

Citate as: Straser, V., Cataldi, D., Cataldi, G., Giuliani, G. (2021). Electromagnetic Monitoring of Italian Volcanoes With the RDF Network, , vol. 4, issue 1, pp. 32-40, Journal Emerging Environmental Technologies and Health Protection (JEETHP), ISSN 2623-4874, e-ISSN 2623-4882, <https://www.telegeco.gr/JEETHP4I1A2.pdf>

## Electromagnetic Monitoring of Italian Volcanoes with the RDF Network

Valentino Straser<sup>1</sup>, Daniele Cataldi<sup>2,3</sup>, Gabriele Cataldi<sup>4</sup>, Giampaolo Gioacchino Giuliani<sup>3</sup>

<sup>1</sup> Department of Science, Environment and Energy UPKL, Brussels, Belgium. Rue de la Presse-1000 Brussels

<sup>2</sup> Radio Emissions Project, Lariano, Rome, Italy.

<sup>3</sup> Permanent Foundation G. Giuliani, L'Aquila, Italy.

<sup>4</sup> Radio Emissions Project, Albano Laziale, Rome, Italy.

---

### Abstract

This paper, presents useful relative technologies in decision making for public health protection in terms of electromagnetism surveilliance datasets at volcanic geographies in Italy. The presented methodology that has been tested, since 2017, could be useful for public health protection detecting pre-seismic signals in actively tectonically sites. The frequencies related to broadband electromagnetic monitoring , instrumentally detected 24h7, adopt the SELF-VLF band, 0 - 32000 Hz. This work, is useful for stakeholders so as to identify potential candidate electromagnetic precursors, in association with impending eruptions. The investigated data showed useful results for main volcanoes in Italy like Vesuvius Volcano and rest areas.

**Keywords:** seismic precursors, volcanic eruptions, electromagnetism signal - RDF system, volcanic activity, SELF-ELF band, public health.

Corresponding Author: Valentino Straser, Strada dei Laghi 8, Terenzo Parma, Italy. Postal code 43040

E-mail: [valentino.straser@gmail.com](mailto:valentino.straser@gmail.com)

---

### 1. INTRODUCTION

The aim of this experimental research, conducted by Radio Emission Project, is the investigation of electromagnetic signals measured at Italian volcanoes. The aim is to analyse proper datasets, signal analysis for electromagnetic magnitudes that can be utilised in predictions or alert utilities to stakeholders mitigating associated risks at

volcanoes for public health protection.

Italian volcanism presents activity in Europe, located in densely populated areas, such as Naples and Catania. This characteristic poses a serious safety and alert situation in decision making for populations over million of living close to volcanic areas. Monitoring technologies at volcanoes could provide important indications at volcanic activity so as to provide an alert proper system that anticipates potential eruptions. The

researchers participated in this work are wondering the possibility in right signal detection for right decision making in relative volcanic activities, earthquakes produced by such volcanoes. Relative studies [1][2][3][4][5][6], have shown that numerous electromagnetism signal spectrum exist at crust al level, related to Earth's crust. These studies have shown that is produced a radio frequency due the relative change of magnitude stress on particular geomorphological sites. The signals can be recorded and the emission point identified using RDF - Radio Direction Finding, where a relative surveillance system has been presented by the Radio Emissions Project (REP) in 2017.

The electromagnetic surveillance scheme is

## 2. MONITORING DATA RADIO DETECTION FINDING

The RDF base stations in Italy involved in the monitoring are located in:

- Pontedera (PI). Latitude: 43.672445 North, Longitude: 10.640100 East.
- Lariano (RM) (1). Latitude: 41.728799 North, Longitude: 12.843205 East.
- Lariano (RM) (2). Latitude: 41.728799 North, Longitude: 12.843205 East.
- Ripa-Fagnano (AQ). Latitude: 3.123060 North, Longitude: 101.653044 East.

The RDF base stations started to register radio-anomalies in relative datasets' characteristics (see Fig. 3 and 4), REP project investigates volcanic sites at Etna, Stromboli and Vesuvius:

Pontedera - Dark violet Light purple.

