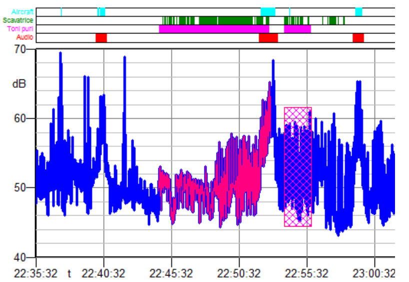
The use of markers in environmental noise measurements



Technical note

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Premise

The increasingly widespread use of environmental noise monitoring techniques, extended over long periods of time, makes it necessary to find suitable solutions to be able to quickly perform and manage specific post-process operations on the acquired measurements.

Operations such as: recognizing, identifying, highlighting, evaluating, comparing, dividing or masking a sound event, a tonal component, the noisiest hours or days, may require analysis times from the operator that are difficult to sustain.

This technical note presents the new marker management introduced in the 'NoiseWorks' software with the aim of helping the operator to search for and highlight all the possible situations of particular interest or criticality, contained in the various types of long-term measurement.

Markers as a graphical annotation tool

Historically, the use of markers was born when it became possible to store the historical profile of the sound level over time in the sound level meter; as a period, we can go back to the mid-90s; the first use was to directly annotate on the historical profile, the event of a particular sound situation that one wanted to highlight. This logically presupposed that it was the operator who decided when to activate a marker and what type of marker; precisely for the reason that the activation of the marker was left to the discretion and readiness of the operator, the trigger function for the activation of the marker was subsequently introduced in order to be able to mark even a period of a few seconds prior to manual activation in order to highlight the entire event.

Subsequently, the information from the markers, stored in the sound level meter, was imported and used in the post-processing software with the aim of not only showing with clear graphical methods all the events marked in the field by the operator, but also of grouping durations and sound levels belonging to the different markers to indicate their relative sound contributions in dB on the global level of the entire measurement period.

Today the function of markers has further evolved and has become an essential tool in the process of reading and analyzing data from unattended monitoring stations. In the post-analysis phase of this type of measurement, Markers are now used to highlight on the time histories, all those situations that require particular attention starting from the automatically identified sound events, the duration of pure tones, any masked measurement periods, periods affected by rain or wind above 5 m/s, audio recordings, or even to highlight any other particularity found by the operator in the a posteriori analysis of the measurement results.

Markers for sound events

The first use of markers was to store in the field, on the sound level meter, the event of a particularly significant acoustic phenomenon, which was to be kept evident even during the subsequent re-examination in the laboratory. This category includes numerous sound events associated with means of transport: airplanes, trains, cars, buses and articulated lorries; recognising the contribution of each of these categories often requires a separate assessment in the context of the global climate of the measured environmental noise. If the contributions of the noise emitted by airplanes flying over and by the transit of trains coming from a nearby railway line concur in a measurement location, it will be necessary to identify all the events associated with the various sources and then group them into categories and establish their specific contributions to reaching the global value detected in the measurement.

In supervised measurements, the task of identifying the events associated with the different sources is up to the operator who, using the Markers function, presses a button on the sound level meter for a few moments, which allows to memorize at the same moments of the measurement also a classification code of the category of the event. This operation allows, during a subsequent examination of the measurement, to identify, separate and add together all the contributions of the sound events belonging to the different categories of the sound sources coded in the field with the markers.

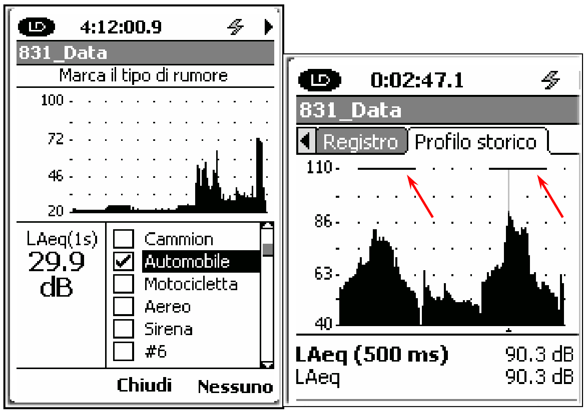


Fig.1- Using Markers in the LD-831 Sound Level Meter.

