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Electromagnetic Monitoring of italian volcanoes with the RDF Network, developed by the Radio Emissions Project

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ABSTRACT

In this study, data from electromagnetic monitoring of Italian volcanoes are presented and discussed. The methodology used has already been tested, since 2017, for the detection of preseismic signals in tectonically active areas. The data collection method is carried out by the Radio Direction Finding electromagnetic monitoring network, based in Lariano, Rome, Italy; Ripa-Fagnano, L'Aquila, Italy and Pontedera, Pisa, Italy.

The frequencies of the broadband electromagnetic monitoring, instrumentally detected 24h7, include the SELF-VLF band, from 0 to 32000 Hz. The purpose of this study, carried out from December 2020 to March 2021, is to identify candidate electromagnetic precursors, associated with the imminence of eruptions, which have shown characteristic markers for the area of Volcano Etna, Volcano Stromboli and Volcano Vesuvius.

Keyword: seismic precursors, eruptions, electromagnetic signals, RDF, volcanic activity, SELF-ELF band.

1 - INTRODUCTION

The Italian volcanic activity is the most active in Europe, counting precisely of active volcanoes that are very close to populous areas.

This characteristic features a serious security problem for millions of people living near volcanic areas. Monitoring these natural structures could provide, in the coming years, important indications for the activation of an alarm system capable of providing useful indications to understand if one or more of these volcanoes is to erupt. An alarm system that does not yet exist in Italy.

To do this, the researchers engaged in this study, have wondered if it was possible to detect the presence of precursor signals able to anticipate, with an end time advance, possible eruptions or earthquake produced by these volcanoes and therefore use these signals as a tool of Forecast, in an area where no one has ever investigated.

Recent studies [**1**][**2**][**3**][**4**][**5**][**6**], A huge amount of electromagnetic signals are emitted at the crustial level, which can be associated with the stress of the terrestrial crust, before there is an earthquake, such studies have therefore made to understand the researchers and the action of mechanical stress on certain areas of the terrestrial surface produces radiofrequency that can be recorded and identifying its emission point thanks to the RDF system - Radio Direction Finding, a monitoring network developed by the Radio Emissions Project in 2017 [**1**].

The electromagnetic monitoring system is essentially composed of a series of antennas oriented with respect to the cardinal points and in orthogonal pattern, of a system of amplification of these signals achieved by the Radio Emissions Project and a computer processing system, of a computerized type. This station is able to provide numerous data from the detected electromagnetic signals, while the correlation and monitoring technique, developed by Dr. Daniele Cataldi and Dr. Gabriele Cataldi for the Radio Emissions Project, provides for the temporal association of these

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signals, respect At their Azimuth of origin (direction of arrival).

Other station of this type, located on Italian soil, allow the triangulation of the natural electromagnetic carrier, and therefore the identification of the geographical area from which these signals come [**1**].

On 10 December 2020, the monitoring of Italian volcanic activity, through the Italian RDF monitoring network developed by the Radio Emissions Project has begun. This monitoring network began to monitor three active volcanoes present in the Italian territory:

1. **Etna Volcano** - Sicily. The most recent measures, carried out in July 2018 by two independent teams with very high resolution GPS, revealed that the current height of Etna is 3.326 m. Etna has a rather complex structure due to training, over time, of numerous volcanic buildings that however in many cases have later collapsed and were replaced, side by side or covered entirely by new eruptive centers. They are recognizable in the "modern phase" of the volcano at least 300 between cones and eruptive fractures [**7**]. The area also appears to moderate seismic risk [**8**] [**9**] due to the effect of the tremor of the volcano.
2. **Stromboli Volcano** - Sicily. The volcanic building is 926 m high on the sea level. and reaches a depth between 1300 m and 2400 meters below sea level [**10**].
3. **Vesuvius Volcano** - Vesuvius is a volcano located in a dominant position compared to the Gulf of Naples. It is one of the two active volcanoes of continental Europe [**11**][**12**], as well as one of the most studied and dangerous in the world due to the high population of the surrounding areas and its explosive characteristics. In fact, the Vesuvian area has a high population density and the number of residents potentially in danger is around 700,000.

1.2 - Historical Data

Image 1 – Image 2 – In the overlying photos: the Etna volcano in some photographic files made in Leo orbit, and at the ground level. They highlight the enormous eruptive activity of the volcano, and highlight the enormous energy released at the crusta level. Credits: NASA, ISS Expedition 5 crew member - http://antwrp.gsfc.nasa.gov/apod/ap030102.html overwritten with a version edited by User: Darkone; Giuseppe from Italia - Tongues of lava in the Valle del Bove.

The Etna volcano is certainly one of the most dangerous Italian volcanoes, historical data demonstrate how different victims have been different due to the phenomena generated by the volcano, as well as the loss of anthropic structures with the result of huge economic damage aggravating the economy of the region Sicily. Between these:

- July 1614 - The phenomenon lasted ten years and emitted beyond a billion cubic meters of lava.
- 1669 - was the most famous and destructive eruption known, destroyed part of Catania, also created an earthquake that destroyed the village of Nicolosi and damaged Trecastagni, Pedara, Mascalucia and Gravina. The same year opened a huge slope starting from the summit and, above Nicolosi, the emission of a huge amount of lava began. The gigantic lava front advanced inexorably beseling Malpasso, Mompilieri, Camporotondo, San Pietro Clarenza, San Giovanni Galermo and Misterbianco in addition to minor villages heading towards the sea.

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- The eruption of 25 November of 1843 - destroyed Bronte and caused 36 victims [**14**].
- November 1928 - Destruction of the town of Mascali. The casting escaped from several side mouths on the eastern volcano side and threatened even Sant'Alfio and Nunziata.
- The eruption of 5 April 1971 began at 3050 meters from a chasm from which the issue of pyroclastic products formed the sub-terminal cone of south-east. The Volcanological Observatory and the Etna cable car were destroyed. In early May a long slope opened at an altitude of 1800 m on the sea level. who reached Fornazzo and threatened Milo. The lava emitted was 75 million cubic meters.
- The 1981 eruption began on March 17th and turned out to be threatened enough: in just a few hours slit from 2550 m away gradually gradually up to 1140 m. The lave emitted, very fluid, reached and cut the circumethea railway; One arm stopped just 200 meters before Randazzo. The lava front cut the provincial road and the Taormina-Alcantara-Randazzo railway of the State Railways, continuing to the shores of the Alcantara river. The destruction of the picturesque and fertile valley is feared, but the fury of the volcano stopped at the rate of 600 m.
- 1983 is to be remembered as well as for the duration of the eruption, 131 days, with 100 million cubic meters of lava issued (which destroyed ski resorts, restaurants, other tourist activities, again the Etna cable car and long stretches of the SP 92), also for the first attempt to the deviation world by means of explosive of lava casting [**15**].

Image 3 – In the overlying photo: Vesuvius volcano in 1944. Credits: http://www.s-wisseduc.ch/stromboli/perm/vesuv/icons/e1944.jpg.

Image 4 – In the overlying photo: I The Vesuvius volcano, taken up in the first half of the 1900s. Credits: https://www.facebook.com/1430377590582223/photos/a.1430378493915466.1073741826.1430377590582223/1477801575839824/?type=1&theater.

The Vulcano Vesuvius is certainly the most dangerous quious volcano in Europe, it is located within the province of Naples, and is able to determine huge damage to people and things, if a sudden eruption appears. Historical data is very important:

- The Eruption of 79 D.C. It is now world history. The famous historic Pliny the old and Pliny The young man, Romans scholars, were direct witnesses to the eruption of Vesuvius of 79 D.C., during which the first died and the second told the event. They were the main historical witnesses of what happened in Pompeii. The eruption of Vesuvius of 79 is the main eruptive event that occurred on Vesuvius in historical times. The eruption, which has profoundly modified the morphology of the volcano and the surrounding territories, has caused the destruction of the cities of Herculaneum, Pompeii, Oplontis and Stabia, whose ruins, remained buried under layers of pumicles, have been reported in light starting from the 18th century.
- The eruption of 1906, effectively described by Frank Alvord Perret and Matilde Serao, was the largest occurred in the 20th century: it is difficult to exactly establish the volume of the ejecta, a lava casting that was headed towards Torre Annunziata was blocked From the walls of the cemetery, and the gaseous cloud that generated in the last hours of activity brushed the top and emptied the magmatic room. Due to the rain of ash was, even in this eruption, almost completely buried Ottaviano, the ancient Ottajano, causing about 300 deaths, so much so that it was called "the new Pompeii".

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For fear of die, 105 people took refuge in a large church of San Giuseppe Vesuviano. The ashes however broke the ceiling and the lava burned the wooden gate: all 105 people in the church died. The costs of the eruption forced the Italian government to renounce the organization of the 1908 Olympics (which had already been assigned), giving them to Great Britain.

- 1929 - An intermediate eruption took place in 1929, when a lava lake was created in the crater, which overflowed on the south-east side and destroyed only some vineyards.
- 1944 - After that of 1929, the next and final eruption, took place between 16 and 29 March 1944, and destroyed Massa di Somma and San Sebastiano again, sprinkled with Ottaviano ashes and all the meridion, and was made famous by the Anglo-American army cinegiornals That at the time he occupied Naples.

  Lava fountains were raised from the crater up to a height of 800 meters, while 26 people in San Sebastiano was literally burned by the rain of ashes, and the crater conduit suffered a radical alteration.

  In fact starting from the end of this eruption the volcano has entered a stage of quiescence, without the smoke plume that had become constant even in times of calm during the last centuries.

The slopes of Vesuvius and the surrounding areas are thickly anthropized and disorderly urbanized. To meet the risks associated with an eruption of Vesuvius, an emergency national plan was prepared which identifies areas with different dangerousness, providing for rescue actions and evacuation plans.

Among the predicted areas, the so-called red area (in turn divided into 5 intercommunal zones), exposed to greater risk from eruption, extends for about 200 km².

The new red area has been expanded, compared to that provided in the 2001 floor, including the territories of 24 municipalities and three neighborhoods of the Municipality of Naples. In addition to the 18th indicated in the Red area (Boscoreale, Boscotrecase, Cercola, Ercolano, Massa di Somma, Ottaviano, Pollena Trocchia, Pompei, Portici, Sant'Anastasia, San Giorgio a Cremano, San Sebastiano al Vesuvio, San Giuseppe Vesuviano, Somma Vesuviana , Terzigno, Torre Annunziata, Torre del Greco, Trecase), the neighborhoods of Barra, Ponticelli and San Giovanni a Teduccio of the Municipality of Naples will be included, the municipalities of Nola, Palma Campania, Poggiomarino, San Gennaro Vesuviano and Scafati, and the Enclave di Pomigliano d'Arco in the municipality of Sant'Anastasia [**13**].

The Stromboli is an active volcano belonging to the Eoliano arch, located on the island of Stromboli, and is one of the most active volcanoes in the world [**16**].

The volcanic building is 926 m high on the sea level. and reaches a depth between 1300 m and 2400 m below sea level [**17**].

Image 5 – Image 6 – Images relating to the eruption of Stromboli, of 22 January 2021. In the image on the left we find a recovery in the visible and infrared spectrum, in the image on the right, we instead find a thermal imaging. Credits: INGV.

The Stromboli is a volcano characterized by regular explosions caused by the outbreak of gas bubbles that

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date back faster than the surrounding magma [**18**]; his eruptions take place with intervals that can vary from minutes to several hours [**16**].

Its "ordinary" activity takes place at a share of 750 on the sea level. From the different eruptive mouths present in the crater area and aligned north-east - south-west.

This activity consists of intermittent explosions of medium energy, usually last a few seconds or ten seconds, and are well separated from each other, during which small amounts of incandescent slag bombs, lapilli, volcanic ashes and lithic blocks are emitted, with speed of output between 20 to 120 meters per second and heights between few dozens up to a few hundred meters.

2 - MONITORING DATA

The monitoring data found through the Italian stations were acquired starting from 10 December 2020. The Italian RDF stations considered, are the following:

- Stazione RDF di Pontedera (PI). Lat: 43.672445 N, Long: 10.640100 E.
- Stazione RDF di Lariano (RM) (1). Lat: 41.728799 N, Long: 12.843205 E.
- Stazione RDF di Lariano (RM) (2). Lat: 41.728799 N, Long: 12.843205 E.
- Stazione RDF di Ripa-Fagnano (AQ). Lat: 3.123060 N, Long: 101.653044 E.

They have begun to document the presence of radioAnomalies having the azimuth of the signals, accident with the geographical position of the same signals detected by the RDF network.

According to these features it was possible to deduce which colorimetric azimuth had to be monitored by each RDF station (as visible in **Fig. 2 e 3**):

RDF STATION	VESUVIUS VOLCANO	ETNA VOLCANO	STROMBOLI VOLCANO
Pontedera (PI)	Dark violet	Light purple	Light purple
Lariano (RM) (1)	Dark violet	Purple / Red	Purple / Red
Lariano (RM) (2)	Dark violet	Purple / Red	Purple / Red
Ripa-Fagnano (AQ)	Light purple	Purple / Red	Purple / Red

Fig. 1 - Table relating to the colorimetric azimuthers of the Italian RDF network, relating to the geographical position of the volcanoes considered in this study. Each volcano is characterized by the intersection of colored azimuthers, which are able to indicate the position of the radio signals (origin). This will be able to indicate which of the recorded signals is generated or not by the different volcanoes under electromagnetic monitoring. Credits: Radio Emissions Project.

The monitoring data was considered based on the electromagnetic frequency of the signals, to their azimuth of origin, duration, intensity, behavior and their geographical origin, in relation to the triangulation system characterized by the four Italian RDF stations.

The colorimetric variation (azimuthes) of the signals is not very high, finding the volcanoes arranged geographically, with respect to the position of the RDF stations receiving, in positions such as to be identified with a variation of minimum azimuth, compared to the color variation of the entire rose Azimuthal (of colors) that the RDF system is able to detect and distinguish (minimum variations with resolution of 0.1 degrees).

This research context also considered the presence of earthquakes (M2 +), which took place during the period in which this study took place, to try to understand if there was a relationship between the appearance of certain electromagnetic signals and the occurrence of these telluric phenomena Products from volcanism.

In this case the archive of these events that was considered is that of the Geofisica and Volcanology National Institute, which was then related to the

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appearance of electromagnetic emissions recorded by the series of sensors developed by the Radio Emissions Project and spread over Italian.

Image 7 – An image of the eruption of the Etna volcano, of 14 December 2020. Credits: Etna TV.

In this regard, the researchers have decided to document the Ethneas and Strombolian volcanic eruptions, since it is spectacular and flashy phenomena as well as important from a scientific point of view, to be able to visually examine the energy produced by volcanoes, energy that was followed, Measured and recorded through the use of the RDF network, located on the Italian territory.

It is the first time that a system of this type is used for the monitoring of active volcanoes.

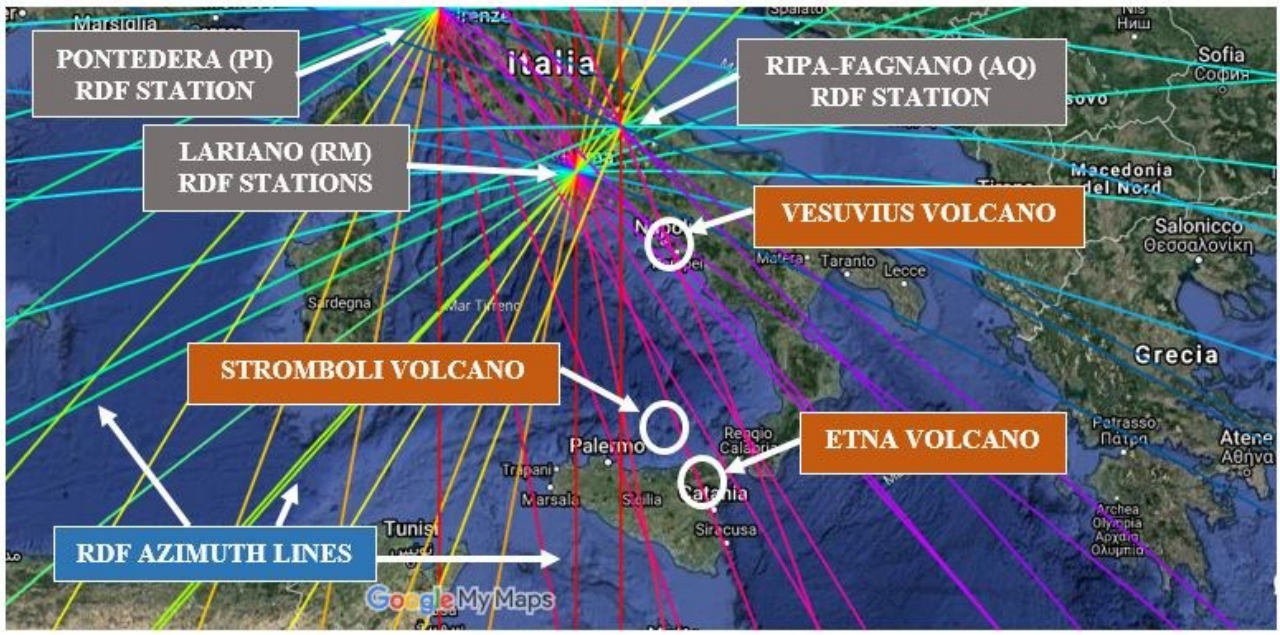

Fig. 2 - Map of the Italian RDF network, with particular reference to the position of the main Italian active volcanoes and quiescent, considered in this study. The colored lines represent the azimuthes of origin of the electromagnetic signals for each RDF station, the variation of colors indicates the azimuthal variation of the electromagnetic signals that each station is able to detect. For each Azimuth the color to the registered electromagnetic signal has the same azimuth of origin. Credits: Radio Emissions Project, Google Maps.

As regards the signals discriminated by the monitoring system, for each RDF station we obtain precise reference azimuth, which is, based on the position of the reference RDF station:

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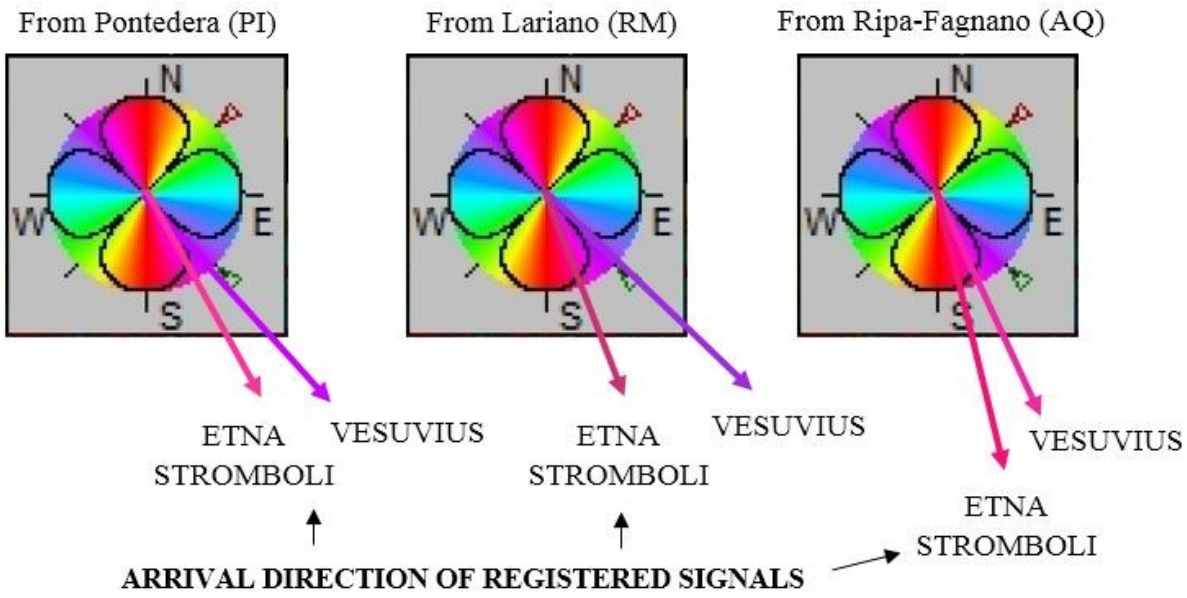


Fig. 3 – RDF compass of the four RDF stations used for reception of signals. The arrival directions of signals are observed, and the respective emission colors of the same, which the RDF system is able to highlight. Each color is associated with a AZIMUTH (arrival direction). As you can understand for each RDF station, the Azimuth changes because the management within which the volcanoes are located is different. Credits: Radio Emissions Project.

Observing the coloring of the electromagnetic signals associated with these Azimuths (**Fig. 2**), it was possible to understand, also thanks to the triangulation of the radio signals themselves from all Italian RDF stations, as a volcano has emitted electromagnetic signals, before the occurrence of earthquakes, generated by volcanic activity or eruptions determined by magmatism.

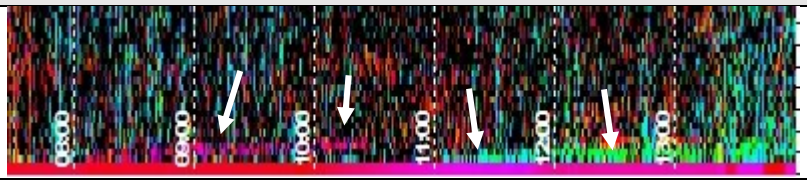
2.1 - TYPE OF RADIO SIGNALS

The monitoring system is able to automatically generate dynamic spectrograms, in which the electromagnetic signals are highlighted by means of colors. Each color is associated with the arrival direction of the signals themselves, compared to the position of the monitoring station which is located on the Italian territory.

Starting therefore from the geographical position of the receiving RDF station, the computerized system is able to develop the electromagnetic signals emitted by the volcanoes, therefore indicating the Azimuth of origin and their morphology with respect to a time scale, identifying the geographical genesis point.

Some examples of radio-emissions associated with those of volcanic activity, and recorded by the RDF network, in the period in which this study took place are those visible in the **Fig. 4**.

The type of recorded signals varies according to the electromagnetic frequency, to the intensity with which they appear and the time, as well as for their behavior over time (appearance, disappearance, frequency oscillation, extension, bandwidth), as Visible in the **Fig. 4**.

