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Experimentation of The Italian RDF - Radio Direction Finding - Network, In The Search For Electromagnetic Seismic Precursors

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ABSTRACT This study has as its object the experimentation of an electromagnetic type detection system, developed by the Radio Emissions Project within the Italian territory, an area in which the first RDF - Radio Direction Finding detection network in the world was created. This study considers the ability of this system to detect pre-seismic electromagnetic signals, emitted at the crustal level, in an area of Sicily where an earthquake of magnitude M 4.2 on the Richter scale then occurred.

Keywords: RDF, Italia, Seismic Precursors, Electromagnetic signals.

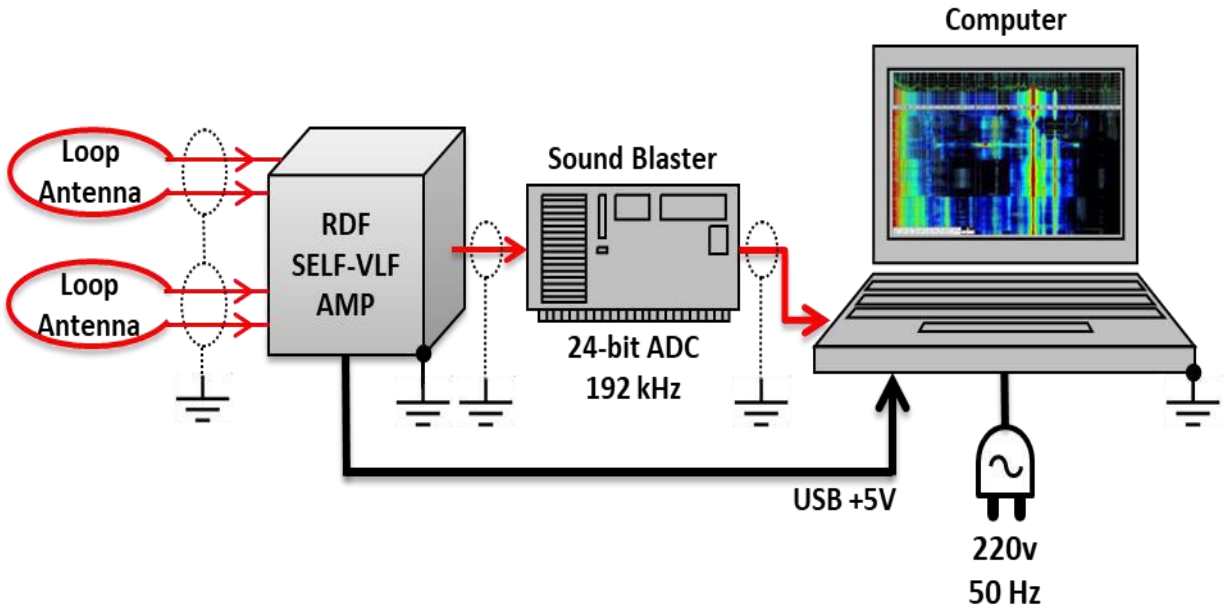
1.0 – INTRODUCTION

The study of seismic precursors, which began between 2008 and 2009, led the research group of the Radio Emissions Project (Italy) to develop a series of detection stations aimed at identifying the electromagnetic signals emitted by the lithosphere (earth's crust), before of the occurrence of an earthquake.

Research in this area has provided indications for designing and implementing a new detection system for the search for electromagnetic seismic precursors associated with earthquakes, and in 2017 has provided sufficient indications for the creation of the first network in the world based on an RDF - Radio Direction Finding, i.e. a series of survey stations (Scheme 1), capable of monitoring different electromagnetic frequency bands, identifying the natural-type signals that are emitted by the earth's crust and therefore identifying their intensity, electromagnetic frequency, duration and above all the direction of arrival (in degrees) with respect to the position of the station itself.

The RDF survey stations are able to monitor and record natural electromagnetic signals continuously (24H7), generating an archive of dynamic spectrograms which can then be analyzed to understand the characteristics and evolution of the identified and understand whether these are able to provide spatial and/or temporal indications on a certain area of the globe in which these signals are generated.

Experimental studies started in 2017, by the Radio Emissions Project [1] have shown that it is possible to detect the presence of such electromagnetic signals, where earthquakes then occur [2-16].