Fig.1 shows the marker management available in the Larson Davis LD-831 sound level meter and at the top of the time profile graph you can see the stripe indicating the activation of one of the 10 available markers; the operator can associate in advance with each of the markers the name of one of the categories of sources that he/she is expected to signal during the measurement.

Usually in the most recent sound level meters, by activating a Marker an audio recording can be started so that the type of sound event can be confirmed later by simply listening again.

For each trace left on the time history in relation to the activation of a Marker, there is also a corresponding signal reported in the numerical tables as shown in Fig.2 where the initial instant of the 'Plane' marker can be observed, and a short distance away from the 'Train' marker which then proceed, indicating the simultaneous presence of the two sound events.

	Tempo (virtuale)	Marker (EU)	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz
6	04/11/2008 18:56:43.600		44.8	42.9	43.3	39.7	47.7
7	04/11/2008 18:56:43.700		43.0	41.8	42.1	42.1	48.8
8	04/11/2008 18:56:43.800		41.7	41.7	40.7	40.0	49.0
9	04/11/2008 18:56:43.900		42.1	43.4	39.3	38.7	48.8
10	04/11/2008 18:56:43		40.2	43.5	37.7	44.0	48.9
11	04/11/2008 18:56:44.100		44.2	46.3	40.0	42.0	49.3
12	04/11/2008 18:56:44.200	Aereo	47.9	46.2	40.3	41.2	48.6
13	04/11/2008 18:56:44.300	Aereo	48.8	44.0	39.2	39.6	48.0
14	04/11/2008 18:56:44.400	Aereo	46.9	40.9	36.8	37.6	47.4
15	04/11/2008 18:56:44.500	Aereo	43.9	43.0	36.8	39.3	47.1
16	04/11/2008 18:56:44.600	Aereo	43.4	46.5	37.2	39.1	48.1
17	04/11/2008 18:56:44.700	Aereo	43.0	44.9	37.6	40.2	48.9
18	04/11/2008 18:56:44.800	treno ,Aereo	42.1	45.1	38.5	39.8	49.0
19	04/11/2008 18:56:44.900	treno ,Aereo	41.7	45.5	37.5	39.0	47.9
20	04/11/2008 18:56:44	treno ,Aereo	45.2	44.6	36.5	40.2	47.9
21	04/11/2008 18:56:45.100	treno ,Aereo	44.9	45.4	35.9	40.4	47.4
22	04/11/2008 18:56:45.200	treno ,Aereo	42.4	46.6	41.4	38.2	45.3
23	04/11/2008 18:56:45.300	treno ,Aereo	39.6	46.7	43.6	36.4	43.6
24	04/11/2008 18:56:45.400	treno ,Aereo	40.5	46.1	42.6	37.1	45.2
25	04/11/2008 18:56:45.500	treno ,Aereo	44.9	45.1	43.3	42.2	45.7

Fig.2- ‘Plane’ and ‘Train’ markers in the numeric table.

The recognition and marking function of a sound event can now be carried out automatically in real time, by the same sound level meter, during the measurement or even with the post-processing software in the post-analysis phase in the laboratory.

With the new sound level meters, it is therefore possible to automatically identify and mark sound events, without the need for the presence of the operator in the field, which was necessary for the manual activation of the Markers, and which could also introduce decisions conditioned by many environmental and subjective parameters.

A typical situation of automatic recognition and marking is the one represented in Fig.3, relating to the environmental noise detected in the vicinity of an airport and therefore characterized by a continuous sequence of sound events from aircraft overflights; the event recognition function has been associated with a marker that traces a red stripe, on the X-axis of the time history graph, for the entire duration of each single event.

The marker trace allows both during the measurement and at each subsequent examination, to have an immediate view of each sound event recognized and therefore marked as an aircraft overflight. At the same time as the marker is activated, the most advanced sound level meters also store all the values associated with the individual events such as LAeq, LAE, LAmax, duration of the event, date and time of the event; to complete the information, the audio recording is also increasingly stored, to allow for possible re-listening in the verification of doubtful cases.

