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Near-field observations of snow-avalanches propagating over a fiber-optic array

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We present and evaluate array processing techniques and algorithms for the characterization of snow avalanche signals recorded with Distributed Acoustic Sensing (DAS).

Avalanche observations rely on comprehensive measurements of sudden and rapid snow mass movement that is hard to predict. Conventional avalanche sensors are limited to observations on or above the surface. Recently, seismic sensors have increased in their popularity for avalanche monitoring and characterization due to their avalanche detection and characterization capabilities. To date, however, seismic instrumentation in avalanche terrain is sparse, thereby limiting the spatial resolution significantly.

As an addition to conventional seismic instrumentation, we propose DAS to measure avalanche-induced ground motion. DAS is a technology using backscattered light along a fiber-optic cable to measure strain (-rate) along the fiber with unprecedented spatial and temporal resolution - in our example with 2 m spatial sampling and a sampling rate of 1kHz.

We analyze DAS data recorded during winter 2020/2021 at the Valleé de la Sionne avalanche test site in the Swiss Alps, utilizing an existing 700 m long fiber-optic cable. Our observations include avalanches propagating on top of the buried cable, delivering near-field observations of avalanche-ground interactions. After analyzing the properties of near-field avalanche DAS recordings, we discuss and evaluate algorithms for (1) automatic avalanche detection, (2) avalanche surge propagation speed evaluation and (3) subsurface property estimation.

Our analysis highlights the complexity of near-field DAS data, as well as the suitability of DAS-based monitoring of avalanches and other hazardous granular flows. Moreover, the clear detectability of avalanche signals using existing fiber-optic infrastructure of telecommunication networks opens the opportunity for unrivalled warning capabilities in Alpine environments.