Lariano (1) - Dark violet Purple - Red Purple - Red

Lariano (2) - Dark violet Purple - Red Purple - Red

Ripa-Fagnano - Light purple Purple - Red Purple - Red

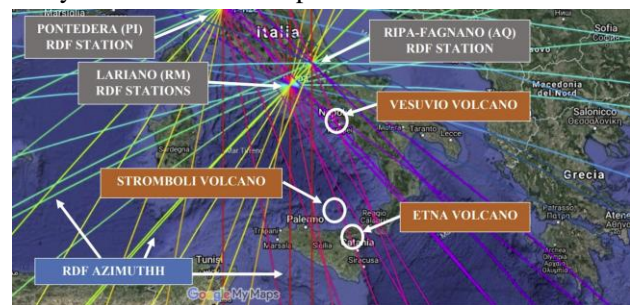
The relative logged colours at the investigated presented system, could be useful to detect activity in volcanoes. The volcanic geological strata can be described at intersection of coloured azimuths, identifying the origin location at particular signal magnitudes. Hence it has as result that right logged signals could demonstrate relative magnitudes to identify hazards for stakeholders protecting public health.

The data were considered on electromagnetism signal frequency particular characteristics that investigated according based on REP project at four relative volcanic sites in Italy.

The colorimetric for azimuth varies in relative signal

having a relative antenna technology system oriented in orthogonal grid, as it realized by the REP project and of a computerized signal processing system. The surveillance base uses proper dataloggers so as to register numerous datasets in detection electromagnetic signals, applying a proper correlation technique to monitor data, developed by researchers at REP project, provides datalogging at these signals. Other stations have been set up properly on soil, that allow to perform an electromagnetism carrier of natural type, and hence to identify of the geographic surface characteristics from which are coming relative signals.

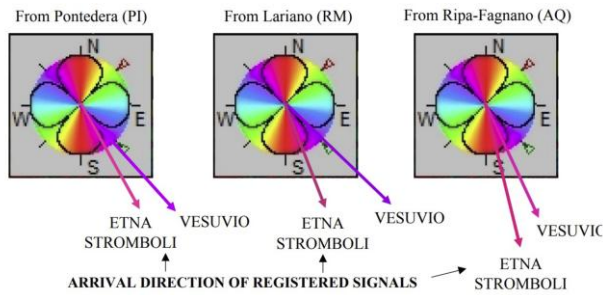
analysis's results that are presented below.



**Figure 1.** Electromagnetic signals' map of the Italian RDF network.

In figure 1 is presented a relative geographical information for the investigated case studies in Italy. The results from REP project show the variation in color that identifies an azimuthal variation according to collected datasets from data loggers that can register the relative datasets. Proper use of Google Maps took place at REP.

The work investigated also the identification of probable earthquakes (M2+), which occurred during that project in variation of electromagnetism signal magnitudes so as to occur such telluric phenomena produced by volcanism, detected in real time by the website of the National Institute of Geophysics and Volcanology ([www.ingv.it/](http://www.ingv.it/)), see Figure 1.



**Figure 2.** Arrival direction of registered signals by the monitoring system, for each RDF station.

In figure 2 is presented orientation that directs registered signals of surveillance system at REP project's measurements bases. Different colour is relative to an Azimuth direction based on signals that arrives according to REP.

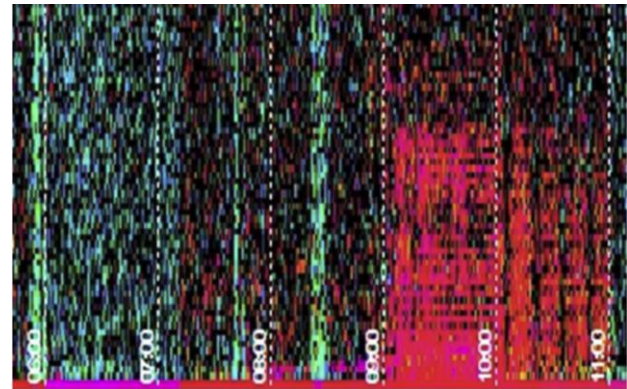
Regarding the signal magnitudes at relative surveillance scheme, at REP project's measurements bases obtained precise reference azimuths for location at particular data logger, see Figure 2.