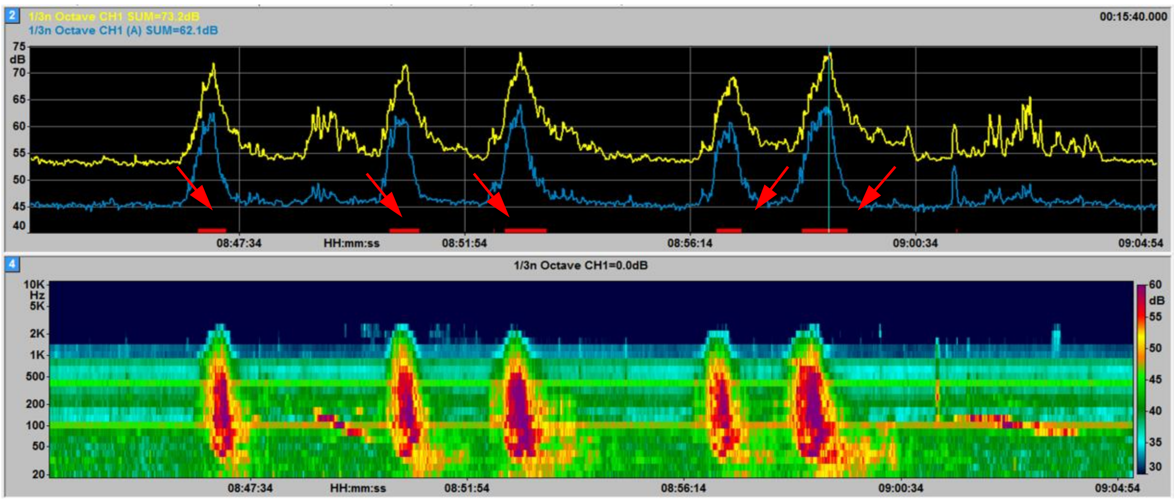


Fig.3- Automatic identification of overflights by tracking the 'Aircraft' marker. (in red)

The soubd level meters equipped with a 1/3 octave analysis system can also acquire the relative time histories in frequency and allow a graphic integration with color sonograms, similar to the one shown in Fig.3 below the time history of the global sound levels. In this way, maintaining the same scale over time and using a chromatic scale, the distribution of the sound energy on the various 1/3 octave bands can be highlighted. For each profile of the sound level associated with an aircraft overflight, we can thus visually verify on the sonogram whether, at the same instants, the event also shows a recognizable spectral imprint.

Marker Handling in NWW3 Software

The widespread use of markers in various types of phonometric instruments has made it necessary to include adequate support in the post-processing software 'NoiseWorks'.

Always taking as an example the Markers used to signal the sound events attributable to aircraft overflights, when we go to 'NWWin3' to view the time histories corresponding to these measurements, we will automatically be able to also report the traces of their Markers.

The position of the marker activation tracks can be chosen either at the bottom along the X-axis of the time history graph or above it; in Fig.4, in addition to the indication of the 'Air' Marker stripes, the corresponding evidence on the time history track is also shown, obtained by applying a background of the same colour used by the marker.