Scheme 1 – Schematization of the RDF monitoring station (developed by Dr. Daniele Cataldi and Dr. Gabriele Cataldi), it is characterized by a set of loop antennas (as many as 2), by an RDF radio receiver (in SELF-VLF band) which amplifies the radio and which it then sends to a PC, on which the signals are processed by a specific software. Credits: Radio Emissions Project.

2.0 – METHOD AND DATA

An earthquake affected the territory of the city of Giuliana (Palermo, Italy) on August 21, 2022, at 04:52:49 UTC, at a depth of 3.6 kilometers, with Magnitude 4.2 on the Richter scale, at GPS coordinates: Latitude 37.6777; Longitude 13.2477 (data from INGV – National Institute of Geophysics and Volcanology). This earthquake, felt throughout the province of Palermo in Sicily, aroused fear and panic in the population, being an earthquake characterized by an average magnitude, which had not occurred in this geographical district for some time.

Before this earthquake occurred, the Italian RDF stations had highlighted the presence of some electromagnetic emissions (natural-type radio signals) that had appeared before the earthquake occurred, precisely in the area highlighted by the monitoring system.

3.0 – DISCUSSION

Fig. 1 shows the distribution of the colorimetric mapping of the Italian RDF network, whose stations considered in this study are the following:

1. Lariano station, Rome, Italy. (GPS: Lat: 41.728799 N, Long: 12.843205 E). Station managed by Dr. Daniele Cataldi.
2. Pontedera station, Pisa, Italy. (GPS: Lat: 43.672445 N, Long: 10.640100 E). Station managed by Mr. Carlo Magretti.

This network, as already mentioned, has highlighted the appearance of a series of electromagnetic signals which are important in a forecasting context. The first station considered is the one located in Northern Italy, namely

that of Pontedera, Pisa, Italy; it highlighted the presence of a series of radio signals, well detached from the natural geomagnetic background (noise), whose red azimuth (highlighted by the computerized processing system) indicated the azimuth in correspondence with an area located in the south of the Italy.

It is evident that, in Fig. 2 (dynamic spectrogram generated by the RDF station of Pontedera Pisa, Italy), there are a series of red/purple emissions, which appeared shortly before the earthquake occurred in the Sicilian geographical area. These red/purple signals indicate the appearance of electromagnetic signals having the same azimuth as the seismic epicenter (Giuliana, Palermo, Italy - M 4.2 on 21 August 2022). In this case the radio signals were recorded starting from 10:15 UTC on August 18, 2022, or almost 3 days before the seismic event occurred in the town of Giuliana (PA). Fig. 3 shows the evolution of these signals, highlighting how they also appeared on August 19, 2022, until 08:00 UTC. While in Fig. 4, the evolution of the signals recorded by the RDF station itself, shows us how the emissions then restarted sharply around 11:00 UTC on August 19, 2022, showing an "impulsive" trend for the entire duration of the spectrogram, i.e. until 15:00 UTC.
Other important references referring to these crustal-type electromagnetic emissions were then captured and recorded also by the RDF station of Lariano, Rome, Italy, between 18 and 19 August 2022, and at the following times: from 17:00 UTC, to 20:00 UTC (18 August 2022), to then reappear massively from 22:00 UTC on 18 August 2022, to 03:00 UTC on 19 August 2022.

The signals then followed an impulsive trend, for many hours, and then reappeared from 12:00 UTC to 16:30 UTC (Fig. 5).