However, by observing the coloration in variation of electromagnetism signal magnitudes in respective azimuths, triangulation it detects which volcano had emitted electromagnetism signal, prior seismic activity, that could be produced by active volcano or eruptions caused by magmatism. By installing more stations, better results will be achieved in alerting to special hazards and protecting public and community health[8][9][10].

**2.1 RADIO SIGNALS CHARACTERISTICS**

As RDF surveillance system automatically generates relative signal spectrums, it examines the variation in relative colour based on particular collected datasets. The relative colour from the investigated system determines orientation at signal arrival based on relative installed surveillance grid in Italy. The relative geographic system elaborates properly the electro magnetic signals, indicating therefore the topographical loction of particular signal sources. The typology varies in time bearing in mind particular datasets characteristics behavior in time (extension, appearance or not, bandwidth, frequency oscillation, see Figure 3.

**2.2 RDF AND VOLCANO SIGNALS**



**Figure3.** The typology of the recorded signals varies according to the electromagnetic frequency, the intensity with which they appear and the time, as well as for their behavior in time

In figure 3 is presented Electromagnetic signals observed of electromagnetism signal particular characteristics, detected by monitoring base at Lariano on December 12, 2020.

The relative presented spectrum presents the particular charecteristics identified based on REP project that could be combined as alert to stakeholders using proper mobile

appications - web utilities for additional alerts in public health protection for residents or tourists that during their visit may be at risk at relative described geographical landscape places.

Electromagnetic emission increases as energy build up increases at a volcano's cone, even at some depth. While there is energy in high magnitudes, seismic events could take place after rocks' breaking within volcanic conies that are composed, which produces electromagnetism signal magnitududes at volcanic site, while these characteristics are recording in such seismic phenomena.

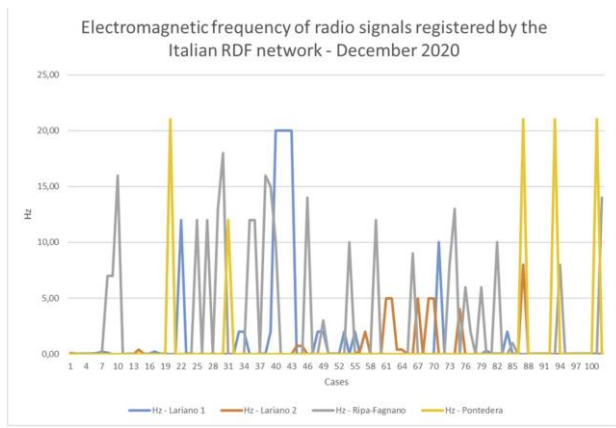
They will exist until the volcanic eruption. Therefore, electromagnetic emission will attenuate, earthquakes and persist until the eruption volcanic phenomena will attenuate and will stop.

Furthermore, wherever inside the Earth's geomorphology is accumulated energy, then electromagnetism signal is emitted, either before a seismic event or before an activity at volcano [8][9][10][11][12][13][14][15][16][17][18][19][20].

The surveillance datasets at volcanic

investigated sites according to REP project in Italy consist of the signal collection at ELF band. Moreover, except the electromagnetism signal datasets, the research work took into account also seismic data, see Figure 4.

The investigated datasets show how the electromagnetism signal variation is important for alerts, in decision making, mitigating associated risks at particular volcanic sites for public health protection. Proper use of such surveillence systems allows to acquire important information on its evolution.



