

Monitoring landslide disturbances using distributed acoustic sensing under extreme weather conditions

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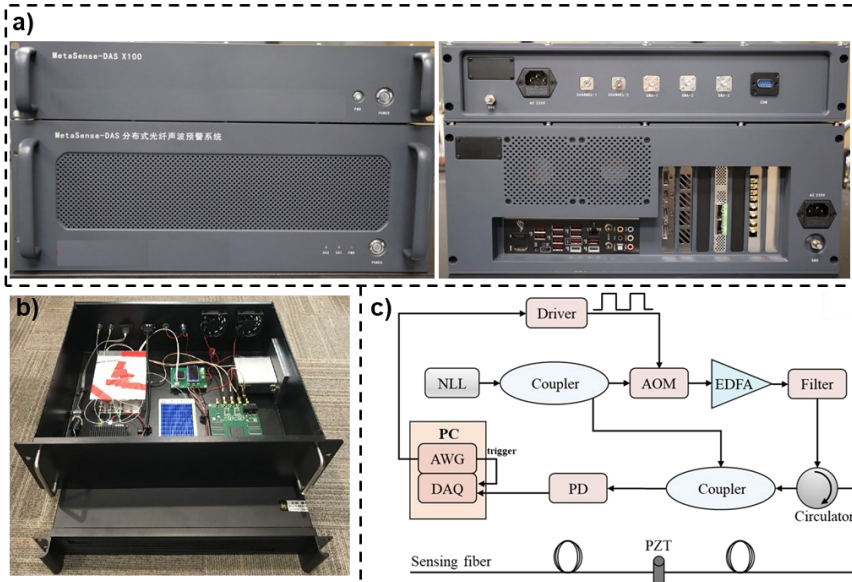
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Device metrics	Performance
Monitoring channel	2 channels
Monitoring distance	96km
Spatial resolution	50m
Sampling spatial resolution	10m
Center wavelength	1550nm
Spectral linewidth	3kHz
Frequency response	2kHz@48km
Acquisition card data transmission	250MB/s@PCIE
Communication	MQTT

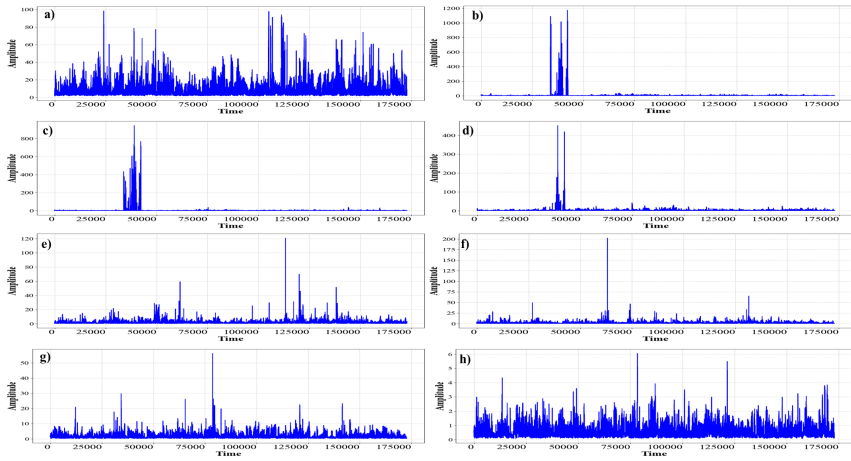
Supplementary Table 1 The Components and key device parameters for DAS system.