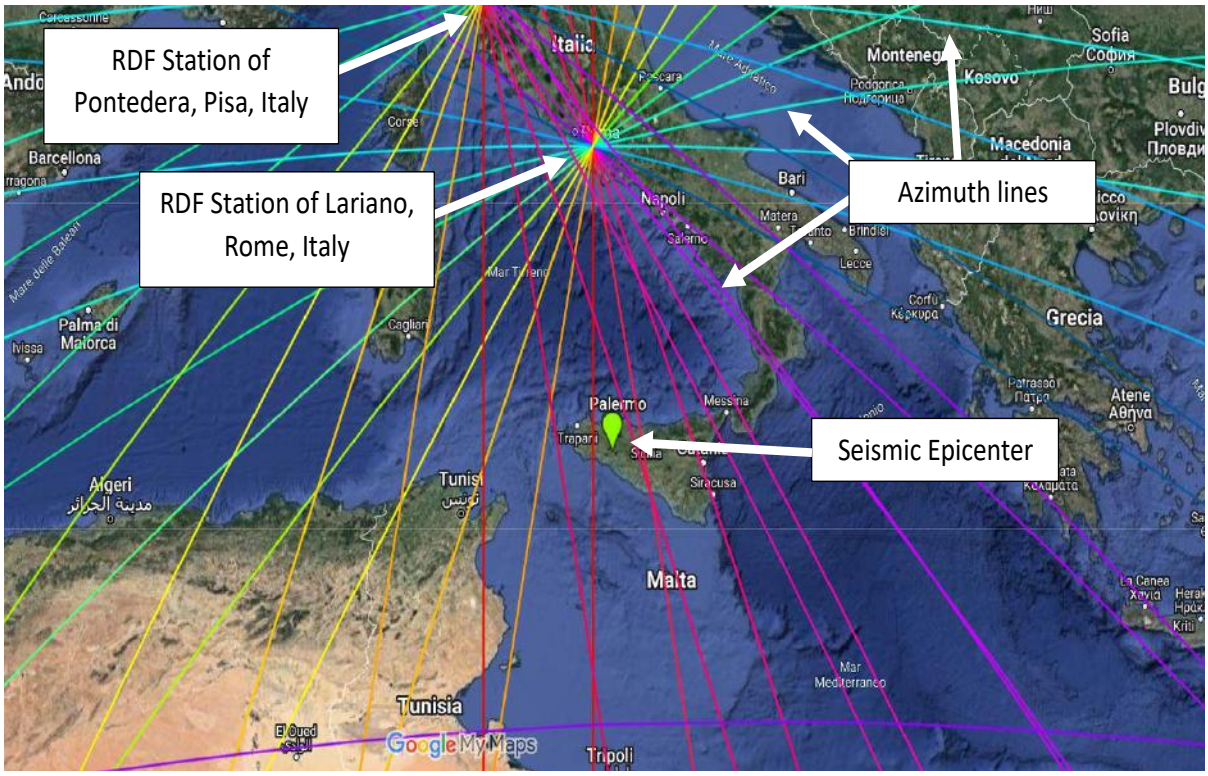


Fig. 1 – Satellite map of the Italian RDF network that identified the pre-seismic electromagnetic signals of the earthquake considered in this study (Giuliana, Palermo, M4.2) occurred in Sicily, Italy. The map shows these RDF stations (Pontedera, Pisa, Italy and Lariano, Rome, Italy) the position of the seismic epicenter in green marker and the coloring of the azimuth lines with respect to each individual RDF station. Credits: Radio Emissions Project.

