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# The effect of snow on impulsive noise propagation - a sound-experiment in the Bavarian alps

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## 1. INTRODUCTION

The sound propagation is strongly affected by the ground-absorption. As you know from your own experience, that fresh fallen snow attenuates the noise of the surrounding area, the sound is perceived more quiet, muffled and deeper. The physical reason is the snows porous surface, which acts differently like a sound-absorber, depending on the consistency. The influence of the porosity to the sound-absorbing ability of snow was already researched metrological with the Kundsche Staurohr[1].

For a report in a science television broadcast by the German television station WDR (Quarks & Co.[2]) the sound absorption of snow was demonstrated by acoustic measurements. For this purpose a sound-experiment with and without snow was scheduled in the Bavarian Alps with reconciliation of the science editorial department of WDR.

## 2. DESING OF EXPERIMERIMENT

To attract media attention the sound-experiment in the Bavarian Alps took place at a plateau in the foothills of the Alps at an altitude of 800m near Oberaudorf (Oberbayern) and the sound was generated by ancient gun salutes fired by riflemen from a traditional local gun club.

Therefore we had to consider the factors of influence on the immission-sided sound level measurements like systematical measurement uncertainties, meteorological factors and background noise as well as the influencing factors related to the location, like reverberation on the rock faces and the diversification of the sound emission by the use of ancient guns.

Furthermore detailed preliminary investigations were not possible because of the given narrow time frame of about 6 weeks and the limited budget for the film crew, measurement team and the riflemen for at least two experimentations, one with and one without snow lying in the ground. For this reason this experiment needs a reproducible test arrangement and execution.

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## 3. EXPERIMENTAL ARRANGEMENT AND EXECUTION

For this experiment we set up a calibrated multi-channel sound level analyzer, two condenser measurement microphones, one measuring amplifier and one dodecahedral omni-directional speaker system, with are used in the room and architectural acoustics, at the plateau.

From experience the sound emission of the guns scatters a lot due to variable production tolerance of the projectile and the charge quantity. To minimize this scattering we first recorded the sound of these guns with the measurement microphones and later played through the amplifier and the omni-directional speaker system; the sound immission of this technical reproduced noise impulses was recorded and evaluated.

In addition, the damping of individual frequencies was analyzed by evaluating a noise signal (white noise and pink noise, both broadband and frequency-selective).

Consequently, this results in the series of measurements:

1. Experiment (without snow)
    a. two shooting-positions with 4 shots
    b. playback of these 4 shots over the dodecahedron
    c. playback of the noise signal
2. Experiment (with snow)
    a. two shooting-positions with 4 shots
    b. playback of these 4 shots over the dodecahedron
    c. playback of the noise signal

The positions of the microphones, the omni-directional speaker system and the riflemen were equal in both situations. The dates for the experiments were about 4 weeks apart. On both measuring days the weather was dry and calm. The following pictures show the measuring location during the experiments.

**Figure 1**: measuring location without snow (left) and with snow (right)

## 4. TEST RESULTS

The energy density of the typical noise impulse of one shot sequence is evident in the following sonogram: it is visible in the linear spectral time, that the impulses stimulate sound all over the range of audibility (broadband stimulation), whereby the main energy input is in the low frequencies (below 80 Hz). Furthermore the interval of time between the shots is cognizable. During the shootings (not reproduced by the omni-directional speaker system) the interval $t_i$ between two shots varies about 1s to 3s.

