



Report of Transnational Access Projects

Project ID: C2_TA3-84-1_2

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Project title: Strong Motion Assessment with DAS

Project acronym: SMAD

Hosting installation: TA3-84-1, Università di Napoli Federico II, Physics Department

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Period of access: In person: 2026-01-25 to 2026-02-05

Report of activities:

Distributed Acoustic Sensing (DAS) is emerging as a new paradigm in seismology. It enables continuous monitoring of ground motion in remote environments such as volcanoes and deep oceans. DAS systems also offer significant potential for earthquake early warning (EEW) applications (Strumia et al., 2026). By approaching submarine faults more closely than onshore instruments, they can provide alerts theoretically up to several seconds earlier in subduction zones (Lior et al., 2023).

A key limitation of current DAS systems is their restricted dynamic range. Present interrogators struggle to accurately measure strong ground deformation at short distances, such as that generated by earthquakes larger than approximately magnitude 5–6 (van den Ende et al., 2024). This limitation is mainly due to phase wrapping within the interval $(-\pi, \pi)$. In this project, we investigated saturation effects and explored novel approaches based on raw optical data to unwrap the recorded phase and potentially extend the dynamic range.

We first collected and analyzed raw optical data from the Colliano experiment. This step aimed to establish a workflow for retrieving accurate strain-rate waveforms from electric field measurements. We followed a homodyne approach to extract phase information from photodiode signals. This method relies on combining the input electric field, phase-shifted by $\pi/2$, with the backscattered field.

Subsequently, we conducted a dedicated laboratory experiment using a 200 m optical fiber connected to a DAS system. The setup was designed so that only a central section (a few meters long) experienced deformation, while the remaining sections remained nearly undeformed. We used a gauge length of 1 m,



spatial sampling of 0.5 m, and a sampling frequency of 10 kHz. Both small and large strain conditions were generated, and raw data were acquired to reconstruct the four components of the combined electric field.

The results confirm that signal saturation occurs under large strain conditions. Moreover, we show that the homodyne approach does not allow for the applicability of cross-correlation methods to estimate the number of phase cycles and, therefore, impedes correct phase unwrapping.

To further investigate this behavior, we developed numerical simulations using a Python-based code (an example is shown in Figure 1). The model reconstructs strain from electric field measurements within a homodyne framework, capturing the relationship between the motion of impurities induced by ground deformation and the recorded photodiode signals. The simulations reproduce both saturation effects at large strain and their dependence on acquisition parameters.

Our results demonstrate that DAS parameter selection—such as temporal and spatial sampling and laser pulse width—strongly influences saturation and can be optimized to extend the system dynamic range. Additionally, simulations suggest that modifying the effective wavelength can slow down phase variations, further improving dynamic range.

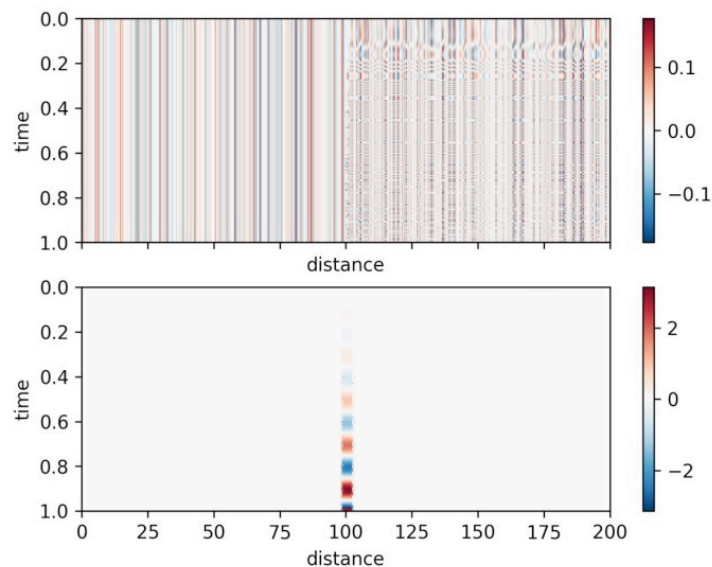


Figure1: Simulation of the relation between the phase of the electric field measured with a homodyne approach and the strain recorded along the fiber.

Project outcomes:

DAS data are available at : Doi: <https://doi.org/10.5281/zenodo.19369960>. Data are distributed under CC-BY 4.0 license

DAS data will be also distributed by the INGV EIDA node and the EPOS platform under the Irpinia Near Fault data provision after agreement on metadata and formats (expected by the end of April 2026).

Note: Data, products, software and publications resulting from TA activities must be publicly accessible under a CC-BY 4.0, GPLv3 or equivalent open license. No embargos beyond June 2026 are allowed. They

must cite Geo-INQUIRE as the source of funding. Minimal citation: *“Geo-INQUIRE is funded by the European Union (GA 101058518)”*.

