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Automatic detection and localization of avalanches in continuous seismic data

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Seismic monitoring systems are well suited to continuously monitor avalanches independent of weather conditions. Indeed, since the 1970s it has been known that avalanches produce characteristics seismic signals. However, identifying these signals in continuous time series still remains a difficult challenge. Recently, a new approach based hidden Markov models (HMM), an advanced machine learning algorithm, was suggested to automatically detect avalanches in continuous seismic data. While a HMM can be trained with as little as one single training sample, recent work has shown that the number of false alarms can be high. We therefore developed a new approach which combines two HMM trained on two different seismic arrays. The first model was build to detect avalanches, while the second model was used to identify airplane signals, the most common source of misclassification. Cross-checking the automatically detected events allowed to reduce the number of false alarms. In a final step we used multiple signal classifications (MUSIC), an array processing technique, to determine the back-azimuth and the velocity of the incoming wave-fields to identify the source of the events to further remove false detections. Since avalanches are moving sources, they generate signals with only small changes in back-azimuth. Events with large changes in back-azimuth angles were therefore considered noise. We used this method on data recorded from January to April 2017 at two field sites above Davos, Switzerland. During this 4 month period we initially identified over 100 events. By using the second HMM and the MUSIC algorithm, we drastically reduced the number of events and obtained an avalanche activity pattern in line with visual observations performed by the avalanche warning service in the area of Davos.