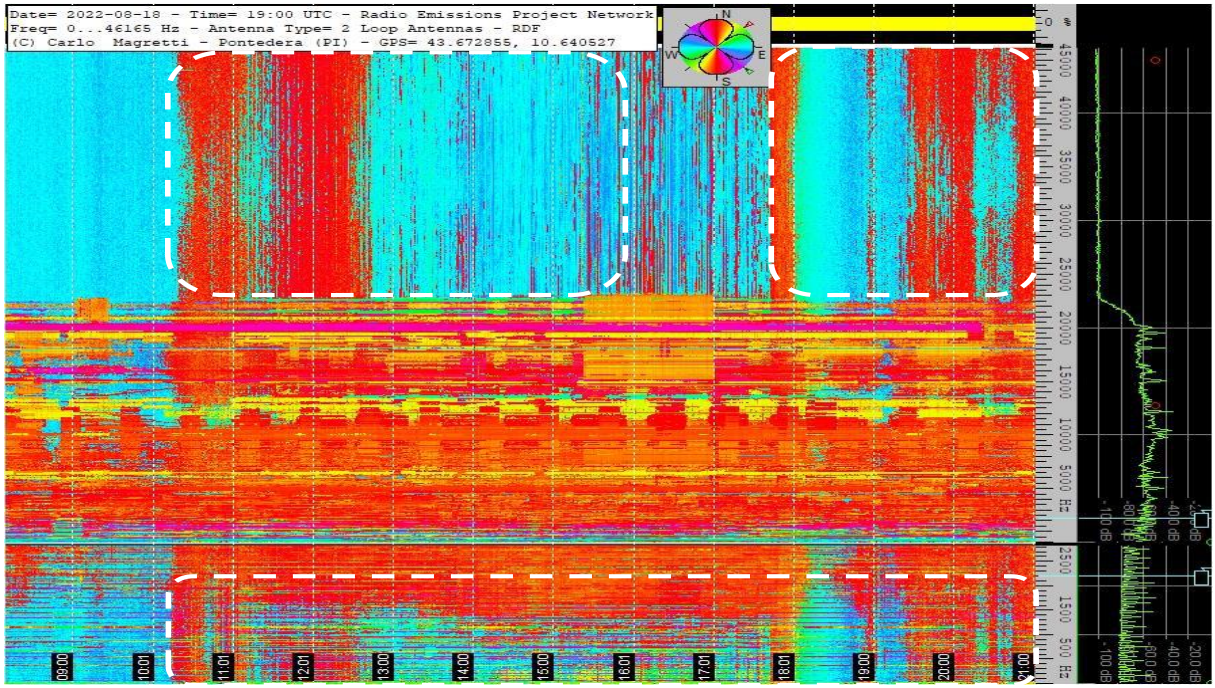


Fig. 2 - Dynamic spectrogram of the Italian RDF network. It is generated by the RDF station in Pontedera, Pisa, Italy, and shows the presence of radio signals having a specific electromagnetic frequency and a precise duration in minutes or hours. In this case the spectrogram shows the timeline in UTC time on the abscissas, and the electromagnetic frequency in Hz on the ordinates. The electromagnetic emissions indicating the azimuth of the seismic epicenter are highlighted in white. Credits: Radio Emissions Project; Mr. Carlo Magretti.

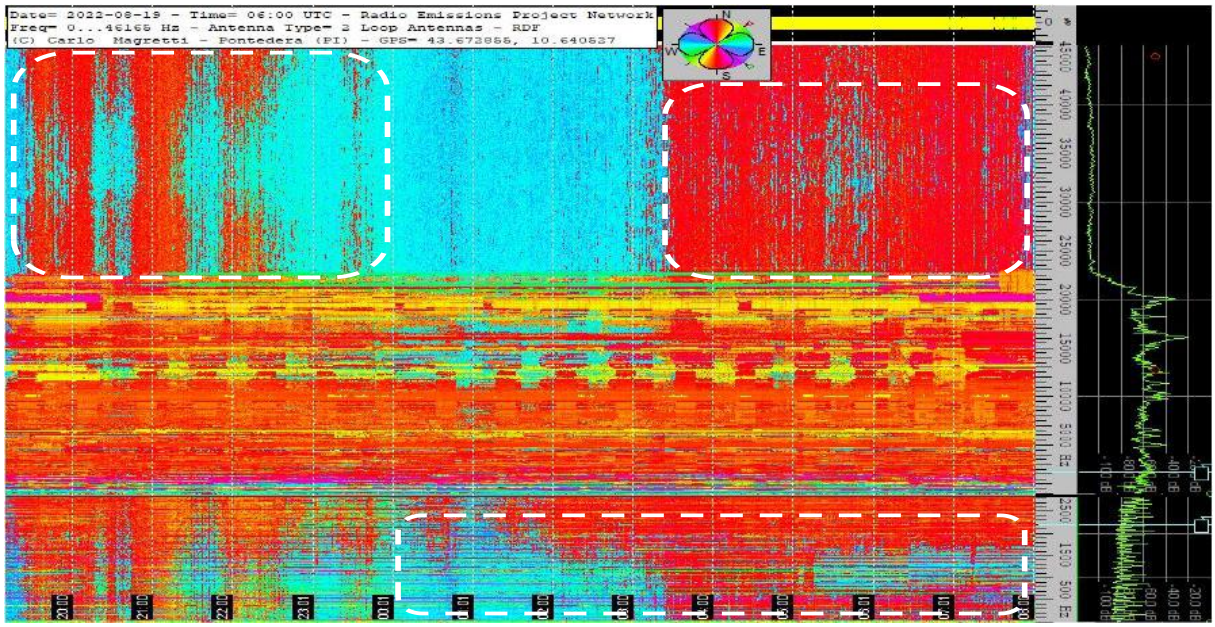


Fig. 3 - Dynamic spectrogram of the Italian RDF network. It is generated by the RDF station in Pontedera, Pisa, Italy, and shows the presence of radio signals having a specific electromagnetic frequency and a precise duration in minutes or hours. In this case the spectrogram shows the timeline in UTC time on the abscissas, and the electromagnetic frequency in Hz on the ordinates. The electromagnetic emissions indicating the azimuth of the seismic epicenter are highlighted in white. Credits: Radio Emissions Project; Mr. Carlo Magretti.