RDF STATION	SPECTROGRAM
10 december 2020 RDF Lariano 1	

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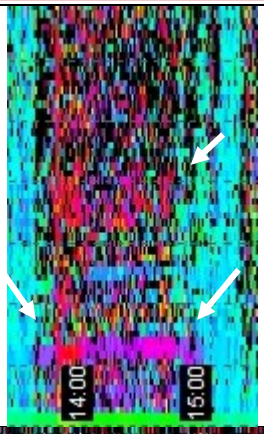
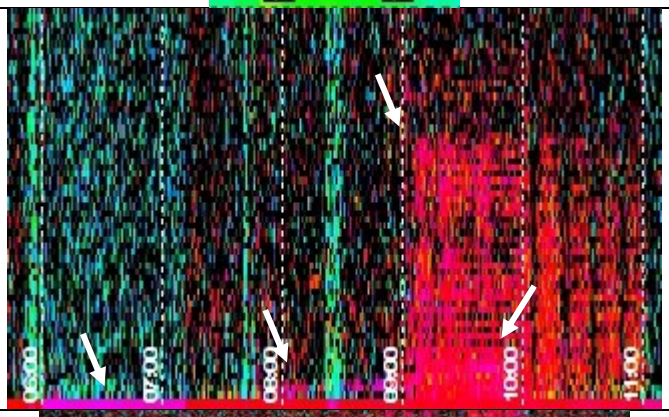
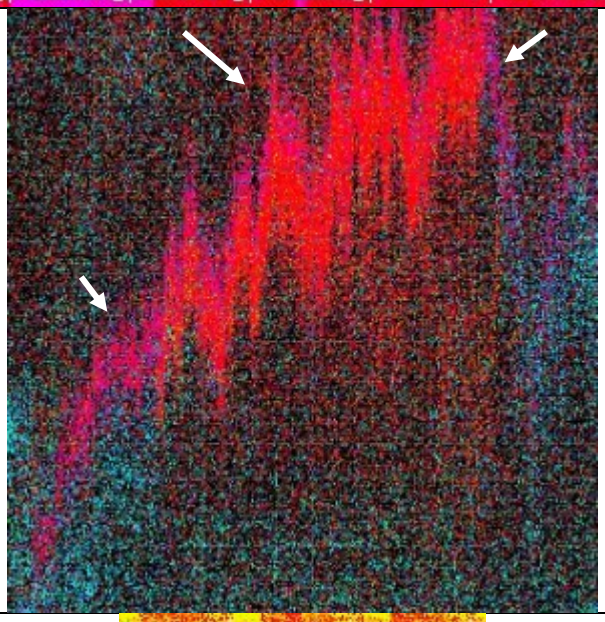
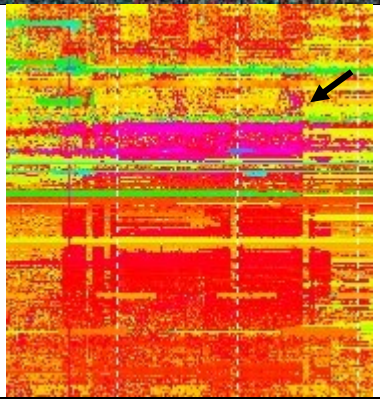
10 december 2020 RDF Lariano 2	
11 december 2020. RDF Lariano 1	
12 december 2020 RDF Ripa-Fagnano	
13 december 2020 RDF Pontedera	

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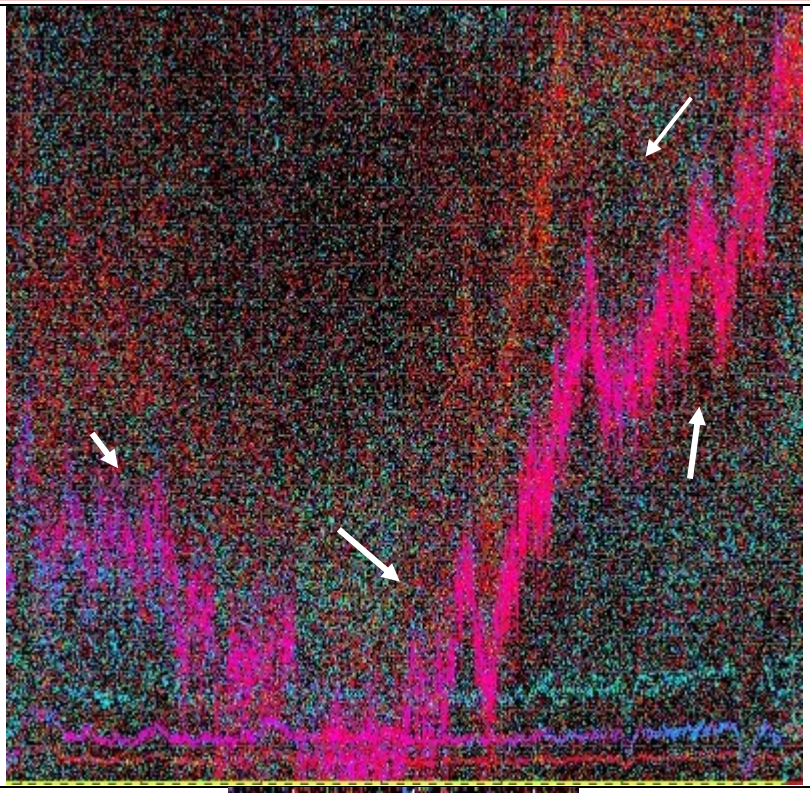
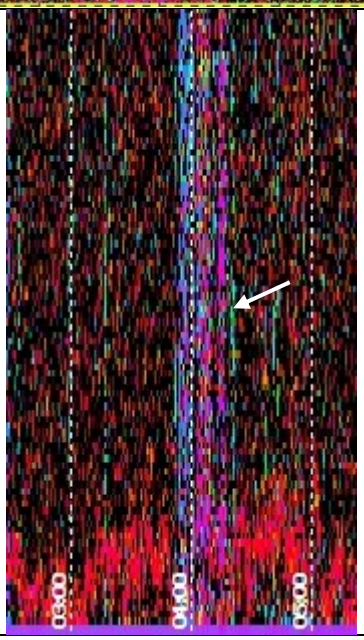
14 december 2020 RDF Ripa-Fagnano	
17 december 2020 RDF Lariano 1	
8 January 2021 RDF Ripa-Fagnano	

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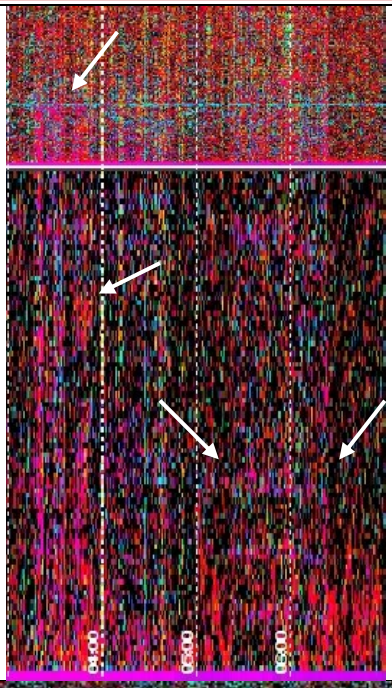
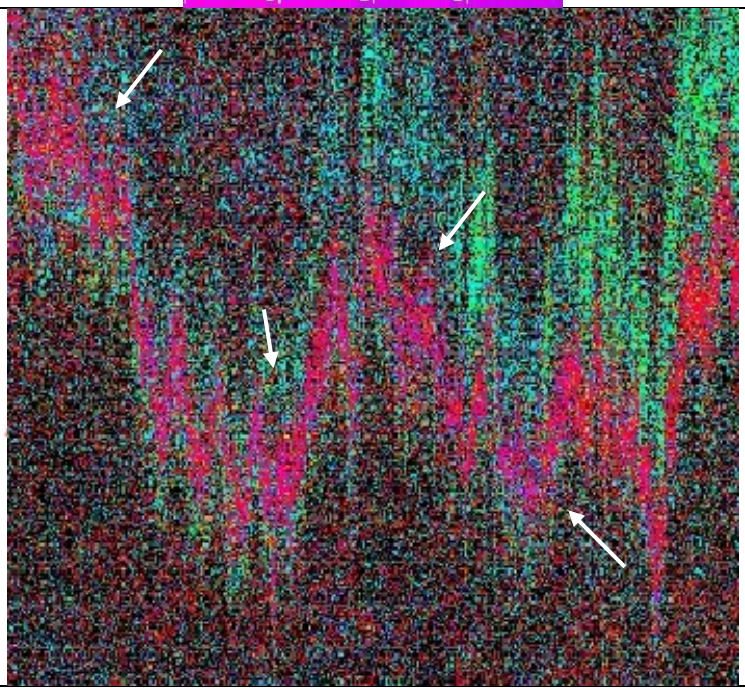
13 January 2021 RDF Lariano 1	
18 January 2021 RDF Ripa-Fagnano	

Fig. 4 – Some examples of electromagnetic signals registered by the Italian RDF network. In this table, some signals are observed, different for morphology and electromagnetic frequency, as well as duration. The visible times on the spectrogram are in UTC. On the Cartesian axis of the order we have the electromagnetic frequency of the signals, and on the Cartesian axis of the abscissions, we have the time period, in utc time, within which these signals have appeared. The dynamic spectrogram also shows, through its colors, the azimuthal origin of these signals, their behavior over time, such as bandwidth, width, durability and intensity (saturation). Credits: Radio Emissions Project.

In forward terms, the study methodology had to take into account the morphology of the registered signals, as they appear on dynamic spectrograms, which represent a "radiography" of the electromagnetic behavior of these emissions.

An arrival direction compared to cardinal points and compared to the position of the monitoring station is associated with each color.

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This investigation method has been extensively tested to start from 2017, when the Italian RDF network was used for the first time in Italy and then widespread in the peaceful area [**1**] [**21**] [**22**] [**23**] [**24**][**25**][**26**][**27**][**28**][**29**][**30**][**31**][**32**][**33**][**34**][**35**].

2.2 - HYPOTHESIS

The hypothesis advanced by the authors of this study, contemplates the phenomenon of piezoelectricity [**19**], ie a phenomenon generated by the interaction between the increase in mechanical stress in the rocks and the subsequent rupture of the crystalline reticoli of the rocks themselves, to which it follows then The actual electromagnetic emission determined by the use of electric charges (ions) [**20**], which are distributed over the entire heat surface subject to mechanical stress. This electromagnetic issue is generated with different kilowatts of energy, such as to bounce in the ionosphere to reach high distances. This is how the electromagnetic signals are able to be detected at considerable distance from an electromagnetic monitoring system based on radio receivers.

Normally magmatism is responsible for the deformation of the walls of a volcano, such deformed deformation and fragments a certain percentage of rocks that the volcano itself is formed. The release of a large amount of moving electric charges, generates radiofrequency [**20**].

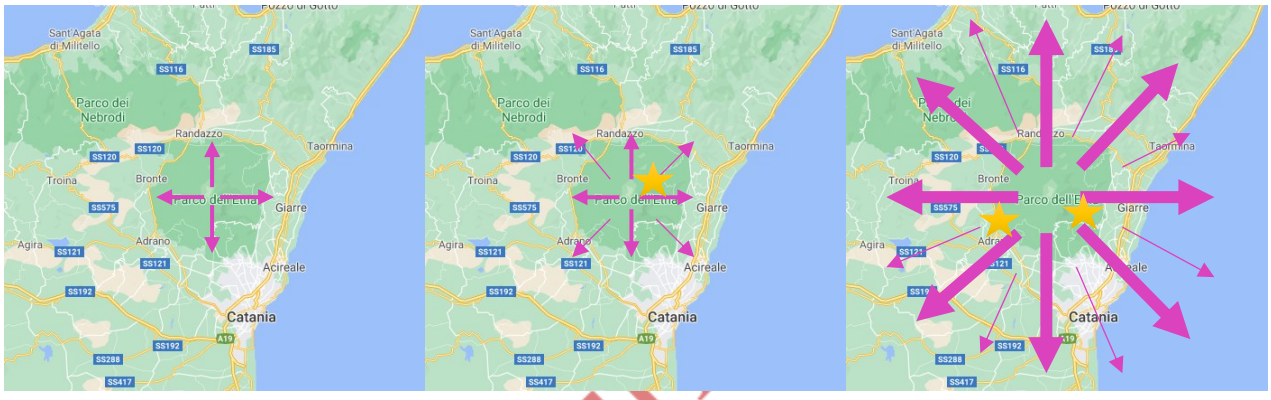

Fig. 5 – Example of emission Elle electromagnetic waves, developed by volcanic activity, in this case the Etna volcano. The work hypothesis contemplates the increase in stress crusta, generated by the magmatic activity of the volcano itself. The increase in energy and its accumulation within the volcanic cone is able to deform the very wall of the cone, whose rocks, subjected to this enormous stress, begin to emit radiofrequency, due to the release of electric charges associate the piezoelectric effect. In this sequence we observe a weak electromagnetic emission, to then increase, together with seismic emissions even to swarms, electromagnetic emissions grow considerably in intensity and number. Credits: Radio Emissions Project.

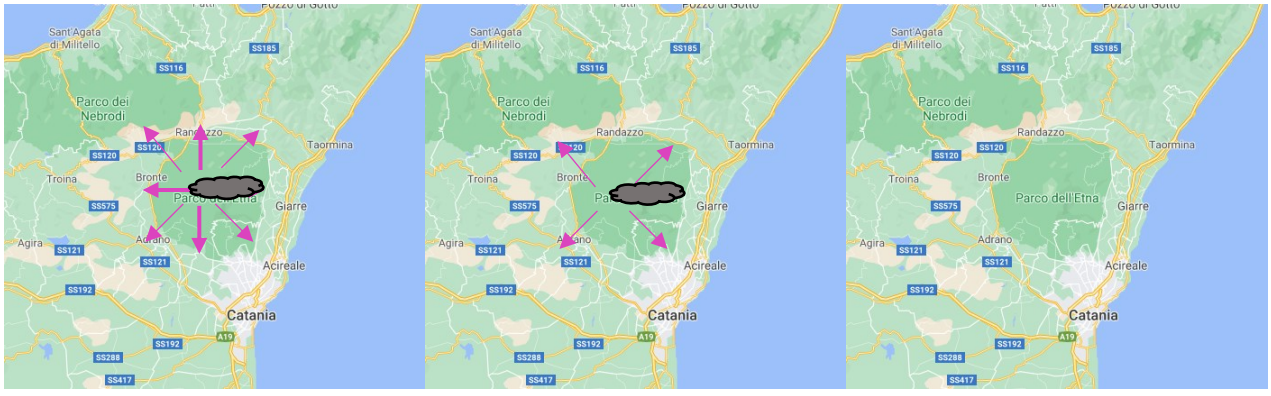

Fig. 6 – Example of electromagnetic emission referring to the activity of volcanoes. In this sequence, a decrease in radio emissions is observed and the subsequent eruption, with the release of energy derived from magmatism. In this temporal settlement electromagnetic emissions decrease considerably. At the end of the eruption the energy system stabilizes, both eruptions and seismic phenomena cease. Credits: Radio Emissions Project.

Electromagnetic issue increases as increasing energy accumulation within the volcanic cone, even at a certain depth.

As the energy grows the earthquakes may occur precisely for rupture of the rocks of which the volcanic cone is composed, therefore it will be possible to detect

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and record electromagnetic emissions from the volcano, with the registration of seismic phenomena. Electromagnetic activity will grow until just before the eruption, or when the accumulated energy will result in the release of Magma outside the volcanic cone.

Electromagnetic emissions will attute, until just before the eruption, or after the occurrence of micro-earthquakes and earthquakes behind the volcanic cone. These emissions will be temporarily terminated to eruption. (**Fig. 5** and **6**).

At this point the energy system will return to normal, electromagnetic emissions will be absent and there will be no more earthquakes.

In this hypothesis of work, the mechanisms of electromagnetic genesis, seem to be identical to those observed starting in 2017 [**1**], ie from the beginning of the experimentation of the electromagnetic detection system based on the RDF system. Ultimately, whenever the terrestrial crust accumulates energy, a certain amount of electromagnetic signals will be issued, both before an earthquake or before a volcanic eruption [**22**][**23**][**24**][**25**][**26**][**27**][**28**][**29**][**30**][**31**][**32**][**33**][**34**][**35**].

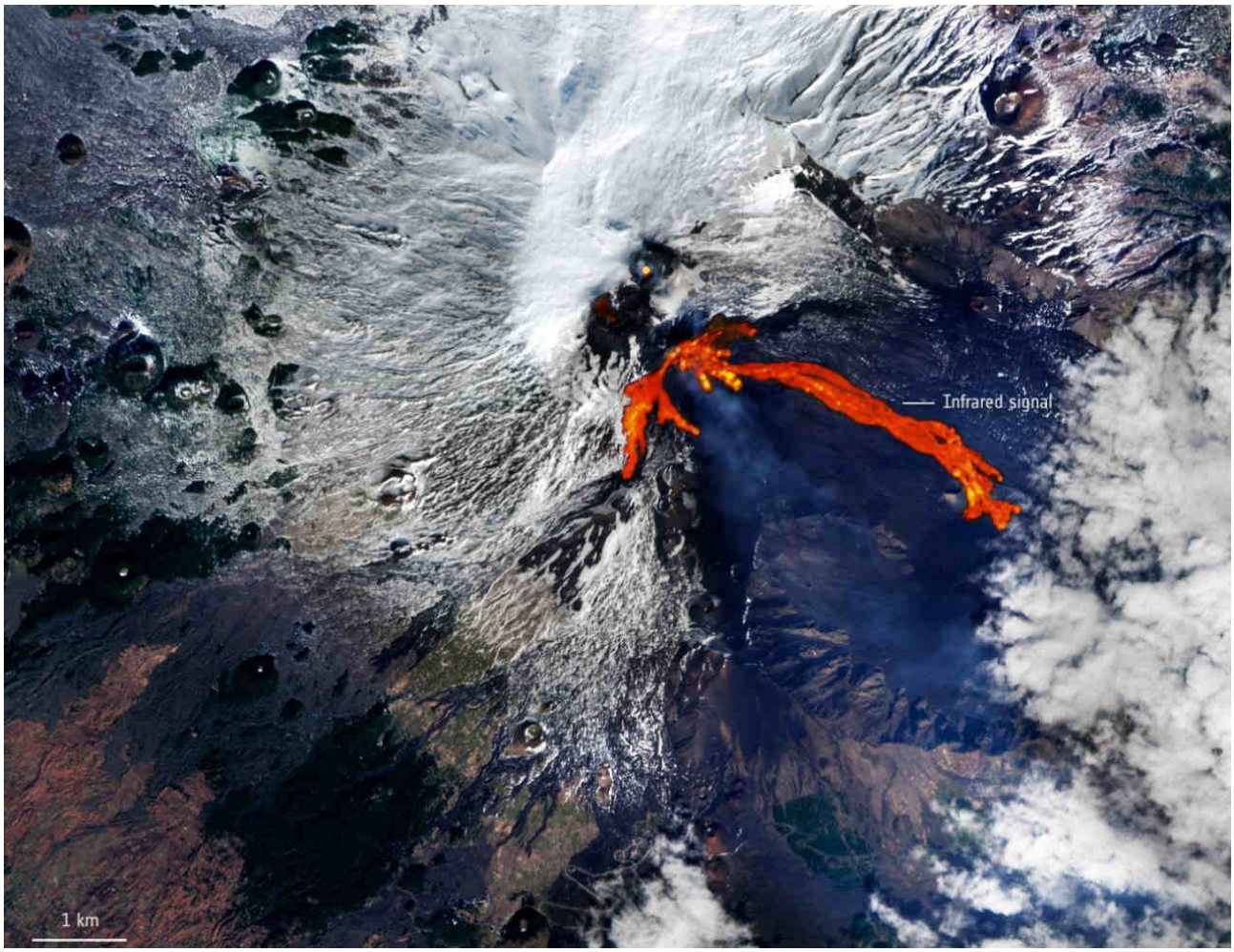

Image 8 – Satellite image of 16 February 2021, captured by the European Sentinel-2 satellite. It shows the lava casting of Etna Volcano, formed during a long and intense eruption. Eruption preceded by strong electromagnetic signals registered by the RDF network and by some earthquakes. Credits: https://www.meteogiornale.it/magazine/2021/02/etna-eruzione-vista-dallo-spazio/.

3 - DATA ANALYSIS

The first electromagnetic signals were recorded starting at 08:30 utc of 10 December 2020, after a few hours from the activation of the monitoring of Italian volcanoes, carried out by the Radio Emissions Project, the day the study began. The study then continued for

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about three and a half months, until its conclusion, which took place on 31 March 2021.

Electromagnetic monitoring data results were very abundant, in this context for the analysis of the same there are several weeks of processing and corroboration.

3.1 - DECEMBER 2020 DATA

The following is the series of data of the three volcano monitoring data considered in this study (Etna, Stromboli and Vesuvius), in December 2020. They considered: the electromagnetic frequency of radio signals coming from the volcanoes themselves, their duration and time of appearance. In addition to data relating to electromagnetic emissions, the study considered the seismic data, or the appearance of earthquakes and eruptions that took place in the same time period in which monitoring has continued.

