Journal of Sensor Technology, 2023, 13, 51-58
https://www.scirp.org/journal/jst
ISSN Online: 2161-1238
ISSN Print: 2161-122X

Radio-Acoustic Study of Thunderstorms

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How to cite this paper: Tomezzoli, G.T. (2023) Radio-Acoustic Study of Thunderstorms. *Journal of Sensor Technology*, **13**, 51-58.
https://doi.org/10.4236/jst.2023.133005

Received: June 24, 2023
Accepted: September 8, 2023
Published: September 11, 2023

Abstract

The observation, in the past, that a thunderstorm perturbed the transmissions of an old vacuum tubes radio with noise discharges in correspondence with lightnings, suggested the possibility of radio-acoustic study of thunderstorms. The noise discharges appeared to convey not only information about lightnings, but also about any other thunderstorm electromagnetic phenomena generating noise discharges. The low-cost instrumentation involved in the radio-acoustic study, comprised a radio Telefunken mod. T33B, a 15 m long indoor wire antenna, a mobile telephone Samsung Galaxy S20 FE 5G provided with the recorder App Enregistreur vocal, a computer HP Pavillion dv5-1254eg and the s/w audio analyser Audacity. A first thunderstorm on 20 June 2023 and a second thunderstorm on 22 June 2023, both above Munich, were radio-acoustic studied. The second thunderstorm was more active than the first and released much more energy.

Keywords

Thunderstorms, Radio-Acoustics, Vacuum Tube Radio, Noise Discharges

1. Introduction

In the past, the observation that thunderstorm lightnings perturbed the transmissions of an old, vacuum tube radio by noise discharges, brought to the idea of radio-acoustic study the thunderstorms. It was at that time clear that lightnings produced not only visible light emissions and thunders, but also electromagnetic emissions at radio frequencies which generated noise discharges. It was rapidly realised that, contrary to the thunderstorm, optical observations and Cloud-to-Ground radio observations, which both require lightnings observation outside clouds for acquiring information also about phenomena inside the clouds, the noise discharges conveyed directly information about any electromagnetic phenomena able to generate them occurring both outside and inside the thunderstorm clouds or cells. This appeared particularly interesting. Moreover, the simple and cheap instrumentation involved, made the thunderstorm radio-acoustic observation also promising. To test the capabilities of the thunderstorm radio-acoustic observation two thunderstorms were radio-acoustic studied.

2. Background

First of all, no real difference practically exists between the atmospheric perturbations identified in literature as thunderstorms or storms, because both are characterised by wind, clouds, lightnings, thunders and rain.

Second, it is important to bear in mind the possible different electromagnetic phenomena associated with thunderstorms [1] [2]:

1) Cloud-to-Ground—Negative (−CG): lightning between cloud and ground, started by a negatively-charged leader; 90% of the CG;

2) Cloud-to-Ground—Positive (+CG): lightning between cloud and ground, started by a positively-charged leader; 10% of the CG;

3) Ground-to-Cloud: lightning between ground and cloud started by either a positive or a negative leader originated by an object (towers, skyscrapers) on the ground;

4) Cloud-to-Cloud [2]: lightning between clouds or intraclouds;

5) Intracloud: lightning inside a single cloud, jumping between different charged regions;

6) Bolt from the blue: lightning originated in the highest regions of a cumulonimbus cloud, traveling horizontally a distance before descending vertically to the earth;

7) Cloud-to-Air: lightning from a cloud to a clear sky region;

8) Sprite and Jet: lightning occurring high above active thunderstorms. Sprites appear as vertical red lightning columns;

9) Ball: rare spherical shaped lightning, moving fast, slow or staying stationary, disappearing slowly or suddenly either quietly or with a loud bang;

10) Staccato: cloud-to-ground single, very bright lightning with considerable branching;

11) Forked: cloud-to-ground lightning exhibiting a fork branching on its path;

12) Ribbon: multiple ribbon appearance lightnings occurring in thunderstorms with high cross winds, the wind blows each successive lightning slightly to one side of the previous lightning;

13) Bead: rare lightning broken up into a string of short, bright sections;

14) Heat: lightning that appears to produce no discernible thunder because it occurs too far away for the thunder to be heard;

15) St. Elmo's fire [3]: glows observed around the masts of sailing ships.

Apparently, there are 30 - 100 lightning each second worldwide [2].

All the phenomena a)-o) appear able to produce radio noise discharges, therefore all of them could easily be radio-acoustic studied, but in addition, the radio-acoustic observation could provide information about phenomena occurring inside the clouds not providing lightning and thunders.

