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Eoliaki Opsi: Computer Generated Compositions Using Environmental Data

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ABSTRACT

A computer-generated composition, software programs, site-specific elevation and climatic data from Ag. Ioannis, Prodromos, Farsala, Panagia, and Kastro locations in the province of Thessaly were vital in constructing the various compositions between 2013 - 2024. Grains from musique concrète and electronic sounds created a powerful way to experience complex micro-sound phenomena. Electronic waveforms are sinusoids at specified frequencies. Sampled acoustic waveforms are read from locations with or without frequency alterations. Together, they create sound diagrams of macro-environmental communication paths. The process derives its sound complexity from the amount of control data it receives. The sourcing, classification and categorisation of data from natural environments lead to inherent errors with data limitations. Extra care is needed to accurately represent data in analysing ecological dynamics, to engage and minimise discrepancies within systems.

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I. INTRODUCTION

Derived from the ancient Greek 'Eoliaki' refers to Aeolia, which is now Thessaly, a province in northern Greece, and 'opsi' is (view). Sounds processed in granular synthesis are separated categorically according to their sound intensity, timbre and are assigned to the frequency spectrum of the elevation data. Temperature and wind speed are climatic data assigned to amplitude and duration. A random order of events is established through the use of the Markovian chain, which is a memoryless probability distribution in which each event depends only on the state attained in the previous event and a non-memoryless random sampling process of cluster and stratified sampling in which the entire sampled population is considered. Performers Pliarhos Stilianos (three-course bouzouki) and Antonis Taxidiotis (four-course bouzouki) contributed audio samples between (15 – 48 seconds) in duration, to the acousmatic part of the composition.

II. DATES SAMPLED AND SOFTWARE USED IN MAPPING, ELEVATION AND CLIMATIC DATA

Data sample dates: 04062013 – 04062014, 25012022 – 07022024, 16022017 – 15022018, 20012020 – 20012021. Climatic data: National Meteorological Service (HNMS). Map location: Topographic elevation data obtained from Google map (contour lines, contour intervals and contour indices) DEM images, 2D polygons from elevation contour polyline intervals created using Spatial Analyst supplemental tools. Surfer: contour, gridding, surface mapping software. TXC converter: converts GPS and mapping data.

Grapher: 2D & 3D technical graphing for scientists, engineers and business professionals.

Mathworks (Matlab): numeric computing platform for data analysis and processing functions like audioread, fft and findpeaks analyzes the frequency content.

Steinberg wavelab 11: sound editing program. GRNMILL, C++ granular synthesis: The samples processed using bandpass-filter, FFT-based FIR filtering with overlap-add method applied to frequencies.

Conversion of elevation data to frequencies

(X) co-ordinates	(Y) co-ordinates		Alt ituted (m)	Frequency (Hz)	
39,573440	22,161725	299792458	168441	1780	Data
39,573621	22,161898	299792458	171009	1753	Data
39,574974	22,162357	299792458	119041	2518	Data
39,575219	22,162279	299792458	113594	2639.1575083191	Data
39,575633	22,162271	299792458	105599	2838.970615252	Data
39,575992	22,162496	299792458	102259	2931.6975327355	Data
39,576293	22,162960	299792458	103036	2909.589444466	Data
39,576815	22,163908	299792458	110906	2703.1220853696	Data
39,577052	22,164488	299792458	108,34	2767	Data
39,577175	22,164899	299792458	109853	2729.0329622314	Data
39,577204	22,165231	299792458	118349	2533.1220204649	Data
39,577261	22,165632	299792458	123842	2420.7656368599	Data
39,577363	22,166330	299792458	118,06	2539.323	Data
39,577479	22,167127	299792458	109941	2726.8485642299	Data
39,577538	22,167524	299792458	105801	2833.5503256113	Data
39,577457	22,168051	299792458	98771	3035.2275262982	Data
39,577299	22,168593	299792458	93901	3192.6439335044	Data
39,577141	22,169263	299792458	94221	3181.8008511903	Data

Fig 1: Kastro N14 230523 conversion of elevation data to frequencies (excerpt)

Conversion of altitude (meters) to frequency (Hertz): Wavelength is the topographic distance (meters) which is the distance between successive crests or troughs of the wave = Traveling speed of light 3 x 10^8 (meters per second) / frequency (Hertz).

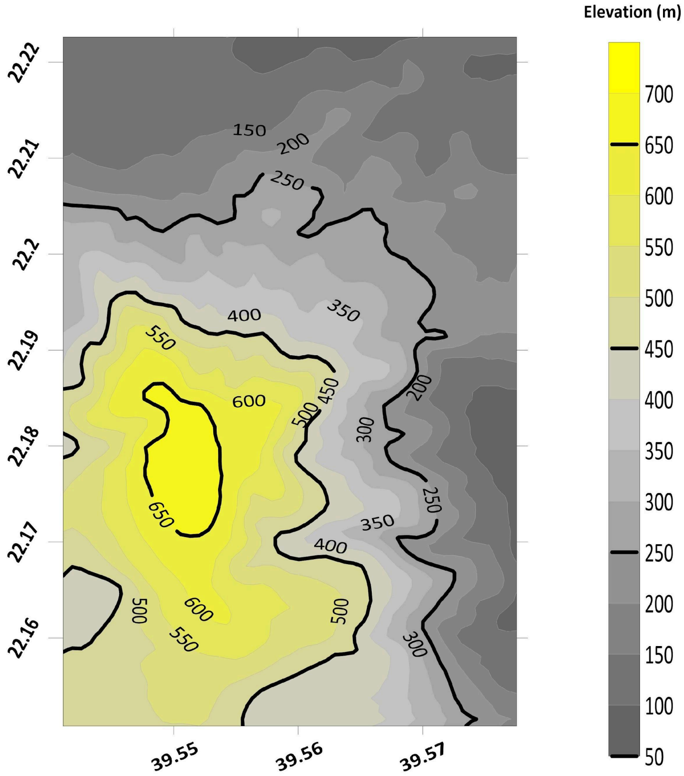

Fig2: *Contour, Gridding, Surface mapping from Kastro N14 230523*

III. STRATEGIC COHERENCE: CHAOTIC SIMULATION OF COMPLEX SYSTEMS

EOLIA is a visible simulation of inherent repetition patterns, self-organisation, similarities, constant feedback loops and interconnectedness within the randomness of complex systems. Establishing an order where elevation data (m) are assigned to frequency (Hz), timbre expressed by descriptive adjectives like bright, warm, mellow, harsh, clear, climatic data: temperature, wind speed is assigned to amplitude (db) and wavelet duration.

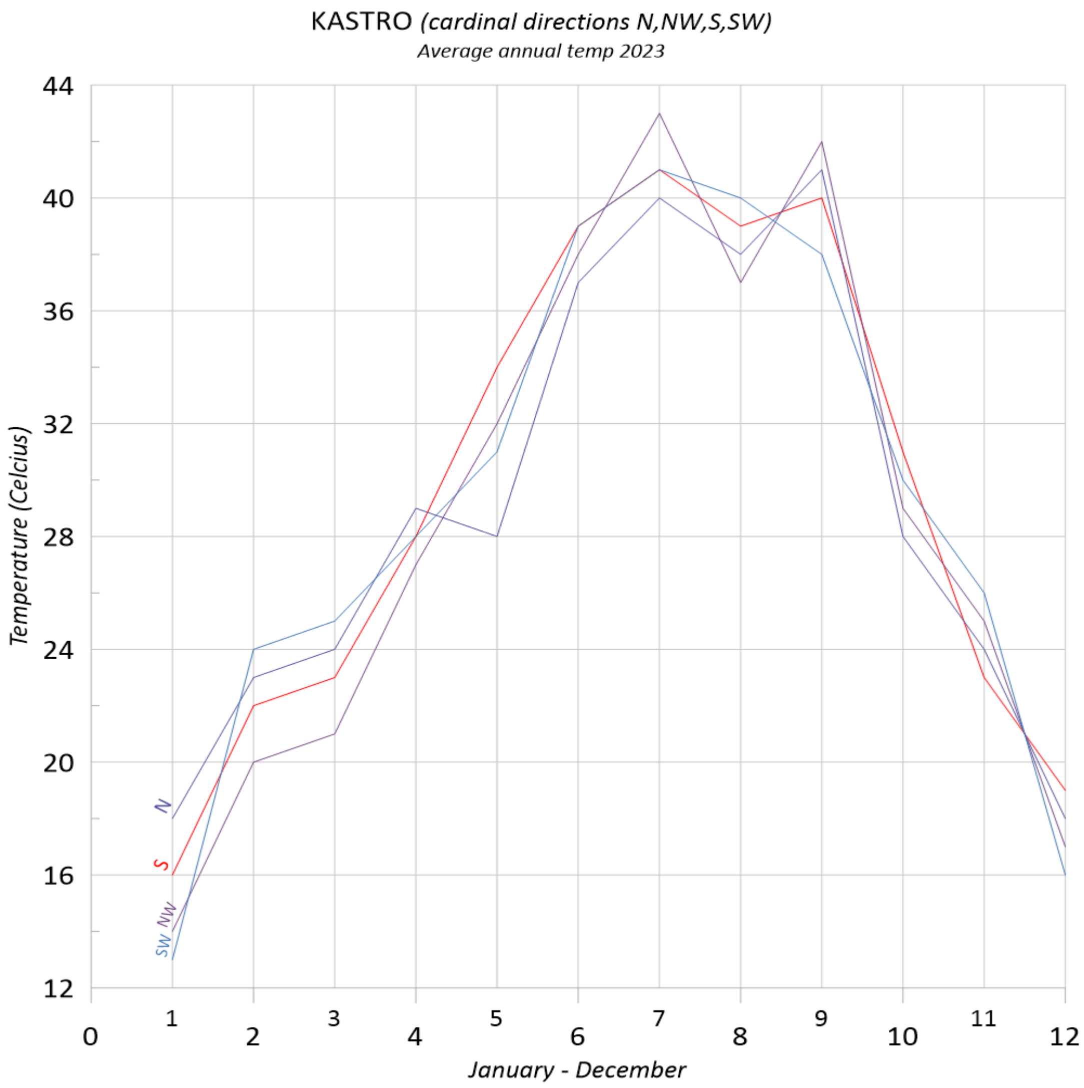

Fig 3: Kastro annual temperature from four cardinal points.

IV. LINKING CLIMATIC TEMPERATURE (C°) DATA TO DECIBELS (DB)

1) Conversion of temperature (Celsius) to absolute temperature, Kelvin (SI units), K = Celsius (°C) + 273.15.