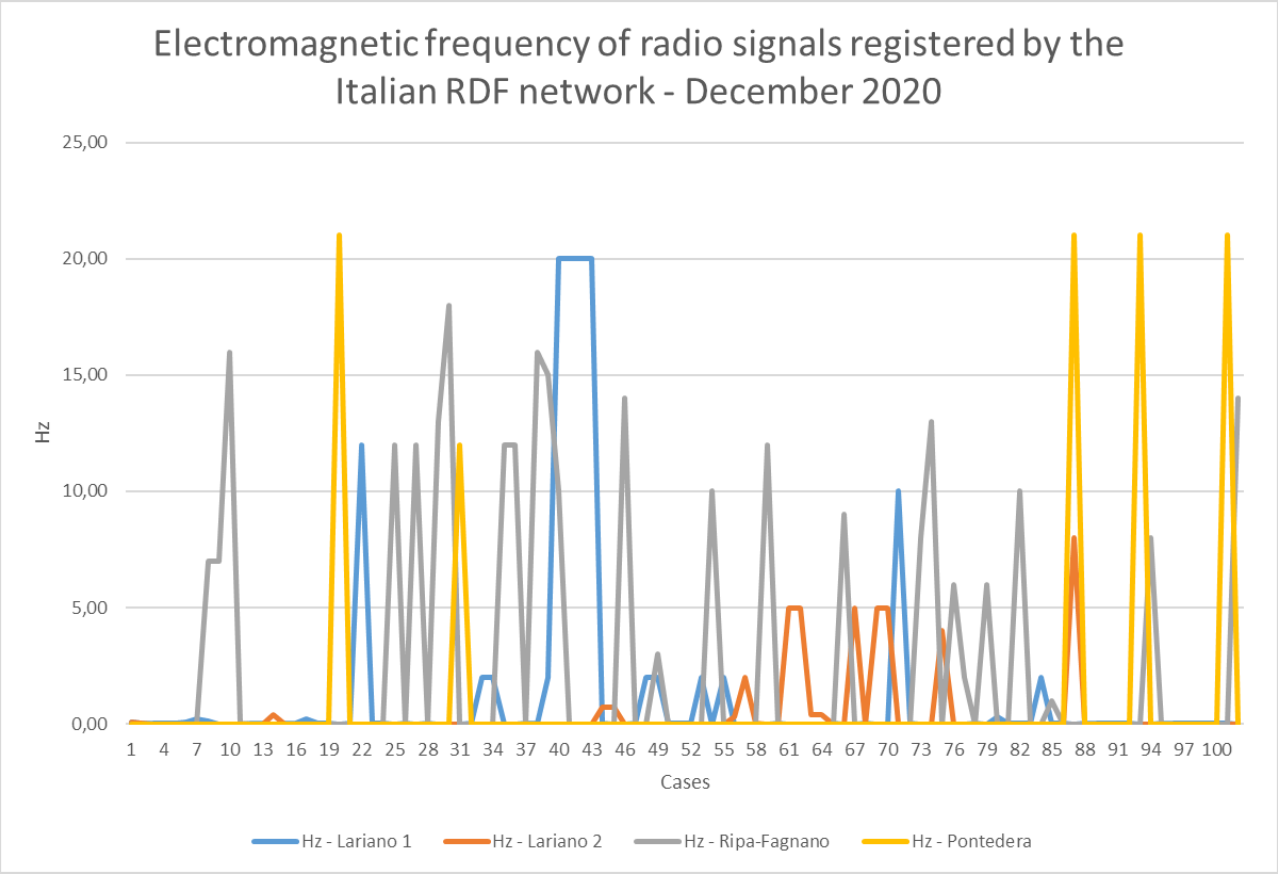

Fig. 7 – Electromagnetic frequency of radios-anomalies recorded by the Italian RDF network. Credits: Radio Emissions Project.

The **Fig. 7**, it shows the distribution of all electromagnetic emissions (radio-anomalies) recorded by the Italian RDF network, signals that have as main features the Azimuth of origin (arrival direction) of the geographical position of volcanoes under monitoring. In this case the data is those recorded between 10 December 2020 and 31 December 2020.

These are the first absolute data of an electromagnetic monitoring carried out with an RDF system ever took place first on a global scale on volcanoes, this given the results to which the researchers found in front have provided indications that for the first time they could help understand certain mechanisms related to magmatism and volcanic paroxysm; This can be defined as a real electrocardiogram that for the first time has been realized thanks to the use of an innovative monitoring technique and still in the experimentation phase.

The **Fig. 8**, **9** and **10**, instead, show the distribution of electromagnetic signals registered by the Italian RDF network, the appearance of eruptions and earthquakes,

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in the same period considered, or always between 10 December 2020 and 31 December 2020.

In this case, the eruptive and seismic activity has been important and allowed the group of researchers to acquire a high number of information, which for the first time it was possible to analyze.

It is interesting to note how the earthquakes always precede volcanic eruptions and as: both earthquakes and eruptions are always preceded by the appearance of electromagnetic signals (radios-anomalies), coming from the volcano itself.

In this case, the eruptions are those of the Etna volcano and the Stromboli volcano, given that Vesuvius still remains quiescent and not able to generate eruptive phenomena, albeit minimal.

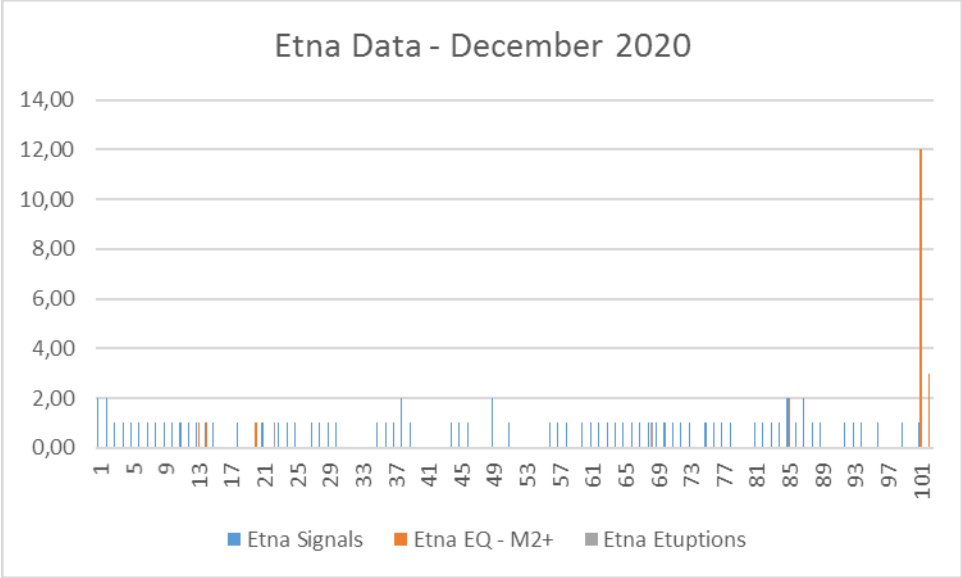

Fig. 8 – Monitoring data of the Etna volcano: radio-anomalies count, M2 + earthquakes and eruptions. Credits: Radio Emissions Project, Ingv.

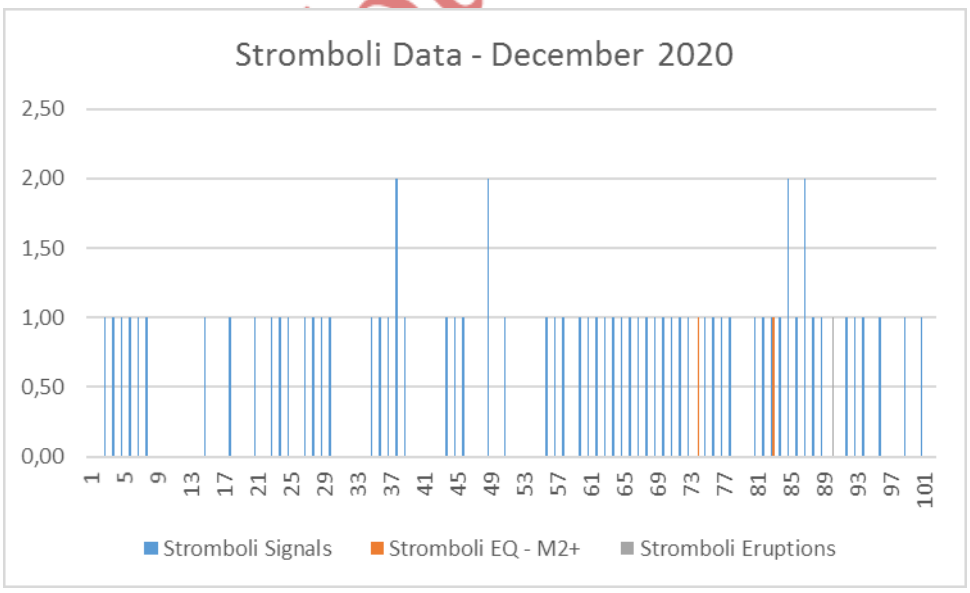

Fig. 9 – Monitoring data of the Etna volcano: radio-anomalies count, M2 + earthquakes and eruptions. Credits: Radio Emissions Project, Ingv.

These are preliminary data, which for the first time are recorded and analyzed with an RDF system. This shows that electromagnetic emissions can precede both the occurrence of the earthquakes (as it was already known), both the occurrence of eruptions, in which a lot of energy accumulates within the lithic structure of the volcanic cone itself and essentially inside of the magmatic room. Forces that for now cannot be measured but thanks to this monitoring technique it is however possible to observe and partly measure.

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The **Fig. 12**, **13**, **14** and **15**, it points out how these electromagnetic emissions are distributed to the earthquakes to the same period. In this case the data analysis was carried out by going to consider each RDF station separately, to understand and understand, compared to their geographical position, what was their effectiveness in detecting and identifying electromagnetic signals that could have a forecast meaning.

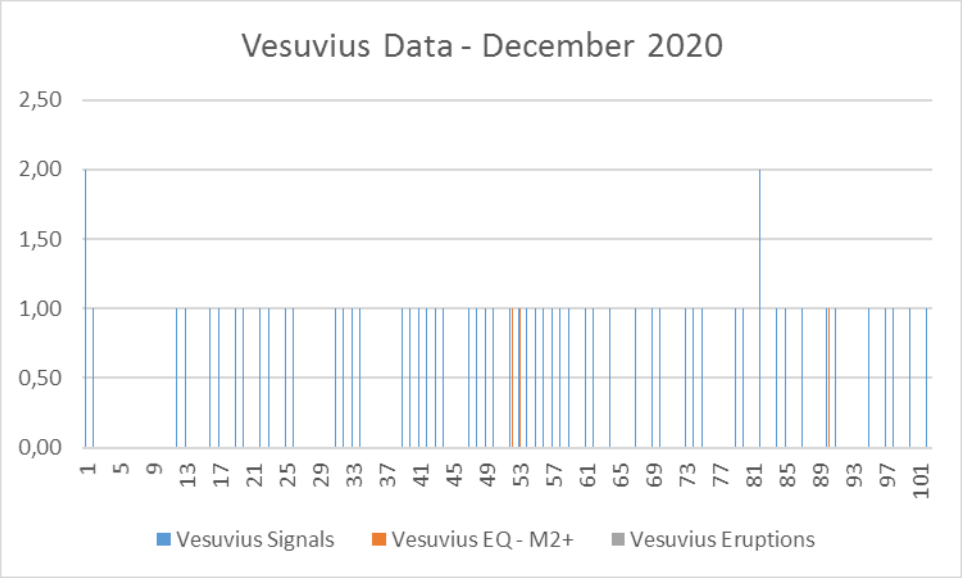

Fig. 10 – Monitoring data of the Etna volcano: radio-anomalies count, M2 + earthquakes and eruptions. Credits: Radio Emissions Project, Ingv.

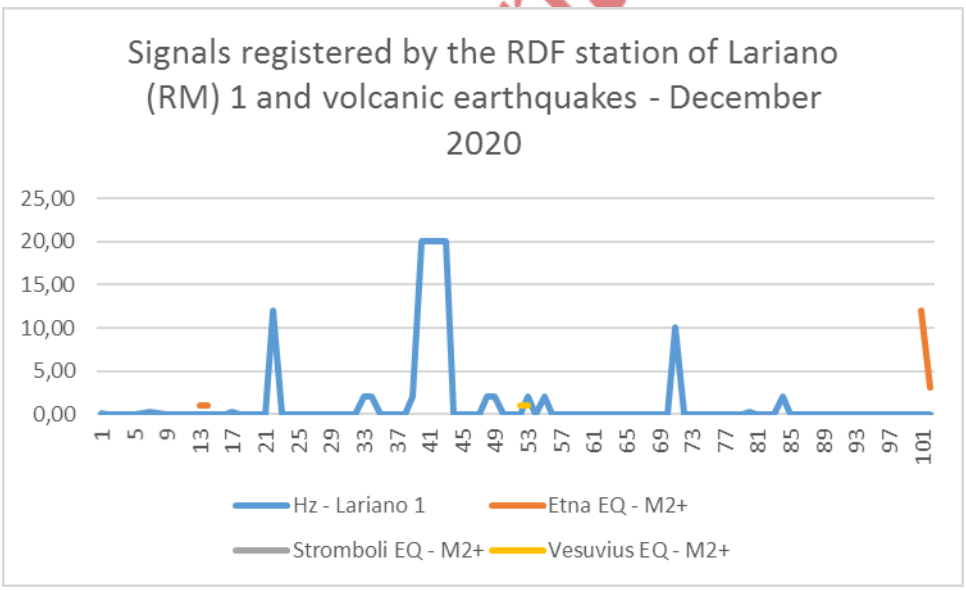

Fig. 11 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

By observing these graphs it is possible to understand that each RDF station is able to highlight the presence of corresponding signals then to a certain type of volcano, where the earthquakes are presented. The concentration, for example, of a number of radios-anomalies, indicates how in that direction and in a certain period of time it will be possible to observe the occurrence of earthquakes, even if weak intensity.

The visible differences between a station and another, compared to their ability to detect a number of radios-anomalies may depend on their geographical position, from the presence of natural obstacles, such as mountains or hills or by the presence of other variables such as ad Example The hardware features of the PCs that make up the monitoring network itself.

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What can still be observed is that despite the substantial differences of each RDF station, if these stations are made to work together, in a single detection system (like a network), they are able to provide precise indications where an earthquake or a ' eruption will appear.

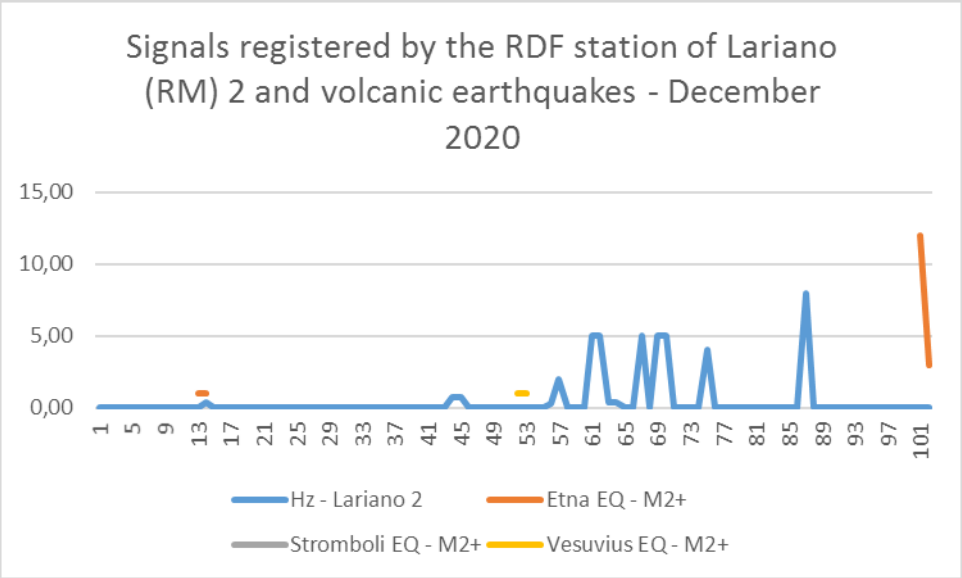

Fig. 12 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

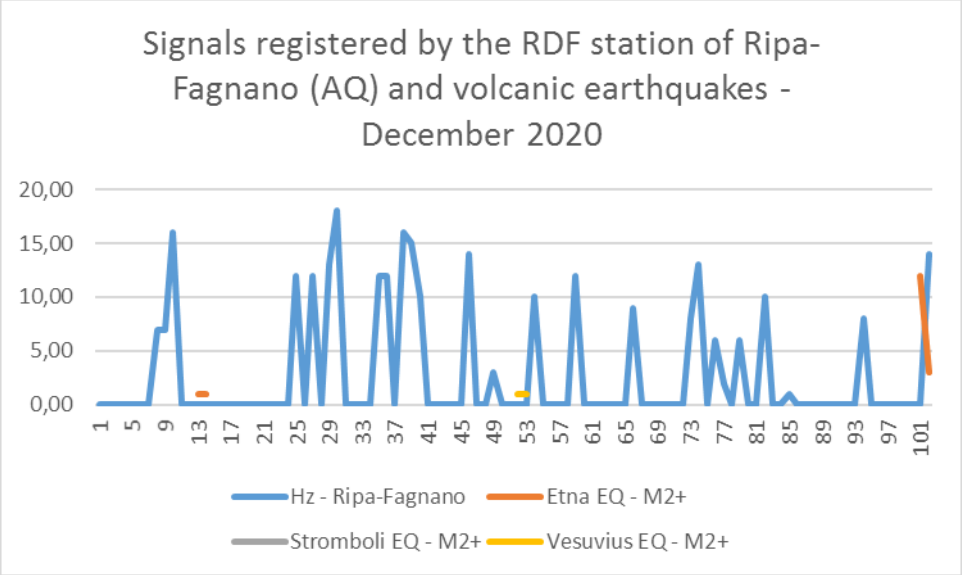

Fig. 13 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

The monitoring data confirms that some electromagnetic signals (radio-anomalies) appear and can be detected, from several stations at the time of their appearance, as visible in the **Fig. 7**.

This indicates that the RDF network is able to confirm the presence of a single signal, from different points of Italy, and that this signal is identified in its azimuth of origin, or from its point of origin.

This shows that the capacity of the monitoring network (Radio Emissions Project Network), is able to detect electromagnetic signals, triangular and allow researchers to identify the direction of arrival and therefore the point in which they are issued on the earth's surface.

Data in December, obviously not the only ones to provide indications of this type, being confirmed by the data of January 2021, February 2021 and March 2021, as we will see later.

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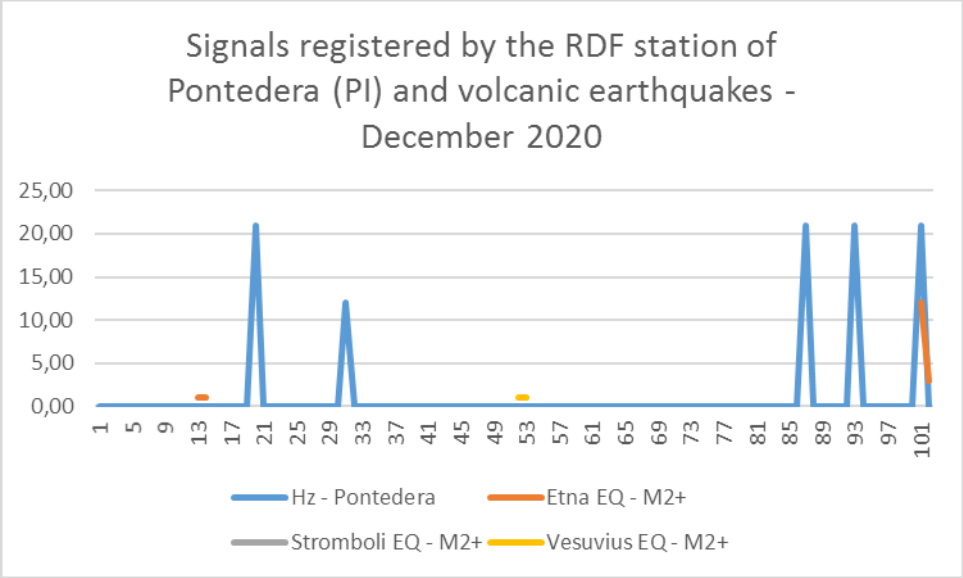

Fig. 14 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

3.2 - JENUARY 2021 DATA

The following is the series of data monitoring the three volcanoes considered in this study (Etna, Stromboli and Vesuvius), in January 2021. They considered: the electromagnetic frequency of radio signals coming from the volcanoes themselves, their duration and time of appearance. In addition to data relating to electromagnetic emissions, the study considered the seismic data, or the appearance of earthquakes and eruptions that took place in the same time period in which monitoring has continued.

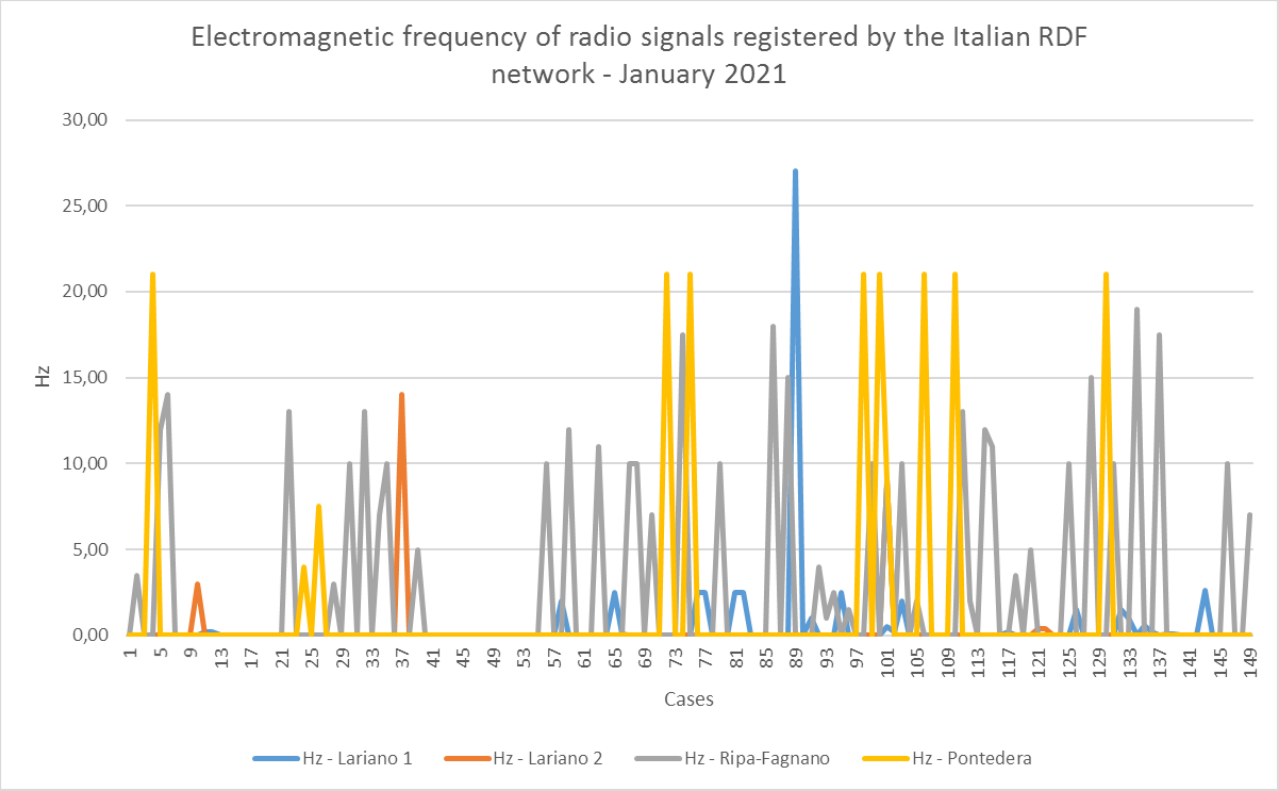

Fig. 15 - Electromagnetic frequency of radios-anomalies recorded by the Italian RDF network. Credits: Radio Emissions Project.