According to the Tandberg hypothesis [4], the cosmic rays "are ionising the air, making conducting paths for the lightning".

A first thunderstorm on 20 June 2023 and a second thunderstorm on 22 June 2023, both above Munich, were radio-acoustic studied. The first thunderstorm duration, determined by the starting of the discharges and the end of the discharges, lasted about one hour without rain, the second thunderstorm lasted about one hour and half followed by abundant rain fall and later, subsequent other storms. In both cases the clouds covering the sky were of stratocumulus or nimbostratus type, no cumulonimbus [5] [6] was remarked. In both cases, the noise discharges were often announced by visible lighting in the clouds. In the first thunderstorm, no thunders have been heard, probably because the thunders were too faint. In the second thunderstorm sometime thunders were audible after lighting in the clouds, sometime thunders were audible in the background not associated with visible lightnings or cloud lighting. In this last case, this was probably caused by different factors: faint lightings generated, not visible lightings, geographical position of the instrumentation with respect to the lightings.

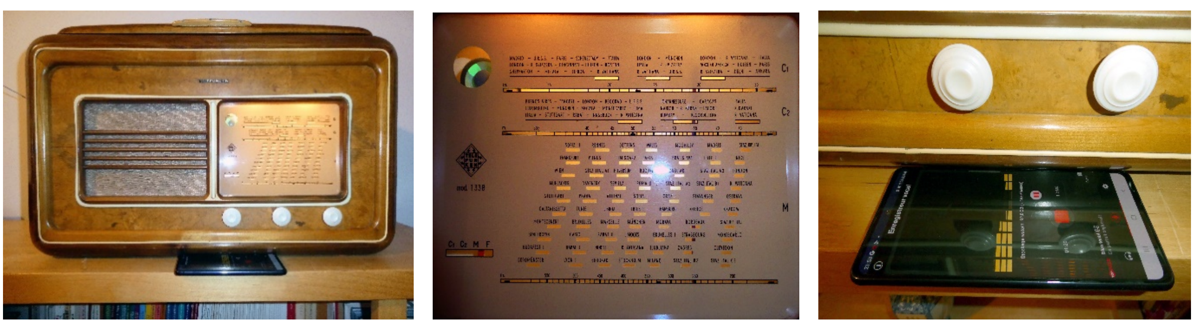
3. Instrumentation and Data Processing

To record the thunderstorms noise discharges following instrumentation (**Figure 1**) was assembled:

- vacuum tube radio Telefunken mod. T33B, 1953/1954;
- 15 m long indoor wire antenna;
- mobile telephone Samsung Galaxy S20 FE 5G, Android 11;
- recorder app. Enregistreur Vocal,.mp3 recorded files;
- portable computer HP Pavillion dv5-1254eg, Windows 7;
- s/w audio.mp3 analyser Audacity.

The radio was tuned to a wavelength not corresponding to the transmissions of a radio station. The actual wavelength selected was indicated on the radio display as M - Bordeaux, Strasbourg.

The.mp3 files containing the noise discharges recorded by Enregistreur Vocal on the Samsung Galaxy S20 FE 5G were visualised and analysed by Audacity on the portable computer.



(a) (b) (c)

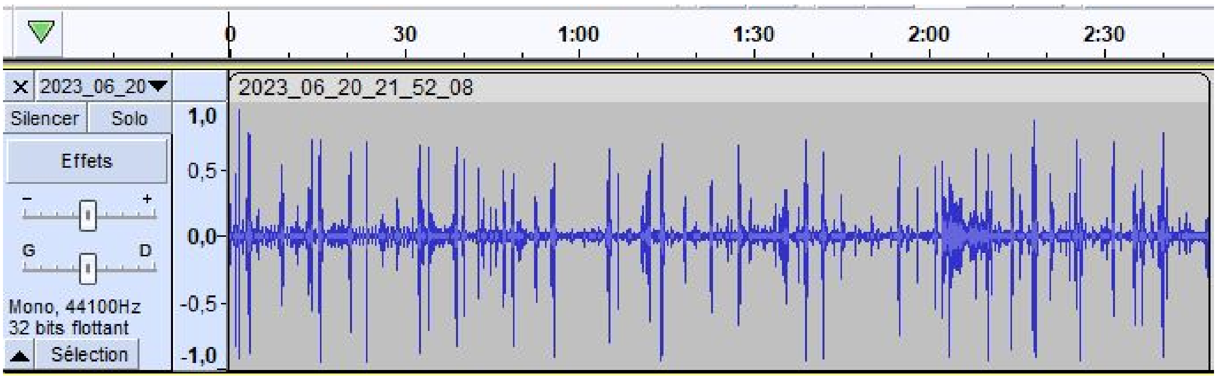
Figure 1. Instrumentation: (a) radio Telefunken mod. T33B, the arrival of the 15m m indoor wire antenna is on the left side; (b) radio display tuning, (c) mobile telephone Samsung Galaxy S20 FE 5G with Enregistreur Vocal in operation.