2) Stefan-Boltzmann law calculates the radiant exitance (power emitted per unit area P/A (W/m^2) referred to as radiant intensity E = (W/m²), and states that the total energy radiated per unit surface area is proportional to the fourth power of the absolute temperature (Tk): E = σ x Tk^4, E = radiant intensity (W/m²), σ (sigma) is the Stefan-Boltzmann constant 5.67 x 10^-8 W/m ·K, T is the absolute temperature in Kelvin.

3) β = 10 x log10 (I/IO). β = Sound intensity (db) measures energy carried by sound waves, I = the intensity of radiation emitted (W/m^2), IO = (10^-12W/m²) reference sound intensity.

If you have a source emitting both light and sound, you can measure the radiant intensity of the light and the sound intensity separately. You can then use the sound intensity to calculate the amplitude level (in db). The sound intensity level relates the sound energy to the perceived loudness.

NW 2023	T Max (C°)	T Min (C°)	Kelvin (Max)	Kelvin (Min)	E (max) (...x10^ -6)	E (min) (...x10^ -6)	β(db) max	β(db) min	β(db) ave
March	22	10	295.15	283.15	16.74	16.05	72.24	72.06	72.15
Feb	18	12	291.16	285.15	16.5	16.16	72.18	72.08	72.13
March	21	9	294.15	282.15	16.68	15.99	72.22	72.04	72.13
Oct	27	15	300.15	288.15	17.01	16.33	72.31	72.13	72.22
March	19	8	292.15	401.9	16.56	15.94	72.19	72.03	72.11
Feb	17	7	290.15	280.15	16.5	15.88	72.18	72.01	72.1
Sept	32	18	305.15	291.15	17.3	16.5	72.38	72.18	72.28
March	20	11	293.15	284.15	16.62	16.33	72.21	72.13	72.17
Feb	16	3	289.15	276.15	16.39	15.65	72.15	71.95	72.05
Sept	32	18	305.15	291.15	17.3	16.5	72.38	72.18	72.28

Fig 4: Kastro (NW cardinal) temperatures collected randomly converted to db values.

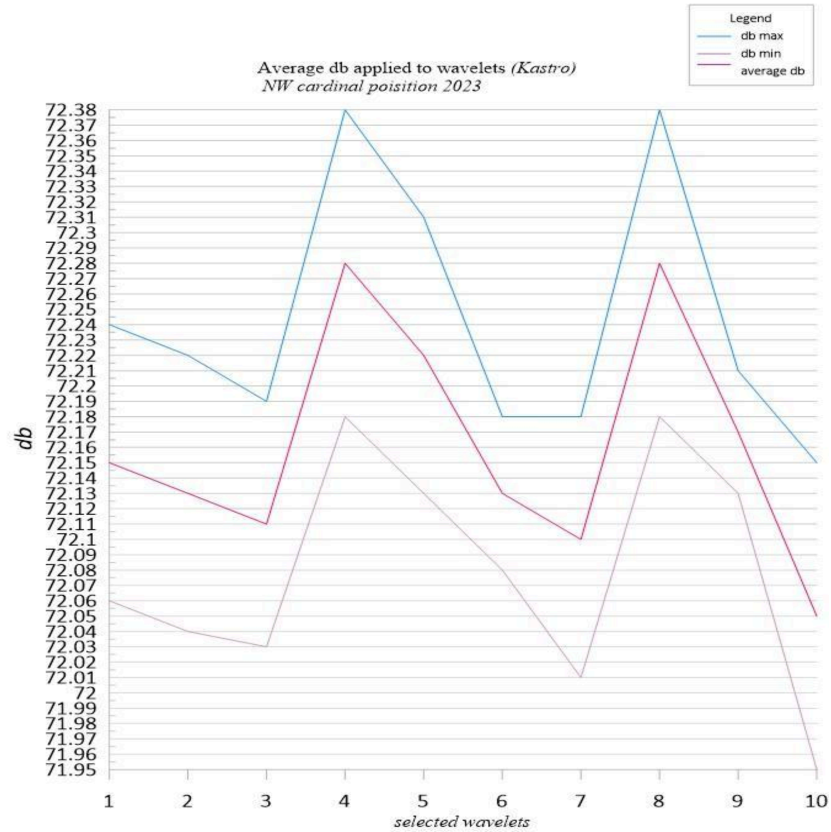

Fig 5: Average amplitude applied to wavelets

V. TEMPERATURE TO INCREASE OR DECREASE DECIBEL POSITIONING OF WAVELETS (SELECT ANY OF 6 DIFFERENT WAYS)

1. Calculate the average value of selected maximum and minimum temperature values, then plot β (db) average versus selected wavelets.
2. Select minimum temperature values from winter months captured (hourly from 11 pm to 6 am), then plot β (db) versus selected wavelets.
3. Select maximum temperature values from winter months captured (hourly from 8 am to 6 pm), then plot β (db) versus selected wavelets.
4. Select minimum temperature values from summer months captured (hourly from 10 pm to 6 am), then plot β (db) versus selected wavelets.
5. Select maximum temperature values from summer months captured (hourly from 6 am to 7 pm), then plot β (db) versus selected wavelets.
6. Select temperature maximum and minimum values, then plot β (db) set between the maximum and minimum (db) parameters versus selected wavelets.

Both selection processes (temperature and wavelets) are chosen by using random sampling.

VI. WIND SPEED TO AUDIO SAMPLE DURATION

Panagia tis Portas (referred to as Panagia) is a monastery of Pyli in Thessaly. The village is a 0.78km² area (780,000m²), having a side length of 883.18m. The wind travelling in the cardinal: south east location at (x) Km/hour is converted to mm/second; therefore, time (sound duration) in seconds = side length (mm)/wind speed (mm/sec).

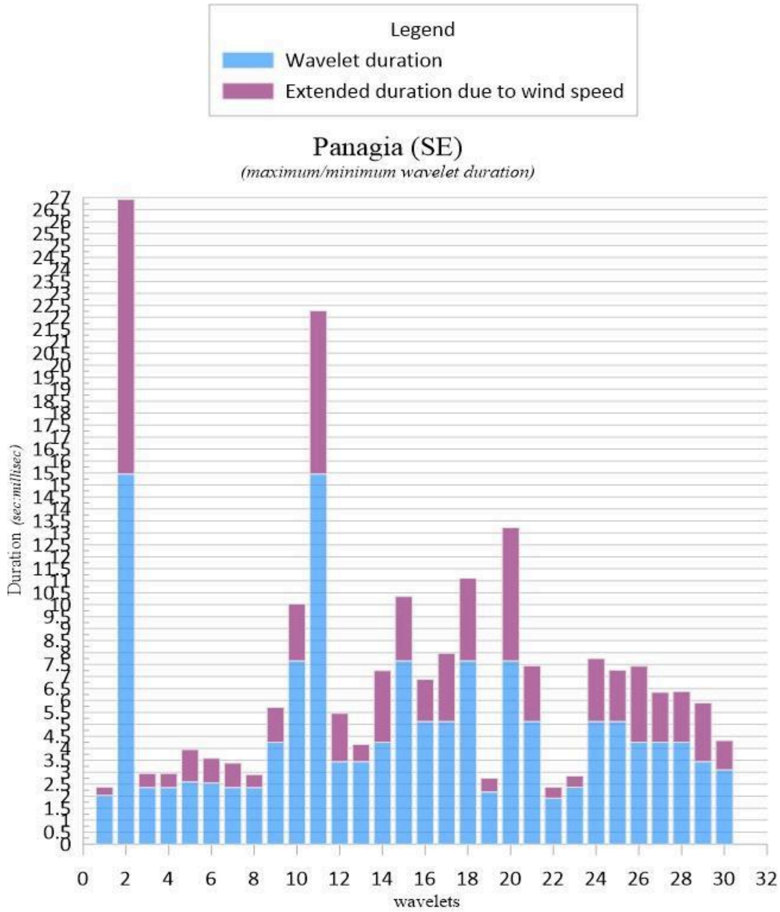

Fig 6: Maximum and minimum wind speeds (Km/h) captured every hour on a 24 hour cycle. Conversion to (mm/s), time = distance(mm/speed)(mm/s) determines the minimum/maximum audio sample duration applied to to extend duration of the score (indicated by purple marking).

The wavelet durations are chosen by random sampling.

Wavelets	Wind speed Min (Sec)	Wind speed Max (Sec)	Wind speed Min m/s	Wind speed Max m/s	Wind speed Min (Km/h)	Wind speed Max (Km/h)
1	2	2.3	441.59	384	1.59	1.38
2	15.5	26.8	56.98	32.95	0.205	0.12
3	2.4	2.9	368	304.54	1.325	1.1
4	2.3	2.89	384	305.6	1.382	1.1001
5	2.4	3	368	294.4	1.325	1.06
6	2.6	3.6	339.69	245.33	1.223	0.883
7	2.35	3.38	375.82	261.3	1.353	0.94
8	2.4	2.85	378	309.9	1.36	1.12
9	4.5	5.48	196.26	161.16	0.706	0.58
10	7.45	10	118.55	88.32	0.427	0.318

Fig 7: Ten wavelets: wind speed in km/h, min/s and seconds, captured as extended duration in fig 6 (excerpt).

VI. WIND SPEED DATA TO INCREASE EXTENDED DURATION (SEC) OF SELECTED WAVELETS (SELECT OF 6 DIFFERENT WAYS)

1. Calculate the average value of selected maximum and minimum wind speed values and plot average time versus selected wavelets.
2. Select minimum wind speed values from winter months captured (hourly from 11 pm to 6 am), plot time versus selected wavelets.
3. Select maximum wind speed values from winter months captured (hourly from 8 am to 6 pm), plot time versus selected wavelets.
4. Select minimum wind speed values from summer months captured (hourly from 10 pm to 6 am), plot time versus selected wavelets.
5. Select maximum wind speed values from summer months captured (hourly from 6 am to 7 pm), plot time versus selected wavelets.
6. Select wind speed maximum and minimum values and plot the time set between the maximum and minimum parameters versus selected wavelets. Both selection processes (temperature and wavelets) are chosen by using random sampling.

VII. MARKOV CHAIN TRANSITION PERIOD BETWEEN DIFFERENT STATES

Areas in the composition require extra assistance in selecting and placing wavelet sounds of a particular range of frequencies. Conceptually, several indecisive decision-making processes can arise. The computer offers extra assistance in selecting and placing, particularly in areas which may be questionable. Mathworks (Matlab) allowed for the programming of the non deterministic Markov chain and selective audio data analysis which offers the possibility of moving from one state to another depending on the current state and not on the sequence of events that preceded it, thus the state is allowed to change only at the discrete instants based on the probabilities associated with the transition matrix.

