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# Observing avalanche dynamics with Distributed Acoustic Sensing

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Avalanche research requires comprehensive measurements of sudden and rapid snow mass movement that is hard to predict. Automatic cameras, radar and infrasound sensors provide valuable observations of avalanche structure and dynamic parameters, such as velocity. Recently, seismic sensors have also gained popularity, because they can monitor avalanche activity over larger spatial scales. Moreover, seismic signals elucidate rheological properties, which can be used to distinguish different types of avalanches and flow regimes. To date, however, seismic instrumentation in avalanche terrain is sparse. This limits the spatial resolution of avalanche details, needed to characterise flow regimes and maximise detection accuracy for avalanche warning.

As an alternative to conventional seismic instrumentation, we propose Distributed Acoustic Sensing (DAS) to measure avalanche-induced ground motion. DAS is based on fibre-optic technology, which has previously been used already for environmental monitoring, e.g., of snow avalanches. Thanks to recent technological advances, modern DAS interrogators allow us to measure dynamic strain along a fibre-optic cable with unprecedented temporal and spatial resolution. It therefore becomes possible to record seismic signals along many kilometres of fibre-optic cables, with a spatial resolution of a few metres, thereby creating large arrays of seismic receivers. We test this approach at an avalanche test site in the Valleé de la Sionne, in the Swiss Alps, using an existing 700 m long fibre-optic cable that is permanently installed underground for the purpose of data transfer of other, independent avalanche measurements.

During winter 2020/2021, we recorded numerous snow avalanches, including several which reached the valley bottom, travelling directly over the cable during runout. The DAS recordings show clear seismic signatures revealing individual flow surges and various phases/modes that may be associated with roll waves and avalanche arrest. We compare our observations to state-of-the-art radar and seismic measurements which ideally complement the DAS data.

Our initial analysis highlights the suitability of DAS-based monitoring and research for avalanches and other hazardous granular flows. Moreover, the clear detectability of avalanche signals using

existing fibre-optic infrastructure of telecommunication networks opens the opportunity for unrivalled warning capabilities in Alpine environments.