4. First Thunderstorm—Results

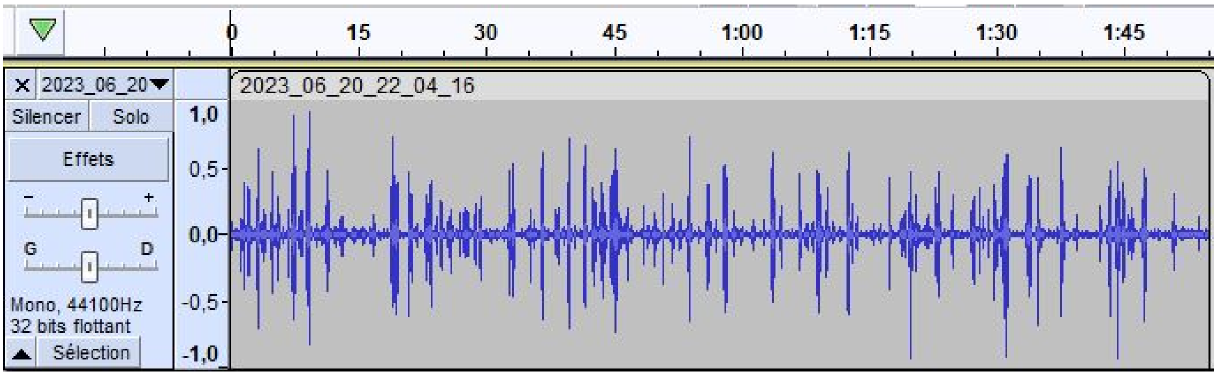
The noise discharges of the first thunderstorm were sampled in different periods of which only the following (**Figure 2**) are presented:

(a) start 21_52_08, duration about 2:50 min; (b) start 22_04_16, duration about 1:55 min; (c) start 22_06_25, duration about 5:30 min; (d) start 23_40_50, duration about 5:00 min.

Each discharge waveform was characterised by a starting and an ending time (**Figure 3**) and comprised many discharging peaks. Each discharge waveform was characterised by a normalised peak amplitude comprised by −1.0 and +1.0 and a duration (ending-starting time). The duration of each discharge waveform was normally less than one seconds which indicates the corresponding



(a)



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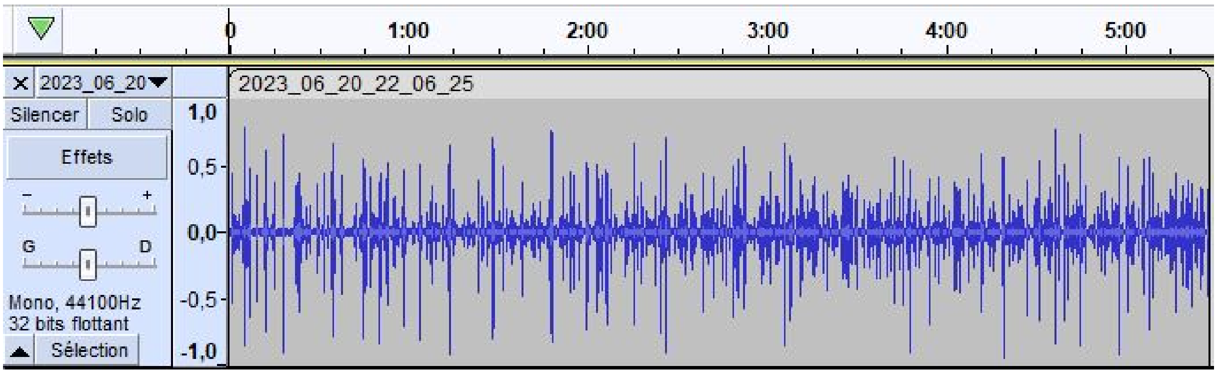