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	
X1	0	0	0	0	0	0	0	0	0	0	[0]
X2	0.4	0.3	0.1	0	0.2	0	0	0	0	0	[1]
X3	0	0	1	0	0	0	0	0	0	0	[1]
X4	0.76	0	0	0.2	0.04	0	0	0	0	0	[1]
X5	0	0	0	0	0	0	0	0	0	0	[0]
X6	0	0	0	0.9	0	0	0	0.1	0	0	[1]
X7	0	0	0	0	0.14	0	0	0.2	0	0.66	[1]
X8	0	0	0	0	0	0	0	0	0	0	[0]
X9	0	0	0	0	0	0	0	0.5	0	0.5	[1]
X10	0	0	0	0	0	0	0	0	0	0	[1]

Fig 8: *Markov Chain transition matrix*

X1	2932
X2	2807
X3	2944
X4	2767
X5	2911
X6	2967
X7	2879
X8	2539
X9	2771
X10	2678

Fig 9: *(X) with specific frequencies*

Files X(1-10) contain a selection of grains from either one or both acousmatic and synthetic sources both with similar frequencies per folder an organic transition occurs in the selection of X1-10., the probability values can be replaced by time (6 min 36 sec 17 ms to 7 min 19 sec 02 ms) in fig9 (graph 69b) to establish positioning of the audio grains.

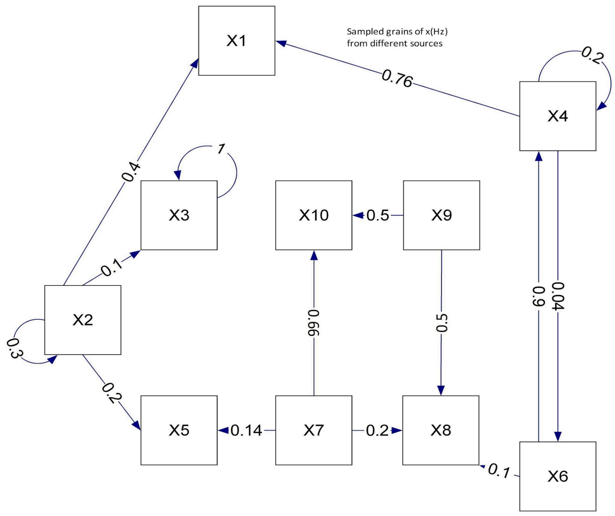

Fig 10: Markov chain graph 69b (Ag. Ioannis) evolution of (Xn) sampled grains envisioned as a direct connected network.

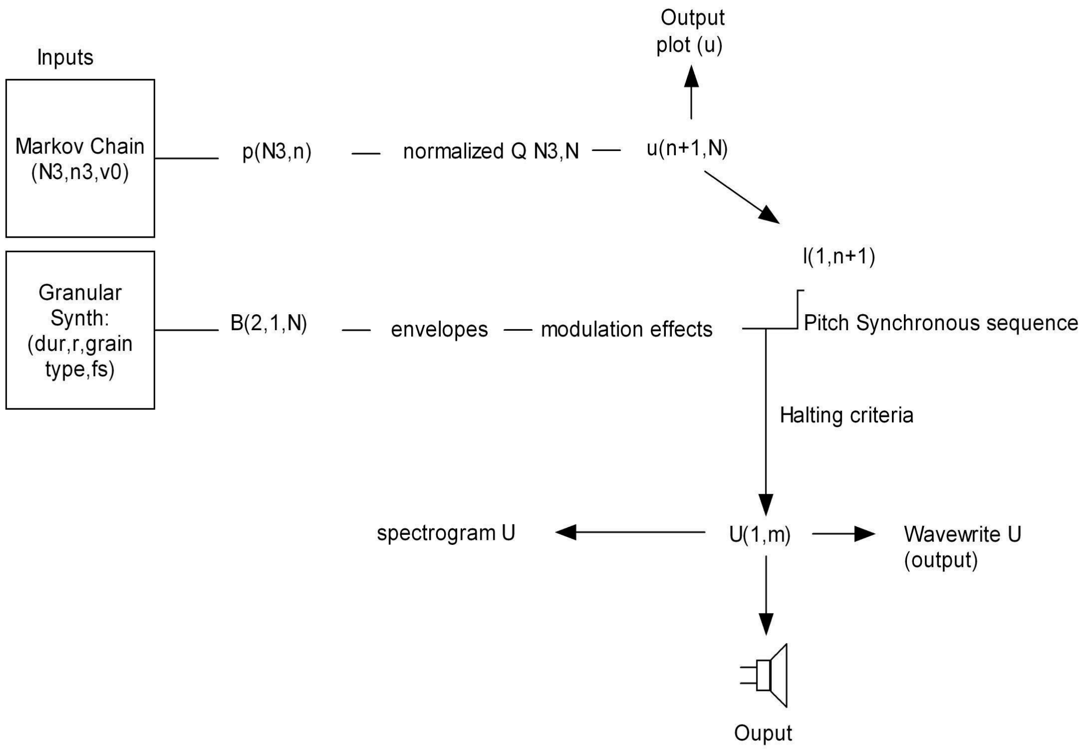

Fig 11: Markov Chain / Granular synthesis model (35f)

Moving from a current state to another, the process can be modelled by representing the system's discrete state (DCMC). Limitations such as a lack of memory, the "memoryless" property, produced two computing problems: failures in evaluating and decoding due to time constraints.

Random sample sampling

Limitations arising in the Markov process allowed for random sampling to take place within each group. Exhibiting memory from the total population gives each participant the same probability of being selected. The pseudo-random number generator determines systematic sampling, selects samples at fixed intervals and is a crucial tool in algorithms and techniques that detect or create clusters, particularly in sampling and simulation methods. Inherently deterministic, they will eventually repeat their output number and cannot eliminate this process. The use of pre-determined sequences, such as time frequency and sample positioning or placement, to achieve a desired effect.

One-stage cluster sampling within a selected frequency creates groups or clusters that represent the frequency, timbre, sound intensity and duration of the sampled population. If used sparingly, random selection of clusters and sampling occur within these selections. Cluster formations are mutually exclusive, so participants don't overlap between the groups. Two-stage cluster sampling randomly selects the cluster and then randomly selects the sampled participants from within that cluster. Stratified sampling splits a sample into predefined groups, or strata, based on differences between shared characteristics, e.g. shared characteristics of frequency, timbre, duration and amplitude.

Conducting cluster sampling

Sample: Decide the target wavelets and also the duration.

Create and evaluate sampling frames: Create a sampling frame by using either an existing framework or creating a new one. Evaluate frameworks based on coverage and clustering and make adjustments accordingly. These groups will be varied, considering the wavelet population, which can be exclusive and comprehensive. Members of a sample are selected individually.

Determine groups: Determine the number of groups by including the same average members in each group. So make sure each of these groups is distinct from one another.

Select clusters: Choose clusters by applying a random selection.

Create sub-types: It is bifurcated into two-stage and multi-stage subtypes based on the number of steps followed by researchers to form clusters.

Cluster sampling

Elements of a wavelet population are randomly selected to be a part of groups. Members from randomly selected clusters are a part of this sample. The composer maintains homogeneity between clusters, divides clusters naturally, the objective is to enhance competence.

Stratified sampling

The composer divides the entire population into even segments (strata), considers individual components of the strata randomly to be a part of sampling units, maintains homogeneity within the strata, and primarily decides the strata division. The key objective is to conduct accurate sampling, along with a properly represented wavelet population.

Multistage sampling

Considered an extended version of cluster sampling. In multistage sampling, you divide the population into clusters and select some clusters at the first stage. At each subsequent stage, you further divide up those selected clusters into smaller clusters, and repeat the process until you get to the last step. At the last step, you only select some members of each cluster for your sample. There is no need to have a sampling frame that lists every member of the population. That's why this method is useful for collecting data from large, dispersed populations.

Selections, location, timeline placements

The electronic sounds from each of the five climatic location data-position areas, which were extracted, are loosely generated by the localised dynamics of the composition, allowing for minimal deviations to occur and equally fair distribution of prepared (acousmatic) sounds to take place. The selected sample number, duration and position of the existing wavelets are noted and are chosen to fill positions in a pre-defined area(s). Random selection of the areas in the timeline is exposed to conscious decision-making. e.g. (Xn) preselected (wavelets).

The status position is the duration, and selecting the area for placement of the wavelet.

If the duration status of the position is greater than that of the wavelet, the computer instructs the neighbouring wavelets to move closer together until the new position duration is equal to the replacement wavelet's duration or splitting of the selected wavelet.

If the duration status of the position is less than the wavelet duration, the computer instructs the neighbouring wavelets to move further apart to accommodate the position of the incoming replacement wavelet or the splitting of the selected wavelet or the choice of choosing other wavelets from a different files until the desired wavelet equal to the duration space is found.

Random selection probability: No repetition of exact selection of wavelets is allowed within a particular location. Probability combinations and permutations of inserting silence, splitting, and rearranging wavelet/s, in their original location, are done in single or multiple ways.

Permutation with or without repetition: wavelets do not differ or differ in order of placement. Combination with or without repetition: each wavelet is selected once or more than once.

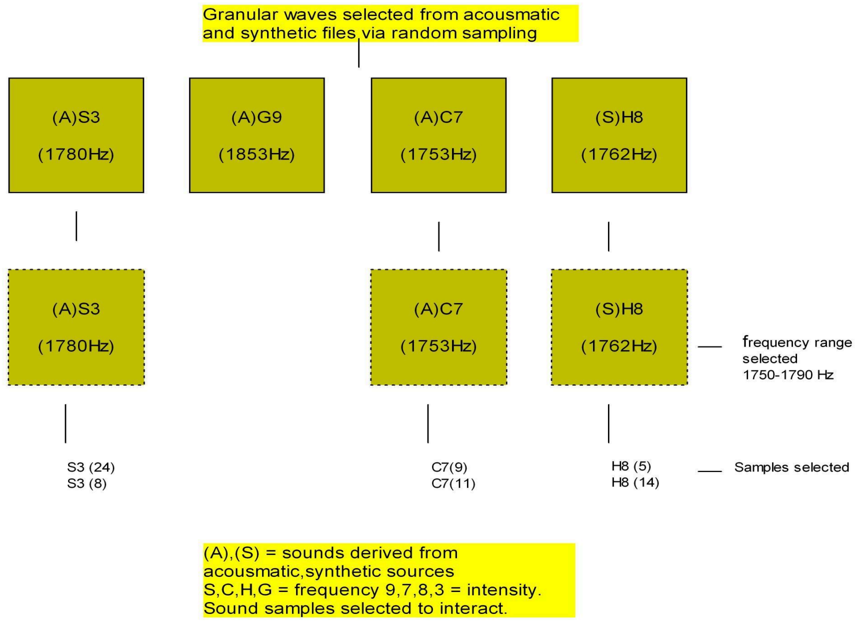

Fig 12: One-stage cluster sampling consisting of acousmatic and synthetic wavelets are categorised into group files with frequency, sound intensity (db) specifications. Random selection of wavelets from different files are either allowed to interact with other wavelets in combination used individually to explore new sound possibilities.