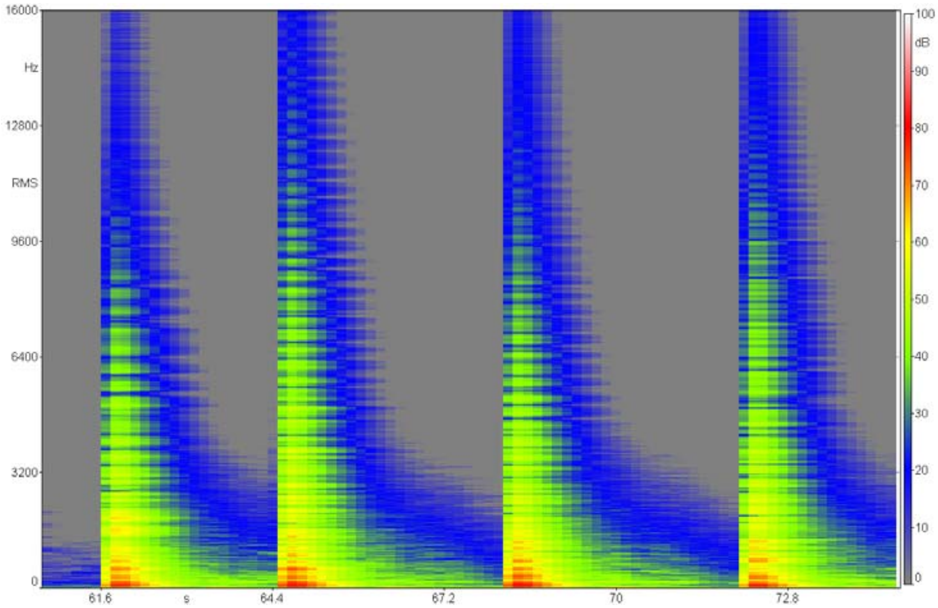


**Figure 2**: sonogram with the typical time-frequency-course of the shooting

To make the effect of the snow comparable to the sound-immission, the different intervals $t_i$ between each shot of the two experiments were balanced during the interpretation. The result shows in Figure 3 the time course of the Fast- and A-weighted sound pressure level at the measuring location with and without snow.

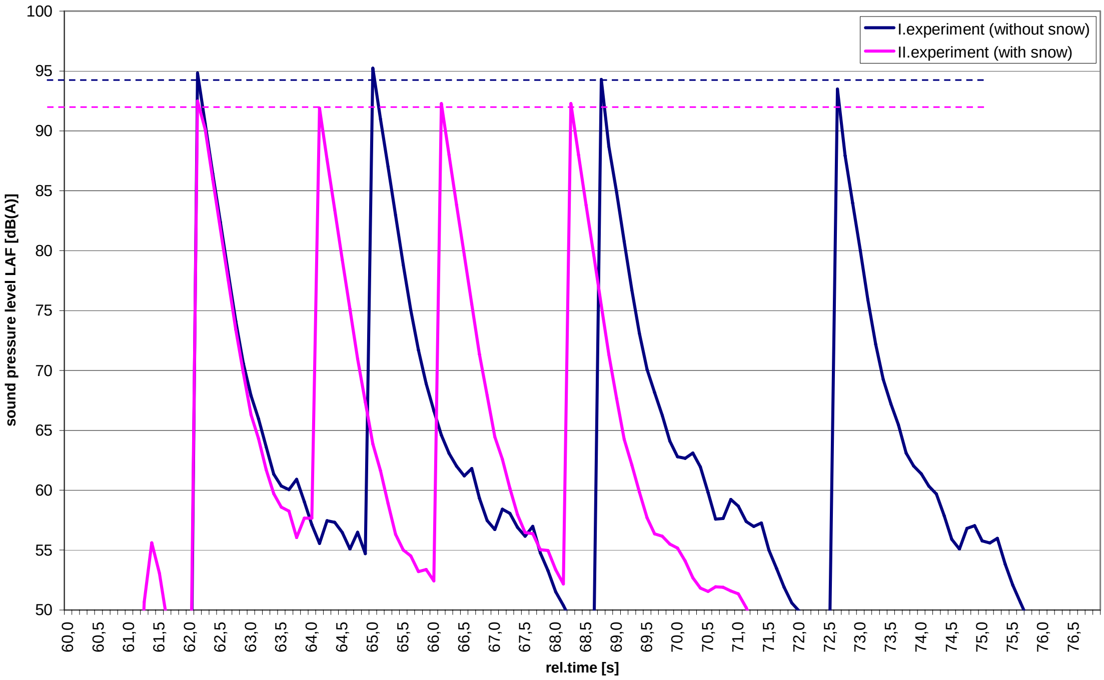


**Figure 3**: Comparison of the A- and Fast-weighted sound pressure level

It becomes evident, that the A-weighted sound pressure level is lowered about 2 dB(A) by the snow. Without snow a clear echo is generated at the microphone with a delay of 1,6s after the main peak, a so called echo-peak. This echo-peak was not measurable in the 2. experiment with snow. Moreover the descending slope of the sound level decreases about 20% faster, measured by the level decrease from 90 to 55 dB.