In this context, the electromagnetic emissions recorded by the RDF station of Pontedera, Pisa, Italy, are well marked and clearly evident, compared to the rest of the radio emissions highlighted on the spectrograms, and whose duration ranged from a few minutes (about 10) to several hours (5.5).
These data show us how the appearance of the signals took place, temporally, close to the time in which the earthquake then occurred in the province of Palermo, a geographical area characterized by red/purple azimuths (from Pontedera station, Pisa, Italy , and the red ones from the Lariano station, Rome, Italy (Fig. 1), identified by the Italian RDF stations themselves.

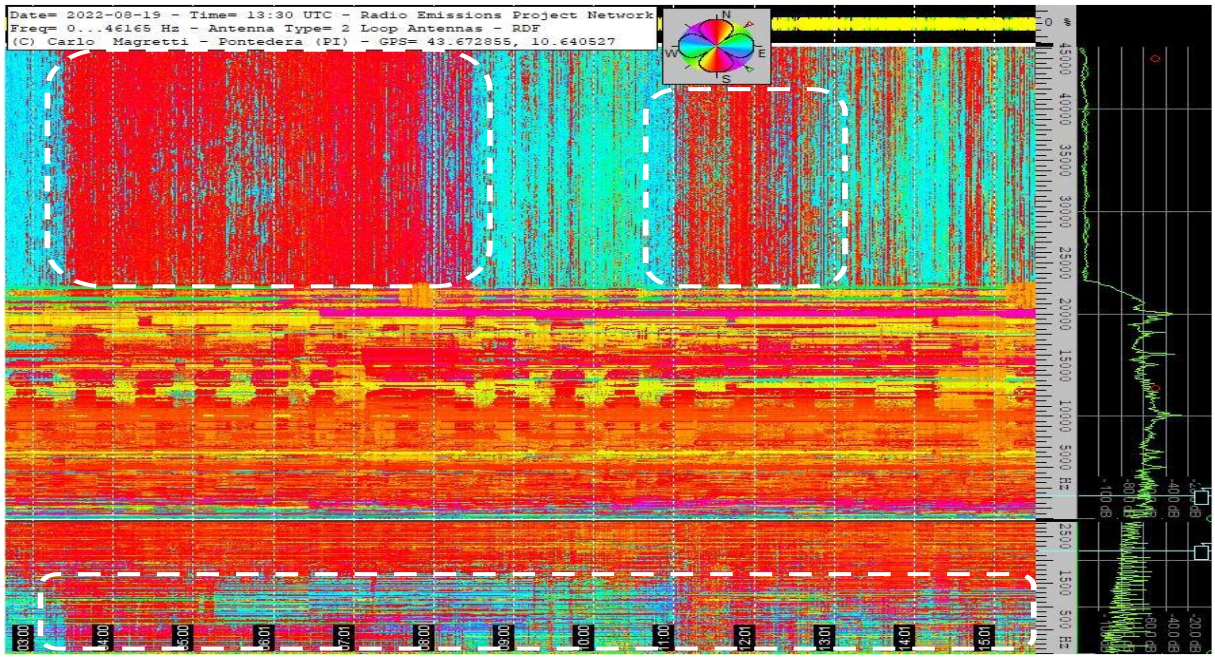


Fig. 4 - Dynamic spectrogram of the Italian RDF network. It is generated by the RDF station in Pontedera, Pisa, Italy, and shows the presence of radio signals having a specific electromagnetic frequency and a precise duration in minutes or hours. In this case the spectrogram shows the timeline in UTC time on the abscissas, and the electromagnetic frequency in Hz on the ordinates. The electromagnetic emissions indicating the azimuth of the seismic epicenter are highlighted in white. Credits: Radio Emissions Project; Mr. Carlo Magretti.