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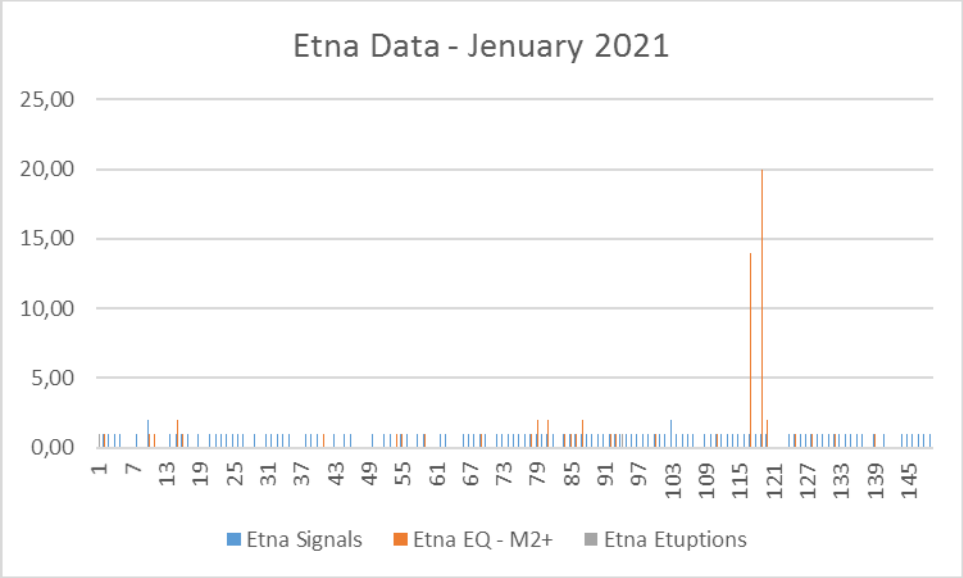

Fig. 16 – Monitoring data of the Etna volcano: radio-anomalies count, M2 + earthquakes and eruptions. Credits: Radio Emissions Project, Ingv.

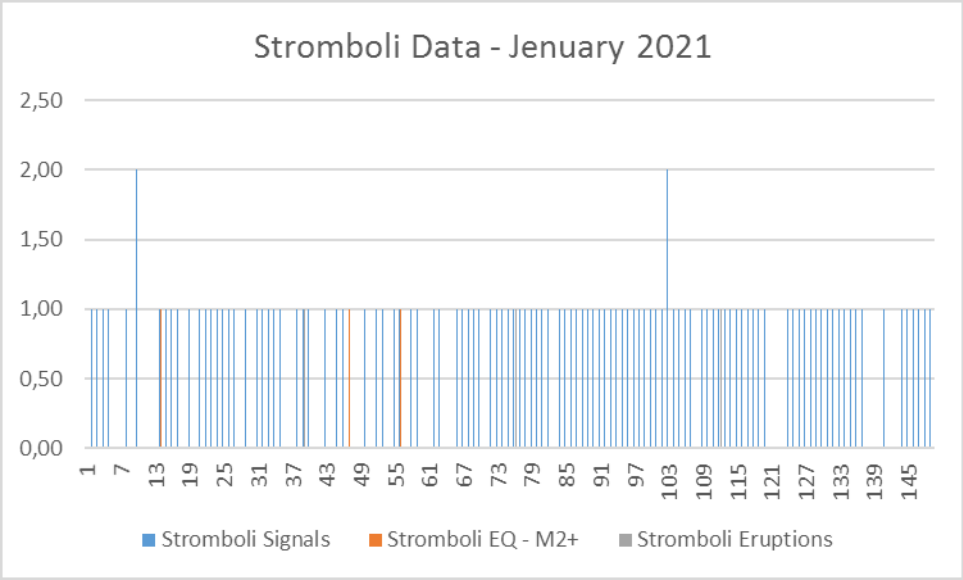

Fig. 17 – Monitoring data of the Stromboli volcano: radio-anomalies count, M2 + earthquakes and eruptions. Credits: Radio Emissions Project, Ingv.

The monitoring data of the month of January 2021, have once again shown significant correspondence between the appearance of electromagnetic signals (radio-anomalies) recorded by the Italian RDF network and the occurrence of earthquakes and eruptions.

The **Fig. 17**, show the temporal distribution of all radios-anomalies recorded by the Italian RDF network, while going to observe the **Fig. 18**, **19**, and **20**, we can better understand how these emissions are distributed compared to the phenomena generated by each individual monitored volcano.

It is evident that the most active volcano is Etna, which precisely in the period in which this study has been implemented presented a massive issue of phenomena, such as earthquakes, seismic swarms and eruptions, as they did not occur for several months. This allowed the group of researchers engaged in this study to obtain a good number of data to be analyzed. In this case the increase in the number of radios-anomalies compared to a certain time period indicated the occurrence of a number of earthquakes and eruptions.

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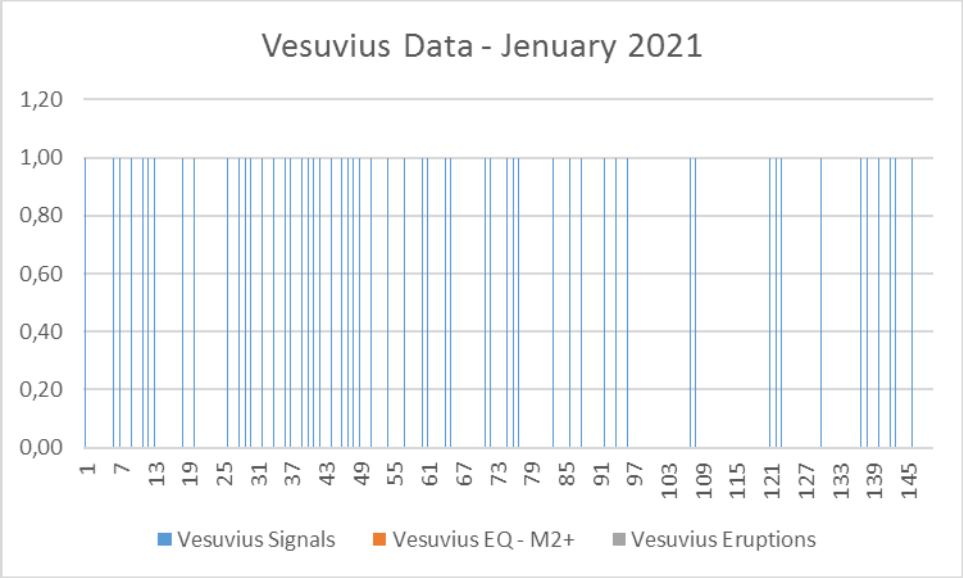

Fig. 18 – Monitoring data of the Vesuvius volcano: radio-anomalies count, M2 + earthquakes and eruptions. Credits: Radio Emissions Project, Ingv.

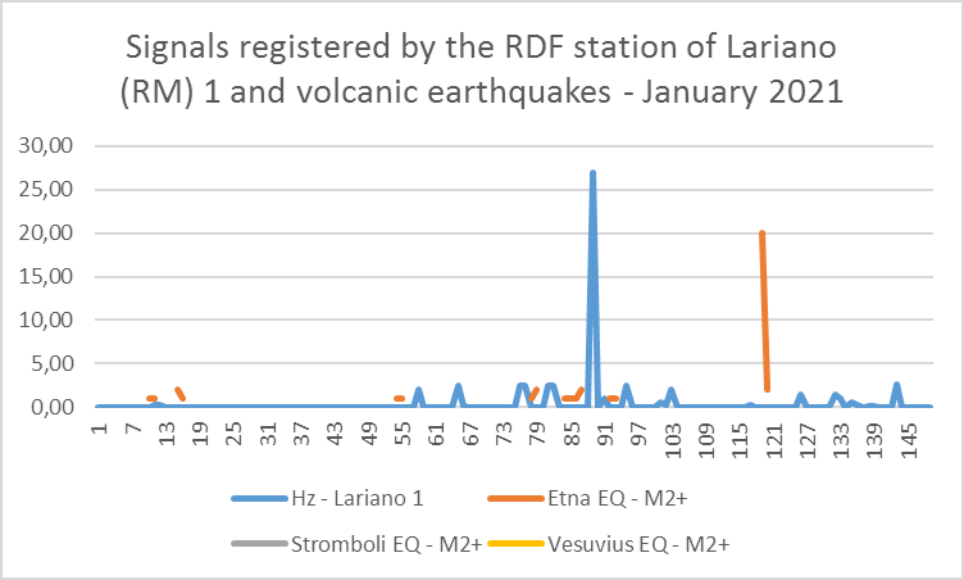

Fig. 19 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

The **Fig. 19**, **20**, **21** and **22**, they again confirmed how there is a very close relationship between the appearance of radios-anomalies and the occurrence of earthquakes. The graphs, in this, are very explicit and do not arouse any doubt.

There are then variables that are confirmed in every time period considered, and these variables concern the single RDF station, which shows to record signals that seem unrelated (at least temporally) with the occurrence of volcanic phenomena. But this could suggest that these signals, although having the azimuth of origin associated with the volcano, could indicate emissions however always of crustial origin and volcanic, perhaps determined by the phase of preparation of the telluric events and / or eruptions, phenomena we know yet little and they probably take several hours or days to manifest.

On this the data is very obvious even if you have yet to work to better understand these mechanisms and what to determine these variables.

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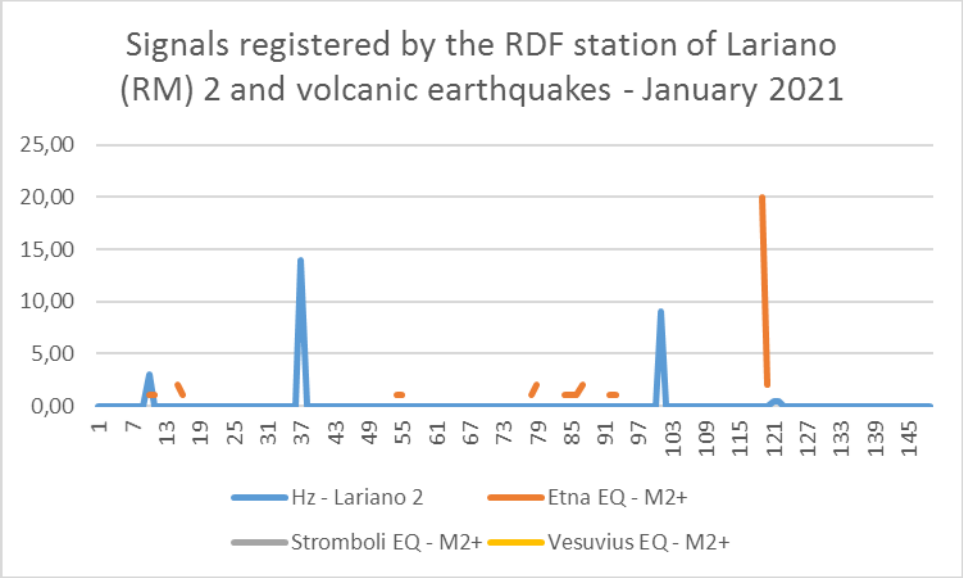

Fig. 20 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

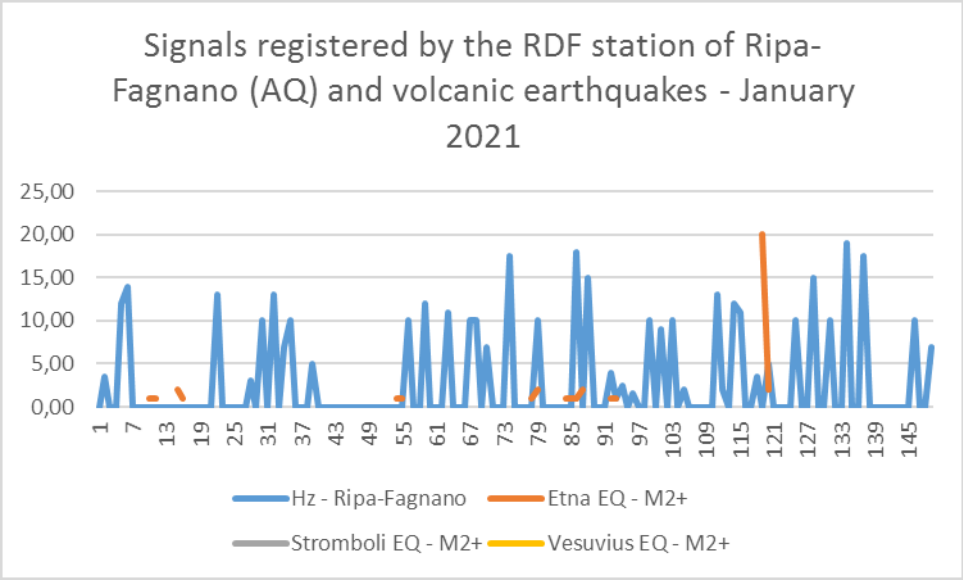

Fig. 21 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

For the first time you have the chance to see what a volcano is able to generate in the electromagnetic spectrum and as such emissions behave in the self-elf spectrum (0.001 Hz - 30 Hz). A sort of dynamic radiography carried out by several detection stations that demonstrate how to occur seismic phenomena correspond certain electromagnetic emissions. This is clearly visible, for example, in the **Fig. 21**, where the station located in the province of L'Aquila in Italy, electromagnetic emissions move together with seismic events. Net differences are for example visible in the **Fig. 20** or again in the **Fig. 22** where for example some earthquakes do not seem to be preceded by any electromagnetic emission (apparently), but essentially all the stations together manage to highlight the presence of these emissions before earthquakes or volcanic rashes occur.

We must then consider the entire RDF network as a single detection system.

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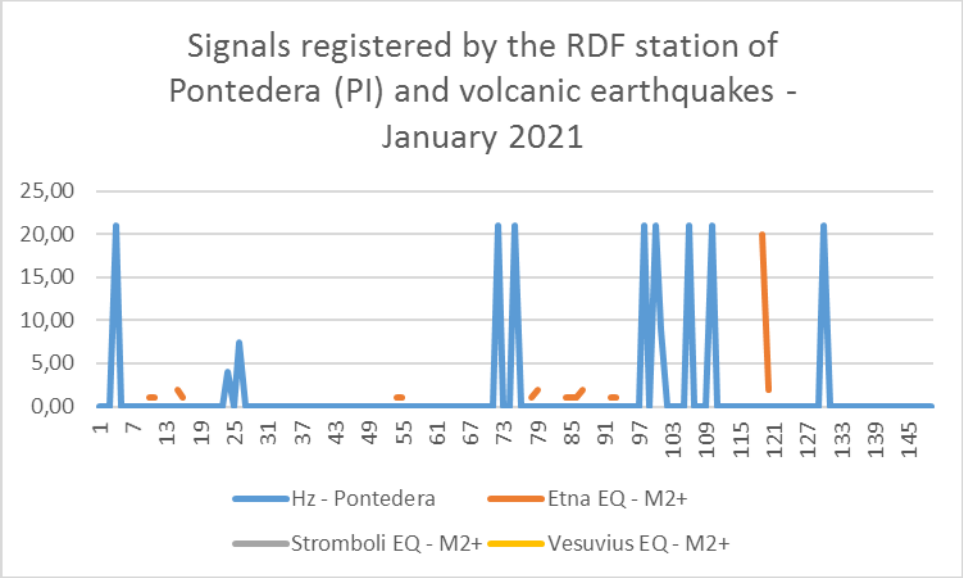

Fig. 22 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

3.3 - FEBRUARY 2021 DATA

The following is the series of data of the three volcano monitoring data considered in this study (Etna, Stromboli and Vesuvius), in February 2021. They considered: the electromagnetic frequency of radio signals coming from the volcanoes themselves, their duration and time of appearance. In addition to data relating to electromagnetic emissions, the study considered the seismic data, or the appearance of earthquakes and eruptions that took place in the same time period in which monitoring has continued.

Fig. 23 – Etna in eruption. The photograph was taken up between the night of 16 and 17 February 2021 and refers to the first paroxysm of the month of February 2021. The photo was taken from Monte Zoccolaro. Credits: Dario Giannobile, https://www.dariogiannobile.com/. By court granting.

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The beautiful images taken by Dario Giannobile (**Fig. 23**), they give us the practical sense of the emitted energy of Etna in February 2021. Precisely in this period the detection system has made it possible to collect further data for the understanding of the seismogenetic mechanisms linked to volcanic activity and its paroxysm.

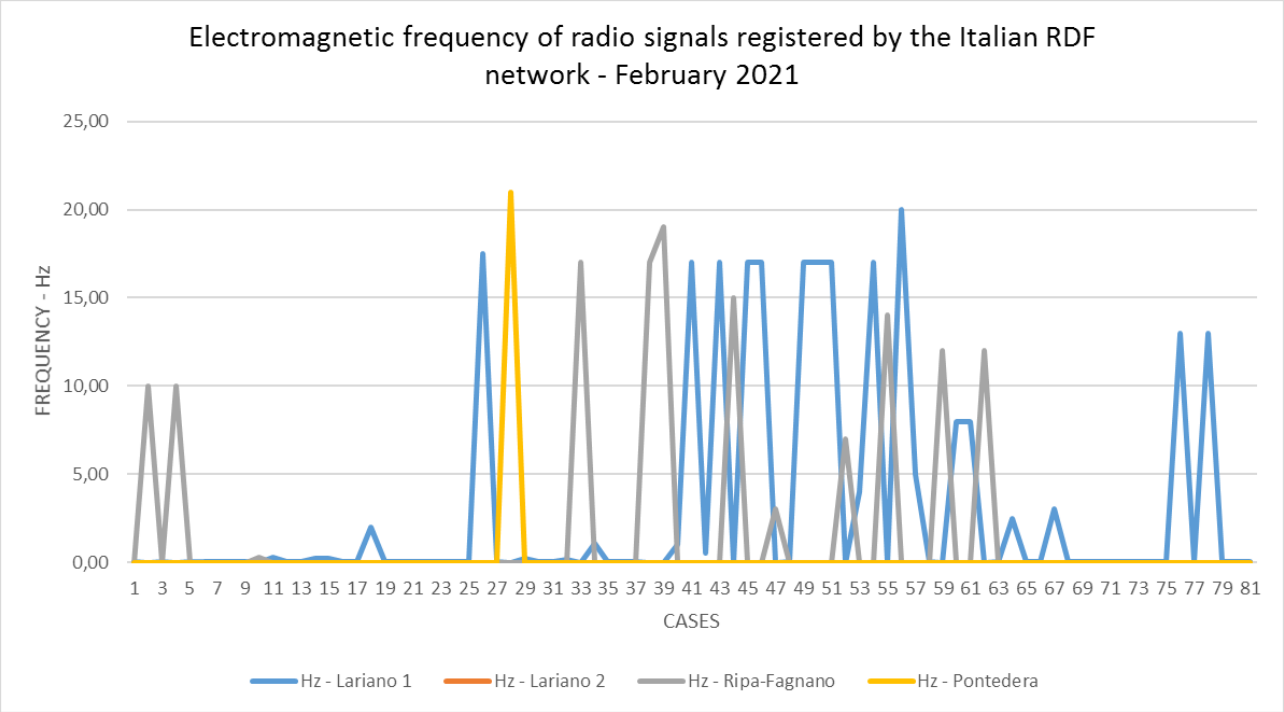

Fig. 24 – Electromagnetic frequency of radios-anomalies recorded by the Italian RDF network. Credits: Radio Emissions Project.

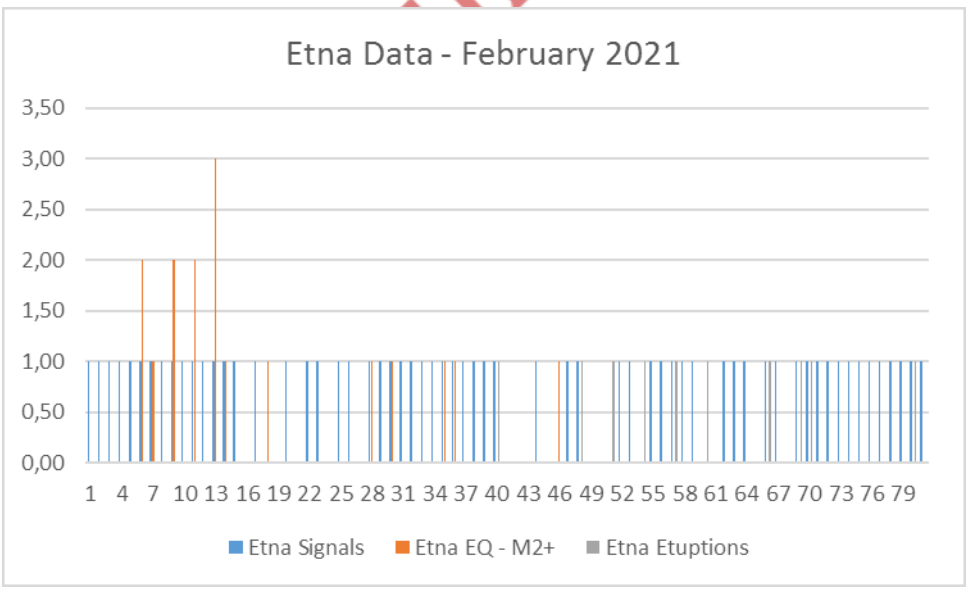

Fig. 35 – Monitoring data of the Etna volcano: radio-anomalies count, M2 + earthquakes and eruptions. Credits: Radio Emissions Project, Ingv.

