ISSN: 2978-3801

Journal of Global Warming and Climate Change

SCIENTIFIC Research and Community

Review Article

Open Access

Electromagnetic Earthquakes: Lithosphere-atmosphere Interactions and Biological Implications in the Northern Apennines (Italy)

Valentino Straser[1]*, Daniele Cataldi[2,3] and Gabriele Cataldi[3]

[1]University of Makeni, Sierra Leone

[2]LTPA Observer Project, Italy

[3]Radio Emissions Project, Italy

ABSTRACT

The complexity of climate change phenomena on a global scale includes numerous variables, which cannot be traced back to a single cause. This study, carried out in Italy by Radio Emissions Project, which can also be used for other countries, aims to add a new variable for the study of climate change on a global scale, represented by the interaction between lithosphere and atmosphere. This variable offers itself as an additional element to the climate change unknowns currently considered, such as precisely CO_2. The hypothesis of this potential relationship is based that electrical charges given off by tectonic stress, but also volcanic dust, may constitute the nuclei of aggregation of water droplets and determine the sometimes very intense precipitation associated with the geophysical event. These are, therefore, circumscribed and short-lived weather events, but when measured on a 10 or 30 year scale they can somewhat accentuate, to a lesser extent to an ongoing climate change. In this study, two cases are presented concerning a potential link between endogenous activity and very intense weather events that have occurred in the past two years: the earthquake swarm in the Marche and Emilia-Romagna regions and the province of Parma. Crustal diagnostics that anticipate seismic events and consequently intense weather events, approximately over an interval of about seven months, are monitored 24 hours a day with Radio Direction Finding technology. The Method, which is still in the experimental phase is capable of intercepting geophysical signals, from areas under tectonic stress, including volcanic activity.

***Corresponding author**

Valentino Straser, University of Makeni, Sierra Leone.

Received: April 10, 2025; **Accepted:** April 15, 2025; **Published:** April 22, 2025

Keywords: Climate Change, Extreme Weather Events, Earthquakes, Electromagnetic Fields, RDF System

Introduction

The basis of this research is the observation that strong earthquakes or seismic swarms are often followed by intense meteorological events, such as heavy and concentrated rainfall in a short time, water bombs or snowfall [1,2].

Volcanic eruptions represent a known relationship between geophysical events and climate changes [3,4]. The stratosphere is the atmospheric layer mainly affected by the materials emitted by volcanoes, due to the ash that interacts with both the polar vortex and the stratospheric winds that have an impact on the distribution of ozone on a global scale. The ozone layer constitutes, in the case of major volcanic eruptions, a further cooling element, such as the ash that shields solar radiation, the dust and the water vapor that favors the increase of clouds and precipitation. Dramatic examples of the drastic effect on the climate and the decrease in temperature on a global scale, are represented by the eruptions of Pinatubo, in 1991, by Tambora, in 1815, by Ilopango in 536, in addition to the disastrous eruptions of the past of Campi Flegrei, Toba and Yellowstone [5]. The analysis of this study focuses on another potentially catastrophic endogenous phenomenon: earthquakes. For several years now, the international scientific community has accepted that the energies accumulated and released by earthquakes produce electric charges, electromagnetic fields and the release of gases into the atmosphere [6-8]. Particles that, similarly to ash and aerosols, can act as aggregation nuclei for precipitation [9]. A potential link between earthquakes, seismic swarms and atmospheric events can be verified in many earthquakes, both in Italy and in the world [10,11].

In this regard, in Italy, we remember the heavy snowfall after the strong earthquake in L'Aquila in 2009, the torrential rain after the earthquake in Emilia in 2012, the abundant snowfall of the seismic crisis in Central Italy in 2016, the long seismic swarm in Romagna that anticipated the disastrous flood in 2023 [12].

These are intense events, but of short duration, which however on a larger scale, taking into account the repetitiveness of the events in seismically active areas, can contribute, with a very low incidence, to influence the climate on a larger scale.

Another piece of data taken into consideration for this study is the influence of geophysical activity on animals sensitive to variations in electromagnetic fields, such as wood pigeons, and to ground tremors before an earthquake [13,14]. The behavior of animals, following electromagnetic anomalies, can be associated with tectonic activity in a given area and anticipate the release of particles into the atmosphere following crustal stress. The case studied is that of the

reverse migration of wood pigeons after the seismic crisis of 2016, an event that had anticipated the abundant and disastrous snowfall in the same area hit by earthquakes, the following winter. To perform a crustal diagnosis in tectonically active areas, and for volcanoes, the Radio Direction Finding (RDF) System was designed by Radio Emissions Project of Rome, currently still in the experimental phase, capable of detecting anomalies, starting from very low frequencies, of the order of 0.1 Hz, associable to the geophysical event within a given time window, usually of about seven days. The RDF system, thanks to a goniometric and triangulation system, also allows to identify the area of origin of the anomaly, often the potential area of the epicentre of an earthquake [15].