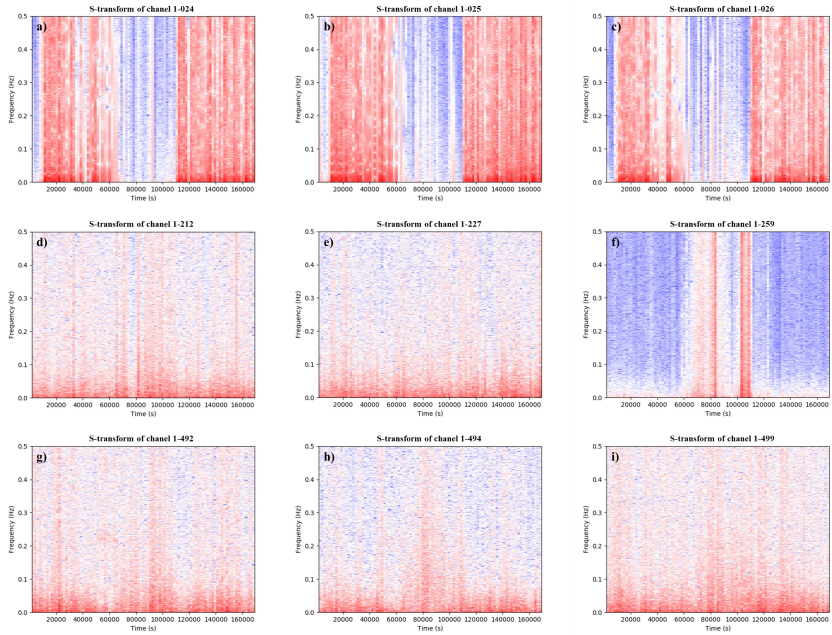
Supplementary Fig. S 1 Schematic illustration of self-developed distributed acoustic sensing (DAS) system structure and component connection. **a** The physical appearance and interface details of the DAS system support multi-channel connection. **b, c** The DAS system employs a 99:1 optical coupler and a sensing fiber, driven by a narrow linewidth laser (NLL). The continuous-wave laser is split into two paths: an upper channel and a lower channel. The signal path is modulated into narrowband pulsed light via an acoustic-optic modulator (AOM). The pulsed light is then amplified using an erbium-doped fiber amplifier (EDFA) before being injected into the sensing fiber through an optical coupler and circulator. The optical signal interacts with the local oscillator signal propagating through the lower reference fiber, producing a beat frequency signal. This beat signal is triggered and modulated by an arbitrary waveform generator (AWG), enabling its acquisition and digitization through a data acquisition (DAQ) system for further analysis.



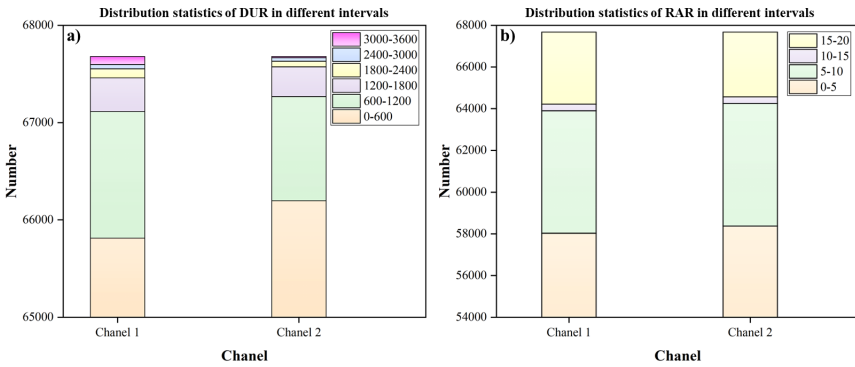
Supplementary Fig. S 2 Post disaster records of the locations of two landslide events. According to relevant reports from the meteorological department and disaster records from pipeline companies, the two incidents occurred approximately on September 14, 2022, from 10:00 to 14:00 and September 15, 2022, from 11:00 to 13:00. These landslide disaster scene image records (a) represents the event at the position of Channel 1, while (b) and (c) represent the event at the position of Channel 2.



Supplementary Fig. S 3 The raw signal waveforms from the DAS system at various locations. **a-d** depict the raw signal acquisition waveforms from the DAS system for channels near the 30 km mark, where a landslide event occurred as indicated in Fig. 1(b). **e-h** show the waveforms for channels near the 40 km mark, where no landslide event was reported. The waveforms illustrate the environmental vibrations and acoustic fields detected by the DAS system.



Supplementary Fig. S 4 Comparison of typical signals with and without landslide events after S-transformation. **a,b,c** represent the time-frequency characteristics of the central defensive zone at the landslide location in Channel 1 during September 14th to 16th, 2022 (UTC). **d,e,f** display the typical signal characteristics of an area in Channel 1 where no landslide occurred, with red indicating stronger energy fluctuations. **g,h,i** illustrate the signal characteristics in Channel 2, far from the landslide event area. This region, located near the fiber's end, exhibits a more significant optical signal.



Supplementary Fig. S 5 The distribution statistics of the two critical indicators (**DUR** and **RAR**) in intervals. The relative distribution sizes of Channel 1 and Channel 2 in each interval are displayed. **a** DUR represents the distribution of signal duration. The interval is divided into six groups, each corresponding to a unit of 600 seconds, with the maximum duration covering the primary time window of 3600s. **b** The radiation distribution represented by RAR is divided into 4 different intervals based on 5 defense zones, with the maximum affected covering 20 defensive zones.