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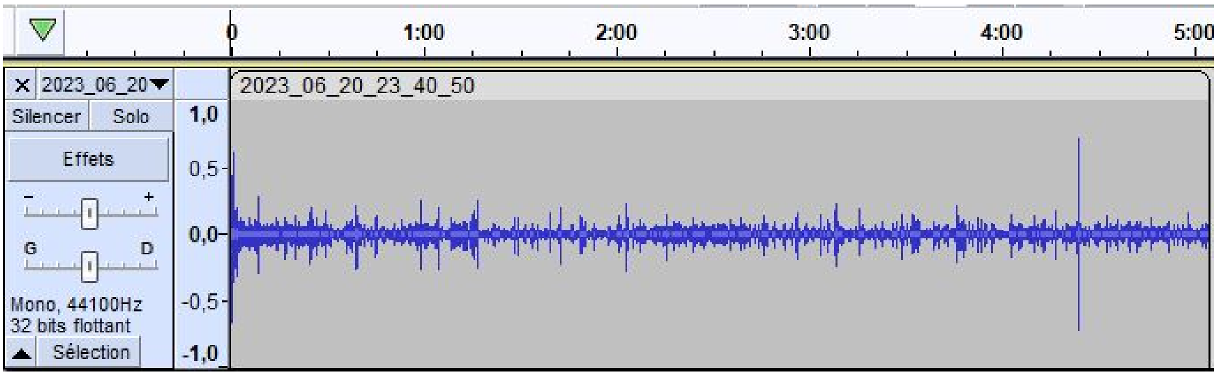
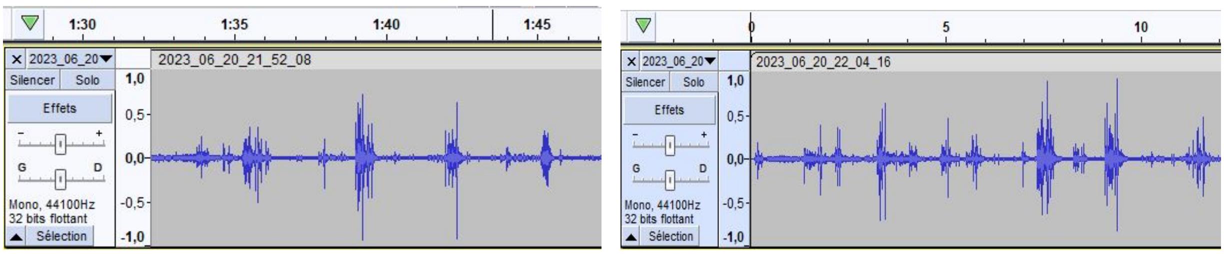


(d)

Figure 2. first thunderstorm, discharges sample periods: (a)-(c) noise discharges waveforms; (d) noise discharges background after the first thunderstorm.



(a) (b)

Figure 3. first thunderstorm noise discharges waveforms details: (a) 2023_06_20_21_52_08; (b) 2023_06_20_22_04_16.

duration of the generating phenomena. The discharges waveforms were separated by a continuum characterised by the absence of peaks, so as to resemble multi-pulse cloud flash (MP) [2].

Looking in more details to the discharge waveforms (**Figure 3**), it is possible to observe that they are formed by minor discharge peaks not crossing the interval −0.5 - 0.5 and major discharging peaks crossing said interval, but not exceeding the interval −1.0 - 1.0. The durations of the discharge peaks were, in the limits of the instrumentation resolution, estimated of about 1/100 sec or less. According to [1] the lightning velocity is about one third of the speed of the light in the vacuum.

The maximum activity of the thunderstorm, characterised by the maximum frequency of the noise discharges, have been reached around 22:00 (**Figure 3(c)**).

The original recorded.mp3 files of the first thunderstorm are available upon request.