RDF (Radio Direction Finding) Technology

The primary objective of the project is the identification and analysis of potential electromagnetic precursors, both seismic and related to volcanic activity, which could provide useful indications for earthquake forecasting and the triggering of violent eruptions on a global scale. The project employs induction magnetometers to detect temporal variations in the geomagnetic field, based on Faraday's law of electromagnetic induction, as well as loop-type antennas. These instruments are designed to capture electromagnetic signals in frequency bands ranging from a few millihertz up to 30 kHz [15]. The monitoring stations, an integral part of the project, are strategically distributed to ensure effective coverage of the research areas of interest. The real-time data provided specifically focus on the monitoring of the natural geomagnetic background, with particular attention to the type and morphology of the signals, their intensity, bandwidth, electromagnetic frequency, and the temporal correlation with variations in proton density measured in space, near the Earth, and in general with space weather activity. Recently, the Radio Emissions Project has started using a detection system based on Radio Direction Finding technology, designed by physicist Daniele and Gabriele Cataldi (Figure 1). The technology in use is equipped with two orthogonally aligned loop antennas, a dual-channel radio receiver capable of working efficiently in the SELF-VLF band which, coupled with a computer, is able to provide both azimuth data and the characteristics of the electromagnetic background, including spectral data: a series of data that allow us to understand whether a radioanomaly the mas is of anthropogenic or natural nature. The use of the data is aimed at making a crustal diagnosis and potential tectonic or volcanic stresses in progress, or wind proton density [16].

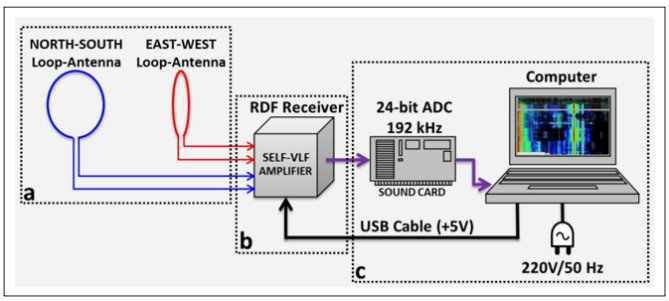

Figure 1: Block Diagram of an Electromagnetic Monitoring Station Implemented with RDF Technology. The Radio Receiver Filters and Amplifies the Ambient Radio Frequency and Sends it to a 24-bit ADC, and Computer Generates Dynamic Spectrograms from the Monitoring Data. (a) Loop Antennas Oriented Orthogonally to Each Other, (b) Dual Channel Analog Radio Receiver, (c) Data Processing System

Methods and Instruments

The method used is that of comparison to verify any elements of correspondence of the physical and geophysical phenomena considered in this research, a consequence of the interaction between the lithosphere and the atmosphere, already studied by other authors [17-21]. The data were obtained from the Radio Direction Finding (RDF) station of Lariano (Rome, Italy), currently in the experimental phase, used for monitoring the variations of the electromagnetic field in the VLF band (0.3-32 kHz). The monitoring station, active since 2017 24H7, consists of two 1 meter diameter Loop antennas containing 50 coils, aligned orthogonally to each other and with respect to the geographic poles. The antennas are interfaced with a computer that reports graphs, detected in the different frequencies that, thanks to a colorimetric scale, it is possible to trace the direction of the magnetic anomalies. The anomaly data are compared in real time with the earthquake websites, in particular that of the National Institute of Geophysics and Volcanology and USGS (www.ingv.it; www.usgs.gov). Precipitation and weather observations, associated with the source of the electromagnetic anomalies, are followed on the website of the Italian Air Force (https://www.meteoam.it/it/mappa-previsioni-osservazioni) and other specialized websites (https://www.3bmeteo.com/radar/italia).

