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Propagation characteristics of acoustic waves in snow

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Acoustic emission analysis is a promising technique for monitoring snow slope stability with potential for application in early warning systems for avalanches. Current research efforts focus on identification and localization of acoustic emission features preceding snow failure and avalanches. However, our knowledge of sound propagation characteristics in snow is still limited. A review of previous studies showed that significant gaps exist and that the results of the various studies are partly contradictory. Furthermore, sound velocity and attenuation have been determined for the frequency range below 10 kHz, while recent snow failure experiments suggest that the peak frequency is in the ultrasound range between 30 kHz to 500 kHz.

We therefore studied the propagation of pencil lead fracture (PLF) signals through snow in the ultrasound frequency range. This was achieved by performing laboratory experiments with columns of artificially produced snow of varying density and temperature. The attenuation constant was obtained by varying the size of the columns to eliminate possible influences of the snow-sensor coupling. The attenuation constant was measured for the entire PLF burst signal and for single frequency components. The propagation velocity was calculated from the arrival time of the acoustic signal.

We then modelled the sound propagation for our experimental setup using Biot's model for wave propagation in porous media. The Model results were in good agreement with our experimental results. For the studied samples, the acoustic signals propagated as fast and slow longitudinal waves, but the main part of the energy was carried by the slow waves. The Young's modulus of our snow samples was determined from the sound velocity. This is highly relevant, as the elastic properties of snow are not well known.