5. Second Thunderstorm—Results

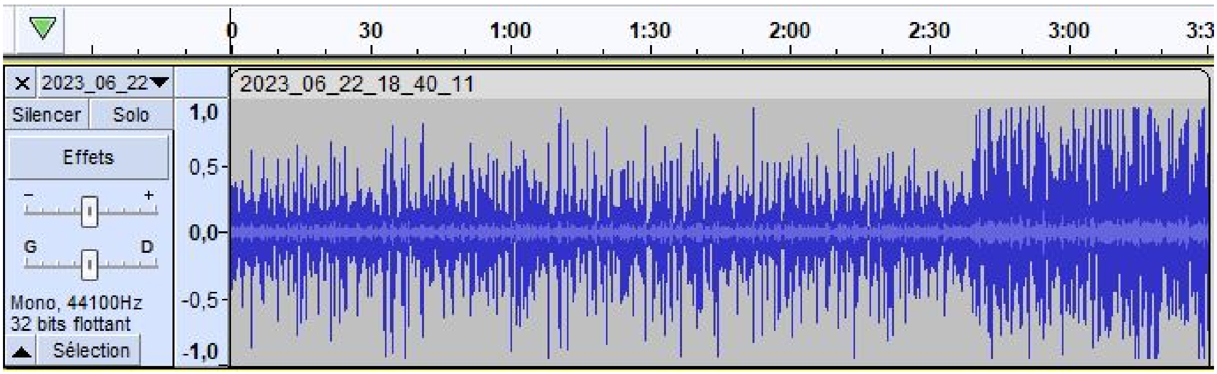
The noise discharges of the second thunderstorm were sampled in different periods of which only the following (**Figure 4**) are presented:

(a) start 18_40_11, duration about 3:30 min; (b) start 19_04_17, duration about 3:30 min; (a) start 18_40_11, duration about 3:30 min; (b) start 19_04_17, duration about 3:30 min;

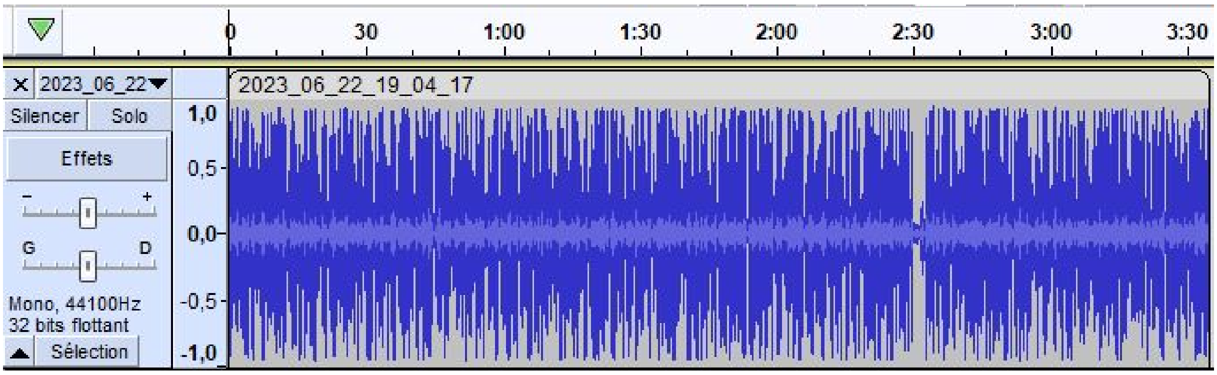
(c) start 19_36_27, duration about 4:00 min; (d) start 20_12_35, duration about 3:40 min.

The discharge waveforms were very close one to the other separated by continuums shorter than those of the first thunderstorm, resembling still a multi-pulse cloud flash (MP) [2]. Because of the larger number of discharge waveforms each with much more major discharging peaks with respect to the first thunderstorm (**Figures 4(a)-4(c)**), it is possible to affirm that the second thunderstorm was more active and its phenomena released much more energy than the first thunderstorm.

Looking in more details to the discharge waveforms (**Figure 5**), it is possible



(a)