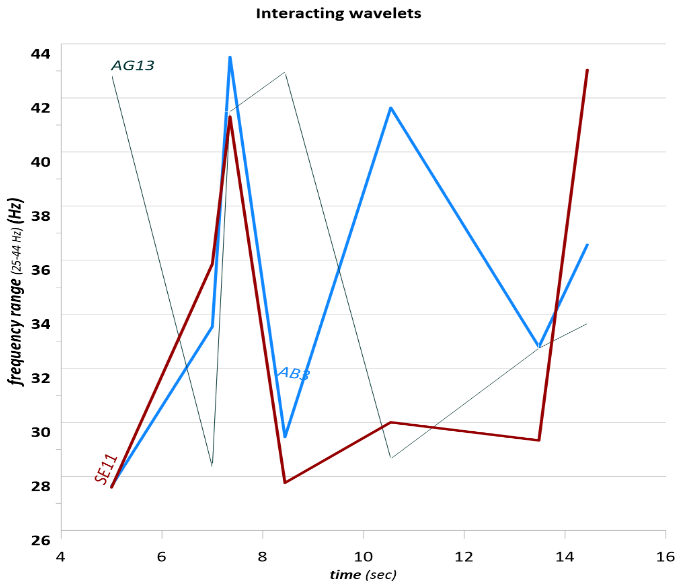

Fig 13: *Interacting wavelets from frequency and intensity folders.*

Overlapping curves of wavelets per unit time shown graphically e.g. SE11 and AB3 overlap at 28 (HZ) , 37 – 39 (HZ), 34.2 (HZ). Samples from both SE11 and AB3 extracted from overlapping frequencies above are combined and labelled in newly created frequency folders. The wavelets are introduced to further granular synthesis in order to develop further which can be used in transition bridging between parts.

VIII. CONCLUSION

Naming various processes or events gives us a sense of comfort, as we do not know how else to express ourselves as we face decisions that must be made without knowing the exact outcome. Arguing that happenings in nature are random and elusive avoids the fact that these processes are extremely complex. In microscopical quantum provides us with real randomness without conscious reasoning it is proposed that one cannot measure accurately both the position and momentum of a particle at the same time, thus terms intrinsic, deterministic and probabilistic all depend on how we solve the measurement problem.

In a macroscopic scale, we usually resort to randomness to model extremely complex phenomena where it is infeasible to have all the necessary information required to predict the observed result. Sound becomes an instruction tool training the ear to follow contour lines which create points of connections between elevations and depressions in topographic maps. Encapsulating the five site-specific locations individually, in a microenvironmental status, they will act by mimicking the communication paths seen in simplistic cellular specimens. Exchanging, disregarding and adopting information from multiple paths, in this project we focused on three of those paths: elevation and climate. In the macroenvironmental status, collectively, they represent the topographic terrain of Eolia, creating strong, tectonic sensations before semantic judgements are passed, for sound is an "energetic" and "spatial" phenomenon, seeking to immerse the listener in the underlying dynamics and motion of natural phenomena in abstraction.

Fractured moments depend on the data obtained, which rely on mathematical, scientific and deterministic complexities of chaotic systems, not to mention those in the underlying areas that remain hidden as we move in a linear timescale. The dynamic and kinetic solutions to this phenomenon, as sound is generated through matrices of its ideological limitations, actions, energy, and mental processes, borrow enlightenment from biological environments, reflecting on the physical reality created, sustaining our obscurity. As everything around us is formed of grains and photonic radiance ruled by stochastic or deterministic rules, EOLIAKI OPSI proposes a small reflection of it, but symbolically and abstractly.

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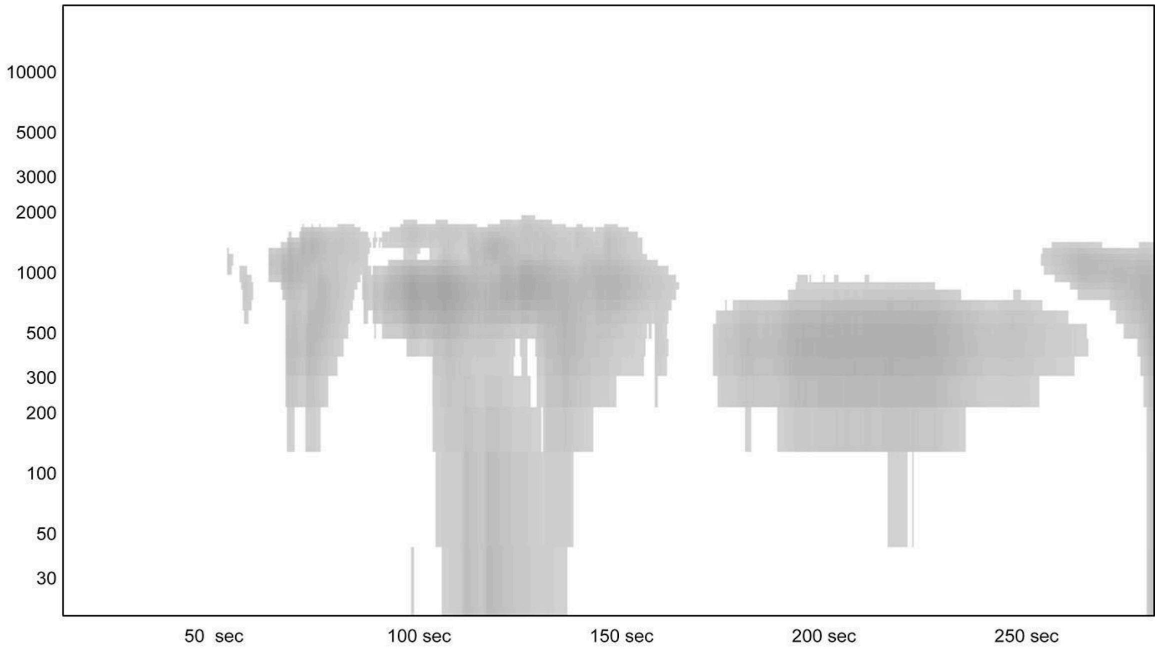
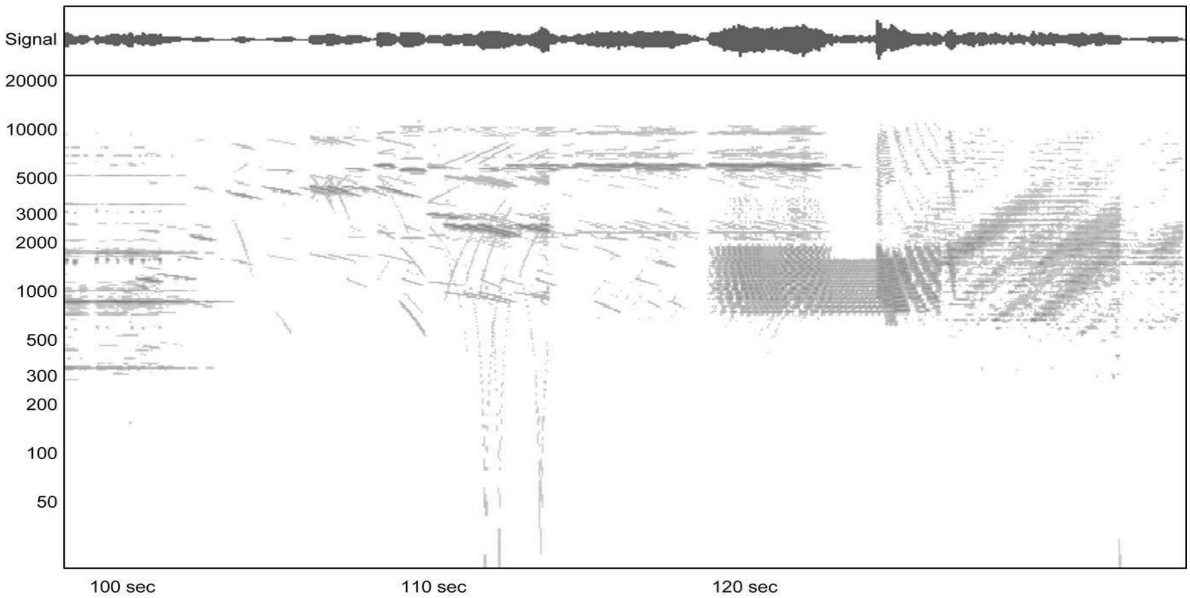
APPENDIX

Spectrograms



Ag. IOANNIS 1



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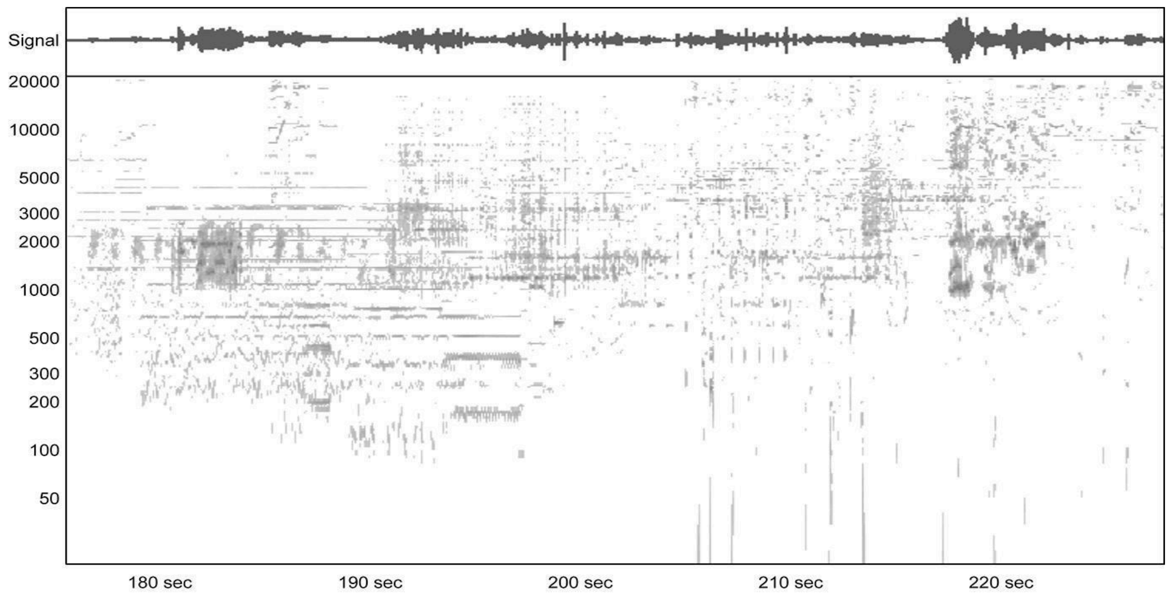