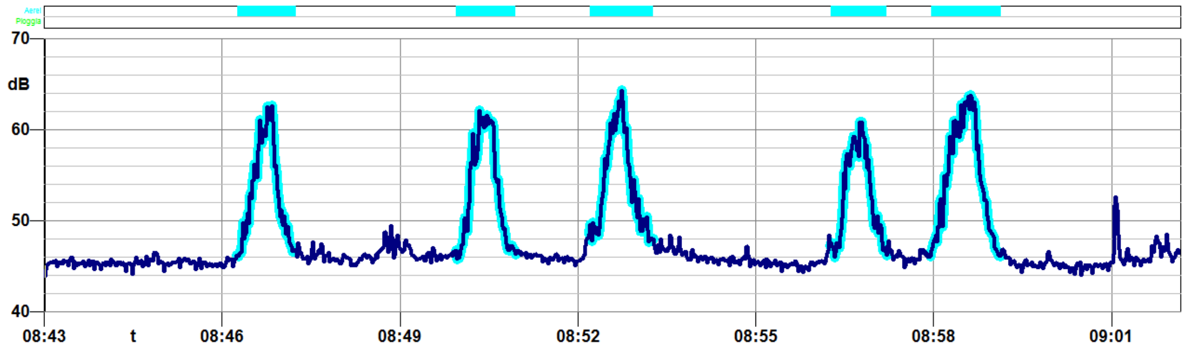


Fig.4- ‘Aircraft’ marker represented in the NWWin3 software time history.

We have seen how the basic function of the Markers is to highlight and group into categories the different types of sound events and consequently we can now consider the importance of specific easy-to-perform functions for the evaluation of all the parameters associated with both single events and groups of events as well as establishing their contribution to the overall value detected over the entire measurement period.

The NWWin3 software allows you to perform various types of functions on the imported measurements, complete with 'Markers', starting from the recalculation of the 'LAeq running' or a continuous integration over time, of the individual samples of short LAeq(t) represented in the time history and which will form at the end of the measurement, the global LAeq value equal to 52.1 dB(A), reported with the red trace in the graph in Fig 5.

All the events identified with the Markers can also be easily masked and it is possible to graphically report on the time history, each masked period to make it clear as always shown in Fig.5.

On the time history with the masks associated with the events identified by the Markers, the new ‘LAeq running’ can now be recalculated corresponding to the value of the original measurement reduced by the sound energy contribution of the events and equal to 47.1 dB(A) as shown by the orange trace.

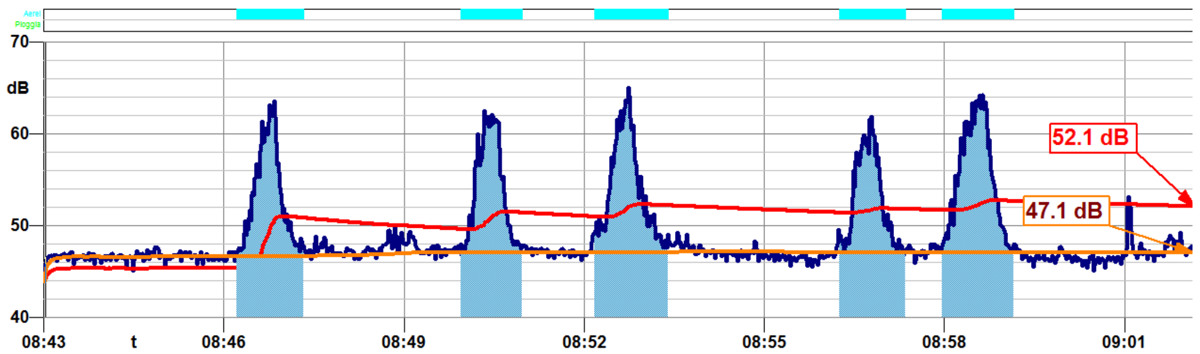


Fig.5- NWWin3 Software: Automatic masking of events highlighted by the ‘Aircraft’ Marker.

Manually Editing Markers

During post-process analyses, especially those relating to measurements generated by unattended monitoring systems, the functions offered by markers for manual use by an expert operator can still be of considerable help in highlighting various critical situations.

In Fig.6, the time history is shown for a period immediately following the one previously examined, characterized by 5 distinct air overflights, now followed by a marked gradual increase in the global noise level with a succession of short and intense single events.

Without further information, the operator would find it difficult to identify the reason for such a significant increase in the noise level which, moreover, is of non-negligible duration; using the progressive LAeq recalculation function, a global of 54.2 dB(A) can be detected compared to an accumulated 52.1 dB(A) up to the moments preceding this new event.

