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Complex system for earthquakes forecast using gas emission observations

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SM6.3 Fault mechanics and earthquakes from near fault observations
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Abstract. Romanian National Institute of Earth Physics (NIEP) develops a gas emission monitoring network as part of a multidisciplinary activity. The goal is to help organizations specialized in emergency situations with short-term earthquakes forecast and information related to pollution and effects of climate change. In Romania, the important seismic area is Vrancea where there are seismic and multidisciplinary monitoring stations. The methods and monitoring solutions are general and they could be applied in any place. The main part of our system is related to CO_2, CO, radon, air ionization in correlation with earth radiation, air ionization, telluric currents, ULF radio waves disturbance, magnetic field, temperature in borehole, infrasound, acoustic waves and meteorological data. The monitoring stations are located on the faults in the curvature of the Carpathian Mountains. The first step is to determine the daily, seasonal and annual evolutions of gas emissions and ionization of the air for at least one year. We are looking for time intervals during which the seismic activity was reduced to determine the normal evolutions of the measured parameters. Then we can determine the effects of active seismic periods on gas emissions. We will apply several methods of analysis and will correlate the particularities of the geological structure in which the monitoring stations are located and the position of the epicenters of earthquakes. The present results are favorable to the analysis by integrating the values measured on variable time windows according to the case. Instantaneous values also include local effects that are not related to tectonic stress. Current measurements indicate the presence of CO at certain times of the day and at certain stations. This is not possible due to tectonic stress, but may be the result of pollution in short-distance cities and air currents that spread it.

Key words: gas emission, multidisciplinary analysis, radon concentration, air ionization, multi-parametric monitoring, earthquake forecast, earthquake precursors

Monitoring Network

Romanian National Institute of Earth Physics (NIEP) develops a multidisciplinary network including a gas emission monitoring equipment (radon, CO_2, CO). The NIEP's platform geobs.infp.ro presents data and alerts messages in real time. Along with gas monitoring, the network provides information on air ionization, atmospheric electric field, earth currents, magnetic field, drilling temperatures, ULF radio field, solar radiation, atmospheric electric discharges, inclinations, infrasound and meteorological data. Stations position relative to geological structure is presented in Figure 1.