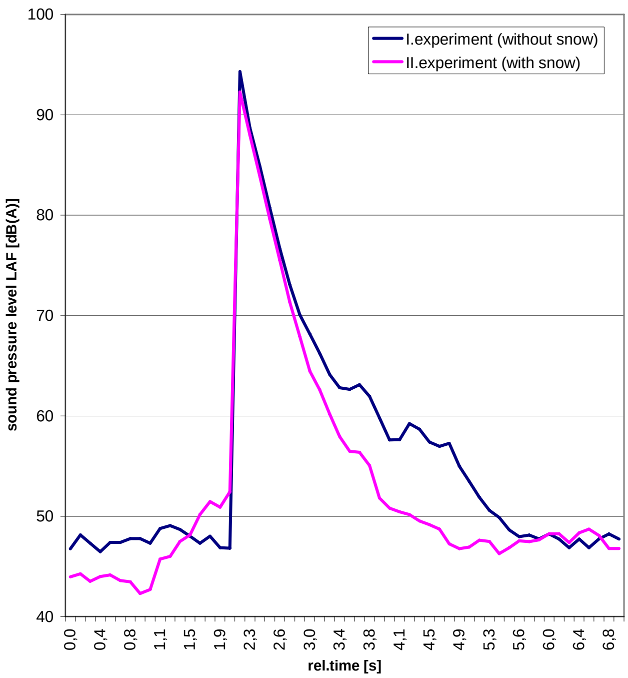


**Figure 4**: Comparison of the sound pressure level

There is also an evident scattering of each shot from one shooting-session. Thus the reproduced shots and the noise signals have been also evaluated and result in appropriate results, but with a considerably higher significance.
To visualize the influence of the snow damping to the noise frequency the spectrum in 1/3 octave bandwidth of both experiments are set in comparison.