The **Fig. 24** shows the concentration of all electromagnetic emissions (radios-anomalies) which have precoured earthquakes and eruptions. In February 2021 the activity of Etna was extremely intense, with up to 2 km high lava fountains. It is evident how the eruptions are preceded by earthquakes and as these are in turn preceded by important electromagnetic emissions. Even the eruptions are in any case preceded by electromagnetic emissions and monitoring highlights it.

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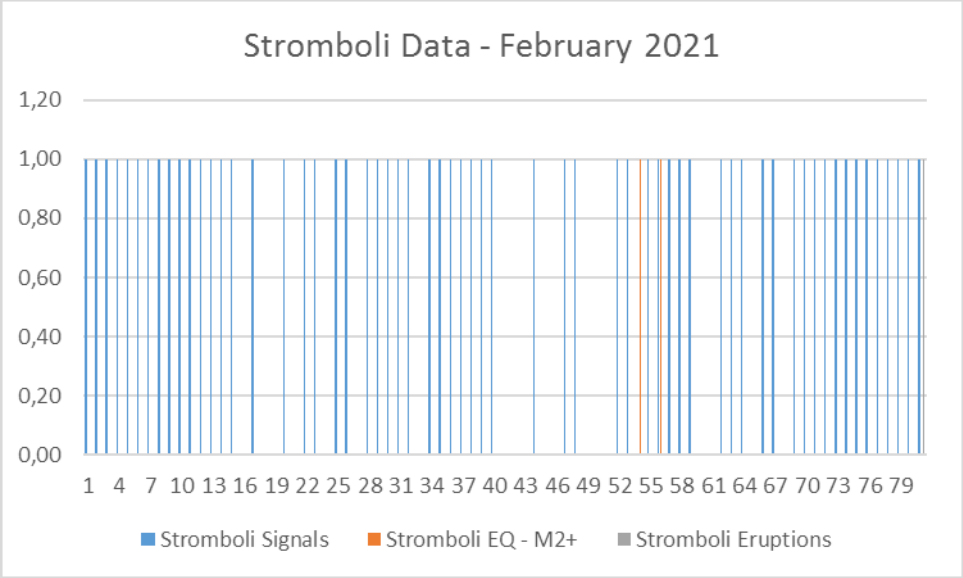

Fig. 26 - Monitoring data of the Stromboli volcano: radio-anomalies count, M2 + earthquakes and eruptions. Credits: Radio Emissions Project, Ingv.

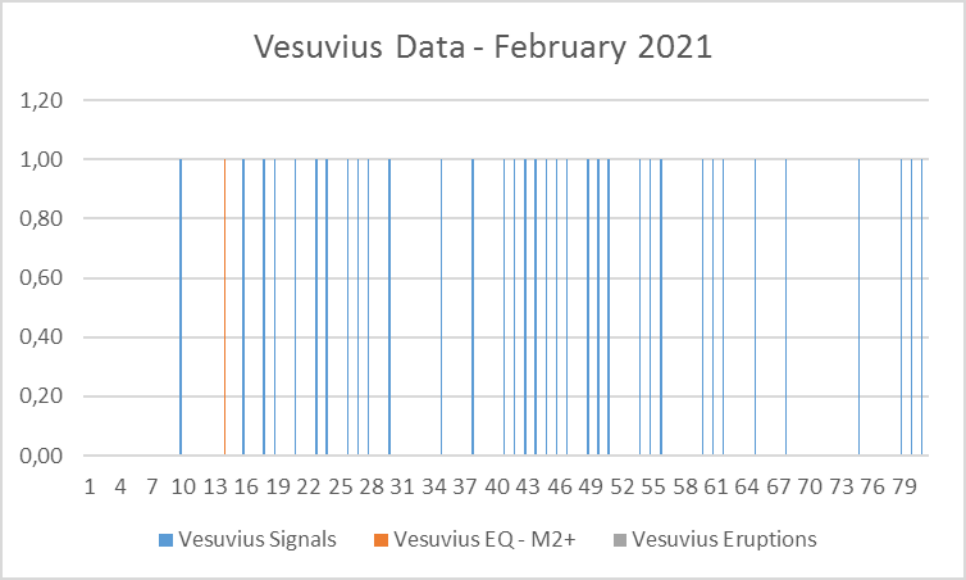

Fig. 27 – Monitoring data of the Vesuvius volcano: radio-anomalies count, M2 + earthquakes and eruptions. Credits: Radio Emissions Project, Ingv.

The **Fig. 25**, **26** and **27**, they show the distribution of the appearance of radios-anomalies in February 2021, in relation to the three different monitored volcanoes: Etna, Stromboli and Vesuvius. The graphs also show the correspondence between appearance of radio signals and the occurrence of earthquakes and volcanic eruptions.

Other indications arrive, always in February 2021, from data relating to individual RDF monitoring stations. The **Fig. 28**, **29** and **30** they show the trend of radio signals, recorded by the RDF stations, in relation to radios-anomalies that have as object the Azimuth of volcanoes under monitoring, where the earthquakes and eruptions were then recorded.

Observing these charts we note a direct relationship between the appearance of radios-anomalies and the occurrence of general phenomena from volcanoes.

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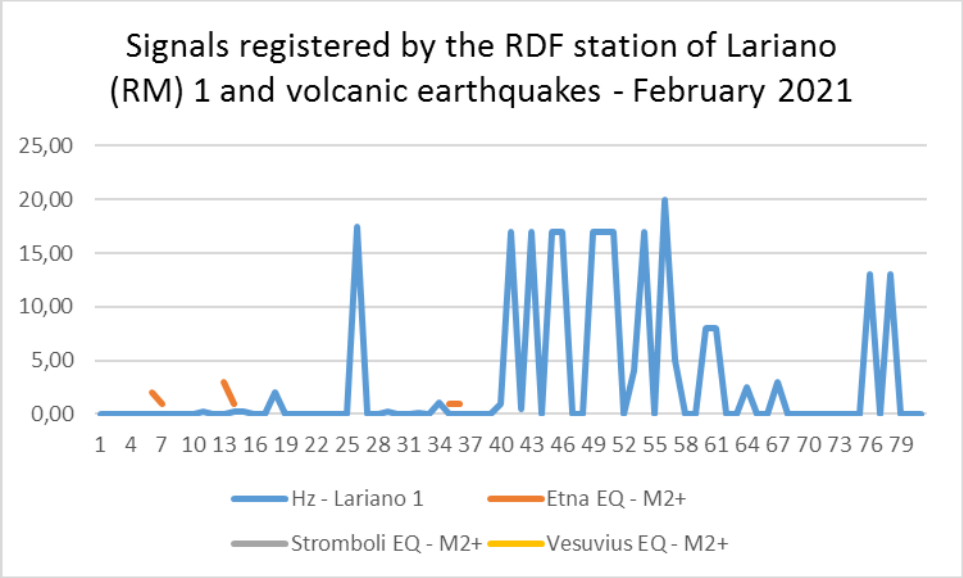

Fig. 28 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

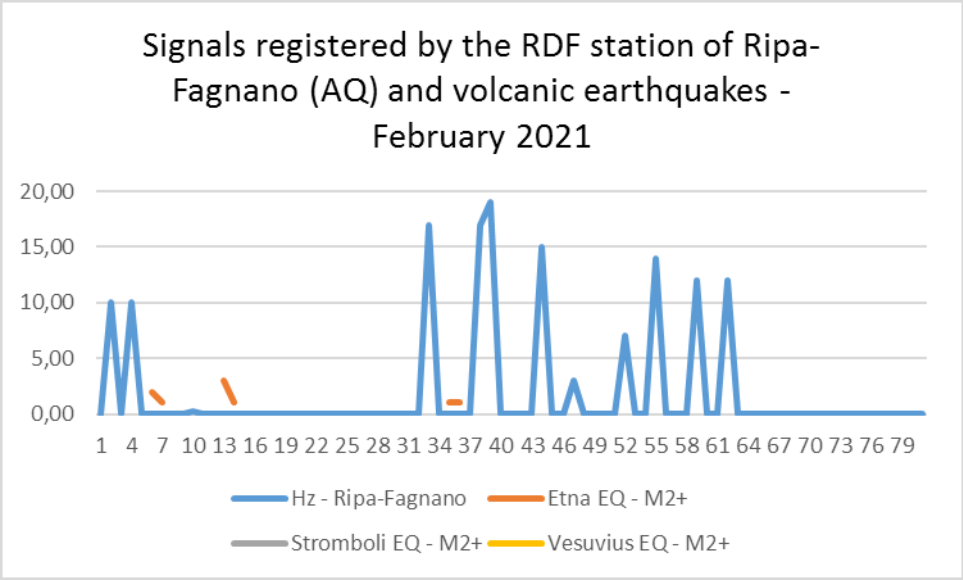

Fig. 29 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

There is no doubt that there is a direct relationship between the issue of electromagnetic phenomenon (precursors) and the occurrence of seisms, due to magmatism and more generally to volcanic activity.

Also in this case, some RDF stations seem more efficient in finding electromagnetic emissions (radio-anomalies) than the others. As already explained about this evidence you will still have to work to understand which variables are implicated in such data diversifications, for now only work hypotheses can be processed.

The monitoring of the Italian volcanic activity in February 2021, ends with the finding of significant amounts of data, produced by the Italian RDF network, developed by the Radio Emissions Project, but for the end of the monitoring the data will then be recorded even in the period of March 2021, as can be observed in the next chapter.

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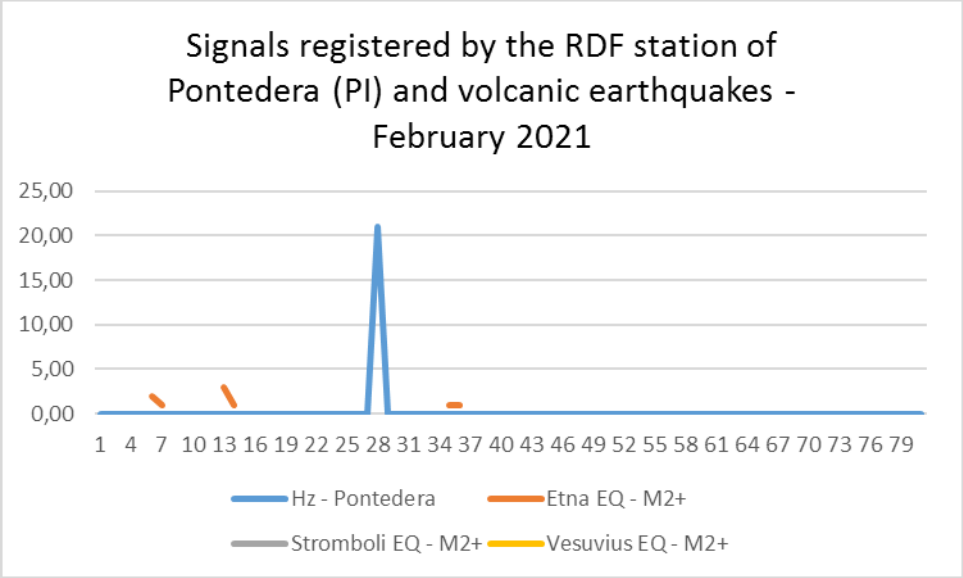

Fig. 30 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

3.4 - MARCH 2021 DATA

The following is the series of data of the three volcano monitoring data considered in this study (Etna, Stromboli and Vesuvius), in March 2021. They considered: the electromagnetic frequency of radio signals coming from the volcanoes themselves, their duration and time of appearance. In addition to data relating to electromagnetic emissions, the study considered the seismic data, or the appearance of earthquakes and eruptions that took place in the same time period in which monitoring has continued.

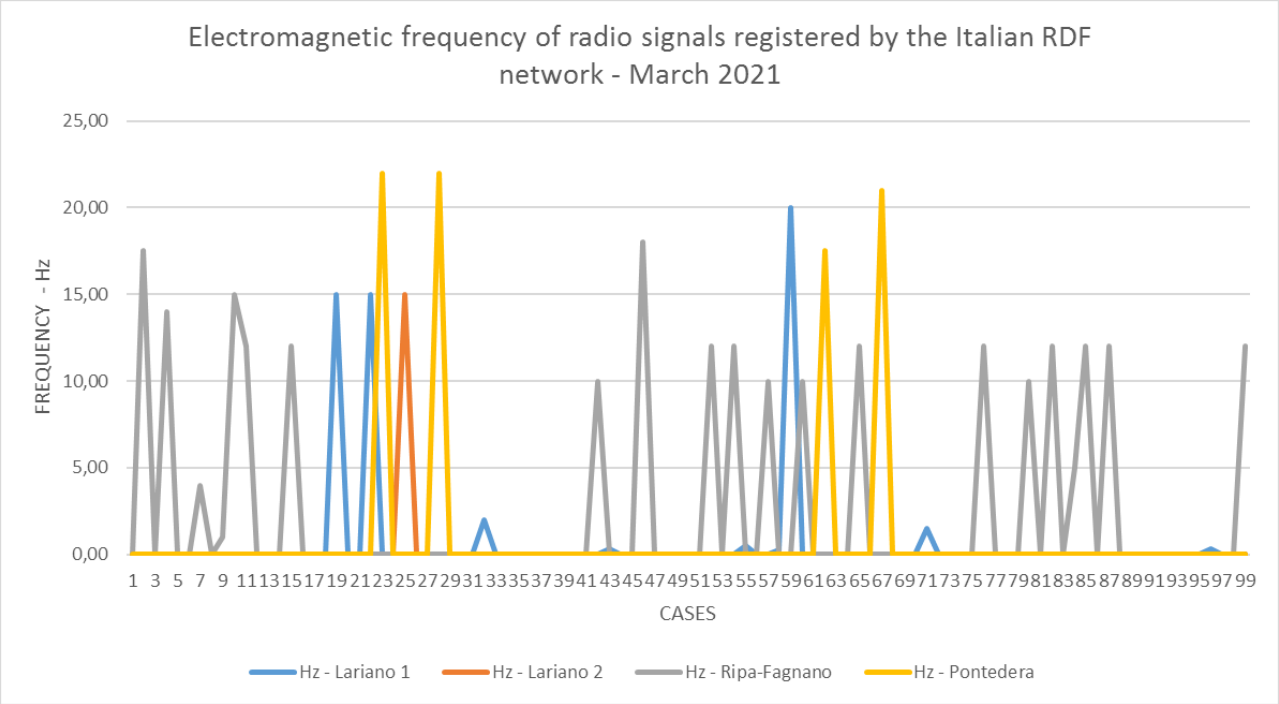

Fig. 31 – Electromagnetic frequency of radios-anomalies recorded by the Italian RDF network. Credits: Radio Emissions Project.

The **Fig. 31** shows the distribution of radios-anomalies recorded by the RDF monitoring network, developed by the Radio Emissions Project, in March 2021.

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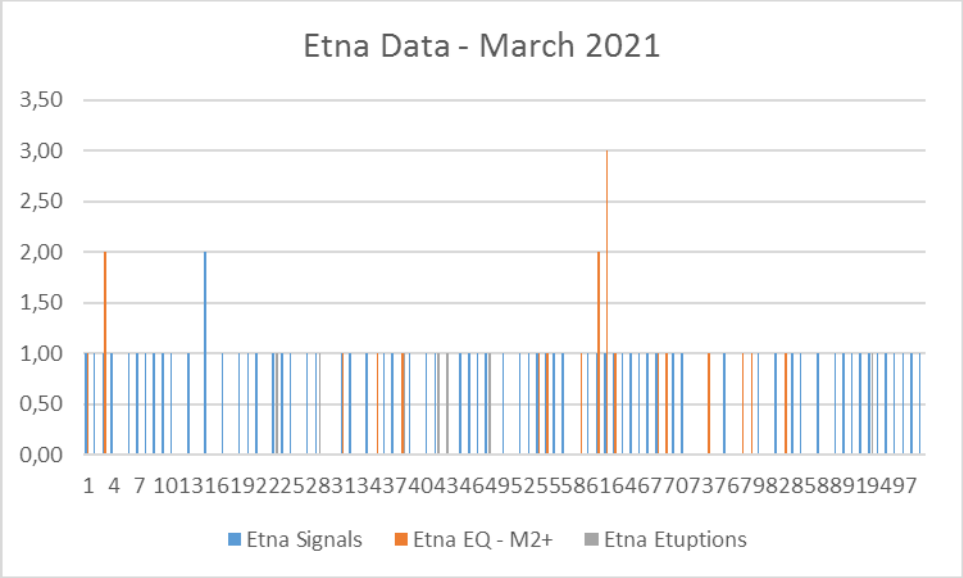

Fig. 32 – Monitoring data of the Etna volcano: radio-anomalies count, M2 + earthquakes and eruptions. Credits: Radio Emissions Project, Ingv.

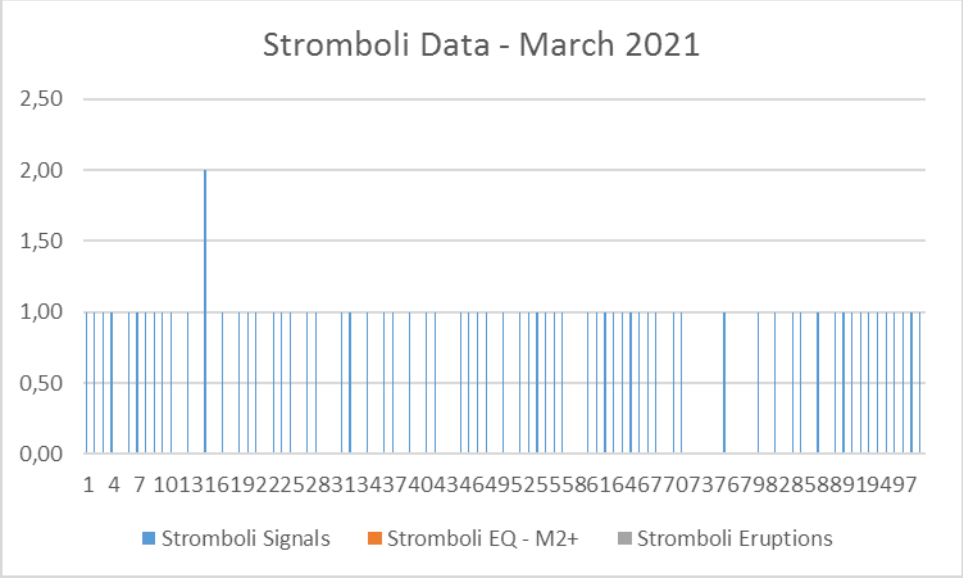

Fig. 33 – Monitoring data of the Stromboli volcano: radio-anomalies count, M2 + earthquakes and eruptions. Credits: Radio Emissions Project, Ingv.

Also in this case, the data show a number of persistent radios-abnormalities, due to the enormous activity of the Etna volcano, which precisely from the beginning of 2021, has presented a strong eruptive and seismic activity. Electromagnetic emissions, as visible in the **Fig. 31**, it is in hiccups, as it is normal in eruptive activities, in which the eruptive phenomena themselves are presented, then end, and then resumed.

This graph therefore respects those that seem to be natural physical laws that are the basis of volcanism, not only. If we also look at the **Fig. 8**, **16** and **25**, we observe that this "hiccup" trend is also visible in the other months monitored.

In March 2021 the activity of Etna Volcano was extremely intense, in fact from **Fig. 32**, **33** and **34**, we observe an intense trend of the phenomena determined by the volcano, and in close report the appearance of electromagnetic emissions monitored by the Italian RDF network developed by the Radio Emissions Project appears.

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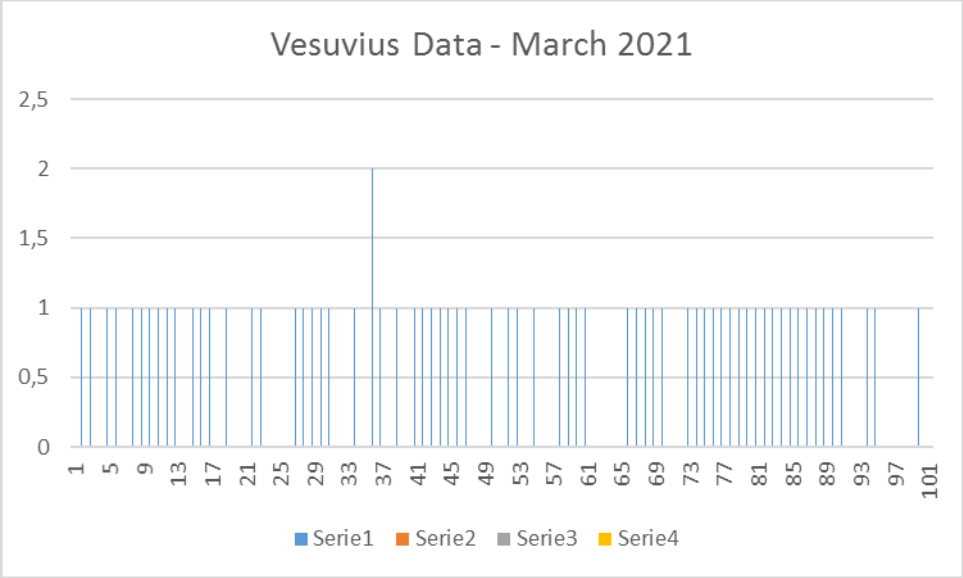

Fig. 34 – Monitoring data of the Vesuvius volcano: radio-anomalies count, M2 + earthquakes and eruptions. Credits: Radio Emissions Project, Ingv.