**Figure 4.** Variations in electromagnetic frequency of radio signals registered by the Italian RDF network.

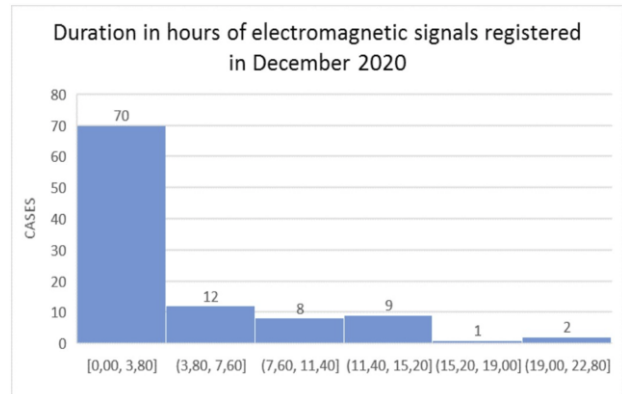
In figure 4 is presented Radio signals - variations in electromagnetic, RDF grid in Italy where have been registered in Italy according to REP project, RDF grid on December 2020. Forces currently are not possible to be measured but could be probably in future be measured after proper modifications and experiments that should be taken into account on a relative modified surveillence system so as to be probable to be observed and somehow to be measured relative magnitudes.

The monitoring REP project, in fact, allows to model the received datasets from dataloggers, triangulate them and to find the identity, direction of signal relative emission at ground levels.

### 2.3 RADIO SIGNALS ON DECEMBER 2020

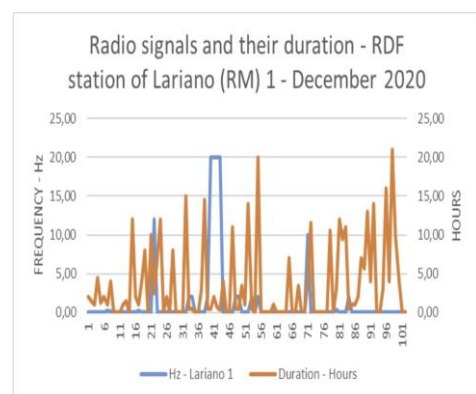
Figure 5, presents radio-anomalies found in datasets based on their characteristics. Hence, there are 70 radio-anomalies that durate 0 - 3.8 hours, and also other epochs of them that durate 3.8-7.6 hours (12 case studies); 7.6-11.4 (8 case studies) and 11.4-15.20 hours

(9 case studies). So the study highlights that radio-anomaly at REP project.



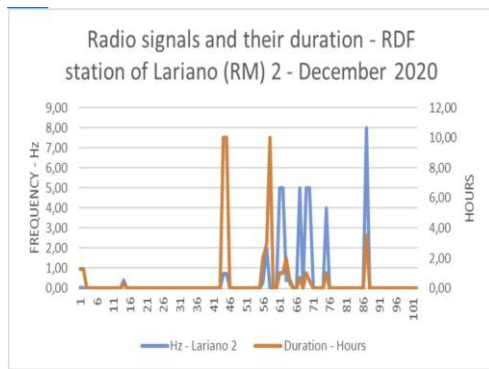
**Figure 5.** Duration in hours of total radios-anomalies recorded by the Italian RDF network, in December 2020. Credits: Radio Emissions Project.

In figure 5 is presented the relative radio-anomalies recorded for REP Italian project. Initial data on radio-anomaly characteristics recorded appear show these may be an inversely proportional relationship between radios-anomalies duration, see figure 6. This evidence could be useful so as to take the right measures in time avoiding relative hazards to stakeholders and protecting public health.