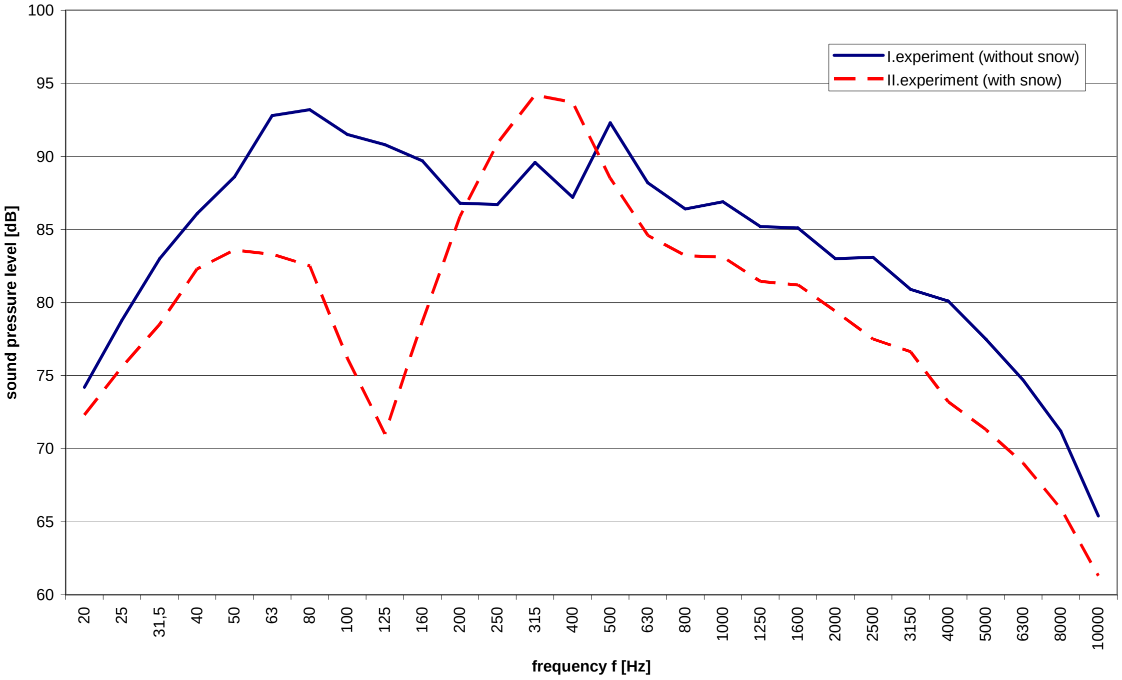


**Figure 5**: Comparison of the Fast- and linear-weighted Max-Hold-1/3 octave-level

By comparing the spectrum in Figure 5 there are 3 frequency ranges identifiable:

1. 20 to 200 Hz, with a maximum level difference of 20 dB at 125 Hz
2. 200 to 500 Hz, in this frequency range we even measured a 5 dB higher level with snow, probably caused by a spectral shift of the sound energy.
3. > 500 Hz, the main result of the superficially snow absorption occurs with a damping of 4 dB at 1000 Hz and 7 dB at 4000 Hz.

Due to the damping in the frequency range over 500 Hz a significant reduction of the perceived loudness is expected. Therefore the effectiveness of the snow damping is additionally shown in psychoacoustic loudness according to DIN 45631. Figure 6 shows the loudness-time functions of the conclusions from Figure 3.

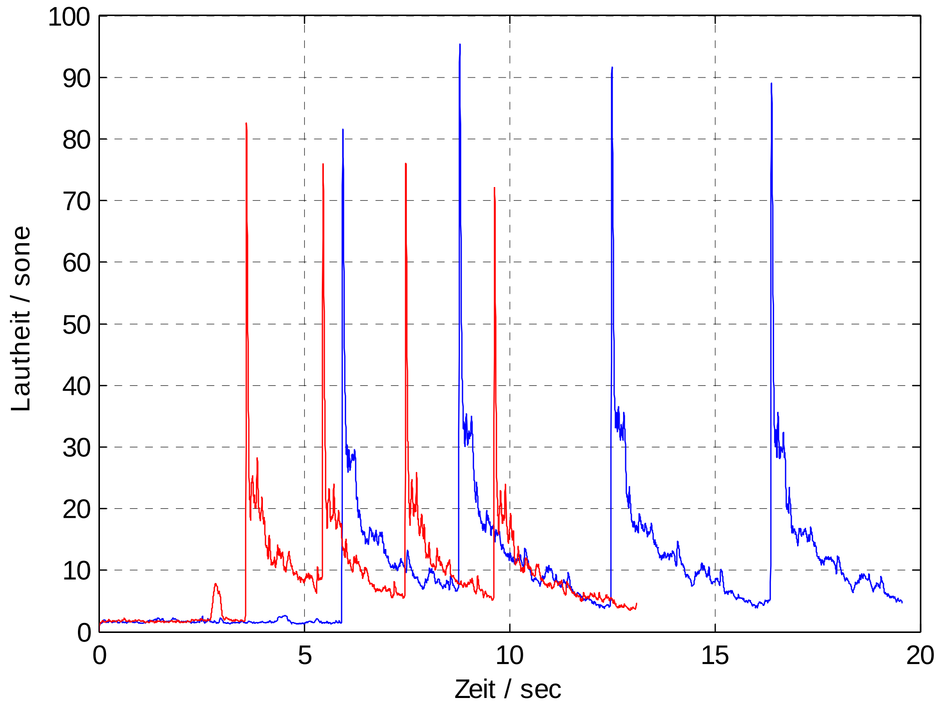


**Figure 6**: loudness-time functions of shooting noise without (blue line) and with (red line) snow

As shown in Figure 6 the loudness of the shots without snow are with an average of 89 sone about 15% louder than the shots with snow, that are in average 77 sone. Considering the equal loudness contours known from literature, it leads to the conclusion that the snow damping especially in the frequency range from 2 to 5 kHz has the biggest influence in reducing the perceived loudness.

## 5. SUMMARY

In this sound experiment the sound level of gunshots has been measured with and without snow on the propagation path. The evaluation by displaying the noise in dB and sone results that there is a noticeable reduction of the sound level with snow lying on the ground.

## REFERENCES


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