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Crustal Exploration and Monitoring Seismic Events with a Fibre-optic Cable Deployed at the Ground Surface in Iceland

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SUMMARY

We present new results of records from a 15 km long fibre-optic cable deployed at the surface in Iceland. We estimate the quality of records of seismic events with the cable for both exploration and monitoring.

Abstract

The fibre-optic distributed acoustic sensing technology (DAS) can be used for exploring earth crustal elastic properties and monitoring both strain and seismic waves with unprecedented acquisition characteristics (Daley *et al*., 2013). The DAS technology principle lies in sending successive and coherent pulses of light in an optical fibre and measuring the back-scattered light issued from elastic scattering at random defaults within the fibre (Massoudi & Newson, 2016). The read-out unit includes an interferometer which measures light interference patterns continuously. The changes in the interference pattern are related to the distance variations between such defaults and therefore the strain applied on the fibre can be detected. Along an optical fibre, DAS can be used to acquire acoustic signals with a high spatial (every meter over kilometres) and temporal resolution (thousand of Hz).

Fibre optic technologies were, up to now, mainly applied in perimeter surveillance applications and pipeline monitoring and in boreholes (e.g., Cox *et al*., 2012). Previous experiments in boreholes have shown that the DAS technology is well suited for probing subsurface elastic properties, showing new ways for cheaper VSP investigations of the Earth crust (Li *et al*., 2015).

Here, we demonstrate that a cable deployed at the surface can also help exploring subsurface properties at crustal scale and monitor earthquake activity in a volcanic environment. Within the framework of the EC funded project IMAGE, we measured in a >15 km-long fibre optic cable at the surface connected to a DAS read-out unit. Acoustic data was acquired continuously for 9 days.

Hammer shots were performed along the surface cable in order to locate individual acoustic traces and calibrate the spatial distribution of the acoustic information (Figure 1). During the monitoring period both signals from on- and offshore explosive sources and natural seismic events could be recorded (Figure 2). We compare the fibre optic data to conventional seismic records from a dense seismic network deployed on Reykjanes. We show that we can probe and monitor earth crust subsurface with dense acquisition of the ground motion, both in space and in time and over a broad frequency range.

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