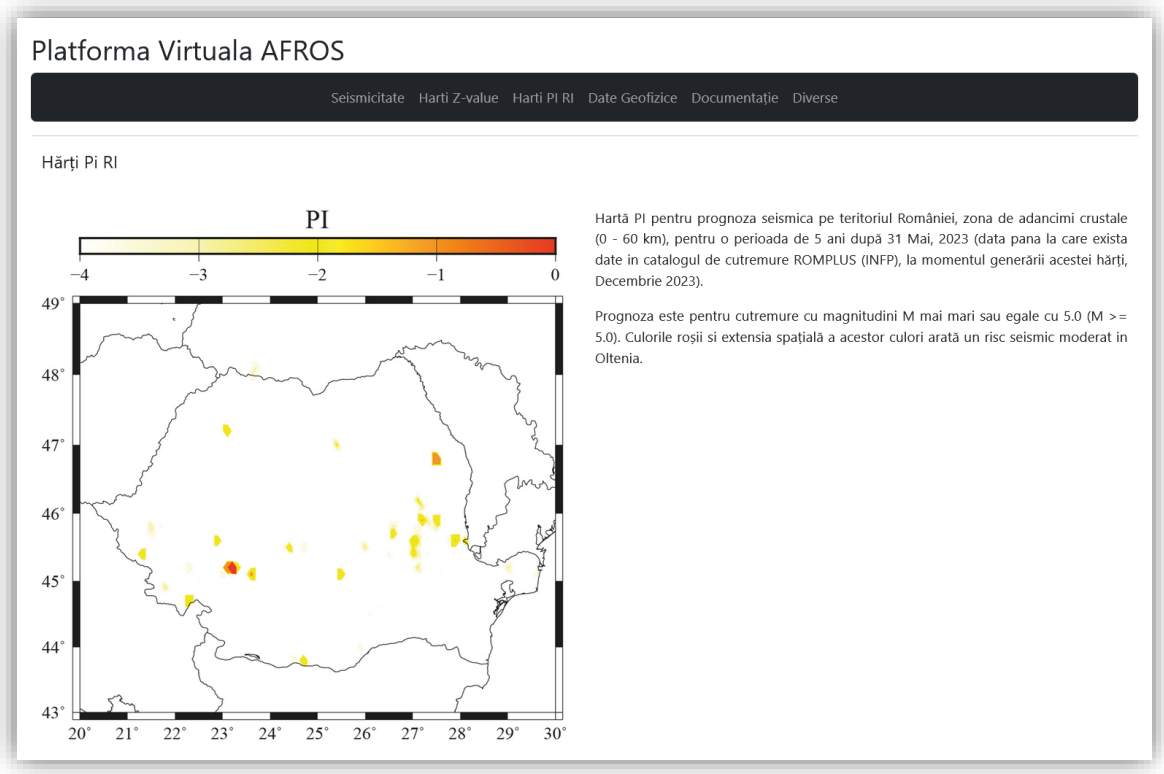

Figura 4. “PI RI Maps”, from the AFROS platform
http://afros.infp.ro/AFROS_en.php?link=dategeofizice

Geophysical Data

In the first part of the "Geophysical data" application from the AFROS Platform, the variations over time of some geophysical and geochemical parameters are presented (the magnetic field at 3 stations in the Vrancea seismogenic zone and the CO_2 and radon emissions - Figure 5). The last 24 hours of recordings are represented in real time. In this way, it complements the magnetic data from the Phenomenal platform (https://ph.infp.ro/), which is updated once a day, at 00:00 UTC.
The data are recorded at the stations: Muntele Rosu (MLR), Plostina (PLOR4 and PLOR7), at Bisoca (BISR) and DLM.

Figure 5. The first part of the "Geophysical data" page, from the AFROS platform http://afros.infp.ro/AFROS_en.php?link=dategeofizice

In the second part of the "Geophysical data" page, the detections of the anomalies that preceded the Vrancea earthquakes are presented. In general, the relationship between gas emission and seismicity is empirical. Starting from the experiments, a relationship of the type is determined for a certain area:

$$\text{Log (AD)} = a*M + b \qquad (4)$$

where A is the amplitude of the radon or CO_2 anomaly, D represents the distance between the station and the epicenter and a and b are constants (Walia, V.; Virk, H.S.; Bajwa, B.S.; Sharma, N. Relationships between radon anomalies and seismic parameters in N-W Himalaya, India. Radiat. Meas. 2003, 36, 393–396).