Case Studies

First Case

The first case presented concerns the flood in Emilia-Romagna and Northern Marche that occurred on May 16-17, 2023. An intense weather disturbance caused 23 rivers and streams in 44 municipalities to overflow, triggering more than 290 landslides and disrupting more than 500 roads. About 36,000 people were evacuated and 15 casualties were reported. The weather disturbance that affected Marche was caused by a depression fed by Atlantic perturbation, which remained stationary between two anticyclonic ridges. This system led to widespread and persistent rainfall over the entire region, with particular intensity in the central-eastern sector. The earthquake swarm also continued in February 2023. The shows the earthquake swarm area and RDF map (Figure 2). The storm-affected area had been preceded by an earthquake swarm that began on July 14 of the previous year, with at least 35 quakes (www.ingv.it), followed by another 14 quakes in the night. More earthquakes followed on November 9, 2022, with a magnitude 5.7 (Mw 5.5) the next day by a new magnitude 4.0 earthquake off the Marche coast. Seismic events continued in December 2022, January 2023 with the major event on January 22 of magnitude 3.5, and on January 28 with magnitude 4.1. In the dinamic spectrogram, recoded May 16, 2023, the RDF station in Rome had begun recording a series of violet, red, orange, and yellow electromagnetic emissions, indicating the areas of Emilia-Romagna, extending up to Marche. Electromagnetic emissions with a frequency mostly ranging between 0.1 Hz and 1 Hz (Figure 3).

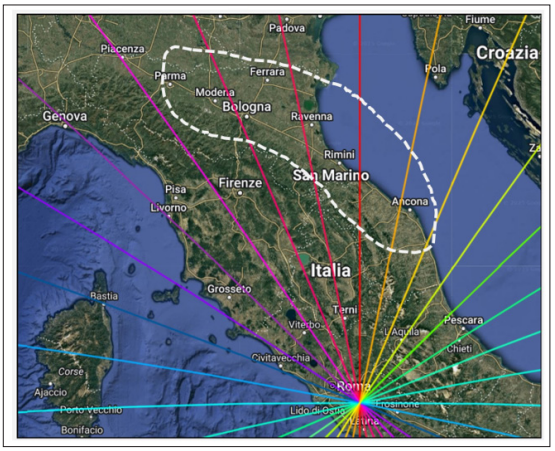

Figure 2: The Electromagnetic Signals Detected Were Highlighted with Precise Azimuths, in this case: Yellow, Orange Red, and Violet, in the Electromagnetic Frequency Ranged Between 0.1 Hz and 1 Hz (SELF Band – 0-3 Hz)

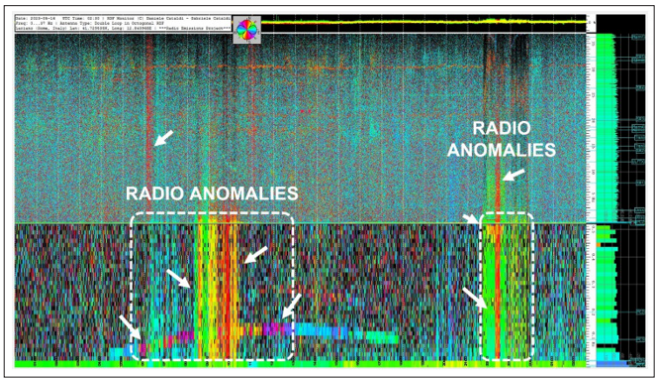

Figure 3: On May 16, 2023, the RDF Station in Lariano (RM), Italy, had Begun Recording a Series of Violet, Red, Orange, and Yellow Electromagnetic Emissions, Indicating the Areas of Emilia-Romagna, Extending up to Marche. Electromagnetic Emissions with a Frequency Mostly Ranging Between 0.1 Hz and 1 Hz

Second Case

The second case presented today concerns the flooding in Parma and Emilia-Romagna (Italy) that occurred in October 2024. The province of Parma affected by the earthquakes has been hit by intense rainfall. The flood events in October 2024 in Emilia-Romagna, and also in Parma, were preceded in the same year by an intense earthquake swarm in February 2024 in the province of Parma. The most significant event occurred on February 9 with a magnitude 4.2 earthquake. The seismic event was preceded and followed by numerous aftershocks, some exceeding magnitude 3.0. In two days since the seismic swarm began on February 7, 2024, 121 earthquakes were recorded by the National Institute of Geophysics and Volcanology in Rome (www.ingv.it). Figure shows the overlap of the purple signal, detected by the RDF station with the epicenter and flood affected area (Figure 4). The first signals (radio anomalies) were recorded on February 2, 2024, and preceded the seismic swarm and the strong M4.2 earthquake by 7 days. While the first mild earthquakes occurred on February 7, 2024, the electromagnetic signals preceded them by 5 days, in frequency band between 0 – 32 kHz (Figure 5). The increase the electromagnetic signals that occurred on February 10 preceded by 5 days the M3.5 earthquake in the province of Parma (February 15, 2024). The strong increase visible in this dynamic spectrogram appeared immediately after the M4.2 magnitude earthquake, which occurred on February 9, 2024. The entire lithospheric area began to emit strong electromagnetic signals, which the detection system highlighted with violet azimuth, meaning coming from Parma.