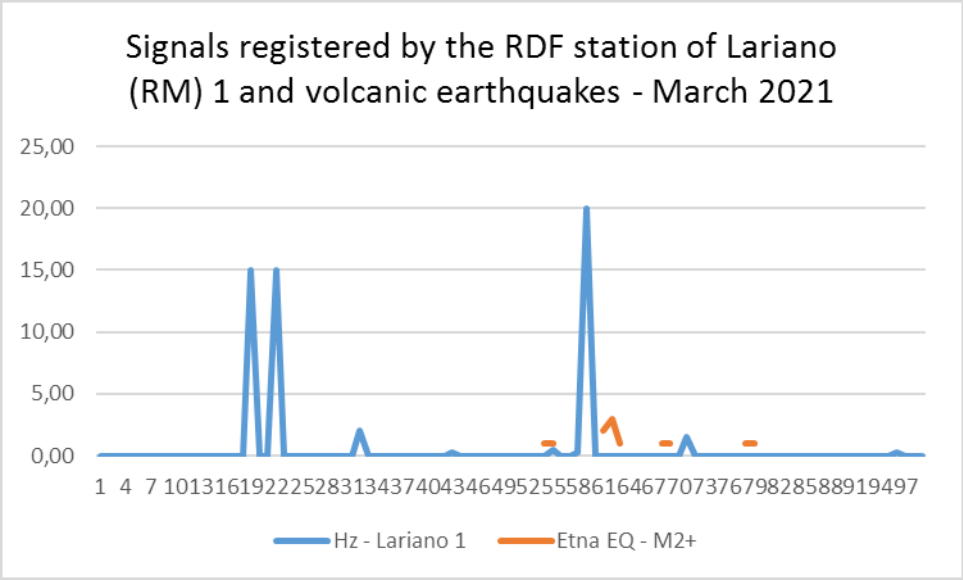

Fig. 35 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

Other interesting indications come from the analysis of the signals registered for each individual station, if connected with the appearance of the seisms that occurred at the volcanic zones. It is once again very evident as earthquakes are preceded by non-underestable radio emissions (**Fig. 35**, **36** and **37**).

In this case the RDF stations that seem to have had greater capacity of signals are that of Lariano (RM) 1 and Ripa-Fagnano (AQ), both positioned in central Italy, the first in the province of Rome, and the second in the province of L'Aquila (Italy).

Interesting data are also visible from the data from the RDF station of Pontedera, Pisa, Italy, located in northern Italy (**Fig. 38**) the electromagnetic variations with the Azimuth of volcanoes under monitoring appear to appear to appear at a temporal correspondence with volcanic seismic activity.

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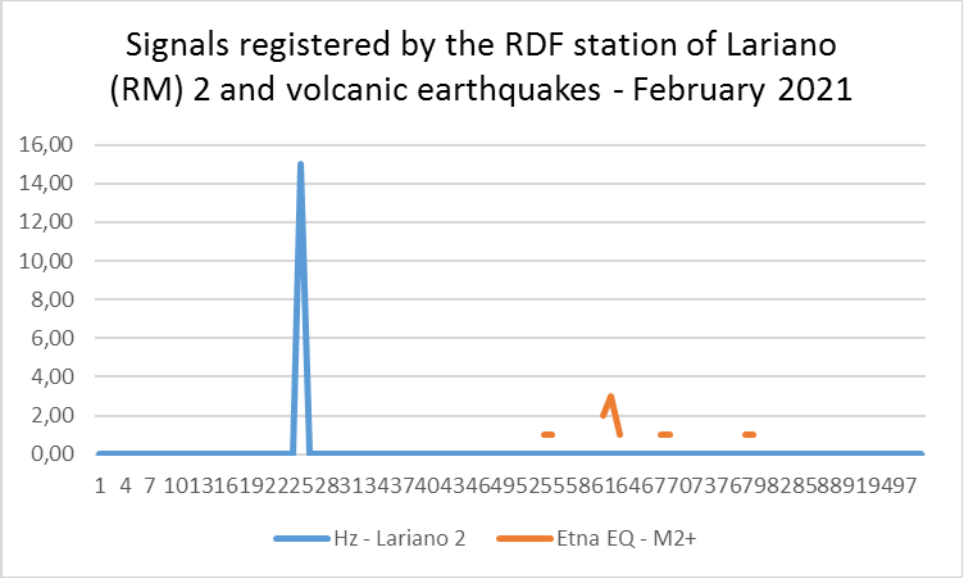

Fig. 36 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

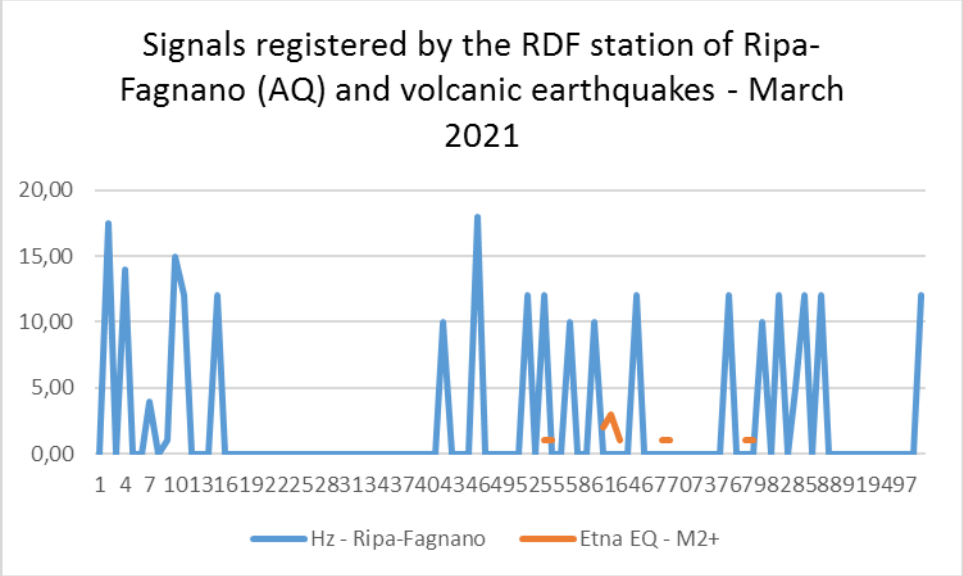

Fig. 37 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

There are no more doubts that there are pre-seismic electromagnetic emissions that precede the small intensity earthquakes and that these signals are also referable to other phenomena, such as those eruptive, registered on the Etna volcano and the Stromboli volcano.

For example, the correspondence between the appearance of the electromagnetic signals visible in the **Fig. 59**, **60**, **61** and **62**, and the appearance of volcanic eruptions at the Etna Volcano and the Stromboli volcano.

This report is for the first time visible, thanks to the RDF network developed by the Radio Emissions Project in Italy.

Then passing to the characteristics of electromagnetic signals we can undoubtedly observe interesting information in "Chapter 3.5" which refers precisely, to the characteristics of recorded radios-anomalies.

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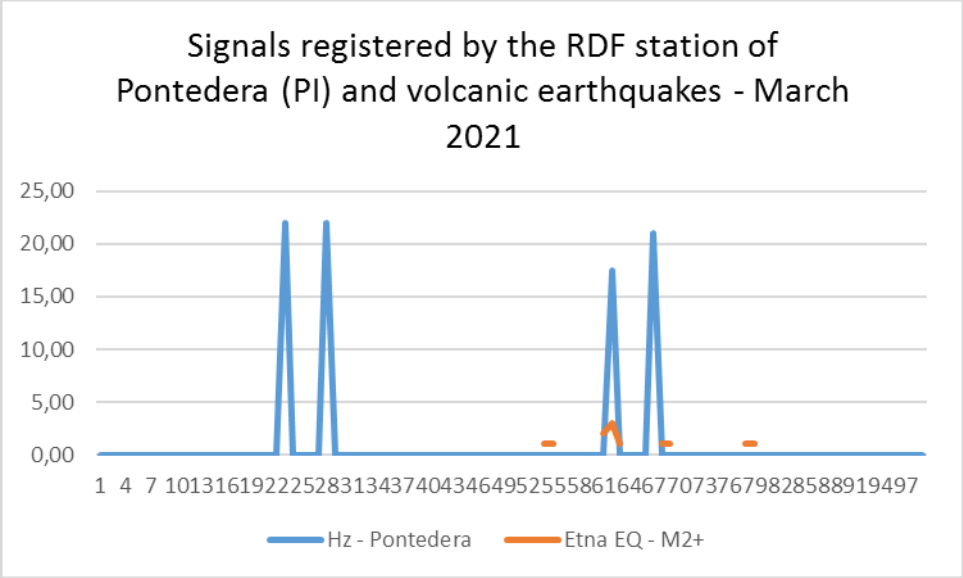

Fig. 38 – Electromagnetic frequency of radio signals registered by the RDF station and its seismic events occurred in the same temporal context. Credits: Radio Emissions Project, Ingv.

3.5 - CHARACTERISTICS OF RADIO SIGNALS

December 2021:

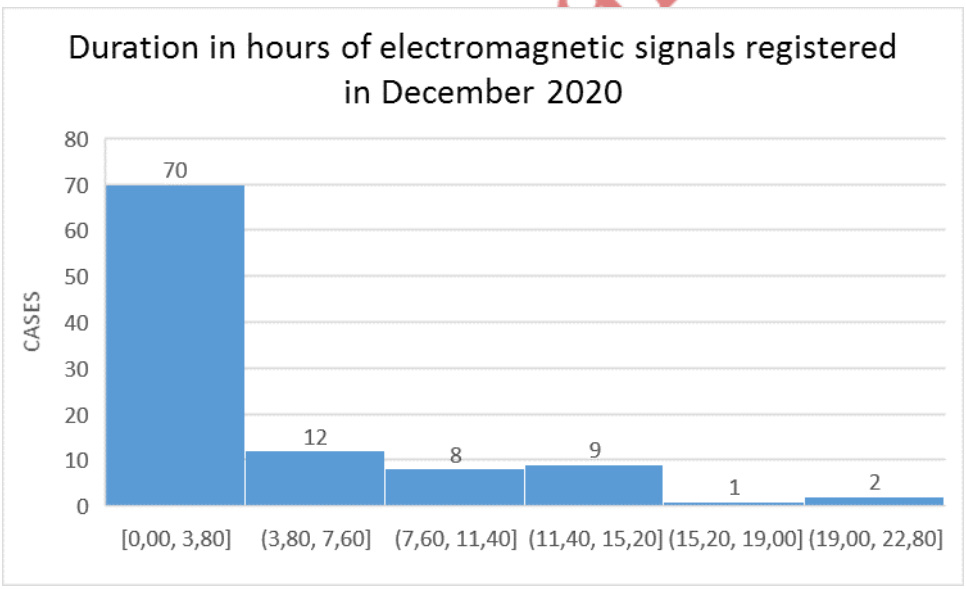

Fig. 39 – Duration in hours of total radios-anomalies recorded by the Italian RDF network, in December 2020. Credits: Radio Emissions Project.

The **Fig. 39**, indicates what is the number of radios-anomalies recorded in December 2020 and the duration of the same in hours. We observe 70 radios-anomalies that have had a duration between 0 and 3.8 hours, then we have a second peak of radio-anomalies that had a duration of 3.8-7.6 hours (12 cases); 7.6-11.4 (8 cases) and 11.4-15.20 hours (9 cases). Other radios-anomalies have had a more marginal distribution.

Therefore the study puts us out that the majority of radios-anomalies recorded in December 2020 has had a maximum duration of 3.8 hours.

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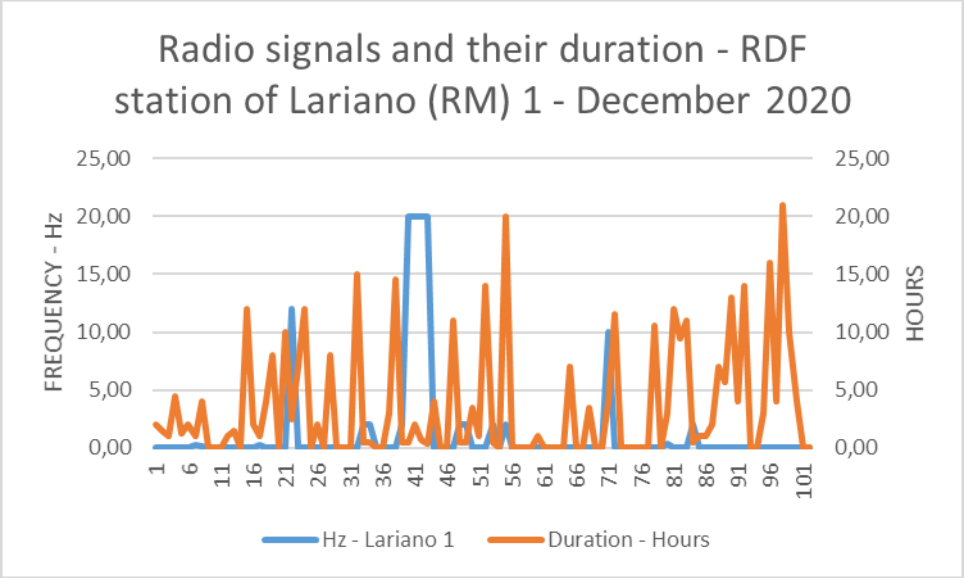

Fig. 40 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

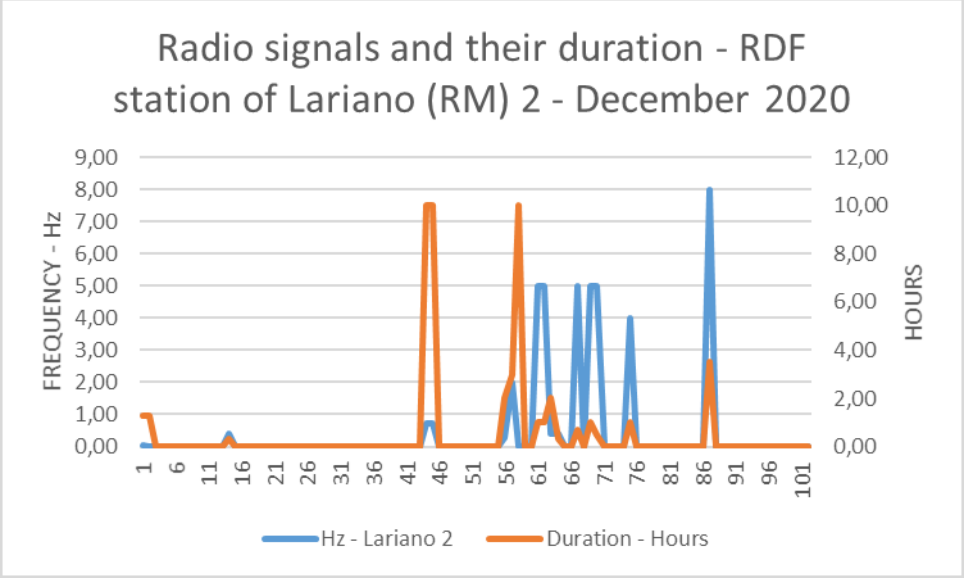

Fig. 41 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

The first data on the characteristics of radio-anomalies recorded in December 2020 seem to confirm that there is a relationship between radios-anomalies and electromagnetic frequency.

This report seems inversely proportional: or to increasing the electromagnetic frequency of the signals, the duration of radio-anomalies drops, and vice-versa (**Fig. 40**, **41**, **42** and **43**).

This evidence had already been observed in the past, but not in relation to volcanic activity [**1**].

This characteristics could be determined for example by the depth of emission of the signals, from the internal structure of the volcanic cone, from the presence of magma or not in the immediate vicinity of the natural radio carrier and the characteristic stars of the rocks, as well as from other unknown variables.

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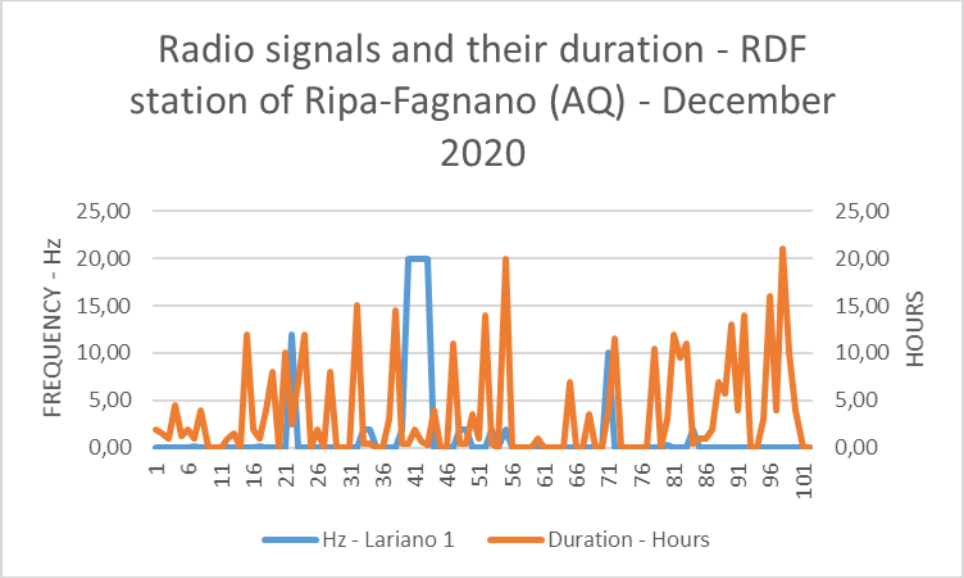

Fig. 42 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

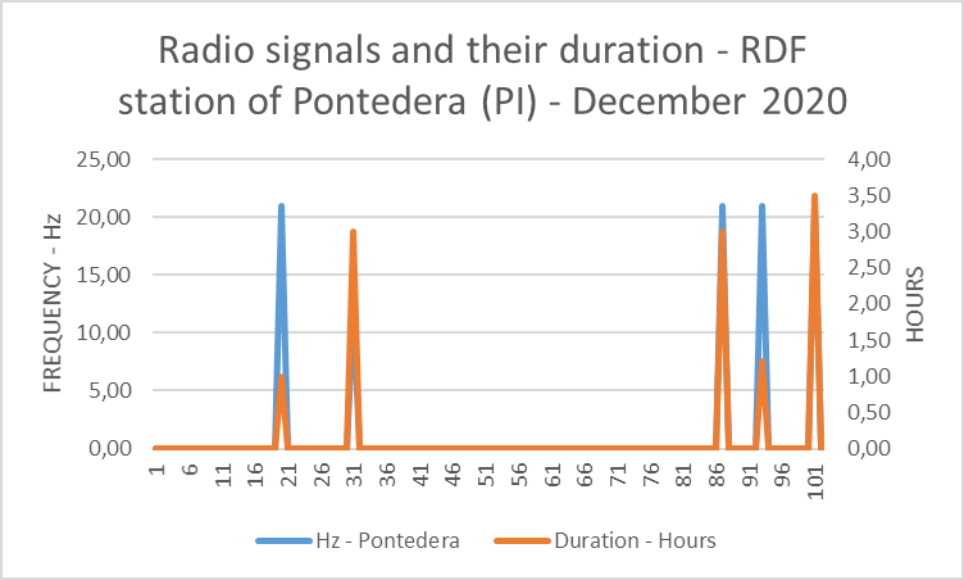

Fig. 43 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

January 2021:

The January 2021 monitoring data, relating to the characteristics of radios-abnormalities are once again interesting, and confirm the trend observed in December 2020, where a greater amount of radios-anomalies are observed with duration from 0 to 2.5 hours (120 Cases), then we have 14 cases with a duration ranging from 2.5 to 5 hours. Additional radio signals seem to be distributed with a low number of cases with a duration of more than 7.5 hours (**Fig. 46**).

Interesting data, then come from the relationship between the electromagnetic frequency and the duration of the registered radio signals (radio-anomalies). Also in this circumstance, the characteristics are the same observed in December 2020, or the relationship between electromagnetic frequency and duration of the signals which is inversely proportional (**Fig. 45**, **46**, **47** and **48**).

Data again confirmed by the preliminary students that took place in 2017 (published in 2018 [**1**]).

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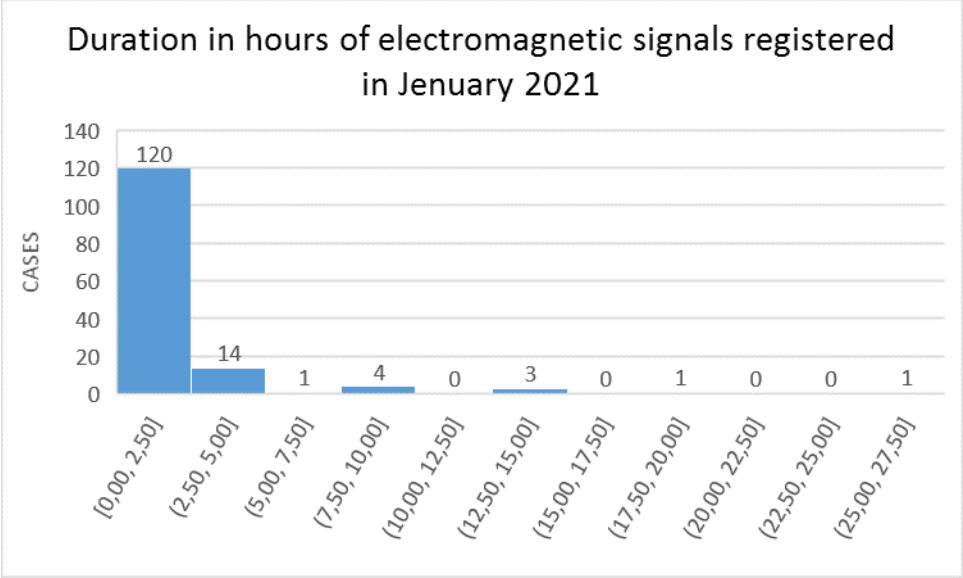

Fig. 44 – Duration in hours of total radios-anomalies recorded by the Italian RDF network, in Jenuary 2021. Credits: Radio Emissions Project.

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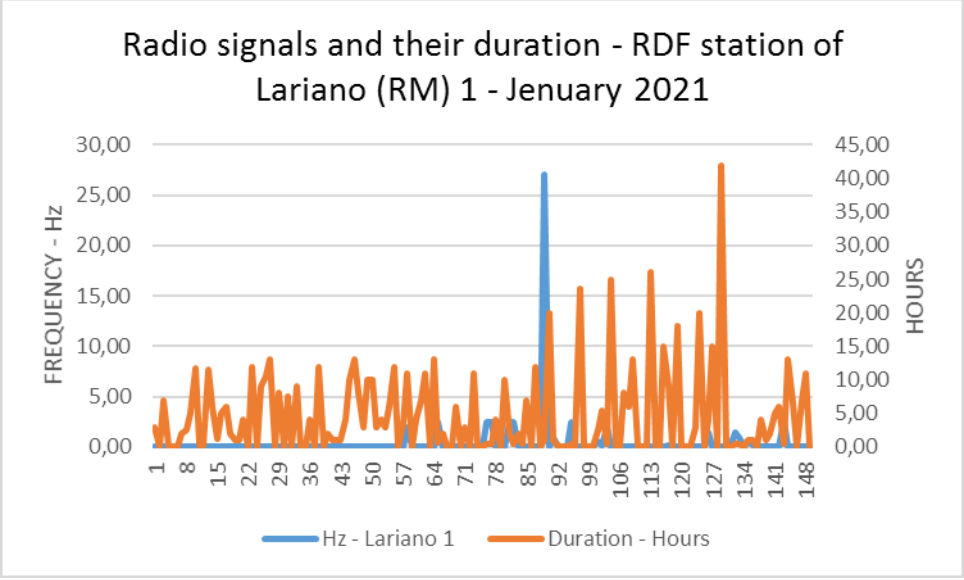

Fig. 45 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

Fundamental characteristic of these radios-anomalies is that of their azimuth of origin, or from the arrival direction that the Italian RDF network could highlight. In all the graphs mentioned in this study, the data refer to the Azimuth of Italian volcanoes.