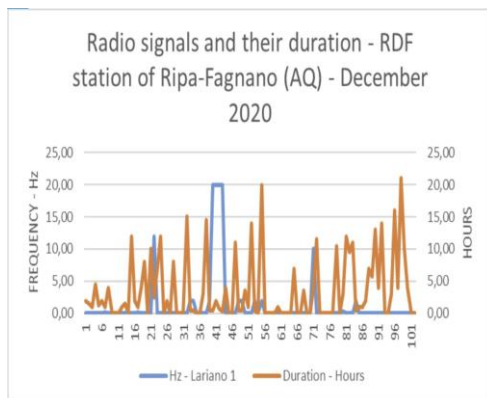


**Figure 6a.** Radio signals and their duration characteristics – RDF Lariano (RM) 1 station

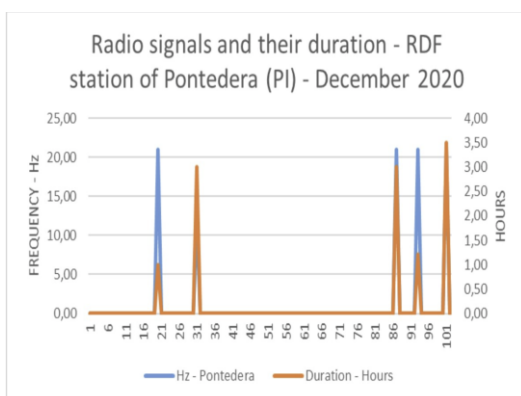




**Figure 6b.** Radio signals and their duration characteristics – RDF Lariano (RM) 2 station



**Figure 6c.** Radio signals and their duration characteristics – RDF Ripa-Fagnano (AQ) station



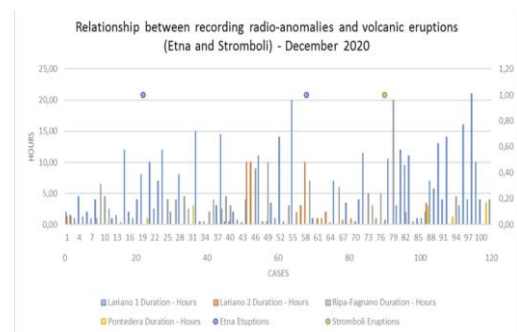
**Figure 6d.** Radio signals and their duration characteristics – RDF Pontedera (AQ) station

In figure 6 a, b, c, d is shown the electromagnetism's frequency magnitudes related to radio anomaly based on relative monitoring stations of: (a) Lariano 1-Roma; (b) Lariano2-Roma, (c) Ripa Fagnano - l'Aquila; (d) Pontedera-Pisa. These datasets, could be investigated in terms of the geomorphological characteristics inside a

volcanic cone, the particular geological characteristics, the star characteristics of the rocks, as other related variables that will come up from several relative investigations in future works.

## 2.4 ERUPTIVE DATA AND ELECTROMAGNETIC ACTIVITY

In figure 7 are presented electromagnetic datasets found at REP. The datasets present peaks of increase in correspondence with the temporal epochs where eruptions took place, peak magnitudes at period that exist the radio-anomalies. Long-duration electromagnetic emissions appear before eruptions, while relative magnitudes decrease after eruption occurs. Hence, radio-anomalies initially exist before relative volcanic phenomenon occurs, and then a drastic decrease as eruption phenomenon takes place, before disappearing.



**Figure 7.** Radio signals and their duration characteristics – RDF Pontedera (AQ) station

In figure 7 is presented the relationship found at investigated radio-anomalies, at relative volcanoes' eruptions, at Etna and Stromboli, REP project. The latter electromagnetic datasets could exist as a hypothesis for future investigations so as to identify alerts in decision making using proper utilities for stakeholders mitigating associated risks and protecting public health. Such future investigations should bear in mind particular crystalline rock geomorphologies, bearing in mind the pressure in relative magma formulation phenomena.

Rock crystal structural geomorphologies

release a flowing of ions according to piezoelectricity phenomenon, these ions would then emit radio-frequency. Furthermore, in similar way, the relative lava pressure is increased at the magma chamber into the cone, which is generating radio-frequency. The eruption data show that eruptions occur when long epochs exist at radio-anomalies, according to REP project. The latter that enormous energy is generated for eruptions and the long epochs depend on rocks' crystalline morphology that is in particular stresses magnitudes.

### 3. HYPOTHESIZED MECHANISM

The main hypothesized mechanism that has been taken into account at this working REP project, bearing in mind the piezoelectricity, as occurs variation of stress magnitudes at particular rock geomorphological surfaces and deformation of crystal in lattices, which is followed by the real electromagnetism magnitudes, relative emissions determined by electrical charges, that are related to particular mechanical stress variations at rock geomorphological surfaces.

This electromagnetic emission, is in energy generation within several magnitudes in KW. Hence, the existence in energy generation of high magnitudes at electrical charges, it generates radio frequency. The presented technology is useful so as to identify volcanic hazards and it could be developed more based on more particular field data.

### 4. CONCLUSIONS

We conclude that the above investigated of electromagnetic datasets characteristics, found at volcanoes in Italy, may have a predictive character for geophysical activity.