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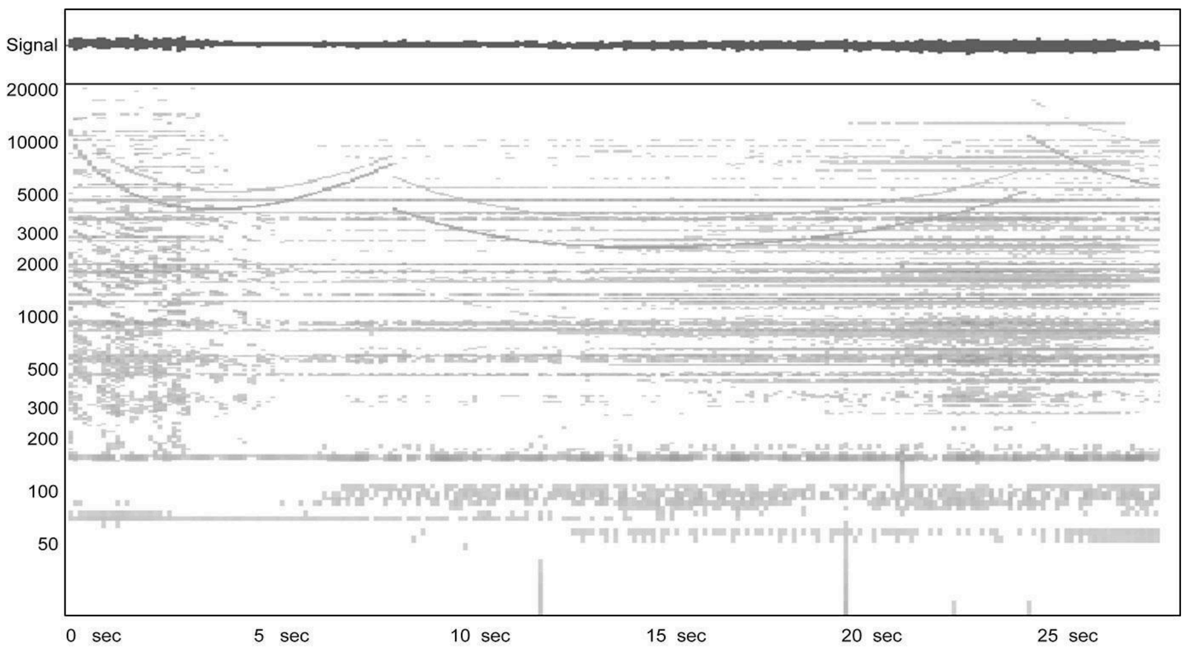

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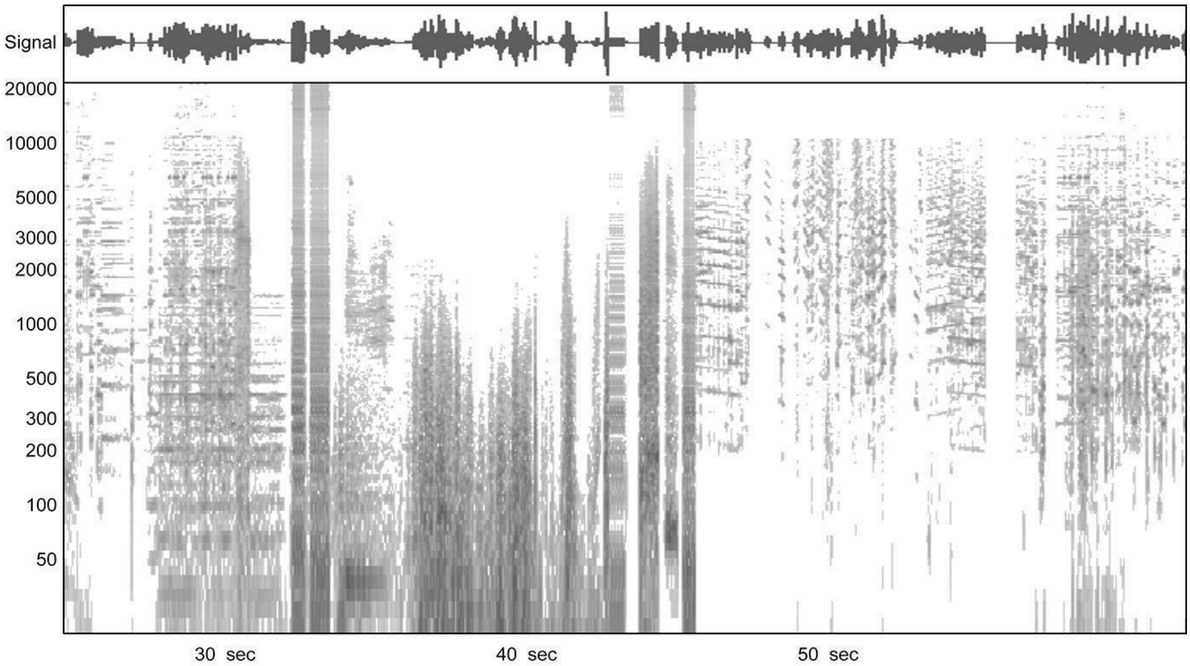
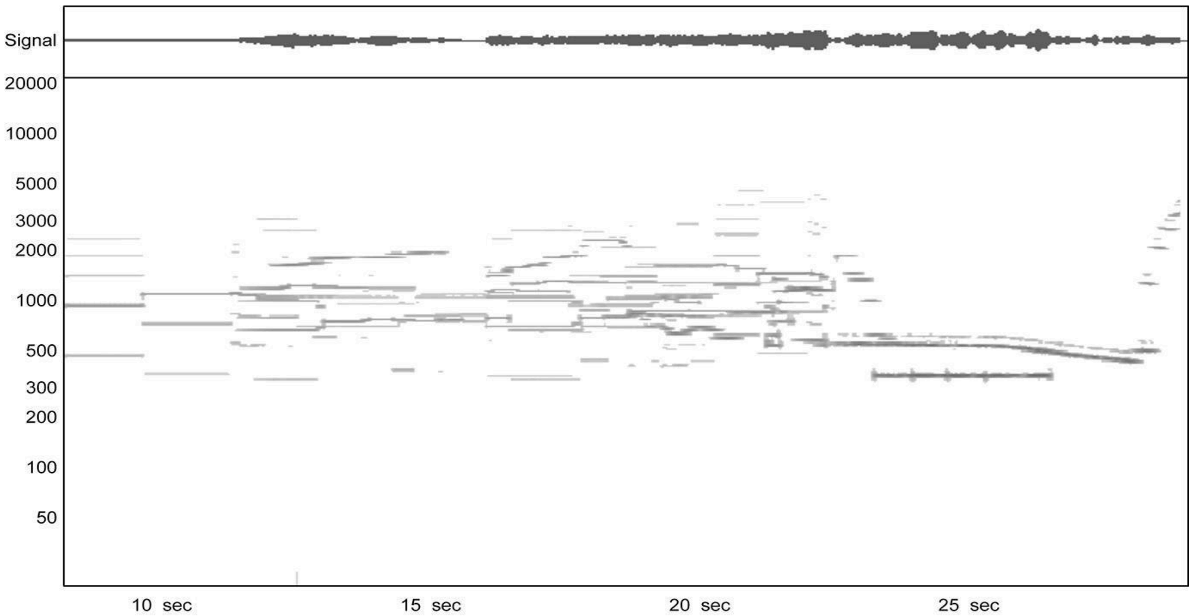


PANAGIA 1



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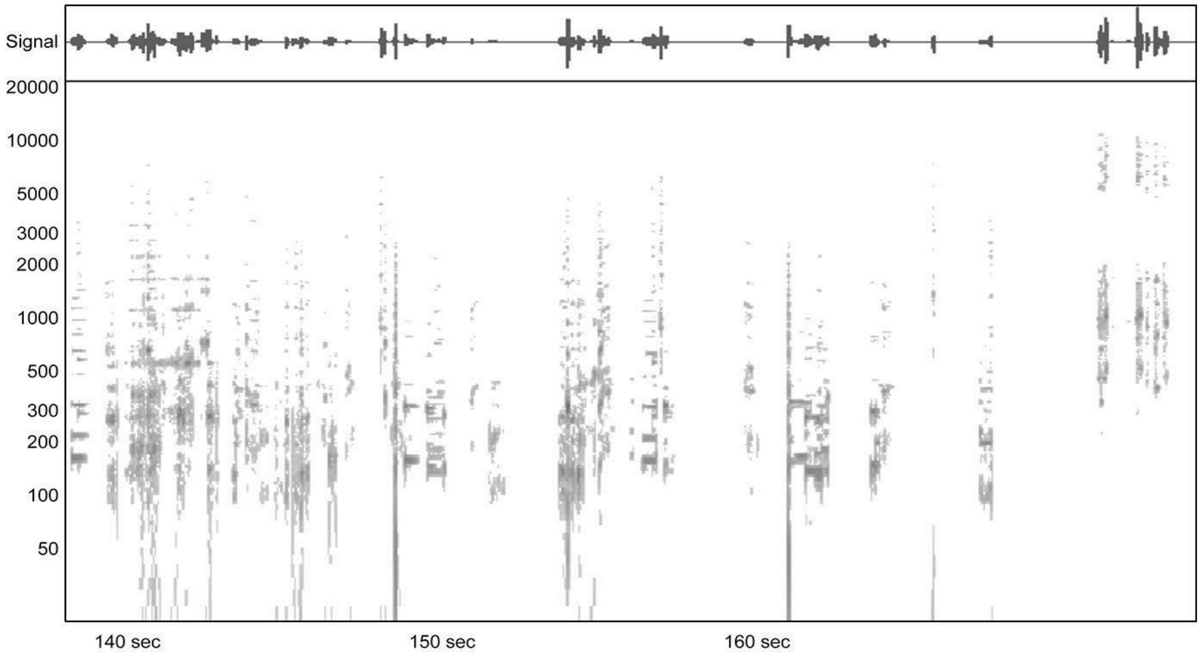