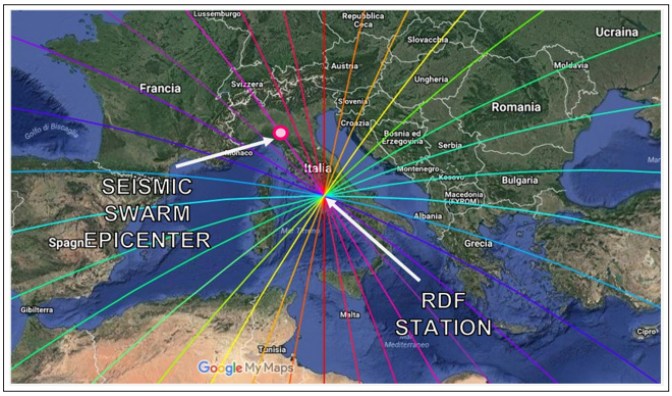

Figure 4: Colorimetric Map of RDF Station of Lariano – Rome (Italy), and Seismic Swarm Epicenter (azimuth line violet), in the Province of Parma (Italy)

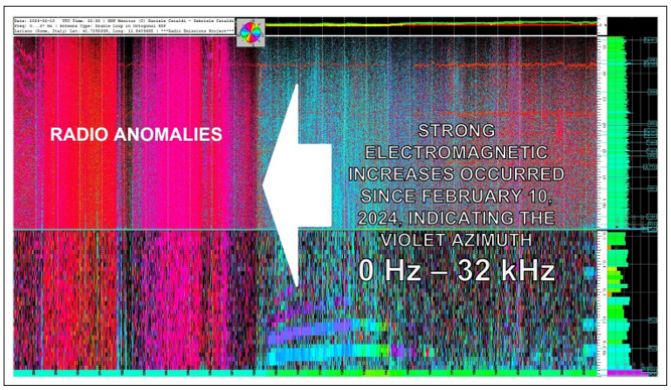

Figure 5: The First Signals (radio anomalies) Were Recorded on February 2, 2024, and Preceded the Seismic Swarm and the Strong M4.2 Earthquake by 7 Days (azimuth line violet)

Volcanic Eruptions of Mount Etna and Signals Detected by RDF Network

Another case regarding the release of materials into the atmosphere, associated with meteorological and climatic events, concerns Italian volcanism. The study monitored Italian volcanoes for three months and 21 days (from December 10, 2020, to March 31, 2021), providing important data on pre-eruption electromagnetic emissions from Mount Etna and pre-seismic signals associated with Italian volcanoes [22]. The study developed an eruption prediction model based on the analysis of trends in electromagnetic data. This approach made it possible to accurately predict the eruption of Mount Etna on February 12, 2022, with a 95% probability of correctness.

The monitoring results showed that:

- Volcanoes behave like radio transmitters.
- Volcanic structures can be assimilated to natural antennas, continuously emitting radio frequencies. These electromagnetic emissions can be detected and monitored through a network of RDF stations.
- The study highlighted that Mount Etna emitted electromagnetic anomalies before its eruptions.
- These signals proved to be constant and recognizable, suggesting the possibility of using the mas eruption precursors.
- Electromagnetic signals also preceded low – to medium magnitude seismic events near the volcanoes.
- The anomalous radio emissions had a variable duration but were always present before an eruption or a seismic event associated with volcanoes. An inversely proportional relationship was observed between the electromagnetic frequency and the signal duration [23].

Conclusion

We conclude that, as things stand, it is not yet possible to draw any certain conclusions. However, the potential link between tectonic activity and meteorology cannot be overlooked, especially if we consider the time intervals between the start of the seismic crisis, detected with the RDF system, and the intense meteorological events which, in the two cases considered for floods, is about seven months. A time interval that can also be verified in the seismic sequence of 2016 in Central Italy, with the two strong earthquakes of magnitude 6.5 on August 24, 2016 and the one of magnitude 6, which occurred on October 30, 2016, which anticipated a particularly snowy winter in 2017. It is hoped that further studies can confirm or deny this hypothesis.

Acknowledgment

We express our sincere thanks to Lincotek for their support in this research.