### REFERENCES

- [1] V. Straser, D. Cataldi, and G. Cataldi, "Radio direction finding system, a new perspective for global crust diagnosis," *New Concepts in Global Tectonics Journal*, vol. 6, pp. 203-211, 2018.
- [2] V. Straser, G. Cataldi, and D. Cataldi, "Seismic signals detected in Italy before the Nikol'skoye (off Kamchatka) earthquake in July 2017," *NCGT Journal*, vol. 5, pp. 391-396, 2017.

The relative data present importance that allow us to identify eruptive phenomena so as to take the right measures in time for stakeholders and public health protection. Such described technologies for public health protection can identify seismic events due to activity in volcanoes. Therefore, this study confirms that an activity in volcanic geomorphology is related to electromagnetic signals, when it is found active.

Hence, geophysical events involving both seismic and volcanic events or both, identifiable by signals visible a few hours earlier so as to take right measures and inform stakeholders in advance for civil protection, public health protection. The methodology presented in this study could prospectively contribute to a new concept of environmental monitoring, applying proper mobile, web utilities for alerts to stakeholders and protecting public health, mitigating associated risks in a holistic view of natural phenomena potentially destructive to human communities.

### CONFLICT OF INTEREST

The authors declare that they do not have conflict of interest.

- [3] V. Straser, G. Cataldi and D. Cataldi, D. Radio-anomalies: tool for earthquakes and tsunami forecasts. *Geophysical Research Abstracts*, Vol. 17, EGU2015-2508, 2015.
- [4] V. Straser, G. Cataldi and D. Cataldi, D. SELF and VLF electromagnetic signal variations that preceded the Central Italy earthquake on August 24, 2016. *New Concepts in Global Tectonics Journal*, Vol. 4, no. 3, p. 464-468, 2016.
- [5] D. Cataldi, G. Cataldi, and V. Straser, "SELF and VLF electromagnetic emissions that preceded the M6. 2 Central Italy