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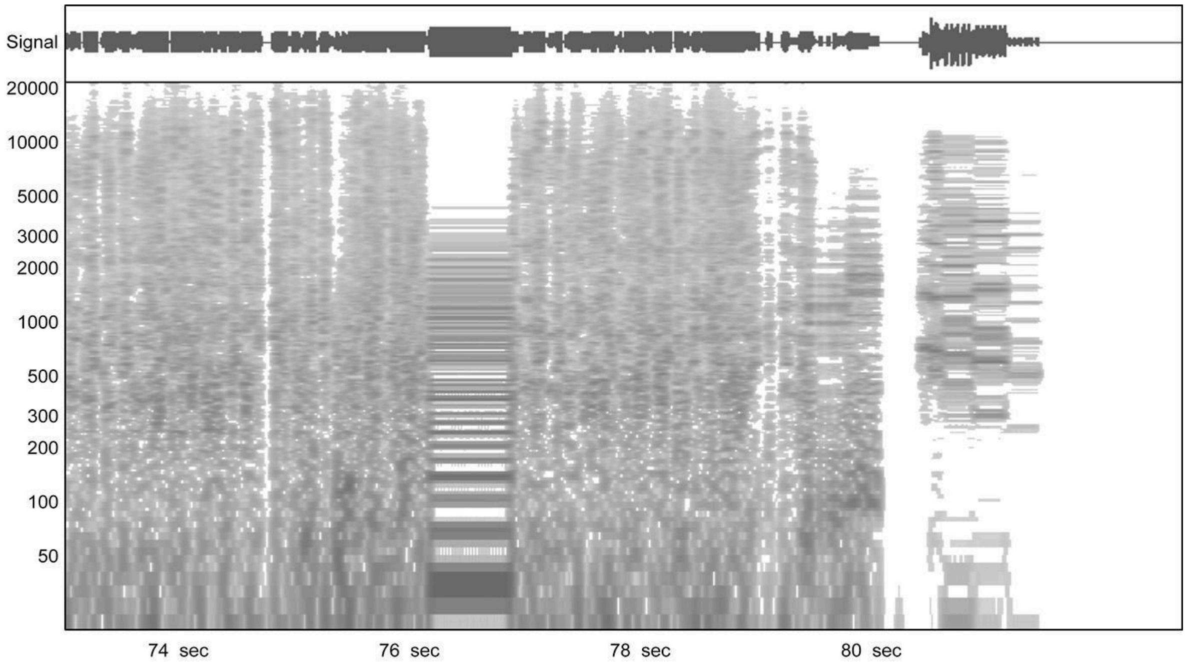

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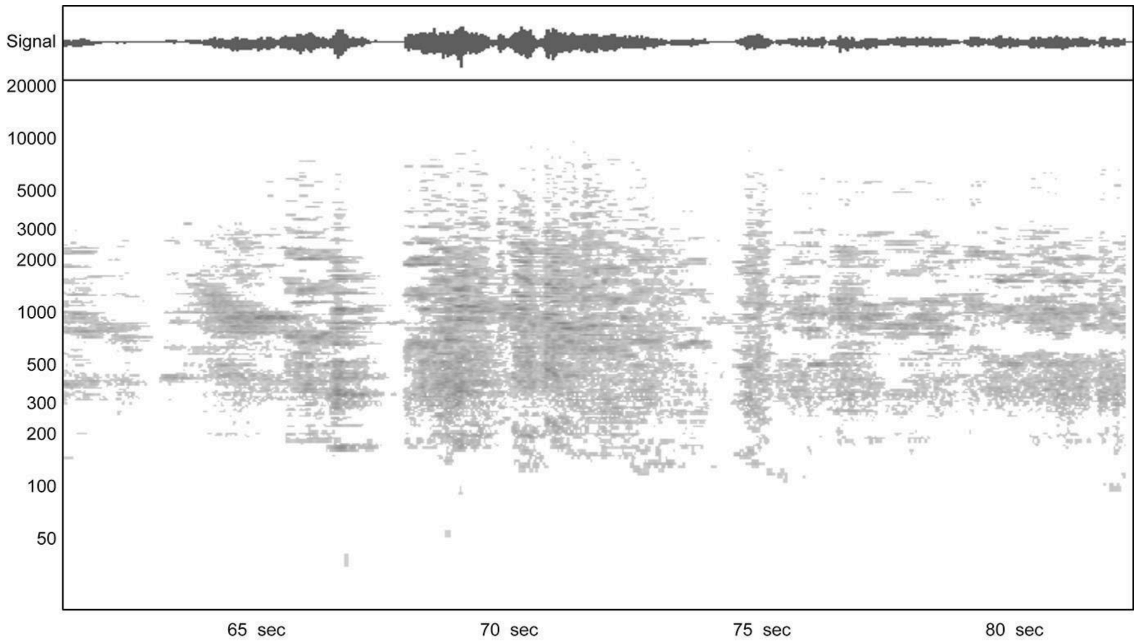
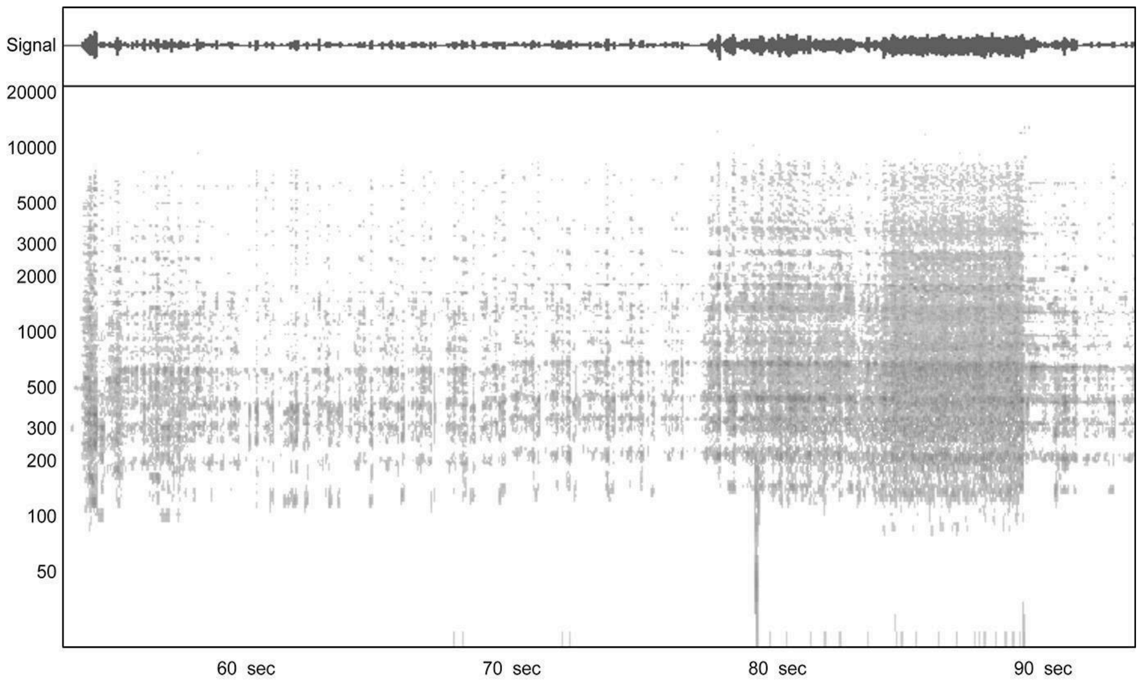


KASTRO 1



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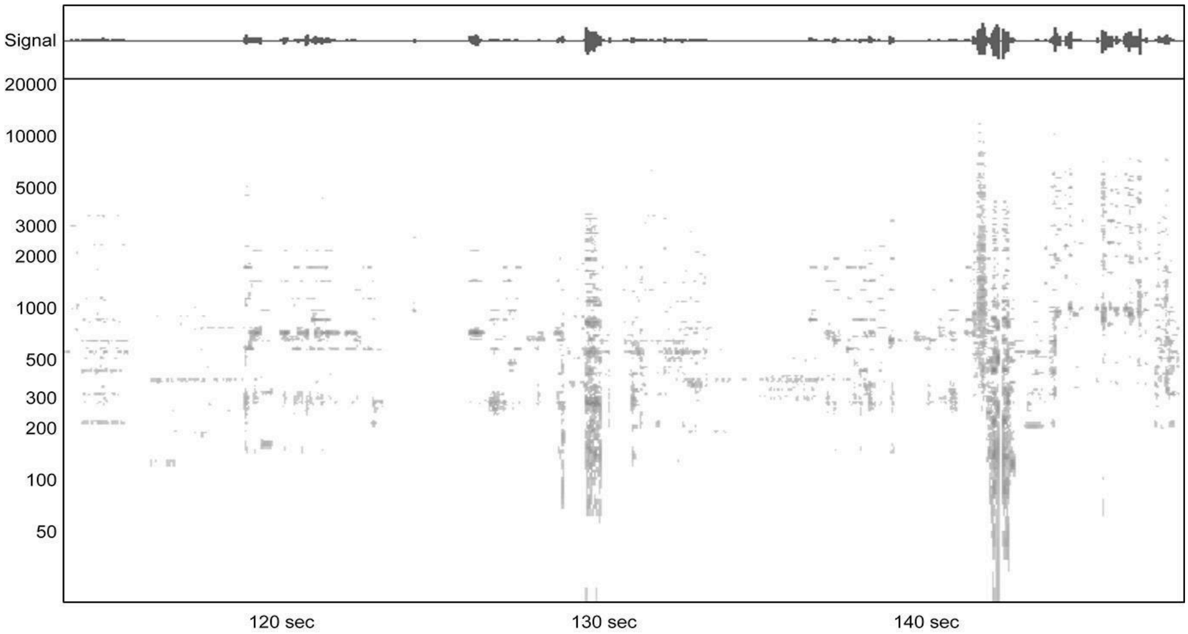

