DETECTING DEBRIS FLOWS BY DISTRIBUTED ACOUSTIC SENSING

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In this work, we have monitored some debris flows in an artificial inclined flume, instrumented with approx. 800 m of fiber, wound in 20 coils. The fiber was interrogated using a distributed acoustic sensing (DAS) system based on a chirped-pulses phase-sensitive optical time-domain reflectometer and the acquired signals were analyzed confirming the viability of DAS for debris flows monitoring.
Keywords: Debris flows, Distributed acoustic sensing.

Debris flows are natural hazardous phenomena where fragmented rocks, mud, water, and air [1] flow down mountainsides in a rapid, gravity-induced flow. Unfortunately, debris flows often cause damages to infrastructure and casualties. Since the flow determines intense ground vibrations, these seismic signals are commonly used to monitor debris flows [1] and, in this work, for the first time to our knowledge, the viability of DAS for debris flows seismic monitoring is investigated. To this aim, we performed a set of experiments in a physical model, consisting of an inclined flume (2.0×1.5 m), with a variable inclination from 0° to 38°, on which it is possible to install a channel 30 cm-wide, where the flow of debris occurs.

The DAS system used in this work is a chirped-pulse phase-sensitive optical time-domain reflectometer [2], which is intrinsically fading resistant. The scheme of this chirped-pulse DAS is shown in Fig. 1, while its specifications are listed in Tab. 1. Further details of this DAS system can be found in [3].

Table 1 Specifications of the chirped-pulse DAS.

Range	35 km (70 km w/ amplification)
Spatial resolution	2-10 m (4 m in the experiments)
Spatial sampling	2 m
Acoustic Bandwidth	1 kHz in the experiments
Noise level	20-30 p$\varepsilon/\sqrt{\text{Hz}}$
RMS noise (@ 1 kHz)	±1 nε

Please note that, given a DAS spatial resolution of few meters, the short length of the flume (2 m) did not allow to deploy the fiber linearly, down to the flume. To cope with this scale problem, we embedded the optical fiber into an engineered mat hosting an array of 20 optical fiber coils (see Fig. 1). Given the DAS resolution, this mat allows to have approx. 400 sensing points, 20 per each acoustic sensor.

Debris (overall weight of debris 40 kg) were left to flow down the flume and the seismic signals have been collected for different diameter and roughness of the gravel particles.

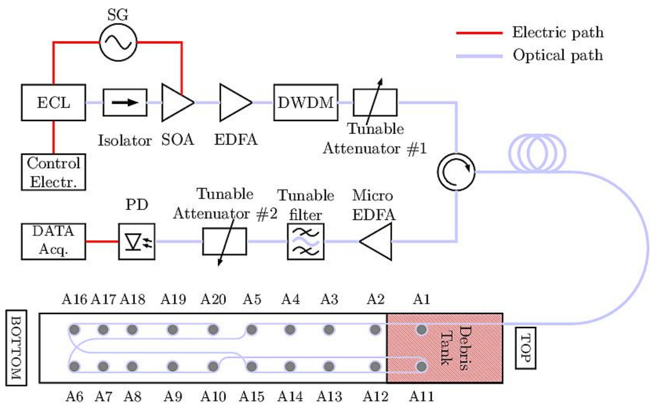

Fig. 1 Chirped-pulses DAS setup and the engineered mat embedding the acoustic sensors deployed in the flume.

As an example, Fig. 2 shows the signal collected at one of the sensing point of the coil A20 to briefly demonstrate the DAS capability to provide seismic signals at a specific location as standard seismic single sensors commonly used in debris flows monitoring.

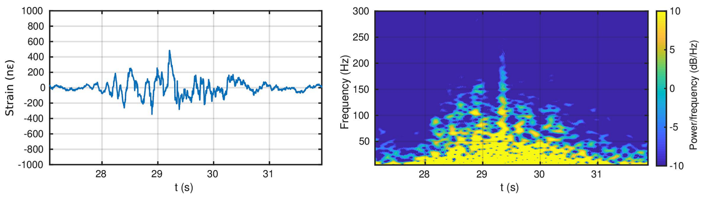

Fig. 2. On the left, the signal collected at one sensing point of the optical acoustic sensor A20 and, on the right, the corresponding spectrogram.

References

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