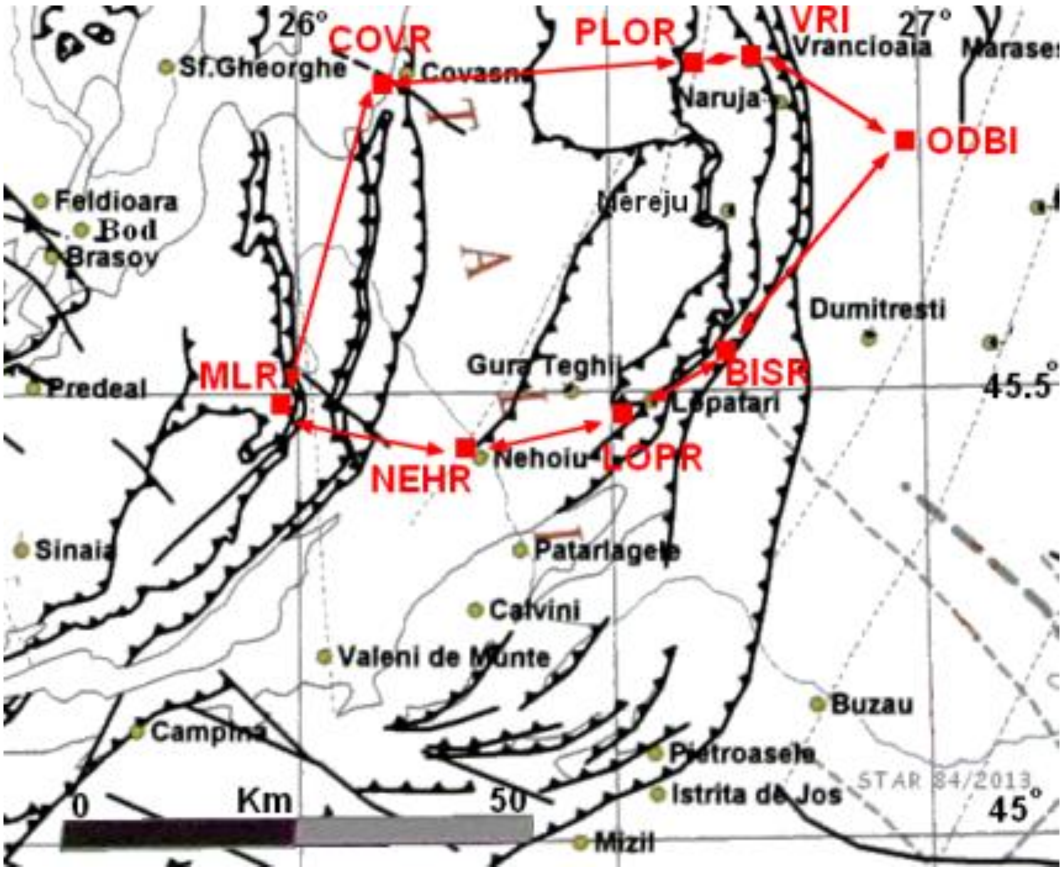

Figure 1. Monitoring network, main faults (map by C. Dinu, V. Raileanu et al. CEEX 647/2005).

Each location is under the effect of a fault. This is important for aerosol, ions, radio ULF wave propagation, radon and cloud monitoring. Every station send automatically information to INFP center where a server save, display and make a power spectrum analysis in real time. Equipment in each gas monitoring station are presented in Table 1. To all this information is added data from other monitoring locations to form a multidisciplinary network that can be integrated into an OEF structure. The result of the monitoring is saved in text files, ASCII with TAB separator, for which a software has been created that analyzes and detects anomalies (Figure 2). In Figure 2 H is humidity, T temperature and GR_b is the parameter of Gutenberg Richter law.

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Table 1

Name	Location	Sensors
BISR	Bisoca	Seismic speed-acceleration, radio ULF, infrasound, inclinometer, meteorological station , radon, CO_2, CO;
LOPR	Lopatari	Acoustic, radon, CO_2, CO, air temperature – humidity;
NEHR	Nehoiu	Seismic speed-acceleration, acoustic, air ionization +/-, meteorological station, CO_2;
PLOR	Plostina	Seismic speed-acceleration, radio, infrasound, meteorological station, air ionization +/-, telluric field, air electrostatic field, inclinometer, air -ground – borehole temperature, radon;
VRI	Vrancioaia	Seismic speed-acceleration, air - ground acoustic, radio, infrasound, ionization, telluric field, solar radiation, ground temperature, meteorological station, air electrostatic field, radon, CO_2, CO;