However, having also the frequency time history available, it is possible to generate the corresponding sonogram which, superimposed on the time history of the weighted sound level (A), as shown in Fig.6, allows us to conclude that the event must be attributed to a summer storm characterised by short initial showers of rain, followed by a more intense downpour and with a background rumble consisting of a large sequence of distant thunders:

- The sound of rain is detectable in the sonogram, by the uniform increase in the level of all frequencies above 800 Hz.
- The loud roar occurs where in the frequency range between 1000 and 4000 Hz the colour turns green, i.e. at levels around 50 – 55 dB.
- Thunder appears in the sonogram as vertical lines of color from yellow to red that from the lowest frequencies run out around 250 Hz, indicating energy concentrated in short instants and at low frequency.

In situations such as the one described, any information recorded by a weather station located near the noise monitoring unit or even audio recordings now available as an option in various types of sound level meters can obviously be helpful.

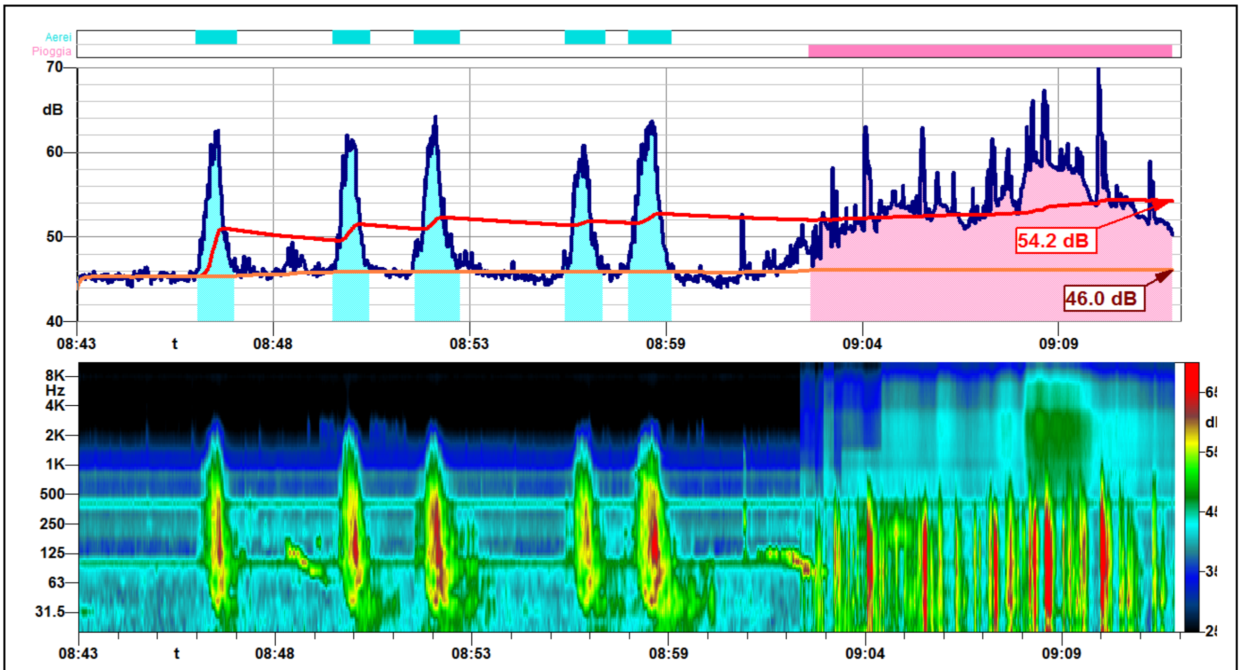


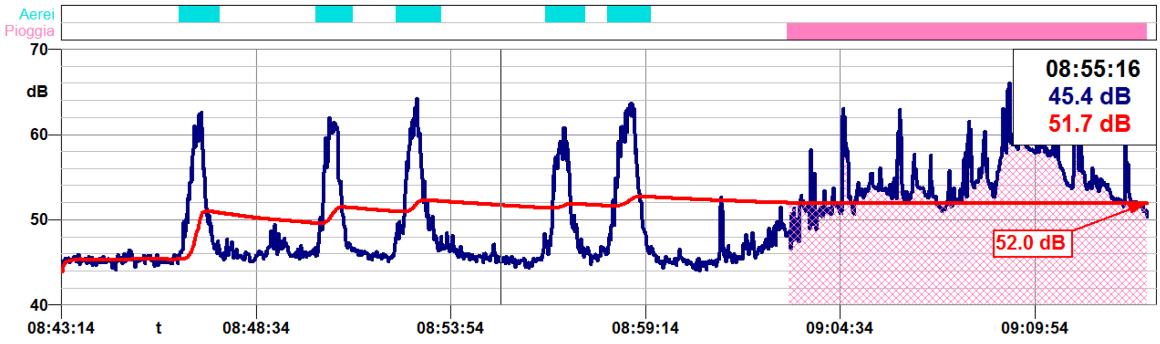
Fig.6- NWWin3 Software: Time History and Sonogram with Markers and Masks for ‘Airplane’ and ‘Rain’ Events.

Once the cause of the new event has been identified, the operator can still use the Marker function to highlight the entire period affected by the meteorological phenomenon and simply by dragging the mouse over the portion of the time history concerned, he will have the possibility of manually creating a specific Marker and naming it as desired, such as 'Storm' or 'Rain'; at the same time, a corresponding strip will be activated in the area dedicated to the Markers, located on the upper part of the graphs.

With the automatic or manual activation of a Marker, the values of LAeq, LAE (SEL), LAmax and LAmin corresponding to the duration highlighted by each of the categories of the activated markers, by the sum of the latter and by the global value of the complete measurement minus the values of the individual categories are always generated and updated.