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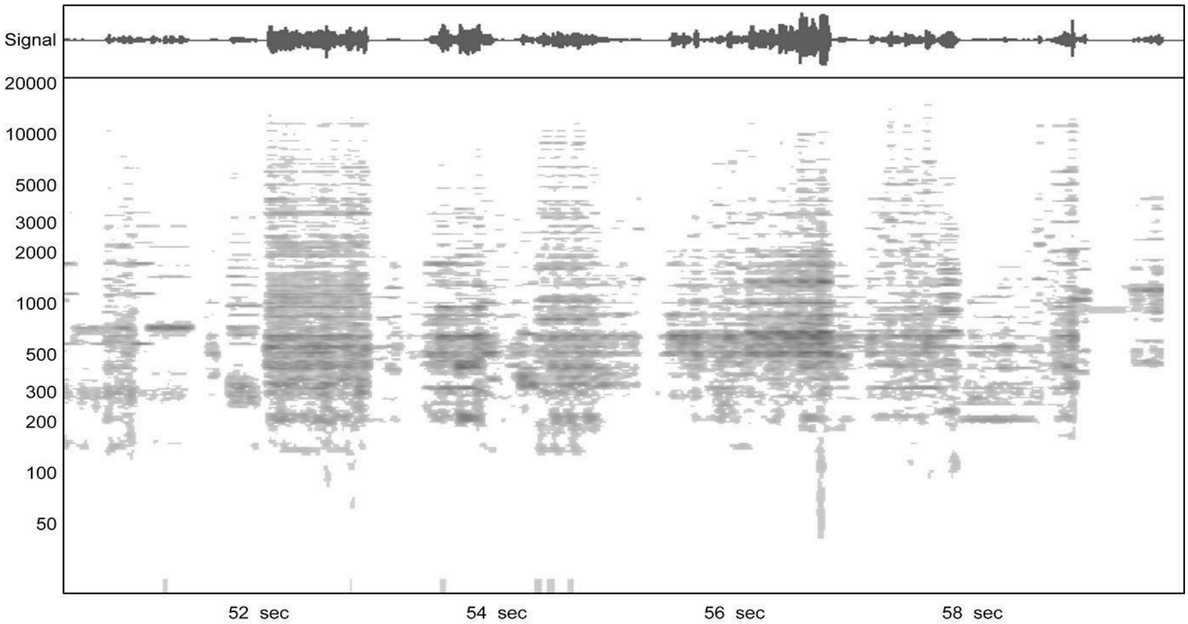

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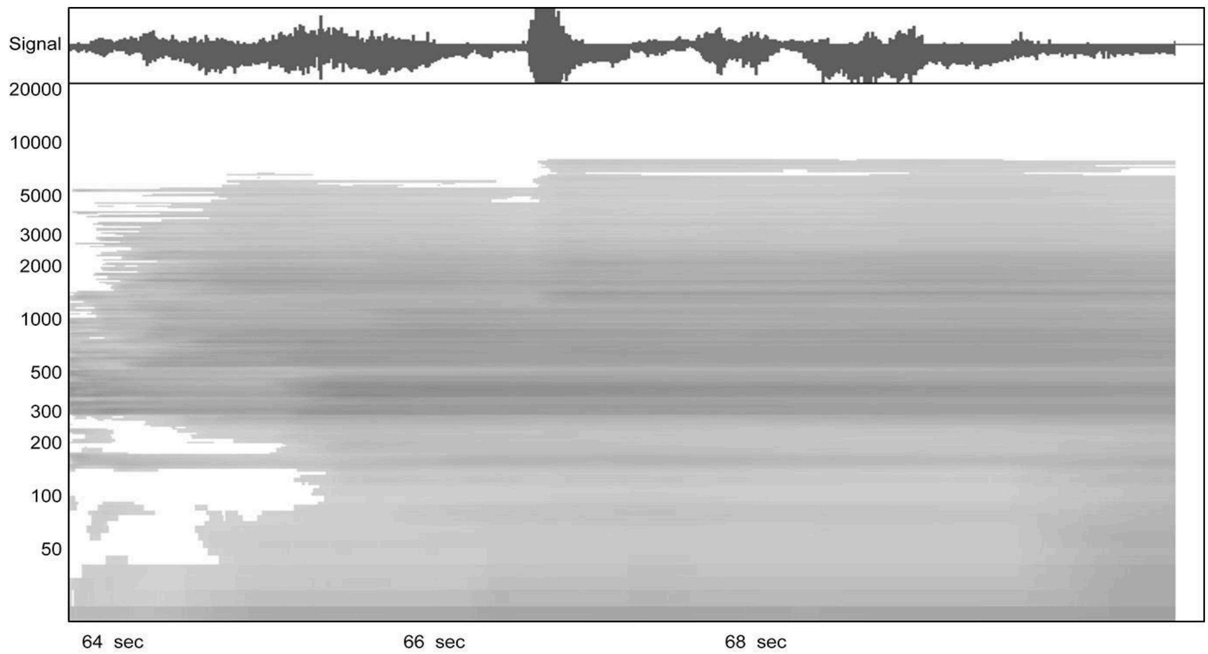

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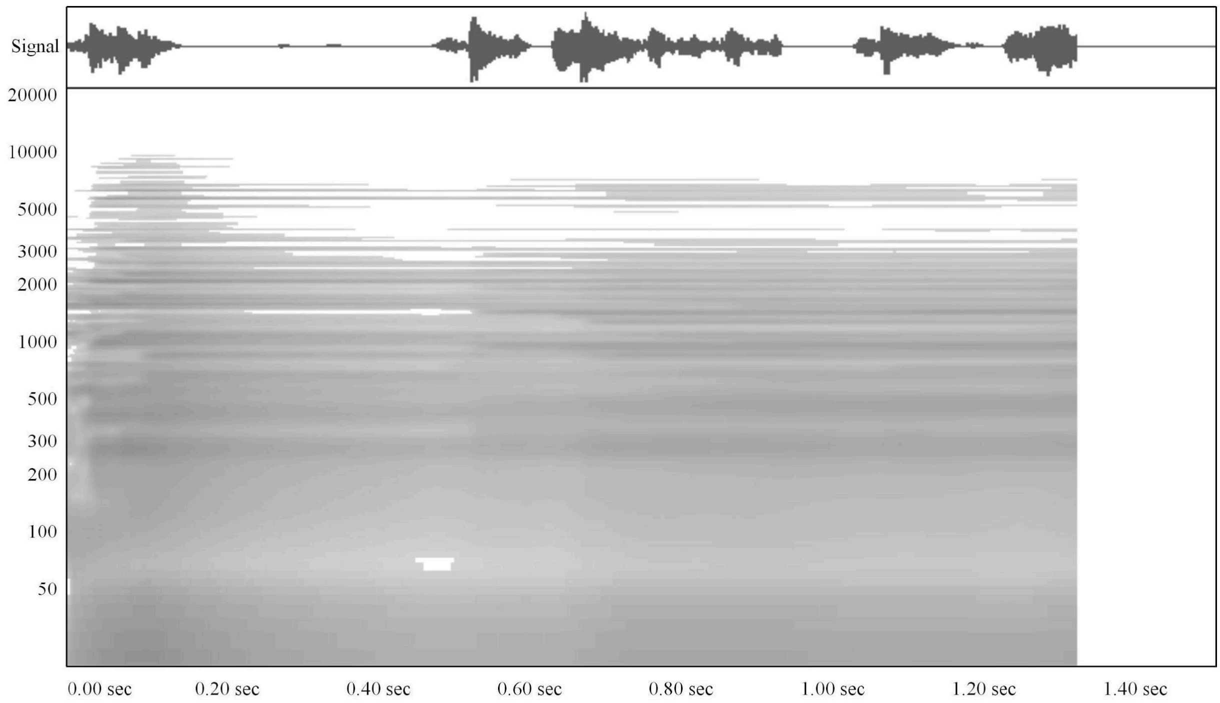
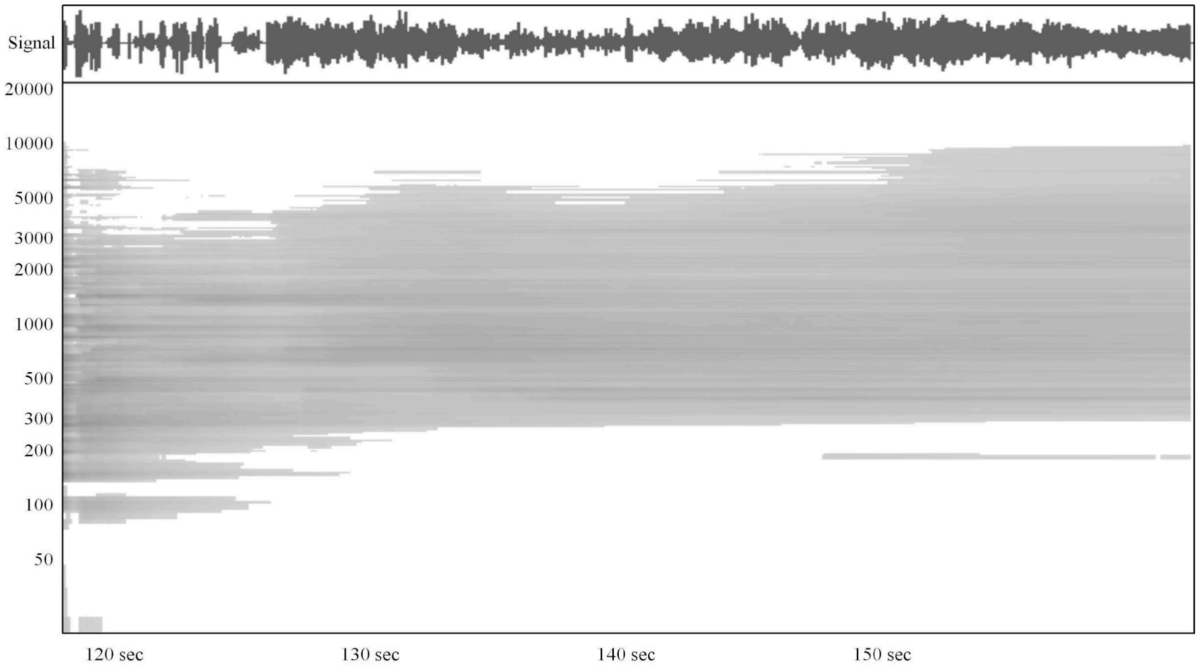