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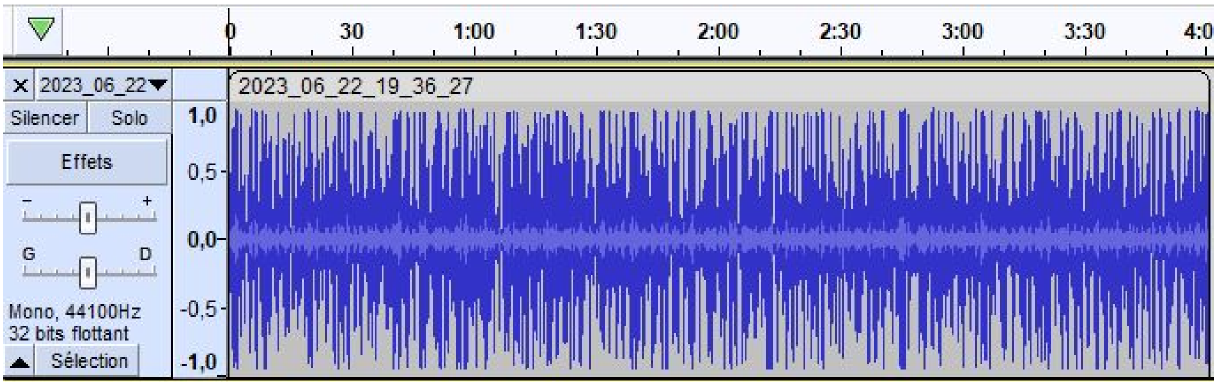
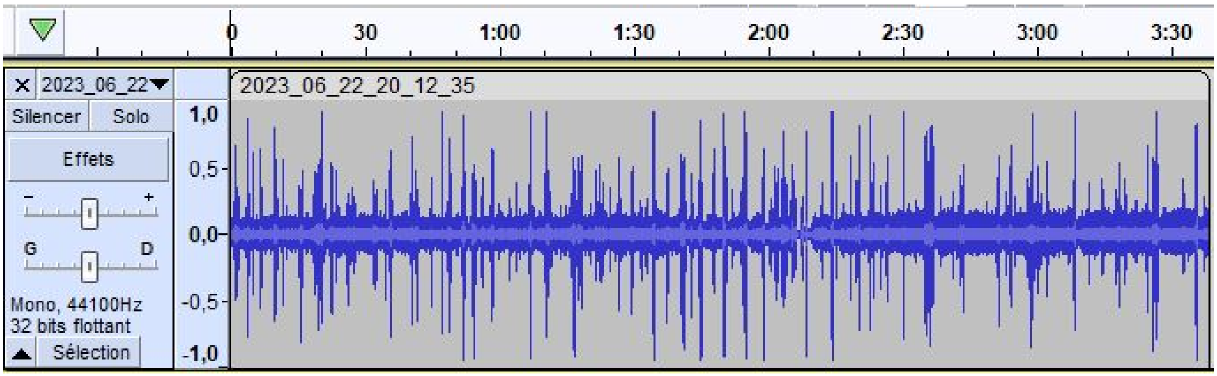
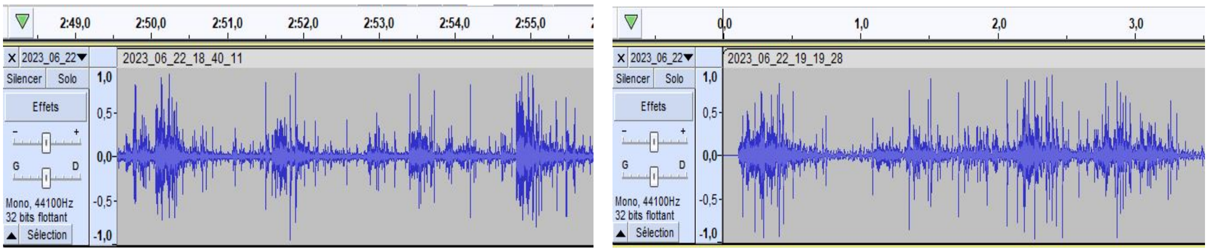


(c)



(d)

Figure 4. Second thunderstorm, discharges sample periods: (a)-(c) noise discharges waveforms; (d) discharges background after the second thunderstorm.



(a) (b)

Figure 5. Second thunderstorm noise discharge waveforms details: (a) 2023_06_22_18_40_11; (b) 2023_06_22_19_19_28.

to observe that, as in the case of the first thunderstorm, they were formed by minor peaks not crossing the interval −0.5 - 0.5 and major peaks crossing said interval, but not crossing the interval −1.0 - 1.0. The durations of the discharge peaks, also in the case of the second thunderstorm, were, in the limits of the instrumentation resolution, estimated of about 1/100 sec or less.

The maximum activity of the second thunderstorm was reached around 19:36.

Lightnings were often seen without corresponding thunders and thunders was heard in the background not always linked with corresponding visible lightnings.

The original recorded.mp3 files of the second thunderstorm are available upon request.

6. Conclusions

The assembled instrumentation revealed itself simple in construction, cheap and reliable in reproducing noise waveforms associated with thunderstorm electromagnetic phenomena. It was possible to directly derive characteristics of said phenomena like duration, composition, frequency which will help to determine their nature and to ascertain that the second thunderstorm was more active than the first one releasing much more energy.

Now that the radio-acoustic observation is established, more thunderstorms can be studied and compared through their noise discharges and more sophisticated techniques: neural networks, artificial intelligence, can further be applied to increase the knowledge about the thunderstorm's electromagnetic phenomena.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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