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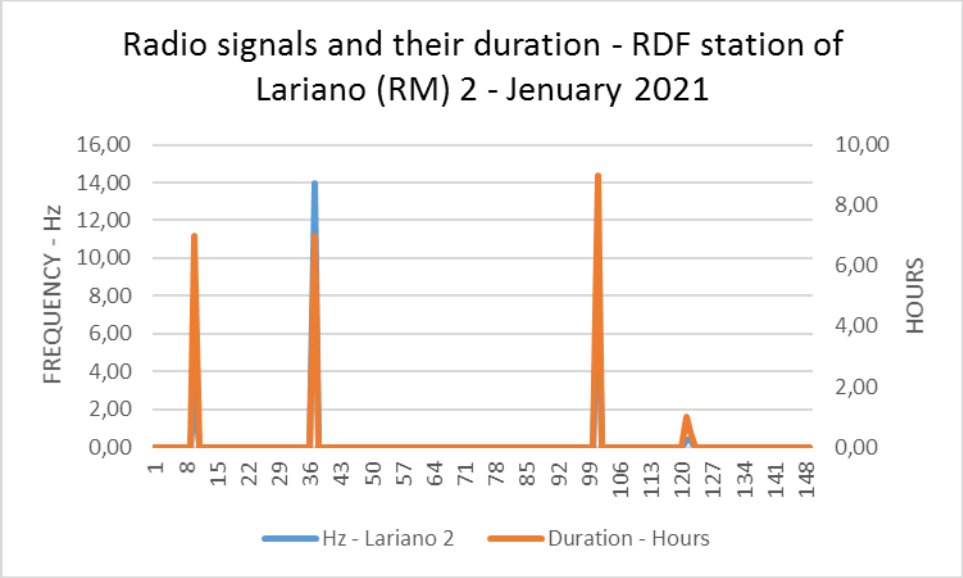

Fig. 46 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

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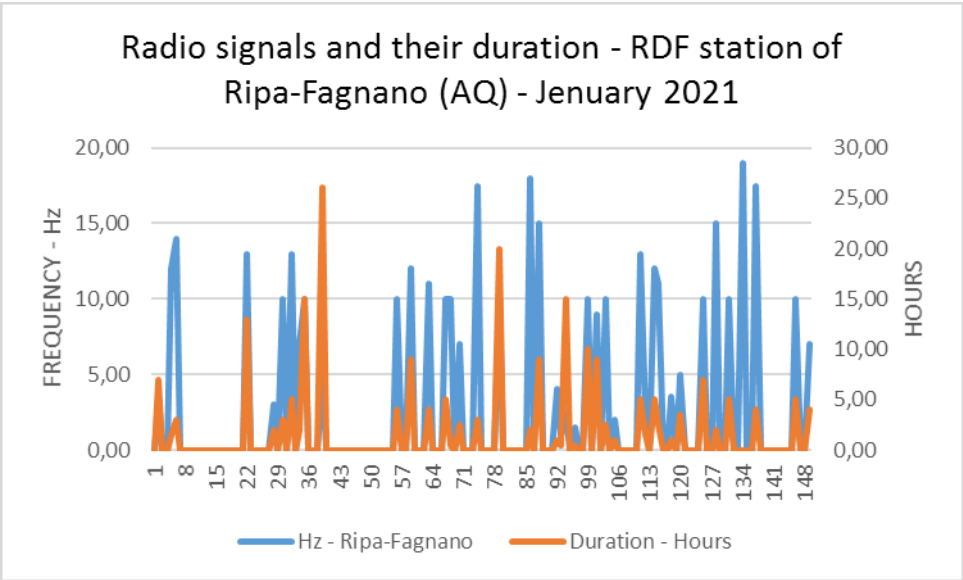

Fig. 47 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

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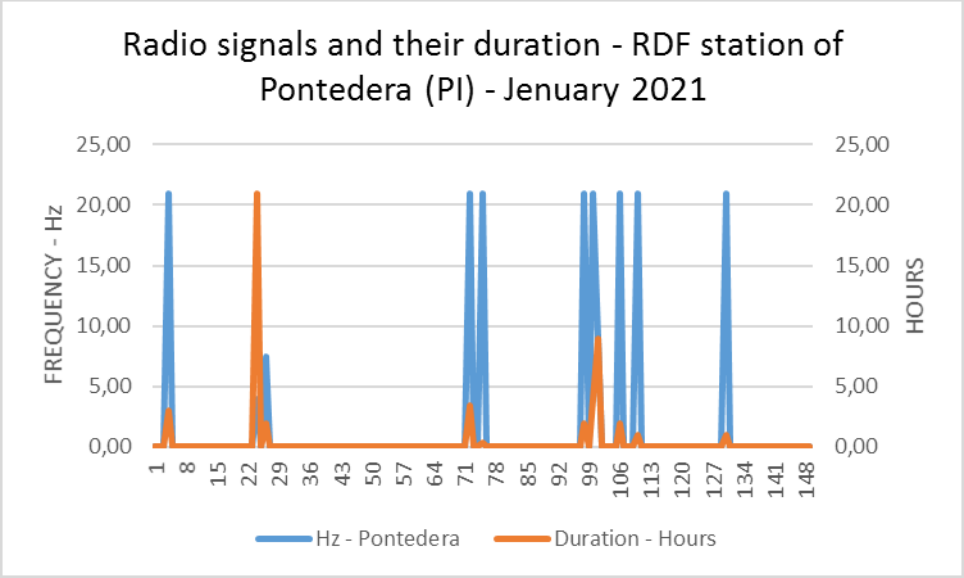

Fig. 48 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

February 2021:

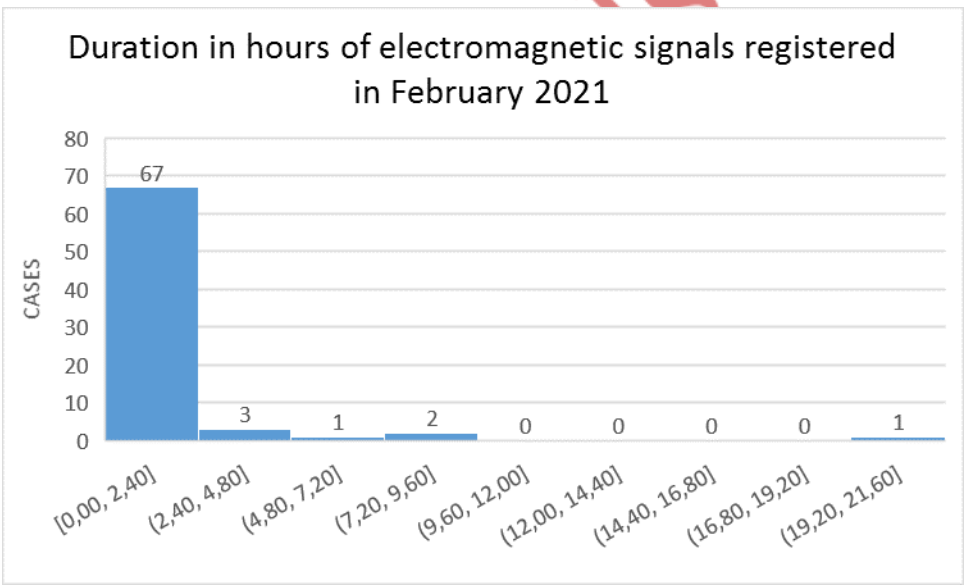

Fig. 49 – Duration in hours of total radios-anomalies recorded by the Italian RDF network, in February 2021. Credits: Radio Emissions Project.

The february 2021 data confirms the readings performed between December 2020 and January 2021. Also in this case the radios-anomalies have almost presented the totality of the radio signals with a very short duration in hours. In this case 67 cases have had a variable duration between 0 and 2.4 hours, then we have 3 cases with a duration between 2.4 and 4.8 hours while in the rest of the radios-anomalies it distributes between 4.8 and 21.6 hours (**Fig. 49**).

The data indicate once again that emissions are almost always short and with Azimuth indicating the volcano area.

Then going to analyze the data of the individual RDF stations, with reference to the characteristics of the electromagnetic signals themselves we note data that is once again confirmed.

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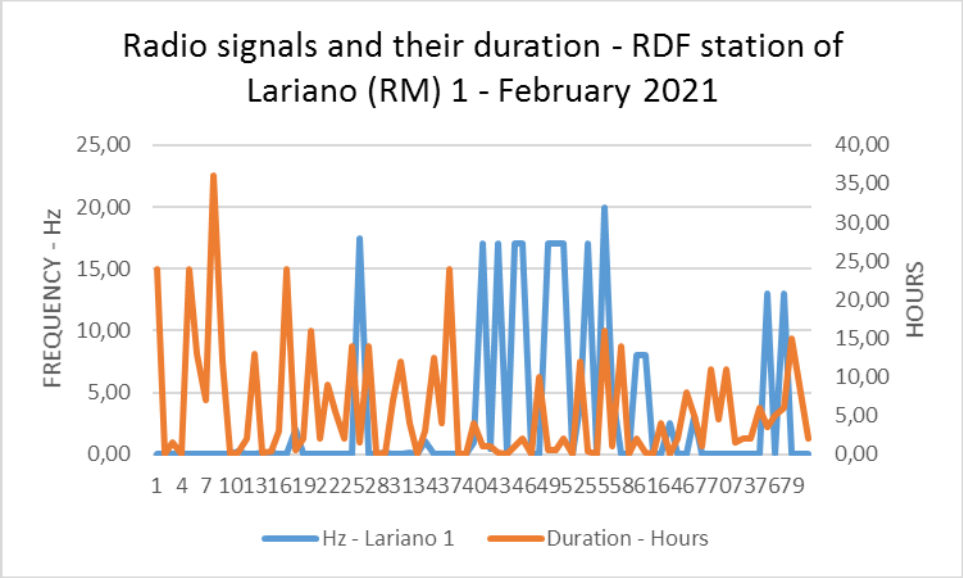

Fig. 50 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

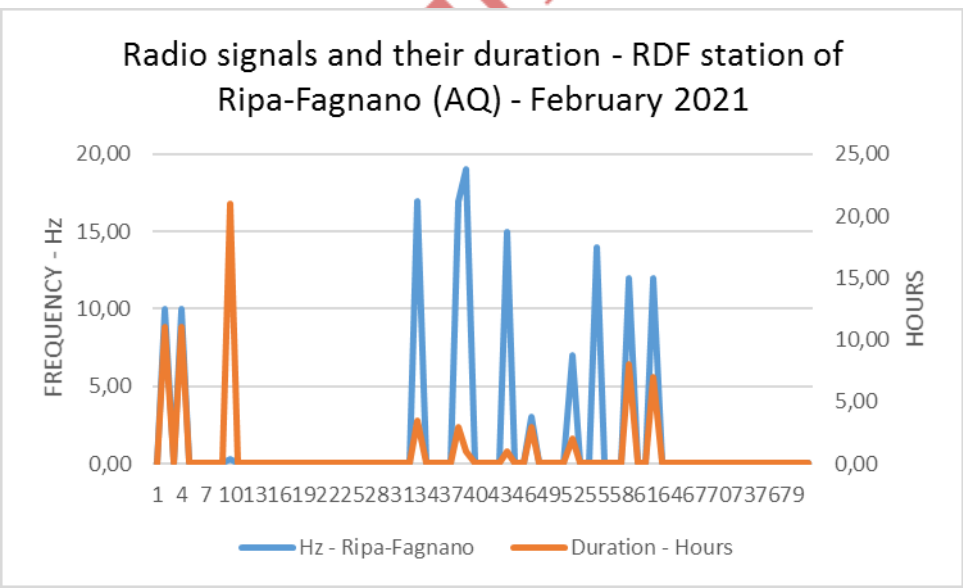

Fig. 51 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

Observing the **Fig. 50**, **51**, and **52**, it is seen as the relationship between electromagnetic frequency and the duration of radios-anomalies is inversely proportional. These characteristics observed even in December 2020 and January 2021 tell us unequivocally than increasing the electromagnetic frequency of the signals we find an increase in the duration of radios-anomalies and vice-versa.

To understand the causes of this characteristics we will still need to investigate in the future.

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Then let's analyze the data of radio-anomalies registered in March 2021, from the Italian RDF network, developed by the Radio Emissions Project, precisely at the end of the analyzes of electromagnetic signals considered in the temporal period ranging from 10 December 2020 to 31 March 2021.

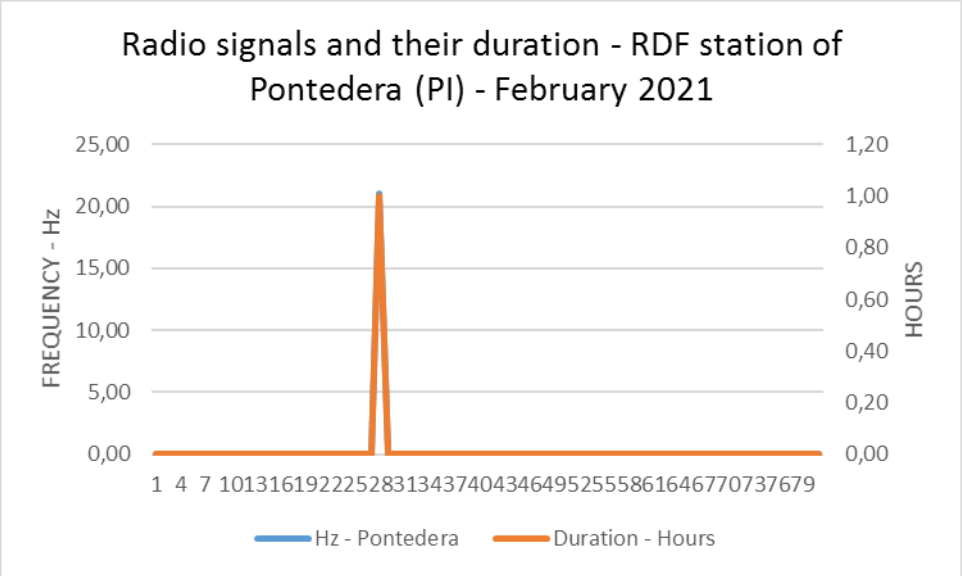

Fig. 52 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

March 2021:

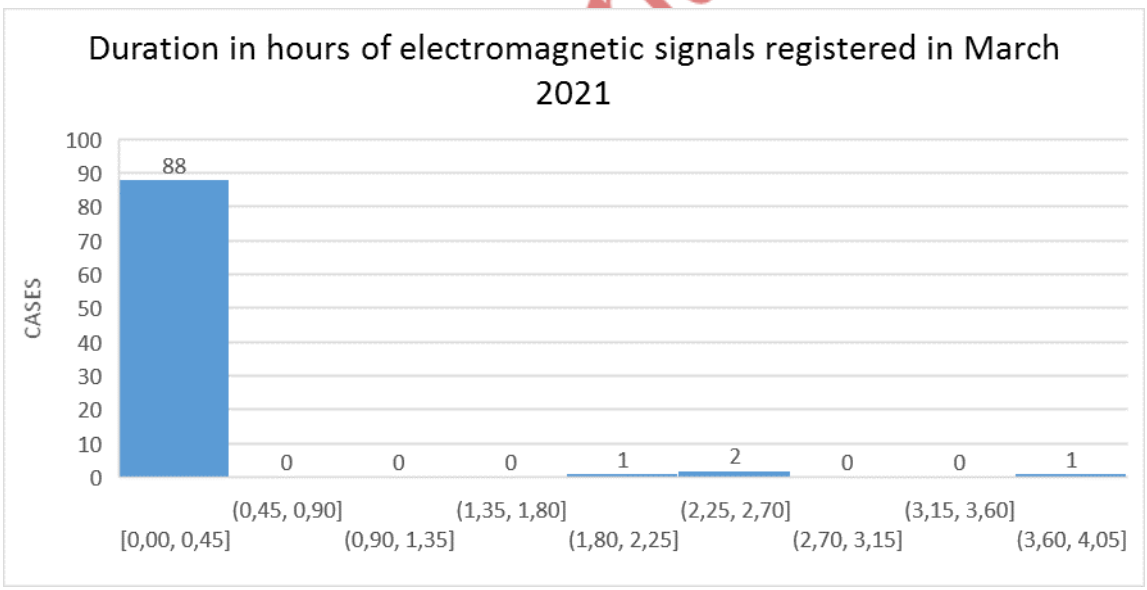

Fig. 53 – Duration in hours of total radios-anomalies recorded by the Italian RDF network, in March 2021. Credits: Radio Emissions Project.

In conclusion of the analysis of data relating to radios-anomalies recorded by the Italian RDF network, we find the data of March 2021. Looking the **Fig. 53**, it is highlighted as the majority of radios-anomalies had a duration between 0 and 0.4 hours, with as many as 88 recorded cases, the rest of the radios-anomalies is distributed with very few cases up to a duration of 4.0 hours.

Data that once again recalcates those registered in December 2020, in January 2021 and in February 2021.

According to the characteristics of these signals, we must go and consider **Fig. 54**, **55**, **56** and **57**. The data indicate how there is a ratio (once again) inversely proportional between the electromagnetic frequency of registered radio signals and their duration.

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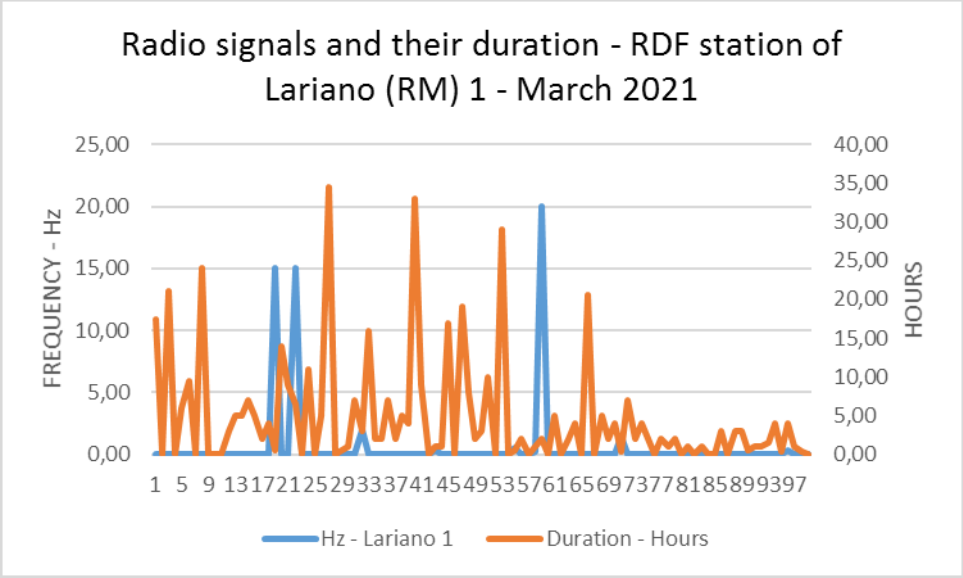

Fig. 54 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

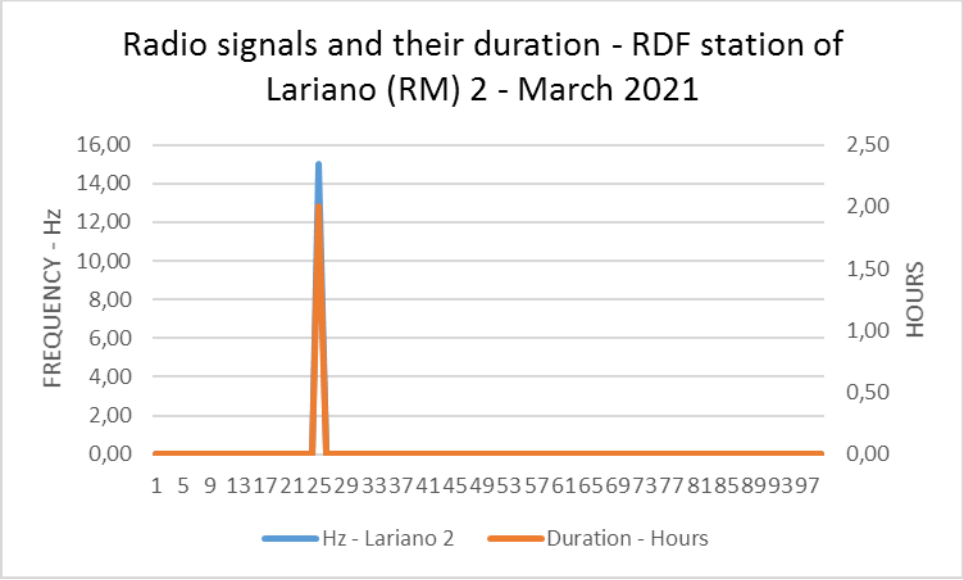

Fig. 55 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

The evidence of such data, recorded between December 2020 and March 2021 indicates that the electromagnetic signals recognized by the Italian RDF network, showed different characteristics, characteristics that appear in every period considered. The analysis of these data, for the first time ever, associated with volcanic and magmatic activity is important in an indicative environmental context, being signals that make before eruptions, before the earthquakes generated by volcanoes and following The evolution of the volcanic activity itself. The considerations that can be made are multiple and all in relation to the capacity that this detection system has shown to own. The total dynamic spectrograms generated by the Italian RDF network, developed by the Radio Emissions Project is 228 for the Lariano station (RM) 1; 15 spectrograms for the RDF station of Lariano (RM) 2; 15 spectrograms for the RDF station of Pontedera (PI); and 93 spectrograms for RDF Station of Ripa-Fagnano (AQ).