Examples for a and b are based on the particularity of the area (Vrancea has intermediate-depth, but also shallow earthquakes):

$$f1(M) = 0.35 \cdot M - 1.11 \qquad (5)$$

$$f2(M) = 0.24 \cdot M - 1.44 \qquad (6)$$

The analysis of the radon data shows that the amplitude can vary at high values or at a low level for a longer period of time after which an earthquake of magnitude greater than 4 (Richter scale) occurs. The emission of gases depends on the deformation of the soil whose pores open or close depending on how the tectonic stress manifests itself. A generally valid relationship between anomalies (A), magnitude (M) and epicentral distance (D) has not yet been found because there are many factors involved. The way gas is measured is one of them. In our case, the sensors were enclosed but not in hermetically sealed enclosures, which might have had an important contribution (due to contribution from the outside air).

In the case of gas emissions (radon and CO_2), the method of integrating signals and applying an STA / LTA (Allen) algorithm to the obtained data is used with good results. The result is a number of detections that are transmitted in real time as "Events files" to the analysis server. Each station has a logical tree weight determined experimentally based on offline analyses. Within them, the number of detections related to an earthquake with a magnitude greater than 4 is checked (if there were, it is marked with TRUE if not with FALSE). Those with TRUE are passed into a table as in the example below where the same weight was considered for all stations (the table is partial, it includes 33 columns).

Statii	**Ponderе**	**22/10/05**	**22/10/06**	**22/10/07**	**22/10/08**	**22/10/23**	**22/10/24**	**22/10/25**	**22/10/27**	**22/10/28**	**22/10/29**	**22/10/30**
BISRAERd_Radon	0.125	2	0	1	1	0	0	0	0	0	0	0
BISRCO2_CO2	0.125	1	2	3	0	0	0	0	0	0	0	0
DLMCO2_CO2	0.125	2	3	0	0	0	0	0	0	0	0	0
DLMdd_Radon	0.125	0	3	0	2	0	0	0	0	0	0	0
LOPrCO2_CO2	0.125	1	3	3	0	0	0	0	0	0	0	0
LOPRdd_Radon	0.125	2	1	2	2	1	0	1	1	0	0	0

NEHRdd_Radon	0.125	2	0	0	0	0	0	0	0	0	0	0
NhCO_Co2	0.125	2	1	0	0	0	0	0	0	0	0	1
Media Zilnică	1	0.046875	0.050781	0.035156	0.019531	0.003906	0	0.003906	0.003906	0	0	0.003906
Valoare medie/ zile	4	0.024414	0.036133	0.041992	0.038086	0.019531	0.008789	0.005859	0.001953	0.001953	0.000977	0.001953

Tabel 1. Quantification of possible anomlies

For each column, the daily weighted average is calculated with the relationship:

Daily average =SUM(channel weight*over-threshold values number/the maximum number of of over-threshold values, .. , .. , , , , ,)/number of stations, 8

The maximum number of over-threshold values is 4 and was determined experimentally for Vrancea. It was also determined experimentally that an interval of 4 days corresponds to the detection groups for all stations in the case of an earthquake with magnitude > 4, with the epicenter in Vrancea.

The result in Figure 6 refers to the 5.3 earthquake of 02.11.2022. In the example, the weight of the stations is the same in the logical decision tree. The algorithm allows their modification, the separation of radon from CO_2 as weights, the modification of the weights according to the station-hypocenter distance, modification of the number of stations, the maximum number of detections per station per day (4 in this example) and others.

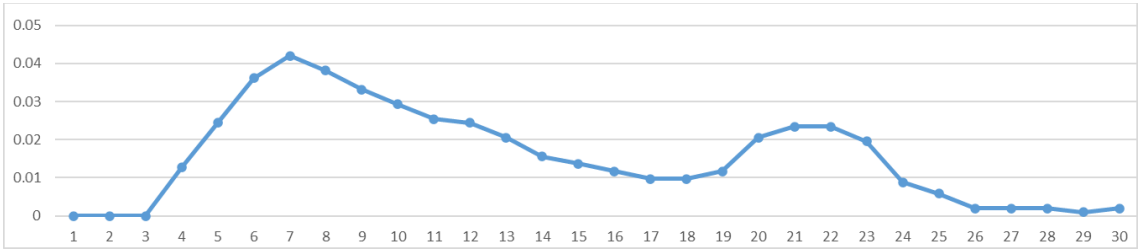

Figure 6. Quantification of anomalies for the magnitude 5.3 earthquake of 02.11.2022. The X-axis shows the days of October 2022.

Documentation

Contains this documentation.

Miscellaneous

Various information useful for the AFROS platform is presented (http://afros.infp.ro/AFROS_en.php?link=diverse). Worth mentioning is the application that represents the selected seismicity in the form of a video, in which the earthquakes that occur are added to the map. The time in the video is proportional to the real time.