This type of calculation allows the production of a numerical table in which the operator can synthetically detect the contribution of sound energy associated with the individual categories of markers and consequently of sound sources.

In the case taken as an example, the two types of sound sources, represented by the aircraft overflights and the rainy period, can be numerically visualized by a table that is linked to the base of the time history graph as shown in Fig.7.



Sorvoli + temporale						
Nome	Inizio	Durata	Leq	SEL	Lmax	Lmin
Totale	08:43:15	00:29:45	54.2 dB	86.7 dB	72.2 dB	43.8 dB
Senza Marcatori	08:43:15	00:14:08	46.0 dB	75.3 dB	52.6 dB	43.8 dB
Solo Marcatori	08:46:27	00:15:37	56.6 dB	86.4 dB	72.2 dB	45.6 dB
Senza Aerei	08:43:15	00:24:01	53.4 dB	84.9 dB	72.2 dB	43.8 dB
Solo Aerei	08:46:27	00:05:44	56.5 dB	81.9 dB	64.2 dB	45.6 dB
Aerei 1	08:46:27	00:01:08	55.6 dB	73.9 dB	62.6 dB	45.8 dB
Aerei 2	08:50:11	00:01:02	56.5 dB	74.4 dB	62.0 dB	45.7 dB
Aerei 3	08:52:24	00:01:15	56.6 dB	75.3 dB	64.2 dB	46.3 dB
Aerei 4	08:56:29	00:01:07	54.8 dB	73.1 dB	60.8 dB	45.6 dB
Aerei 5	08:58:12	00:01:12	58.2 dB	76.7 dB	63.7 dB	46.1 dB
Senza Pioggia	08:43:15	00:19:52	52.0 dB	82.7 dB	64.2 dB	43.8 dB
Solo Pioggia	09:03:07	00:09:53	56.7 dB	84.4 dB	72.2 dB	46.5 dB
Pioggia 1	09:03:07	00:09:53	56.7 dB	84.4 dB	72.2 dB	46.5 dB

Fig.7- Software NWWin3: Time History with numerical table of Markers'.

In the table in Fig.7 the Markers are divided into categories, each with the values of the individual contributions; the marker of the air overflights indicates a Leq of 53.4 dB for the entire measurement excluding all the overflights and a 56.5 dB for only the 5 marked overflights; then the values associated with the markers of the individual overflights also follow. For the 'Rain' marker, we find a contribution of 56.7 dB and a value of the measurement excluding the rainy period equal to 52.0 dB.