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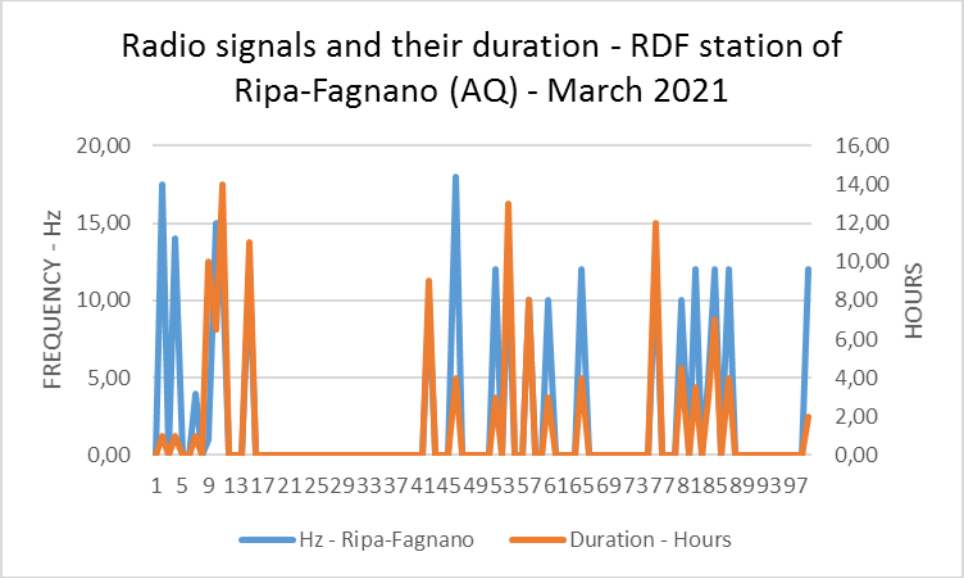

Fig. 56 – Electromagnetic frequency of radios-anomalies recorded by the RDF station and their duration in hours. Credits: Radio Emissions Project.

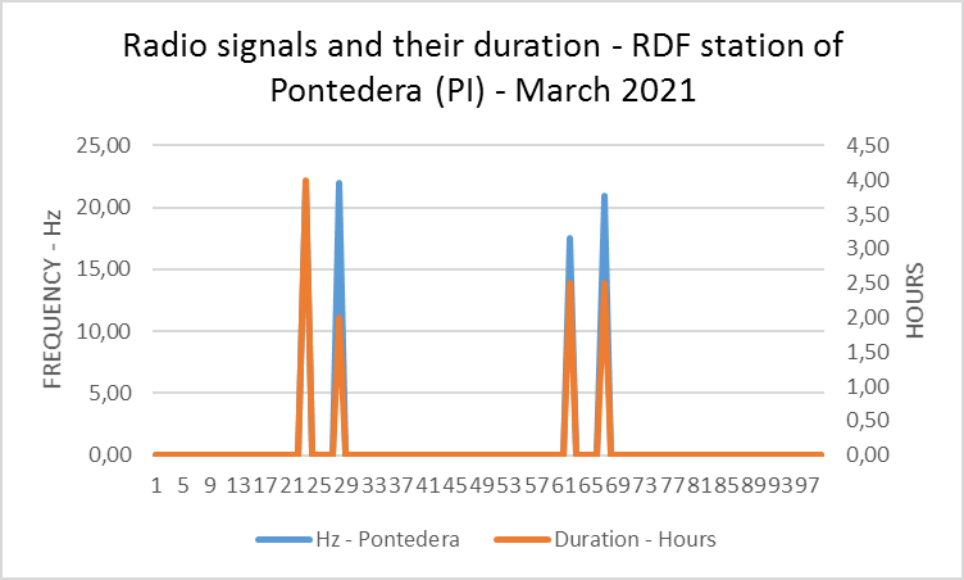

Fig. 57 – Frequenza elettromagnetica delle radios-anomalie registrate dalla stazione RDF e dalla loro durata in ore. Credits: Radio Emissions Project.

With such data, it is clear how a large amount of information can be available both on electromagnetic signals and on the use of the RDF network itself, not only on the Italian territory but more generally globally. The eructive data are for the first time I was analyzed by the Italian RDF network, in a context of important activity for the European continent, this monitoring system can definitely be extended on a global scale to follow the evolution of volcanic activity of dangerous volcanoes, To attempt to mitigate the occurrence of destructive eruptions and able to determine dead or huge damage to air navigation and more generally for human activities. The latest data considered in this study, are those relating to the eruptive activity, with reference to the behavior of radio-anomalies themselves.

3.6 - ERUCTIVE DATA AND ELECTROMAGNETIC ACTIVITY

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The eruptive activity was analyzed in depth by the Italian RDF network, during which this study took place. The data is as follows:

December 2020:

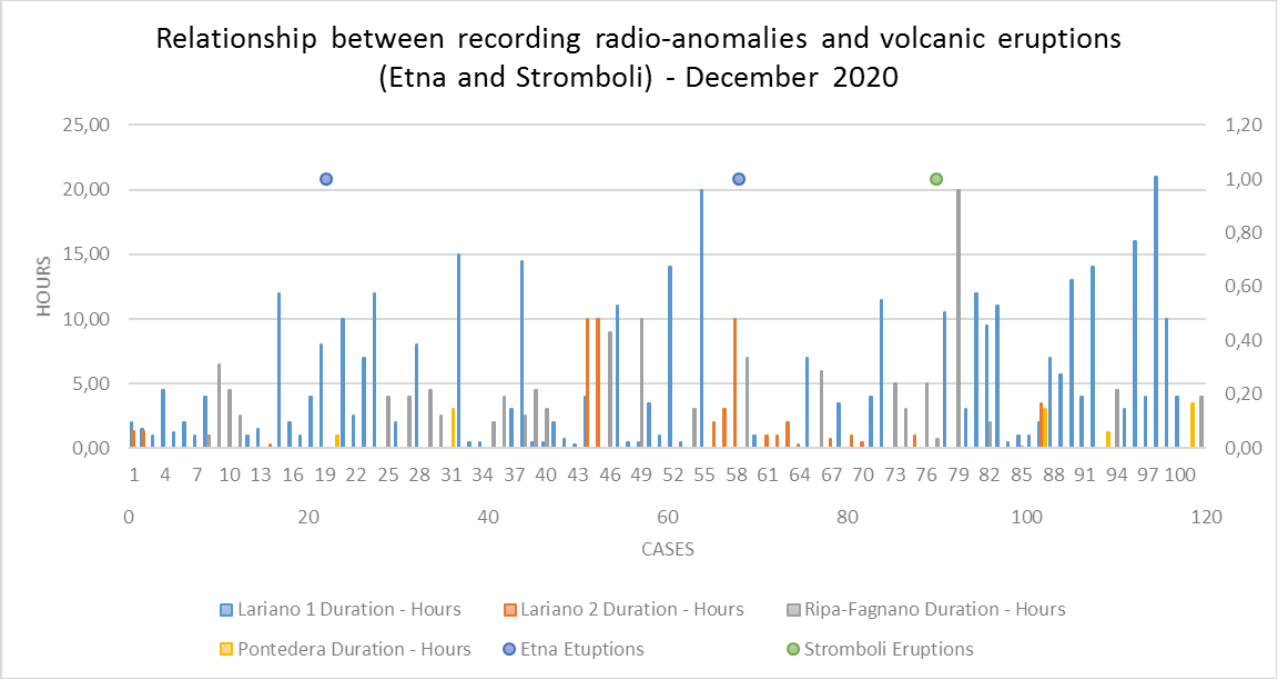

Fig. 58 – Relationship between recording radios-anomalies and volcanic eruptions (Etna and Stromboli)- December 2020. Credits: Radio Emissions Project.

Jenuary 2021:

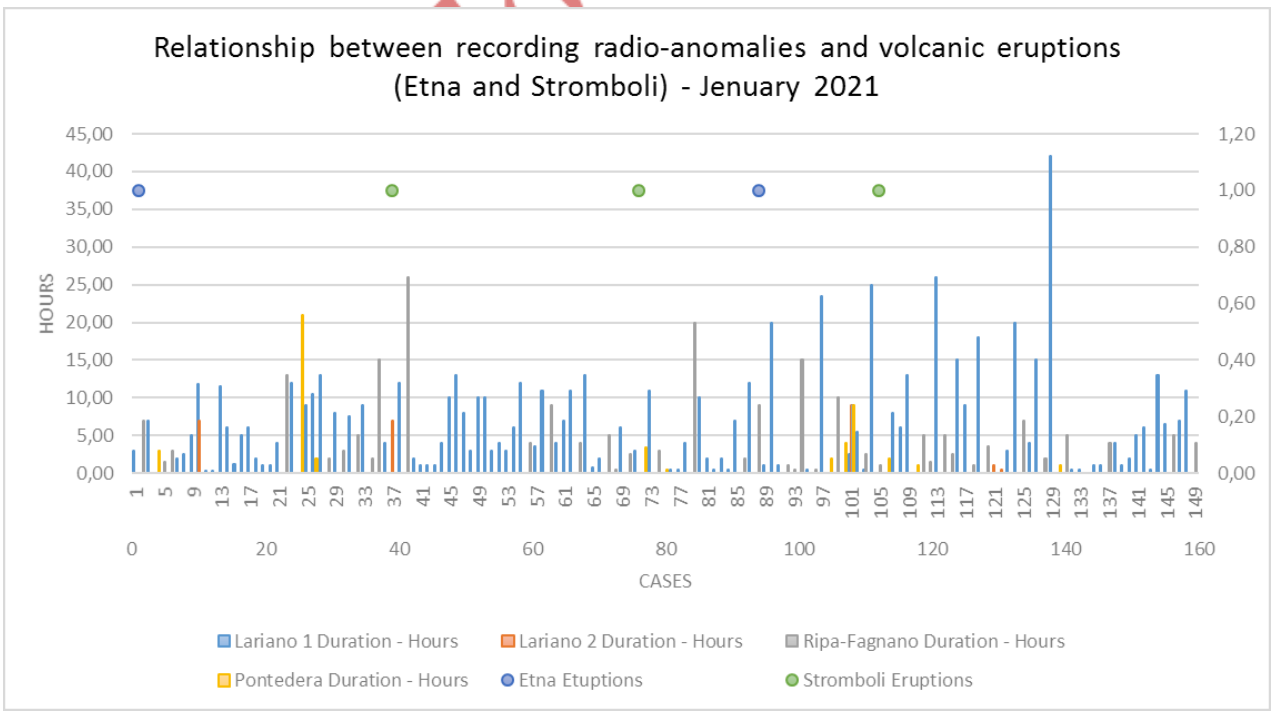

Fig. 59 – Relationship between recording radios-anomalies and volcanic eruptions (Etna and Stromboli) - Jenuary 2021. Credits: Radio Emissions Project.

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February 2021:

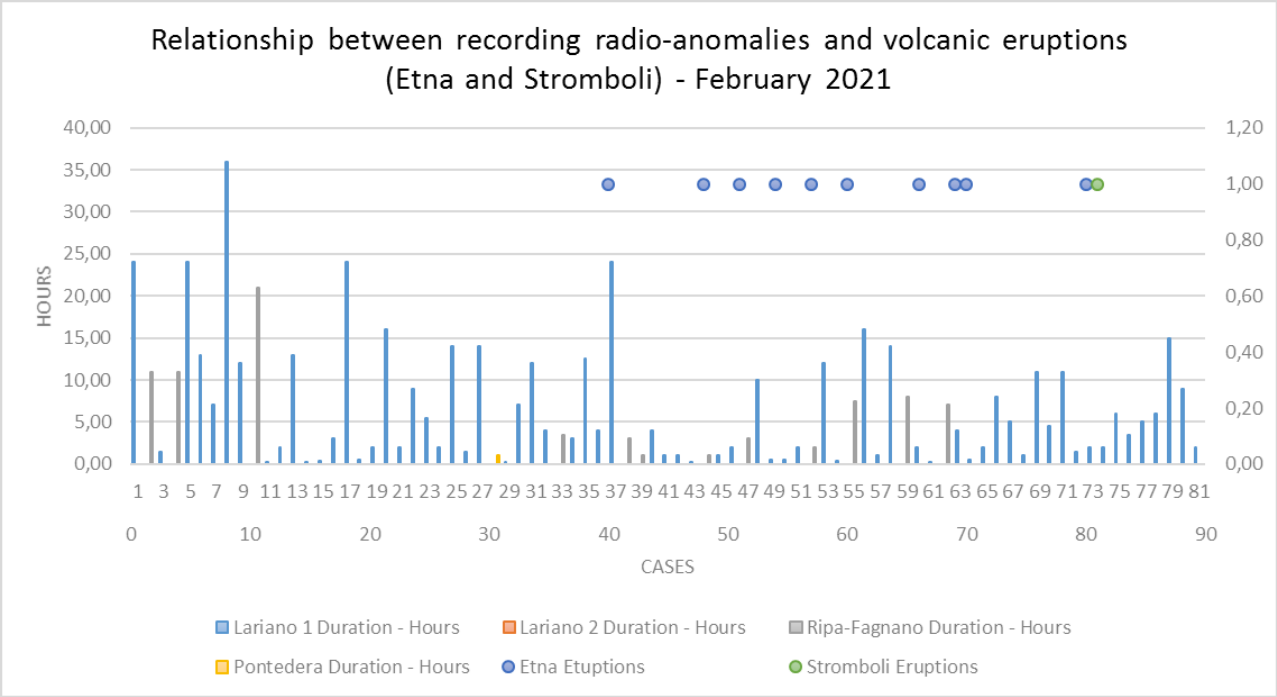

Fig. 60 – Relationship between recording radios-anomalies and volcanic eruptions (Etna and Stromboli) - February 2021. Credits: Radio Emissions Project.

March 2021:

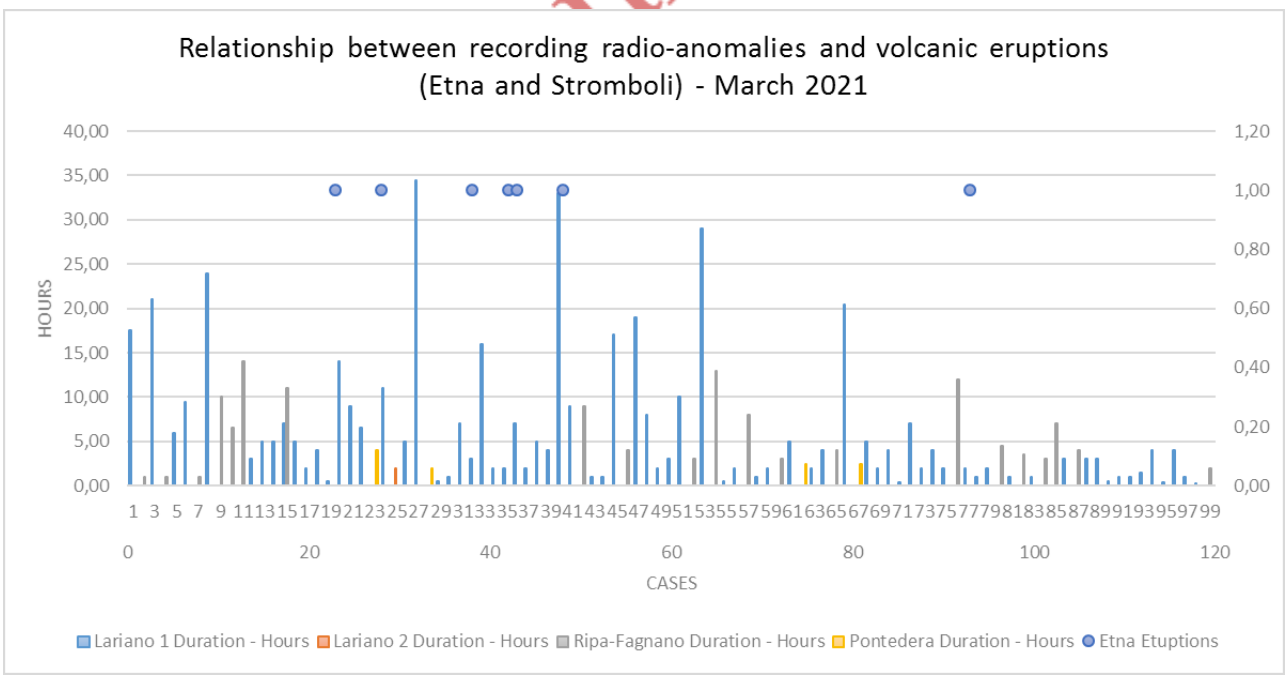

Fig. 61 – Relationship between recording radios-anomalies and volcanic eruptions (Etna and Stromboli) - March 2021. Credits: Radio Emissions Project.

The **Fig. 58**, **59**, **60** and **61** highlights the presence of electromagnetic emissions recorded before and during the eruptive activity. These data, or those referred to the eruptive activity, are perhaps the most interesting ones because never before today analyzed with an RDF electromagnetic monitoring system.

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The data indicate increment peaks at the time period in which the eruptions occurred, peaks concerning the duration in hours of radios-anomalies. It is evident that before the eruptions there are long-lasting electromagnetic emissions, to then decrease when the eruption is in progress. Therefore we note an increase in the duration of radios-anomalies before the eruption takes place, to then decrease drastically during the eruption, before disappearing.

These electromagnetic emissions could be general from the crystalline rocks of the rocks, of which the volcanic cone is characterized, especially in the internal sections, put a hard test by pressure determined by magmatism. Obviously this is a hypothesis.

The crystalline structures would free flowing ion currents due to piezoelectricity [**19**], such ions would therefore emit radio-frequency [**20**], which would then be propagated outside, in the earth-ionosphere cavity and here also picked up at a distance. Similarly, the internal magma in the magmatic chamber increases the pressure of the lava inside the volcanic cone, determining a swelling of the structures of the cone, and therefore generating radiofrequency.

The eructive data shows that the eruptions occur when there is an increase in the duration of radio-anomalies, higher durability highlighted by all Italian RDF stations, implicated in the study. This indicates that eruptions are generated by enormous energy and that longer duration in hours depends on the greater involvement of crystalline structures (rocks) subject to stress. It is therefore not a question of an energy quantity lower than that which can produce an earthquake, but of a very intense amount of energy.

4 – Conclusions

The context in which this study takes place, refers to a European area with high seismic risk, the understanding of volcanic events is only part of the scientific approach able, one day, to allow to predict the phenomena generated by the volcanoes, Such as seismic shocks, explosions and eruptions, which, in a geographical context of this type, certainly represent a risk for the Italian population that in the future must be mitigated.

The purpose of such research therefore has had the analysis of the electromagnetic signals issued by the volcanoes, to understand or understand if electromagnetic emissions had been able to have a predictive commissioned with respect to the geophysical activities expressed by the monitored volcanoes.

It is evident that the future strategy, which sees the science committed to the study of seismic and volcanological activity is focused on the use of new technologies and forecasting techniques, able to provide important predictive models, which can be used, one day, for Help the population, and predict destructive events before they determine a risk for man and for the habitat.

On this line, the "mission" of the researchers involved in this study was oriented.

The data is very important and for the first time allow you to confirm that the eruptive phenomena can be preceded by electromagnetic signals in the SELF-ELF band (0.001 Hz and 30 Hz); That these radio emissions can not only experience the occurrence of eruptions, but also of earthquakes of volcanic origin.

As regards the average frequency of electromagnetic emissions, it appeared before the eruptions, it stands at 10.75 Hz, out of a total of 26 eruptions preceded by intense electromagnetic emissions. The lower electromagnetic frequency recorded that preceded an eruption is 2.5 Hz, while the highest one reached 35 Hz (just higher than the ELF band). In this area it depends on the type of emission, or its sudden appearance, from its behavior in frequency and from the Its duration, as well as signal intensity.

It is therefore obvious that this study could confirm that a volcano represents a natural carrier of continuous electromagnetic signals, especially if active. The volcanic activity is distributed in different parts of the world and therefore if these volcanoes emit electromagnetic emissions (if active) is clear that the natural electromagnetic fund is full. A new vision therefore, of these natural structures that are no longer only characterized by earthquakes, ashes and lava, but above all of visible signals in the electromagnetic spectrum.

In this context it is therefore important to proceed with the research, to achieve a monitoring network able to monitor potentially destructive volcanoes on a global scale. Not only that, it would be interesting to be able to obtain further information on the seismogenetic mechanisms of volcanic origin and understand part of the phenomena that induce electromagnetic emission through the magmatic mechanism.

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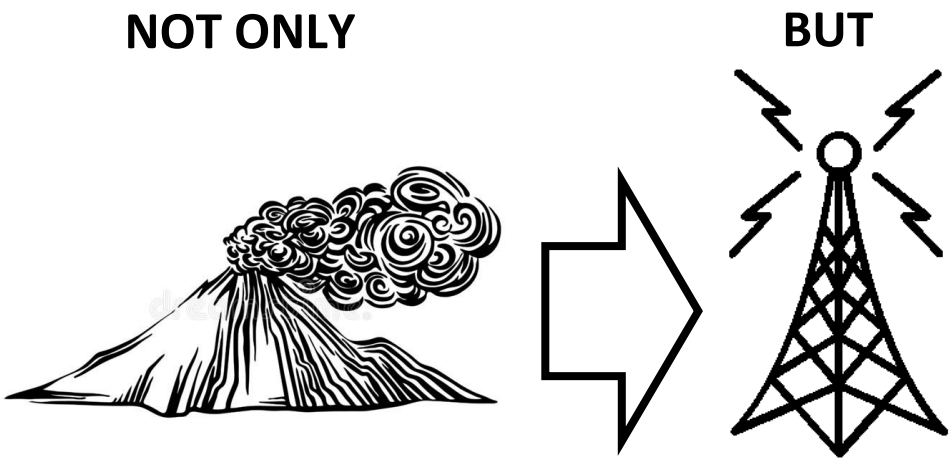

Fig. 62 – A new vision of the volcano, according to the Radio Emissions Project. No longer a cone of land that emits lava and smoke, but a real electromagnetic antenna that emits radiofrequency. Credits: Radio Emissions Project.

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