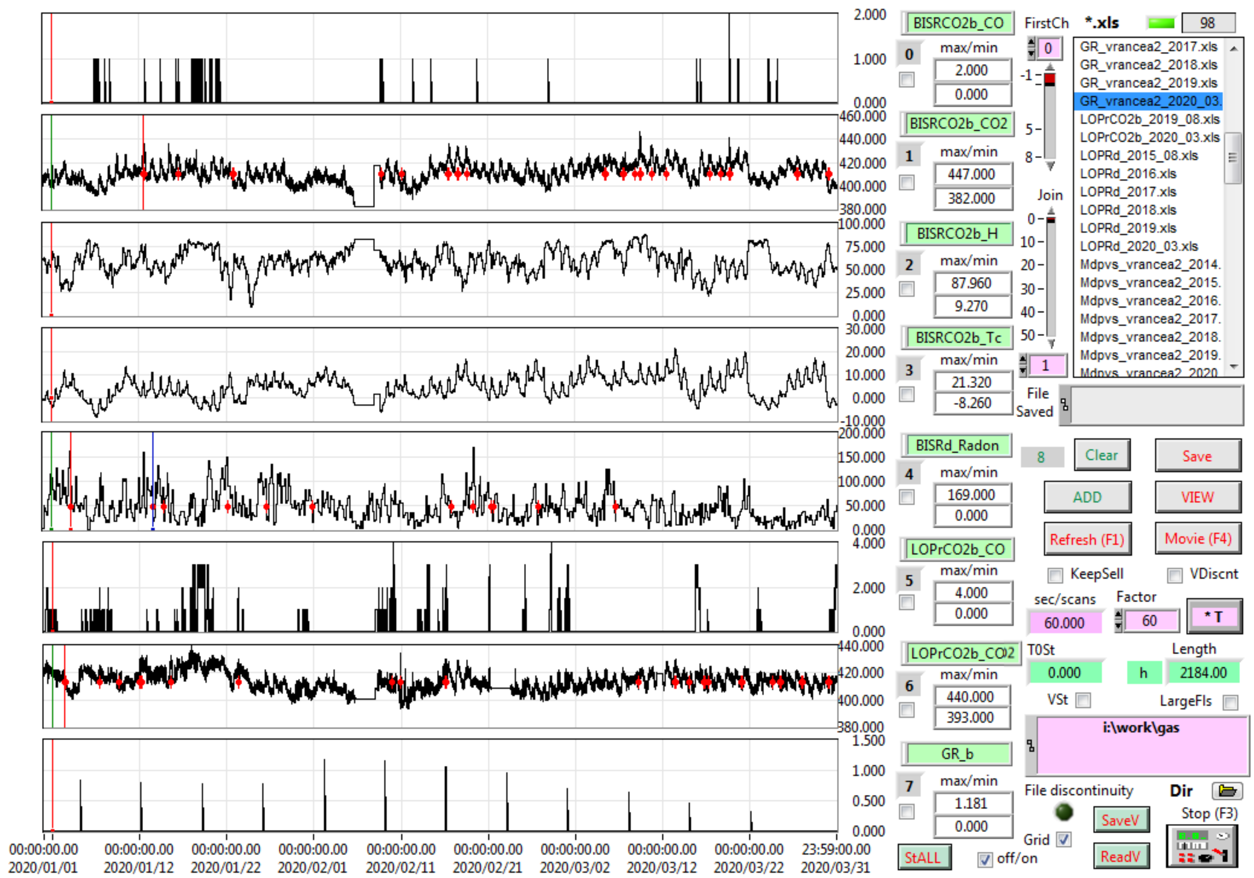

Figure 2. Analysis and detection software.

The first level of detection that transmits messages in real time on the geobs.infp.ro platform is performed in the monitoring station (Figure 3, 4).

Figure 3. Analysis and detection software.

CO2

Statie	CO(ppm)	CO2(ppm)	Umiditate(%)	Temeperatura(C)	Tdewpoint(C)	Timp
BISR	0.000	421.000	49.560	21.640	10.630	20/05/01 10:30:44
VRI	0.000	467.000	51.290	17.820	7.620	20/05/01 10:30:56
LOPr	0.000	419.000	47.600	22.700	10.990	20/05/01 10:30:04

Evenimente temperatura foraj

Statie: BISRCO2 - 20/05/01 10:24:27 CO2 421.000>=421.000

Statie: LOPrCO2 - 20/05/01 10:04:29 CO2 417.000< 417.900

Statie: VRIco2 - 20/05/01 00:52:00 CO2 510.000>=440.000 20/05/01 00:52:00 H 49.780>=48.000 20/05/01 00:52:00 Tc 18.220>=16.000

Figure 4. CO2, CO data and alert messages in real time on geob.infp.ro platform.

Figure 3 shows meteorological information, CO, CO_2, humidity, temperature in monitoring place, radon (Radon Scout PLUS equipment) and solar radiation (at the left bottom, W/m^2).

The second detection level is an offline facility of our analysis software (Figure 2). We use three methods, one of them being STA / LTA (Figure 5).