By removing the contribution highlighted by the sum of the Markers from the overall measurement we obtain 46.0 dB, while the sum of all the markers is 56.6 dB, on the entire measurement which showed an overall value of 54.2 dB.

Similarly, the values of SEL, Lmax, Lmin and duration of each Marker are also reported for a complete overview and to assist the operator in the evaluation processes of the weight to be attributed to the specific contributions of the individual categories of identified sources.

Tonal Component Markers

The NWWin3 software has recently introduced the function for searching for tonal components over time. Now, this function can also generate a Marker that identifies both on the time histories and on the sonograms, the possible presence of tonal components, identified in full compliance with the DM 16-03-1998.

Always considering the measurement taken as an example in this technical note, we can try to perform the tonal search by activating the specific Marker; the results are reported in the time history and corresponding sonogram of Fig.8.

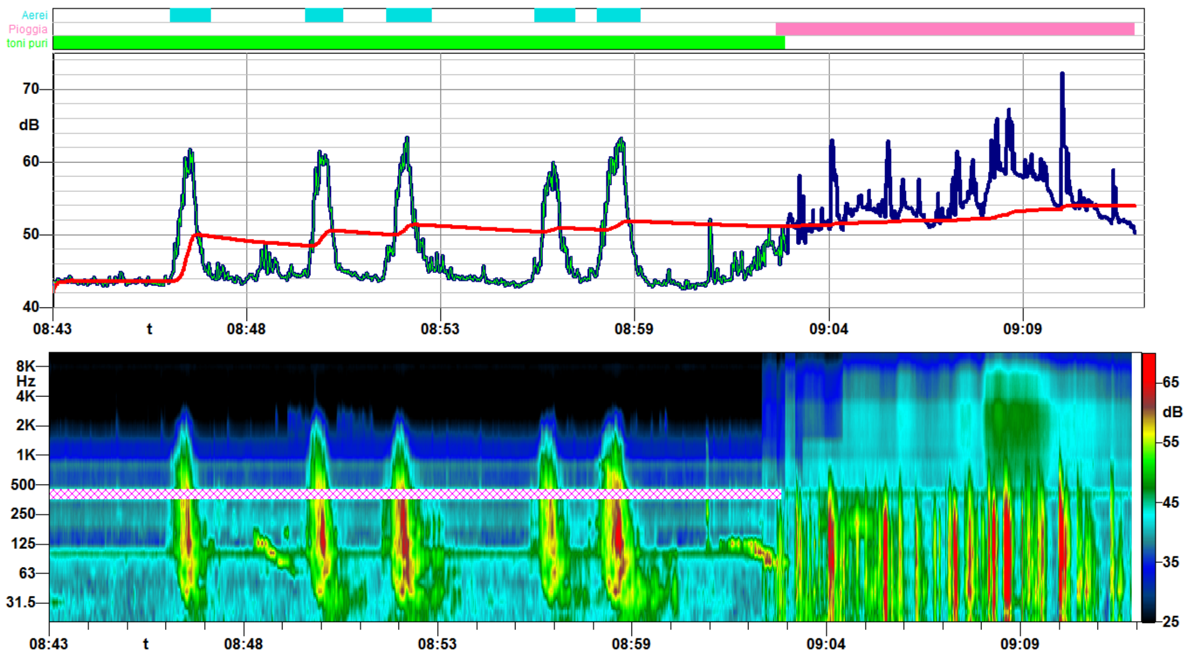


Fig.8- NWWin3: Time History and sonogram with tonal component identification markers DM 16-03-98

Activating the Marker for tonal components allows you to identify and highlight all periods of presence of a tonal even on long duration measurements and for any frequency band between 20 Hz and 20 kHz; the only parameter that must be set by the operator for this search is the minimum duration on which you want the tonal component to be identified.

The results of the research are clearly visible in the graphs in Fig.8, reported both as Markers in the green strip above the time history graph, and on the profile of the time history itself as a green trace and in the sonogram as a pink grid bar, present in the entire period from 8:43 until the arrival of the storm at 9:03.