PRODROMOS 1



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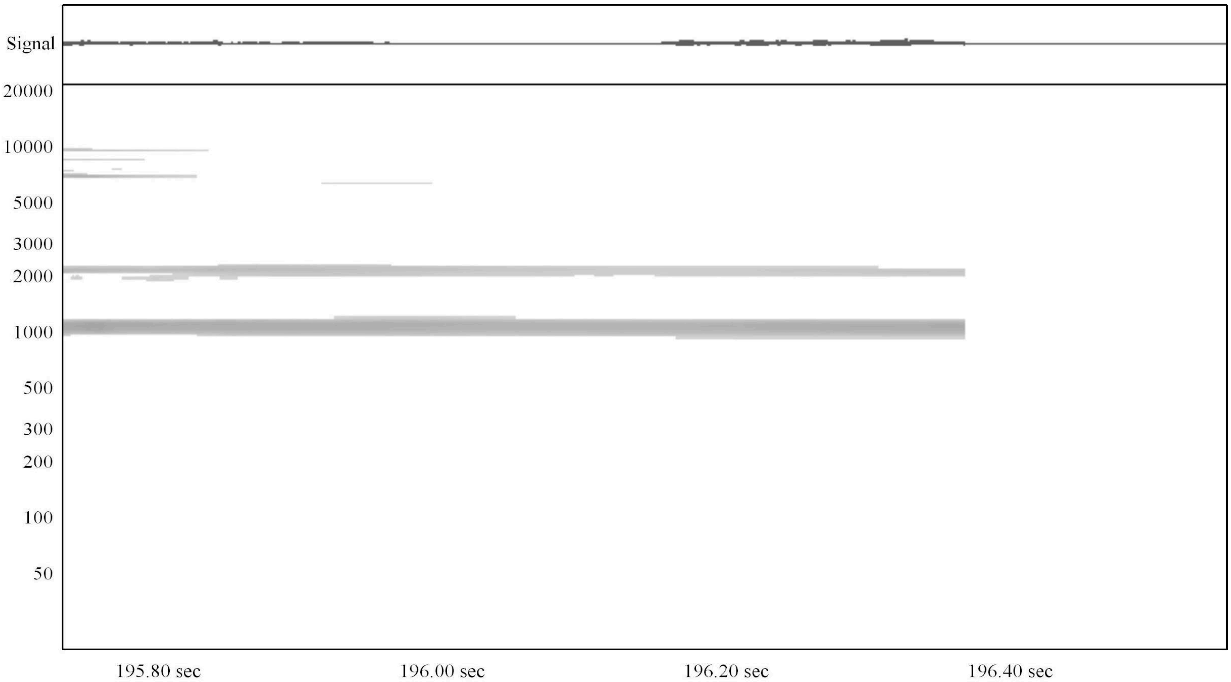

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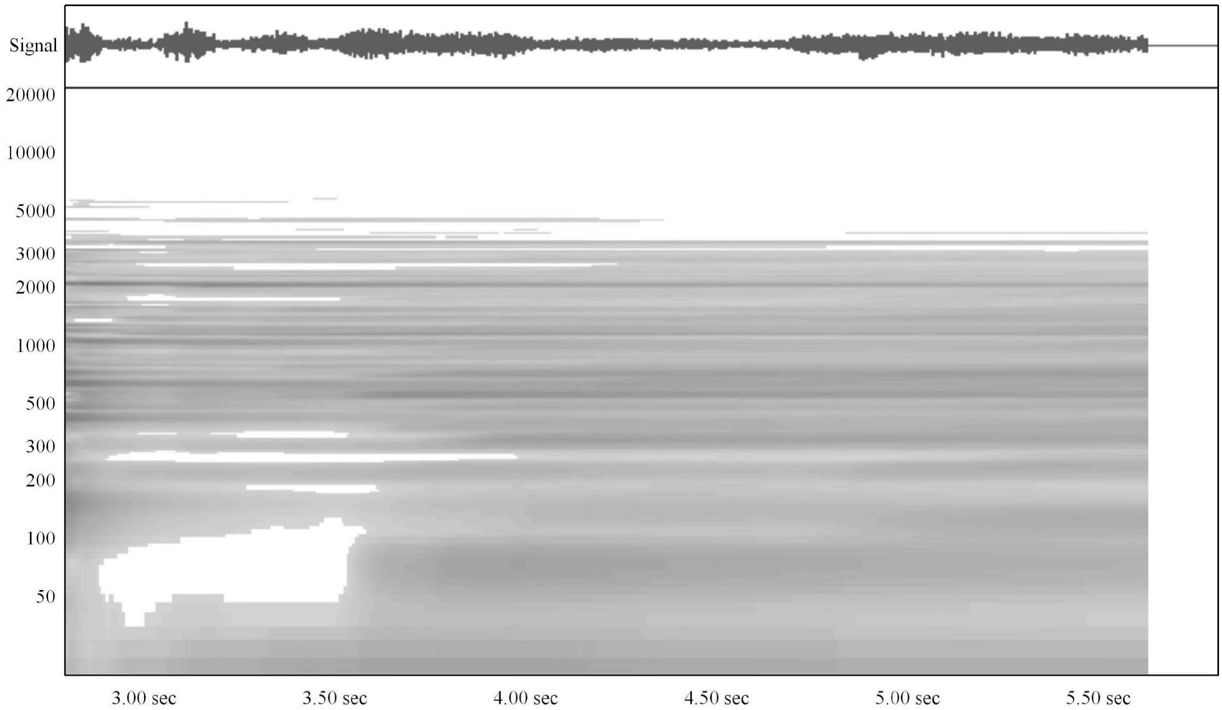

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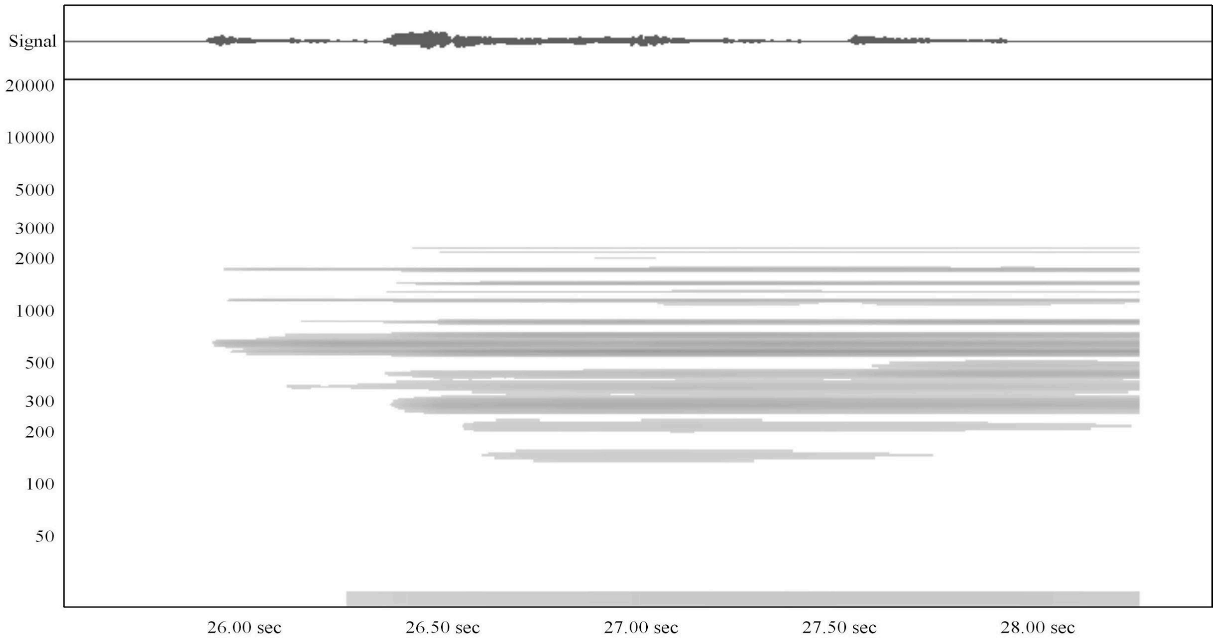
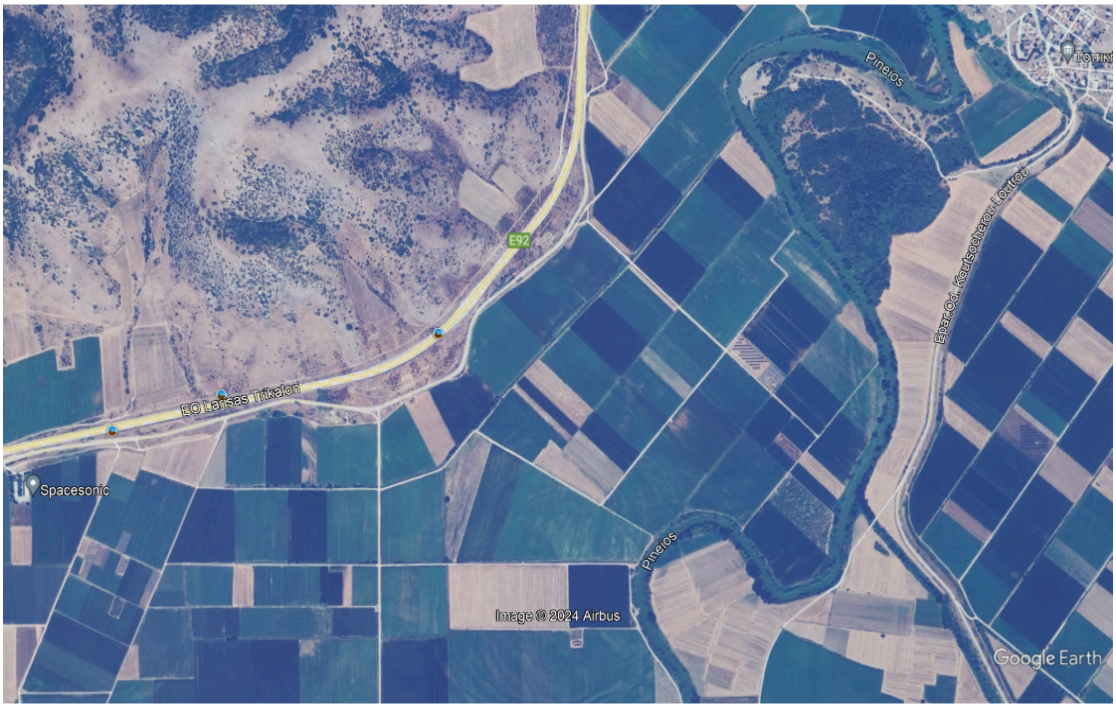


FARSALA 1

TOPOGRAPHIC IMAGES:



KASTRO (35P)

PANAGIA (25c)

PRODROMOS (15f)

Ag.IOANNIS (7q)


EO Lamias Larisas
Kaoil
Aigli
3
Lidl
30
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FARSALA (13i)