- earthquake occurred on August 24, 2016," EGU General Assembly Conference Abstracts, 2017.
- [6] G. Cataldi, D. Cataldi and V. Straser. Solar and Geomagnetic Activity Variations Correlated to Italian M6+ Earthquakes Occurred in 2016, *Geophysical Research Abstracts*, Vol. 19, EGU2017-3681, 2017.
- [7] A. Tibaldi, C. Corazzato, F. Gamberi e M. Mariani, Subaerial-submarine evidence of structures feeding magma to Stromboli Volcano, Italy, and relations with edifice flank failure and creep, in *Tectonophysics*, vol. 469, n. 1-4, 2009, p. 112-136. <https://www.sciencedirect.com/science/article/pii/S0040195109000651>.
- [8] C. J. Horwell, P. J. Baxter, The respiratory health hazards of volcanic ash: A review for volcanic risk mitigation, *Bulletin of Volcanology*69(1):1-24, 2006, DOI: [10.1007/s00445-006-0052-y](https://doi.org/10.1007/s00445-006-0052-y)
- [9] A. Fries, J. Lemus, P.A. Jarvis, A. B. Clarke, J.C. Phillips, I. Manzella and C. Bonadonna, The Influence of Particle Concentration on the Formation of Settling-Driven Gravitational Instabilities at the Base of Volcanic Clouds. *Front. Earth Sci.* 9:640090, 2021. doi: 10.3389/feart.2021.640090
- [10] I. Tomašek, D.E.Damby, D. Andronico, P.J.Baxter, I. Boonen, P. Claeys, M.S.Denison, C.J.Horwell, M. Kervyn, U. Kueppers, M.N.Romanias, M. Elskens, Assessing the biological reactivity Of organic compounds on volcanic ash: implications For human health hazard, *Bulletin of Volcanology*, 83:30, <https://doi.org/10.1007/s00445-021-01453-4>
- [11] V. Straser, D. Cataldi, G. Cataldi. Radio Direction Finding (RDF) - Geomagnetic Monitoring Study of the Himalaya Area in Search of Pre-Seismic Electromagnetic Signals - - *Asian Review of Environmental and Earth Sciences* - Vol. 6, No. 1, 16-27, 2019.
- [12] V. Straser, D. Cataldi, G. Cataldi. Registration of Pre-Seismic Signals Related to the Mediterranean Area with the RDF System Developed by the Radio Emissions Project — *International Journal of Engineering Science Invention (IJESI)*, vol. 8 Issue 03 Series. II, p.26-35, 2019.
- [13] Straser V., Cataldi D., Cataldi G., 2019. Electromagnetic monitoring of the New Madrid Fault us area with the RDF system - Radio Direction Finding of the radio emissions Project. *New Concepts in Global Tectonics Journal*, V. 7, No. 1, p. 43-62
- [14] V. Straser, G.G. Giuliani, D. Cataldi, G. Cataldi. Multi-parametric investigation of pre-seismic origin phenomena through the use of RDF technology (Radio Direction Finding) and the monitoring of radon gas stream (Rn<sub>222</sub>) —*New Concepts in GeoplasmaTectonics Journal* – vol. 8, n. 1, 2020.
- [15] D. Cataldi, G. G. Giuliani, V. Straser, G. Cataldi. Radio signals and changes of flow of radon gas (Rn<sub>222</sub>) which led the seismic sequence and the earthquake of magnitude mw 4.4 that has been recorded in central italy (Balsorano, L'Aquila) on november 7, 2019 — *New Concepts in GeoplasmaTectonics Journal*, vol. 8, n. 1, 2020.
- [16] F. Di Stefano, G. Giuliani, D. Ouzounov, D. Cataldi, C. Fidani, A. D'errico, and G. Fioravanti. Support for Prevention and Preparedness of the Strait of Messina - Reggio Calabria An Earthquake Forecasting Project. *Atti della Accademia Peloritana dei Pericolanti - Classe di Scienze Fisiche, Matematiche e Naturali* - May 4, 2020.
- [17] V. Straser, G. Cataldi, D. Cataldi. Radio Direction Finding for short-term crustal diagnosis and pre-seismic signals. The case of the Colonna Earthquake, Rome (Italy) — *European Journal of Advances in Engineering and Technology*, vol. 7(7):46-59, 2020.
- [18] T. Rabe (1), D. Cataldi (2), Z. Z. Abidin (3), G. Cataldi (4), V. Straser (5). International study Italy-Malaysia pre-seismic signals recorded by RDF – Radio Direction Finding monitoring network, before earthquakes: Mw 6.3, occurred at 111 km SW of Puerto Madero in Mexico and Mw 6.3, occurred at 267 km NW of Ozernovskiy in Russia, November 20, 2019. *New Concepts In GeoplasmaTectonic Journal*, vol. 8, n. 2, 2020.
- [19] V. Straser, D. Cataldi Radio, G. Cataldi. Radio Direction Finding (RDF) - Geomagnetic monitoring study of the Japanese area related to pre-seismic electromagnetic signals. *New Concepts in GeoplasmaTectonic Journal*, vol. 8, n. 2, 2020
- [20] D. Cataldi, V. Straser, G. Cataldi, Giampaolo G. Giuliani, Z. Z. Adibin. Registration of Pre-Seismic Radio Signals Related To The Russian And Jamaican Earthquakes with The RDF System Developed by The Radio Emissions Project — *International Advance Journal of Engineering Research (IAJER)*, vol. 3, Issue 9, p. 1-30, 2020.
- [21] V. Straser, D. Cataldi, G. Cataldi, G. G. Giuliani, J. R. Wright.

Effects of Hurricane Laura on the New Madrid Fault area - results of electromagnetic monitoring through the RDF Network - Radio Direction-Finding and Arkansas Electromagnetic Monitoring Station. *New Concepts in GeoplasmaTectonic Journal* vol. 8, n. 3, 2020.

[22] V. Straser, D. Cataldi, G. Cataldi. Pre-Seismic Signals recorded by the Italian RDF Network Before the occurrence of some Earthquakes in Northern Italy. *International Journal of Software & Hardware Research in Engineering (IJSHRE)* - ISSN-2347-4890 – vol. 9 Issue 1, 2021.

[23] V. Straser, D. Cataldi, G. Cataldi. Radio Direction Finding, a new

method for the investigation of preseismic phenomena. The case of Japan. *International Journal of Engineering Sciences & Research Technology*.