References

1. Straser V, Casati M, Cataldi G (2016) "Water bombs" and seismic areas: Two sides to the same problem? EGU General Assembly 2016: https://ui.adsabs.harvard.edu/abs/2016EGUGA..18.2401S/abstract.
2. Straser V (2015) A potential relationship between seismic swarm and violent rainstorm? New Concepts in Global Tectonics Journal 3: 467-475.
3. Stothers RB (1984) The great Tambora eruption in 1815 and its aftermath. Science 224: 1191-1198.
4. McCormick MP, Thomason LW, Trepte CR (1995) Atmospheric effects of the Mt Pinatubo eruption. Nature 373: 6513.
5. Petralia MD, Ravi K (2012) The Toba volcanic super-eruption of 74,000 years ago: Climate change, environments, and evolving humans. Quaternary International 258: 1-4.
6. Pulinets S (2004) Ionospheric Precursors of Earthquakes; Recent Advances in Theory and Practical Applications. TAO 15: 413-435.
7. Hayakawa M (2019) Seismo Electromagnetics and Earthquake Prediction: History and New Directions. International Journal of Electronics and Applied Research 6: 1-23.
8. Sorokin VM, Yaschenko AK, Hayakawa M (2006) Formation mechanism of the lower-ionospheric disturbances by the atmosphere electric current over a seismic region. Journal of Atmospheric and Solar-Terrestrial Physics 68: 1260-1268.
9. Hayakawa M, Rozhnoi A, Solovieva S, Yang SS (2019) On electromagnetic precursors to the Hokkaido earthquake in September, 2018 and consideration of lithosphere-atmosphere-ionosphere coupling. International Journal of Electronics and Applied Research 6: 41-59.
10. Straser V, Cataldi D, Cataldi G, Giuliani GG, Wright JR (2020) Effects of hurricane laura on the New Madrid Fault area - results of electromagnetic monitoring through the RDF network - Radio Direction Finding and Arkansas electromagnetic monitoring station. New Concepts In Global Tectonics Journal 8: 187-218.
11. Straser V, Cataldi D, Cataldi G (2023) Weather Events Associated with Strong Earthquakes and Seismic Swarms in Italy. Advances in Geological and Geotechnical Engineering Research 5: 39-54.
12. Grant RA, Halliday T (2010) Predicting the Unpredictable, Evidence of Pre-Seismic Anticipatory Behaviour in the Common Toad. Journal of Zoology 281: 263-271.
13. Tributsch H (1984) When the Snakes Awake: Animals and Earthquake Prediction. Cambridge Mass. MIT Press.
14. Straser V, Cataldi D, Cataldi G (2017) Radio Direction Finding System, a new perspective for global crust diagnosis. New Concepts in Global Tectonics Journal 6: 203-2011.
15. Straser V, Cataldi G (2014) Solar wind proton density increase and geomagnetic storms as seismic precursors. New Concepts in Global Tectonics Journal 2: 49-62.
16. Pulinets SA, Ouzounov D (2011) Lithosphere-Atmosphere-Ionosphere Coupling (LAIC) model – An unified concept for earthquake precursors validation. Journal of Asian Earth Sciences 41: 371-382.
17. Uyeda S, Nagao T, Kamogawa M (2009) Short-term earthquake prediction: Current status of seismo-electromagnetics. Tectonophysics 470: 205-213.
18. Freund FT, Takeuchi A, Lau BW, Post R, Keefner J, et al. (2004) Stress-induced changes in the electrical conductivity of igneous rocks. Earth Planets Space 56: 1159-1168.
19. Rabeh T, Cataldi G, Straser V (2014) Possibility of coupling the magnetosphere–ionosphere during the time of earthquakes. Conference: EGU 16.
20. Ouzounov O, Pulinets S, Liu JY, Hattori K, Han P (2018) Multiparameter Assessment of Pre-Earthquake Atmospheric Signals. Advanced Earth and Space Sciences https://agupubs.onlinelibrary.wiley.com/doi/10.1002/9781119156949.ch20.
21. Straser V, Cataldi D, Cataldi G, Giuliani GG (2021) Pre-Seismic Signals Recorded By The Italian RDF Network Before The Occurrence Of Some Earthquakes In Northern Italy. International Journal of Software & Hardware Research in Engineering (IJSHRE) 9: 63-76.
22. Nahornyi V, Straser V, Cataldi D (2022) Prediction of the Vibration Moment of Mount Etna Based on Electromagnetic Signal Monitoring. MM Science Journal 5943-5948.
23. Behnke SA, Thomas RJ, Edens HE, Krehbiel PR, Rison W (2014) The 2010 eruption of Eyjafjallajökull: Lightning and plume charge structure. Journal of Geophysical Research: Atmospheres 19: 833-859.