4 – CONCLUSIONS

The data indicate that the Italian RDF stations have identified the appearance of electromagnetic signals, which temporally occurred close to an earthquake of medium intensity, which occurred in Sicily (Italy). These signals, according to the data processed and highlighted by the Italian RDF network, were emitted at the crustal level, from the geographical area where the earthquake was then located. This indicates that the measurement system was able to detect, in good time, the precursory signals of an electromagnetic type, which preceded the earthquake in question.

The colorimetric indication of the azimuths highlighted on the spectrograms indicate that the signals have arrived precisely in the direction of the Sicilian area, as highlighted by the spectrograms (Fig. 2, 3, 4 and 5).

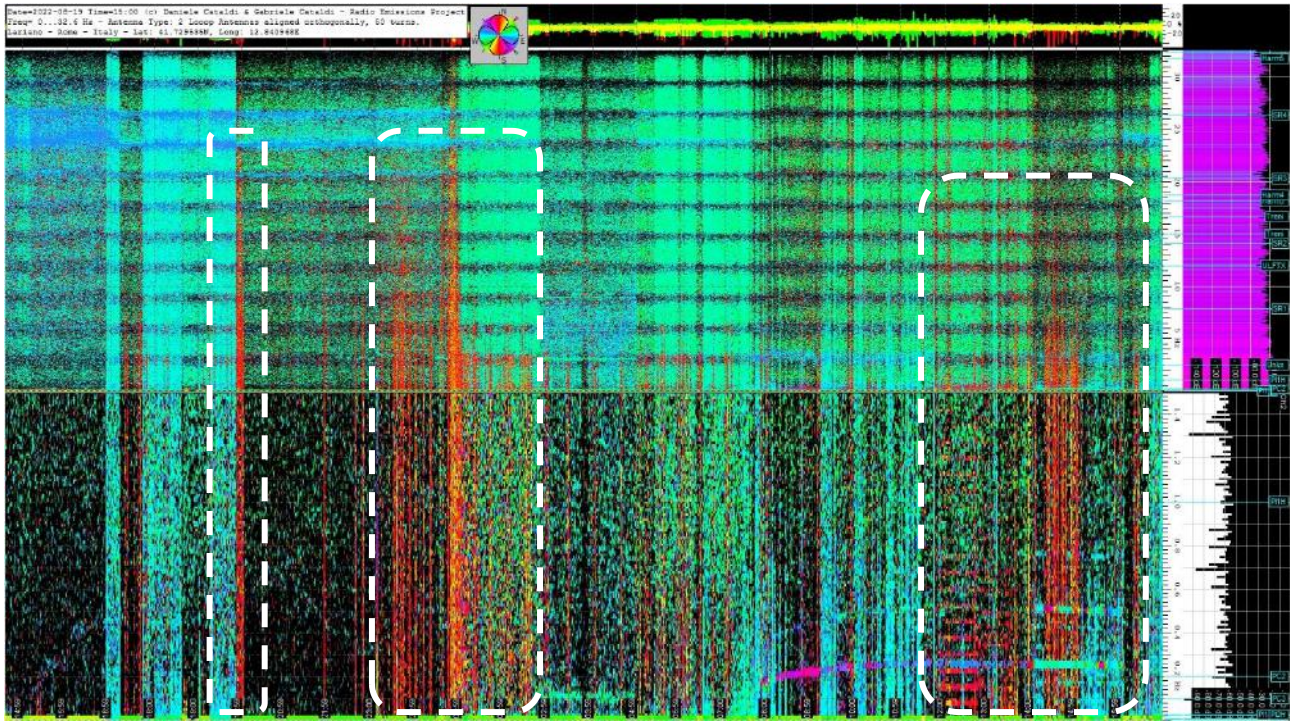


Fig. 5 - Dynamic spectrogram of the Italian RDF network. It is generated by the RDF station in Lariano, Rome, Italy, and shows the presence of radio signals having a specific electromagnetic frequency and a precise duration in minutes or hours. In this case the spectrogram shows the timeline in UTC time on the abscissas, and the electromagnetic frequency in Hz on the ordinates. The electromagnetic emissions indicating the azimuth of the seismic epicenter are highlighted in white. Credits: Radio Emissions Project; Dr. Daniele Cataldi.

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