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The use of seismic ground particle motion for snow avalanche release area identification

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Knowledge of the snow avalanche release area is key information in snow avalanche studies. However, it is not easy to obtain from a remote location. The study of the seismic vibrations produced in the initial stages of the snow avalanche, makes possible to identify their origin and to link them to the starting area of the snow avalanche. We developed a methodology for this purpose, applied to seismic data acquired from a 3D seismic station (2Hz eigenfrequency) placed at Cavern A in Vallée de la Sionne experimental site (VDLS, WSL-SLF), deployed in 2013 by UB-RISKNAT. This is the closest position to the snow avalanche release areas, at 700 m to the farthest point. We focus on spontaneous triggered snow avalanches to achieve better signal-to-noise ratio and to be more realistic on its application.

For the isolation of the Signal Onset (SON) section of seismic data, which corresponds to those vibrations produced by the initial stage of the snow avalanche, we use the STA/LTA ratios and seismic signal amplitude, common methodologies in seismology. The STA/LTA is used for the identification of the first vibrations produced by the movement of the snow mass and the seismic signal amplitude thresholds for the identification of the end of the SON section -when the snow avalanche front reaches the seismic sensor position-. The 3D seismic data [ZNE components] of the SON section were processed in time windows. The study of polarization of the particle motion to obtain the direction of the back-azimuth of the signal (Vidale, 1986; Jurckevicks, 1988) was carried out for each time window of the seismic signal. The accumulation of back-azimuth directions for the entire SON section is related to the origin of the vibrations and, by extension, to the snow avalanche release area.

The entire algorithm has been automated. In its application on all the trigger activations at VDLS since 2015 until 2020, it was achieved a success rate of 78% on snow avalanche release area identification. In addition, we defined an algorithm based on STA/LTA ratio to select the snow avalanches from other seismic events, used with a success rate of 95%.

We present the application of our method in a case study, a large spontaneous snow avalanche released on 16th February 2018 at VDLS. The snow avalanche had two main release areas, clearly identified in photos of the site. The two developed fronts can be recognized in the seismic data. The directions to the release areas from Cavern A position can be identified using the presented

method. Also, more interpretations can be done on the downhill snow avalanche path.