Figure 5. Event detection using STA/LTA method

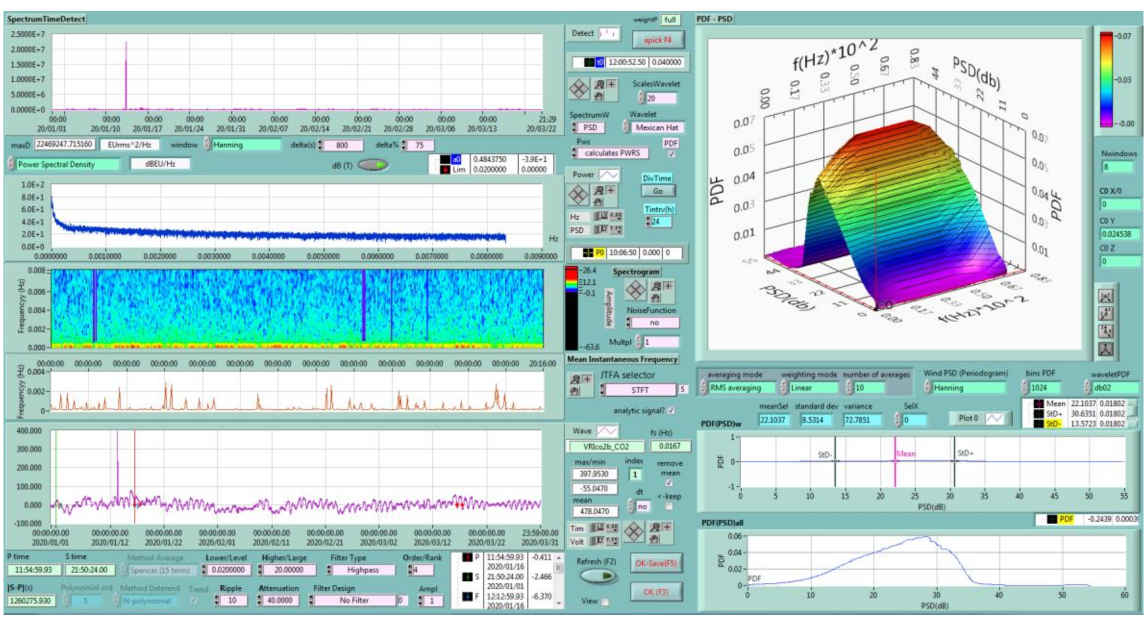

Figure 6. STFT, PSD PDF CO_2 analysis, Vrancioaia station.

The same software performs the spectral analysis of the monitored signals that ensures the detection of the frequency of events (Figure 6). The analysis of daily and seasonal variation will reduce false detections, too (Figure 7).

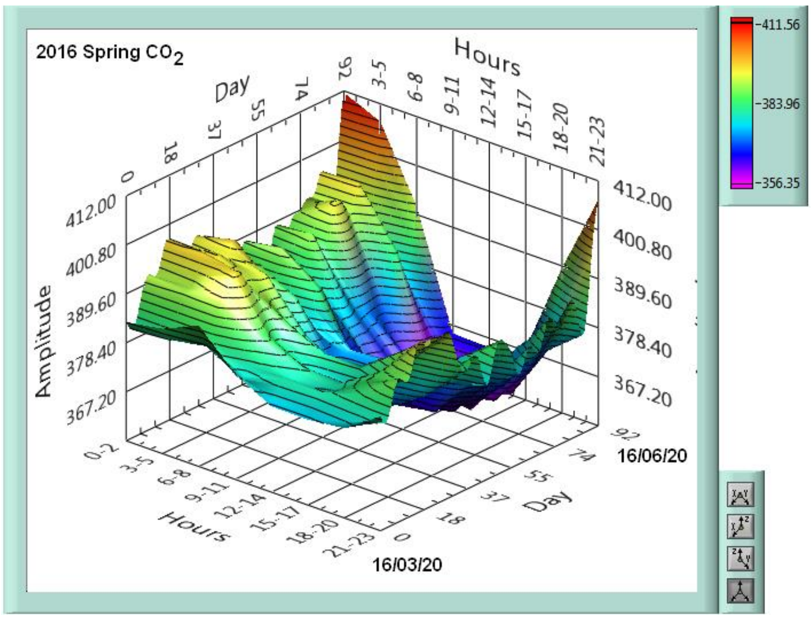

Figure 7. CO_2 evolution in Nehoiu station, 2016, spring.

Conclusions

The expansion of the CO2 / CO monitoring network is recent but we realized the analysis software. We are looking for a relationship between gas emissions and seismicity expressed by the Gutenberg Richter law in Table 1 which presents the preliminary results on the possibility of making a seismic forecast.

Table 1

Type	Station	Probability	Uncertain	Weight
Radon	Bisoca	0.57	4.98	0.18
Radon	Lopatari	0.29	3.93	0.14
Radon	Nehoiu	0.4	1.15	0.04
Radon	Vrancioaia	0.5	14.87	0.54
Radon	Plostina	0.44	2.7	0.1
Ions+	Nehoiu	0.57	9.74	4.98
Ions-	Nehoiu	0.5	8.88	4.98
CO_2	Nehoiu	0.57	3.09	4.98
Temp Borehole	Plostina	0.57	37,71	4.98
GR law	a-b param	0.5	5.92	4.98

The main conclusion is that only a multidisciplinary network allows correlation of events and ensures a reliable forecast..